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ENGINEERING AND DEVELOPMENT

PROGRAM PLAN

AIRCRAFT SAFETY

12 OCTOBER 1972

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DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Aircraft and Noise Abatement Division

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16. Abstract

The Aircraft Safety Program Engineering and Development Plan describes the objectives, the scope of work, and the proposed funding requirements to meet the Federal Aviation Administrations research needs in aircraft safety for the 1973-1982 period. The plan covers work in Airworthiness, Crashworthiness, Aircraft Performance, Pilot Performance and Airline Hijacking and Sabotage.

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1. EXECUTIVE SUMMARY

1.1 Introduction

Program 18 - Aircraft Safety. The program objective is to establish an engineering and operational technical base and economic feasibility of new "minimum level of safety" regulations together with means of compliance for the ever evolving aircraft design concepts and environmental conditions. This encompasses aircraft airworthiness, crash survivability, flight operations and performance and pilot performance. In these broad areas, certain key efforts are being pursued which are:

a. Modified Fuel Specification and Engine Certification

b. General Aviation Safety Demonstration Aircraft

c. Aircraft Rational Landing Distance

d. Flight Characteristics (CTOL and STOL) Criteria

e. STOL Aircraft Performance and Operations Criteria

f. Weapon and Bomb Detection Equipment

Program 18 is uniquely aimed at improving safety and so differs from NASA and manufacturers research efforts which are aimed primarily at performance improvement. Joint programs with NASA and the military permit complementary use of aircraft and facilities to provide an appropriate range of research efforts to serve respective agency needs.

Safety is the prime consideration of aviation security activities. Thus Program 18 also includes development of methods to prevent hijacking and sabotage of aircraft.

1.2 Critical Issues

1.2.1 Level of Effort - The overall level of effort in Aircraft Safety has stayed constant at the $3+ million per year level for the past 5 years. Is this level adequate to provide for both the emergency project requirements of the agency's operating services and for the sustained safety R&D efforts needed to develop the technical base for updated regulations and to provide safety advisory material to the aviation community?

Conflict exists between the needs for continued R&D in such areas as turbine engine safety, cabin and crash fire safety, aircraft flight characteristics and operating problems, to name some examples, and the projects that are needed to satisfy the needs of the agency's operating services. These latter needs, when they arise are sufficiently critical to warrant an immediate response, the funds for which must be taken from the fixed level of Aviation Safety R&D, leaving a rapidly fluctuating level of funding available for the more continuous type of R&D requirement.

1.2.2 In House Versus Contract R&D

A portion of the effort at the National Aviation Facilities Experimental Center (NAFEC) is supported by the Aircraft Safety Program to provide a safety testing facility and a body of technical personnel with expertise in the specialized area of aircraft safety. This support requires around half of this programs total budget, with the remainder going for Headquarters program manager technical personnel and for contracts with industry and other government agencies.

What should be the relative level of in house R&D versus contract R&D to meet the conflicting demands for maintaining technical expertise within the government and for obtaining the best technical output from industry via contracts. This issue is a continuing one since both these needs have claim on the same body of funds.

1.2.3 Implementing R&D Results

What should be the means for implementing the results from Aircraft Safety R&D efforts? Two means are now employed.

One is the issuance of final reports describing the objectives, the work done and the conclusions made. These are for use by the aviation community on a voluntary basis for improvement of aircraft safety. The other is to use the R&D results for the issuance of Notices of Proposed Rulemaking (NPRM) to amend the Federal Air Regulations, for the mandatory incorporation of the changes in aircraft or their operations required for safety. Means for evaluating the relative effectiveness of these two approaches are needed to maximize the safety benefits to the aviation community.

1.3 Projection of Demand

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

- The requests from operating services for R&D work have averaged ten per year with an average cost of $375,000 each over a two-year period, or somewhat less than $2 million per year.

- The development efforts required to steadily attack existing and forecast safety problems by seeking better solutions and applying new technology, to relate to industry's aircraft development cycle and to anticipate additional requests from the operating services requires $5 million per year.

1.4 Development Approach and Product Schedule

The program is divided into:

181	Airworthiness Criteria
182	Operational and Performance Criteria
183	Crashsurvivability Criteria
184	Airmen's Performance Criteria
185	Anti-Hijacking and Sabotage Criteria

Key Program Efforts	Schedule
o Modified Fuel Specification and Engine Certification	9/74
o General Aviation Safety Demonstration Aircraft	9/77
o Aircraft Rational Landing Distance	5/73

		Schedule
o	Flight Characteristics (CTOL and STOL) Criteria	74-75-76
o	STOL Aircraft Performance and Operations Criteria	74-75-76
o	Weapon and Bomb Detection Equipment	74-75-76

In Addition, there are some 20-30 projects which use a less significant part of the resources. Portions of the program are conducted at NAFEC. A portion is accomplished through outside contracts including interagency agreements which allow FAA the expedious time 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.

1.5 Resource Requirements

The key program efforts require a total of $2-3.5 million per year over the next five years as follows:

Fiscal Year -	1973	1974	1975	1976	1977
		Thousands of Dollars			
Modified Fuel	430	1400	300	-	-
General Aviation Safety Aircraft	320	500	1000	500	2000
Rational Landing Distance	300	400	300	-	-
Flight Characteristics	130	850	775	625	1000
STOL Performance and Operations	200	680	800	500	200
Weapon & Bomb Detection Equipment	400	350	400	400	400
	1780	3180	3575	2025	3600

The remainder of program efforts require a total of $3-4 million per year.

Thus, the total requirements is $6-7 million per year to keep the FAA abreast of industry aircraft development cycles.

Funding

FY 1973 and 1974 are $3,121 and $4,701K, respectively.

2. INTRODUCTION

Program 18, Aircraft Safety, has as its general objective the 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 them to a wide variety of hazards that must be attacked by an equally wide variety of safety improvement 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.

