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ENGINEERING AND DEVELOPMENT PROGRAM PLAN - AIRCRAFT SAFETY.(U)
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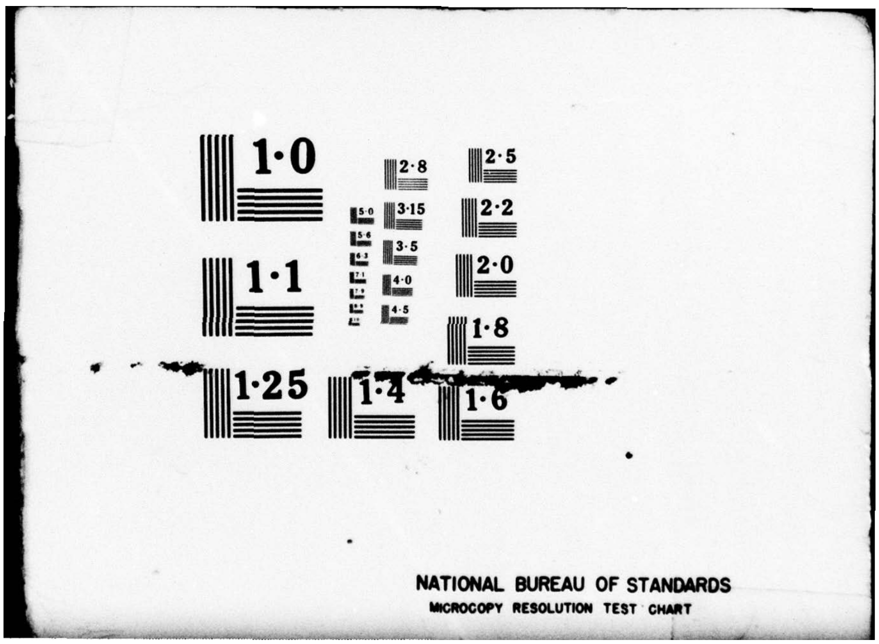
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REPORT NO. FAA-ED-18-1A

LEVEL II

ENGINEERING AND DEVELOPMENT PROGRAM PLAN— AIRCRAFT SAFETY

JUNE 1978

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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
Washington, D.C. 20590

APPROVED: ______________________
Director, Systems Research and
Development Service

APPROVED: ______________________
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16. Abstract

The Aircraft Safety Program Engineering and Development Plan describes the objectives, the scope of work and the funding requirements to meet the Federal Aviation Administration's research need in aircraft safety for the 1978-85 period. The Plan covers work in Fire Safety, Transport Safety, and General Aviation Aircraft Safety.

Although Aviation Security is included in Program 18, it is reported under Engineering and Development Plan ED-18-2.

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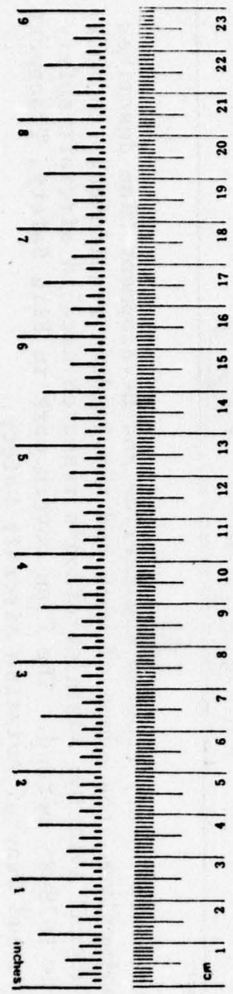
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

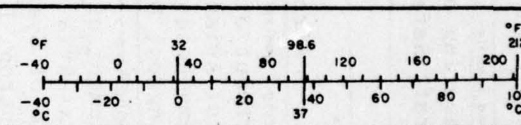
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1. EXECUTIVE SUMMARY

1.1 Introduction

Program 18 - Aircraft Safety. The objective of the Aircraft Safety Program is to provide the technical and economic data bases to assist in determining feasibility of new rules or the elimination of rules approaching obsolescence, acceptability of the techniques for showing compliance, and to develop in-service monitoring for aircraft and engine airworthiness, crashworthiness, flight performance, and operations and for pilot performance and aviation security. Included under this broad objective are all civil aircraft ranging from small general aviation fixed and rotary wing aircraft to aircraft used for business and commercial activities, and the small, medium, and large transport and advanced technology aircraft. The multiple activities, operations, and environments that are engaged in or encountered by these aircraft, the airmen that operate them and the passengers and cargo that are carried, result in a wide variety of hazards that must be attacked by an equally wide variety of safety improvement efforts. These are exemplified by the following specific goals:

a. Develop airframe, engine, flight characteristics and equipment criteria for conventional, rotary wing and advanced technology aircraft.

b. Develop operational techniques and criteria, taking into account aircraft performance, handling qualities, man-machine, and atmospheric considerations.

c. Obtain in-service and research data for assessment of currency and adequacy of engineering and operational standards.

d. Develop impact and fire protection crash survivability criteria.

e. Determine extent to which flight simulators can be used for flight operations research, aircraft certification and airman training and certification.

f. Develop pilot qualification, recurrency, and training certification criteria including techniques and equipment.

g. Develop technical, economic and operational feasibility of techniques, devices and systems to prevent hijacking and sabotage.

Program 18 is uniquely aimed at maintaining and improving safety and is complementary to NASA, DOD, and other Government and non-Government research efforts which are aimed at the aircraft performance improvement process. Joint programs with NASA, the military and other agencies permit complementary use of aircraft and facilities to provide an appropriate range of research efforts to serve respective agency needs.

1.2 Projection of Demand

Research and development is conducted in response to specific requests from the FAA's operating services and in anticipation of the need for certification or operating criteria in critical safety problem areas.

- The short-term requests from operating services for E&D work have averaged ten per year with an average cost of $360,000 each over a two-year period, or somewhat less than $4 million per year.

- Long-term development efforts are required to steadily attack existing and forecast safety problems resulting from industry's use of new technology. These must be undertaken early enough in the industry's aircraft development cycle to permit FAA to provide minimum safety level airworthiness considerations.

- This Program Plan contains, or is based on, a desired level of expenditure and schedules which may not reflect actual budget limitations and priorities. For this reason, the individual levels of expenditure for the program and the sum of all of the program funding requirements will not necessarily correlate with the actual FAA Engineering and Development budget, for any given fiscal period. Subsequent adjustments to this Program Plan will attempt to minimize these differences.

1.3 Development Approach and Products

The program is divided into the following elements. Major current and planned efforts are listed.

Fire Safety

In-flight fire and crash fire protection requirements:

- Modified Fuel
- Fuel Tank Inerting
- Fuselage Compartment Fire Management; Flammability, Smoke and Toxicity Criteria for Cabin Interior Materials
- Propulsion Fire Prevention, Detection, Extinguishment

Transport Safety

Airworthiness, flight performance and operation requirements:

- Flight Simulation Complementary to Aircraft Certification
- Improved Structural Flight Loads Criteria
- Aircrew, Cockpit Display and Aircraft System Dynamics Interface Requirements
- Methods of Compliance - Flight Loads
- Methods of Compliance - Maintenance

- Minimum Flight Performance and Flying Qualities Requirements
- Propulsion Engine Anti-Icing Requirements
- Turbine Engine Blade and Rotor Containment Criteria
- Composite Structures Certification Requirements
- Advanced Integrated Flight Systems Technolcgy Certification Requirements
- Turbine Engine Foreign Object Damage Criteria
- Structural Crash Energy Design Criteria
- Safe Bomb Placement Identification and Structural Standards for Interior Bomb Blasts
- Helicopter IFR Certification Requirements
- Helicopter All Weather Requirements
- Helicopter Operational Integration and Control Procedures and Techniques
- Helicopter Noise, Vibration and Other Environmental Criteria
- Tire Safety Improvement

General Aviation Aircraft Safety

- Pilot-Cockpit Compatibility
- Improved Structural Flight Loads Criteria
- Method of Compliance - Flight Loads
- Stall Avoidance and Deterrent Requirements
- Continuing Critical Review of Aircraft Certification Requirements with View Toward Simplification and Consolidation
- Minimum performance and Flying Qualities Requirements
- Aircraft Structure Crash Energy Design Requirements

Airman Training and Certification

- Training Techniques and Equipment
- Certification Requirements
- Recurrency Requirements

Aviation Security (Note: Although Aviation Security is included in Program 18, it is reported under Engineering and Development Plan ED-18-2.)

