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Engineering and Development Technical Program Plan

Aircraft Systems Fire Safety

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Program Plan

U.S. Department of Transportation
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2.1.1.1 Lavatory Fire Protection.

2.1.1.1.1 Objective.

The objective of this project is to develop improved fire protection measures for transport aircraft lavatories.

2.1.1.1.2 Background.

Two fatal in-flight fires have occurred where the origin of the fire was inside a lavatory. The first known accident of this type occurred in a Varig 707 in 1974 and resulted in 123 fatalities. Careless disposal of a cigarette into the waste paper disposal bin was attributed to be the cause of the fire. More recently, on June 2, 1983, an Air Canada DC9 caught on fire, beginning in the lavatory, resulting in 23 fatalities. Although the investigation by the National Transportation Safety Board is on-going, it is believed that the ignition source was the result of a problem in the electrical circuitry to the toilet flushing motor. Both accidents were similar in terms of a number of significant respects. First, the crew was alerted at a point in time that was probably at a relatively early stage of the fire, by detection of smoke by a cabin occupant. However, because the fire was hidden, its base or origin could not be determined, and subsequent firefighting measures proved ineffective. Moreover, actions taken by the crew to minimize the smoke or fire may have produced the opposite effect. For example, in the Varig accident the opening of a window in the cockpit to clear smoke created a low-pressure area which actually resulted in more smoke accumulation. In the Air Canada accident, CABIN ~~lavatory~~ ventilation was shut off in an attempt to deprive the fire of oxygen; however, this action also terminated the high exhaust rate of heat, smoke and gases overboard and, in the final analysis, may have been counterproductive in this respect.

In terms of fire protection requirements, a lavatory appears to lie in-between a cockpit or passenger cabin and an inaccessible cargo compartment, in that it is accessible but intermittently occupied. Since the Varig accident, improvements in fire safety have resulted from a number of actions taken by Federal Aviation Administration (FAA) and industry, including a total ban on smoking in the lavatory, and fire hardening of the waste paper receptacle compartment by sealing air gaps, installing self-actuated Halon 1301 bottles, using metal waste baskets and other means. However, it appears that a systems approach is required to safeguard against any potential accidental fire scenario, especially a hidden fire whose location cannot be readily determined, with proper consideration of the complex requirements for early detection and effective suppression, and the effects of current materials and ventilation design.

2.1.1.1.3 Technical Approach.

A four-task approach is planned to cover the broad areas of problem definition, extinguishment (and ventilation), and materials. The bulk of the work will be performed in-house, supported by selective contracts and interagency agreements.

2.1.1.1.3.1. Problem Definition.

The initial effort will be a paper study to document the important lavatory design features having a bearing on fire safety for the different aircraft models comprising the United States (U.S.) transport fleet. Examples of these features include ventilation (grill size, exhaust rate), types of materials, location of potential ignition sources (waste paper receptacle, flushing toilet motor, electrical outlets, etc.), overall dimensions and integration of lavatory with cabin. The importance of this effort is to assure that each potentially important design feature is addressed during testing so that any proposed improvement will cover the spectrum of lavatory designs. Also, aircraft incident records will be studied to document past ignition sources for lavatory fires.

Concurrent with the paper study, velocity measurements will be taken inside the lavatories of all the aircraft models comprising the U.S. fleet. Of greatest importance will be the velocity measurements in hidden areas, such as behind wall paneling, inside the amenities area, and near the flushing toilet motor, in addition to the measurements in the open space. An attempt will be made to construct a mass flow balance. These measurements will give insight to smoke detection requirements, the ability of extinguishing agents to penetrate into certain areas and potential fire paths. Except for some very recent and limited measurements of this type by Pan American Airlines, it is believed that this data is nonexistent. The work will be performed by in-house personnel under a mutual agreement with a nearby airline, or by contracting with one or more airlines to allow for these measurements.

A series of full-scale fire tests will be performed in real lavatories to gain an understanding of the characteristics and hazards of a hidden lavatory fire. This work will produce knowledge about the patterns of fire spread and smoke accumulation, time framework for significant events and means by which a lavatory fire spreads into the passenger cabin. An example of the latter is whether the fire or smoke can spread into the attic space for a long period of time without being evidenced in the main cabin. About 10 surplus 707 lavatories will be purchased from the Air Force and tested in the DC10 test article presently being used for class C cargo compartment fire protection studies. A simulated cabin ventilation system exists in this test article. An attempt will be made to match as closely as possible the ventilation patterns measured earlier in commercial transport lavatories with those set up in the test lavatories. Also, cabin interior materials adjacent to the lavatory or along the path of potential fire spread from the lavatory will be installed; e.g., drop ceiling, attic, carpet, and seats. Extensive temperature, smoke, gases and video/photographic measurements will be taken in the lavatory, main cabin, and attic.

2.1.1.1.3.2 Detection.

The main goal of this project is to determine the requirements for early detection of potential lavatory fires, with emphasis on hidden fires. Commercial automatic fire/smoke detectors of various principles and models will be examined and compared for responsiveness under the following conditions:

a. at different suitable locations in real lavatories using artificial smokes (under para. 2.1.1.1.3.1),

b. at different suitable locations for various fire scenarios under realistic fire conditions (under para. 2.1.1.1.3.1 and 2.1.1.1.3.3), and

c. inside the NBS smoke chamber using a series of fire exposure conditions and lavatory materials.