Aircraft Safety work takes a variety of forms. There are major development programs such as the General Aviation Safety Demonstration Aircraft and the Modified Fuel efforts that are multi-year with definite end goals to be reached. Also, there are shorter range projects that can be grouped into classes, such as, Conventional Takeoff and Landing Aircraft (CTOL) Flight Characteristics, where attaining the project goal is one step in attacking the safety problems in that class of work. An example would be the completion of flight tests and analyses of flying and handling qualities of light general aviation aircraft to permit improvement of the certification requirements in FAR 23. This would be just one phase of the overall CTOL Flight Characteristics work. Finally, there are some types of effort that are continuous in nature with a steady stream of safety outputs. An example is the fire testing of new cabin interior materials at NAFEC in the search for materials with improved fire resistance and reduced toxic fumes and smoke output.

The extreme variety of technologies and types of work that are required in the Aircraft Safety Program are exemplified by the specific goals which are listed as follows:

a. Develop airframe, engine, flight characteristics and equipment criteria for conventional and quiet short-haul aircraft.

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

c. Obtain in-service 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 simulation can substitute for flight time.

f. Develop pilot qualification, recurrency, and training certification criteria.

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

The Aircraft Safety Program is structured to match these goals almost on a one-to-one basis. 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 in terms of:

a. Response to specific 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. R&D on recognized safety problems that exist or are forecast to arise pertinent to the aircraft and its components, airmen, passengers and passenger security and airports.

c. R&D to provide a knowledge and data base to establish standards (special conditions, etc.) 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 R&D efforts are a combination of these categories.

As of September 1972, thirty-six requests for R&D work on Aircraft Safety were active. Table I lists these showing the number of the request and its title. As can be seen, the primary source for these requests is the Flight Standards Service, with the Airports Service, and the Office of Air Transportation Security providing the remainder.

Although not listed as a specific request for R&D, a portion of the Aircraft Safety Program budget is provided by the Quiet Short-Haul Air Transportation Systems Office for both engineering and operational support of its program.

TABLE 3-1

ACTIVE REQUESTS FOR AIRCRAFT SAFETY R&D

Number	Title
FS-100-62-48	Fire Protection Standards-Aircraft Cabin Interior Materials
FS-100-65-73	Evaluate factors influencing in-service propeller fatigue failures
FS-400-68-28	Capabilities, Specifications and Effectiveness of Pilot Ground Trainers
FS-400-68-28A	Development and Proving of an Objective Private Pilot Flight Test
FS-100-68-88	FAR 23 Flight Characteristics Requirements
FS-100-68-92	Cryogenic Nitrogen as a Fire Extinguishing Agent
FS-300-69-6	Study of Advanced Nondestructive Testing Procedures
FS-100-69-93	Ground Crash/Obstacle Impact Load Environment
FS-100-69-98	Select and Install a Turbulence Measuring Device or System
FS-100-69-99	Evaluation of factors affecting accuracy, reliability, and maintain-ability of aircraft static systems
FS-100-69-101	Derivatives for Calculating Gust Loads Due to Continuous Turbulence
FS-100-69-102	Flight Characteristics Criteria for Stol Aircraft
FS-100-69-	Evaluation of the state-of-the-art for materials smoke generation criteria

Number	Title
FS-60-70-1	Stol Instrument Approach Facility
FS-100-70-104	Turbine Engine Combustor Failures
FS-100-70-105	DC-9 Fuel System Nitrogen Inerting Subsystem
FS-100-70-106	FRP Airframe Lightning Strike Resistance
FS-100-70-107	Investigation of oxygen concentrations and measurement techniques for inerted fuel tanks
FS-100-70-108	Nonmetallic Fuel Tanks, Lightning Protection
FS-100-71-112A	Characteristics - 35 Runways
FS-100-71-114	Tentative Airworthiness Standards for Powered Jet Transport Category Aircraft
FS-100-71-115	Jet Aircraft Handling Qualities Data
FS-100-71-116	Stability criteria for large transport aircraft
FS-300-72-1	Ionization probe to detect failures in jet engines
FS-100-72-117	Development of Nitrogen Separation Techniques for Fuel Tank Inerting
FS-100-72-118	Funds to support Phase II of the Joint FAA-USAF-NASA Runway Research Program
FS-100-72-119	Program for Fuel Conductivity and Charging Tendency Survey
FS-100-72-121	Analysis of VG and VGH Data
FS-100-72-122	Development of Dynamic Crash Loads Criteria

Number	Title
FS-100-72-123	Turbine Rotor Burst Protection
FS-100-72-124	Development Dynamic Crash Loads Criteria
AS-580-72-1	Develop Optimum Runway Groove Configuration
SE-330-3-71	Aircraft Sabotage Explosion Tests
SE-330-5-71	Emergency Jettison of Bomb/Sabotage Device

Number	Title
FS-100-72-123	Turbine Rotor Burst Protection
FS-100-72-124	Development Dynamic Crash Loads Criteria
AS-580-72-1	Develop Optimum Runway Groove Configuration
SE-330-3-71	Aircraft Sabotage Explosion Tests
SE-330-5-71	Emergency Jettison of Bomb/Sabotage Device

5. ALTERNATIVE APPROACHES AND

SELECTED APPROACH AND SYSTEM DESCRIPTION

The alternative to the agency carrying out R&D efforts to provide the technical base for improving and updating safety regulations is for the agency to do nothing and rely on data provided by industry to use in performing this function. Such action would amount to blatant refusal by agency personnel to carry out the responsibilities called for inthe Federal Aviation Act of 1958 to insure safety in air commerce. There are various ways for the FAA to organize for obtaining information to upgrade certification and operational criteria but such information must be obtained.