- Weapon Detection Systems
- Bomb Detection Systems
- Airport Security Concepts

Portions of the program are conducted at NAFEC. A portion is accomplished through outside contracts including interagency agreements which allow FAA the expeditious access to and use of other agency's in-house and contractual capabilities. The NASA/DOT/FAA interagency agreement providing for joint use of the NASA/Ames simulators is especially useful in the flight characteristics, performance, and operations programs involving future generations of aircraft.

1.4 Resource Requirements

To be responsive to requests from operating services in a timely manner funding levels of the following order are required. Specific projects and costs are in the body of this Plan.

FISCAL YEAR FUNDING *

	76	76T	77	78	79	80	81-85
Fire Safety	678	0	634	460	2000	4400	18000
Transport Safety	1203	67	934	830	2190	3990	30000
General Aviation Flight Safety	401	145	414	395	485	684	5000
	2282	212	1982	1685	4675	9074	53000

* These funds represent contract dollar estimates and may not agree with congressional appropriations beyond FY-1978.

2. INTRODUCTION

Program 18, Aircraft Safety, has as its general objective the maintenance and improvement of safety for passengers, airmen, and aircraft, both on the ground and in flight. Included under this broad requirement are all civil aircraft ranging from small general aviation fixed and rotary wing aircraft, to aircraft used for business and commercial activities and culminating in the small, medium, and large transport aircraft used by the certificated air carriers. The multiple activities, operations, and environments that are engaged in or encountered by these aircraft, the airmen that operate them and the passengers that are carried exposes the aircraft to a wide variety of hazards that must be attacked by an equally wide variety of safety improvements efforts. Program 18, Aircraft Safety, is the agency's Engineering and Development Program for accomplishing these safety efforts. This program plan describes these efforts, the requirements for them, their outputs and how these are utilized and the funding requirements for the next ten-year period.

The variety of technologies and types of work that are required in the Aircraft Safety Program are exemplified by the specific goals which were listed on page 5.

The Aircraft Safety Program is structured to match these goals. Program details are presented in the following sections of this Plan.

3. BACKGROUND/REQUIREMENT/NEED/PROBLEM

The Federal Aviation Act of 1958 empowers the Secretary of Transportation to "undertake or supervise such developmental work and service testing as tends to the creation of improved aircraft, aircraft engines, propellers and appliances." (Section 312). He is also empowered "and it shall be his duty to promote safety of flight of civil aircraft in air commerce by prescribing and revising from time to time:

a. Such minimum standards governing the design, materials, workmanship, construction and performance of aircraft, aircraft engines and propellers as may be required in the interest of safety;

b. Such minimum standards governing appliances as may be required in the interest of safety."

These basic legal requirements are acted upon by the agency E&D effort in terms of:

a. Response to specific short-term requests from the operating offices and services of the agency to provide the basis for new rulemaking, new operating procedures or new advisory publications.

b. E&D on recognized safety problems that exist or are forecast to arise pertinent to the aircraft and its components, airmen, passengers and passenger security at airports.

c. E&D to provide a knowledge and data base to establish standards (special conditions, etc.) and means to comply with them for new aircraft designs that will be presented to the agency for certification.

The majority of the efforts in the Aircraft Safety Program fall into the first and third categories listed; response to immediate and specific requests from the operating services and preparing the way to meet the future certification needs of these services. Some E&D efforts are a combination of all these categories.

As of June 1978, there were 39 active requests for E&D work on Aircraft safety. Table 3-1 lists these showing the diverse nature of the work requested. As can be seen, the primary source for these requests is the Flight Standards Service, with the Office of General Aviation and the Office of Air Transportation Security providing the remainder.

TABLE 3-1

ACTIVE REQUESTS FOR AIRCRAFT SAFETY R&D

AFS-100-073-133	Fail Safe Structural Inspection and Design Criteria
AFS-100-073-135	Electrical Charge on Fuel Filters During Refueling Operations
AFS-100-075-143	Nitrogen Generation System for Fuel Tank Inerting
AFS-100-075-145	Fuselage/Cabin Fire Management System
AFS-100-076-150	Aircraft Cabin Materials/Combustion Hazards
AFS-100-076-151	Evaluation of Transport Aircraft Emergency Lighting Under Adverse Conditions
AFS-100-076-155	Guidelines for the Use of Titanium in Aircraft Engines
AFS-100-076-156	Transport Aircraft Tire Performance
AFS-100-077-157	Airworthiness Certification Rules and Flight Test Procedures Improvement Criteria
AFS-100-077-159	Supplementary Research and Development of Aircraft Loads
AFS-100-077-160	Helicopter Icing Certification Criteria
AFS-500-077-001	Validate Seat/Restraint System Computer Model
AFS-800-075-001	General Aviation Ground Pilot Trainers
AFS-800-076-001	Paint Schemes for the Improvement of Aircraft Propeller and Helicopter Rotor Blade Conspicuity
AGA-ARD-076-001	Pilot Training Techniques
ACS-200-075-001	Least Risk Bomb Location - Commercial Aircraft
ACS-200-075-002	Explosion Effects Tests - Commercial Aircraft
ACS-200-076-001	Emergency Jettison of Bomb/Sabotage Devices
ACS-200-076-002	Evaluation of Explosive Vapor Detection Devices

The following requirements from the Flight Standards Service were established by means other than the formal FAA Form 9550.1, "Request for R,D,&E Effort."

1. Turbine Blade/Rotor Containment
2. Full-Scale Fuselage Fire Test Facility

3. Cabin Fire Characteristics Model

4. Emergency Evacuation Equipment

5. Foreign Object Damage to Turbine Engines

6. Loads Development Based Aerodynamic Characteristics

7. Helicopter IFR Operations

8. Improved Gust Load Criteria for General Aviation Aircraft

9. Transport Aircraft Crashworthiness

10. General Aviation Aircraft Crashworthiness

11. Crash Resistant Fuel Tanks

12. Engine Inlet Anti-Icing Systems

13. Support of USAF Engine Nacelle Fire Simulator

14. Use of Simulators in Certification

15. Effects of Extended Towing on Transport Nose Gear Safe Life

16. General Aviation Aircraft Cockpit Standardization

17. Hardware and Software Functional Assessment Concepts

18. Advanced Integrated Flight Systems Technology

19. Certification Procedures for Digital Flight Control Systems

20. Effects of Lightning on Digital Avionics

4. PROGRAM STRUCTURE

The Aircraft Safety Program consists of four major elements: Fire Safety, Transport Safety, General Aviation Flight Safety and Aviation Security.

4.1 Fire Safety

4.1.1 Problem - A sufficient number of crashes occur where occupants would have survived if the subsequent fuel fire had not caused fatalities. An effort to both reduce the possibility of ignition and the severity of the fuel-fed fire is appropriate and if successful will provide increased time for the cabin environment to remain habitable allowing additional time for evacuation. The need to address the potentially hazardous effects of cabin material fires, toxic gases, smoke and the flash fire propensity must proceed. The possible in-flight hazard from engines and fuel systems must be examined in order to maintain and/or improve the current level of safety.