Because of economic considerations, the feasibility of using home detectors must be established. Also, mounting a detector in the overboard exhaust duct will be studied.

The final product of this effort will be a specification for aircraft lavatory fire detectors. This will be accomplished through an interagency agreement with NBS, relying on their experience and background on home fire detectors. The need for specific requirements to alleviate or minimize false alarms and for detector operation at cabin pressure will be addressed.

Perhaps the greatest problem associated with a hidden lavatory fire is not as much early detection as it is locating the base of the fire.

In both the Varig and Air Canada accidents the exact location of the fire was not apparent to the crewmembers. Several interesting devices are available and will be examined as an aid for locating hidden fires. One device is a small, lightweight, and inexpensive plastic probe which is designed to "pop-up" at a specific temperature. These could be imbedded in the lavatory surfaces adjacent to fire-prone areas. Another device is a portable infrared scanner. Other promising devices will likely be identified and examined as the testing proceeds.

2.1.1.1.3.3 Extinguishment.

Another important goal of this project is to determine effective methods for extinguishing or suppressing various tpes of hidden lavatory fires. A full-scale "standardized" lavatory test article will be constructed of non-combustible (Kaowool™/ceramic panels) outer wall, incorporating essential design features (ventilation, size, configuration) established under para 2.1.1.1.3.1. This test article will be utilized to examine and compare the following approaches for fire extinguishment:

a. Utilization of Halon hand-held extinguishers, including (a) simple discharge through a partially opened lavatory door, (b) discharge through a wall or door port straight into the lavatory space or through special lines to carry the agent into accessible areas, and (c) use of penetrator nozzles to gain access to hidden areas.

b. Fixed total flooding systems, emphasing agent penetration into potential hidden fire areas.

Various extinguishing system design parameters will be studied such as agents (Halon 1301 versus Halon 1211), nozzles, nozzle locations, etc. The effect of lavatory ventilation will be examined during these experiments. It must be established as to whether hidden fires can be effectively extinguished or suppressed without shutting off the lavatory ventilation.

A lower level of effort will examine the performance of "potty bottles" currrently installed in the waste paper receptacle compartments in some aircraft. A potty bottle is a small disposable container designed to release less than a pound of Halon 1301 when thermally actuated. One possible "problem" that will be studied is whether the discharge of a potty bottle causes flaming paper towels clogging the disposal chute to be strewn into the lavatory and possibly causing ignition.

2.1.1.1.3.4 Materials.

The behavior of currently used materials during realistic lavatory fire tests will be studied. Two general classes of materials will be examined. (1) thermoplastics and (2) composite panels. With regard to thermoplastics, of concern is whether the use of ABS in such applications as toilet shrouds and counter tops poses any unusual problem which would require consideration of more fire resistance and more expensive materials such as polyethersulfode and polyetherimide. Composite panels comprise the shell of a lavatory and must function as effective fire barriers to contain a fire within the lavatory for long periods of time. Inservice panels will be tested from this viewpoint with proper consideration of joining and sealing methods used in actual lavatory construction. The realistic tests will be performed using the lavatory test article contructed under paragraph 2.1.1.1.3.3.

2.1.1.1.4 Resources.

The in-house manpower and contract monies required are summarized below:

Task	M/Y	$
Problem Definition		
Paper Study	0.25	
Velocity Measurements	0.67	15-100K*
Realistic Lavatory Fire Tests	2.5	150K
Detection	4.0	250K
Extinguishment	3.0	100K
Materials	2.0	100K

*if outside contract necessary

2.1.1.1.5 Schedule.

Task	Months Begin	End
Problem Definition		
Paper Study	0	3
Velocity Measurements	0	3
Realistic Lavatory Fire Tests	2	8
Detection	0	15
Extinguishment	12	21
Materials	18	24

2.1.1.1.6 Deliverables.

The main deliverable will be data and information leading to design criteria for fire protection of lavatories against hidden in-flight fires. This data and information will cover early detection and rapid extinguishment of fires, and proper usage of materials, documented in formal technical reports. A specification for automatic lavatory fire detectors will be developed.

2.1.1.2 Emergency Smoke Ventilation.

2.1.1.2.1 Objective.

The objective of this effort is to develop optimal procedures for use of the aircraft environmental systems for fire control and smoke evacuation.

2.1.1.2.2 Background.

In-flight fires that are hidden and/or out of control represent a serious threat because of the long time needed for descent and landing. Even in an emergency descent mode, several minutes are required to drop 30,000 feet. The time to travel to the nearest useable airport and set up a proper approach can take a long time additionally. In this period, the fire can grow significantly, can damage or destroy essential parts of the aircraft control system, and can kill the occupants from exposure to smoke, heat, and toxic gases.

There are capabilities, to this date uncharted, which might afford the crew more control over their ultimate destiny. At the very least, there are capabilities of modifying the flight profile, cabin pressurization, and cabin ventilation. Ventilation plays a strong role in dumping heat and smoke while pressure plays a strong role in fire growth. Ultimately, operations research techniques could be used to get the optimal trade-off between minimizing the time to land an aircraft and maximizing the fire control through the environmental system control and flight profile selection.

The *sine qua non*, nevertheless, is the development of a sound data base from small- and full-scale tests on the relationships of ventilation and pressure to fire growth under a range of scenarios.

