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, noise 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 and decision making.

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-light, 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 requirements identification 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 requirements identification 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 <u>GENERAL</u>

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. 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), however 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

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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

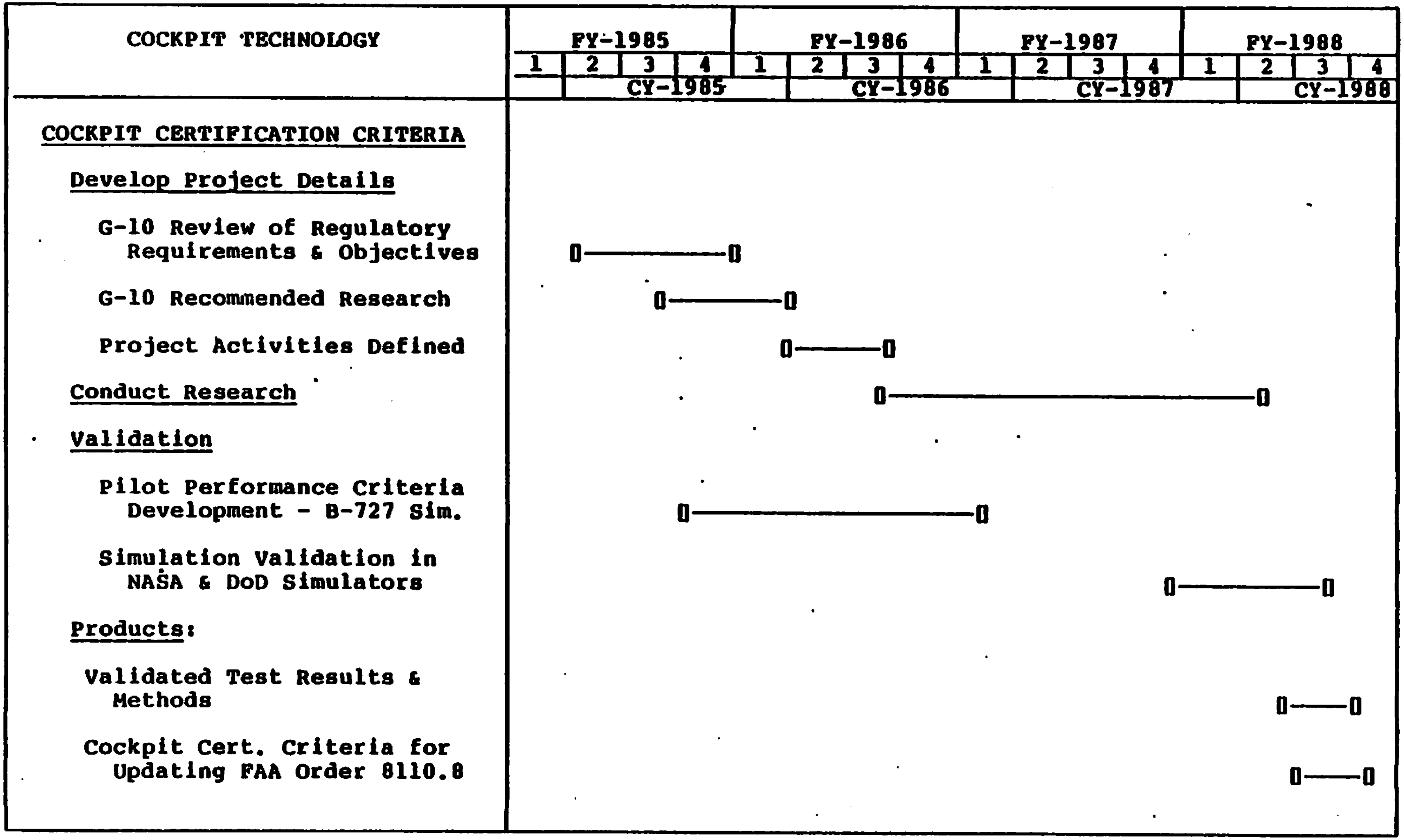
STATUS: (Enter current information)

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.

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

Products:

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

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)

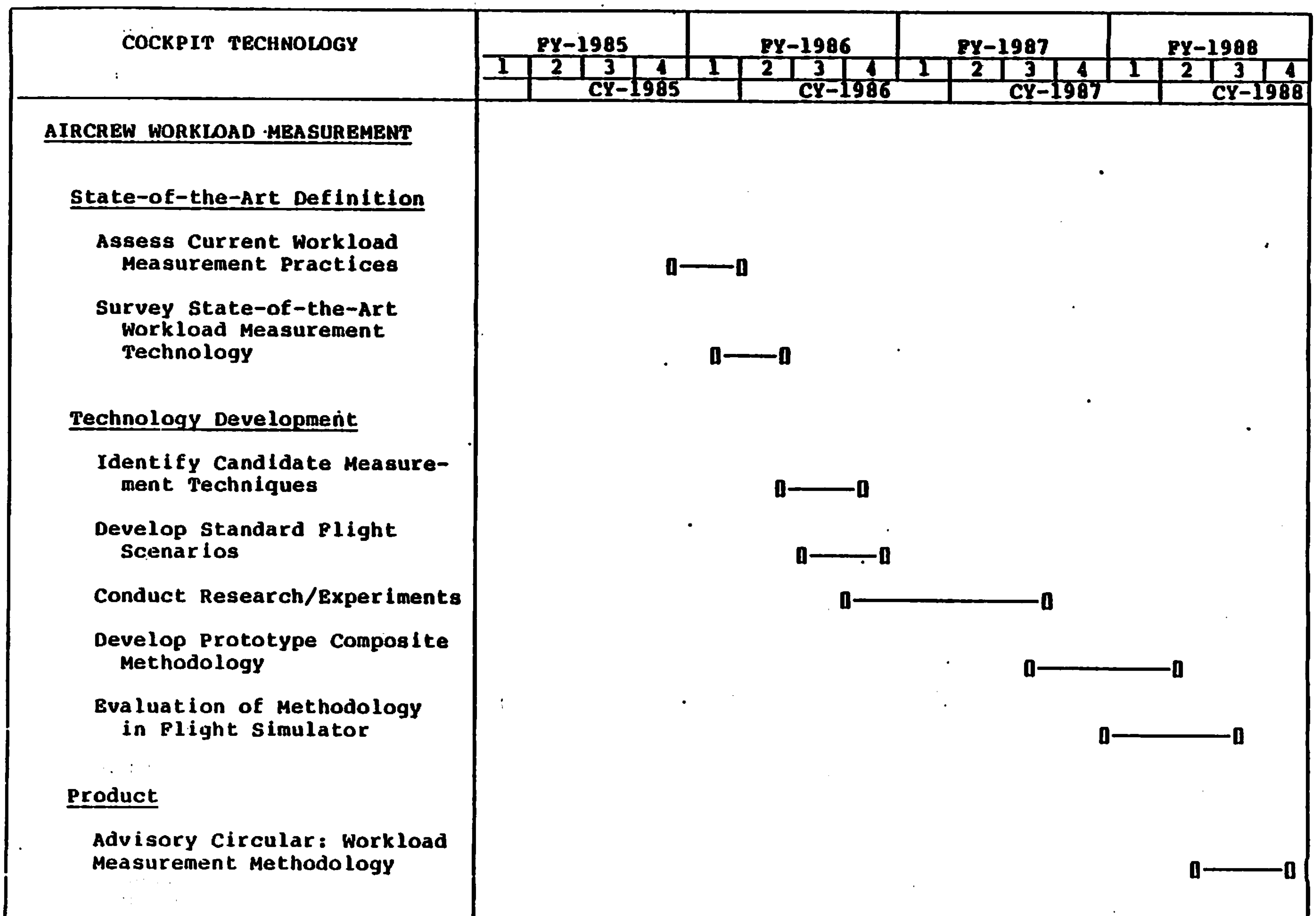
	Scheduled Completion	Revised Scheduled Completion	Actual Completion
IAA USAF	3/85		
Contracted Study - Initiated	8/85		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- Basic research in workload assessment, NASA-Ames;
- Task-matched methods of workload assessment, USAF-AMRL:
- Physiological correlates of operator workload, Douglas Aircraft; and
- 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)

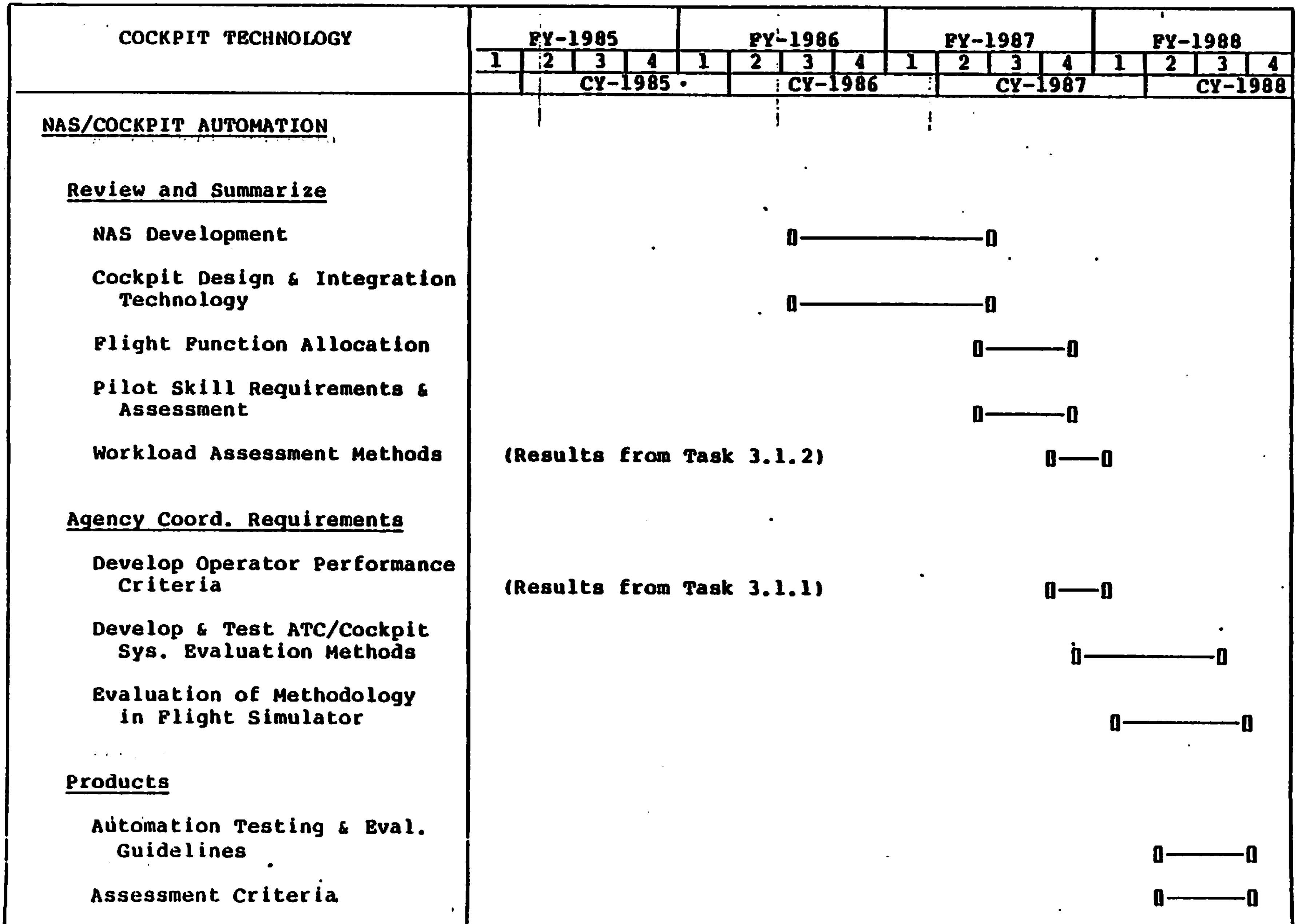
	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Define User Requirements	4/86		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

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


COCKPIT TECHNOLOGY
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FY-1988
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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:

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

Products:

- Guidelines for using voice-activated systems in the cockpit.
- 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		
VOICE ACTIVATED SYSTEMS																
Survey State-of-The-Art				0—	—	—	—0									
Initiate Interagency Agreement with USAF				0—	—	—	—	—0								
Identify Applications in Cockpit																
Evaluate Systems																
Simulation																
Flight Test																
Products																
Guidelines for Cockpit Use								0—0								
Performance Criteria								0—0								

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		
<u>MANUAL REVERSION</u>																
<u>Develop FAA/NASA Investigation</u>																
Investigate Issues			[]——	——[]												
Develop Project Plan (if warranted)				[]---	---	---[]										
<u>Evaluate Potential Solutions</u>						[]---	---	---	---[]							
Situation Displays																
Special Training																
Special Procedures																
<u>Products</u>																
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)

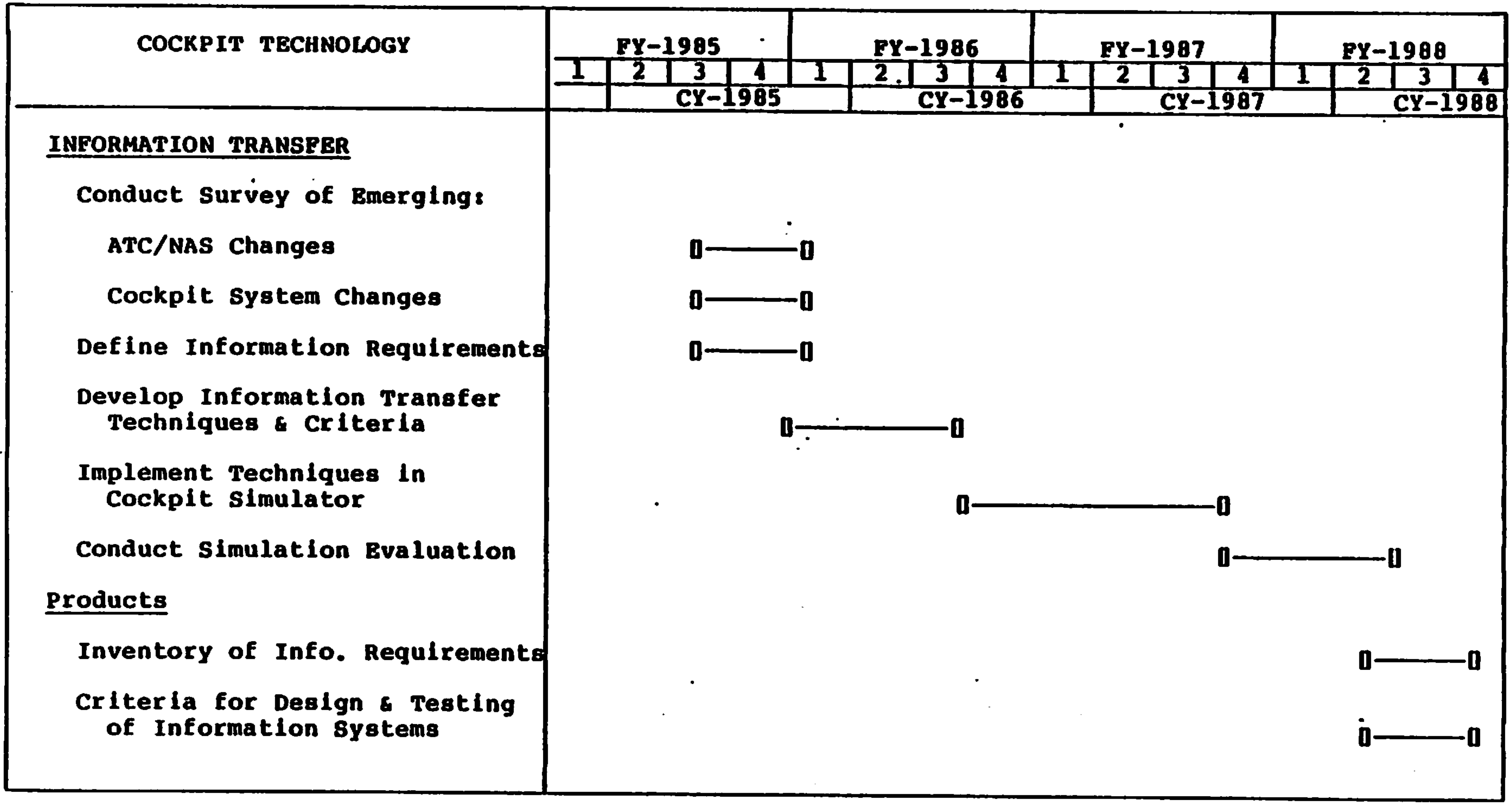
	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Define Data Link Issue	8/85		

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:

- 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;
- Improve instrument approach chart information transfer and use efficiency through improved information flow and prioritized information sequencing/structuring;
- Reduce the time required to sort and select needed information; and
- Minimize the probability of misinterpretation of charted information.

The development program should include the following projects/tasks:

Survey, Analysis, Problem Definition, and Planning:

- Conduct surveys and collect descriptive data for flight operations, avionic interface applications, and ATC operations;
- Develop a detailed critique of the data collected to identify pilot user problems in flight operations associated with approach procedures, charting, and support materials;
- Identify current problem areas related to approach procedures and approach charting; and
- 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:

- Review present IFR procedures and identify problems associated with the construction and development of instrument approach procedures;
- 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:

- The construction of standard instrument departure procedures (SIDs) and standard terminal arrival procedures (STARs); and
- 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:

- Human performance checklists for developing instrument approach procedures, SIDs and STARs; and
- 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		

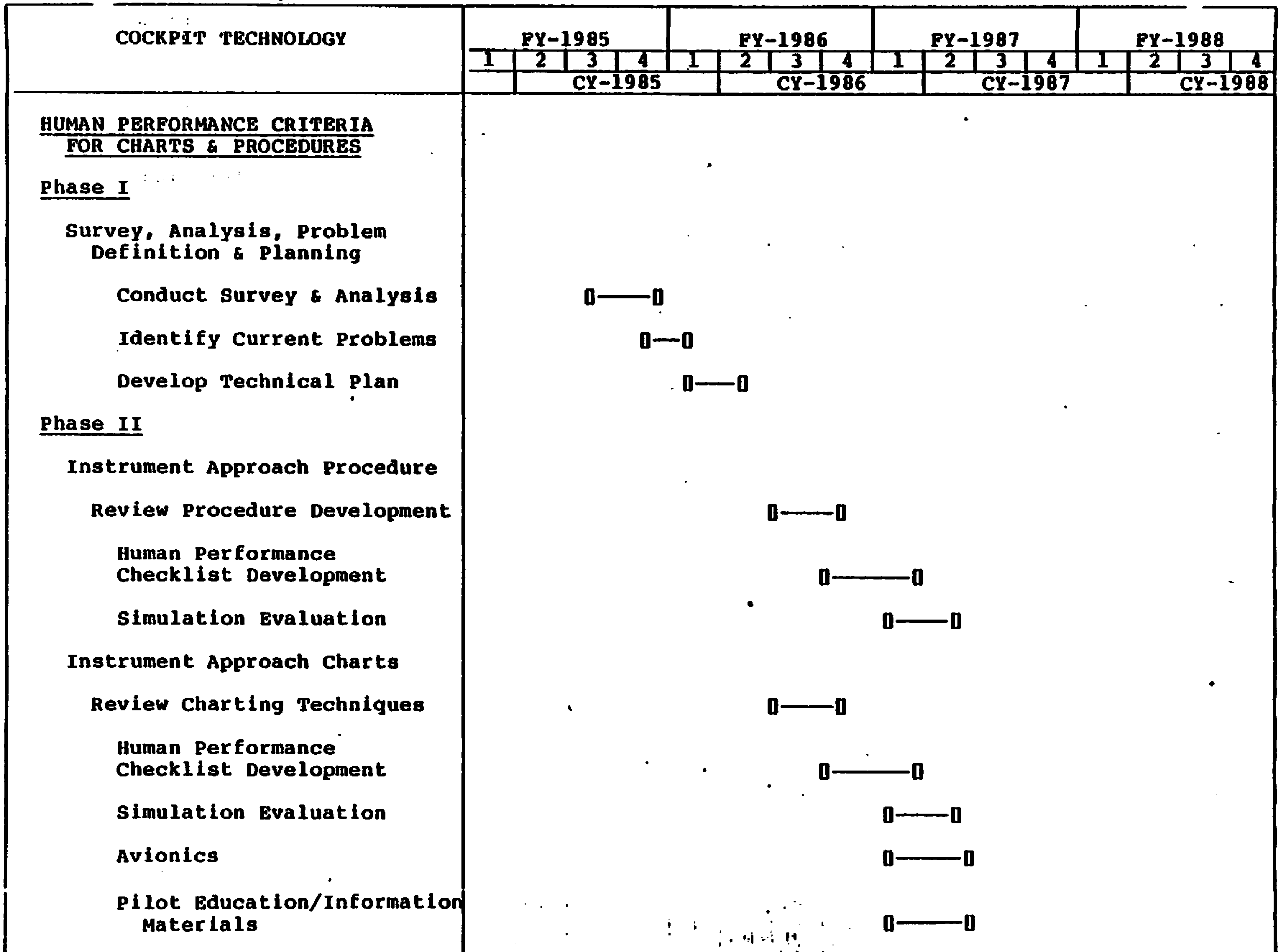
STATUS: (Enter current information)

Initiated 1/85

REMARKS/NOTES:

Related Work

o VFR Chart Performance Evaluation Study, APM-430.


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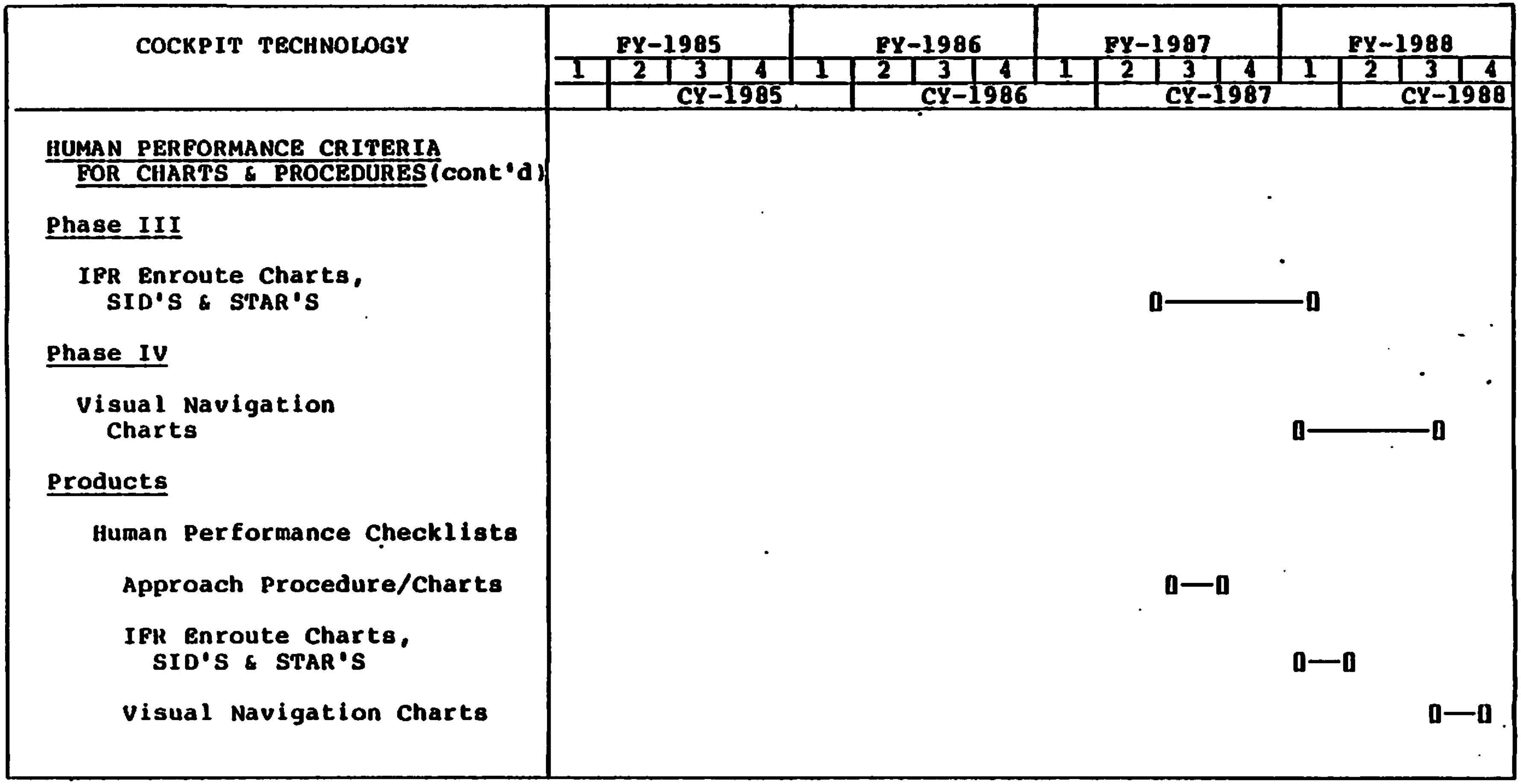
CY-1988
HUMAN PERFORMANCE CRITERIA FOR CHARTS & PROCEDURES
Phase I
Survey, Analysis, Problem Definition & Planning
Conduct Survey & Analysis
Identify Current Problems
Develop Technical Plan
Phase II
Instrument Approach Procedure
Review Procedure Development
Human Performance Checklist Development
Simulation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


COCKPIT TECHNOLOGY
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CY-1985
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CY-1987
CY-1988
HUMAN PERFORMANCE CRITERIA FOR CHARTS & PROCEDURES(cont'd)
Phase III
IFR Enroute Charts, SID'S & STAR'S
Phase IV
Visual Navigation Charts
Products
Human Performance Checklists
Approach Procedure/Charts
IFR Enroute Charts, SID'S & STAR'S
Visual Navigation Charts

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:

- Lack of timely weather information, especially in deteriorating weather;
- Lack of exact interpretations of weather information (visibility reports); and
- 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:

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

- o Improving preflight planning, especially regarding runway information during winter months and planning alternatives in the event of weather changes; and
- o Developing a fuller understanding of the mechanics of weather observation and forecasting.

o ATC:

- o Improving the handling of nonroutine events caused by weather-related traffic diversions (e.g., sector coordination problems); and
- o Improving assistance to pilots who are confronting deteriorating weather.

o Weather information services:

- o More timely dissemination of weather information;
- o Improving pilots' access to weather information for flight planning purposes; and
- o Timely collection and distribution of PIREPS.