4.1.2 Program

The program tasks subsequently outlined provide the technical and where appropriate the economic basis for new or revised standards.

4.1.2.1 Modified Fuel

The objective of this effort is the development, testing and eventual service use of a modified jet fuel which will reduce the severity of a post-crash fire and thereby increase the time available for passenger evacuation.

A series of anti-misting fuel additives were developed in pilot batches by several chemical companies both here and in England. Instead of the fine mist which forms and is readily ignited from ruptured tanks, the anti-misting fuel is thickened when it is released into the airstream and forms a coarse spray which inhibits flame propagation. The amount of additive required is a minor fraction of the fuel weight which makes them attractive and more amenable to use in current jet aircraft.

Elements of this effort to be carried out in the next several years involve:

- Small-scale air-shear tests to determine the best candidate additive, its operational envelope and the required concentration.
- Large-scale tests to validate the small-scale tests.
- Development of a specification for modified fuel.
- Engine and fuel system compatibility - operational tests culminating in certification criteria for aircraft using modified fuel.
- An analysis of the logistics pertinent to air carrier fleet use of the modified fuel to establish the cost-benefit involved.

4.1.2.2 Cabin Post-Crash Fire Safety

This effort involves continued investigation of cabin materials in terms of their flammability, smoke, toxicity, and flash fire propensity to develop technical data to support improved airworthiness regulations. It also covers the detection and control of cabin fire spread by means of hazard detection, suppression, and possibly gas removal systems.

Planning is aimed to develop criteria to update the crash fire survivability of aircraft cabins. The hazards of flame, smoke, and toxic gases, and flash fire are being defined so that each can be reduced by regulations to increase safety during post-crash passenger and crew evacuation.

The cabin crash safety program addresses two safety approaches; the interior cabin material hazard when burning and the management of the fire. Interior material combustion hazards are considered to be cabin heat, smoke, and gases. There is an urgent requirement for a methodology by which a cabin material can be ranked for the toxicity of its gas emissions. A solution is being sought by integrating materials combustion gas data with rat incapacitation/death time so that a candidate materials toxicity ranking can be calculated. An advanced method is anticipated which may be suitable for an interim approach to the regulatory process. Subsequent work is needed to relate toxicity and other combustion hazards to human tolerances. This is being done by developing a method to assess the collective hazards affect of a burning interior material on a cabin occupant involved in an emergency evacuation. This approach, "combined hazard index," is being developed by a contractor.

This index will integrate the hazards of flammability, heat, smoke, and toxicity. A laboratory test or series of tests would be developed to measure these properties. Extrapolation into a full-scale cabin fire environment will be accomplished with a mathematical model of a cabin fire. The model will be validated against the full-scale burn results. The time-history level of each hazard will be compared with limiting tolerances for humans. The index ranking will thus integrate hazard level with escape time.

Another approach to the cabin fire safety effort is the controlled management of the post-crash cabin fire by early detection, suppression, either active or passive, and possibly removal of hazardous products. In many impact-survivable crashes as the aircraft comes to rest, either intact or with fuselage breached, a fire will occur.

Various schemes for minimizing the effects of the hazards caused by the fire must be assessed in a realistic systematized basis. Each unique method of fire or passenger evacuation control must be considered as one element of a total system that would lead toward reducing the hazard thereby improving the propabilities of survival.

Limited tests have shown that a passive system of fire suppression, such as cabin partitions appropriately located and designed, might be an effective means for fire containment. Design criteria, identifying optimum locations, materials, and types of partitions needed, together with the tests to validate the effectiveness of the concept, must be developed.

Development of an effective active system of fire suppression, using an extinguishing agent, requires more development. Preliminary tests, using Halon 1301 system, have shown that: 1) a dispensing system could be developed for an airplane, but 2) a more effective extinguishing agent must be developed for the cabin environment.

Novel concepts for smoke and gas removal will be studied as part of the total management system.

Development efforts towards improving emergency evacuation aids and egress have been initiated. A program towards improvement of emergency interior lighting and evaluation of various concepts during full-scale fire tests is underway. Areas such as improved post-crash communications, fire resistant evacuation slides, etc., are examples of items being studied.

An interim full-scale fire test facility is being developed using a surplus C-133 fuselage with a raised floor to closely simulate the cross-section of a DC-10. This facility will allow the full-scale evaluation of external fuel-fed fires as well as interior cabim material fires. This facility will enable a mathematical model of a cabin interior fire to be validated which may serve as the bridge between full-scale testing and the laboratory scale testing to be developed for demonstrating compliance with future cabin post-crash flammability requirements.

4.1.2.3 <u>In-Flight Fire Safety</u>

The fuel tanks in turbine-powered transports have large volumes of fuel vapor mixed with air as the fuel is consumed. This situation can constitute a serious explosive hazard. A method of inerting this volume has been developed wherein an inert gas i.e., nitrogen, is injected into the tank ullage volume to prevent combustion. The current work will determine the practicality of extracting nitrogen enriched air from engine bleed air rather than carrying liquid nitrogen in bottles on board and eliminate the attendant logistics problem of storing and servicing aircraft with liquid nitrogen at airports.

A second effort will develop a standard technique and test criteria that will be utilized in qualifying the electrostatic charging characteristics of fuel filter elements used in systems supplying fuel to transport aircraft.

4.1.3 <u>Products</u>

4.1.3.1 <u>Products - Past Years</u>

- A Study of Electrical Conductivity and Charging Tendency Characteristics of Aircraft Turbine Fuels 1975

- Photographic Investigation of Modified Fuel Breakup and Ignition — 1975
- Flammability Specification for Flight Attendant Uniforms — 1976
- A Preliminary Evaluation of Compartmentation in Controlling Spread of Cabin Fire — 1976
- Feasibility/Tradeoffs-Fuselage Fire Detector/Extinguisher System — 1976
- Basic Methodology for Computer Modeling Cabin Fire — 1976
- Measurement of Toxic Gases and Smoke of Cabin Interior Materials Using NBS Smoke Chamber and Colorimetric Tubes — 1976
- A Crashworthiness Analysis with Emphasis on Fire Hazard 1964-1974 — 1976
- Feasibility of Adapting a Thin Film Permeable Membrane to Jet Transport Fuel Tank Inerting System — 1976
- Development of a Proposed Flammability Standard for Commercial Transport Flight Attendant Uniforms — 1976
- Investigate Decomposition of Fire Extinguisher Agent Under Cabin Fire Conditions — 1977
- Development of Flight Attendant Fire Protective Over-Garment — 1977
- Measurement Toxic Gases and Smoke/Thermal Decomposition - 75 Cabin Interior Materials — 1977
- Relative Toxic Combustion Hazards of 75 Cabin Materials — 1977
- Design Criteria for On-Board Nitrogen Generation — 1978

4.1.3.2 Future Products

- Cabin Environmental Hazards Caused by Post-Crash Fuel Spill Fire — 1978
- Time Dependent Fire Behavior of Cabin Materials — 1978
- Relative Toxic Gas Hazard Index - Cabin Materials — 1978

. Cabin Compartment Fire Control Criteria 1978

. Electrostatic Charging of Fuel Filter Elements 1978

. Integrated Cabin Fire Control Criteria 1979

. Aircraft Fuel System and Engine Compatibility Tests Using Modified Fuel 1979

. Development of a Combined Hazard Index for Interior Cabin Materials 1979

. Assess Feasibility of Advanced Engine Fire Extinguishing Agents Developed by NASA 1979

. Basic Methodology for Physical Modeling of Cabin Fire 1979

. Improved Emergency Evacuation Criteria 1979

. Anti-Misting Fuel Ground and Flight Evaluation to Determine System/Engine Compatibility 1980

. Investigate Feasibility of Crash Resistant Fuel Tanks 1980

. Composite Structural Behavior During Crashes 1980

4.1.4 Fire Safety Resources (Contract Funds $000)

	76	76T	77	78	79	80	81-85
Modified Fuel	70	0	87	0	600	2100	6000
Cabin Crash Safety	388	0	478	460	1400	2300	10000
In-Flight Fire Safety Total	220	0	69	0	0	0	2000
Total	678*	0	634*	460*	2000	4400	18000

* Actual Congressional appropriation, future years are planning figures.