Recent analytical work at the FAA Technical Center has shown how ventilation can slow the rate of temperature rise. A recent dissertation from Harvard shows the relationships of flash-fire phenomena to flammability limits. These types analyses can be married to show what to expect of ventilation. As to pressure effects, the burning rate of a material is related to the Spalding B number and is directly relateable to the mass concentration of oxgen.

2.1.1.2.3 Technical Approach.

The approach needed here would be interdiscipline in nature. Expertise is required in fire testing, aircraft systems, operations research, and aircraft flying. The first major thrust is the identification of the role of pressure and ventilation on control of fire through a combined analytic and small-scale approach. This is followed by full-scale verification. Finally, the data will be used in an operations research effort to optimize options available to the aircraft crew. The In-flight Fire Test Facility (see 3.2.2) will be used for the full-scale work. In the first year, 10 surplus B707 fuselages will be acquired for use over the entire program as well as for use in the full-scale simulations for Oxygen System Safety (see 2.2.2) and ACES (see 2.5.3).

A fuselage will be inserted into the In-flight Fire Test Facility and a specific scenario will be identified for testing. At first, small fires will be used so that a given fuselage will be able to sustain the greatest number of fire tests. Instrumentation throughout the aircraft will indicate hazards to passengers, crew, and to the integrity of the aircraft systems. Sample flight profiles will be varied to determine the optimum combination of cabin pressure and ventilation rate for minimizing hazard development for that scenario. The next scenario will be started and the same progression will ensure.

Interface with available expertise in such groups as the American Society of Heating, Refrigerating, and Air-conditioning Engineers will be maintained throughout the effort.

2.1.1.2.4 Resources.

The in-house manpower and contract dollar resources over a 4-year period are as follows:

	Manpower	Dollars
Year 1	5	800K
Year 2	5	400K
Year 3	8	1,000K
Year 4	12	500K

The skills over this period would gradually shift from exclusively fire specialists at the start to a combination of operations research analyses, flight specialists, aircraft systems specialists, and fire specialists at the end. The resources here are based on the assumption that the facility described under 3.2.2 will be available.

2.1.1.2.5 Schedule.

Month 6	Project Plan (detailed)
Month 12	Receive 10 B707 fuselages
Month 18	Small-scale tests
Month 24	Facility completion
Month 36	Full-scale test completion
Month 48	Systems analysis report

2.1.1.2.6 Deliverables.

The deliverable is a recommended procedure or set of procedures for managing the flight profile and cabin environmental system during an in-flight fire. (see 3.2.2).

2.1.1.3 General Aviation and Rotorcraft.

2.1.1.3.1 General Aviation and Rotorcraft Fire Protection.

2.1.1.3.1.1 Objective.

The objective of this effort is the definition of the proper types and amounts of extinguisher agents for use in small aircraft and rotorcraft.

2.1.1.3.1.2 Background.

The firefighting capabilities in large aircraft have recently been upgraded through increased deployment of halon hand extinguishers. Because of the large volumes of these aircraft as well as crew training and cockpit oxygen availability, the selection criteria for hand extinguishers are reasonable and effective. This state of affairs does not yet exist among rotorcraft and small aircraft.

Small aircraft and rotorcraft can have volumes small enough so that neat agent toxicity can be a problem if the compartments are not adequately ventilated. At present, there is adequate data for hand extinguisher selection for a well ventilated small aircraft like the Cessna 210, but no work has been done by the FAA to this point on rotorcraft or pressurized aircraft like the Citation 3. Additionally, the FAA does not have an adequate data base to adequately judge the safeness and effectiveness of cabin total flooding halon 1301 systems such as those marketed by Total Flood Corporation.

2.1.1.3.1.3 Technical Approach.

For hand extinguishers, a small pressurized aircraft will be obtained from the Drug Enforcement Agency and ventilated from the high pressure air facility to simulate in-flight ventilation rates. Data acquisition will be conducted in the manner used in the Cessna 210 project. Flight testing will be used for the rotorcraft evaluation and the Statham technique will be used for testing.

Total Flood System for the cabin/cockpit will be installed in the Cessna 210, the pressurized aircraft, and the rotorcraft. Evaluation of agent concentration and decay will be conducted in the same test modes used in the hand extinguisher work. Additionally, the class A fire fighting effectiveness for both fixed-wing aircraft and rotorcraft will be evaluated under simulated flight conditions.

2.1.1.3.1.4 Resources.

The in-house manpower and contract dollar resources over a 3-year period are as follows:

	Manpower (MY)	Dollars
Year 1	2	60K
Year 2	2	100K
Year 3	2	150K

2.1.1.3.1.5 Schedule.

Month 12	Report on hand extinguisher in pressurized aircraft
Month 24	Report on total flooding in fixed-wing aircraft
Month 36	Report on extinguishers in rotorcraft

2.1.1.3.1.6 Deliverables.

Technical bases for advisory circulars.

2.1.1.3.2 General Aviation Interior Materials.

2.1.1.3.2.1 Objective.

The objective of this effort is to evaluate the adequacy of current flammability requirements prescribed by FAA for general aviation (GA) interior materials.

2.1.1.3.2.2 Background.

It is recognized that transport aircraft cabin materials are far more fire resistant than the materials used in GA. Generally, FAA regulations specify the usage of materials in transport cabins that are "self-extinguishing" when tested in a vertical orientation. In contrast, the requirements for GA are a horizontal burn-rate; i.e., either flame resistant (less than 4 inches/minute) or flash resistant (less than 20 inches/minute), depending on the year the airplane was certified. Laboratory experiments have shown that vertical burn-rates can be ten times greater than horizontal burn-rates. Therefore, there is concern that some in-flight fires in GA may become uncontrollable because the interior materials are not adequately fire resistant.