Products:

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, and 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)

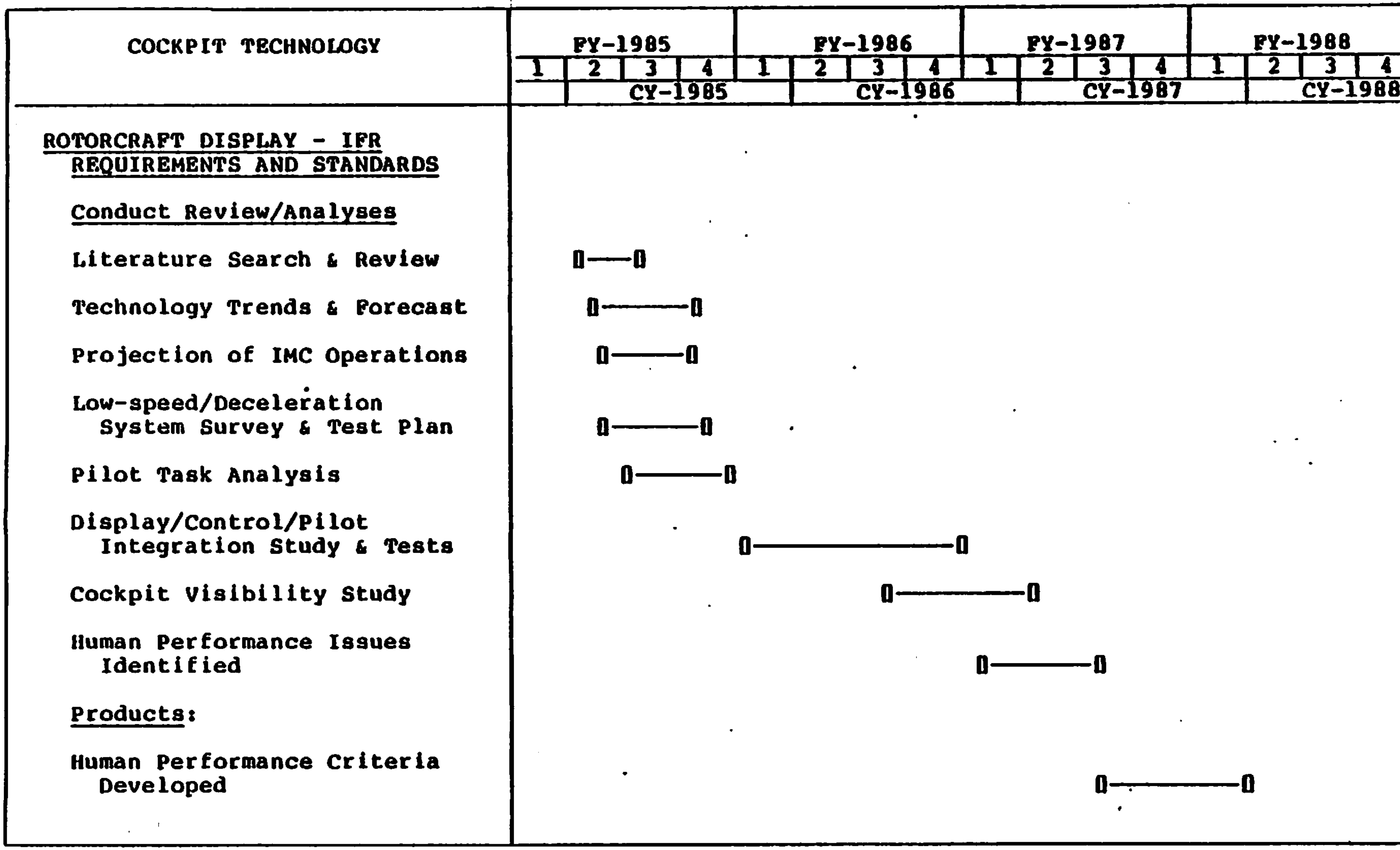
		Scheduled Completion	Revised Scheduled Completion	Actual Completion
1.	Literature search and review	4/85		
2.	Technology trends and forecast	8/85		
3.	Projection of IMC operations/needs	7/85		
4.	Low-speed/deceleration system survey and test plan	9/85		
5.	Pilot task analysis	9/85		
6.	Display/control/pilot 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:

- 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;
- Investigate non-fatal aircraft accidents to determine the causes of pilot error; and
- 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:

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

- 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.
- Use the interview results to identify any significant patterns of human performance or system deficiencies.
- 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.
- 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:

- Identification of error-inducing system and equipment designs;
- Training requirements that may be used to compensate for design limitations; and
- 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)

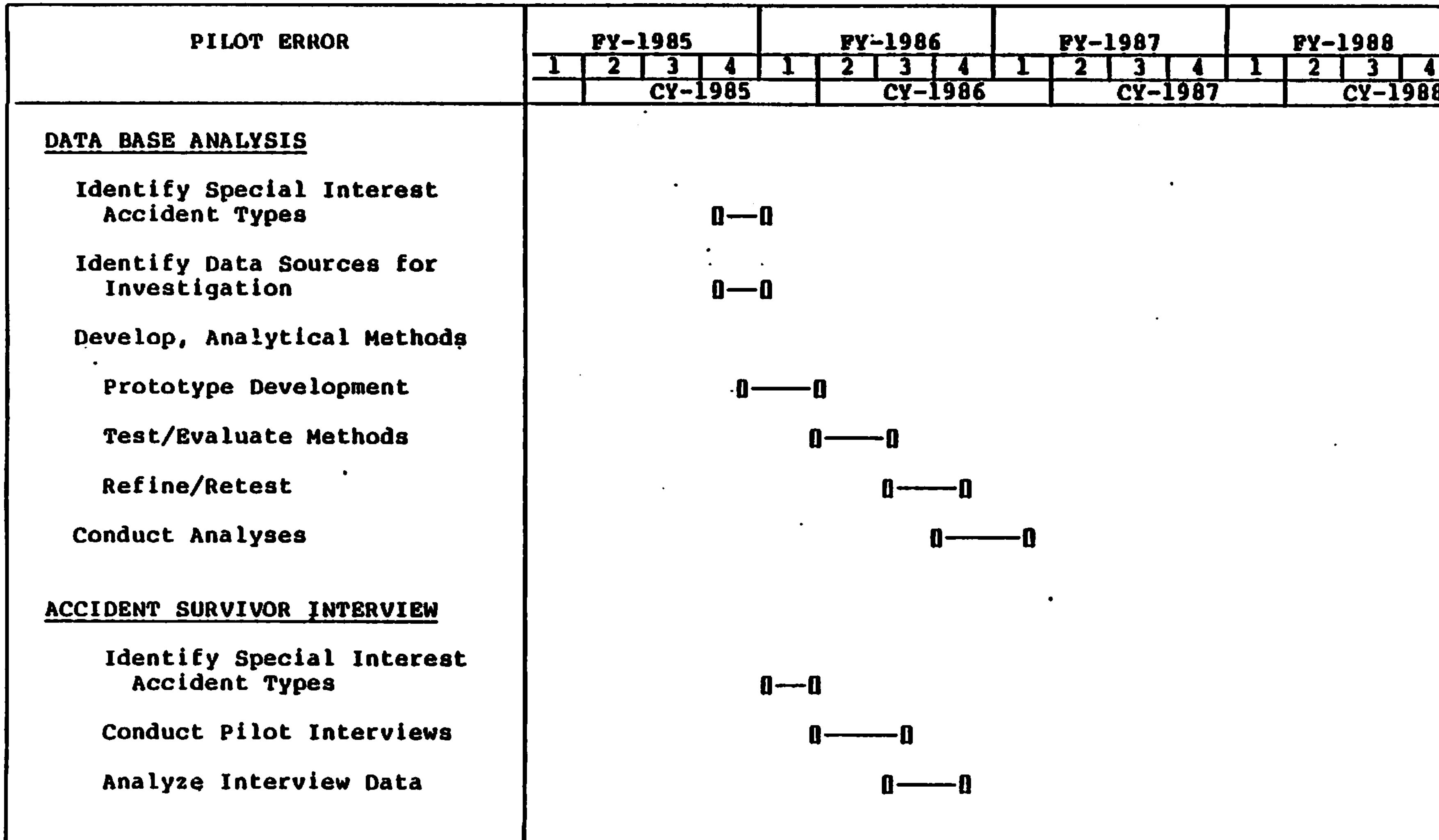
	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Identify areas of special interest	7/85		

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

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:

- Factors influencing system/crew compatibility that should be addressed in the design of future systems;
- Possible modifications of current automated systems; and
- 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

- 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:

- o Survey and document the problems which have occurred in the operation of commercial flights due to inadequate crew communication and coordination.
- o Establish a set of training requirements to address the documented problems.
- o 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).
- o 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

- 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:

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

<u>Objective:</u>
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.

<u>Background and Requirement:</u>
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.

<u>Approach:</u>
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

- 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:

- Identify potential training applications for low-cost training devices.
- Assess the capabilities of currently available devices.
- 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

- 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:

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

- 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.

<u>Products:</u>

- Revisions of selected sections of Part 121 that are related to flight crew responsibilities.
- 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

- Effects of fatigue on flight crew interaction in the B-727, NASA-Ames; and
- 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 Deferred/Cancelled:**
Date of Revision: **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

- Airplane Simulation Uses in Airman Certificaton, AFO-260; and
- 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:

- o Strength of materials;
- o Electrical and electronic systems;
- o Rotorcraft;
- o Turbine engines; and
- o 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:

- Develop clear statements of requirements to update the qualification level of future candidates seeking A & P certification; and
- 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

- 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:

- Flight Operations Research Branch;
- Flight Management Branch; and
- 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:

- Data link presentation of ATC information;
- Workload and cockpit automation; and
- 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° 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.

<u>Boeing Aircraft Company</u>

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:

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

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

- o Design and evaluation of cockpit displays;
- o Research on general aviation instruction and training; and
- o 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:

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

The work is broad and varied and includess:

- Development and evaluation of cockpit displays;
- Development of pilot training methods and cirrucula;
- Development and evaluation of cockpit alerting systems;
- Development of methods and procedures of cockpit certification; and
- 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

- Treadmill
- Complete optics and vision laboratory
- Microwave research laboratory
- Indoor swimming pool 14' deep by 40' square
- Liquid chromatograph
- Gas chromatograph
- ATC-510 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.

APPENDIX A: FUNDING

APPENDIX B: TABLES OF RESEARCH FACILITIES AND ACTIVITIES

AVIATION BEHAVIORAL TECHNOLOGY NEW STARTS FY-85

RESOURCES (M$)

PROJECT	FY 85	FY 86	FY 87
ROTORCRAFT DISPLAY/CONTROL STANDARDIZATION	.2	.6	-
DATA LINK	-	-	-
HUMAN PERFORMANCE CRITERIA FOR APPROACH PROCEDURES & CHARTS	.3	1.5	-
LOFT	.1	.1	-
WORKLOAD	.6	.8	.3
PILOT ERROR	.1	.1	.1
MANUAL REVERSION VALIDATE PROBLEM	.05	-	-
IN-FLIGHT DATA	-	.1	.1
INFORMATION TRANSFER	.2	.4	.6
ABT DATA BASE MAINTENANCE	.1	.1	.1

TABLE 1

NASA - AMES MAN VEHICLE SYSTEMS RESEARCH DIVISION

PROBLEM AREA	OBJECTIVES	METHOD	UNIQUE FACILITIES	COOPERATIVE ARRANGEMENTS	PRODUCTS
FLIGHT MANAGEMENT SYSTEMS					
Cockpit Display of Traffic Information (CDTI)	Develop format guidelines Determine pilot capabilities	"Flown" in simulators by pilots	S 05 "747" (Part Task triner and simulator)	Langley F A A	Reports
Operation Automation Interaction	Pilot experience with DC-9-80 and B-767	Questionnaires from line pilots	Human-computer interaction laboratory	Langely	Reports
	ATC language understanding		Advanced concepts flight simulator	Georgia Tech. U of Miami	
Workload and Performance Assessmant	Error detection in flight procedures	Computer program		Tufts	
	Develop principles and tools for designing cockpit instrument panels with multiple (CRT) windows	Computer program	Kupier airborn labortory Multi-cockpit facility	Stanford Lockheed	
		Physiological and subjective measures Real flight Line operations Fixed and motion based simulators		U S A F Universities Airframe Mfg Contractors	Workload handbook Research papers

NASA - AMES MAN VEHICLE SYSTEMS RESEARCH DIVISION (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	UNIQUE FACILITIES	COOPERATIVE ARRANGEMENTS	PRODUCTS
HUMAN PERFORMANCE IN OPERATIONAL SETTINGS					
Aviation Safety Reporting System (ASRS)	Identify factors in aviation system that contribute to operator error	Reports of incidents by pilots and controllers	Reporting system ensuring reporter anonymity	Contract with Batelle FAA founded	Data analysis Data dumps
Pilot Problems	Identify Dimensions correlates and antecedents of crew behavior Effects and counter measures for fatigue and dysrythmia on crew performance Provide quantitative measures of crew performance	USAF/MAC long haul flights Intercontinental commercial flights Full mission simulator Physiological measures	727 - FMS	NASA U S Army USAF Universities	Performance measures

NASA - AMES MAN VEHICLE SYSTEMS RESEARCH DIVISION (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	UNIQUE FACILITIES	COOPERATIVE ARRANGEMENTS	PRODUCTS
SIMULATION TECHNOLOGY					
Simulation Utilization Pilot Perception	Develop human factors and engineering principles and validation techniques for directing and evaluating the effective use of flight simulators Understanding · visual cues · visual perception of displays Develop · computational models of human vision · display design principles model for evaluaitng fidelity of motion stimulation	·Field survey of full mission simulators scenario development guidlines Discussions with airlines and FAA on research needs in pilot perception in advanced training simulators Computer planning to study crew coordination and information transfer in full mission simulation	Calligraphic and raster display systems Man carrying rotational device		
SPACE HUMAN FACTORS					

IDENTIFY SPECIFIC RESEARCH NEEDS TO SUPPORT SPACE STATION [illegible] COMPUTER BASED DISPLAY AND [illegible] AIDS EQUIPMENT AND DEVELOP A LOW FIDELITY SPACE STATION [illegible] MOCK UP

NASA - LANGLEY FLIGHT CONTROL SYSTEMS DIVISION HUMAN FACTORS RESEARCH UNDERWAY, ANTICIPATED AND COMPLETED (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	RESEARCH CONTACT	STATUS
Cockpit Displays	Determine feasibility of advance display concepts for improved pilot-aircraft interface, includes: 3D pictorial displays, electronic maps with integrated status displays, and pictorial map displays	Experimental version of displays used in simulator flight by a few instrument rated pilots - Used general aviation aircraft simulator (GAAS) cessna 402b configuration	Branch staff and contractors	Varies
Information Transfer Air - Ground	Investigate innovative concepts for efficient transfer and management of critical flight and air traffic control information Include: Voice recognition Data link simulators Weather information Pilot cockpit interface design	Tested in GAAS with instrument rated pilots	Minneapolis Honeywell - Robert North Mitre - Tim Dieudonne Ohio University - Dick McFarlane Miami - Earl Weiner	In progress Proposed Completed
Aircraft Controls	Evaluate manual and advanced automatic flight control systems and interfaces to reduce control workload Determine type and cause of pilot blunders with automated systems	Complexity/benefit study of autopilot Evaluate intelligent autopilot Evaluate non conventional controllers Evaluate automatic terminal approach system Evaluate computer controlled autopilot - avionics	University of Illinois - Lyn Staple University of Kansas - Dave Dawning Systems Technology Inc. - Roger Holt (Hugh Bergeron)	Contractor report in progress Contractor report Pending In progress In progress

TABLE 2

NASA - LANGLEY FLIGHT CONTROL SYSTEMS DIVISION HUMAN FACTORS RESEARCH UNDERWAY, ANTICIPATED AND COMPLETED

PROBLEM AREA	OBJECTIVES	METHOD	RESEARCH CONTACT	STATUS
FLIGHT OPERATIONS RESEARCH BRANCH Head: J D Shaughnessy				
Workload and Performance Assessment (Research Methods)	Provide objective quantifiable measure of workload	Correlate evoked response potential with performance measures and subjective rating scales (POSWAT)	Alan Pope	Underway
Simulation (Research Methods)	Identify low fidelity areas of flight simulators	Record evoked response potentials of simulator pilots as indicators of unfamiliar simulator "flight" characteristics	Alan Pope	Underway
Displays	Determine pilot use of digital and analog altitude display alternatives	Record pilot visual scan patterns with occulometer as he uses display alternatives in simulators	Randall Harris	Underway
Communications (Pilot - ATC)	Investigate utility of data link in single pilot IFR flight	Tested use of flight data console in simulator flight	J D. Shaughnessy	Contract completed
Definition of SPIFR Problems	Identify and analyze problems, key issues, and trends in GA single pilot IFR operations	Reviewd NTSB	Spectrum Technology - D	Contractor report
		Survey of 4,943 instrument rated pilots. ASRS incident data analysis	Harris (David Hinton)	Contractor report
		Workshop on displays, controls, and information transfer	Ohio State - G S Weislogel (Hugh Bergeron)	Technical memo
		Summary of above work and correlation of identified problems	Hugh Bergeron	Proceedings published

NASA - LANGLEY FLIGHT CONTROL SYSTEMS DIVISION HUMAN FACTORS RESEARCH UNDERWAY, ANTICIPATED AND COMPLETED (cont'd)

EQUIPMENT	FEATURES	HUMAN FACTORS
Occulometer	Relative position of eye derived from pupil image and cornea reflection of infrared light. Several mirrors track pilot head. Caculations and control of mirrors done with digital mini-computers	Determination of pilot scan patterns in evaluation of displays
Mission oriented terminal area simulation (MOTAS)	Four controller stations with system generated messages for controllers to read to simulator pilots. Four pseduo pilot consoles for driving non-programmed traffic alone and with mixed canned traffic	Studies of flight and ATC system interaction
Visual motion simulator	General purpose simulator. Two man cockpit, six degree of freedom motion base, 60° out of window color display for left and right seat. Left side instrumented as transport aircraft, right side as a typical helicopter	Studies requiring a combination of visual motion clues
Terminal configured vehicle simulator (TCV)	Duplicate of AFT-deck cockpit in the Boeing 737-100 aircraft. Provides means of ground base simulation supporting ATOPs research program. Cockpit has interchangeable CRT display capabilities	Evaluation of advanced display and control concepts on pilot expectations and behavior
General Aviation Aircraft Simulator (GAAS)	Flight quality general aviation simulator mounted on a two degree of freedom motion base 60° field of view out the window. Currently configured as a Cessna 420B	Single pilot IFR studies
Visual Landing Display System (VLDS)	Camera/model board system for generating a visual out-of-the-window ground scene for pilots of the flight simulators. Dual scaled 1500/1 and 750/1. It provides six degrees of freedom, and field view of 40°H and 360°V	Studies involving simulated landings and evaluation of ground based visual navaids

NASA - LANGLEY FLIGHT CONTROL SYSTEMS DIVISION HUMAN FACTORS RESEARCH UNDERWAY, ANTICIPATED AND COMPLETED (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	RESEARCH CONTACT	STATUS
Utility of CDTI	Examine utility CDTI for maintaining in-trail separation during terminal area approach operations	Simulated approaches in fixed - base simulator configured as a transport aircraft Collected separation performance data and pilot subjective ratings	David Williams	Technical papers
In Flight Procedural Errors	Detection of errors in control	Develop system for monitoring control setting with regard to ACFT phase of flight (Flight phase status monitoring)	NASA - S A Morello	Under discussion
		Work done cooperatively with Boeing, Lockheed, Douglas, Continuation of voluntary standards and warnings work	FAA -	Under discussion
ADVANCED TRANSPORT OPERATING SYSTEMS PROGRAM OFFICE (ATOPS) Head: M A Burgess				
Terminal Area Information Transfer	Automation of information transfer	Optimize data link applications and pilot-machine Interface (details of work not defined)	M A Burgess	In planning
FAA ENGINEERING AND DEVELOPMENT FIELD OFFICE				
Heliport visual aids	Design and evaluate lighting configuration heliports	Develop heliport for Langely's camera model terrain board Pilots fly helicopter simulator through IFR conditions to 250' breakout over heliport Evaluate lighting based on pilot opinion	H A Verstynen	Lighting simulation being developed

TABLE 3

WRIGHT PATTERSON AFB: SELECTED LABORATORIES

PROBLEM AREA	OBJECTIVES	METHOD	RESEARCH CONTACT	COOPERATIVE ARRANGEMENTS
AVIATION MEDICAL RESEARCH LABORATORY				
Workload	Develop, refine, and validate subjective method of measuring cognitive workload Called Subjective Workload Assessment Technique (SWAT)	Laboratory, simulator and flight testing	G Reid (AMRL)	Wright State University Systems Research Laboratory, McDonnell Douglas, U S Navy
	Development of methods for selecting task-matched metrics for workload assessment	Development of central processing model, selection of standardized loading tasks, laboratory test and evaluation	C Shingledecker (AMRL)	Systems Research Laboratory, Inc
Human factors repository	Develop a human factors engineering systems and equipment development guide	Review of current handbooks, technical reports, and literature on human performance and capability	K Boff (AMRL)	University of Dayton, New York University, Essex Corporation, selected researchers
Automated information management	Evaluate Artificial Intelligence (AI) techniques as means for improving management and accessing of design and operation information	Identify information issues for air crew functions, C3, and systems design efforts Review current state of knowledge Make recommendations regarding research and development efforts in Artificial Intelligence	K Boff (AMRL)	Bolt, Beranek & Newman, Inc
Automation allocation in cockpit design	Develop methods and techniques for applying automation to flight deck functions	Analytical with simulation verification Mission analysis, function identification, function allocation, cockpit design	Maj Cole (AMRL)	Bolt, Beranek &Newman; Grumman, BDM; Northrop; Leer Siegler, McDonnell

WRIGHT PATTERSON AFB: SELECTED LABORATORIES (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	RESEARCH CONTACT	COOPERATIVE ARRANGEMENTS
FLIGHT DYNAMICS LABORATORY/FLIGHT CONTROL DIVISION				
Advanced display concepts	Develop mission-oriented map and target displays	Displays to be generated on CRT through use of on-board data base. Approach has direct application for presenting navigation and TCA flight path information to carrier pilots	J. Reising	
Voice-actuated systems	Develop voice-recognition system for cockpit use under combat conditions	Test contractor-developed systems in the laboratory, flight simulators, fighters and transport aircraft. Voice technology is useful in reducing head-down time and has direct application to civil aviation	E. Werkowitz	Texas Instrument, Votan
Keyboard use	Reduction in display call-up time	Comparison of branching logic to situation-tailored logic	J. Reising	
FLIGHT - TEST FACILITIES				
Air carrier simulation	Simulate air carrier cockpit environment	707 multicrew simulator; 30° of freedom, night operation only; computer generated imagery	R. Geiselhart	
Test selected displays & controls in flight	Test new display control developments in line-oriented flight	707 aircraft used for transporting AF officials. Currently fitted with voice operated radio tuning	J. McDowell	FAA MLS operational tests

WRIGHT PATTERSON AFB: SELECTED LABORATORIES (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	RESEARCH CONTACT	COOPERATIVE ARRANGEMENTS
FLIGHT DYNAMICS LABORATORY/FLIGHT CONTROL DIVISION				
Simulated visual scenes	Provide visual ground information for simulators	Three dimensional terrain modules .15' x 47', airport traffic control lights, category II lighting, and urban lighting, different visibility conditions--1 5000 scale	P Blatt	
Total in-flight simulation	Test new cockpits and flight dynamics in real flight	C-131 aircraft with special control surfaces to provide 6 of freedom simulation capability and independent nose-mounted cockpit for simulation pilot	P Blatt	Calspan

TABLE 4

SIKORSKY AIRCRAFT

RESEARCH ACTIVITIES

PROBLEM AREA	OBJECTIVE/APPROACH	PRINCIPAL CONTACT	SPONSOR
SIDEARM CONTROLLER			NASA (ARMY)
VOICE SYSTEMS			
VOICE RECOGNITION	Provide voice capability for activating displays and controls	R. Kass	SIKORSKY
VOICE WARNING	For warnings in the cockpit	R. Kass	SIKORSKY
VOICE INTERACTION	Develop capability for helicopter systems to interact with pilot vocally	R. Kass	SIKORSKY
WORKLOAD MEASUREMENT	Psychophysical measures	B. Hamilton	SIKORSKY
DISPLAY DEVELOPMENT (HEADS UP & HELMET MOUNTED)	Information and formatting unique to helicopters	F. Davidson	SIKORSKY
MAN/MACHINE FUNCTION ALLOCATION	Computer based system using an iterative approach	B. Hamilton K. Duncan	

UNIQUE FACILITIES:

FIXED BASE HELICOPTER SIMULATOR	With 3-screen projection system
CREW STATION RESEARCH COCKPIT	Single pilot tandom crew station
MOTION BASE SIMULATOR	6° of freedom, 360° dome visual system (anticipated in 1985)

TABLE 5

DOUGLAS AIRCRAFT CO.

RESEARCH ACTIVITIES				
PROBLEM AREA	**OBJECTIVES**	**METHOD**	**RESEARCH CONTACT**	**COOPERATIVE ARRANGEMENTS**
FLIGHT PHASE STATUS MONITORING	To reduce number of alerts and warnings and prioritize according to requirements for pilot attention	Analytical development, demonstration and evaluation through simulation	L G Summers	Boeing, Lockheed, FAA, NASA - Langley
SYSTEM STATUS DISPLAYS	Development of cockpit displays for showing status of aircraft flight systems	Prototype development, laboratory evaluation of pictorial, graphic, and alphanumeric options	L G Summers	NASA - Langley
APPROACH PLATES	Increase usability of approach plates & develop formats suitable for booklet or CRT presentation	Systems analysis of pilot requirements, standardization of symbology, display of information according to importance and time of pilot need		Aviation Systems Concepts, FAA
ADVANCED TRAINING SYSTEMS	Identification and definition of potential military contracted air crew training programs		J R Swinck	Past programs with the Navy
MENTAL WORKLOAD	Develop physiological measures of mental workload	Laboratory experimentation		NASA, Ames
HEAD-UP DISPLAY	Type certification of HUD	Certification demonstrations and type certification credit through flight simulation testing	J B Erickson	FAA
ADVANCED FLIGHT DISPLAYS	Development and evaluation of display formats for CRT flight displays	Establishment of design guidelines for the development of primary flight displays	L G Summers	In house
MAINTENANCE: HUMAN FACTORS ROLE	To define the role of human factors in maintenance	Analytical	J B Erickson	In-house

DOUGLAS AIRCRAFT CO. (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	RESEARCH CONTACT	COOPERATIVE ARRANGEMENTS
COCKPIT DESIGN	Development of computer design aids for determination of cockpit geometry		Erickson	In-house
Crew-automation Interaction	To optimize data inputs	Development and evaluation of hardware alternatives including redesigned keyboards and touch panel control/display devices	Erickson	In-house

UNIQUE FACILITIES:

SIMULATORS:

1. **SIX-AXIS MOTION-BASE TRAINING SIMULATOR**
   Problems in DC-10 flight systems can be presented to training crew.
   Record and playback feature permits crew review and study of problem exercises.
2. **DEVELOPMENTAL FLIGHT SIMULATEOR**
   Motion based for development of controls and displays requiring pilot involvement.
   Equiped with generalized wide-body transport cockpit.
   Cockpits can be reconfigured or replaced as required.
3. **FIXED BASE TRANSPORT COCKPIT SIMULATOR**
   Instruments, throttle quadrent, and other control elements may be changed.
   Includes Mc Fadden programmable load-feel systems.