4.2 Transport Safety

4.2.1 Problem

New technology is emerging that has high probability of being used in the next generation of jet transport aircraft. Examples are composite structures, active control systems, digital avionics and flight control systems, and super-critical wing aerodynamics. While these advances will permit more efficient transport aircraft permitting a high rate of return on investment by means of high productivity and low operating costs, they pose safety and certification problems that have not yet been encountered by the FAA.

Composite structure are stronger and lighter than conventional aluminum structures but their lack of yielding deformation before failure makes their behavior under crash loads uncertain. Environmental effects on these materials have yet to be explored.

Active control systems permit much smaller tail sections and an inherently unstable aircraft. They also provide for gust alleviation and flutter suppression. This agency has not yet certificated an aircraft where failure of an electronic control system results in an uncontrollable aircraft subject to flutter destruction. Yet the high productivity of these aircraft can be attained only by use of all these technical advances.

Digital electronics is approaching the capability to effectively compete with today's analog systems while at the same time providing additional functional capability. The use of airborne digital computers introduces different airworthiness concerns from those of the past. These include software validation, rehability assessment verification, lightning and electromagnetic interference effects and failure detection.

The new large capacity high speed computers with graphics can provide the means to analyze complex structures for large deformation/failure time dependent conditions such as occur in a crash. Validated programs will provide the basis for the designer to incorporate controlled structural deformation and failure in a crash enhancing occupant survival.

Sufficient R&D must be done pertinent to the certification implications of these advances to assure that the body of rules and their means of compliance result in safe transport aircraft that maintain or improve the level of safety in public air transportation that now exists.

4.2.2 Program

The program tasks listed below provide the technical and economic basis for new or revised standards and accepted means of showing compliance for transport airframe, propulsion, flight characteristics, performance, operations, and training.

4.2.2.1 Aircraft Airworthiness

(1) Non-Destructive Inspection Equipment

One of the keys to safety is the assurance that the aircraft as manufactured is without material flaws and that in service, if flaws occur, they are detected before they become serious.

New and promising techniques to inspect new materials and construction techniques, as well as improved methods for current materials and construction will be evaluated for aircraft maintenance standards.

(2) Bomb Blast Structural Effects on Transport Aircraft

To assure safety if an explosive device is discovered inflight, the aircraft operations manual should contain information on the area of the aircraft best designed to absorb explosive loads without creating hazard to the overall integrity of the aircraft and vital systems. One approach being studied is based on the assumption that the aircraft can be unpressurized and the device placed in some area such as an unlatched door to vent the blast over-board.

(3) Airframe and System Safety/Reliability Management

The modernization of maintenance concepts have progressed logically from the "one visit" overhaul through progressive maintenance to "on condition" maintenance. The current trend is to measure the safe condition of the aircraft in terms of reliability indices. Implementation of this type of maintenance requires consideration in the initial design and must be carried through strength validation, manufacture, operation, and maintenance. Data collection systems, computer data analysis programs, strength validation procedures, design and maintenance reliability indices, maintenance data displays and comparison and feedback programs to design and strength validation will be needed to serve as the basis for new certification criteria.

(4) Composite Materials

The DOD and NASA have sponsored and stimulated the development of new materials such as the boron and graphite filament reinforced composites. The DOD has several primary components being designed or in service. Military requirements are not always compatible with civil needs. The FAA will need additional standards in areas such as the environmental and endurance aspects, lightning protection, long life joining techniques, quality control and inspection, etc.

(5) Emergency Jettison of Explosive Device

There exist a need for an alternative to the least risk location for placing an explosive device discovered in-flight. One alternative is to jettison the suspected explosive device. The actual ability to throw an object is not in itself difficult, however, it does again require an aircraft to descend to an altitude where depressurization can be accomplished unless each aircraft were equipped with a device that would allow jettisoning an object while the cabin were pressurized. Secondary considerations are the tendency for object to bounce along the fuselage as they are buffeted by the slip-stream and the potential ingestion by rear-mounted engine. The major consideration is that many explosive devices can be triggered by changing their attitude; therefore, the initial effort will be to establish the feasibility of jettisoning a device without changing its attitude.

(6) Transport Aircraft Crashworthiness

Selected aircraft crash analysis have indicated that the ability to apply crashworthiness criteria into the basic structural configuration early in the design cycle would save lives. In cooperation with NASA, a contract to develop an advanced technology structural crashworthiness method was initiated. This effort will extend a finite element elastic-plastic computer program in the NASTRAN and PLANS library of structural analysis programs into a dynamic non-linear large deflection and failure analysis procedure of aircraft structures that will allow a proposed design to be evaluated for its crashworthiness as a function time. The program, DYCAST, will be validated using tests of simplified structure and sections of actual aircraft. The final phase will include validation using full-scale crash tests, incorporation of routines to handle energy absorbing concepts and reduction schemes to reduce the size of program to adapt it to the capabilities of industry computers.

Crashworthy transport airplane fuselage tanks and other accompanying fuel system crashworthy features, may be adaptable from current advanced technology. A program to determine the applicability of this technology to transport airplane fuselage tank installations for protection during crash landings will be undertaken.

At present the technology for using expanded metal fail fuel tank filler, being developed by a joint U.S. DOT - Canadian Program, for explosion and fire protection under post-crash conditions will be monitored for possible future application to both transport and general aviation fuel tanks.

(7) Fail Safe Structural Inspection and Design Criteria

Structural inspection programs for commercial transport aircraft are initially established by a subjective evaluation process that depends primarily on the operational experience of similar aircraft. Subsequently the inspection intervals are extended for specific users depending on the program and actual experience. However, the increasing complexity of future aircraft suggest that there is a need to quantify the evaluation process more precisely. A program has been developed to simulate structural defects, failures and inspections. The logic accounts for aircraft design analysis, fatigue tests, production-service-corrosion defects, probability of crack/corrosion detection and aircraft modification economics. This logic is very complex indicating the extensive computer execution time is required to evaluate an inspection program. A major problem is the lack of engineering information from the day-by-day operator requiring the assumptions be made for corrosion, production and service defects. The validation and refinement of this program will require close cooperation with a manufacturer and user.

(8) Aircraft Tire Performance

During recent years a significant number of transport tires have failed in service and have resulted in operational hazards and/or costly damage to the airframe. Causes can relate to low inflation pressure, service inspection procedures and overloads related to failure of a dual tire. Studies are being conducted to identify technologies or procedures which can mitigate these hazards.

4.2.2.2 Propulsion Airworthiness

(1) Icing Protection

A summary report on turbine powerplant icing data and the development of a procedure for predicting and evaluating ice protection systems will be produced to assist in up-grading the airworthiness requirements.

(2) Turbine Rotor/Blade Containment

An examination of improved means to contain turbine blades either by the engine, nacelle and/or selective armoring of critical airframe areas will be conducted to reduce this hazard and provide criteria for regulatory action.