The fire problem associated with GA materials is an in-flight problem. Improvements in postcrash fire safety are being addressed by more crashworthy fuel tanks/lines. In-flight fires usually originate from relatively smalll ignition sources. It has often been stated that the vertical Bunsen burner test prescribed by FAA in FAR 25.853 accurately reflects the ignitability of a material subjected to a small ignition source. This project will attempt to determine whether significant improvements in GA in-flight cabin fire safety can be expected through the use of "self-extinguishing" materials.

2.1.1.3.2.3 Technical Approach.

The benefits of self-extinguishing materials over materials that are flame or flash resistant, during a GA cabin fire, must be determined by conducting full-scale fire tests. The Cessna 210 airplane used for extinguishing tests described in Section 2.1.1.3.1 will be used as the test article after the extinguishing work is completed. This airplane will be fire hardened and protected in a fashion similar to the C-133 wide-body test article. A series of realistic in-flight fires will be conducted with the interior furnished with self-extinguishing materials and with the interior furnished with flame- or flash-resistant materials. The need for more fire-resistant materials in GA will be based on the observed differences in fire development between the two classes of materials.

2.1.1.3.2.4 Resources and Schedule.

An engineer and two technicians are required over a period of 15 months to complete this project. The estimated contract dollars are $75K.

2.1.1.3.2.5 Deliverables.

The final product is data and information contained in a final report that addresses the benefits of more fire resistant cabin materials during various in-flight fire scenarios.

2.1.2 Postcrash.

2.1.2.1 Postcrash Cabin Fire Fighting

2.1.2.1.1 Objective.

The objectives of this project are (1) to examine a compare the effectiveness of (a) an on-board foam/water sprinkler system a (b) innovative fuselage skin penetrator nozzles, operated by the Crash-Fire-Rescue (CFR) services, against postcrash cabin fires, and (2) to perform detailed studies of the design impact and costs associated with the implementation of the most promising systems.

2.1.2.1.2 Background

One of the principal objectives of the CFR services is to respond to aircraft accidents/incidents and extinguish all exterior fires to permit the sole self-evacuation of occupants. However, this limited scope objective is currently being reviewed by experts in the field. Accident reports are existent in which the CFR services accomplished their basic mission, but the aircraft was subsequently lost because of the uncontrollable interior cabin fires which had been ignited by external fuel-spill fires.

Limited test work or field experience exists for each of the concepts to be studied, as follows:

a. Application rates from an onboard sprinkler system were adjusted to extinguish seat fires in a small number of FAA fire tests in a DC-7 fuselage.

b. The NASA skin penetrator nozzle is tactically deployed at all potential landing sites of the space shuttle for extinguishing interior cabin fires, if required; and

c. The feasibility of employing the USAF's penetrator nozzle was established in FAA Technical Center report (FAA-NA-79-43 June 1979), employing one particular fire scenario.

2.1.2.1.3 Technical Approach.

The technical approach consists of (a) realistic full-scale cabin fire tests to determine and compare the effectiveness of each system under evaluation; and (b) a cost/design impact study of the most promising system(s).

2.1.2.1.3.1 Fire Tests.

The full-scale cabin fire tests will be conducted in the C-133 test article because of the need for highly controllable conditions to make systems performance comparisons meaningful. Also, the C-133 test article is extensively instrumented for mapping out cabin fire hazards and is more representative of contemporary cabin configurations than a DC-7 fuselage. The fire tests will be preceeded by preliminary tests to gather design information. For example, the number, type, location and discharge rate of sprinkler heads will be determined initially. Also, some rough evacuation tests may have to be conducted if the required discharge rates produce a deluge effect. For the penetrator nozzles, tests will be conducted to evaluate ease of fuselage penetration and nozzle operation, and discharge patterns produced by the candidate extinguishing agents. Each system's performance will be evaluated under a number of fire intensities, including, if feasible, post-flashover conditions.

2.1.2.1.3.2 Design/Cost Impact Study.

A contract will be awarded to determine the design/cost impact of the most promising system(s) on the U.S. fleet and/or CFR services, which ever is applicable. Taking the results from section 2.1.2.1.3.1 estimates will be made of benefit/cost ratios.

2.1.2.1.4 Resources/Schedule.

The estimated resource requirements are as follows:

	M/Y	$K
Year 1	3.5	75
Year 2	2.0	150

2.1.2.1.5 Deliverables

Formal technical reports will document the comparative effectiveness of an on-board sprinkler system and penetrator nozzles, operated by the CFR services, against postcrash internal fuselage fires. Information on the design impact, costs and estimated benefit/cost ratios of the most promising system(s) will also documented.

2.1.2.2 Fuselage Burn-Through Resistance.

2.1.2.2.1 Objective.

The objective of this project is to improve the resistance of an aircraft fuselage to penetration or burn-through by an external fuel fire in a postcrash environment.