ANTHROPOMETRIC MEASURING DEVICE

Computer-based electromagnetic device for measuring distances in three-dimensional space.
Enables the rapid and low cost measurement of a user populations body dimensions.

TABLE 6

BOEING COMMERCIAL AIRCRAFT COMPANY

PROBLEM AREA	OBJECTIVES	METHOD	UNIQUE FACILITIES	COOPERATIVE ARRANGEMENTS	CONTACTS	PRODUCTS
Workload Models and Assessment Methods	Investigate and assess performance measures and develop pilot workload models including • Analytic • Geometry • Link analysis • Vision field • Workload • Simulation • Impact dynamics • Evacuation	• Systems functions requirement analysis • Operations analysis • Human factors information/criteria analysis • Workload measurement instrumentation	• Eye View Monitor (EVM)-Gulf & Western Oculometer System • Prome News III simulator Model; • All electronic research cab; • Two-crew performance data systems	• USAF • Gulf & Western • NASA-2a PC	Smith, W D	• Psycho-physical measures • Systems models
Cockpit display and Control Applications	Develop and evaluate control inputs and display formats and perform application studies for display and control media including • Flat panel TFE • LED • Color chart • Voice systems • Infinity optics • Symbol generators • Mass memory CGI windows • Touch sensetive control/ display • Transport HUD • MFS/MFD • TCAS displays • DABS • Holographic windows • • Alerting system integration/ standardization • Integrated aircraft mgmt technology • Improved info synthesis & display	1 Development of individual electronic display-control systems including, • HUD • LED and TFEL flat panels, and • Multi function control display units (MFCDU) Activities include development and demonstration of system concepts and hardware 2 Conduct of integration presentation assessments and human factors studies using computer modeling and simulation flight view evaluation	• 737 flight training simulator with holographic HUD; • Gulf and Western Eye View Monitor; • Basic Engineering Laboratory; • Mock up and integration cab, • Advanced flight deck software development laboratory, • Extensive mainframe and new computer facilities for batch, interface and graphics processing	• FAA-APM 430, APM 340 • Flight Dynamics MC, • Litton Systems Canada, • Milard-Rose Corp (Grimes Division); • John Fluke Mfg •Gulf and Western • FAA-Stanford Research Institute • Organic Poly Tech Institute • NASA-Langley RC	Smith, W D Boucek, G P Pratt, T A	• Reports • Applications and assessment hardware and software

BOEING COMMERCIAL AIRCRAFT COMPANY (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	UNIQUE FACILITIES	COOPERATIVE ARRANGEMENTS	CONTACTS	PRODUCTS
Digital Systems Applications	To develop data bus interface and distribution system to support digital applications in a totally integrated flight deck, this program is hardware oriented and includes microprocessor, modular, and fiber optics applications	Development and acquistion of specialized hardware and software for microprocessor - control/display applications including: • microprocessor designing using A02M processing computer for HUD graphics generation programming; • Z-80 computer emulator for TCHS evaluation; • Data collection system for recording aircraft parameters	• R02M processing computer; • B737 simulator with varian host computer; • B737 Last computer • Intel 8086 - based TCHS controller; • Multiple flat panel developing controller; • Osborne Extreme computer based RAM transfering system; • Omni II logic analyze	• NASA-Langley	Smith, W D Boucek, G P Prall, T D	Computer hardware and software configurations for digital display applications

BOEING COMMERCIAL AIRCRAFT COMPANY (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	UNIQUE FACILITIES	COOPERATIVE ARRANGEMENTS	CONTACTS	PRODUCTS
Systems Integration	Identify, explore and resolve problems in overall cockpit design and integration, including: • layout and architectual requirements for display-control systems: - anthropometric dimensioning - workspace layout - composite nose shapes; • Display information processing formats - integrated concept dynamics; - all electronic flight deck • new technology applications - voice systems - TCAS, • user friendly operating - Ada-Vax • HUD system performance - right seat holograpic Hud installation	• Multi-staged concept and application; development • Simulation applications and evaluations; • Advanced electronics cab mock-ups	• Basic engineering laboratory; • Crew systems specialists; • Systems mock-up and integration cab - State of the art B-767 color displays - HUD; - Voice recognition (VOTEM); - digital control/display operating systems and configurations • Advanced flight development support systems laboratories - 757/767 symbol generators - software development capability	• Flight Dynamics Inc • Collins Air Transit Division • FAA-APM 340 • NASA- Langley	Smith, W D Hanson, D C.	- Concept and technology demonstrations - display/control requirements assessment - cockpit configuration designs

TABLE 7

FLIGHT SAFETY INTERNATIONAL

PROBLEM AREA	OBJECTIVES	METHOD	UNIQUE FACILITIES	COOPERATIVE ARRANGEMENTS	CONTACTS	PRODUCTS
Workload and time management	Develop training of flight crews to manage and control distribution of workload. Identify and manage peak workload problems	Simulator exercises; LOFT; CAI; Classroom teaching materials; Counseling	Commuter/commercial aircraft simulators; Classroom AV; IBM PCs for CAI Program development staff	U of Texas; Battelle (Bill Monan)	C Crowder M Schwartz	CAI programs; AV materials; Classroom teaching materials
Fatigue and stress	Define fatigue and stress elements & situations; Identify specific elements & instances. Identify means of coping with instances & situations	Simulator scenarios; LOFT; Analysis and programming	Commuter/ commercial simulators	Commuter Airlines; U of Texas	C Crowder	Simulator scenarios
Pilot error	Identify elements of pilot judgement; Develop decision-making models; Analyze pattern recognition	Analyze emergency performance in simulators; Cognitive mapping; Visual scan studies; Response to simulated flight conditions	Commuter/ commercial simulators Add commuter/ commercial simulators		C. Crowder	Report CAI materials; Training models; Reports
LOFT models for commuters/ air taxis	Develop LOFT scenarios; Program simulators; Implement training procedures	Review FAR 135 requirements; Develop scenarios; Obtain program certification; Implement in training	Commuter/ commercial simulators; Scenario/ programming staff		C Crowder	Scenarios; Report
Affordable FAR 135 training devices	Develop parameters for visual motion training devices that are economical for FAR 135 carriers.	Review certification of training devices; Determine cost of compliance; Assess alternatives; Develop cost/benefit criteria; Identify device parameters. Develop proposal for type-specific and generic devices	3-degree of freedom visual motion training devices for commuter aircraft			Report

TABLE 8

UNITED AIR LINES HUMAN FACTORS RESEARCH RESOURCES

PROBLEM AREA	OBJECTIVES	METHOD	UNIQUE FACILITIES	COOPERATIVE ARRANGEMENTS	CONTACTS	PRODUCTS
Pilot selection	Determine criteria for selection strategies; Evaluate procedures to select the highest quality pilots available	Review application, testing, interview, and other selection procedures, Identify selection criteria; Undertake criteria-based assessment of selection procedures	Tests based on current pilot group; DC-10 computer-graded simulator check		Nugent, P Traub, W H	Procedures evaluation report
Initial training	Assess procedures to: - Train new hires to line proficiency as second officers, - Determine ability of new hire to upgrade	Evaluate: - Plato interactive training, - Classroom instruction syllabi - Simulator sessions, - Oral exams; - Checkrides	Plato system, Hands-on emergency training; Cockpit procedures trainers, 8 Phase II simulators, 1 Phase III simulator		Nugent, P Traub, W H	Training assessment report
Upgrade training	Assess FAA/company proficiency training	Review: - Instrument scan training, - Plato interactive course, - Classroom, - Cockpit procedures trainer, - Simulator sessions	Plato system, Cockpit procedures trainers, 8 Phase II simulators, 1 Phase III simulator		Nugent, P Traub, W H Schroyer, D	Report
Emergency preparedness	Determine optimum program for emergency preparedness training to Prepare flight officers & flight attendants to respond to emergencies as prescribed in the FARS	Evaluate - Classroom lectures, Audio/visual aids, Hands on training, Evacuation simulator	B 767 evacuation simulator; CPR mannequin, Plato system, Emergency equipment for hands-on training	Pan-American facilities in Honolulu for flight attendant training; CAMI, Interairline training conference; FAA	Traub, W H	Flight safety training procedures
FAA certification of training	View methods used to - Insure compliance with FARS	Analyze POI program review procedures, Describe company compliance practices	Appropriate classrooms, Training devices, Simulators		Nugent, P	Certificated programs

UNITED AIR LINES HUMAN FACTORS RESEARCH RESOURCES (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	UNIQUE FACILITIES	COOPERATIVE ARRANGEMENTS	CONTACTS	PRODUCTS
Cockpit resource management	Command skills; Improve human relations, Improve safety margins; Improve teamwork, synergism	Evaluate LOFT; Human relations training; and performance review procedures	Phase III simulator; 8 two Phase II simulators, 20II program	SMI (consultants); FAA	Nugent, P Carroll, E (consultant)	Cockpit Resource Management (CRM) program assesment
Windshear	Develop recognition and avoidance procedures for inadvertant encounters	Assess Audio/visual programs and simulator training	Simulator profiles of generic and actual windshear incidents/accidents	Boeing; National Academy of Sciences	Traub, W H	Windshear training video tapes; Simulator windshear scenarios; Increased flight safety
Simulator fidelity	Determine simulator fidelity requirements for pilot training and proficiency checks and assess current FAR 61 58, 61 157, 121 407, 121, 125, and 135	Identify training objectives and pilot performance measures; Compare the accomplishment of training objectives and performance outcomes under different simulator fidelity conditions, e g fixed-base devices, and devices with varying degrees of freedom of motion, different visual scene technologies, night, dusk, and daylight visuals; varying sound and motion cues, instrument fidelity and response times, etc	8 Phase II simulators; 1 Phase III simulator	Recommend. Massachusetts Institute of Technology; Man/Vehicle Laboratory	Nugent, P Traub, W H Young, L (MIT)	Report
Manual reversion	To assess the ability of pilots to retain control of aircraft when highly automated flight management systems fail during actual flight phases	LOS and performance evaluations of B-767 line pilots' responses to systems failures during selected maneuvers and in LOFT	B-767 Phase II simulator; LOFT scenarios		Nugent, P. Traub, W H	Report

UNITED AIR LINES HUMAN FACTORS RESEARCH RESOURCS (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	UNIQUE FACILITIES	COOPERATIVE ARRANGEMENTS	CONTACTS	PRODUCTS
Loss of manual flying skills	To assess degradations in manual flying skills that may result from routine use of highly automated flight	Use performance evaluations to compare the proficiency of B-767 and 757 pilots in selected maneuvers immediately after transition and at times subsequent to transition; Use simulators configured without full automation to test flying proficiency; Compare manual flying	B 767, 757, & 727, Phase II simulators	SMI (consultants); FAA	Nugent, P Traub, W H	Report

TABLE 9

OHIO STATE UNIVERSITY: DEPARTMENT OF AVIATION

PROBLEM AREA	OBJECTIVES	METHOD	RESEARCH CONTACT	COOPERATIVE ARRANGEMENTS
		PROJECTS		
Pilot error	Develop list and taxonomy of pilot errors	Literature review and analysis	R S Jensen (OSU)	NASA-Ames Battelle, Columbus
Crew fatigue	Determine the impact of evening flights on crew interaction	140 corporate pilots, 45 min flight in simulated Sabreliner	R.S Jensen (OSU)	NASA-Ames
Pilot judgment	Train private pilots to make safe judgmental decisions	Assess the need for judgment training, support the development and evaluation of judgment training textbooks	R S Jensen (OSU)	FAA, Embry-Riddle, U of Montreal
Cockpit displays	Reduction of pilot visual workload	Developed tactile displays for steering yoke Tested in real flight	R D. Gilson (OSU)	NASA
High technology	Examine the impact of high technology on the role, responsibility, authority, and performance of pilots	Symposia at OSU in 1981, 1983	R S Jensen (OSU)	NASA-Ames Battelle, Columbus

OHIO STATE UNIVERSITY: DEPARTMENT OF AVIATION (cont'd)

EQUIPMENT	CHARACTERISTICS	HUMAN FACTORS APPLICATIONS
	UNIQUE FACILITIES	
Flight school	20 aircraft (single- and multi-engine) 200 students per year (private pilot to ATP)	Available as test subjects
Commercial pilots from corporate aircraft	On layover at Columbus waiting passengers 140 volunteers currently being used as test subjects	Test subjects for fatigue study
Ohio State University Airport	4 runways, longest--5000 ft., FAA control tower, restaurant, FBO	Used when in-flight testing conducted
T-40 simulator	Twin-jet cockpit simulator of the Sabreliner	Used in study of fatigue and cockpit resource management
GAT-1 simulator	Link simulator with projection visual system	Used in test and evaluation of cockpit displays

TABLE 10

FAA HUMAN FACTORS PROGRAM

OVERVIEW

The FAA has a number of research and development programs underway which are concerned with pilot performance and the pilot's interface with the aircraft and with the National Airspace System. There are three offices within FAA headquarters through which the majority of the pilot performance research is administered:

Office of Aviation Safety (ASF);
Office of Aviation Medicine (AAM);
Program Engineering and Maintenance Service (APM)

Most of the work is accomplished by commercial operators within the aviation community, non-profit organizations representing NAS user groups within that community, NASA or DOD, depending upon who has the research capability most appropriate for the problem at hand. Other human performance work is done by the FAA research facilities at the FAA Technical Centre in Atlantic City, New Jersey, or at the Mike Monroney Aeronautical Centre in Oklahoma City, Oklahoma. Separate tables have been prepared to represent the facilities and work being done at these two FAA research centres.

PROBLEM AREA	OBJECTIVES	METHOD	FAA PROGRAM OFFICE & CONTACT*	RESEARCH LOCATION
COCKPIT EQUIPMENT				
HUD	Development of data to support certification as a primary flight instrument in low visibility conditions	Data collected in 727 full mission simulator	APM-430 McVicker	FAA Aeronautical Center
Color Displays	Development of guidelines for use of color displays in the cockpit	Research integrated with flight phase status monitor	APM-430	General Physics Corp
Flight Phase Status Monitor	Development of standardized alerting systems prioritizing alarms with regard to phase of flight	Concept development, prototype, simulator evaluation	APM-430	Douglas and Boeing
MLS Cockpit Display	Determine constraints on presentation of MLS information in the cockpit	Survey of equipment currently in use within the fleet	APM-430 McVicker	ARINC Research Langley, Tech Center

FAA HUMAN FACTORS PROGRAM (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	FAA PROGRAM OFFICE & CONTACT	RESEARCH LOCATION
Aeronautical Charting Products	Test and evaluate proposed chart design changes developed in response to National Airspace Review recommendations	Survey of general aviation pilots, measure pilot performance in flight	APM-430 Weiss	In-house
Standard Instruments Charts	Develop approach plate formats that are compatible with VFR & IFR sectionals and CRT-generated plates	Systems analysis, prototypes, testing in simulator	APM-430 Weiss AAM-540 Diehl	In-house
Cockpit Data Management in the Evolving ATC System	Development of guidelines for regulatory authorities considering system requirements for TCAS, Mode S, and MLS data, as well as analysis of failure modes and effects. Includes development of analytical tools for determining effects of new cockpit information systems on pilot performance	Analysis and evaluation of prototype modifications using Part 25 cockpit simulator	APM-430 Weiss	ARINC research United Airlines
FACILITIES AND PROCEDURES FOR FIXED-WING AIRCRAFT				
MLS approaches	Develop TERPS criteria for complex approaches	737 flying MLS approaches at Wallops Flight Facility	APM-430 Clark	Joint NASA-FAA
FACILITIES AND PROCEDURES FOR HELICOPTERS				
TERPS	Develop TERPS and obstruction clearance criteria	Simulation test with flight verification	APM-430 Schlickenmaier	Tech Center NASA
Cockpit displays	Develop specifications for integrated displays	Helicopter test facility	APM-430 Schlickenmaier	Tech Center

FAA HUMAN FACTORS PROGRAM (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	FAA PROGRAM OFFICE & CONTACT	RESEARCH LOCATION
Low-altitude obstructions	Evaluation of standard marking systems Requirements for airborne detection systems	Suitability analysis Survey	APM-430 Schlicknemaier	Tech Center
MLS criteria	Development of criteria for executing go-around procedures when using MLS	Helicopter test facility	APM-430 McVicker	Tech Center
Helipad design	Development of prototype lighting system for helipads	Simulated flight using model board	Fujisaki	NASA-Langley
AIRCREW				
Aircrew Workload Measurement	Development of an application-oriented method of measuring pilot workload	Laboratory research conducted in air transport developmental cockpit simulator	APM-430 Hwoschinsky	Air Force Flight Dynamics Laboratory Boeing/Douglas
Pilot discipline (G.A.)	Develop educational material on self-discipline for distribution to pilots	Analysis	ASF-200 Hwoschinsky	Conroy
Pilot judgement	Evaluate curricula and methods for training judgement in general aviation pilots	Field evaluation	AAM-500 Hwoschinsky	GAMA, TC, Eastern Region

FAA HUMAN FACTORS PROGRAM (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	FAA PROGRAM OFFICE & CONTACT	RESEARCH LOCATION
Low-cost G..A. Visual simulation	Develop part task simulator requirements for teaching and maintaining psychomotor flying skills	Development of criteria for minimum performance	APM-430 Hwoschinsky	H H Areospace
Simulation in training and certification	Development of guidelines and methodology for using simulator testing in airman certification	Analysis	AFO-260 Gilliam	Seville Research
ACCIDENT INVESTIGATION				
Accident investigation	Document accident investigation practices used by the FAA	Observation and interview	ASF-100 Rawson	FSF
AIR TRAFFIC CONTROL				
ATC-NAS-controller interface	Development of systems requirements for sector suites	Analysis	AAP-100 D Weathers	Computer Technology Associates, Inc
ATC-acquisitions	To ensure ATC equipment designed and built by contractors has been thoroughly engineered	Development of guidelines and requirements for human engineering plans from contractors	ASF-300 Tinsley	Technical Center

TABLE 11

FAA CIVIL AEROMEDICAL INSTITUTE: HUMAN FACTORS RESEARCH PROGRAM CHARACTERISTICS

AVIATION PSYCHOLOGY					
PROBLEM AREA	OBJECTIVES	METHOD	UNIQUE FACILITIES	COOPERATIVE ARRANGEMENTS	PRODUCTS
Long Periods of Display Monitoring Is Often Associated with Decrements in Vigilance Performance	Evaluate critical flicker fusion as a means of assessing fatigue during vigilance performance To compare type A and type B personalities regarding display monitoring in a passive ATC task	Monitor computer generated ATC radar display activity Measures of CFF, EMG & monitoring performance taken Paid Ss 18 to 29 years old Computer generated monitoring task: · Subjects typed using Jenkins activity survey Each S's · Performs active and passive versions of the task	ATC display simulator		Utility of CFF for determining optimum duty cycles Information vital for selecting controllers for highly automated systems
Monitor ATC Training Program Effectiveness	Develop regular statistical reports and special research products regarding ATCS selection, screening, and training systems status	To computerize all training information on who has entered the en-route and terminal segments of the ATC training pogram	Student controller training data		Means of comparing training performance to training program success of ATC students
To Upgrade the ATCS Training Programs	Determine the feasibility of upgrading academic portion of ATCS training through computer-base instruction (CBI)	Develop CBI modules and validate their usefulness in training			Research reports of limited distribution
Need to Validate Selection and Training Procedures	To provide improved screening of ATCS for radar air traffic control & to provide improved training in use of the radar system	Analysis of biographical questionnaires completed by incoming ATCS students			Results of analyses will be reported quarterly to selected F A A offices

FAA CIVIL AEROMEDICAL INSTITUTE: HUMAN FACTORS RESEARCH PROGRAM CHARACTERISTICS (cont'd)

AVIATION PSYCHOLOGY

PROBLEM AREA	OBJECTIVES	METHOD	UNIQUE FACILITIES	COOPERATIVE ARRANGEMENTS	PRODUCTS
Cockpit Design and Airman Characteristics	Determine implications of color-coded cockpit displays for airman color vision standards	Survey of color-coded cockpit displays Review data on color vision waivers from CAMI'S certification branch	Aeromedical certification data base		Recomendations regarding color vision requirements for pilots
Changing Air Traffic Control Equipment & Procedures	Assess effectiveness of new ATCS selection procedures	Measures will include F A A academy scores, field attrition, and training performance indices	ATC academy		Procedures for ATC selection
Post-Strike Operational Errors	Determine the relationship of personal, situational, and job factors to ATC operational errors	Analysis of information from air traffic service operational error/ deviation investigation and reporting program	Access to controllers		Information for countermeasure development
Controllers Work in Shifts Through a 24 Hour Day	Establishment of data base concerning influence of work shift on morale and job performance	Controller interviews for job attitudes, working conditions, lifestyle, life changes and supervisor effectiveness Data collected through questionnaires Volunteer respondents	Access to controllers		Information to be used in developing work schedule policies
Need to Increase Efficiency of ATCS Radar Training		Redevelopment of the radar training facility with subsequent evaluation through automated data collection, reduction and analysis			Monthly reports to selected F A A offices

FAA CIVIL AEROMEDICAL INSTITUTE: HUMAN FACTORS RESEARCH PROGRAM CHARACTERISTICS (cont'd)

PROBLEM AREA	OBJECTIVES	METHOD	UNIQUE FACILITIES	COOPERATIVE ARRANGEMENTS	PRODUCTS
PROTECTION AND SURVIVAL LABORATORY					
Lack of Knowledge in the Aviation Community of Factors Influencing Aircraft Cabin Safety	To obtain field data to establish basic requirements for research in cabin emergency procedures, and to make research findings accessible to F A A. and aviation industry personnel	Review F A A and N T S B files and air carrier enroute cabin safety forms	Access to pertinent records		Repository of cabin safety information
Water Survival for Aircraft Occupants	To develop new lightweight survival gear that provides protection against immersion and hypothermia for use in transport and commuter aircraft And to reduce the cost of constructing such survival equipment	Developing and testing concepts for improved types of life preservers, slide rafts, and conventional rafts, and floating bulkheads Water performance tests once physiological effects of emersion hypothermia are studied	Indoor 140' by 40' swimming pool		Technical reports
Many Injuries and Fatalities Occuring in Civil Aviation Crashes Could Be Prevented Through Restraint Systems Redesign	To evaluate the ability of new seating restraint systems and aircraft interior designs for prevention crash injury	Dynamic testing of selected prototype and operational equipment Crash impact pulse shape may be varied	Deceleration sled	N H T S A	Raw data and memoranda to clients
Protection of Passengers in Aircraft Under Adverse Conditions	Examine physical charicteristics of various emergency lighting systems in smoke enviornments Effects of decompression on use of protective breathing equipment Identify alternative methods to protect passengers against in flight fires			F A A Technical Center	
AVIATION PHYSIOLOGY					
Influence of therapeutic drugs on flight safety	Determine influence of Beta-Adrenergic blockers on altitude and fatigue tolerances	Hyperbaric altitude pedal ergometry, Physiologic measures, Psychomotor performance	Hyperbaric pressure chamber Pedalling machine		Reports

FAA CIVIL AEROMEDICAL INSTITUTE: HUMAN FACTORS RESEARCH PROGRAM CHARACTERISTICS (cont'd)

AVIATION TOXICOLOGY BRANCH

PROBLEM AREA	OBJECTIVES	METHOD	UNIQUE FACILITIES	COOPERATIVE ARRANGEMENTS	PRODUCTS
Human Error in Aircraft Accidents	Determine effects of age on flight safety	Review of air carrier accident statistics			Report
Seat and Shoulder Harneses	Reduce injuries in crashes	Collect crash data at accident sites	F A A -CAMI supports NTSB investigation of G A crashes	Supporting NTSB	Information on restraint system adequacy
Effects of Radiation on Aviation Personnel	Define radiation health hazards	Calculations and direct measurement	Microwave research laboratory		
Inhalation and Combustion Toxicology	Compare gross composition smoke generated for toxicity tests by radiant heat	Rat assay	Small animal toxicological facilities		Handbook of microwave radiation tables
Influence of Alcohol and Drugs on Aviation Safety	Monitor the prevalence of alcohol, drugs, and medication in aircraft and other vehicle accidents	Analysis of fluid samples from pilots and others	Liquid and gas chromatographs	F R A and U S C G	Reports
Pesticide Effects on Health and Performance of Agricultural Pilots	Determine effects of long term exposure to agricultural chemicals on applicator personnel	Interviews with accident victims & pilots with behavioral symptoms of poisoning			Reports

TABLE 12

FAA TECHNICAL CENTER: HUMAN FACTORS ACTIVITIES AND CAPABILITIES

The Tech Center's human factor capability is currently focussed on air traffic control systems and their development, test, and evaluation. Conceptually at least, the Tech Center's role in ATC is complementary to that of the FAA's Civil Aeromedical Center. Whereas CAMI's work is primarily concerned with the selection, training, and evaluation of air traffic controllers for a particular ATC system, the Tech Center's role is to design and/or evaluate ATC equipment and procedures for a given population of controllers. Although there are human factors psychologists in other divisions, most of the human fators expertise seems to reside in the Air Traffic Controll Systems Technology Division (ACT 200). Also, several human factors professionals are in the Systems Integration Division (ACT 500). Currently the Technical Center's human factors role seems to be limited to the test and evaluation of equipment developed by contractors.