(3) Turbine Engine Bird Ingestion

A typical large commercial operator can expect to experience one bird strike per day, on the average. Repair costs alone are expensive but can be much more serious as the recent loss of a jumbojet aircraft during takeoff from Kennedy International Airport illustrates. A study to determine a practical design technique which would prevent or minimize bird ingestion damage to small turbine engines with minimum performance penalties is underway. This is a reasonable approach, since bird impact effects do not scale down with engine size or power, but rather become more of a design problem. A cost-benefit summary will be provided and consideration of composite materials will be studied.

(4) Aircraft Engine Nacelle Fire Test Simulator

This is basically a USAF facility with modest FAA financial support that will provide access to a test facility capable of simulating pressures, temperatures and airflows expected in turbine engines through 1985.

(5) Advanced Electronic Engine Controls Criteria

Advanced electronic engine controls criteria will be evaluated in order to prepare a data base for development of regulatory requirements to certificate this new control method.

(6) Usage Criteria for Titanium in Turbine Engines

This project will assess the current use of titanium in turbine engines in both civil and military aircraft and determine what knowledge can be obtained from service, design and test experience. Establish the basis for uniform guidelines in the usage of titanium in turbine engine designs.

4.2.2.3 Flight Performance/Operations

To provide a data base and criteria for the development of revised and new regulations or special conditions applicable to new aircraft design at the time the manufacturer applies to FAA for a type certificate requires appropriate advance investigation by FAA of the flight envelope for those areas unique to the design class. FAA decisions on requirements to achieve a minimum acceptable level of safety are critical to the manufacturers since all wish to start from a comparable base and need the requirements as early as possible for design and production purposes.

Because of the greatly expanded speed, altitude, and maneuvering capabilities of recent and proposed aircraft, there are correspondingly large changes in the flight characteristics.

The dynamic response characteristics, rather than the old, more familiar static stability and control parameters determine the flying qualities; that is, the safety of flight inherent in the aircraft as well as the ease of control and comfort. For some aircraft configurations and for certain flight regimes stability augmentation is required to achieve minimum acceptable flight characteristics. Active flight controls, driven by automatic stabilization systems, are being used to correct and compensate for inherent airframe design instabilities. All of these require revised regulations and/or new acceptable means of showing compliance with a general regulation.

The program covers the range of existing and probable future civil aircraft configurations such as rotary-wing, executive jet and advanced transport. The overall program is open-ended and paced by advancing state-of-aeronautical technologies, concentrating on controllability and maneuverability levels for critical flight regimes. Most of the E&D effort is experimental rather than analytical and subject to the availability of suitable research facilities, especially ground-based and in-flight simulators such as variable-stability aircraft. Because of the close relationship of civil and military handling qualities criteria and the efficiency of adding FAA test requirements to on-going performance development programs of military services and NASA, some of this work is undertaken jointly with these organizations.

(1) Validation of Adequacy of Certification and Operation Standards

In order to develop corrective actions and new or revised certification and operating standards, data applicable to various flight conditions must be collected on new transports in operation. This will require the installation of airborne data acquisition systems to obtain statistically significant samples of normal operational data.

(2) Advanced Integrated Flight Systems Technology

The FAA will be confronted, in the near future, with with the task of revising and modernizing its airworthiness standards and certification procedures to maintain flight safety for transport aircraft utilizing advanced systems technology. Present standards address certification from the concept of separate engineering disciplines. Aircraft incorporating advanced digital flight controls and avionics, active controls and related concepts will be dependent on the interaction of the pilot, the control and augmentation syste, the propulsion system, and the structure as a total integrated system. For the FAA to meet its responsibilities, concentrated effort must be initiated to acquire generic data and information to assure that airworthiness standards and certification procedures keep pace with the technology.

The energy shortage of the early 1970's showed the need for improved aircraft performance and efficiency. In January 1975, the United States Senate Committee on Aeronautical and Space Sciences suggested that the National Aeronautics and Space Administration (NASA), "... consider establishing a clearly defined goal of demonstrating the technology necessary to make possible a new generation of fuel-efficient aircraft." In response, NASA established a task force of Government scientists and engineers who served as a basis for the establishment of the NASA Aircraft Energy Efficiency (ACEE) Program. The ACEE Program promotes advanced systems technology as one means of improving energy efficiency.

Simultaneous to NASA efforts, the FAA was completing a staff study to determine active control technology ACT). Also, a joint NASA and FAA workshop was undertaken to investigate methods for certification of digital flight control and avionic systems. These activities indicated that the introduction of derivative aircraft using advanced systems are expected in the 1981 and 1983 time frame. A new generation or more advanced aircraft which may be critically dependent upon systems concepts is expected about 1985 or later.

Anticipating an impact on airworthiness standards and certification procedures, the FAA Flight Standards Service (AFS), Office of Systems Engineering Management (AEM), and Systems Research and Development Service (ARD) established the Advanced Integrated Flight Systems (AIFS) Technology Program in December 1976.

Detailed program objectives and resource levels have been incorporated in a separate Engineering and Development Program Plan, FAA-ED-18-3.

(4) Loads Development Based on Aerodynamic Characteristics

A study and analysis of aircraft structural flight loads criteria with consideration given to the effects of aircraft stability, control and handling qualities on the structural loading is being conducted. Current regulations do not adequately address the interactions of structural loads with aircraft dynamics and pilot control inputs. These interactions are particularly important in the context of flight through turbulence and in the recovery from abnormal flight attitudes, regardless of how the abnormal attitudes was developed. For aircraft with sophisticated stability and control augmentation systems, the handling qualities and hence the interaction between the pilot and the total aircraft system may have significant influence on structural flight loads. This loading may be quite different than that based on static stability and simple maneuvering. The results of this work will form a basis for improving and updating the appropriate regulations.

4.2.2.4 Helicopter

The progression of rotary wing technology and the proliferation of helicopters, primarily within the military, have brought the helicopter well within the realm of economic practicality. The expansion of the civil fleet to over 5000 aircraft today with the projection of 10,000 by 1980 clearly attests to this fact. In addition, the evolution of society's transportation needs has given birth to a wide range of applications for this unique air vehicle not filled by its conventional counterpart. Employment in roles such as faster intracity transport, particularly with the urban dislocation of conventional airfields, traffic control and emergency evacuation of crash victims, to meet expanding congestion and remote site support operations to accommodate the never ending quest and exploration of natural resources exemplify only a few of the many applications for today's helicopter. As a result, the civilian sector is looking increasingly to the unique operational characteristics of this VTOL aircraft to satisfy the needs of tomorrow.

Because of the relative newness of the helicopter, vis a vis its fixed wing sister, a need exists to promulgate additional standards, regulations and criteria to provide for their increased and safe utilization. Present regulations relating to helicopters are dated and understandably restrictive.* Those regulations applicable to all aircraft operation are primarily designed to accommodate fixed wing aircraft with little provision for the unique characteristics of the helicopter. In fact, the slow en route and approach speed, low altitude operation hover capability and downwash velocity tend to mitigate against its operation within the system and negate the advantages associated with the use of this type of aircraft.

It follows logically then that the Federal Aviation Administration, as the Nation's regulatory agency of the National Airways System should involve in a program of research directed at generating sufficient expertise upon which to base regulatory decisions relating to helicopter operation and the evolution of the National Airspace System to achieve optimum integration of its operation within the system to meet present and future transportation needs.

* The present interim standard relating to helicopter IFR operation is an example of this.

This program involves the generation of sufficient expertise and data to assist the regulatory activities in providing for the safe and optimum operation of helicopters within the National Airspace System. This includes provision for the helicopter not only as a transportation medium but also its use in a wide variety of unique and diverse applications not satisfied by other transportation means.