2.1.2.2.2 Background.

A typical survivable postcrash aircraft fire scenario consists of a relatively intact fuselage exposed to a large adjacent fuel fire. The cabin will be immediately subjected to intense radiant heat and flames through fuselage openings next to the fuel fire. However, if the fuselage is completely intact in this region, fire burn-through into the cabin is resisted for a period of time. This resistance is the result of heat-sink effects in the aluminum skin and structural elements, moisture evolution and heat insulation by the thermal acoustical blankets, and fire resistance of interior composite panels. In the Continental DC10 accident at LAX on March 1, 1978, the fuel fire did not penetrate the fuselage for 2 to 2 1/2 minutes. In some accidents, this is an adequate time period for occupants to safely evacuate the airplane. Other accidents may require evacuation time on the order of 5 minutes, such as the DC10 accident in Malaga, Spain in October 1982. When evacuation times approach 3 to 5 minutes, fuselage burn-through will ignite the cabin interior and possibly prevent escape by the passengers still inside the cabin.

When the fuel fire covers the side of the fuselage, full-scale tests at the Technical Center demonstrated that the initial flame penetration will be through the window assembly. Replacement of the inner "fail-safe" pane by a modified epoxy pane developed by NASA (EX-112) was found to provide a significant improvement in flame resistance. Because the EX-112 pane cannot be economically produced on a commercial scale because of its high chemical reactivity and relatively short pot life, and because its physical properties are below the minimum requirements of the conventional stretched acrylic pane, a contract was awarded in FY-84 to develop a commercially producible, thermally improved window transparency meeting all of the requirements of the current window transparency.

With the anticipated significant improvement in burn-through resistance of window assemblies, a need exists to upgrade the remaining fuselage structures to at least that level of resistance. The route of fire burn-through and the structural components requiring improved fire resistance must be determined. In addition, replacement of the aluminum with advanced structural polymeric composites in the future can either lengthen or shorten the fuselage burn-through time dependent on the following parameters: thermal diffusivity, polymer degradation temperature, effective heat of degradation, percent char yield, and high temperature structural degradation. Thus, the effects of burn-through times by evolution to polymeric composite replacements for metal must also be evaluated.

2.1.2.2.3 Technical Approach.

The overall technical approach will include burn-through characterization of components in the laboratory, failure analysis of major aircraft models for select fire scenarios, and full-scale testing to support the development of burn-through performance requirements. Testing will be performed in-house and the failure analysis will be a contractural effort.

2.1.2.2.3.1 Failure Analysis.

A contract will be awarded to examine the pertinent design features of major transport models (DC8, DC9, DC10, L1011, 727, 737, 747, 757, 767, and A300) having a bearing on fuselage burn-through. Skin thickness, thermal insulation type and thickness, floor design, interior panel construction, floor-sidewall interface, attachment method and any other relevant features will be documented in detail. Fire scenarios will be developed to identify potential failure modes. Based on this analysis, full-scale and small-scale fire tests will be recommended to validate the path of burn-through and develop performance requirements to upgrade the burn-through resistance of the fuselage system.

2.1.2.2.3.2 Fire Tests.

Small-scale fire tests will be performed initially to characterize the burn-through resistance of a variety of fuselage components, including skins, insulation, interior panels, flooring and advanced structural composites. The composite types will probably include a range of both components (phenolics, epoxies, graphite, Kevlar, etc.) and a range of structural configurations (laminates with and without honeycomb core). This work will also culminate in the development of a suitable small-scale test method for burn-through resistance. Full-scale tests will be performed to examine the failure analysis derived in section 2.1.2.2.3.1, and to project potential improvements in burn-through resistance. Ultimately, small-scale test performance requirements for appropriate fuselage components or an assembly configuration will be developed to upgrade the overall burn-through resistance of the fuselage system.

2.1.2.2.4 Resources.

The in-house technical manpower is expected to be 3 man-years in year 1 and 4 man-years in year 2. The contractual effort is estimated at $150K and the cost of equipment, supplies and test materials is estimated at $125K.

2.1.2.2.5 Schedule.

The total duration of the effort is anticipated at 30 months starting in FY-86.

2.1.2.2.6 Deliverables.

The final product will be fire test performance requirements to upgrade the overall burn-through resistance of the aircraft fleet against a large external fuel fire. At least two formal reports will document the technical effort leading to this final product.

2.1.3 Milestone Schedule.

The milestone schedule for the projects and tasks comprising the fuselage fire management element of this program is shown in figure 1. The milestone schedule is based on the resouce requirements shown in table 1 and the assumption that the current Cabin Fire Safety Program will be completed completed by October 1, 1984.