WORK REQUIRING HUMAN FACTORS ACTIVITIES

- **ATWAT** Air Traffic Workload Assessment Technique
  - Being developed from POSWAT by John Fabre (ACT 200) for use in determining if AERA reduces controller workload
- **Reduction in General Aviation weather related crashes**
  - 3 year contract to Embry Riddle Aeronautical University
- **Automated Flight Service Station**
  - Mockups prepared and available in FSS laboratory for human factors evaluation
- **Central Weather Service Unit**
  - Being developed for meteorologists station in en route centers
  - Prototype to be delivered by Jet Propulsion Laboratory in 1987. Human factors work not clear
- **AERA** Automated En Route ATC
  - Operational suitability tests of the AERA concept will be conducted September 1986 and will include assessments of controller workload
- **Sector Suite**
  - Will be designed and built by contractors. Award to be made by August 1984
  - Test and evaluation will be done by ACT 100
- **Separation of Parallel Runways**
  - Study to determine controllers' ability to detect lateral departure from ILS path as a function of display design, radar update rate, and radar noise. Lee Paul ACT 200
- **Unpaved Runway Alignment Aids (?)**
- **Microwave Landing System**
  - Study to support the development of guidelines for MLS approach paths to heliports. Over 200 approaches and departures are being flown by pilots selected from industry and helicopter special interest groups. Data on flight performance and pilot opinion are being collected. Jim Arias, ACT 100

FAA TECHNICAL CENTER: HUMAN FACTORS ACTIVITIES AND CAPABILITIES (cont'd)

CAPABILITY: FACILITIES

- **Air Traffic Control Simulation Facility (ATCSF)**
  Air traffic control display laboratory includes eight controller positions with complete alphanumeric, special character and sector generation capabilities. Every type of en-route center or technical display scene can be simulated in real slow or accelerated time.
  The facility also includes cockpit simulators which model flight characteristics of twin engine executive aircraft.

- **En Route System Support Facility (ESSF)**
  Includes a complete duplicate of an en route center radar room complete with rows of functioning sector suites, weather center, and flow control, coordinator, and supervisor positions. Pseudo pilots may operate a number of separate "pilot" consoles to communicate directly with the sector controllers in simulating actual en route control situations.

- **Experimental Tower CAB (ETC)**
  An actual elevated tower cab with eight windowed sides. Used to test form and fit of new displays and control panels and as a design tool for modernizing FAA tower cab interiors.

- **Flight Service Station Laboratory**
  Includes in service and prototype equipment in FSS modernization. Work includes techniques and mechanisms for pilot self briefings including procedures for information retrieval, and formatting of information.

- **Center Weather Service Console Design**
  Relations between console layouts and requirements of center meteorologists being examined.

- **Cabin Fire Safety Smoke Laboratory**
  Can be used in test and evaluation of indicators for use in directing postcrash cabin evacuations.

FAA TECHNICAL CENTER: HUMAN FACTORS ACTIVITIES AND CAPABILITIES (cont'd)

CAPABILITY: HUMAN FACTORS PSYCHOLOGISTS			
Name	Division	Specialty Area	Comments
Donald Connelly	ACT 500	voice data entry	retires in 6 months
Edward Buckley	ACT 500	ATC system evaluation	Branch Chief
Mitchell Grossberg	ACT 500	Computer automated ATC display systems	
George Lang	ACT 200	human factors/systems engineering	
Earl Stein	ACT 200	Generalist	currently AERA lab program
Lee Paul	ACT 200	ATC display console data devices	parallel runway separation
Gerard Spanier	ACT 200	man machine engineering in ATC	Flight Service Station & center weather service consoles
Ephraim Shochet	ACT 100	FSS information formatting; voice response systems	
Bruce Rosenberg	ACT 100	workload assessment	developed PASWAT
Helen Hamilton	ACT 100	sector suite design	student pilot
Tom Zurinkas		research assistant	
Jacqueline Rehmann		research assistant	
James Talotta		research assistant	

APPENDIX C: SUMMARY OF DOD HUMAN FACTORS RESEARCH REPRESENTED IN MATRIS

CIVIL AVIATION SAFETY RELATED
DEPARTMENT OF DEFENSE AVIATION HUMAN FACTORS RESEARCH

Retrievals from the Defense Logistics Agency Manpower and Training Research Information System (MATRIS) provided information on unclassified DOD aviation human factors research. This document describes human factors research sponsored by DOD that relates to civilian aviation safety human factors problems of concern to the Federal Aviation Administration.

1. NAS/COCKPIT AUTOMATION AND PILOT WORKLOAD

DOD projects were sponsored by the Office of Naval Research (ONR), the Aerospace Medical Research Laboratory (AMRL), the Air Force Office of Scientific Research (AFOSR), and the Army Research Institute (ARI). These projects explored a variety of human performance, technical development and applications issues related to automation and pilot workload in military mission contexts. Research topics include:

- fatigue effects on performance;
- visual performance efficiency;
- hand-eye coordination;
- digital display configurations;
- flight and fire control keyboard designs;
- helmet mounted displays;
- automatic control requirements;
- night vision requirements and capabilities;
- occulometer research applications; and
- decision making models; and
- digital flight controller-multiple function keyboard use.

2. HUMAN PERFORMANCE CRITERIA RELATED TO COCKPIT CERTIFICATION

ONR, AMRL, AFOSR, the Naval Training Equipment Center (NTEC), and the Naval Air Systems Command (NASC) sponsored research in areas related human performance in military aircraft cockpit configurations. This research includes investigations of:

- windscreen optical effects;
- metrics conversion;
- acoustics;
- control augmentation;
- crew station design criteria;
- instrument lumenescence and lighting;
- voice technology parameters;
- risk assessment;
- side stick controllers;
- avionics displays;
- visual performance criteria;
- display optical variables;
- image quality;
- HUD;
- glideslope indicators;
- 3-D displays;
- mental workload;
- performance theory;
- divided attention;
- viewing tasks;
- tactual displays;
- vibration effects on performance; and
- tracking tasks.

3. OPERATOR INFORMATION REQUIREMENTS

Research by ONR, AMRL, AFOSR, the Air Force Human Resources Laboratory (AFHRL), and the David W. Taylor Naval Ship R & D Center (DTNSC), in areas related to this concern, includes investigations of:

- display requirements;
- HUD;
- intervening environmental factors;
- C3;
- display technology;
- CRT raster structures (impact on informtion conveyance);
- signal/noise ratios;
- color displays; and
- equipment anthropometrics.

4. VOICE ACTIVATED SYSTEMS

AMRL AND NASC research on voice activated systems includes:

- multi-system control/display integration;
- response capabilities;
- prototype equipment performance;
- hardware development;

- laboratory simulation;
- software configuration development; and
- systems evaluations.

5. RESEARCH RELATED TO NEW TECHNOLOGY APPLIED TO SAFETY

The AFOSR sponsored evaluations of the effectiveness of situational emergency training as an alternative to traditional emergency procedures training. Study topics include:

- an assessment of emergency cue characteristics;
- instructional materials evaluation; and
- systems information flow analysis.

6. SIMPLE SIMULATORS

Research related to the development of low-cost simulator configurations includes:

- assessment of the acquisition and transfer of flying skills from low-cost, low-fidelity, part- task simulators;
- CAI programs for instrument instruction;
- use of part-task trainers for retraining;
- evaluation of low-cost techniques emphasizing mini- and micro-computers, computer graphics and simplified controls for part-task training; and
- assessment of B-52 aerial refueling part-task trainer.

This research was sponsored by AFHRL, the Naval Training Equipment Center, and the Army Research Institute.

7. SIMULATOR TRAINING FIDELITY CRITERIA

DOD studies of the relationship between the fidelity with which simulated flight condition cues represent the cues experienced in actual flight, and training outcomes include:

- operator control models for motion configurations;
- experiments on task loads;
- utilities of motion cues for pilots with different flight experience levels;
- visual and motion cue integration studies;
- studies of task structure and pilot response limitations;
- study of a multiplicative motor noise model;

- development of wide-angle visual systems with high resolution target imagery;
- study of 6-seat and visual factors in advanced simulator for undergraduate pilot training;
- development of mission profiles;
- studies of the effects of mission length on learning piloting skills;
- procurement of simulators for the cobra attack helicopter;
- use of stereoscopic displays in helicopter simulators;
- investigation of the transfer effectiveness of simulator visual display parameters for training carrier landings;
- man-in-the-loop experiments for specific flight control scenarios;
- evaluation of 6-seat motion cueing;
- NAP-of the earth computer image generation;
- helmet-mounted display technology;
- development of a performance equivalence methodology; and
- visual system simulation of B-52 model aircraft.

This work was sponsored by AFOSR, NTEC, AFHRL, ARI, and AMRL.

8. PERFORMANCE FEEDBACK IN SIMULATORS

Work in this area includes:

- development and evaluation of automated feedback programs for flight simulator training;
- development of performance-error analysis methods;
- development of rating scales and automated aids for inflight performance evaluation;
- development of an inexpensive in-flight portable data collection device to suport research on aviator performance; and
- evaluation of an "intelligent" instructional system for critiquing students' behavior.

This work was sponsored by NTEC, AFHRL, and ARI.

9. PILOT PROFICIENCY WITH AUTOMATED SYSTEMS

Research efforts include studies to develop and evaluate methods for measuring the effectiveness with which pilots use automated flight control systems. These studies involve:

- development of maneuver-non-specific, proficiency level measures;
- investigation of reacquisition and maintenance of flying skills;

- identification of criteria for selection of automated performance measures;
- simulator performance assessment criteria development; and
- development of measurements for pilot skill in air combat maneuvering.

AFHRL, the Air Force Academy, and NTEC. sponsored these studies.

10. LINE ORIENTED FLIGHT TRAINING ENHANCEMENT

The Office of Naval Research (ONR), sponsored a study conducted by Texas Christian University on "Personnel Technology: Development of Leadership Effectiveness". This study assessed the validity of assumptions about modal descriptions of leader behavior, evaluated subordinates' perceptions of leader behaviors, and subordinates' affective and behavioral reactions in effective leader-subordinate relationships.

11. JUDGEMENT TRAINING AND EVALUATION

DOD studies related to judgement training and evaluation focused on:

- human understanding of complex systems;
- models of skill acquisition;
- defining visual referents in relationship to complex task performance;
- identifying tactical decision making methods and techniques;
- deductive and inductive reasoning, construct problem solving and perscriptive models for training analogical reasoning for complex skills;
- decision making with multiple sources of probabilistic information;
- optimal information processing techniques;
- investigating cognitive skill flight requirements;
- analogical understanding of complex physical systems; and
- pilot judgements and decisions in emergency situations.

Work in these areas was sponsored by ONR, AFHRL, and AFOSR.

12. HUMAN PERFORMANCE CRITERIA FOR APPROACH PROCEDURES

Studies sponsored by ONR, AFOSF, and AFHRL investigated:

- carrier landing approach requirements, systems and pilot performance; and
- cyclophoria and pilot prediction of the runway plane.

13. FATIGUE AND CREW INTERACTION

Systems analysis of performance related to physiological stress in high performance aircraft was sponsored by AFOS and conducted by the Uiversity of California at Davis. Physiological, psychological, sleep and performance data in a combat stress enviornment were collected by Dunlap and Associates, Inc. under contract to ONR, in a longitudinal study of interaction between individual measures and environmental factors relating to carrier pilot performance.

14. AIRCREW WORKLOAD MEASUREMENT

A substantial number of workload studies conducted under DOD sponsorship were listed. These include:

- measurement of aircrew performance under task loading (AFHRL);
- psychophysics of mental workload under concurrent task conditions (ONR);
- development of a neurophysiological workload test battery (AMRL);
- encephalographic indicants of cognitive functioning;
- multi-task performance quantification (AMRL);
- development of a methodology for aircrew workload assessment (AMRL);
- attention and task complexity (AFHRL);
- attention allocation and workload (AFOSR);
- workload and attention assessment using behavioral and psychophysiological techniques (AFHRL);
- a capacity-theoretic approach to workload assessment (AFOSR);
- evoked response potentials (AFOSR);
- aggregate workload mathematical models and indicator systems (AFOSR);
- thermal stress factors research (AFOSR);
- cardiovascular adaptation to stress (AFOSR);
- physiological stress response measurement (AFOSR);
- environmental stress adaptation (AFOSR);
- man-machine interface evaluations (Naval Air Development Center [NADC]);

- development and evaluation of a workload assessment device (NADC);
- use of electrophysiological and development of stochastic models for myoelectric variables for cognitive workload assessment (AFOSR);
- fatigue effects on the acquisition of flying skills and patterns of stress response in pilots at varying workload levels (AFHRL);
- strength and endurance measures for aircrew selection (AFHRL);
- physical size, strength and endurance criteria for task and environmental requirements (AMRL);
- tolerance requirements in hyperbaric environments (ONR);
- collection of stress, sleep and mood data related to carrier pilot landing performance in combat environments (ONR);
- human factors engineering analysis of operator workload in a task processing environment (NADC); and
- prototype cross-coupled instability tracking device for in-flight workload measurement.

15. DATA ACQUISITION AND ANALYSIS

Data related to aircraft accidents and incidents was acquired by the Naval Health Research Center, AFOSR, AMRL, and the Naval Aerospace Medical Research Laboratory.

16. SELECTION, TRAINING AND LICENSING OF MAINTENANCE PERSONNEL

A broad range of DOD-sponsored projects relate to issues of selecting and training of personnel for aviation maintenance jobs. These include:

- research on instructional methods and devices;
- development of maintenance task simulators, trainers and part-task trainers;
- identification of factors affecting the performance of maintenance personnel;
- team training logistics;
- combat unit maintenance capabilities;
- CAI training for maintenance tasks;
- development of specifications for electromechanical maintenance training systems;
- comprehensive aviation systems training program development;
- general aviation maintenance training methodology development;

- instructional systems development for management and technical procedures training;
- simulated avionics maintenance trainer development and evaluation;
- development of an Aircraft Maintenance Effectiveness Simulation Model; and
- behavioral analysis approach to for support personnel training.

This work was sponsored by AHRL, AFHRL, NTEC, the Naval Personnel Research and Development Center, the Naval Weapons Center, the Naval Surface Weapons Center, ONR, and the Naval Air Systems Command.

HUMAN FACTORS PROBLEM AREAS

AS PERCEIVED

BY

THE AVIATION COMMUNITY

Category 1 - Data Acquisition and Analysis

	Issue or Recommendation	Suggester	Workshop	Page
Better Accident Investigation (18)				
1.1	Need new criteria for selection of accident investigation, especially non-fatal accidents	Lawton (AOPA)	3	22-23
1.2	Accident investigation quality not quantity	Lawton (AOPA)	3	22-23
1.3	Re-examine post accidents where pilot error was accepted as the cause and determine <u>why</u>	McClure (ALPA)	1 Vol I	74
1.4	Need more accident data	Trammell (AOPA)	3	97
1.5	Better accident analysis from present data--more crew surveys	Gabriel (AIA Douglas)	1 Vol II	39
1.6	Better data analysis	McClure (ALPA)	1 Vol I	68
1.7	More attention to why of accident-- Human Performance Study Team for accident evaluation to look at: 1. Medical factors 2. Operational Environmental Factors 3. Behavioral Factors 4. Equipment Design Factors	Leppard (ALPA)	1 Vol I	66
1.8	Develop a systematic methodology (tools, procedures, forms) for investigation of aircraft accidents to more adequately establish <u>why</u> the human error occurred.	Miller (Consultant)	1 Vol I	39
1.9	Examination of data regarding recent accident (non-fatal and fatal) by competent human factors specialists (preferably with pilot experience	Jensen (ATA)	5	Issue form
1.10 thru 1.18	Accidents/Incidents How do they fit into the human factors role.	Pilot Panel (9)	3	Questionnaire

Category 1 - Data Acquisition and Analysis

	Issue or Recommendation	Suggester	Workshop	Page
Identification of Human Factors Problem (9)				
1.19 thru 1.27	How do we identify a human factors problem? 1. How do we measure it? 2. How is acceptability defined? 3. Establish a foundation of how to solve identification.	Pilot Panel (9)	3	Questionnaire
Support for ASRS (5)				
1.28	Emphasis on Safety Reporting System	Trammell (AOPA)	3	97
1.29	Strong support for ASRS	Edmunds (ALPA)	1 Vol I	94-95
1.30	Strong Support for ASRS	Presidential Task Force	Task Force Report	11
1.31	Use ASRS to categorize and prioritize ATC problems	Simons (PATCO)	3	104
1.32	Expand ASRS Program	McClure (ALPA)	1 Vol I	74
Helicopter (3)				
1.33	Is Human Factors a real problem? If so, scope the problem, educate appropriate sector, and improve item.	Strother (AIA Bell)	3	105
1.34	Need more human factors data from accidents	Strother (AIA Bell)	3	105
1.35	Survey users to identify problems	Strother (AIA Bell)	3	105

Category 1 - Data Acquisition and Analysis

	Issue or Recommendation	Suggester	Workshop	Page
Inflight Human Factors Data (2)				
1.36	Collection of Inflight Human Factors Data 1. Pilot solicited survey 2. Cockpit observations by qualified personnel (human factors oriented and trained) 3. Solicit information from ALPA technical committees, manufacturers, and other aviation experts.	McClure (ALPA)	1 Vol I	74
1.37	Value of Inflight Data for: 1. Detect exceedance of limitations 2. Detect unusual behavior which may be hazardous 3. Identify potential problems 4. Provide data for specific investigations/ requirements. 5. Support research and resolve ops problems 6. CVR with Flight Recorder will improve HF data 7. Used in certification	Ruben (U.K. CAA)	3	39 & 46
General Aviation (2)				
1.38	Need general aviation data—exposure, currency	Lawton (AOPA)	3	22-23
1.39	Need to know recency of experience in accident rate	Trammell (AOPA)	3	97
Analyze Inflight Computer Errors (1)				
1.40	Need analysis of the type of errors pilots are making with computers, i.e. RNAV	Miller (Consultant)	2	161

Category 1 - Data Acquisition and Analysis

	Issue or Recommendation	Suggester	Workshop	Page
ASRS Immunity (1)				
1.41	Strengthen Immunity Provisions ASRS	Presidential Task Force	Task Force Report	11
CVR Tapes (1)				
1.42	Protect Conversations on CVR Tapes	Presidential Task Force	Task Force Report	11
Statistical Techniques (1)				
1.43	Need better statistical techniques for accident data in helicopters	Rossback (HAI)	3	10

Category 2 - Cockpit Information, Equipment Design and Certification

	Issue or Recommendation	Suggester	Workshop	Page
Cockpit Automation (16)				
2.1	What is needed to fly manually? What is needed for automatic monitoring? What is left out?	Howell (ALPA)	H F Task Force Meeting ALPA	-
2.2	Manual Reversion a. Auto equipment failure - need adequate equipment for other control options b. Concern of level of proficiency for manual takeover	Howell (ALPA)	1 Vol I	85
2.3	Automation without sufficient monitoring a. Ideally - fully redundant b. Need trend information c. Need flight path information d. Plan for human monitoring without adequate information - should consider automated monitoring	Howell (ALPA)	1 Vol I	85
2.4	What is the information and techniques required for the monitoring of automated systems.	Thielke (FEIA)	3	76
2.5	Determine optional levels of cockpit automation	Young (USAF)	4	98
2.6	Application of automation a. What type of automation is needed b. Distribution of central/monitoring functions c. Manual proficiency	Roscoe (U. of N.M.) Edmunds (ALPA)	5	Issue Form
2.7	Determine requirements and procedures for integration of ground and airborne system to minimize pilot workload and maximize his effectiveness	Young (USAF)	4	98

Category 2 - Cockpit Information, Equipment Design and Certification

	Issue or Recommendation	Suggesters	Workshop	Page
2.8-2.16	How do we effectively monitor flight deck automation	Pilot Panel (9)	3	Questionnaire
Flight Test Guide (14)				
2.17	Engineering Flight Test Guide - no criteria to show compliance with FAR 25.1523 App. D	O'Brien (ALPA)	1 Vol I	91
2.18	Specification of Human Performance in the certification process	O'Brien (ALPA)	1 Vol I	86-87
2.19	In crew complement certification process exercise MEL and conduct workload studies with acceptable failures	Presidential Task Force	Report	8-9
2.20	Certification should be based on standard equipment configuration and not optional equipment which may be ordered by some airlines	Howell (ALPA)	1 Vol II	93
2.21	High Priority - Complete and keep current Chap 187 of FAA Order 8110.8	Presidential Task Force	Report	8-9
2.22-2.30	Human Factors in certification - what parameters are used?	Pilot Panel (9)	3	Questionnaire
CRT's (9)				
2.31	Visual Noise	Connors (Embry Riddle)	3	61-74
2.32	Visual Problems in Turbulence	Thielke (FEIA)	3	80
2.33	Scan Rate Interactions	Thielke (FEIA)	3	80
2.34	Sun-Brightness	Thielke (FEIA)	3	80
2.35	Radiation Hazard	Thielke (FEIA)	3	80

Category 2 – Cockpit Information, Equipment Design and Certification

	Issue or Recommendation	Suggesters	Workshop	Page
2.36	Color	Thielke (FEIA)	3	80
2.37	Investigation of human factors involved in the introduction of cathode ray tube displays in airline cockpits	Jensen (ATA)	5	Issue Form
2.38	Information presentation, format, size, shape, color, symbology for standardization to reduce error and fatigue	Lawton (AOPA)	5	Issue Form
2.39	Use color displays	Connors (Embry Riddle)	3	61-74
Communications (9)				
2.40-2.48	Verbal and visual	Pilot Panel (9)	3	Questionnaire
Helicopter (5)				
2.49	FAA needs ability to certificate by 1982, fly by wire and fly by light	Bertone (HAI Sikorski)	3	12
2.50	More attention to seat design, noise, vibration environment, advanced control display, and communication technology integration	Rossback (HAI)	3	11
2.51	Need human factors study noise/vibration effects on long missions 8-10 hours	Bertone (HAI Sikorski)	3	12
2.52	Deficiencies in external lighting	Strother (HAI-Bell)	3	105
2.53	Standardize controls and display	Strother (HAI-Bell)	3	105

Category 2 - Cockpit Information, Equipment Design and Certification

	Issue or Recommendation	Suggesters	Workshop	Page
Flight Test for Certification (4)				
2.54	FAA should use line qualified pilots in certification process. Need procedures like current DER's	Presidential Task Force	Report	8-9
2.55	Include pilot early in design and participation in aircraft certification process and ATC design	Howell (ALPA)	1 Vol I	84
2.56	Certification of 757-767, use latest crew complement certification techniques including: a. Improved subjective evaluation by qualified pilot b. Line operations (full mission) simulation using selected line pilots	Presidential Task Force	Report	8-9
2.57	For certification, full mission simulation to include normal and worst case (full range) flight conditions	O'Brien (ALPA)	1 Vol I	92
Computer Input Devices (3)				
2.58	Problems with keyboards-assess alternate methods for computer interaction - Speech interaction systems	Gabriel (AIA Douglas)	1 Vol II	32
2.59	Problems with keyboard entry devices	Howell (ALPA)	1 Vol I	85
2.60	Need Performance Guidelines - certification criteria for voice interaction	Bertone (HAI Sikorski)	3	12

Category 2 - Cockpit Information, Equipment Design and Certification

	Issue or Recommendation	Suggester	Workshop	Page
Digital Software (3)				
2.61	Staff and develop procedures for digital software certification. Specific procedures for certification and monitoring of software configuration changes.	Presidential Task Force	Report	8-9
2.62	Need software discipline, software control	Appleton (DeHavilland)	2	69
2.63	Need validation and control of digital software	Bertone (HAI Sikorski)	3	12
Cockpit Standardization (2)				
2.64	There is little in the FAR's that require location size or shape of controls or displays be standardized	No Name	5	Issue Form
2.65	There are a number of new systems being developed for new and older aircraft that do not benefit from a design philosophy or standard that fully considers the human element	Edelman (Republic)	5	Issue Form
Altitude Errors (1)				
2.66	The effectiveness of Flight Path Control (altitude) monitoring by electronic devices in the cockpit. Reliability of the monitoring device in providing basic guidance. Lack of consistent and standardized operations.	Orlady (Orlady Assoc)	5	Issue Form

Category 2 - Cockpit Information, Equipment Design and Certification

	Issue or Recommendation	Suggester	Workshop	Page
Cockpit Visibility (1)				
2.67	Many current aircraft do not meet visibility standards specified in Title 14 of the Code of Federal Regulations. A draft advisory circular incorporates an SAE committee recommendation to relax these standards to allow even poorer visibility.	Roscoe (U. of N.M.)	5	Issue Form
Flight Management (1)				
2.68	Need flight management performance requirement - flight critical item	Bertone (HAI Sikorski)	3	12
Data Link (1)				
2.69	Loss of big picture when using data link. Need adequate information on traffic, other aircraft on approach, departure, etc., so traffic flow is clear to pilot	Howell (ALPA)	1 Vol I	85
G/A Noise and Vibration (1)				
2.70	No published studies available for noise and vibration in new and/or old general aviation and related effects on pilot fatigue	Lawton (AOPA)	5	Issue Form

Category 2 - Cockpit Information, Equipment Design and Certification

	Issue or Recommendation	Suggester	Workshop	Page
HUD (1)				
2.71	Continue to develop HUD for VFR slot orientation, black hole approach, low visual use, departures transition instrument from IMC to visual	Witter (American Airlines)	1 Vol II.	85
Alerts and Warnings (1)				
2.72	Too many alerts and warnings	Connors (Embry Riddle)	3	61-74
New Technology (2)				
2.73	Package new technology to enhance safety	Trammell (AOPA)	3	97
G/A Wx Display (1)				
2.74	New G/A aircraft - need better Wx information	Trammell (AOPA)	3	97
MEL (1)				
2.75	Individual items are assessed separately. Need to assess total and combinations of outages	Howell (ALPA)	1 Vol I	84

Category 2 - Cockpit Information, Equipment Design and Certification

	Issue or Recommendation	Suggester	Workshop	Page
CVR's (1)				
2.76	Need better CVR's and put in G/A aircraft	Miller (Consultant)	1 Vol II.	Addendum
FPA (1)				
2.77	Explore the extent and impact of the potential use of flight path angle information on CRT's on the flight instrument panel	Russell (ATA)	1 Vol II	82
Display Standardization (1)				
2.78	Display format standardization to minimize crew transition difficulties	Gabriel (AIA Douglas)	1 Vol II	31
Minimum Cockpit Equipment (1)				
2.79	Standardize minimum cockpit equipment - Dual Digital ADF's, VHF, HUD's or VAM, Advanced CRT's	Connors (Embry Riddle)	3	61-74
Drum Pointer Altimeter (1)				
2.80	Deficiencies of Drum Pointer Altimeter. Why do altitude errors occur?	McClure (ALPA)	1 Vol I	68