In the individual elements and projects that go to make up the Aircraft Safety Program, most of the decisions concerning alternatives goes into the selection of what safety projects to undertake within the constraints of budgetary considerations. Once such a safety problem area is defined and selected, the ordinary way of doing R&D work comes into play to make the examination of alternative technical approaches automatic. Most, if not all, studies and equipment developments are conducted by means of contracts to industry under fairly broad work statements. The proposals resulting from invitations to bid on such contracts provide a variety of approaches to solving the safety problem or developing the hardware needed for tests. From the diversity of the efforts that go on in Aircraft Safety, it can be seen that a detailed discussion of all the alternative technical approaches that are considered for each of the projects described would result in a product for exceeding the size of this program plan; consequently, this is not attempted.

6. PROGRAM STRUCTURE, SUB-PROGRAMS, PROJECTS AND/OR TASKS REQUIRED

The Aircraft Safety Program consists of three main categories; one dealing with the physical characteristics of the aircraft itself, one dealing with aircraft operations and pilot performance and one concerned with airline security against sabotage and anti-hijacking. These categories were rather too broad so the total program was subdivided into five elements which are described below:

Physical Characteristics of Aircraft:

181 Airworthiness Criteria

In this element are efforts concerning the airframe, its engines and equipment and the aircraft flight characteristics. About half of the effort is devoted to safety problems such as lightning protection and turbine burner-can through while the other half is concerned with the development of improved regulatory standards such as landing gear taxi loads, and flying and handling qualities design criteria. Both CTOL and V/STOL aircraft are considered.

183 Crash Survivability Criteria

Where element 181 dealt with safety in flight, this element deals with the protection of occupants during and after a crash. Such protection takes two forms; one of surviving the crash impact with the ground and the other of protection against subsequent fuel fire. Modern aircraft encounter severe loads even when landing on long smooth runways. These loads become catastrophic when any other ground contact occurs -- these are crashes. Although air carrier aircraft crashes are few each year, the potential hazard is great to a large number of people. General aviation aircraft carry few people but thousands of them crash yearly.

Since fire protection calls for special expertise, in flight fires are included in this element together with crash fires.

Aircraft Operations and Pilot Performance:

182 Operational Criteria

Flight safety is directly related to the performance abilities and characteristics of aircraft, how well they are flown by pilots and how flight paths are shaped by Air Traffic Control (ATC), environmental protection considerations, and weather.

184 Airmen's Performance Criteria

This element deals with pilot performance and training. Air carrier pilots with the Air Transport Rating are the most highly-trained airmen, and it is certainly in their professional interest and the airline record to keep them so. Consequently, there are no current R&D efforts treating this class of pilot. General aviation airmen on the other hand attain the lowest level of pilot expertise permitted by regulation, often do not fly regularly enough to maintain even this level of proficiency and fly relatively unsophisticated aircraft. These are the pilots having all the accidents. Their training and continued proficiency are the objects of the efforts in this are the objects of the efforts in this element. Improved training methods assessment of the degradation of flight skills with non-use and the development of innovative improvements in ground pilot trainers are some of the current R&D efforts.

Airline Security:

185 Anti-Hijacking and Sabotage

This element deals exclusively with passenger and crew protection against hijacking and bomb threats by criminals. Since a wide variety of weapons and explosives could be and have been used for hijacking and for extortion, a diverse program is underway to detect weapons and explosives on persons, in baggage and in aircraft. Detection schemes ranging from magnetic and X-ray to nuclear physical methods have been explored to determine their effectivity and cost in providing adequate levels of airport security. These efforts continue.

The brief descriptions above of the breakdown and contents of the Aircraft Safety Program are presented in much greater detail in the following discussion of the various subprograms and projects that comprise each element. Each plan briefly presents the Problem, Program, Product and Resources.

6.1 Airframe Airworthiness Criteria

6.1.1 Problem

Airframe airworthiness standards and means of compliance must change to provide for:

New aircraft configuration, construction, and materials, such as:

- Multiple landing gears
- Wing and tail surfaces activated to suppress flutter and gusts
- Supercritical wing
- Composite plastic structures

Improved analytical capability to accurately perform:

- Flight and ground loads analysis (power spectral density as opposed to discrete loads)
- Structural analysis

6.1.2 Program

(1) Flight Loads Design Criteria

(a) 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 combining of shears, bending moments, and torsions from the statistically defined loads to represent realistic design conditions.

(b) For the past ten years NASA has been acquiring and reducing VG/VGH data on a number of general aviation aircraft. An analysis will be made regarding its impact on FAR 23.

(2) Ground Loads Design Criteria

(a) The current ground loads design criteria FARs are among the oldest regulations currently being applied. Through the years changes and/or special conditions have been used in an attempt to meet the needs of new landing gear configurations. None of these requirements have been based on actual operation of the aircraft. An instrumentation system to gather statistical data on landing and ground handling operations will be developed. This will be followed by measurements being taken on a number of aircraft. This will permit revision and/or validation, and/or addition to regulations.

(b) A taxi load design procedure was developed in prior years and was validated using the meager current aircraft response data available from the manufacturer and NASA. At that time insufficient runway data was available to properly consider the phasing and asymmetry of the roughness. This type of information is now available and the procedure will be validated to the new data.

(3) 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 applications.

(4) Bomb Disposal - Methods will be developed to ensure safety if a bomb is captured in flight. These include the best place to store on-board the aircraft, safe means to jettison the bomb, and on-board explosion tubes to vent the blast forces over-board.

(5) Airframe and System Safety/Reliability Management - The modernization of maintenance concepts has 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 developed and serve as the basis for new certification criteria.

(6) 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 and we foresee additional information will be needed in areas such as environmental and endurance aspects, lightning protection, long life joining techniques, quality control and inspection; etc., to meet the agency's requirements for suitability of materials.