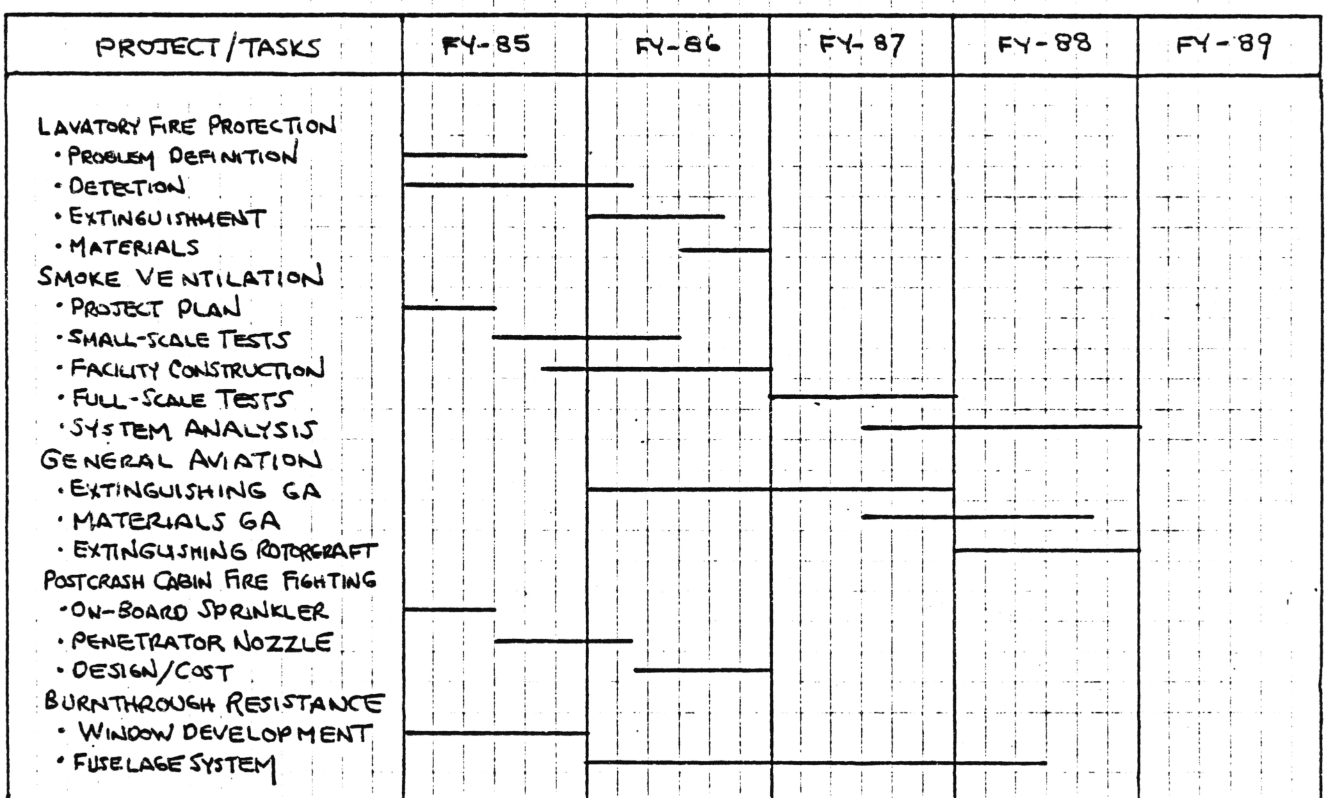

FIGURE 1. FUSELAGE FIRE MANAGEMENT MILESTONE SCHEDULE

TABLE 1. AIRCRAFT SYSTEMS FIRE SAFETY RESOURCE REQUIREMENTS

PROJECT	FY-85		FY-86		FY-87		FY-88		FY-89	
	M/Y	$K	M/Y	$K	M/Y	$K	M/Y	$K	M/Y	$K
LAVATORY FIRE PROTECTION	7.5	500	5.0	200	—	—	—	—	—	—
SMOKE VENTILATION	5.0	600	5.0	500	8.0	1000	12.0	500	—	—
GENERAL AVIATION	—	—	2.0	60	5.0	175	2.0	150	—	—
POSTCRASH CABIN FIRE FIGHTING	3.5	75	2.0	150	—	—	—	—	—	—
BURNTHROUGH	.25	—	3.0	175	4.0	100	—	—	—	—
EVACUATION SLIDES	1.5	100	—	—	—	—	—	—	—	—
OXYGEN SYSTEMS	0.5	170	0.5	50	2.0	70	6.0	120	6.0	120
PROTECTIVE BREATHING DEVICES	3.0	350	3.0	500	3.0	150	—	—	—	—
HYDRAULIC FLUIDS	—	—	—	—	—	—	—	—	3.25	250
ELECTRICAL WIRING	—	—	—	—	—	—	—	—	3.25	250
CHEMISTRY AND TOXICITY	3.5	200	4.0	250	4.0	50	4.0	60	4.0	70
SUSTAINING ENGINEERING	0.5	—	1.0	10	1.0	—	0.5	—	0.5	—
POWERPLANT FIRE PROTECTION	—	—	—	—	0.75	135	2.25	290	3.5	220
MODELING	2.0	100	3.0	120	3.0	120	3.0	120	3.0	120
ACES	2.0	200	4.0	200	4.0	400	6.0	200	10.0	1500
ACCIDENT INVESTIGATIONS	0.5	15	0.5	20	0.5	20	0.5	20	0.5	20
REIMBURSABLE AGREEMENTS	5.0	40	5.0	50	5.0	50	5.0	50	5.0	50
TOTALS	35.0	2350	38.0	2285	40.25	2270	41.25	1510	39.0	2600

2.2 SYSTEMS.

2.2.1 Passenger Protective Breathing Devices.

2.2.1.1 Objective.

The objective of this project is to determine the effectiveness of and design requirements for protective breathing devices for use by passengers during a cabin fire.