Emphasis will be placed in improved safety of helicopter operations and expanded capability to operate within the IFR and all weather environment. This includes development of comprehensive data and techniques to better quantify those standards. Technical areas of interest will be, application of stability augmentation concepts, icing systems, flight displays and environmental considerations of noise and vibration.

Also of paramount importance will be the integration of helicopter operations within the National Airspace System and the evolution of the system to accommodate optimally helicopter operations with emphasis on taking maximum advantage of the helicopter's unique inherent characteristics. Specific areas of interest in this category will be terminal area operations and procedures, low level operations, flight planning requirements and emergency procedures.

<u>Program</u>

For convenience, the Program Plan is divided into two major sections; one section listing projects relating to the aircraft and the other listing projects relating to the system in which the aircraft operates. Obviously, this division is not clear cut because of the strong interrelationships between the two. If the technology relates to the helicopter as an entity, it is placed under the heading of <u>Helicopter Airworthiness Characteristics</u>. Similarly, if the technology relates to either the Aircraft Traffic Control (ATC) system or control of the aircraft from the ground, it is placed under the heading of <u>Helicopter Operations and Systems Criteria</u>.

<u>Helicopter Airworthiness Characteristics</u>

1. <u>IFR Handling Qualities Standard</u> - Recent improvements in aircraft characteristics and stability systems have brought a commensurate requirement to improve operations and expand into IMC conditions. This is particularly true with the off-shore operation in the Gulf of Mexico. A standard now exists, but it is dated and its application requires considerable judgment on the part of the certifying pilot. This program would define minimum handling qualities standards based on present day experience and current technology. Hopefully, much of the subjectivity will be eliminated affording greater standardization during the certifying process.

This program would place emphasis on non-airplane techniques in the approach mode and address tradeoffs for high and low density areas and provide credit where appropriate for handling qualities improvement systems such as stability augmentation, autopilots and flight directors.

2. Pilot Workload - Related to the above program, a more objective quantification of measuring pilot workload under all conditions is required. The subjective pilot rating scale has filled a very real need and will continue to be used in conjunction with a quantified system that this program addresses. It is envisioned that one will complement the other and by so doing, a more valid basis for workload measurement will be created.

3. Control Systems - New control systems, designed to improve the piloting task as well as systems reliability, are being developed. These systems vary from the very simple pilot assist boosted to the highly complex stability optimal systems and involve, in some cases, fly-by-wire and fluidic technology. Although significant advantage is accrued through the application of these systems, they raise related issues such as acceptable control authority and analysis of failure modes. Environmental effects such as lightning should be determined and acceptable criteria defined prior to commitment to service aircraft.

4. Helicopter Icing Approval Methods - There is a need to develop guidance materials and obtain certification criteria for the approval of helicopters to fly into known icing conditions. There is also a need to review the current icing envelopes used to approve transport category aircraft and determine if these envelopes are applicable or should a different environment be defined for helicopters. Many military helicopters have been equipped for various degrees of ice protection and this information, as well as the operating experience, must be reviewed to preclude any duplication of effort. A plan will be developed to identify what specific voids in technology exist that must be explored to allow civil helicopters to be approved for flight into known icing conditions.

5. Flight Display Criteria - Another approach to improvement in handling qualities and reduction in pilot workload has been the development of new flight displays. Tape instruments and heads-up displays are examples of these new concepts. Each system has the major objective of more simply and efficiently displaying required information to the pilot, thus improving the piloting task. As these systems are developed, it is important to evaluate the potential applicability of each system and their impact on present cockpit displays to include cockpit arrangement, elimination of present systems or instruments, combination of functions, etc. Based on these data criteria should be developed defining minimum essential systems with credit allowed for desirable systems which improve pilot performance.

6. Helicopter Vibration - Helicopters are normally associated with high vibration levels relative to fixed wing aircraft. This characteristic has had an adverse impact on the piloting task, caused hearing loss in pilots, resulted in high maintenance costs from fatigue, and has been the major cause for low acceptability levels of the helicopter as a means of public transportation. New concepts such as the nodal beam and focused pylon are being developed to attenuate and perhaps eliminate vibration. Research is required to address acceptable vibration levels and exposure, from the standpoints of the pilot and the passenger, and from reduced maintenance costs resulting from longer service life. Conversely, the impact of eliminating vibration as a pilot cue should be considered.

7. Simulators in Certification - The use of simulation techniques in a variety of roles to gain insight and answers to real world problems has become a classic technique. From structural simulators to flight simulators, design engineers are able to identify and resolve problems long before commitment to hardware and the transfer function of training received on simulators to actual aircraft has long been established. One of the major advantages of this technique is safety in that catastrophic failure in the simulation will not cause a similar catastrophe in the real world. The applicability of simulators in fulfilling the regulatory function of the FAA is obvious. Their use in the certification process and in the establishment and updating of criteria and standards are examples. In order to be completely applicable, however, research is required to substantiate the validity of simulation through improvement in fidelity and correlation of data with actual data. Such questions as what cues, how many, and to what degree of fidelity are required, and what level of simulation constitutes a valid simulation. Any adverse physiological effects by type and magnitude should be addressed. The results of the program envisioned would provide the operating agencies with an economic and safe tool for their use.

8. Safety Consideration of New Design Concepts - Considerable effort is going into development of new design concepts primarily in the area of rotors to improve efficiency, increase capability, reduce noise, and generally improve on the classic constraints of present systems such as airspeed limitations, blade stall, and related noise vibration characteristics. Such concepts include the advancing blade concepts and the tilt rotor prop (XV-15). All these concepts have the potential to ameliorate the present adverse characteristics or eliminate them entirely. More at issue is that they all have potential to civilian helicopters entering the future commercial market. As this occurs, each concept will have to be certified for conceptual and operational reliability and safety. It is logical then that the FAA, as the certifying agency, maintain as a minimum a continuing cognizance in each rotor concept and other new related design concepts as they are developed to provide a data base upon which to base standards and criteria for their certification.

Helicopter Operations and Systems Criteria

1. Terminal Area Operations - Present day regulations and procedures governing terminal area operations are based on primarily fixed wing characteristics. They do not take into account the unique characteristics of helicopters. For example, a three degree linear glide slope and relatively high approach speeds are not optimum for the helicopter. Research is required to generate data upon which to base changes to the present procedures. Considerations must be given to the application of curvilinear flight paths to termination points off conventional runways, different decision heights and RVR minimums.

2. Flight Planning Requirements - Because of the relatively short operating range and reduced landing space requirements, present planning criteria should be reviewed to provide for the helicopter. Specific consideration should be given to the definition of alternate airfield requirements and fuel reserve.

3. Low Level Operations - Considerable research is being performed into low level operation of helicopters within the Army. Although their motivation in conducting this research is primarily survival in the tactical environment, the applicability of low level operation in alleviating congestion of medium and high altitudes should be of prime interest to FAA. The feasibility of safely operating in this environment under all weather conditions should be determined and a review of present altitude restrictions made. Related equipment requirements and operational procedures having the potential applicability to this type of operation should be reviewed and analyzed to provide a basis for regulatory process in the event feasibility is established.

4. Emergency Procedure Requirements - Because of the reduced landing space requirements of the helicopter relative to the fixed wing, consideration should be given to modification of emergency procedure requirements applicable to helicopters. Particular emphasis should be placed on low fuel state emergencies and a requirement to vector aircraft away from high density areas.