6.1.3 Products

		Schedule
(1)	Transport flight loads design procedures	12/1974
(2)	Light aircraft flight loads design requirements	12/1974
(3)	Transport in-service ground loads data collection	6/1976
(4)	Transport taxi ground loads design procedure	12/1973

Products Cont'd	Schedule
(5) Nondestructive inspection techniques	6/1975
(6) Bomb disposal design	6/1974
(7) Airframe and system safety/ reliability management	6/1980
(8) Composite materials regulatory compliance means	6/1980

6.1.4 Resources

Resources	1973	1974	1975	1976	1977	1978-82
(1) Transport Flight Loads Design Procedures		300				
(2) Light Aircraft Flight Loads Design Requirements		250				
(3) Transport In-Service Ground Loads Data Collection			300	100	100	
(4) Transport Taxi Ground Loads Design Procedure		100				
(5) Nondestructive Inspection Techniques	141		100	100	100	
(6) Bomb Disposal Design	16	80	150			
(7) Airframe and System Safety/ Reliability Management			300	200	200	100/yr.
(8) Composite Materials Regulatory Compliance Means			100	200	200	100/yr.
(9) 9550 Requests				400	500	500/yr.
TOTALS	157	730	950	1000	1000	700/yr.

6.2 Propulsion Airworthiness Criteria

6.2.1 Problem

Propulsion airworthiness standards must change to cover and provide for:

1. Advancing turbine engine technology such as higher temperatures and pressure ratios.
2. New engine cycles and concepts.
3. New fuels.
4. In-service failure problems having fundamental design impact.

6.2.2 Program

1. Fire Protection

   a. Burner Can Burn Through - In airline service and laboratory testing flames emitted from engines with pressure ratios of 12 can destroy several feet of surrounding structure. Future engines having pressure ratios over 30 could produce a catastrophic flame. The properties of such flames are being determined together with the characteristics of materials to contain them and methods for early detection are being devised so that new airworthiness regulations can be developed.

   b. Hi-Bypass Ratio Installation - New high pressure ratio turbofans have engine compressor case temperatures well over 1000^{o}F thereby almost guaranteeing a fire if any fuel, oil, or hydraulic fluid leakage occurs. High pressure bleed ducts from these engines also pose critical problems. There is serious doubt that current certification requirements will produce a safe engine installation. An analysis of these problems will be followed by appropriate engine tests to develop improved criteria.

c. Advanced Fire Extinguishment - Extinguishments that are effective in the 1000^{o} temperature environment of new engines will be evaluated.

d. Fire Detection Systems - Tests of three noval approaches to integrated and self-generating fire detection systems will be conducted.

2. Engine Failure Detection

A technique of relating ionized particles in the exhaust stream of engine failures as a method of forecasting engine failure will be investigated.

3. Icing Protection

Means of updating the regulatory requirements applicable to large turbofan engines to include specific ice detection and removal on the fan and front compressor stages blades, in addition to the ice protection now required on the inlet cowling and center bullet fairing.

4. Propeller Failure

Investigation of factors influencing propeller blade failures concerns devising and testing a vastly improved apparatus for flight test measurement of propeller blade vibrations and stresses. This unit will be used for aircraft type certification demonstrations and will permit updating the applicable regulations.

5. Powerplant Installation Fire and Explosion

Identification of the hazards associated with inadvertent explosive ignition of combustible fluids or vapors in various powerplant installation designs with the emphasis being on overpressure relief will be conducted.

6. Future Projects - FY 75 through FY 82 Projects would be:

a. Advanced Electronic Engine Controls Criteria to prepare data base for development of regulatory requirements to certificate this new control method.

b. Rotary Combustion Engine Safety Criteria would evaluate these new engines and determine regulatory changes and procedures required.

c. New Standard Burner for Fire Test Certification would provide a device more representative of fires in new engines. The burner and test conditions used today for certification are less hot than actual engine fires.

d. Jet Flameout Analysis and Prevention would be a joint FAA/NASA effort to understand this complex phenomenon, and thus preclude occurrence.

e. Incipient Fire Detection would develop a means to sense fuel vapor before a fire started and permit prevention of the actual fire.

f. Electrostatic Charge Density Criteria would assess the maximum allowable charge that could be caused by rapid fuel pumping. Current rapid refueling is probably nearing this not well defined limit.

g. Stall Margin Sensors for compressors and fans of large turbines would be assessed since this is becoming a critical safety item in high compression ratio engines.

h. Improved Airborne Engine Vibration Measurement would be developed since current systems operate only on the ground.

i. Safety Standards for Fuels other than Kerosene would be determined for advanced engines.

j. Tentative Standards for Nuclear Engines would be needed several years prior to the development of experimental nuclear engines. Such standards would be developed.

6.2.3 Products (Numbers correspond to items described in Program above)

	SCHEDULE
1. a. Acceptable design criteria for prevention of Critical areas in event of burner can burn through.	1/74
b. Acceptable high bypass ratio installation design criteria.	7/75
c. Qualification of advanced fire extinguishments.	7/75
d. Qualification of advanced fire detection systems.	7/74
2. Qualification of prediction techniques for engine failure.	1/75
3. Ice protection standards for large turbofan and front compressor stage blades.	1/76
4. Acceptable flight test measurement means of propeller vibration and stresses for aircraft certification.	1/74
5. Acceptable powerplant installation design criteria for inadvertent explosive ignition of vapors.	1/75
6. Acceptable design criteria for new engine cycle, fuel and other powerplant systems aspects.	1980-85

6.2.4 Resources

	1973	1974	1975	1976	1977	1978-82
Burner Can Burn Through	75	20				
Hi Bypass Turbofan Fire		200	100	100	100	
Incipient Failure Detector	25	100	100			
Advance Fire Extinguishment		20	50			
Powerplant Inlet Icing		210	100	100	100	
Propeller Blade Failures	15	50	100	100	100	500
Self-Generating Fire Detectors		50				
Explosive Protection Criteria	100	50	50			
Electronic Engine Controls		50	200	200	100	300
Rotary Engine Criteria				100	100	200
New Standard Burner	100	100				
Jet Flameout Analysis				100	100	
Incipient Fire Detection		100	100	100		
Electrostatic Charge Criteria		50	50	50		
Stall Margin Sensors				100	300	200
Engine Vibration Measurement			200	100	100	400
Standards - New Fuels					100	600
Standards - Nuclear Engines					100	800
Miscellaneous						1000
	215	990	1150	1050	1200	4000

6.3 CTOL and V/STOL Flight Characteristics

6.3.1 Problem

To provide an interpretation of the general regulation or new special conditions applicable to a new aircraft design at the time the manufacturer applies to FAA for a type certificate requiring appropriate advance investigation by FAA of the flight envelope for those areas unique to the design class; i.e., jets, SST and STOL. FAA decisions on minimum level of safety are critical to the manufacturers since all wish to start from an equal base rather than risk designing to an unacceptable or to too high a level of safety. Such action could be extremely costly not only to a specific manufacturer but to the airlines and hence the public in the end.