Category 2 - Cockpit Information, Equipment Design and Certification

	Issue or Recommendation	Suggester	Workshop	Page
Helicopter (1)				
2.81	Seat design for comfort to avoid back problems. Anthropometry requirements - male/female - coordinate with FAA, CAA, NATO	Strother (HAI Bell)	3	105

Category 3 - Operations/Procedures, Training, Selection, Airmen Certification

	Issue or Recommendation	Suggesters	Workshop	Page
General Training (10)				
3.1	Need system/concept understanding	Howell (ALPA)	1 Vol I	85
3.2	Economic cost reduces quality of training	Howell (ALPA)	1 Vol I	85
3.3	Need adequate fidelity in simulator - particularly new systems, i.e. omega	Howell (ALPA)	1 Vol I	85
3.4	Total simulator vs. airplane training. How realistic must a simulator be in order to be as effective as airplane training?	Foushee (NASA)	5	Issue Form
3.5	Skill maintenance: pilot proficiency	Hyman (Oklahoma U.)	5	Issue Form
3.6	Maintenance of pilot qualifications in more than one aircraft	Edelman (Republic)	5	Issue Form
3.7	Should computer aided instructions be used as second level instruction to upgrade pilots to advanced electronic displays?	Connor (Embry Riddle)	5	Issue Form
3.8	Use simplistic simulators when possible	Connor (Embry Riddle)	5	Issue Form
3.9	Stop training pilot's ego, start training judgment	Connor (Embry Riddle)	5	61-74
3.10	More in-depth investigation into training	Miller (Consultant)	I Vol II	Addendum
LOFT Training (4)				
3.11	LOFT training meets all training needs	Brady (ATA-Eastern)	I Vol II	78
3.12	LOFT training good - also, need normal simulator/ emergency procedure training for First Officer Upgrade	Howell (ALPA)	Task Force/ ALPA Meeting	-

Category 3 - Operations/Procedures, Training, Selection, Airmen Certification

	Issue or Recommendation	Suggesters	Workshop	Page
3.13	LOFT example of progressive approach to training	Howell (ALPA)	1 Vol I	83
3.14	Cockpit management training with LOFT is impressive way to reduce crew-related accidents	Presidential Task Force	Report	11
Cockpit Management (3)				
3.15	What are the requirements for cockpit management training? What information is then needed and how taught to meet requirement. Assemble data bank on all that is known about cockpit management	Mudge (ALPA)	1 Vol I	78
3.16	There is a need for cockpit management training	Howell (ALPA)	Task Force/ ALPA Meeting	-
3.17	Resource Management. Crew Coordination. The role structure of the cockpit. Little research has been undertaken to clarify the process.	Foushee (NASA)	5	Issue Form
G/A Training (3)				
3.18	Judgement. "Poor Judgement" is responsible for most GA accidents. Can "Good Judgement" be taught or measured	No Name	5	Issue Form
3.19	Train to prevent stall/spin accidents	Trammell (AOPA)	3	97
3.20	Train for improved cockpit discipline	Trammell (AOPA)	3	97

Category 3 - Operations/Procedures, Training, Selection, Airmen Certification

	Issue or Recommendation	Suggesters	Workshop	Page
Ageing (3)				
3.21	Development of methods for evaluating changes in functional and operational capabilities of aviation personnel produced by environmental and medical factors including ageing.	Revzin (CAMI)	5	Issue Form
3.22	Should/can minimum performance standards be set for pilot performance over and above current standards/regulations?	Mohr (USAF)	5	Issue Form
3.23	Continue to support (fund) U. S. Navy 1000 aviator study to examine the effects of ageing on pilot performance.	Anderson (TSC)	1 Vol I	52
Wx (2)				
3.24	Need realistic guidelines for severe storm areas	Mudge (ALPA)	1 Vol I	81
3.25	Need better Wx collection and dissemination	Lawton (AOPA)	3	22-23
Noise Abatement (2)				
3.26	Standardize noise abatement procedures and exempt newer, quieter aircraft	Presidential Task Force	Report	10
3.27	Need national criteria for standardized noise abatement procedures. Should review all present procedures	Howell (ALPA)	1 Vol I	84

Category 3 - Operations/Procedures, Training, Selection, Airmen Certification

	Issue or Recommendation	Suggesters	Workshop	Page
FAR's (1)				
3.28	Simplify and clarify FAR's to make them more understandable and easier to use	Presidential Task Force	Report	11
Instrument Rating (1)				
3.29	Continue to study hour requirements for instrument ticket	Trammell (AOPA)	3	97
Incapacitation (1)				
3.30	Train crewmembers to recognize subtle incapacitation of a fellow crewmember and to follow appropriate procedures in the event of such an emergency	Presidential Task Force	Report	11
Automated Systems (1)				
3.31	Lack of confidence in automated systems due to: lack of use and lack of system understanding	Howell (ALPA)	1 Vol I	86
Waivers/Exemptions (1)				
3.32	Waivers/exemptions to accepted criteria then become standards. Need to assess waiver procedure	Howell (ALPA)	1 Vol I	84

Category 3 - Operations/Procedures, Training, Selection, Airmen Certification

	Issue or Recommendation	Suggesters	Workshop	Page
Altitude Awareness (1)				
3.33	There is a need for altitude awareness	Smith (ATA United)	1 Vol II	54
First Officer/ATP (1)				
3.34	First Officer should have ATP	Presidential Task Force	Report	11
Non-Safety Duties (1)				
3.35	Flight crews of whatever size should be relieved of and insulated from demands and distractions that do not relate to flying the aircraft	Presidential Task Force	Report	10
Visual Separation (1)				
3.36	Evaluate Visual Separation Standards (See & Avoid)	McClure (ALPA)	1 Vol I	73
Stress of Economics (1)				
3.37	Stress of economics in airline operations resulting in (a) min. fuel loads - need for diversions, (b) training - looks good on paper, actually deficient - use of home study ineffective, i.e. omega, (c) need for higher level of system concept for problem analysis	Howell (ALPA)	1 Vol I	83

Category 3 – Operations/Procedures, Training, Selection, Airmen Certification

	Issue or Recommendation	Suggesters	Workshop	Page
Minimum/Separation Reduction (1)				
3.38	BCAS – Pilots will not support credit for reduced separation. Improved landing aids result in lower minimums not an additional level of safety, therefore, resulting in a decreased margin of error.	Howell (ALPA)	1 Vol I	84
Charts (1)				
3.39	Improve design of enroute terminal area, and approach charts	Presidential Task Force	Report	11
Transfer Training (1)				
3.40	To assess the transfer of training from current displays and controls to new displays and controls	Strother (HAI Bell)	3	106

Category 4 - Pilot Performance, Workload, Fatigue, Stress, Age, Motivation

	Issue or Recommendation	Suggester	Workshop	Page
Workload (9)				
4.1	Do extremely high and/or low levels of crew activity (workload) lead to unsafe situations. A related issue is to determine the correlation (positive or negative) between workload and safety as determined by satisfactory task performance.	Neeland (USAF/FAA)	5	Issue Form
4.2	What are the differences in cockpit workload requirements between single pilot, lightly equipped general aviation aircraft and multi-crew aircraft, operating in IFR in high density terminal areas.	Melton (CAMI)	5	Issue Form
4.3	Need for measure and model of state of arousal	Reighard (FAA)	1 Vol I	42
4.4	Evaluate EEG and other workload assessment devices	Ettinger (USAF)	1 Vol I	43
4.5	Evaluate the utility of subjective workload rating	Howard (Aeronautics Products Assoc.)	1 Vol I	50
4.6	Need improved workload assessment methods	Gabriel (AIA-Douglas)	1 Vol I	32
4.7	Need real definition of pilot performance standards	Gabriel (AIA-Douglas)	1 Vol I	37-38
4.8	Need to validate workload measurement methodology	Ruggerio (AIA-Boeing)	1 Vol I	50
4.9	Develop standard of acceptable range for workload	Gabriel (AIA-Douglas)	1 Vol I	52
Fatigue (10)				
4.10	Determine effects of infrasonic on fatigue	Connor (Embry Riddle)	3	61-74
4.11	Determine effects of desynchronosis	Connor (Embry Riddle)	3	61-74

Category 4 - Pilot Performance, Workload, Fatigue, Stress, Age, Motivation

	Issue or Recommendation	Suggester	Workshop	Page
4.12	Identify fatigue factors associated with flight deck operations	Connor (Embry Riddle)	3	61-74
4.13	Operational fatigue/fatigue management. Fatigue is the most frequently stated problem of pilots in airline operations	Melton (CAMI)	5	Issue Form
4.14	In the restricted context of long duty periods aloft, components of fatigue (biological and environmental) need to be identified, their effects qualified, and potential counteractants assessed for diminution of adverse fatigue effects on flight-related functions	Connor (Embry Riddle) Orlady (Orlady Assoc.) Lategole (CAMI)	5	Issue Form
4.15	Disturbed sleep patterns associated with civil transport flight	Howitt (CAA-U.K.) Dodge (Wright State U.)	5	Issue Form
4.16	Develop measures of fatigue and workload then develop a method and model to relate both in the operational environment	Streimer (Cal State U.)	Vol I	40-41
4.17	The effects of biological rhythms on performance	Holloway (U. of Okla.)	5	Issue Form
4.18	Need full-scale simulation to study workload, fatigue, and stress and the relationship between them	Smith (ATA United Airlines)	1 Vol I	74-75
4.19	Consider available scientific information relative to desynchronosis in regulatory process for flight and duty time	Smith (ATA United Airlines)	1 Vol I	76

Nutrition (4)

4.20	Relationships of nutrition and performance	Connor (Embry Riddle)	3	61-74
4.21	Effects of dehydration	Connor (Embry Riddle)	3	61-74

Category 4 – Pilot Performance, Workload, Fatigue, Stress, Age, Motivation

	Issue or Recommendation	Suggester	Workshop	Page
4.22	Is there a need to research long and short-term effects of nutrition, dehydration, and limited motion or activity relative to pilot "on duty" awareness	Nord (Aviation Management Advisors, Inc.)	5	Issue Form
4.23	Lack of information on nutrition that could significantly affect crew workload performance	Connor (Embry Riddle)	5	Issue Form
Stress (2)				
4.24	Continue and expand the research of aircrew performance degradation due to self-induced stressors such as self-medication, drug abuse, poor sleep and eating patterns, alcohol, etc.	Erwin (USAF)	5	Issue Form
4.25	The relationship between inadequate stress coping strategies and aircrew performance	Alkov (Naval Safety Center)	5	Issue Form
Man/Man Relationships (1)				
4.26	Human performance studies should address the man-man relationship	Edmunds (ALPA)	1 Vol I	94-95
G/A Noise (1)				
4.27	Need to study the effect of noise level on pilot performance in new G/A aircraft	Trammell (AOPA)	3	97

Category 4 - Pilot Performance, Workload, Fatigue, Stress, Age, Motivation

	Issue or Recommendation	Suggester	Workshop	Page
Pilot Model (1)				
4.28	Need conceptual model which relates human response to given inputs in complex situation	Ettinger (USAF)	1 Vol I	29–30
Performance Feedback (1)				
4.29	Need feedback loop to crew for improved crew performance through higher level of motivation	Gabriel (AIA Douglas)	1 Vol I	40
Toxic Effects (1)				
4.30	Need data on the effects of toxic substances with other external factors on pilot performance	Revzin (CAMI)	5	Issue Form
Optimum Workload (2)				
4.31	What is that optimum workload, that optimum human involvement in the scenario which minimizes the chance of error from that human performer	Howell (ALPA)	1 Vol I	96
4.32	Need definition of optimum workload	Speyer (Airbus)	1 Vol II	46
Employee Assist Program (1)				
4.33	Need analyses/guidelines for employee assistance programs--alcoholism, family, physical, financial, chemical dependency, psychological	Smith (ATA United Airlines)	1 Vol II	65

Category 4 - Pilot Performance, Workload, Fatigue, Stress, Age, Motivation

Issue or Recommendation		Suggester	Workshop	Page
Myopia (1)				
4.34	Empty-field myopia, night myopia and hyperopia and instrument myopia caused by imagery displays all cause misperceptions of size and distance in flight	Roscoe (U. of N.M.)	5	Issue Form
Aircraft Owner Change (1)				
4.35	With aircraft ownership transfer, new owner may not be trained on equipment	Trammell (AOPA)	3	97

Category 5 - ATC Selection, Training, and Evaluation

	Issue or Recommendation	Suggester	Workshop	Page
Controller Training (3)				
5.1	Develop definitions of "generations" of ATC and specify "generation" specific training requirements	Christensen (General Physics Corp)	4	148
5.2	To develop trainers (a) define system design and transition changes to automated ATC units (b) define hard task training requirements for each stage (c) define trainer requirements and modular features of trainers for each stage	Christensen (General Physics Corp)	4	150
5.3	Develop and apply methods to assure currency of controller training	Parsons (HumRO)	4	166
Controller Selection (2)				
5.4	Develop improved criteria and measures for selection and evaluation of controllers	Parsons (HumRO)	4	166
5.5	Impact of color displays on the ATC personnel system. Many waivers have been granted for deficiencies in color vision. Possible increase in systems errors by those who are deficient. Operational requirements/functional purposes need clearer definition.	Pickeral (FAA)	5	Issue Form
Controller Modeling (1)				
5.6	Develop models incorporating physiological and psychological characteristics of controllers and maintainers which are important for successful job performance and which may be applied in screening procedures, development of training, and evaluation programs	Christensen (General Physics Corp)	4	151

Category 6 – ATC Performance and Workload

	Issue or Recommendation	Suggester	Workshop	Page
Task Analysis (12)				
6.1	Objective measures of controller performance on the job are necessary for many near-term research areas as criteria against which to evaluate alternative approaches.	No Name	5	Issue Form
6.2	An objective measure derived by researchers in cooperation with ATCS would be an important initial step is assessing automation needs and potentials, developing job motivators, revising ATC training, etc.	Graham (Midwest Research Institute)	5	Issue Form
6.3	Need microanalysis of controller task performance to provide a basis for assessing impact of changes in controller work, on controller workload, and on traits and knowledge required to be a good controller.	No Name	5	Issue Form
6.4	A comprehensive skills analysis that specifies the knowledge, skills, and abilities necessary for ATC job performance is needed as a basis for many areas of human factors research on ATC.	No Name	5	Issue Form
6.5	Task analysis with the projected use of humans in the decisionmaking process for ATC. Data bases need to be developed to assist in the selection process, and in the man-machine relationship.	No Name	5	Issue Form
6.6	Task analysis, system error studies need to be conducted not on a one-time basis, but should be continually updated as ATC systems continue to evolve.	No Name	5	Issue Form
6.7	Lack of clear and documented understanding of controller skills and knowledge requirements. Information is required to provide a baseline for change as job requirements are changed and for developing and validating controller selection criteria.	No Name	5	Issue Form

Category 6 – ATC Performance and Workload

	Issue or Recommendation	Suggester	Workshop	Page
6.8	Develop a skill analysis of the ATC job. This is needed to adequately assess the elements of the job that are critical. It will serve as a data base for future evaluation and proposed changes.	No Name	5	Issue Form
6.9	Analysis of cognitive functions of air traffic control. The issue relates to understanding what "mastery" performance by the controller really is.	No Name	5	Issue Form
6.10	What is the role of the controller in Wx information transfer	Simons (PATCO)	3	104
6.11	Need to reassess the role of the controller/pilot	Simons (PATCO)	3	104
6.12	Need baseline study on how en route controller assimilates and uses the information available at work station	Simons (PATCO)	3	104
Error Reduction (3)				
6.13	Determine the factors related to system errors, both individual and system. Additional information is needed to determine the elements of the controller's performance that make him more or less susceptible to developing an error. Research in this area has been limited to only a few studies at this time.	No Name	5	Issue Form
6.14	Pursue ATC error reduction	Simons (PATCO)	3	104
6.15	Determine error modes and remedial measures for controllers in low load situations and in highly automated systems.	Parsons	4	103

Category 6 - ATC Performance and Workload

	Issue or Recommendation	Suggester	Workshop	Page
Communications (1)				
6.16	FAA should investigate controller/pilot communications processes with emphasis on determining behavioral and psychological aspects involved in normal performance as well as stressful situations and in error situations.	Simons (PATCO)	3	104
Social Aspects (1)				
6.17	Need to study the social aspects of the controller work environment to find means of increasing levels of job satisfaction and perhaps job performance.	No Name	5	Issue Form
CRT's (1)				
6.18	What impact does X-ray emissions from CRT have on the neurology system?	No Name	5	Issue Form
Job Satisfaction (1)				
6.19	Relationship of classes of feedback to job satisfaction/dissatisfaction.	Tucker (Catholic U.)	5	Issue Form
New Computer (1)				
6.20	Expedite next generation of ATC computer	Simons (PATCO)	3	38

Category 6 - ATC Performance and Workload

	Issue or Recommendation	Suggester	Workshop	Page
Wx Radar (1)				
6.21	Give priority to installing real time weather radar	Simons (PATCO)	3	38
Staffing (1)				
6.22	Using excessive overtime due to understaffing shortens controller work times which results in a high cost of replacement.	Simons (PATCO)	3	38

Category 7 - ATC System Development

	Issue or Recommendation	Suggester	Workshop	Page
Future ATC System (49)				
7.1	Objective measures that are accurate and comprehensive are necessary as tools for evaluating alternative future systems.	No Name	5	Issue Form
7.2	Determine and apply procedures to assure application of an integrated concept in the development of systems	Young (USAF)	4	98
7.3	Research on various man-machine combinations to determine optimal future systems	No Name	5	Issue Form
7.4	Definition of man/machne interface for proposed new ATC concepts such as CAS, MLS, M&S, CDTI. Also definition of new pilot/controller interface procedures.	Jennings (FAA)	5	Issue Form
7.5	When alterations are proposed, human factors are needed to assess the effects of these changes	No Name	5	Issue Form
7.6	How to develop techniques that will allow determination of optimal levels of ATC automation	No Name	5	Issue Form
7.7	Assure new system development meets user needs	Church (ATA)	4	107
7.8	Determine human factors problems in current computer system and avoid developing new ones	Church (ATA)	4	107
7.9	Identify and resolve human factors problems in current and new systems	Church (ATA)	4	109
7.10	Resolve light (visual) problems in centers	Church (ATA)	4	109
7.11	Revise work station as team sector concept to account for change in controller role	Church (ATA)	4	110

Category 7 - ATC System Development

	Issue or Recommendation	Suggester	Workshop	Page
7.12	Review and revise guidelines for allocation of information and responsibilities among classes of controllers as new system and concepts are implemented	Church (ATA)	4	110
7.13	Review and revise guidelines for balancing workload between operational sectors	Church (ATA)	4	110
7.14	Develop guidelines for assuring flexibility within system to respond to variance of need	Church (ATA)	4	110
7.15	Review and revise failure mode of operations	Church (ATA)	4	110
7.16	Review and revise types and nature of data presentation	Church (ATA)	4	110
7.17	Identify and address human factors issues in development of new automated control concepts	Church (ATA)	4	111-112
7.18	Study nature and cause of human error	Church (ATA)	4	112
7.19	Develop and apply systematic procedure in the development of air-ground communications	Galanter (Columbia U.)	4	153
7.20	Develop and apply systematic procedure in introduction of new concepts	Galanter (Columbia U.)	4	154
7.21	Determine and obviate degradation of initial controller pilot relationships due to introduction of new information transmission, processing, and display systems	Galanter (Columbia U.)	4	154
7.22	Develop and apply procedures to establish better communications betwen users and specialists designing and developing new systems	Galanter (Columbia U.)	4	156

Category 7 - ATC System Development

	Issue or Recommendation	Suggester	Workshop	Page
7.23	Develop and apply systematic methods of evaluating and demonstrating effectiveness of new system concepts	Galanter (Columbia U.)	4	156
7.24	Develop and apply procedures to increase mutual knowledge and understanding of the problems, capabilities, and limitations of controllers and pilots in the flight environment	Galanter (Columbia U.)	4	156
7.25	Examine overall system design to identify potential improvements to current system and directions to evolve into a more efficient new system	Galanter (Columbia U.)	4	155-156
7.26	Develop clear definitions of future ATC system, the roles of pilots and controllers, the information required to each in order to define and develop required hardware and software systems.	Galanter (Columbia U.)	4	156
7.27	Develop failure mode procedures to obviate degradation of safety resulting from software glitches in highly automated systems	Galanter (Columbia U.)	4	157
7.28	Research to define controller role, duties, and responsibilities in new automated environment	Barrow (UNIVAC)	4	135-137
7.29	More research and evaluation of concepts of equipment, procedures, etc. using simulation	Barrow (UNIVAC)	4	137
7.30	Include all critical groups in system development, controllers, human factors engineers, technicians	Barrow (UNIVAC)	4	137
7.31	Determine optimal lines and types of inputs from human factors into the development cycle	Barrow (UNIVAC)	4	137
7.32	Develop clear delineation of controller responsibilities through transition and with new system	Barrow (UNIVAC)	4	138

Category 7 - ATC System Development

	Issue or Recommendation	Suggester	Workshop	Page
7.33	Develop clear, effective failure mode procedures and responsibilities for new automated systems	Barrow (UNIVAC)	4	139
7.34	Determine display information requirements for automated systems	Barrow (UNIVAC)	4	139
7.35	Determine skill and training requirements for new automated systems	Barrow (UNIVAC)	4	138
7.36	Determine impact and remedial measures for controller reaction in automated environment, e.g.:feel of diminishment of role status and importance, boredom, inattention, complacency	Barrow (UNIVAC)	4	139
7.37	Conduct studies of the psychological composition and environment of ATC	Warner (AOPA)	4	102
7.38	Determine optimal allocation of responsibility between pilot and controller	Warner (AOPA)	4	105
7.39	Accomplish a comprehensive examination of the ATC system from a human factors viewpoint and modifications required	Warner (AOPA)	4	105
7.40	Include human factors people in the design of ATC computer replacement program	~~Tyson~~ Theisen (Essex Corp.)	1 Vol I	58-59
7.41	More information to the pilot so that he can participate actively in the air traffic control process	Connelly (MIT)	1 Vol I	113
7.42	Need human factors in ATC	Connelly (MIT)	1 Vol II	113
7.43	Determine and apply methods and procedures for isolating personnel from negative impact caused by installation of new equipment (a) timing and grouping of changes (b) design system to facilitate switchover to new or return to old in a failure mode of operation.	Christensen (General Physics Corp)	4	149

Category 7 - ATC System Development

	Issue or Recommendation	Suggester	Workshop	Page
7.44	Develop program to assure identification and resolution of design errors before putting equipment into field.	Hanson (Airways Systems Specialist)	4	39
7.45	Determine and develop required memory joggers to facilitate performance in transitioning to new system	Christensen (General Physics Corp)	4	150
7.46	Determine and resolve design induced errors in new and current systems	Theisen (Essex)	4	39
7.47	What is the optimum configuration of the en route ATC sector?	No Name	5	Issue Form
7.48	Sector suite design based on controller needs	Parsons (HumRO)	4	161
7.49	Determine requirements for cordinating automation in the cockpit and in ATC	Younger (American Airlines)	4	26
Separation Assurance (4)				
7.50	Separation assurance should be FAA's highest priority--find ATC improvements	The President's Task Force	Report	9
7.51	Examine possibility of ATC radar beacon system in implementation of collision avoidance	The President's Task Force	Report	9
7.52	Positive control for all heavily used airspace	The President's ::Task Force	Report	10
7.53	Use reliever airports for traffic segregation	The President's ::Task Force	Report	10

Category 7 - ATC System Development

	Issue or Recommendation	Suggester	Workshop	Page
Work Environment (1)				
7.54	Define and apply remedial measures to alleviate impact of nonair specific work environment on controllers and obviate such problems in future implementation (temperature, noise, lighting, etc.)	Parsons (HumRO)	4	158
ATC Mix (1)				
7.55	Need study of ATC mix - helicopter/fast/slow/fixed wing	Strother (HAI Bell)	3	105
Voice Input (1)				
7.56	Voice input. Can flight plan or clearance information be translated to computer language with important consequent reductions in ATCS button pushing?	No Name	5	
Pilot/Controller Relationship(1)				
7.57	Develop techniques for assessing pilot-controller relationships. Develop and apply techniques to assure no degradation of pilot-controller relationships during mid-term and long-term transition conditions	Christensen (General Physics Corp)	4	149
Consolidate Center (1)				
7.58	Determine feasibility of consolidating centers (enlarging sectors) to take advantage of benefits of automation (AERA)	Pokinsky (ALPA)	4	27

Category 7 - ATC System Development

	Issue or Recommendation	Suggester	Workshop	Page
Evaluate Alternative Mixes (1)				
7.59	Evaluate and develop required criteria and reliable, valid and sensitive measures of human factors engineering parameters to evaluate alternative mixes of system design, procedures, training, etc.	Christensen (General Physics Corp)	4	151
System Transition (1)				
7.60	Systematically and objectively gather and interpret historical data on transitions and establish protocol for near-term and long-term transitions.	Christensen (General Physics Corp)	4	150

Category 8 - ATC Procedures

	Issue or Recommendation	Suggester	Workshop	Page
Wx (2)				
8.1	Severe weather avoidance - Need AT involvement	Howell (ALPA)	Meeting ALPA/HF Task Force	
8.2	Improvements should be made in provision of pre-flight weather briefings and timely and accurate inflight weather information, particularly in terminal areas.	Presidential Task Force	Report	10
Mode C (1)				
8.3	To enhance the effectiveness of the ATC system, we recommend that FAA require all aircraft using heavily traveled airspace to be equipped with at least Mode C (altitude encoder) transponders	Presidential Task Force	Report	10
Communications (1)				
8.4	Reduce ATC communications during critical phases of flight, i.e. final approach	Fredrickson (ATA Northwest)	1 Vol II	90
4-D Nav (1)				
8.5	The real problem with 4-D flight is integrating it into the ATC system	Heimbold (AIA Lockheed)	1 Vol II	21

Category 8 - ATC Procedures

	Issue or Recommendation	Suggester	Workshop	Page
Special Events				
8.6	Better control of helicopters around special events is needed.	Strother (HAI Bell)	3	105