2.2.1.2 Background.

FAA NPRM 69-2 proposed the use of smoke hoods for passengers to provide protection against the hazards of a cabin fire during an emergency evacuation. The smoke hood was essentially a transparent, heat resistant plastic bag with a neck seal. Air trapped in the bag during donning constituted an adequate supply for breathing by the wearer during "typical" evacuation times. However, a number of important issues about the effectiveness, safety and practicality of smoke hoods resulted in the withdrawal of NPRM 69-2 by FAA on August 18, 1980. The primary issues were the following: (1) the time required to don a smoke hood would result in a significant increase in evacuation time; (2) the smoke hood, in itself, was a potential hazard caused by the consumption of oxygen in the trapped air; and (3) practical considerations such as deployment, pilferage, and liability were not adequately resolved.

In the more than 13 years that have transpired since the withdrawal of NPRM 69-2, two major developments point to the need for reconsideration of — not necessarily smoke hoods — but the concept of passenger breathing devices. Foremost is the appearance in the marketplace of devices that go beyond the simple smoke hood; e.g., a number of hoods with a smoke filter, various hoods with portable oxygen/air supplies, large hoods that fasten at the waist, a hood supplied by air from the passenger fresh-air supply nozzle ("gassper"), emergency escape masks, etc. Secondly, a series of in-flight fires in U.S. built aircraft operated by foreign carriers, with upwards of 600 fatalities, suggest the need for passenger protection against smoke accumulation in the cabin while the airplane is in flight. The most recent example was the Air Canada DC9 accident on June 2, 1983 wherein copious amounts of smoke reduced visibility inside the passenger cabin to less than an arm's length. Would additional lives have been saved if protective breathing devices were available, or would the additional time required for evacuaton have trapped additional occupants in the all-consuming flash-fire?

2.2.1.3. Technical Approach.

A broad program is requied to cover the areas of need for the device, safety and effectiveness, compatability with aircraft design, concept development, training requirements and psychological considerations, and evacuation effects. In-house resources at CAMI and the Technical Center will be utilized, supplemented by an outside contract and possibly an interagency agreement wiht NBS. Two basic devices will be examined: (1) portable devices with means of stowage in the cabin to be established and possible connection to existing air distribution systems, and (2) emergency oxygen masks modified for smoke protection.

2.2.1.3.1 Cabin Hazard Analysis.

Will protective breathing devices be effective or are they even needed in the cabin environment created by in-flight or postcrash cabin fires? This question will be addressed by conducting realistic full-scale cabin fire tests at the Technical Center. In the postcrash environment, additional measurement stations and more extensive measurements are needed, as well as more completely furnished test articles in order to map out the hazards throughout a cabin before and after flash-over to examine the potential need and efficacy of a protective breathing device. Similarly, in-flight fire tests performed under para. 2.1.1.1.3.1 will describe the toxic hazards associated with longer duration, hidden in-flight fires.

2.2.1.3.2 Laboratory Tests for Safety and Effectiveness.

All existing protective breathing devices available on the marketplace or of a prototype design will be tested in the laboratory. A battery of tests will be conducted to characterize each of the devices as follows, where applicable: (1) donning time, (2) visibility, (3) leakage, (4) sound transmission, (5) heat resistance, (6) weight, (7) filtering efficiency against major toxic gasses (CO, HCl, HF, HCN, etc), (8) useable air supply, etc.

2.2.1.3.3 Compatability With Aircraft Design.

Each protective breathing device will be examined on the basis of compatibility will <u>all</u> aircraft models in the U.S. fleet. Of particular importance, will be the availability and accessibility of supplemental air for hoods equipped with quick connect lines, exploration of potential stowage areas for portable devices, and aircraft modifications and costs associated with providing supplemental air or oxygen requirements, if not available. Decision analyses will be applied to select the optimum protective breathing device.

2.2.1.3.4 Development of Modified Emergency Oxygen Mask.

Recent work performed at CAMI has indicated the feasibility of a simple rebreather bag to impart smoke protection to an emergency oxygen mask. Additional work, preferably with an experienced manufacturer of aircraft oxygen masks, will be necessary to properly develop and design a dual purpose mask for aircraft application.

2.2.1.3.5 Psychological Studies and Training.

A contractual study will be undertaken to examine several concerns with the effective use of protective breathing devices. Psychological testing is required to establish what percentage of the broad spectrum of aircraft passengers will actually be able to don these devices. Also, the most effective means of instructing passengers during pre-flight briefings on the proper donning of these devices must be determined.

2.2.1.3.6 Evacuation Studies.

Realistic evacuation tests with human subjects would have to be performed to determine what the effect is of donning a protective breathing device in the time it takes to evacuate an airplane. In particular, promising devices not previously tested at CAMI would have to be studied.

2.2.1.4. Resources.

It is estimated that 3 man-years at CAMI and 3 man-years at the Technical Center (work for a period of 3 years) is required to perform this project. Contract monies are summarized below.

Task	$
Cabin Hazard Analysis	125K
Laboratory Tests	75K
Compatibility Study	200K
Modified Oxygen Mask	300K
Psychology and Training	200K
Evacuation Studies	150K

2.2.1.5. Schedule.

Task	Month Begin	Month End
Cabin Hazard Analysis	0	6
Laboratory Tests	0	12
Compatibility Study	6	18
Modified Oxygen Mask	12	30
Psychology and Training	18	30
Evacuation Studies	24	36

2.2.1.6. Deliverables.

The main deliverables will be data and information relative to the safety and effectiveness of passenger protective breathing devices for application during cabin fires. This will be documented into formal technical reports that could be used for advisory or regulatory material. A final design of a dual function mask for emergency oxygen and smoke protection for aircraft application will be developed. for responsiveness under the following conditions:

2.2.2 Oxygen System Safety.

2.2.2.1 Objective.

The objective of this effort is the definition of any potential hazard caused by use of the emergency masks during an in-flight fire as well as definition of the performance of the oxygen system during fire growth processes.