The greatly increased speed, altitude and maneuvering capabilities of many recently introduced aircraft have served to emphasize some of the inherent deficiencies of the present regulations. Except in certain isolated instances the specific requirements for stability, trim and control are descriptive or qualitative in nature, and frequently not truly meaningful with respect to the flight characteristic under consideration.

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 and comfort. For some aircraft configurations and for certain flight regimes stability augmentation is required to achieve minimum acceptable flight characteristics. Powered flight controls, plus automatic stabilization systems, are being used to correct and compensate for inherent airframe design uncertainties.

6.3.2 Program

The program covers the range of existing and probable future civil aircraft configurations such as VTOL, STOL, rotary-wing, small general aviation, executive jet and advanced transport. The overall program is open-ended and paced by the advancing state-of-aeronautical technologies, concentrating on controllability and maneuverability levels for critical flight regimes. Most of the R&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 the military cervices and NASA, some of this work is undertaken jointly with these organizations.

(1) Development of executive jets - interactions of non-optimum flight control parameters.

(2) Large advanced transports

Minimum acceptable longitudinal stability.

Stability augmentation failure modes.

(3) Lightplanes

Crosswind criteria

Longitudinal stick-free stability

Maneuvering criteria

Flight control near stall.

6.3.3 Product

Revised and new regulatory requirements for each type of aircraft.

6.3.4 Resources

	1973	1974	1975	1976	1977	1978-82
Advanced Transports (except V/STOL)	0	300	200	100	300	300/yr.
V/STOL		300	300	400	400	300/yr.
Executive Jets		150	150		200	200/yr.
Light Aircraft		100	125	125	100	100/yr.
	0	850	775	625	1000	900/yr.

6.4 Operations and Performance Criteria

6.4.1 Problem

Current certification and operating rules may in many areas be incompatible with forthcoming aircraft design concepts. Programs which develop a basis for new rules in all aspects of performance are required. As an example, landing and takeoff performance criteria based on a referenced stall speed are no longer appropriate for V/STOL aircraft concepts. One immediate need is for a rational landing performance rule for use in certification of Concorde SST. Since many of the forthcoming advanced transports may be aerodynamically unstable without full time active control systems and dependent on a loads alleviation system to provide structural integrity in many flight regimes, the minimum safe flight performance and operating criteria for various failure modes will be needed.

A basis for establishing requirements for better accounting of environmental conditions in the certification of aircraft performance is needed. Crosswinds and icing are examples of such conditions.

6.4.2 Program

(1) Develop and install airborne data acquisition systems upon introduction of a new type aircraft into service to obtain statistically significant samples of normal operational data.

Using this data, develop corrective actions and new or revised certification standards.

(2) Determine the unique performance and operational regimes of STOL, SST, and Advanced Technology Transports and develop appropriate certification and operational standards.

(3) Evaluate the feasibility of using an airborne turbulence intensity measuring system to provide a universal value to reduce the hazard posed by unexpected encounters with clear air turbulence. Develop the means of integrating the turbulence intensity levels into the airway/weather system in real time for use by all aircraft in the hazard area. Monitor the progress of advance concepts to detect and quantify turbulence in advance of an encounter and evaluate the most promising system.

6.4.3 Product

(1) Revised or new regulatory requirements or corrective action for new aircraft based on the actual flight spectrum data obtained from similar operational aircraft.

(2) Slipstream Augmented Lift STOL Aircraft Performance and Operational Standards, Supersonic Aircraft Standards, Generalized Power Augmented Lift Performance and Operational Standards, and Advanced Technology Transport Standards.

6.4.4 Resources

	1973	1974	1975	1976	1977	1978-82
	L1011	747	STOL	SST	ATL	
In-Flight Data Acquisition on Operational Aircraft	480	550	500	800	550	2525
New Aircraft Standards	510	750	600	400	750	2850
Clear Air Turbulence System	150	Taxi 200	GA 200	100	50	625
			1300	1350	1000	6000

6.5 Crash Survivability Criteria

6.5.1 Problem

Despite all the precautions taken by the agency and the air transportation industry to insure flight safety, crashes do occur, occasionally with air carrier aircraft and frequently with general aviation aircraft. Approximately 200 fatalities occur each year in transport aircraft crashes and around 1500 in general aviation crashes.

Two major factors cause fatalities in a crash, the initial impact and deceleration to a stop and the subsequent fire caused by the spilt fuel. These are about even in their contribution to air carrier accident fatalities while in general aviation the impact and deceleration is the major cause of fatalities.

In aircraft safety the emphasis to date has been on preventing accidents from occurring by means of safer aircraft and aircraft operations, better trained and proficient pilots, improved airport runways and more effective air traffic control methods. These efforts have been necessary and should continue. The availability of new technology, the demands from consumer groups, and the impetus provided by other DOT safety vehicle demonstration projects requires that increased emphasis be placed on improving the survivability during and after the crash.

There are a variety of R&D efforts that must be carried out to improve the crashworthiness regulatory requirements and to reduce the severity of ground impact and crash fires. The most urgent of these efforts are described below.

6.5.2 Program

Impact Survivability Criteria

The efforts in this area have been assembled recently into a general aviation safety demonstration aircraft project. This was done to emphasize the need for improved crash survivability in light aircraft and to make highly visible to the aviation community those improvements that could be made within the state of the art that also would maintain the performance and marketability of such aircraft.