Category 9 - Airways, F. ilities, Airports

	Issue or Recommendation	Suggester	Workshop	Page
Vertical Guidance (2)				
9.1	Some form of vertical guidance, such as visual approach slope indicators, should be installed on all runways used by air carriers. Airports served by air carriers should also have instrument landing system (ILS) facilities. ILS and related ground support facilities should be upgraded to keep pace with advances in aircraft capability such as autoland.	Presidential Task Force	Report	10
9.2	Need for vertical visual guidance during approach	Gabriel (AIA Douglas	1 Vol II	40
Heliports (1)				
9.3	Need to study the design requirements of heliports. The problem of lighting obstacles around heliports, the special problem of low altitude navigation aids	Strothers (HAI Bell)	3	107
9.4	Recommendations for human factors considerations in terminal design	Morra (Asst.Ops. Manager K.C. Airport	1 Vol II	Addendum
Approach, Landing Aids (1)				
9.5	Latest aids all runways - ILS, glide slope, DME, grooving, CAT II lighting	Connors (Embry Riddle)	3	62
Landing Minima (1)				
9.6	Improved approach and landing aids result in lower minimums - not an additional level of safety, therefore, a resultant decrease in the margin of error.	Howell (ALPA)	1 Vol I	84

Category 10 - Maintenance

	Issue or Recommendation	Suggester	Workshop	Page
ATC Technicians/Automation				
10.1	Identify, develop understanding of, causes, and develop countermeasures for mental and physical limitations of human interfacing with system	Combs (USAF)	4	140
10.2	Identify basic causes due to management practices, outside problems and pressures	Combs (USAF)	4	140
10.3	Develop and apply means to assure a safe environment conducive to effective error free performance	Combs (USAF)	4	141
10.4	Determine training and skill requirements and procedures for transition to new automated system	Combs (USAF)	4	142
10.5	Assure availability or development of training technology to meet training requirements for transition to new automated system	Combs (USAF)	4	142
10.6	Define competence levels and certification requirements for technicians working with new automated system	Combs (USAF)	4	142
10.7	Assure technicians and controllers participation in preliminary requirements definition as well as all subsequent stages of system design, development, and evaluation	Combs (USAF)	4	142
10.8	Determine sources and remedial measures for failure in detection and reporting of system problems	Combs (USAF)	4	143
10.9	Identify and develop remedial measures for management and organizational factors resulting in reduced performance levels	Combs (USAF)	4	143

Category 10 - Maintenance

	Issue or Recommendation	Suggester	Workshop	Page
10.10	Review technicians roles and responsibilities and identify work changes and other means to modernize incentives for technicians acceptance of increased responsibility	Combs (USAF)	4	144
10.11	Develop a standardized system of certification of all procedures for all kinds of systems	Combs (USAF)	4	144
10.12	Determine and obviate potential adverse impact of reduction of preventative maintenance	Combs (USAF)	4	144
10.13	Assure development of availability of maintenance and troubleshooting aids	Combs (USAF)	4	144
10.14	Assure current technical accuracy in all documentation and manuals in troubleshooting aids	Combs (USAF)	4	144
10.15	Develop and provide a standardized testing equipment program for all present and future facilities	Combs (USAF)	4	144
10.16	Assure adequate funding to avoid short cutting human factors and maintenance elements in system acquisition	Combs (USAF)	4	144
10.17	Assure system design to meet technicians needs	Johannsen (Professional) (Airways Systems Spec)	4	171
10.18	Determine optional allocation of roles and responsibilities in evolving system	Johannsen (Professional) (Airways Systems Spec)	4	171

System Changeover (5)

10.19	Develop procedures to assure training and psychological needs are met in transitioning to new system	Johannsen (Professional) (Airways Systems Spec)	4	171

Category 10 - Maintenance

	Issue or Recommendation	Suggester	Workshop	Page
10.20	Determine strategies for effectively and efficiently learning new skills while maintaining existing skills	Christensen (General Physics Corp)	4	149
10.21	Develop criteria, reference and maintain training for learning new skills	Christensen (General Physics Corp)	4	150
10.22	Determine impact on the ATC system operation of conditional training requirements and evaluate alternative approaches	Christensen (General Physics Corp)	4	151
10.23	Determine current and projected performance problems through the span of skill areas of each maintainer and develop remedial measures	Christensen (General Physics Corp)	4	151
FAR 147 (7)				
10.24	Need to update FAR 147	Kulp (Embry Riddle)	6	45
10.25	Need to upgrade the present curriculum to reflect current technology and developing technology	Kulp (Embry Riddle)	6	45
10.26	Systematically determine the role of the aviation maintenance technician in insuring aircraft airworthiness	Kulp (Embry Riddle)	6	45
10.27	Need to regularly (easy process) incorporate changes in FAR curriculum	Kulp (Embry Riddle)	6	45
10.28	Redesign FAA testing and certification. Problem solving not rote memory	Kulp (Embry Riddle)	6	45
10.29	Manufacturer should share new technology with schools	Kost (Aviation Maintenance Foundation)	6	95

Category 10 - Maintenance

	Issue or Recommendation	Suggester	Workshop	Page
10.30	Form advisory committee with the purpose of transferring new technology to schools - provide schools with new products and schools provide knowledge of practical design	Kost (Aviation Maintenance Foundation)	6	96
A&P Licensing (3)				
10.31	Split A&P license into specialized categories	Kost (Aviation Maintenance Foundation)	6	92
10.32	A&P license renewal each 3 years	Kost (Aviation Maintenance Foundation)	6	93
10.33	Recycle and retrain maintenance people in the field	Rice (Aviation Tech Education Council)	6	38
Maintenance Manuals (2)				
10.34	Standardization of terminology, nomenclature in manuals and other documentation	Campbell (Transport Canada)	1 Vol II	48
10.35	Need improved maintenance manuals	Gabriel (AIA Douglas)	1 Vol II	33
Training Equipment (2)				
10.36	Need advanced equipment to train on such as PT-6 and Garrett:331 engines	Kost (Aviation Maintenance Foundation)	6	86
10.37	Schools not equipped to teach repair of bonded structures or honeycomb structures	Kost (Aviation Maintenance Foundation)	6	86

Category 10 - Maintenance

	Issue or Recommendation	Suggester	Workshop	Page
Recruitment (1)				
10.38	How do we attract additional maintenance people?	Graham (USAF)	6	61
10.39	There is a need for an apprentice program	Kost (Aviation Maintenance Foundation)	6	99
High School Training (1)				
10.40	Encourage maintenance training in high school such as courses in metallurgy and electronics	Graham (USAF)	6	62
Civil/Military Cooperation (1)				
10.41	Need civil/military cooperation in training	Graham (USAF)	6	61
Maintainability (1)				
10.42	Use simple designs to reduce maintenance requirements	Graham (USAF) Moody (Cessna	6	61
Testing (1)				
10.43	Evaluate testing philosophy - should test for understanding of system, application to problem solving. The practical application of learned information	Strauch (Embry Riddle)	6	48
Gear Doors (1)				
10.44	Boeing nose gear door - hazard to maintenance	Gaffney (Boeing)	6	31

Category 11 - Human Performance Program Management

	Issue or Recommendation	Suggester	Workshop	Page
Systems Approach (10)				
11.1	Need systems approach - need consider operational scenarios - total system impact	Howell (ALPA)	1 Vol I	83
11.2	New systems must be designed to handle higher density of aircraft	Howell (ALPA)	1 Vol I	83
11.3	New systems must be tolerant of system errors	Howell (ALPA)	1 Vol I	83
11.4	FAA/DOT needs to promote value of air commerce to an area	Howell (ALPA)	1 Vol I	83
11.5	Mix may get worse due to business flying	Howell (ALPA)	1 Vol I	83
11.6	Systems approach needed	Lowry (AIA)	1 Vol II	1
11.7	Develop systematic procedures for obtaining controller and maintainer attitudes, opinions, and recommendations to be considered in determinations of needs for and design of system and for methods of affecting changes with minimal disruption and maximum user satisfaction	Christensen (General Physics Corp)	4	150
11.8	Determine the nature and timing of human factors engineering contributions at each phase of new system development implementation and operation	Christensen (General Physics Corp)	4	151
11.9	Determine needs and applicable human factors engineering methods to resolve problems in operational system	Christensen (General Physics Corp)	4	151
11.10	Human factors program should include general aviation and ATC interface - NTSB will cooperate with program development	Laynor (NTSB)	1 Vol II	55

Category 11 – Human Performance Program Management

	Issue or Recommendation	Suggester	Workshop	Page
Workload Measurement (2)				
11.11	Support USAF work in objective workload and measurement	Fadden (AIA Boeing)	1 Vol II	50
11.12	Use human factors in flight crew assessment (a) evaluators trained in aircraft procedures (b) record test crew errors (c) videotape using multiple cockpit cameras (d) test data be made available to researchers	O'Brien (ALPA) ✓	1 Vol I	92-93
Code Books (1)				
11.13	Restructure NTSB/ICAO code books	Miller (Consultant)	1 Vol II	Addendum
Accident Investigation (2)				
11.14	Use simulators in accident investigation	Miller (Consultant)	1 Vol II	Addendum
11.15	Develop human factors investigation protocol	Miller (Consultant)	1 Vol II	Addendum
HF Indoctrination (1)				
11.16	Need human factors indoctrination for senior aviation officials	Miller (Consultant)	1 Vol II	Addendum

Category 11 - Human Performance Program Management

	Issue or Recommendation	Suggester	Workshop	Page
Program Structure (1)				
11.17	Need a balanced program - universities, consultants, Government agencies, industry	Houston (ATA American)	1 Vol II	94
Handbook (1)				
11.18	Need for aviation human factors handbook	Houston (ATA American	1 Vol II	94
Oversight Group (1)				
11.19	Need for competent experienced oversight or advisory group	Houston (ATA American)	1 Vol II	94
Human Characteristics (1)				
11.20	Improve the overall level of knowledge of fundamental human characteristics (a) need more knowledge of human reaction to automatically generated warnings and alerts (b) need better understanding where significant role changes are contemplated, validation of the human ability to peform the new role	Russell (ATA)	1 Vol II	81
HF Expert (1)				
11.21	Have qualified human factors expert in AVS	Miller (Consultant)	1 Vol I	60-61
Coordination (1)				
11.22	Need better FAA/DOD coordination in Human Factors work	Taylor (U. of Illinois)	1 Vol I	55

Category 11 - Human Performance Program Management

	Issue or Recommendation	Suggester	Workshop	Page
LOFT (1)				
11.23	LOFT training has a tremendous potential as a system research tool and should be considered for use.	Orlady (Orlady Assoc. Inc.)	1 Vol II	105
Metrication (1)				
11.24	Need safety and economic study to be presented to ICAO to scope metrication conversion problem	Friend (ANMC)	3	82
Data Repository (1)				
11.25	Need for a current human factors repository as to program stutus, research considered, and individuals involved.	Connor (Embry Riddle)	5	Issue Form
FAA Attitude (1)				
11.26	FAA has negative attitude toward program	Howell (ALPA)	1 Vol I	83
Basic Research (1)				
11.27	Need for basic research in human experimental psychology	Galanter (Columbia University)	1 Vol II	44
Open Certification (1)				
11.28	Open crew complement certification to interested parties	O'Brien (ALPA)	1 Vol II	93

APPENDIX E: COCKPIT-RELATED HUMAN FACTORS PROBLEMS IDENTIFIED FROM WORKSHOP LIST

FA-490/AFS-84-1

SELECTED HUMAN FACTORS PROBLEMS IN CIVIL AVIATION
(a preliminary list)

A. Blumenstiel
S. Huntley
J. Koonce*
S. Salvatore

U.S. Department of Transportation
Transportation Systems Center
Office of Research and Analysis
Operator/Vehicle Systems Division
Cambridge, Massachusetts 02142

March 30, 1984

*University of Massachusetts

SELECTED HUMAN FACTORS PROBLEMS IN CIVIL AVIATION

SELECTED HUMAN FACTORS PROBLEMS
IN CIVIL AVIATION

1.0 MAN/MACHINE INTERFACE

1.1 Cockpit

1.1.1 Design Considerations

- Human Factors Repository: A central repository of human factors information is not available to designers of aviation systems.
- Crew Fatigue: The effects of different flight deck operations upon crew fatigue levels are not understood.
- Error Types and Frequencies: The specific errors made by crew members in their use of cockpit equipment, the frequency of these errors, and the conditions under which errors are made are not known.
- Failure Analysis: Currently no specific, generally accepted method is widely used by the manufacturers of aviation systems for systematically determining human performance failures that could occur in using those systems.
- Function Allocation: A widely accepted method for allocating flying functions to man or machine does not currently exist.
- System Add-Ons: Human factors are often ignored in the development and integration of systems for for use on new or older aircraft.
- Integration: Requirements and procedures for integrating ground and airborne systems to maximize pilot effectiveness do not exist.

1.1.2 Automation

- Implications: The implications of cockpit automation for workload limits, task involvement demands, heads-down time, etc. are not understood.
- Status Monitoring: There is a lack of clarity concerning the information and techniques required to monitor the status of automated flight systems, e.g., autoland, so that crew members are able to detect and react appropriately to automation malfunctions.
- Flight Information and Control: Cockpit designers do not have a good grasp of the information that is required to fly advanced aircraft in cases of automation failures. For example, there is a need to perform research to determine the information and

control that a DC-10 pilot needs in order to safely land the aircraft when the autoland system fails under zero zero conditions.

- Pilot Proficiency: Increased reliance by pilots on automated flight systems may reduce pilot proficiency in manual flight during equipment outages.

1.1.3 Displays

- Altimeters: Pilots continue to make errors in reading altimeter displays.

- Cockpit Standardization: The absence of standardized controls and displays in general aviation aircraft contributes to pilot errors.

- Pilot Familiarity: Pleasure pilots' unfamiliarity with the operations of newly acquired aircraft contributes to the incidence of general aviation crashes.

- Standardization of Glass Cockpit Symbology: Bugtypes, display symbology and control shapes are not standardized in the new glass cockpits.

- Standardization of Commercial Aircraft Cockpits: The location, size and shape of many controls and displays in existing commercial aircraft are not standardized.

- Color Displays: Cockpit designers to not take sufficient advantage of color displays.

1.1.4 Controls

- Voice Interactive Systems: There are no performance guidelines either for determining the conditions under which voice interactive systems may be used, or for determining the charactersitics of such systems, which will make them safe for use in aircraft cockpits.

- Sidearm Controllers: Several airframe manufacturers are doing research on sidearm controllers and anticipating their deployment in civilian aircraft. Yet, performance guidelines for determining the conditions under which these controllers may be used in civilian aircraft or for determining the most acceptable configurations for their deployment have not been developed.

1.1.5 Alerts and Warnings

- False Alarms and Uninformative Warning Systems: Commercial aircraft alert and warning systems often generate false alarms and do not always provide information on the source of the trouble.

- Take Off Warnings: Take-off warning horns do not identify specific problems, for example, whether the problem is flaps, spoilers, or stabilizer setting.

1.1.6 Visual Anomalies, Visibility Standards and Misperceptions of Size and Distance: Empty field myopia, night myopia and hyperopia, and instrument myopia caused by visual imagery displays lead to misperceptions of size and distance in flight.

1.1.7 Information Enhancement

- Flight Path Control: Procedures for use of electronic Flight Path Control (altitude) devices in the cockpit are inconsistent and have not been standardized.
- Rotation Point: Use of time-to-speed and distance-to-speed markers are not accepted by the air carrier industry.
- Flight Path Angle: Flight instrument panels currently in use do not provide pilots with information on flight path angle.
- Altitude Estimation: Line pilots have trouble estimating vertical distance above airports during VFR landings. Reliable external distance cues may not be available and VASI and ILS equipment may be absent, as well.
- G/A Weather Displays: Weather displays in general aviation aircraft are inadequate.

1.1.8 Visibility Standards

- Many current aircraft do not meet the visibility standards specified in Title 14 of the CFR.

1.1.9 Design Induced Errors

- Fuel Controls: The relationship between fuel selector switch movements and switch function is illogical, and the relationship between fuel gauges and fuel selector switches is unclear.
- Standardization of Critical Controls: Critical controls are not standardized.
- Labeling of Controls: Controls may be poorly labeled.
- Manuals: Manuals may include inconsistent specifications of take-off distances and speeds with different flight configurations (flap positions, gear position, etc.). Manuals for many light aircraft are not sufficiently detailed with regard to unusual operating characteristics. For example, take off speeds for other than hard surfaced runways may not be specified and there may not be instructions for restarting engines after inflight fuel starvation.

1.2 Maintenance

1.2.1 Aircraft Design

- <u>Ease of Maintenance</u>: Aircraft are not designed for easy maintenance. This results in some maintenance items being systematically overlooked with consequent reductions in flight safety.

- <u>Checking Condition of Aircraft</u>: Aircraft may not be designed so that their readiness for service is apparent. For example, oil filler caps may appear to be screwed on when they are not.

1.2.2 Instruction Placards

- <u>Composition and Placement</u>: Instruction placards mounted on aircraft are sometimes poorly written and poorly placed. The instruction placard for filling the DC-10 hydraulic reservoir is one example that has been noted.

1.2.3 Manuals

- <u>Composition and Contents</u>: Maintenance manuals are not designed for the user. They are not written in a straightforward language, do not provide step-by-step procedures, and do not identify tools required for specific complex jobs.

- <u>Standardization of Language</u>: Terminology and nomenclature in maintenance manuals is not standardized.

2.0 PILOT PERFORMANCE

2.1 External Stress

2.1.1 Noise and Vibration

- Standards: There are neither data nor usable standards regarding the influence of noise and vibration upon pilot performance.

2.1.2 Fatigue

- Physiological and Environmental Correlates: Identification and understanding of the physiological and environmental aspects of fatigue and countermeasures for the effects of fatigue during long flight duty periods are needed.

- Fatigue and Time Zone Changes:
  - The cumulative effects on pilot performance of fatigue and desynchronosis due to transit through multiple time zones are neither understood nor adequately considered in airman duty-time regulations;
  - Little is known about the interaction of desynchronosis with physical condition and age.

2.2 Internal Stress

2.2.1 Life Stress

- Stress and Pilot Error: A relationship between life stress and the probability of pilot error is suspected but not verified for civilian pilots.

2.2.2 Licit Drugs

- Understanding and Guidelines: There is a lack of understanding or guidelines on the use of therapeutic drugs by pilots including:
  - Quinine water effects on inner ear functions;
  - Enderin (cardiac medication) reduction of pilot sensitivity to negative G forces; and
  - Antihistamine interaction with altitude, leading to hypoxia.

2.2.3 Alcohol

- Contribution to Crashes: Alcohol is associated with approximately 16 percent of fatal G/A crashes. Problems contributing to crash likelihood include:
  - Pilot drinking;
  - Pilot bravado;
  - Complacency of before-flight witnesses; and
  - Complacency of passengers.

2.2.4 Biorhythms

- The relationship between biorhythms and pilot performance is not understood.

2.3 Measurement

2.3.1 Workload

- Assessment Methodology: Currently there is no universally recognized method for assessing pilot workload. Designers and manufacturers need such a method to assess cockpit control and display alternatives.

2.3.2 Effects of Changes in Equipment and Procedures on Operator Performance

- Measurement of Long-Term Effects: Means for determining long-term effects of changes in equipment and procedures on operator performance are not available.

2.3.3 Long-term Effects

- Measurement and Evaluation: Broadly accepted methods are not available for evaluating gradual, long-term changes in functional and operational capabilities of aviation personnel that may be produced by medication, life experiences, aging, exposure to agricultural chemicals, and by microwave radiation.

2.3.4 Fatigue and Complacency

- Measures of Readiness to Perform: Methods which are satisfactory for operations-oriented research, or for monitoring operator alertness while on the job, are not available for measuring the relationship between fatigue and arousal and the readiness of pilots and controllers to perform.

2.4 How Pilots Fly

2.4.1 Information Requirements

- Flight Cues: There is only limited information concerning the cues that pilots use to fly, the relative importance of these cues, how they relate to one another, and their specific influences on flying behavior.

2.4.2 Obtaining Information

- Cockpit Displays: The manner in which pilots extract information from cockpit displays is poorly understood.

2.4.3 Workload

- Task Involvement Levels: The optimum levels of task involvement for minimizing the likelihood of human errors are not known.

3.0 REGULATORY ISSUES

3.1 Flight Crew

3.1.1 Crew Compliment

- Compliance with FAR 24.1523, Appendix D: There are no specific human performance or data analysis requirements in the FAA Engineering Flight Test Guide for determining crew compliments or for demonstrating compliance with FAR 24.1523, Appendix D.

3.1.2 IFR Training and Certification

- Weather: Current flight time qualification requirements for IFR training may contribute to the incidence with which VFR pilots fly in instrument meteorological conditons (IMC), and crash.

- Terrain: General aviation pilots receive IFR certification without regard to the type of terrain that they fly over.

3.1.3 BFR

- Flying Skills: Regulations for recertification of G/A pilots do not take adequate account of the degeneration of flying skills over time. Adequate demonstration of flying proficiency is not required.

3.2 Aircraft

3.2.1 Instrumentation

- Currency: Regulations for cockpit instrumentation are outdated. They do not include requirements for current state-of-the-art instruments and do not represent the needs of modern, commercial aviation.

3.2.2 Certification Procedures

- Human Performance Testing: FAA requirements for assessing human performance factors in the certification of aircraft systems and controls is vague.

- Use of Line Pilots: The FAA does not use line-qualified pilots in the certification process. That is, the pilots who certify aircraft are not those who are most familiar with the environment in which the aircraft that they are certifying will be used.

- Oversight: General aviation aircraft may be certificated although deficiencies in their design may result in unsafe flight characteristics under certain conditions. One type of aircraft for example, has been reported to have a strong tendency to roll if it is close to stall speed, with its landing gear and flaps down, if power is applied for a go-around attempt.

3.3 Maintenance

3.3.1 Certification

- Qualification of Mechanics: There is no requirement for recurrent certification of mechanics, and thus no assurance that mechanics are trained in servicing modern technology equipment.

3.3.2 Violations

- Inspection Oversight: Lack of rigor in inspections may permit operators to modify aircraft to below certificated limits. It has been alleged, for example, that a plane recently crashed because the left engine failed and the blade on the remaining engine had been filed below minimums.

3.3.3 Aircraft Design

- Assembly Errors: Aircraft designs permit assembly errors by maintenance personnel. On some aircraft, ailerons can be rigged in reverse, for example.

4.0 OPERATIONS AND PROCEDURES

4.1 Pre-Flight

4.1.1 Inspections

- Checklists: Many General Aviation pilots do not use checklists during pre-flight inspections; these inspections may, therefore, be incorrectly conducted.

- Flight planning: Inadequate flight planning is a major cause of general aviation crashes resulting from:
  - fuel exhaustion;
  - no identified alternative airports;
  - weight allowances exceeded; and
  - weather changes unanticipated.

4.1.2 Rental Procedures

- Flight Objectives Checks: Checkout procedures for rental aircraft are often incomplete and the purposes for which the aircraft will be used are not taken into account in releasing the aircraft for use by customers.

4.1.3 Weather Information

- Pilot Omissions:
  - Unless specifically requested, pilots may not be advised of critical SIGMETS at FSS briefings;
  - Many pilots do not request weather updates when en-route; and
  - Pilots misjudge severity of weather and their own ability to fly in IMC.

4.1.4 Crews for Commercial Flights

- No criteria or guidelines for assembling crew members for commercial flights currently exist.

4.2 En Route

4.2.1 Storm Avoidance

- Company Policies: Airline companies' storm avoidance policies may be impractical and insufficient. Realistic guidelines to assist line pilots in making decisions about flying in stormy conditions are needed.

4.2.2 Air Crew Fatigue

- Sleep Disruptions: Long, East-West transport flights may lead to sleep disruptions and associated fatigue on the part of the flight crew members.

4.2.3 Altitude Assignment Violations

- Monitoring Flight Progress: Despite complex systems of alerts and warnings, line pilots commonly violate altitude assignments. This may result from misunderstandings and/or failures to monitor the progress of the flight.

4.3 Approach and Landing

4.3.1 Charts and Approach Plates

- Symbology and Clutter: Sectional charts and approach plates are difficult to read and may be misleading:
  - the symbology used on NOAA and Jeppson charts is not the same;
  - charts are cluttered, and
  - the importance and order of use of information is ignored in approach plate layouts.

4.3.2 Visual Separation

- See and Avoid: Pilots do not, and perhaps cannot see all of the other aircraft that they are in danger of colliding with and need to avoid.

4.3.3 Workload

- Single Pilot: Flight procedures and activities required at high density terminal areas may easily overload the single pilot. For example, when forced to make a go-around, the pilot must reconfigure the aircraft, pick up new headings, change radio frequencies and engage in ATC communications.

4.3.4 Noise Abatement

- Standardization of Procedures: Noise abatement procedures at different airports are not standardized and may place unacceptable workloads on pilots.

4.3.5 Minimum Separation

- Margin for Error: Lower minimums resulting from improved approach and landing aids decrease the pilots' margin for error and therefore may decrease flight safety.

4.3.6 Non-Flight Related Activities

- Critical Flight Phases: During critical phases of flight, flight crews may be encumbered by non-flight-related activities, such as obtaining airline connection information for passengers, while maneuvering during final approach.

4.3.7 IFR/VFR Transition

- Reduction of Minimums: Transition from IFR to VFR when landing in low visibility conditions is becoming more and more dangerous as flight minimums are reduced.

4.3.8 Landing Proficiency

- Automation: The reliability of modern aircraft may lead to complacency on the part of pilots and this, in turn, may lead to reductions in their readiness to anticipate and respond effectively in emergency situations.

- Duty Time Limits: Flight crews assigned to international flights do not get sufficient practice in landings to retain acceptable levels of proficiency. Monthly duty time limits, long distances flown between landings, and sharing of the few landings that are made by captain and first officer contribute to this problem.

- Feedback: Line pilots receive little feedback on their landing performance. As a result, their proficiency may deteriorate.

4.4 Maintenance

4.4.1 Complacency

- Periodic Inspections: Complacency in conducting periodic inspections of commercial aircraft results in undetected flaws and reductions in safety margins. For example, X-ray negatives showing fractures in the wing of a DC-9 were examined during six separate inspections without detection of the flaws.

4.4.2 Errors

- Installation of Parts: Installation of incorrect parts and incorrect installation of correct parts incorrectly contribute to crashes of commercial and general aviation aircraft.

4.4.3 Communications

- Maintenance to Pilot: There is a lack of reliable procedures which insure that owners and pilots of pleasure aircraft are informed of incomplete maintenance. A Beech 99 out of Richmond allegedly failed because the pilot was not informed of a faulty stabilizer actuator which had been discovered earlier by a mechanic but not repaired.

- Pilot to Maintenance: There is a lack of reliable procedures which insure that the owners and pilots of pleasure aircraft adequately inform maintenance personnel about problems in need of attention. This results in inadequate maintenance and reduces the safety of the aircraft.