4.2.3 Products

4.2.3.1 Products - Past Years

. Simulator Evaluations of Tentative STOL Airworthiness 1975

. A STOL Airworthiness Investigation Using Simulators of Representative STOL Aircraft 1975

- Identification of Minimum Acceptable Characteristics for STOL Manual Flight Path Control — Vol II 1975; Vol I 1976
- A Pilot Model for Human Pilot Behavior During Wake Vortex Encounter Upsets — 1976
- Wake Vortex Encounter Hazard Criteria for Two Aircraft Categories — 1976
- Report on Current State-of-the-Art of Active Control Technology for Civil Aircraft — 1976
- Report on Pilot Response to Autopilot Malfunctions in an FAA Sabreliner Flight Inspection Aircraft — 1976
- Feasibility Report for Development of Runway Directional Control Simulator — 1976
- Summary of Results of Simulation Studies of STOL Airworthiness Criteria — 1976
- Development of a Specification for a Standard Burner for Engine Fire Zone Component Tests — 1976
- Simulation of Advanced Sabreliner on NASA-Ames FSAA in Conjunction with Use of Simulators in Certification Program — 1977
- Fail Safe Structural Inspection Methodology — 1977
- Document Helicopter Pilot Workload Reduction With PIFAX-H Improved Display — 1977
- Identify State-of-the-Art Engine Anti-Ice/De-Icing Criteria — 1977
- Feasibility of Jettisoning on Explosive Device In-Flight — 1977
- Development of Transport Aircraft Crashworthiness Methodology — 1977
- Development of Small Turbine Engine Bird Ingestion Criteria — 1977
- In-Flight Bomb Placement Criteria for B-707/DC-10 — 1977

. Structural Airworthiness Criteria for Loads due to in Cabin Explosion	1977
. Runway Directional Control Simulator	1977
. Review of Current Practices in Use of Simulation in Transport Certification	1977
. Program Library and Data Base Documentation for the Provision of Aircraft Performance and Dynamic Response Models	1977
. Operational System for the Utilization of Aircraft Performance and Dynamic Response Models	1977
. Design Criteria for Bird Ingestion into Small Turbine Engines	1978
.. Turbine Rotor/Blade Containment Criteria	1978

4.2.3.2 Future Products

. Final Recommendations for Update of FAR Part XX, Airworthiness Standards of Powered Lift Transport Category Aircraft, Subpart B, Flight	1978
. Evaluation of Transport Aircraft Emergency Lighting	1978
. Determine Usage Criteria for Titanium in Turbine Engines	1978
. Helicopter Preliminary IFR Handling Qualities	1979
. Demonstration and Validation of Fail Safe Structural Inspection Method by Demonstration in Service	1979
. Development of preliminary Helicopter Icing Criteria and Design Criteria	1980
. Improved Emergency Evacuation Lighting Criteria Developed	1979
. USAF Engine Nacelle Fire Simulator Operational	1979
. Quantification Techniques for Helicopter Pilot Workload	1980
. Validation of Transport Aircraft Crashworthiness Methodology	1980
. New Helicopter Control Systems Concepts Evaluation	1980
. Electronic Engine Control Criteria	1981/1984

. Advanced Technology Crashworthy Assessment — 1981

. Active Control Systems - Structural Requirements — 1978-1984

. Advanced Integrated Flight Systems - Procedures and Methods for Airworthiness Criteria Compliance — 1978-1984

. Active Control Systems - Minimum Handling Qualities Requirements with System Failures — 1979-1984

. Advanced Technology Transport Standards — 1981-1984

. Helicopter Low Level Operations Procedures — 1980-1985

. Certification Guidelines for Digital Avionics — 1979-1984

. Evolution of Terminal Procedures for Helicopter — 1979-1985

. Criteria for Use of Simulators in Certification — 1978-1982

. New Helicopter Design Concepts — 1980-1985

4.2.4 Transport Safety Resources (Contract Funds $000)

	76	76T	77	78	79	80	81-85
Airframe Airworthiness	179	42	459	75	500	1500	5000
Propulsion Airworthiness	502	0	0	200	0	300	5000
Flight Performance/ Operations	522	25	475	555	1690	2190	20000
	1203	67	937	830	2190	3990	30000

4.3 General Aviation Aircraft Safety

4.3.1 Problem

Light aircraft flown for personal and business uses have one of the poorest safety records of all forms of transportation. Each year some 1400 fatalities occur out of approximately 5000 accidents involving the destruction of over 1000 aircraft.

Pilot error is listed by the National Transportation Safety Board as the principal cause in over 87 percent of the fatal accidents. These errors range, in order of frequency of occurrence, from failure to maintain flying speed (stall/spin), continued flight into adverse weather including spatial disorientation, improper preflight procedures, the exercise of poor judgement and flying while physically impaired to a large variety of miscellaneous reasons for crashes. The aricraft/pilot combination is the main contributor to light aircraft crashes. Physical failure of the aircraft itself, without the pilot aiding it, is relatively rare, with engine malfunction being the largest factor. Structural failure of the aircraft is a rare phenomenon, and is likely induced by pilot inputs when it does occur.

4.3.2 Program

The problem of crash survivability, the devising of solutions to the multiple causes of aircraft accidents, and the influence on safe flight of aircraft stability and control, handling qualities and performance are all areas which require continuing and aggressive attention. All accidents culminate in the aircraft impacting the earth and it is this impact that causes most of the fatalities, although fire occurs in many cases - resulting in fatal burns. The large number of fatalities that occur with relatively little aircraft structural damage warrant a major effort to provide the analytical and experimental test base for upgrading the crash load requirements of FAR 23 to include dynamic crash load protection and to provide a means for compliance. Improved crash survivability appears to be a most effective way to improve light aircraft safety since it would apply to all accidents without regard to their cause, but improved knowledge and understanding of the principles of flight by pilots is likely the most fruitful route to the prevention of accidents.

4.3.2.1 General Aviation Safety

The efforts in this area are assembled into several distinct areas. Flight Safety, Impact Survivability, and Airmen Training and Certification. These emphasize improved crash survivability protection in light aircraft and those aircraft and flight safety crash prevention improvements that could be made within the state-of-the-art. Of course, the suggested improvements should not degrade the performance and marketability of the aircraft, but must provide for a reduction of pilot related accident causal factors.

These efforts will establish a validated basis for safety standards leading to safer aircraft and will be developed with the cooperation of the aviation community including the airframe manufacturers, user organizations and appropriate government agencies.

4.3.2.2 General Aviation Flight Safety

There are several areas of emphasis to develop practical airworthiness improvements that apply aerospace state-of-the-art to general aviation within the economic bounds of the industry.

(1) Flight Characteristics Criteria

The minimum acceptable flight characteristics criteria for light aircraft will be developed on the basis of both analytical and experimental flight tests. These will cover flight control near stall, maneuvering criteria, lateral and longitudinal stability and crosswind landing and ground handling criteria. The main areas of emphasis is the avoidance of stall/spin accidents through a program to develop and evaluate criteria and/or hardware for use in airplane design to avoid stalls in operational service. Other flight characteristics criteria are in need of improvement in the interest of accident prevention. Most of the needed improvements would impact upon FAR 23. For example, there is no requirement on the dynamic stability and control parameter, stick force as a function of normal acceleration. Because of the resulting poor feel characteristics,apilot may easily overstress an aircraft especially in turbulence. Mechanical stability and control augmentation devices are often used to overcome such deficiencies, but such devices introduce additional dynamic characteristics which may result in pilot induced oscillations, especially when the aircraft enters ground effect and the pilot commences the landing flare. These and similar handling qualities and performance factors will be subject to continuing evaluation with the objective of improving aircraft safety through regulatory modification.

(2) Power Spectral Density Analysis

In prior years the agency developed and validated a design procedure for analyzing large airplane response to continuous turbulence. This will be extended to provide for more simplified procedures for general aviation aircraft certificated under FAR 23.

(3) Pilot/Cockpit Compatibility

Determine by design studies, ground and flight evaluation, and human engineering considerations those characteristics of general aviation aircraft design which may contribute to pilot error.