This effort would establish a validated basis for safety standards leading to safer aircraft through reduction of aircraft related accident causes and improvement of the survivability potential.

The total effort is planned to be accomplished in four phases as follows:

Phase I - Design Definition (FY-72 - FY-75)

During this phase, analytical techniques for crash survivability design will be developed and verified by full-scale crash tests. This effort will emphasize:

- fuel-system crashworthiness
- occupant packaging including energy absorption devices and restraint systems

This phase will conclude with a design definition study. The study will review many possible combinations of safety concepts to find a practical combination of those yielding optimum expected safety improvements within the performance and economic bounds of a marketable product.

A specification will be prepared listing the essential design goals of the Experimental Safety Aircraft.

<u>Phase II - Competitive Preliminary Design (FY-75 - FY-76)</u>

During this phase competitive preliminary design trade-offs studies will be performed which will evaluate safety improvements versus marketability, performance and utility. Parallel multi-contractual efforts will provide wide industry involvement. Ground rules for the design competition will likely include:

(a) aircraft must be type certificable

(b) must exceed existing safety standards in specifically selected areas

(c) must be competitive in marketplace

(d) must contain current technology in noise, pollution, aerodynamics, fabrication methods, structures, propulsion, and systems and equipment

(e) must be measurably better in crash survivability, instrumentation, and stall/spin

(f) must be producible by the general aviation industry

Three parallel and competitive contracts will be awarded. The effort will be evaluated by a government task force and a single contractor chosen to undertake Phase III.

Phase III - Experimental Safety Aircraft (FY-77 - FY-78)

The Experimental Safety Aircraft (two flight test articles) will be designed and manufactured, during this phase. The aircraft design will embody all of the developed concepts to alleviate the effects of the crash environment upon the occupants and to lessen the likelihood of crash as a result of aircraft design.

At all stages of the development, economic, weight, performance, or any other costs will be minimized to produce a practical and pragmatic solution to the crash survivability problem. Within these bounds, existing technology developed in the military and automobile programs will be used to the largest possible extent.

This development will expedite the improvement of safety performance of the aircraft system, rather than the traditional evolutionary, gradual process now in existence.

Phase IV - Demonstration (FY-78)

This phase will begin with the first flight of the Experimental Safety Aircraft and terminate with the public introduction and demonstration of the safety improvements embodied in the design and construction of the aircraft. Regulatory actions necessary to update standards will be completed; some of the regulatory actions can be initiated piecemeal during previous phases.

After the analytical structural dynamic response models have been developed and verified by crash tests under Phase I of the above program, they will be applied to the more complex structures of air carrier transport aircraft by means of the following projects.

Transport Aircraft Dynamic Structural Response

During the latter phases of the General Aviation Program the analytical structural dynamic response models will be extended to large transport aircraft structures to provide a method of analyzing and certificating the FAR 25 crash impact load criteria. Devise a suitable series of tests to validate the models by correlating analysis responses with tests responses.

Improved Crash Load Detemmination

For both light aircraft and transport aircraft device and implement a means of measuring actual crash load time histories along the horizontal, vertical and lateral axes of the airframe. Accumulate such data to form a statistically valid base for crash load requirements for FAR's.

Emergency Egress for Large Aircraft

Analyze alternate egress methods other than the flexible chutes now used since these chutes are adversely affected by high winds and cause substantial injuries to evacuating passengers. Fabricate test versions of the most promising alternatives and evaluate so that suitable regulatory amendments can be made.

Fire Survivability Criteria

The efforts in this area pertain primarily to large transport aircraft since serious crash fires occur mostly with this type of vehicle because of their size and fuel capacity. As was mentioned earlier the fire efforts include both fire prevention in flight and crash fire prevention insofar as fuel tanks and cabin/cargo space is concerned. Following are descriptions of the major projects:

Modified Fuel Program

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

Early work resulted in fuels that were gels with superb crash fire prevention characteristics but with wevere pumping and engine operating problems.

More recent work resulted in reducing the viscosity of these gels to improve their operating qualities while maintaining their crash fire reducing potential. While progress was being made on gels, a new series of anti-misting fuel additives was developed by several chemical companies, that appeared so promising that the program was reoriented to concentrate on these types of modified fuels. Their anti-misting properties should reduce or eliminate the fuel spray from crash ruptured tanks and the resulting fire ball. Also the amount of additive required is around 0.3% of fuel weight which makes them economically attractive and much more amenable to use in current jet aircraft.

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

- Full-scale crash tests of surplus RB-66 jet bombers and UH-1 helicopters to verify the crash fire reduction.
- Engine operational tests culminating in full agency certification of an engine using a modified fuel.
- Fuel system modifications required to handle modified fuels and full scale tests.
- Flight tests in the agency Convair 880 jet aircraft with one of its engines replaced by the modified fuel engine.
- Analysis of the logistics pertinent to air carrier fleet use of modified fuel together with analysis of the costs and benefits involved.
- Development of a specification of modified fuel.

Fuel Tank Inerting in Jet Aircraft

The large fuel tanks in heavy jet aircraft develop large volumes of fuel vapor mixed with air as fuel is consumed. These constitute a serious explosion hazard. A method of inerting this volume has been developed wherein an inert gas, nitrogen, is injected into the tank ullage volume to prevent combustion. Current and future work will determine the practicality of extracting nitrogen from engine bleed air rather than carrying liquid nitrogen in bottles on board and to eliminate the attendant logistics problems of storing liquid nitrogen at airports.

Minimize Airframe Crash Fires

This effort involved continued improvement of cabin materials in terms of their flammability, smoke and toxic properties. It also covers increasing the fire resistance of the fuselage structure to external fuel fires and the controlling and isolating cabin fire spread by means of curtains, partitions and extinguishing agents.