- Maintenance Shift Change Briefings: Maintenance personnel going off-shift may not adequately brief personnel coming on-shift about the status of the aircraft that they are repairing. For example, it was alleged that, in one instance, incomplete briefing of maintenance personnel at shift change resulted in the engine cowling of a DC-10 blowing of in flight. Three different maintenance shifts serviced the aircraft, in sequence, and the second two shifts were inadequately briefed on the status of the repairs.

4.5 Communications

- Workload: There are too many ATC communications demands on pilots during critical phases of flight, e.g., during final approach.

- Errors: Causes of communication errors between controllers and pilots include:
  - cockpit noise
  - aircraft call sign confusions
  - pilot expectations
  - failure to follow communications procedures

- ATC Upgrade: There is a lack of planned effort to assure that degradation of pilot/controller relationships does not occur during ATC system upgrade.

5.0 TRAINING

5.1 Commercial Pilots

5.1.1 Crew Skills/Aircraft Operations Mismatch

- Pilot Qualifications: Some pilots who are flying commercial aircraft are not currently qualified to do so. Standards and procedures presently used to classify and identify pilots in terms of qualification levels are not always effective.

- Curricula Currency: Development and deployment of pilot training curricula lags behind cockpit technology. For example, some pilots are unfamiliar with procedures required to bypass autoland in instances of system failure or final approach procedure changes.

- Pilot Knowledge of System Capability: Mismatch between systems used and operators' understanding of systems may result in failure to use systems due to lack of confidence in them. This, in turn, may result in decisions, such as shooting the minimums, that lead to unnecessary risk.

- ATP Emergency Training: Flight crew personnel may not receive sufficient instruction in implementation of emergency procedures. This may result in inappropriate and ineffective reactions by flight crews in emergency situations such as aborted take offs.

- Commuter Airline Operator Emergency Training: Because of financial constraints, commuter airlines may be unable to provide simulator training in emergency procedures for their flight crews, resulting in impaired ability to deal effectively with certain inflight emergency conditions.

- First-Officer-For-Command Training: First officers working for emergent airlines which, because they have financial difficulties, cannot affort to provide adequate training, may be promoted to command positions without being thoroughly trained for that job.

- Cockpit Resource Management: Deficient human relations and management capabilities in command officers may decrease flight safety in high workload and in other situations requiring effective cooperation among crew members.

- Requirements: Currently there is no specific requirement that air carrier crews receive formal training in the management of cockpit resources.

5.2 General Aviation Pilots

- Familiarity with Aircraft: Second and third owners of light aircraft are not as adequately trained in operating the aircraft and its equipment as are original owners.

- **Emergency Procedures:** General aviation pleasure pilots are not trained to handle in-flight emergencies such as:
  - engine failure
  - control malfunctions
  - unanticipated weather

- **Unusual Flight Conditions:** Many general aviation pilots are unfamiliar with aircraft capabilities under unusual conditions of flight:
  - short field take offs
  - extreme cross winds
  - combinations of conditions

- **Flight Instructor Qualifications:** Certification of flight instructors does not consider their teaching ability.

5.3 Simulation

- **Substitution for Flight Time:** The characteristics of simulation which are required for training in flight simulators to adequately substitute for training in actual aircraft have not been determined.

- **Real Flight Expectations:** The influence of simulation training on expectations in real flight is unknown.

5.4 Maintenance

5.4.1 Curricula

- **Advanced Electronics:** Currently, training requirements for avionics technicians do not include expertise in microprocessing technology. This knowledge is necessary to service advanced avionics systems.

- **Airframe Repair:** Schools are not equipped to teach repair of bonded structures or honeycomb structures to airframe mechanics.

- **Avionics:** There is no current standardized curriculum for training mechanics to repair advanced avionics systems.

5.4.2 Assessment

- **Trouble-Shooting Skills:** Skills in trouble-shooting and problem solving are not measured by current certification tests for aircraft maintenance personnel.

- **Test Instruments:** There are no validated instruments for assessing the usefulness of current practices for teaching A & Ps to maintain modern, sophisticated aircraft.

5.4.3 Skill/Job Requirement Mismatches

- Military Training: Aircraft mechanics who are trained in the military may be certificated to assume responsibility for civil aircraft repairs and inspections without being required to attend FAR 145 school.

- Maintenance of Avionics: Aircraft mechanics who have not been trained in, or examined on the requisite skills are expected to maintain and certify complex avionics in light aircraft.

- Certification Authority: Mechanics may repair and certify aircraft with which they have no current experience. For example, licensed A & Ps whose current experience is limited to turbine engines are also authorized to repair, inspect and certificate reciprocating engine aircraft.

6.0 ACCIDENT INVESTIGATION

6.1 Deficiencies in General Procedures

- Information Sharing: The civil aviation section does not take advantage of investigatory techniques or safety information developed by D.O.D.

- Non-Fatal Accident Investigations: Non-fatal accidents are not thoroughly investigated although the characteristics of these accidents may be practically identical to those of accidents resulting in fatalities. Therfore, opportunities to obtain first-hand accounts from persons involved in accidents are lost.

- Comparability of Data from Accident Investigations: Criteria for determining the detail with which accident investigations are conducted are not standard. Therefore, levels of detail are not uniform across investigations and the results of different investigations may not be comparable.

- Investigation of Commercial Aviation Accidents: Investigations of commercial aircraft accidents are not conducted by people trained in human factors engineering who are also familiar with flight operations and flight deck equipment.

- Uniformity: The lack of uniformity and thoroughness of investigations of general aviation crashes reduces the usefulness of data produced by those investigations.

- Configuration of General Aviation Aircraft: Detailed information on control settings and equipment compliment is often not obtained.

- Maintenance History: There is often little attempt in accident investigations to determine the reason for maintenance errors (or inactions) that contribute to airplane crashes from mechanical failure.

- Data Collection Forms: The new NTSB accident investigation forms structure the investigators' thinking in ways that may interfere with the discovery of what really happened.

6.2 Determination of Pilot Error

- Limited Use of Flight Data Voice Recordings: Currently, DFR and CVR are not sufficiently used to enable thorough understanding of role of pilot error in crashes.

- Inaccuracy: DFR equipment in crashed aricraft have provided inaccurate information on aircraft flight parameters.

- Lack of Transcribing Equipment: Lack of equipment to transcribe CVR records has reduced their utility in accident investigations.

- Flight Crew Testimony: Accident reports frequently do not include pilots' testimony in explanation of pilot errors.

- Critera for Attributing Aircraft Accidents to Pilot Error and Other Human Factors: Specific criteria for determining the extent to which aircraft accidents are due to pilot error have not been established.

- Insufficient Data: Insufficient data on crew performance and characteristics are collected during accident investigations to specify human errors that contributed to a crash and why these human errors occurred. For example, insufficient information was collected in the case of Pensacola 727 crash to determine why the flight engineer turned the GPWS off.

- Pilot Characteristics: General aviation accident investigations do not collect sufficient information on pilot characteristics to enable analysis of the extent to which these characteristics contribute to crashes. For example, information on recency of flying experience may not be obtained.

- Work Environment: In most accidents, information on flight conditions and operational situations that promote pilot errors are not systematically addressed, e.g., cockpit design, pilot workload, environmental conditions.

6.3 Data Characteristics

- ASRS: ASRS data on inflight emergencies does not contain sufficient information for determining contributing human factors in these incidents.

- Data Base Organizations: Computerized safety data bases are not structured to facilitate analysis of human factors data.

- Exposure Data: The relative criticality of flight conditions and performance problems cannot be determined because of insufficient exposure data, e.g., reliable and representative data on pilot flying time under various conditions are not available.

- Application of Results: Currently there are no established procedures whereby the results of accident investigations can influence system design efforts and whereby suspected human factors problems in system designs can influence accident investigation procedures.

7.0 HELICOPTER OPERATIONS

7.1 Terminal Procedures

- Aircraft Mix: It is difficult to control and fly helicopters mixed with the faster, fixed wing aircraft within the context of current terminal procedures;
- Vertical Obstructions: It is difficult for helicopter pilots to see vertical obstructions near landing areas, such as antenna towers that are illuminated for detection by conventional aircraft, but not for detection by rotorcraft.

7.2 Cockpit Design

- Standardization: Extreme lack of standardization of displays and controls in helicopters contribute to transfer of training problems for helicopter pilots.
- Pilot Performance Data: There is insufficient pilot performance data to permit development of standardized guidelines for helicopter displays and controls.
- Seats: Anthropometric specifications for pilot seats to be used in helicopters are not available to cockpit designers.

7.3 Air Traffic Control

- Radar Clutter: Air traffic controllers have difficulty identifying helicopters on their radar scopes because helicopter returns often fall within radar clutter.
- Direction of Movement: Because of the nature of external lighting on helicopters, it is often difficult for arrival controllers to determine their direction of horizontal movement.

7.4 Helipad Design

- Low Altitude Navigation Aids: Design requirements for heliports are not well understood, particularly those for low altitude navigation aids.

8.0 AIRPORTS AND FACILITIES

8.1 Surface Lighting and Signing

- Standardization: Runaway and taxiway signs and lights are not standardized across airports and are difficult to see under conditions of restricted visibility. Often runways cannot be discriminated from taxiways.
- Ground Conditions: Information painted on the ground is lost in snow and fog.

APPENDIX F: SOLICITATION AND RESULTS OF G-10 RANKING OF 30 HUMAN FACTORS PROBLEMS

U.S. Department of Transportation
Research and Special Programs Administration

Transportation Systems Center

Kendall Square
Cambridge, Massachusetts 02142

May 18, 1984

Dear G-10 Committee Member:

At the last committee meeting in Long Beach, I told you that the Transportation Systems Center was developing a human factors research plan for the FAA, and that we would like to obtain the endorsement of the committee for the plan. The first step in obtaining this endorsement is to obtain committee approval of the list of issues that will be addressed in the plan. Toward that end, we would like your response to the 30 issues described in the enclosed material.

These 30 safety issues were selected from a list of 371 items that were identified through interviews with various members of the civil aviation community and a review of the proceedings from the series of human factors workshops that was conducted by the FAA a few years ago. We recognize that many important human factors issues which could be addressed by the FAA are not included here. Because of limits in the resources potentially available for new FY'85 research initiatives, we selected only a few of the issues from the total set for near-term attention. With your assistance, we will reduce this number to about 10 items which we will propose to the FAA for inclusion in their FY'84 research and development plan.

To identify the 30 safety issues we rated each of the 371 items as high, medium, or low regarding the following characteristics:

*Flight Safety - Current influence of the issue on crash probability, and the potential impact of a solution on that influence;

*Promotion of Aviation - The degree to which addressing the issue would advance aviation technology and the popularity of flying in this country;

*Importance - The apparent significance of the issue as reflected by the attention it is currently receiving in technical reports and in discussion among members of the aviation community;

Commonality - Commonness of the issue throughout the aviation community;

FAA Relevance - Degree to which work on the issue would support current FAA activities;

Near-Term Pay Off - Potential for work on the issue to produce implementable results within two or three years; and

Feasibility - Feasibility of implementing products of research once completed, and the likely impact of that implementation on flight safety and on the promotion of aviation.

When comparing the ratings given the 371 safety issues, we placed special emphasis on ratings that they received regarding the three starred characteristics.

Regarding the enclosed list, please do the following:

1. Rank the items in the list according to their importance to civil aviation;

2. Indicate your rankings by writing a number from 1 to 30 next to each safety issue, and

3. Return the material with your comments to me at the G-10 committee meeting on the 24th of May, or send it to me no later than the 11th of June at the following address:

Dr. M. Stephen Huntley, Jr.
DTS-45
Transportation Systems Center
Kendall Square
Cambridge, MA 02142

Tel. - (617) 494-2339
FTS - 837-2339

We probably will include the safety issues that are ranked in the top ten in our FAA human factors research plan. As soon as we have a draft version of the plan, it will be presented to the committee for the review and comment of its members.

Thank you for your time, attention, and effort. Please contact me if you have any questions regarding the list.

Sincerely,

Steve Huntley

M. Stephen Huntley, Jr., Ph.D.
Engineering Psychologist

HUMAN PERFORMANCE SAFETY ISSUES

1. Pilot

   A. Cockpit Information, Equipment Design, and Certification

      (1) Automation - Automation and modernization of the NAS must not adversely affect pilot workload. Adequate human factors engineering must be included in the design of advanced techonolgy cockpits.

      (2) Manual Reversion - When operating automated systems, the pilot must have adequate information to safely revert to manual control.

      (3) Information Requirements - The information required for monitoring automated flight and for manual control must be determined and the difference in these requirements must be identified.

      (4) Human Factors Certification Criteria- The FAA must clearly define the certification criteria for advanced technology cockpits.

      (5) Standardized Information Presentation - Studies are required to determine the best formats for display presentations and to establish formating standards.

      (6) Rotorcraft - Display and Control Standardization - Standards are required which permit IFR flight within acceptable levels of workload.

      (7) Keyboard Entry Devices - Establish a program to avoid equipment designs which are susceptible to human error.

      (8) Voice Actuated Systems - Performance guidelines and criteria for applying voice activated control systems in the cockpit are required.

      (9) Digital Software - Valid criteria for certifying digital software for use in airborn systems must be developed.

      (10) Data Link - Guidelines for the presentation of data link information must be developed to minimize pilot workload and to ensure the timely transfer of information to the cockpit. An impact assessment on the loss of the "party line" an pilot performance and flight safety is required.

(11) New Technology Applied to Safety - The use of new technology to attain higher levels of safety through accident prevention.

B. Operations, Procedures, Training, Selection, and Airmen Certification.

(12) Simulator Fidelity Criteria - The relationship between simulator fidelity and credit for training needs to be determined.

(13) Simple Simulators - The role of the inexpensive simulator in pilot training needs to be determined.

(14) Performance Feedback in Simulation - The influence of performance feedback during simulation training needs to be determined.

(15) Pilot Proficiency/Automated Systems - The training required to retain manual flight control proficiency of pilots using automated flight systems needs to be determined.

(16) LOFT - Use for cockpit management training and to identify human performance safety issues.

(17) Judgement Training - What is the influence of judgement training on pilot decision making? What are the effective applications of this training?

(18) Weather collection/Dissemination - Determine if the weather data to be provided by the developing NAS will meet the pilots' requirements.

(19) Simplify FARs - Reduce the regulatory burden and regulatory conflicts.

(20) Economic Stress on Training - Assess the impact of economics on the quality of training.

(21) Approach Charts - Determine the usefulness of a prioritized information approach chart format for manual and automated information presentation applications.

(22) Fatigue- Determine the effects of fatigue on crew interactions and develop countermeasures for adverse effects.

(23) Workload - Develop a baseline workload assessment methodology.

2. <u>Maintenance</u>

(24) <u>Update FAR147</u> - Required training curricula should reflect the advance that have been made in aircraft design.

(25) <u>A&P Licensing</u> - Assess adequacy of present licensing procedure.

(26) <u>Testing Procedure</u> - Testing should evaluate the applicants problem solving ability as well as conceptual understanding. It should not be limited to measuring rote memory capability.

3. <u>Data Acquisition and Analysis</u>

(27) <u>Pilot Error</u> - Develop methods for determining the why of pilot error.

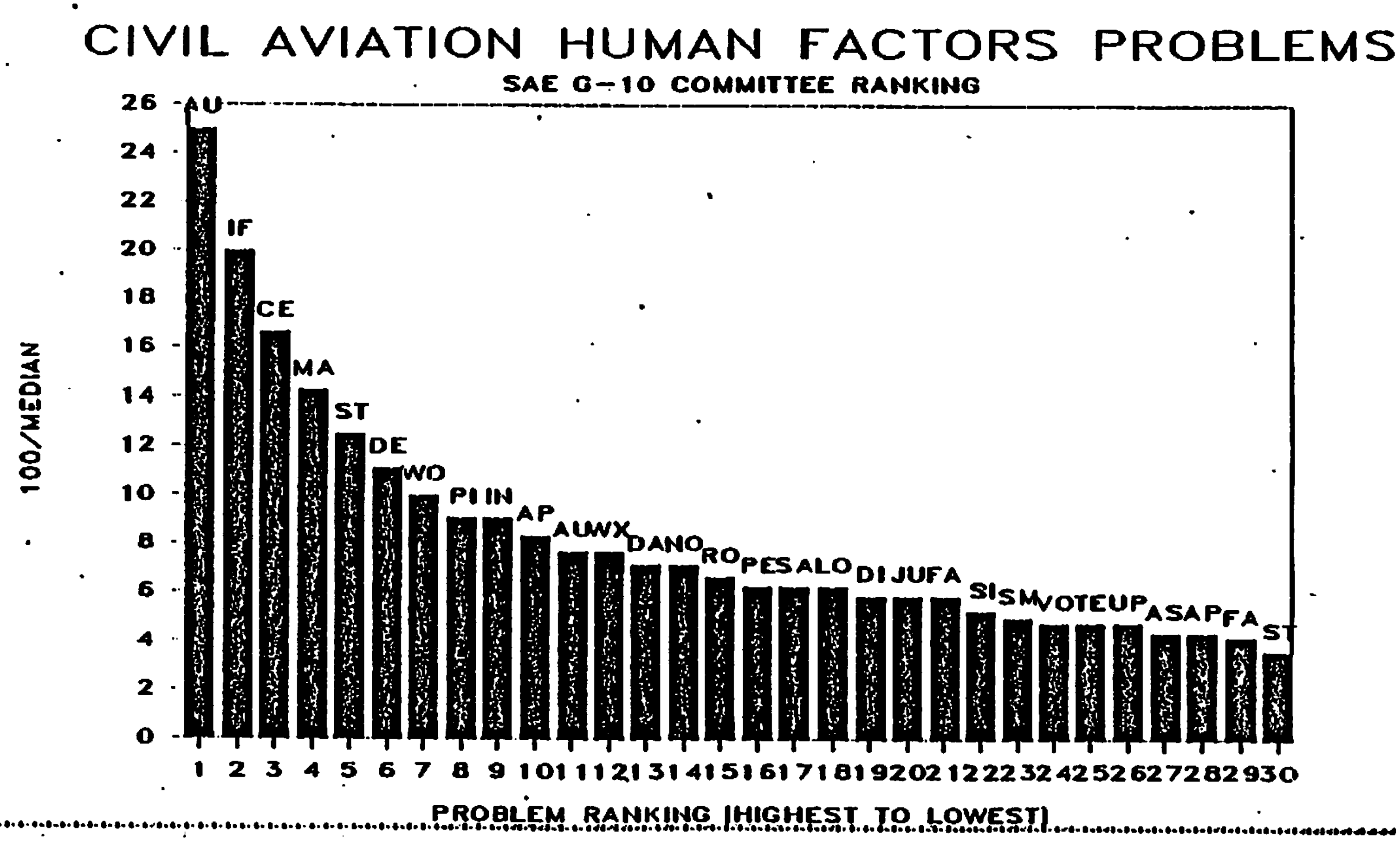
(28) <u>Non-Fatal Accidents</u> - Criteria for human error analyses of non-fatal accidents are needed.

(29) <u>ASRS</u> - ASRS should be used to identify human performance safety issues.

(30) <u>In Flight Data</u> - Establish procedures, acceptable to the industry, to identify automated systems incompatibility, so that designers can avoid future conflicts. What is [redacted] working well and why?

AVIATION HUMAN FACTORS PROBLEMS
SAE G10-COMMITTEE RANKING BY MEDIAN

RANK	LABEL	NO. PROBLEM	100/ AVG	STANDARD DEVIATION	MEDIAN	100/ MEDIAN
1	AU	1 AUTOMATION	20	3	4	25
2	IR	3 INFORMATION REQUIREMENTS	22	3	5	20
3	CE	4 CERTIFICATION CRIT.	12	6	6	17
4	MA	2 MANUAL REVERSION	16	5	7	14
5	ST	5 STANDARDIZED INFORMATION	12	4	8	13
6	DE	7 KEYBOARD ENTRY	9	6	9	11
7	WO	23 WORKLOAD	12	7	10	10
8	IN	30 IN-FLIGHT DATA	6	7	11	9
9	PI	27 PILOT ERROR	10	10	11	9
10	AP	21 APPROACH CHARTS	9	4	12	8
11	WX	18 WEATHER DATA	7	9	13	8
12	AU	15 AUTOMATION PROFICIENCY	11	5	13	8
13	NO	28 NON-FATAL ACCIDENTS	7	11	14	7
14	DA	10 DATA LINK	7	4	14	7
15	RO	6 ROTORCRAFT STANDARDIZATION	7	8	15	7
16	LO	16 LOFT	7	6	16	6
17	SA	11 SAFETY TECHNOLOGY	6	7	16	6
18	PE	14 PERFORMANCE FEEDBACK	6	6	16	6
19	JU	17 JUDGEMENT TRAINING	7	8	17	6
20	FA	22 FATIGUE	7	8	17	6
21	DI	9 DIGITAL SOFTWARE	6	3	17	6
22	SI	12 SIMULATOR FIDELITY	6	7	19	5
23	SM	13 SIMPLE SIMULATORS	6	7	20	5
24	UP	24 UPDATE FAR 147	5	6	21	5
25	VO	8 VOICE SYSTEMS	5	7	21	5
26	TE	26 TESTING PROCS.	6	9	21	5
27	AS	29 ASRS	5	1	23	4
28	AP	25 ATP LICENSING	5	8	23	4
29	FA	19 SIMPLIFY FARS	4	3	24	4
30	ST	20 STRESS ON TRAINING	4	7	28	4


CIVIL AVIATION HUMAN FACTORS PROBLEMS
SAE G-10 COMMITTEE RANKING
100/MEDIAN
26
24
22
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18
16
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12
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ST
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
PROBLEM RANKING (HIGHEST TO LOWEST)

G-10 RANKING RESULTS
(TOP 15 ITEMS OUT OF 30)

AUTOMATION

- Pilot Workload - To ensure that modernization of the NAS and cockpit designs does increase pilot workload.

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

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

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

COCKPIT INFORMATION REQUIREMENTS

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

- Weather - Identify weather information required by pilots and compare with that to be supplied in the developing NAS.

COCKPIT INFORMATION FORMATTING

- Data Link - Develop guidelines for the formatting and presentation of information transmitted to the pilot.

- Cockpit Displays - Develop standards for the structure, formatting, and presentation of flight system and navigation information in advanced cockpits.

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

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

WORKLOAD

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

PILOT ERROR

- Causes - Determine why pilots make the errors that they do and develop countermeasures where feasible. Determination methods to be considered for this purpose include:
  - Human error analysis of non-fatal accidents; and
  - Collection of in-flight data to determine why some cockpit systems are operated error free and others not.

ROTOR CRAFT

- Displays and Control Standardization - Develop standard guidelines and criteria based upon objective and quantitative measures of human performance for designing advanced technology helicopter displays and controls.

APPENDIX F: NTSB RECOMMENDATIONS

NATIONAL TRANSPORTATION SAFETY BOARD

CREW COORDINATION

RECOMMENDATION: A-84-043

DATE OF ACCIDENT: May 5, 1983
ACCIDENT CITY: MIAMI
ACCIDENT STATE: FL
REPORT NUMBER: AAR-84-04

ACCIDENT SYNOPSIS:

ON MAY 5, 1983, EASTERN AIR LINES FLIGHT 855, A LOCKHEED L-1011 AIRPLANE, N334EA, WAS EN ROUTE FROM MIAMI, FLORIDA, TO NASSAU, GRAND BAHAMA ISLAND, WHEN THE FLIGHTCREW NOTED A LOSS OF OIL PRESSURE ON THE NO. 2 ENGINE AND SHUT IT DOWN. RATHER THAN CONTINUE THE DESCENT TO NASSAU, WHICH WAS ABOUT 50 NAUTICAL MILES AWAY, THE CAPTAIN DECIDED TO RETURN TO MIAMI BECAUSE OF BETTER WEATHER AND TERMINAL APPROACH AIDS THERE. HOWEVER, AFTER THE AIRPLANE'S COURSE WAS REVERSED AND LEVELED AT 16,000 FEET, THE NO. 3 ENGINE FLAMED OUT. ABOUT 5 MINUTES LATER, THE NO. 1 ENGINE FLAMED OUT. WITH NONE OF THE AIRPLANE'S ENGINES OPERATING, THE FLIGHTCREW BEGAN A DESCENT TO MAXIMIZE THE GLIDE DISTANCE, AND BEGAN EFFORTS TO RESTART THE NO. 2 ENGINE. AT THE SAME TIME, THE FLIGHTCREW CONSIDERED IT PROBABLE THAT THEY WOULD BE FORCED TO DITCH THE AIRPLANE. THE FLIGHT ENGINEER TOLD THE SENIOR FLIGHT ATTENDANT TO PREPARE THE CABIN FOR DITCHING. AFTER DESCENDING ABOUT 11,000 FEET, THE FLIGHTCREW SUCCEEDED IN RESTARTING THE NO. 2 ENGINE AND SUBSEQUENTLY LANDED THE AIRPLANE SAFELY IN MIAMI. THERE WERE NO INJURIES TO THE 162 PASSENGERS AND 10 CREWMEMBERS.

LOG NUMBER: 1682
RECOMMENDATION NUMBER: A-84-043
DATE OF ISSUE: May 7, 1984
NTSB STATUS: OPEN - RESPONSE RECEIVED

RECOMMENDATION:

THE NTSB RECOMMENDS THAT EASTERN AIR LINES: REVIEW AND MODIFY AS NEEDED, ITS FLIGHT MANUALS, FLIGHT ATTENDANT MANUALS, AND TRAINING PROGRAMS TO ASSURE COMPATIBILITY OF EMERGENCY PROCEDURES AND CHECKLISTS, AND TO REQUIRE JOINT COCKPIT AND CABIN CREW TRAINING WITH RESPECT TO EMERGENCY PROCEDURES; SPECIFIC ATTENTION SHOULD BE GIVEN TO CONDUCTING PERIODIC EMERGENCY DRILLS IN WHICH COCKPIT/CABIN CREW COORDINATION AND COMMUNICATION ARE PRACTICED AND PASSENGER BRIEFINGS ARE SIMULATED REGARDING EVENTS THAT MAY BE EXPECTED DURING SUCH EMERGENCIES.