(4) Small Aircraft Loads Development Based on Aerodynamic Characteristics

The development of improved standards for structural flight loads and the provision of simple procedures for complying with the standards is an area of continuing effort. Improved standards are revisions which either increases the level of safety or simplify the standard or procedure for showing compliance while maintaining the level of safety.

A study and analysis of structural flight loads will be conducted to form a basis for improving and updating the appropriate regulations. The interactions between stability, control, handling qualities and structural loading will be the primary interest. These interactions are particularly important in the context of flight through turbulence and in the recovery from abnormal flight altitudes. The response of different aircraft to turbulence and to pilot control inputs can significantly differ. The resulting dynamic loading on the airframe will also differ and such loading is not adequately addressed by existing regulations. Therefore, a re-evaluation of loads estimation techniques with emphasis on aircraft dynamics and handling qualities is needed in the interest of continuing and improved aircraft safety.

4.3.2.3 Impact Survivability Criteria

The effort to improve crash survivability protection in light aircraft is divided into three chronological phases.

Phase I - Development of Analytical Techniques. During this phase, analytical techniques for crash survivability design will be developed. The development will emphasize:

- application of existing technology in structural dynamic analysis
- cabin design to insure maximum protection of the occupants through controlled crash characteristics
- occupant packaging including energy absorption devices and restraint systems
- crash resistant fuel system demonstration

The emphasis on development of analytical techniques recognizes the full-scale crash test verification of each new model or improvement would place an economic burden on an industry.

Phase II- Verification of Analytical Techniques

During this phase, full-scale crash tests would be conducted to verify the full range of the analytical techniques developed during

Phase I. Manuals clearly describing the analytical techniques would be prepared and widely distributed to assure the understanding and availability of the new techniques to the industry

Phase III - Parametric Design Analysis

During this phase, trade-off studies would evaluate crash safety improvement versus economic and other costs, such as weight, performance, marketability, etc. The study would review many possible combinations of crash safety concepts to find a practical combination yielding optimum expected crash safety improvements. A proposed dynamic crash design criteria would be finalized based on the analysis of various practical aircraft configurations and a statistical analysis of aircraft accident data.

4.3.2.4 Airman Training and Certification

Problem

The general aviation accident rate continues to concern NTSB and FAA. The fact that over 80 percent of the fatal accidents can be attributed partially or fully to pilot error justifies a comprehensive program to update the capabilities of all pilot categories.

Program

The E&D program presented here addresses the problem of producing solutions to the multiple causes of aircraft accidents in which pilot causal factors predominate. Pilot training, certification and proficiency projects will be accomplished to provide these solutions.

(1) Training Techniques and Equipment

This effort responds to the need for improving the training and performance of the general aviation pilot. Primary areas of emphasis are outlined below:

1. Develop improved flight and ground training syllabi for all categories of pilots so that these pilots can be trained to a standard of operational competence.

2. Develop ground trainer or other methods for developing judgemental qualities in pilots in lieu of extensive flight experience.

3. Develop improvements in civil flight and ground training syllabi in the area of stall awareness and stall recovery techniques.

(2) Certification Requirements

1. Develop revised certification requirements in terms of maneuvers, skills, experience, etc., as a result of data emanating from experimental training programs.

2. Develop revised certification requirements for acceptability of pilot ground trainers as training devices.

(3) Recurrency Requirements

Develop pilot skill degradation data through experimental programs using civil pilot subjects. Such data will be used to justify currency requirements in the regulations. Such data will also provide feedback for improved initial and advanced flight training.

4.3.3 Products

4.3.3.1 Products - Past Years

- Development of Crash Analysis Procedures 1976
- Seat/Occupant/Restraint System Analytical Procedures Developed 1976
- Simplified Gust Load Analysis Techniques 1976
- Develop Improvements in Civil Flight and Ground Training Syllabi in the Area of Stall Awareness and Stall Recovery Techniques 1976
- General Aviation Pilot Stall Awareness Training Study 1977
- Stall Avoidance Flight Parameters Evaluation 1977
- Aircraft Structural Crash Analysis Method 1977
- Cockpit Instrumentation and Controls Standardization Requirements Analysis 1978
- Small Aircraft Structural Flight Loads Criteria Based on Aircraft and Atmospheric Dynamics — Interim 1977, Final 1979
- Crashworthy General Aviation Fuel System Demonstration 1978

4.3.3.2 Future Products

- Aircraft Crash Analysis Methods Validation Using Full Scale Crash Tests 1978
- Longitudinal Flight Control Criteria for Small Aircraft 1978
- Seat/Man/Restraint Crash Simulation Model Verification 1978
- Crashworthy General Aviation Fuel System Demonstration 1978
- General Aviation Crashworthiness Design Guidelines 1978

. Develop Methods and Equipment as Appropriate for Imparting Judgmental Qualities in Flight Training Students 1978

. Provide Data to Support Flight and Ground Training Technology and Syllabi More Responsive to the Requirements of the Future 1978

. Provide Data to Support More Stringent Currency Requirements for All Categories of Pilots 1980

. Criteria for Simplification of Lateral - Directional Flying Qualities 1980

. Definition of Interdependence Between Performance and Flying Qualities as Related to Certification Testing 1981

. Criteria Showing Interdependence Between Static and Dynamic Lateral Directional Characteristics and the Influence on Performance of Lateral Directional Maneuvering, Particularly in the Approach and Landing Flight Phase 1981

4.3.4 General Aviation Aircraft Safety Resources(Contract Funds $000)

	76	76T	77	78	79	80	81-85
General Aviation Flight Safety	133	0	30	85	0	0	1750
General Aviation Crash Safety	268	0	267	210	200	300	1750
Airman Training and Certification	0	145	117	100	285	384	1500
	401	145	414	395	485	684	5000

4.4 Aviation Security

This program has been separated from the basic aircraft safety and an individual program plan written to cover current and future projects. Engineering and Development Program Plan FAA-ED-18-2.

5. Resource Requirements (Contract Funds $000)

	76	76T	77	78	79	80	81-85
Fire Safety	678	0	634	460	2000	4400	18000
Transport Safety	1203	67	934	830	2190	3990	30000
General Aviation Safety	401	145	414	395	485	684	5000
	2282	212	1982	1685	4675	9074	53000

6. Interface and Coordination With Other Programs

The variety of efforts in the Aircraft Safety Program require a large number of coordinated efforts with other government agencies, industry and the military services. Many agencies not only have superb testing facilities for aircraft, engines and operational tests but also have investigated and solved safety problems common to those of civil aircraft. This commonality of interests leads to the conduct of joint safety programs whose results are mutually beneficial to these agencies and the FAA. Examples of other agencies with whom joint efforts are carried out are in the National Aeronautics and Space Administration, the Atomic Energy Commission National Bureau of Standards and Department of Defense.

A list of current Interagency Agreements is provided below.

U.S. Army FA72WAI-275 Fuel Electrostatics

NASA Ames FA72WAI-285 Simulation Facilities

NASA Langley FA74WAI-482 Aircraft Crash Simulation Techniques

NASA Langley FA76WAI-607 FAA Crash Test Program

U.S. Air Force FA76WAI-626 Engine Nacelle Fire Test Simulator

NASA Joint Aircraft Fire Safety Research Program November 10, 1977

NASA Ames FA77WAI-738 Redundant Reconfigurable Digital Flight Control Program

NASA Langley FA77WAI-756 Lightning Study Flight Tests

NASA Langley FA78WAI-855 Hardware and Software Functional Assessment Concepts

U.S. Navy FA78WAI-896 Large-Scale Anti-Misting Fuel Release Tests

U.S. Army FA78WAI-880 Anti-Misting Fuel Behavior