Minimize In-Flight Fire Hazard - Cargo Compartments

This work is to develop cargo compartment design and fire detection and extinguishing criteria to reduce the hazard of inflight cargo compartment fires. Covered under this work are the fire safety integrity of airborne cargo containers, the fire characteristics and detection and extinguishing criteria for large bulk load cargo compartments, including those transporting gasoline powered vehicles.

Develop Crash Resistant Fuel System - General Aviation Aircraft

This work will adopt the technology, components and materials, which were successfully developed by the Army for helicopters, to the design and criteria for crash resistant fuel systems for general aviation aircraft.

Airport Survey of Fuel Conductivity and Charging Tendency

This work will determine, through a survey of airport fueling facilities, the electrical charge levels of fuel being delivered into transport aircraft and will be conducted under an interagency agreement with the U. S. Army, Aberdeen Proving Grounds. Maximum acceptable limits of fuel charge will result.

Systems for Suppression of External Fires

The requirements will be determined for the suppression of external crash fuel fires and systems designed for this purpose. The most feasible of these systems will be fabricated and tested to determine if such a requirement could be made regulatory.

6.5.3 Products

		Schedule
1.	Aircraft crash analysis methods; crash tests initiated	12/74
2.	Experimental Safety Aircraft competitive Preliminary Design	5/75
3.	Construction of Experimental Safety Aircraft completed	9/77
4.	Complete demonstrations - Experimental Safety Aircraft	7/78
5.	Modified fuel specification	9/74
6.	Design criteria for on-board nitrogen generation	12/74
7.	Crash resistant fuel system specification - G.A.	11/74
8.	Transport aircraft crash analysis	7/75

6.5.4 Resources (In $1000)

		1973	1974	1975	1976	1977	1978-82
1.	Crash Analysis	250	500				
2.	Prel. Design - ESA			1000			
3.	Construction - ESA				500	1800	
4.	Demonstration - ESA					200	
5.	Modified Fuel	430	1400	300			
6.	Nitrogen Inerting		250				
7.	Crash Resistant Fuel System - G.A.	70					
8.	Transport Aircraft Crash Analysis				1000		
9.	9550 Requests						500/year
		750	2150	1300	1500	2000	2500

b. Pilot knowledge of the use, function and integration of flight instruments has been measured as in 1. a. above.

c. Degradation of ability to perform flight maneuvers required for private and commercial certification is being measured under current contract effort.

d. Remaining categories of pilots will be measured similarly.

2. Field flight evaluation of objective flight test.

a. Abbreviated field evaluation of an objective private pilot flight test developed under prior year contract is presently underway as part of effort indicated in 1.c. above.

b. Development and full-field evaluation of objective flight tests for all pilot categories are programmed.

6.6.3 Products

1. Private data to support more stringent currency requirements for all categories of pilots.

2. Provide data to support flight and ground training technology and syllabi more responsive to the requirements of the future.

6.6 Airmen Performance Criteria

6.6.1 Problem

Changes in Federal Air Regulations involving civil airman training, certification and currency requirements are necessary to insure that pilots operating in the more complex flying environment of the future will be prepared to cope with the problems of that environment. These include:

1. Pilots trained by more widely dispersed flight schools with the corresponding difficulty of supervision by FAA.
2. Quantum jump in aircraft traffic (potential mid-air collisions).
3. Increased air pollution limiting visibility requiring greater vigilance and better instrument qualifications.
4. Faster aircraft requiring quick, accurate decisions.
5. More complicated NAS requiring more sophisticated pilots for the same flight performed in earlier years.

6.6.2 Program

1. Determine skill degradation rates of all pilot categories-private, commercial, instrument, and multi-engine as a function of total and recent flying experience.

    a. Instrument flying "motor skills" - (ability to perform specific maneuvers) of noninstrument rated private and commercial pilots have been measured and a statistical curve developed for use in estimating the amount of instruction time required to return these pilots to certification flight performance level.

6.6.4 Resources

	1973	1974	1975	1976	1977	1978-82
Skill degradation studies	0	100	100	100	150	650
Objective flight tests development evaluation	0	50	100	100	100	500
TOTAL	0	150	200	200	250	1150

6.7 Anti-Hijacking and Sabotage Criteria

6.7.1 Problem

In the last ten years there were 127 hijacking of U.S. commercial airlines. Of these, all but ten have occurred since 1968. Fortunately, the loss of life from hijackings has been limited to three people, but the indirect operational and passenger reaction cost in lost business has been significant. Explosive sabotage has been limited to three aircraft explosions in the last ten years, only one of which occurred during flight and causing passenger fatalities. However, bomb threats have dramatically increased in the last few years and now approach 1000 per year.

6.7.2 Program

The objectives of the R&D program is to develop systems and devices which are effective and economically viably in operational use to prevent and deter either hijackings or sabotage for whatever reason in the civil air transportation system. The effort involves assessment of the various technologies available such as electronic explosive vapor detection, neutron explosive detection, imaging x-rays, dogs for explosive detection, trace element seeding of explosives to permit detection and telephone call tracing. These are potential techniques to detect explosives on passengers and in baggage and in aircraft. Techniques for weapon detection involve magnetometers, x-rays, non-imaging methods, holography and sonics. The agency recently has been requested by the Department of Transportation to evaluate the requirements and potential devices for the security of all functional aspects of the entire airport complex.

The outputs from the projects described below will be used in establishing regulatory requirements for commercial airlines or for guidance in purchasing airport equipment for use by law enforcement agencies.

Explosive Vapor Detection

The September 1971 effort is the first effort to quantify the requirement of an electronic vapor detection to replace the use of dogs. This effort defines the disfusion of explosive vapors between their source and potential detection locations for several applications in the air transportation environment. The results indicate the detector sensitivities required may well be achievable with further development.

The 1972 effort will complete the requirement definition by identifying dynamite vapor emission rates and molecules, and determining the modified emission rates of the explosive where contained in typical passenger luggage. It will also identify possible normal atmosphere substances that could be interference to the detector function.