NATIONAL TRANSPORTATION SAFETY BOARD

RECOMMENDATION: A-84-076

CREW COORDINATION

DATE OF ACCIDENT: June 2, 1983
ACCIDENT CITY: CINCINNATI
ACCIDENT STATE: OH
REPORT NUMBER: AAR-84-09

ACCIDENT SYNOPSIS:

THE NATIONAL TRANSPORTATION SAFETY BOARD HAS COMPLETED ITS INVESTIGATION OF THE ACCIDENT INVOLVING AIR CANADA FLIGHT 797, WHICH OCCURRED ON JUNE 2, 1983, WHEN AN IN-FLIGHT FIRE FORCED THE FLIGHTCREW OF THE MCDONNELL DOUGLAS DC-9 AIRPLANE TO MAKE AN EMERGENCY LANDING AT THE GREATER CINCINNATI AIRPORT. UPON LANDING, A FLASH FIRE OCCURRED IN THE CABIN. THE FIVE CREWMEMBERS AND 18 PASSENGERS WERE ABLE TO EVACUATE THE BURNING CABIN; THE REMAINING 23 PASSENGERS DIED IN THE FIRE. THE SAFETY BOARD'S INVESTIGATION HAS DETERMINED THAT THE FIRE PROPAGATED THROUGH THE AIRPLANE'S LEFT REAR LAVATORY, BUT WAS UNABLE TO IDENTIFY POSITIVELY THE SOURCE OF IGNITION. THE SAFETY BOARD WAS NOT ABLE TO DETERMINE THE EXTENT TO WHICH THE FLIGHTCREW'S DELAY IN INITIATING AN EMERGENCY DESCENT FOR LANDING CONTRIBUTED TO THE ACCIDENT AT STANDIFORD FIELD, LOUISVILLE, KENTUCKY, ABOUT 3 TO 5 MINUTES SOONER THAN THE LANDING AT CINCINNATI. THE SHORTENED EXPOSURE TIME OF THE PASSENGERS TO THE TOXIC ENVIRONMENT IN THE CABIN WOULD UNDOUBTEDLY HAVE MEANT LESS DEGRADATION OF THEIR PHYSICAL AND MENTAL CAPACITY AND WOULD HAVE ENHANCED THEIR CHANCES OF SUCCESSFULLY LEAVING THE CABIN BEFORE IT WAS CONSUMED BY FIRE.

LOG NUMBER: 1706
RECOMMENDATION NUMBER: A-84-076
DATE OF ISSUE: July 12, 1984
NTSB STATUS: OPEN - RESPONSE RECEIVED

RECOMMENDATION:

THE NTSB RECOMMENDS THAT THE FEDERAL AVIATION ADMINISTRATION: REQUIRE THAT AIR CARRIER PRINCIPAL OPERATIONS INSPECTORS REVIEW THE TRAINING PROGRAMS OF THEIR RESPECTIVE CARRIERS AND IF NECESSARY SPECIFY THAT THEY BE AMENDED TO EMPHASIZE REQUIREMENTS:

- FOR FLIGHTCREWS TO TAKE IMMEDIATE AND AGGRESSIVE ACTION TO DETERMINE THE SOURCE AND SEVERITY OF ANY REPORTED CABIN FIRE AND TO BEGIN AN EMERGENCY DESCENT FOR LANDING OR DITCHING IF THE SOURCE AND SEVERITY OF THE FIRE ARE NOT POSITIVELY AND QUICKLY DETERMINED OR IF IMMEDIATE EXTINCTION IS NOT ASSURED.

- FOR FLIGHT ATTENDANTS TO RECOGNIZE THE URGENCY OF INFORMING FLIGHTCREWS OF THE LOCATION, SOURCE, AND SEVERITY OF ANY FIRE OR SMOKE WITHIN THE CABIN.

- FOR BOTH FLIGHTCREWS AND FLIGHT ATTENDANTS TO BE KNOWLEDGABLE OF THE PROPER METHODS OF AGGRESSIVELY ATTACKING A CABIN FIRE BY INCLUDING HANDS-ON-TRAINING IN THE DONNING OF PROTECTIVE BREATHING EQUIPMENT, THE USE OF THE FIRE AX TO GAIN ACCESS TO THE SOURCE OF THE FIRE THROUGH INTERIOR PANELS WHICH CAN BE PENETRATED WITHOUT RISK TO ESSENTIAL AIRCRAFT COMPONENTS, AND THE DISCHARGE OF AN APPROPRIATE HAND FIRE EXTINGUISHER ON AN ACTUAL FIRE.

NATIONAL TRANSPORTATION SAFETY BOARD

PILOT INFORMATION REQUIREMENTS

SPECIAL STUDY NUMBER: AAR-82-15,SIR83
DATE OF SPECIAL STUDY: January 23, 1982

SPECIAL STUDY SYNOPSIS:

ON JANUARY 23, 1982, WORLD AIRWAYS, INC., FLIGHT 30H, A MCDONNELL DOUGLAS DC-10-30, WAS A REGULARLY SCHEDULED PASSENGER FLIGHT FROM OAKLAND, CALIFORNIA, TO BOSTON, MASSACHUSETTS, WITH AN EN ROUTE STOP AT NEWARK, NEW JERSEY. FOLLOWING A NONPRECISION INSTRUMENT APPROACH TO RUNWAY 15R AT BOSTON-LOGAN INTERNATIONAL AIRPORT, THE AIRPLANE TOUCHED DOWN ABOUT 2,500 FEET BEYOND THE DISPLACED THRESHOLD OF THE RUNWAY, LEAVING 6,691 FEET REMAINING ON WHICH TO STOP. ABOUT 1936:40, THE AIRPLANE VEERED TO AVOID THE APPROACH LIGHT PIER AT THE DEPARTURE END OF THE RUNWAY AND SLID INTO THE SHALLOW WATER OF BOSTON HARBOR. THE NOSE SECTION SEPARATED FROM THE FORWARD FUSELAGE AFTER THE AIRPLANE DROPPED ONTO THE SHORE EMBANKMENT. OF THE 212 PERSONS ON BOARD, 2 ARE MISSING AND PRESUMED DEAD. THE OTHERS EVACUATED THE AIRPLANE SAFELY, BUT WITH SOME INJURIES. THE REPORTED WEATHER WAS A MEASURED 800-FOOT OVERCAST, 2 1/2 MILE VISIBILITY, LIGHT RAIN AND FOG, TEMPERATURE 35 DEGREES, AND WIND 165 DEGREES AT 3 KNS. THE WET RUNWAY WAS COVERED WITH HARD-PACKED SNOW AND A COATING OF RAIN AND/OR GLAZED ICE.

LOG NUMBER: 1530
RECOMMENDATION NUMBER: A-82-157
DATE OF ISSUE: December 23, 1982
NTSB STATUS: CLOSED - ACCEPTABLE ACTION

RECOMMENDATION:

THE NTSB RECOMMENDS THAT THE FEDERAL AVIATION ADMINISTRATION: AMEND AIR TRAFFIC CONTROL PROCEDURES TO REQUIRE THAT CONTROLLERS DISSEMINATE "POOR" AND "NIL" BRAKING ACTION REPORTS PROMPTLY TO AIRPORT MANAGEMENT AND TO ALL DEPARTING AND ARRIVING FLIGHTS UNTIL AIRPORT MANAGEMENT REPORTS THAT THE BRAKING ACTION IS "GOOD".

LOG NUMBER: 1530
RECOMMENDATION NUMBER: A-82-158
DATE OF ISSUE: December 23, 1982
NTSB STATUS: CLOSED - ACCEPTABLE ACTION

RECOMMENDATION:

THE NTSB RECOMMENDS THAT THE FEDERAL AVIATION ADMINISTRATION: STRESS IN INITIAL AND RECURRENT AIR TRAFFIC CONTROLLER TRAINING PROGRAMS, THE IMPORTANCE OF TRANSMITTING ALL KNOWN CONTAMINATED RUNWAY CONDITION INFORMATION TO DEPARTING AND ARRIVING FLIGHTS, THAT A "FAIR" OR "POOR" BRAKING REPORT FROM A PILOT MAY INDICATE CONDITIONS WHICH ARE HAZARDOUS FOR A HEAVIER AIRPLANE, AND THAT DEPARTING AND ARRIVING PILOTS SHOULD BE INFORMED WHEN NO RECENT LANDING BY A COMPARABLE AIRPLANE HAS BEEN MADE.

LOG NUMBER: 1530
RECOMMENDATION NUMBER: A-82-159
DATE OF ISSUE: December 23, 1982
NTSB STATUS: CLOSED - ACCEPTABLE ACTION

RECOMMENDATION:

THE NTSB RECOMMENDS THAT THE FEDERAL AVIATION ADMINISTRATION: AMEND AIR TRAFFIC CONTROL PROCEDURES TO REQUIRE THAT AUTOMATIC TERMINAL INFORMATION SERVICE (ATIS) BROADCASTS: (1) BE UPDATED PROMPTLY AFTER RECEIPT OF REPORTS OF BRAKING CONDITIONS WORSE THAN THOSE REPORTED IN THE CURRENT BROADCAST, AND (2) WHEN CONDITIONS ARE CONDUCIVE TO DETERIORATING BRAKING ACTION, INCLUDE A STATEMENT THAT BRAKING ACTION ADVISORIES ARE IN EFFECT.

LOG NUMBER: 1530
RECOMMENDATION NUMBER: A-82-160
DATE OF ISSUE: December 23, 1982
NTSB STATUS: CLOSED - ACCEPTABLE ACTION

RECOMMENDATION:

THE NTSB RECOMMENDS THAT THE FEDERAL AVIATION ADMINISTRATION: AT SUCH TIME AS AIR TRAFFIC CONTROL PROCEDURES ARE AMENDED TO REQUIRE AUTOMATIC TERMINAL INFORMATION SERVICE (ATIS) BROADCASTS TO BE MODIFIED, AMEND THE AIRMAN'S INFORMATION MANUAL TO ALERT PILOTS THAT WHEN ADVISED ON ATIS THAT BRAKING ACTION ADVISORIES ARE IN EFFECT THEY SHOULD BE PREPARED FOR DETERIORATING BRAKING CONDITIONS, THAT THEY SHOULD REQUEST CURRENT RUNWAY CONDITION INFORMATION IF NOT VOLUNTEERED BY CONTROLLERS, AND THAT THEY SHOULD BE PREPARED TO PROVIDE A DESCRIPTIVE RUNWAY CONDITION REPORT TO CONTROLLERS AFTER LANDING.

LOG NUMBER: 1530
RECOMMENDATION NUMBER: A-82-161
DATE OF ISSUE: December 23, 1982
NTSB STATUS: OPEN - ACCEPTABLE ACTION

RECOMMENDATION:

THE NTSB RECOMMENDS THAT THE FEDERAL AVIATION ADMINISTRATION: REQUIRE THAT AIR CARRIER PRINCIPAL OPERATIONS INSPECTORS REVIEW THE OPERATING PROCEDURES AND ADVISORY INFORMATION PROVIDED TO FLIGHTCREWS FOR LANDING ON SLIPPERY RUNWAYS TO VERIFY THAT THE PROCEDURES AND INFORMATION ARE CONSISTENT WITH PROVIDING MINIMUM AIRPLANE STOPPING DISTANCE.

LOG NUMBER: 1530
RECOMMENDATION NUMBER: A-82-163
DATE OF ISSUE: December 23, 1982
NTSB STATUS: OPEN - UNACCEPTABLE ACTION

RECOMMENDATION:

THE NTSB RECOMMENDS THAT THE FEDERAL AVIATION ADMINISTRATION: AMEND 14 CFR 25.107, 25.111, AND 25.113 TO REQUIRE THAT MANUFACTURERS OF TRANSPORT CATEGORY AIRPLANES PROVIDE SUFFICIENT DATA FOR OPERATORS TO DETERMINE THE LOWEST DECISION SPEED (V1) FOR AIRPLANE TAKEOFF WEIGHT, AMBIENT CONDITIONS, AND DEPARTURE RUNWAY LENGTH WHICH WILL COMPLY WITH EXISTING TAKEOFF CRITERIA IN THE EVENT OF AN ENGINE POWER LOSS AT OR AFTER REACHING V1.

LOG NUMBER: 1530
RECOMMENDATION NUMBER: A-82-164
DATE OF ISSUE: December 23, 1982
NTSB STATUS: OPEN - UNACCEPTABLE ACTION

RECOMMENDATION:

THE NTSB RECOMMENDS THAT THE FEDERAL AVIATION ADMINISTRATION: AMEND 14 CFR 121.189 AND 14 CFR 135.379 TO REQUIRE THAT OPERATORS OF TURBINE ENGINE-POWERED, LARGE TRANSPORT CATEGORY AIRPLANES PROVIDE FLIGHTCREWS WITH DATA FROM WHICH THE LOWEST V1 SPEED COMPLYING WITH SPECIFIED TAKEOFF CRITERIA CAN BE DETERMINED.

LOG NUMBER: 1530
RECOMMENDATION NUMBER: A-82-168
DATE OF ISSUE: December 23, 1982
NTSB STATUS: OPEN - ACCEPTABLE ACTION

RECOMMENDATION:

THE NTSB RECOMMENDS THAT THE FEDERAL AVIATION ADMINISTRATION: IN COORDINATION WITH THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, EXPAND THE CURRENT RESEARCH PROGRAM TO EVALUATE RUNWAY FRICTION MEASURING DEVICES WHICH CORRELATE FRICTION MEASUREMENTS WITH AIRPLANE STOPPING PERFORMANCE TO EXAMINE THE USE OF AIRPLANE SYSTEMS SUCH AS ANTISKID BRAKE AND INERTIAL NAVIGATION SYSTEMS TO CALCULATE AND DISPLAY IN THE COCKPIT MEASUREMENTS OF ACTUAL EFFECTIVE BRAKING COEFFICIENTS ATTAINED.

NATIONAL TRANSPORTATION SAFETY BOARD

ROTORCRAFT DISPLAYS AND CONTROLS

RECOMMENDATION: A-78-023

DATE OF ACCIDENT: March 11, 1977
ACCIDENT CITY: COLDFOOT
ACCIDENT STATE: AK
REPORT NUMBER:

ACCIDENT SYNOPSIS:

ON MARCH 11, 1977, AN AEROSPATIALE SA-318C ALLOUETTE II HELICOPTER WAS INVOLVED IN AN ACCIDENT NEAR COLDFOOT, ALASKA. THE NATIONAL TRANSPORTATION SAFETY BOARD'S INVESTIGATION OF THE ACCIDENT REVEALED A DESIGN FEATURE OF THE CYCLIC GRIP WHICH MAY COMPROMISE A PILOT'S ABILITY TO HANDLE CERTAIN EMERGENCY SITUATIONS.

LOG NUMBER: 0836
RECOMMENDATION NUMBER: A-78-023
DATE OF ISSUE: April 13, 1978
NTSB STATUS: OPEN - ACCEPTABLE ACTION

RECOMMENDATION NUMBER:

THE NTSB RECOMMENDS THAT THE FEDERAL AVIATION ADMINISTRATION: 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.

NATIONAL TRANSPORTATION SAFETY BOARD

APPROACH CHARTS

RECOMMENDATION: A-84-82

DATE OF ACCIDENT: March 8, 1984
ACCIDENT CITY: ROSSLYN
ACCIDENT STATE: VA
REPORT NUMBER:

ACCIDENT SYNOPSIS:

BETWEEN 4 P.M. AND 5 P.M. ON MARCH 8, 1984, THE NATIONAL TRANSPORTATION SAFETY BOARD RECEIVED SEVERAL TELEPHONE CALLS FROM WITNESSES WHO HAD OBSERVED AIRCRAFT FLYING CLOSE TO TALL BUILDINGS LOCATED IN THE ROSSLYN, VIRGINIA, AREA. THESE AIRCRAFT WERE CONDUCTING APPROACHES TO LAND AT WASHINGTON NATIONAL AIRPORT, WASHINGTON, D.C. THE WITNESSES WERE LOCATED ON THE GROUND AND IN THE BUILDING AT 1000 WILSON BOULEVARD. AS A RESULT OF THE REPORTS AND BECAUSE OF PREVIOUS SIMILAR INCIDENTS INVESTIGATED BY THE SAFETY BOARD, THE SAFETY BOARD CONDUCTED A COMPREHENSIVE INVESTIGATION OF THE INCIDENTS. GROUND WITNESSES, FLIGHTCREWS, AND AIR TRAFFIC CONTROLLERS WERE INTERVIEWED, FLIGHT DATA RECORDERS (FDR) FROM INVOLVED AIRCRAFT WERE READ OUT, AND RECORDED RADAR DATA WERE PLOTTED. AN ANALYSIS OF THIS INFORMATION HAS UNCOVERED SEVERAL SAFETY HAZARDS WHICH WARRANT CORRECTIVE ACTION BY THE FAA. THESE INVOLVE THE INTERPRETATION OF DESCENT PROFILE ALTITUDE RESTRICTIONS ON INSTRUMENT APPROACH PROCEDURE CHARTS, EFFECTIVENESS OF THE MINIMUM SAFE ALTITUDE WARNING SYSTEM (MSAW), AND AIR TRAFFIC CONTROLLER PROCEDURES FOR ISSUING SAFETY ADVISORIES TO AIRCRAFT.

LOG NUMBER: 1688
RECOMMENDATION NUMBER: A-84-082
DATE OF ISSUE: August 13, 1984
NTSB STATUS: OPEN - AWAIT REPLY

RECOMMENDATION:

THE NTSB RECOMMENDS THAT THE FEDERAL AVIATION ADMINISTRATION: PRESCRIBE STANDARDIZED ALTITUDE SYMBOLOGY TO BE USED IN THE PROFILE VIEW OF APPROACH PROCEDURE CHARTS.

NATIONAL TRANSPORTATION SAFETY BOARD

HUMAN PERFORMANCE

RECOMMENDATION: A-82-091

DATE OF ACCIDENT: January 20, 1981
ACCIDENT CITY: SPOKANE
ACCIDENT STATE: WA
REPORT NUMBER:

ACCIDENT SYNOPSIS:

ON JANUARY 20, 1981, A CASCADE AIRWAYS, INC. BEECH 99A AIRCRAFT EN ROUTE FROM MOSES LAKE, WASHINGTON, TO SPOKANE, WASHINGTON, CRASHED ABOUT 4.5 MILES SOUTHWEST OF SPOKANE INTERNATIONAL AIRPORT. THE ACCIDENT OCCURRED WHILE THE PILOT WAS MAKING A LOCALIZER INSTRUMENT APPROACH TO RUNWAY 3. SEVEN PERSONS INCLUDING THE FLIGHTCREW WERE KILLED, AND TWO PASSNEGERS WERE INJURED SERIOUSLY.

LOG NUMBER: 1487
RECOMMENDATION NUMBER: A-82-091
DATE OF ISSUE: August 18, 1982
NTSB STATUS: OPEN - ACCEPTABLE ACTION

RECOMMENDATION:

THE NTSB RECOMMENDS THAT THE FEDERAL AVIATION ADMINISTRATION: ESTABLISH FORMAL HUMAN PERFORMANCE CRITERIA FOR THE DEVELOPMENT AND EVALUATION OF INSTRUMENT APPROACH PROCEDURES AND INSTRUMENT APPROACH CHARTS.

NATIONAL TRANSPORTATION SAFETY BOARD

APPROACH CHARTS

RECOMMENDATION: A-81-034

DATE OF ACCIDENT: October 24, 1980
ACCIDENT CITY: GAINESVILLE
ACCIDENT STATE: FL
REPORT NUMBER:

ACCIDENT SYNOPSIS:

ON OCTOBER 24, 1980, A BEECHCRAFT BE-18S, N65V, CRASHED AND BURNED AFTER STRIKING A TELEVISION ANTENNA TOWER WHILE EXECUTING A MISSED APPROACH FROM THE GAINESVILLE, FLORIDA, REGIONAL AIRPORT. ALL THREE OCCUPANTS OF THE AIRCRAFT WERE KILLED. THE PILOT OF THE AIRCRAFT HAD BEEN CONDUCTING AN INSTRUMENT LANDING SYSTEM (ILS) APPROACH IN POOR WEATHER CONDITIONS JUST BEFORE THE ACCIDENT OCCURRED. WHEN THE PILOT REPORTED THAT HE HAD MISSED THE APPROACH, THE AIR TRAFFIC CONTROLLER ADVISED HIM TO EXECUTE THE PUBLISHED MISSED APPROACH PROCEDURES. SHORTLY THEREAFTER, THE PILOT REPORTED THAT N65V HAD LOST AN ENGINE. THE AIRCRAFT PROCEEDED STRAIGHT OUT ON A NEAR-CENTERLINE COURSE (280 DEGREE MAGNETIC) FROM THE END OF THE RUNWAY 28, THE ILS RUNWAY, UNTIL COLLIDING WITH THE ANTENNA TOWER, WHICH WAS APPROXIMATELY 5.2 NAUTICAL MILES FROM THE AIRPORT.

LOG NUMBER: 1254
RECOMMENDATION NUMBER: A-81-034
DATE OF ISSUE: March 30, 1981
NTSB STATUS: OPEN - ACCEPTABLE ACTION

RECOMMENDATION:

THE NTSB RECOMMENDS THAT THE INTER-AGENCY AIR CARTOGRAPHIC COMMITTEE: TAKE STEPS TO AMEND ALL APPROPRIATE NOS APPROACH CHARTS TO DEPICT THE MISSED APPROACH TRACK WITH A CURVED ARROW IN THE DIRECTION OF THE REQUIRED TURN, REGARDLESS OF WHERE THE TURN BEGINS. THESE CHANGES SHOULD BE ACCOMPLISHED ALONG WITH ROUTINE AMENDMENTS RESULTING FROM PERIODIC REVIEWS.

NATIONAL TRANSPORTATION SAFETY BOARD

APPROACH CHARTS

RECOMMENDATION: A-80-060

DATE OF ACCIDENT: October 31, 1979
ACCIDENT CITY: MEXICO CITY
ACCIDENT STATE: MEX
REPORT NUMBER:

ACCIDENT SYNOPSIS:

ON OCTOBER 31, 1979, WESTERN AIRLINES, INC., MCDONNELL DOUGLAS DC-10-10, N-903WA, CRASHED AT MEXICO CITY INTERNATIONAL AIRPORT, MEXICO. ALTHOUGH THE AIRCRAFT WAS CLEARED TO LAND BY MEANS OF A SIDESTEP MANEUVER ON RUNWAY 23R, THE CREW CONTINUED THE APPROACH TO RUNWAY 23L, WHICH HAD BEEN CLOSED FOR REPAIRS. THE AIRCRAFT STRUCK HEAVY EQUIPMENT ON RUNWAY 23L AS THE CREW ATTEMPTED TO EXECUTE A MISSED APPROACH. OF THE 76 PASSENGERS AND 13 CREWMEMBERS ABOARD, 61 PASSENGERS AND 11 CREWMEMBERS WERE FATALLY INJURED, 13 PASSENGERS AND 2 CREWMEMBERS WERE SERIOUSLY INJURED. ONE PERSON ON THE GROUND WAS FATALLY INJURED.

LOG NUMBER: 1149
RECOMMENDATION NUMBER: A-80-060
DATE OF ISSUE: July 14, 1980
NTSB STATUS: OPEN - ACCEPTABLE ALTERNATE ACTION

RECOMMENDATION:

THE NTSB RECOMMENDS THAT THE FEDERAL AVIATION ADMINISTRATION: PUBLISH AN ADVISORY CIRCULAR, OR AMEND AN EXISTING ADVISORY CIRCULAR, TO DISSEMINATE INFORMATION ON THE SIDESTEP MANEUVER PROCEDURES, TERMINAL ATC COMMUNICATION PROCEDURES, RADAR SEPARATION AND EQUIPMENT REQUIREMENTS, AND LANDING MINIMA APPLICABLE TO THE USE OF THE SIDESTEP MANEUVER BY AMERICAN AIR CARRIERS AT BOTH DOMESTIC AND FOREIGN AIRPORTS.

NATIONAL TRANSPORTATION SAFETY BOARD

APPROACH CHARTS

RECOMMENDATION: A-80-051

DATE OF ACCIDENT:
ACCIDENT CITY:
ACCIDENT STATE:
REPORT NUMBER:

ACCIDENT SYNOPSIS:

A SAFETY BOARD REVIEW OF 14 CFR 91.23 (FUEL REQUIREMENTS FOR FLIGHT IN IFR CONDITIONS) AND 91.83 (FLIGHT PLAN; INFORMATION REQUIRED) HAS REVEALED A DISPARITY WITH RESPECT TO THE REQUIREMENT THAT A PILOT FILE FOR AN ALTERNATE AIRPORT IN A FLIGHT PLAN. THE REGULATIONS STATE THAT A PILOT IS NOT REQUIRED TO FILE FOR AN ALTERNATE AIRPORT ON AN INSTRUMENT FLIGHT RULES (IFR) FLIGHT PLAN IF THE FORECAST WEATHER AT THE INTENDED DESTINATION AIRPORT, FOR A PERIOD OF 1 HOUR BEFORE TO 1 HOUR AFTER THE ESTIMATED LANDING TIME, INDICATED A CEILING OF 2,000 FEET ABOVE THE AIRPORT AND VISIBILITY OF 3 MILES. THUS, IF THE INTENDED DESTINATION CEILING IS 2,000 FEET, THE CURRENT REGULATIONS DO NOT REQUIRE THAT PILOTS FLYING INTO THESE AIRPORTS FILE FOR AN ALTERNATE DESTINATION WHEN THE WEATHER IS BELOW APPROACH MINIMUMS. ALTHOUGH THIS SITUATION HAS NOT CONTRIBUTED TO AN ACCIDENT, THE SAFETY BOARD BELIEVES THAT THE HAZARD POTENTIAL IS SUFFICIENT TO WARRANT CORRECTIVE MEASURES TO ALERT PILOTS TO THE DISPARITY IN THESE REGULATIONS.

LOG NUMBER:	1167
RECOMMENDATION NUMBER:	A-80-051
DATE OF ISSUE:	June 30, 1980
NTSB STATUS:	OPEN - ACCEPTABLE ACTION

RECOMMENDATION:

THE NTSB RECOMMENDS THAT THE FEDERAL AVIATION ADMINISTRATION: ALERT PILOTS TO THE DISPARITY BETWEEN THE REQUIREMENTS OF 14 CFR 91.23 AND 91.83 AND THE APPROACH MINIMUMS FOR CERTAIN HIGH ALTITUDE AIRPORTS, BY PUBLISHING IN THE AIRMAN INFORMATION MANUAL AND ON APPROPRIATE APPROVED APPROACH CHARTS A SPECIFIC REQUIREMENT TO FILE FOR AN ALTERNATE AIRPORT FOR THOSE AIRPORTS WHERE APPROACH MINIMUMS ARE HIGHER THAN 2,000 FEET ABOVE AIRPORT ELEVATION.