Assuming the sensitivity requirements indicated from the above study are compatible with potential projected detectors, a program will be initiated to achieve the required hardware capability. The cost and schedule and such hardware program are difficult to definitize at this time.

Dogs

Dogs are currently the best solution to search task for explosives in the airport environment. The January 1972 effort is to train four animals and handlers for this specific purpose and demonstrate both their usefulness and limitations at Washington, D.C. Metropolitan Airports.

A recent decision has been made to use available FEAA funds for procurring 40 animals and handlers for use in emergency explosive search at 20 region airports.

Neutrons

The prior and initial application efforts for this concept indicated a discrimination problem between the nitrogen and explosives and personal baggage items containing copper. The February 1972 program with AEC Livermore will be a laboratory efforts to resolve this discrimination problem and identify the best neutron sources. Optimum instrumentation and operational safety aspects of the equipment will also be covered.

At the completion of this effort, a decision will be made concerning the development of an operational unit. This decision will also be influenced by the development of other techniques for this purpose.

Seeding of Explosives

The lack of a practical explosion detector dictates this program be reconsidered. Seeding with Colbalt 60 has been proven technically feasible but was discarded for safety reasons. Other non-radioactive seeding elements are possible. The seeding of products for identification has not been accepted for reasons of economics, logistics, manufacturing, and legal aspects and this study will consider these aspects.

The decision on any follow-on program resulting from this study will be dependent on the findings and other developments in explosive detection.

Electro-Magnetic Weapon Detector for Baggage

This type of detector has been successfully developed for people and will be a most practical device if the required performance can be achieved with carry-on baggage. The only current alternative is physical search. The 1972 work will determine the characteristics of the magnetic field, if any, that will permit weapon detection with reasonable false alarms in normal baggage handling systems.

If this technique can be demonstrated a combined weapon detector for people and hand carried baggage is justified by operational needs.

Non-Imaging Weapon and/or Explosive Detector for Baggage

This effort is directed as an alternative to the electro-magnetic approach and in addition to weapons will be used for explosive detection. The output of this program will be an operationally evaluated piece of hardware assuming successful completion of the prior prerequisite phases of the planned contract.

6.7.3 Products

	Schedule
Explosive Vapor Detection Equipment	6/74
Operational Use of Dogs at 20 Airports	6/74
Neutron Activation Equipment	12/74
Demonstrate Explosive Seeding	3/74
Airport Security Concepts - Requirements	6/73
Electro Magnetic Hand Carried Baggage Detector	4/74
Non-Imaging Explosive Detector	1/74

6.7.4 Resources

	1973	1974	1975	1976	1977	1978-82
Explosive Vapor Detection	85	85	75	100		
Dogs	35					
Neutron Activation	75	200				
Explosive Seeding		50	75			
Airport Security Concepts	50	50	200			
Electromagnetic Detectors		150				
Non-Imaging Detectors		300				
New Concepts & Techniques			200	400	300	2000
TOTALS	245	835	550	500	300	2000

7. RESOURCE REQUIREMENTS

Key Programs	1973	1974	1975	1976	1977	1978-82/yr
Flight Characteristics (CTOL & STOL) Criteria	130	850	775	625	1000	800
STOL Aircraft Performance & Operation Criteria	200	680	800	500	200	---
General Aviation Safety Demonstration Aircraft	320	500	1000	500	2000	500
Modified Fuel Specifications & Engineering Certification	430	400	300	---	---	---
Aircraft Rational Landing Distance	300	400	300	---	---	---
Weapon and Bomb Detection Equipment	400	350	400	400	400	---
	1780	3180	3575	2025	3600	1300/yr.
General Programs						
Airworthiness Criteria						
Airframe	160	730	950	1000	1000	1000
Propulsion	400	990	1150	1050	1200	1000
Equipment	150	120	120	300	300	500
Operations and Performance Criteria	342	700	1000	800	800	1200
Crashsurvivability Criteria						
Impact	160	0	100	200	300	600
Fire	200	150	150	200	200	200
Pilot Performance	159	125	125	200	200	200
TOTAL	3351	5995	7170	5775	7600	5900/yr.

8. 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 but primarily with the military services. The Department of Defense agencies not only have superb testing facilities for aircraft, engines and operational tests but also have some safety problems with military aircraft that are similar to those of civil aircraft. This commonality of interests leads to the conduct of joint safety programs whose results are mutually beneficial to both the DOD and the FAA. Examples of other agencies with whom joint efforts are carried out are the National Aeronautics and Space Administration, the Atomic Energy Commission and the National Bureau of Standards.

A list of current Interagency Agreements is provided below.

USAF-FAA DOT-FA72WAI-272
Optimum Runway Groove Shape

USAF-FAA-NASA DOT-FA72WA1-278
Landing Performance Computer Correlation Program

U.S. Army - FAA DOT-FAWA1-275
Fuel Electrostatics

National Bureau of Standards - FAA DOT-FA67-NF-AP-21
Study of Cabin Flash Fires

Atomic Energy Commission - FAA DOT-FA71WAI-211
Neutron Activation of Explosives for Detection

Fairfax County, Va. - FAA DOT-FA72WAI-251
Dogs for Explosive Detection

U.S. Navy - FAA DOT-FA72WAI-246
X-22 Variable Stability V/STOL Program

U.S. Air Force - FAA DOT-FA72WAI-243
Total In-Flight Simulator (TIFS) Variable Stability Transport Program

NASA-FAA DOT-FA-72-WAI-285
Simulation Facilities of Ames Research Center

NASA-FAA DOT-FA-72-WA1-308
Flight Path Control Spoiler Evaluation

U.S. Navy - FAA DOT-FA-71-WAI-231
Review of FAA V/STOL Standards (Part XX)

British and French Civil Air Authorities - FAA Informal Working Agreements on STOL Aircraft Standards

U.S. Navy - FAA DOT-FA71-NA-AP-98
Engine Combustor Tests with Modified Fuel

U.S. Navy - FAA DOT-FA-72-NA-AP-17
Modified Fuel Crash Tests