2.2.2.2 Background.

The emergency oxgen system of an aircraft is directed to lifeguarding occupants in the event of depressurization. Design of the system also is directed towards preventing failures of the system that could cause a fire. However, the role of the oxygen systems as they are exposed to a developing fire is not clear. This lack of information causes confusion over such critical issues as whether to deploy masks during an in-flight fire. There is also confusion as to the effects of a postcrash fire or in-flight fire on the intact system. For instance, it might be safer to deploy masks and deplete the oxgen systems before fire has a chance to cause system failure which would allow the oxygen to feed the fire. Most polymers in aircraft have a limiting oxygen index (LOI) in excess of 21. Thus, they tend to be relatively non-flammable at atmospheric conditions and probably even less so at altitude. However, enriching air with oxygen can make these non-flammable materials more flammable.

2.2.2.3 Technical Approach.

The work will include a number of separate pieces. A contract will be let to develop the state-of-the-art of the oxygen systems. The work statement will include both identification of the type systems used in commercial aircraft including air-taxi and commuter models and the service history of these aircraft, in this regard. Simultaneously, a data base from the literature will be developed on combustion of various materials in enriched environments. Significant gaps will be filled through in-house small-scale test work. The contractual information coupled with the combustion data base will be used to project what fire scenarios may be susceptible to oxygen involvement. Full-scale testing will be used to validate these projections. The testing will be done in the In-flight Fire Test Facility (see 3.2.2).

2.2.2.4 Resources.

This project will last 5 years with the first 2 years involving in-house planning and literature searching at the rate of 1/2 man-year per year. The contracted study will be done at this time and will cost 220K. Year 3 will involve small-scale test work and projections of the most significant fire scenarios. Year 3 will use 2 man-years with equipment and supply costs of 70K. Year 4 will involve full-scale tests of postcrash fire scenarios and year 5 will involve the full-scale in-flight scenarios. Years 4 and 5 will each require 6 man-years and 120K.

2.2.2.5 Schedule.

The significant milestones are -

8 months: award contract
24 months: contract completed
36 months: completion of scenario projections
48 months: full-scale postcrash report
60 months: full-scale in-flight fire report

2.2.2.6 Deliverables.

The deliverables here will be technical description of when and how oxygen systems should be used during an in-flight fire and a determination of the system integrity during a postcrash fire.

2.2.3 Evacuation Slides.

2.2.3.1 Objectives.

The objectives of this project are as follows: (1) Modify ASTM F828, Test Method for Radiant Heat Resistance of Aircraft Inflatable Evacuation Slide/Slide Raft Materials to include seam construction testing relevant to full-scale postcrash fire conditions; (2) Demonstrate the relevancy of the modified laboratory test method in conjunction with the improved radiant heat resistance of new aluminized slides under realistic full-scale fire conditions.

2.2.3.2 Background.

As a result of the Continental Airlines DC10 accident at the Los Angeles Airport in March 1978, the FAA Technical Center conducted a preliminary assessment of the fire protection characteristics of various escape slide materials. This study was followed by a more comprehensive program during which F828 was designed and developed and additional full-scale technical data was collected in support of correlating laboratory and full-scale results. Information was supplied to FAA Headquarters in support of the current Technical Standard Order (TSO) related to testing slide materials exposed to thermal radiation. During this program an aluminized coating was developed for retrofitting inservice evacuation slides. The program was concluded with a Symposium held at the Technical Center to present the results to industry. During the test program, inconsistent laboratory and full-scale test results were observed for materials which exhibited seam failures. Also, full-scale test results were not obtained for newly fabricated aluminized slides due to their limited availability. These data will provide a more complete analysis of the improvement of the aluminized slides under realistic fire conditions.

2.2.3.3 Technical Approach.

The project effort is divided into two tasks:

Task 1- ASTM F828 will be modified to include seam construction testing of slide samples. This will require use of building 203 facilities with existing instrumentation associated with F828. Some machine shop time may be required. This task could possibly be accomplished with modification to the pressure cylinder only.

Task 2- Approximately six emergency evacuation slides (state-of-the-art aluminized) will be procured to verify the relevancy of the modified laboratory seam construction radiant heat test under full-scale postcrash fire conditions. These slides will employ varying seam constructions and neoprene/nylon versus urethane/nylon aluminized materials. Full-scale tests will utilize building 275 full-scale fire test facility. Instrumentation set-up will replicate previous full-scale slide tests. Indoor tests will necessitate use of a 10-foot fire pan which may produce different results than previous 30- X 30-foot outdoor fire tests.

2.2.3.4 Resources.

Funding

Slides and Hardware — 100K

Man Power

2/3 Engineer man-year
1/2 Technican man-year

2.2.3.5 Schedule.

The project will be completed within 8 months upon receipt of the evacuation slides.

2.2.3.6 Deliverables.

The project with be documented in a final report and the modified test method will be presented to FAA and ASTM.

2.2.4 Milestone Schedule.

The milestone schedule for the projects and tasks comprising the systems element of this program is shown in figure 2. The milestone schedule is based on the resource requirements shown in table 1 and the assumption that the current Cabin Fire Safety Program will be completed by October 1, 1984.

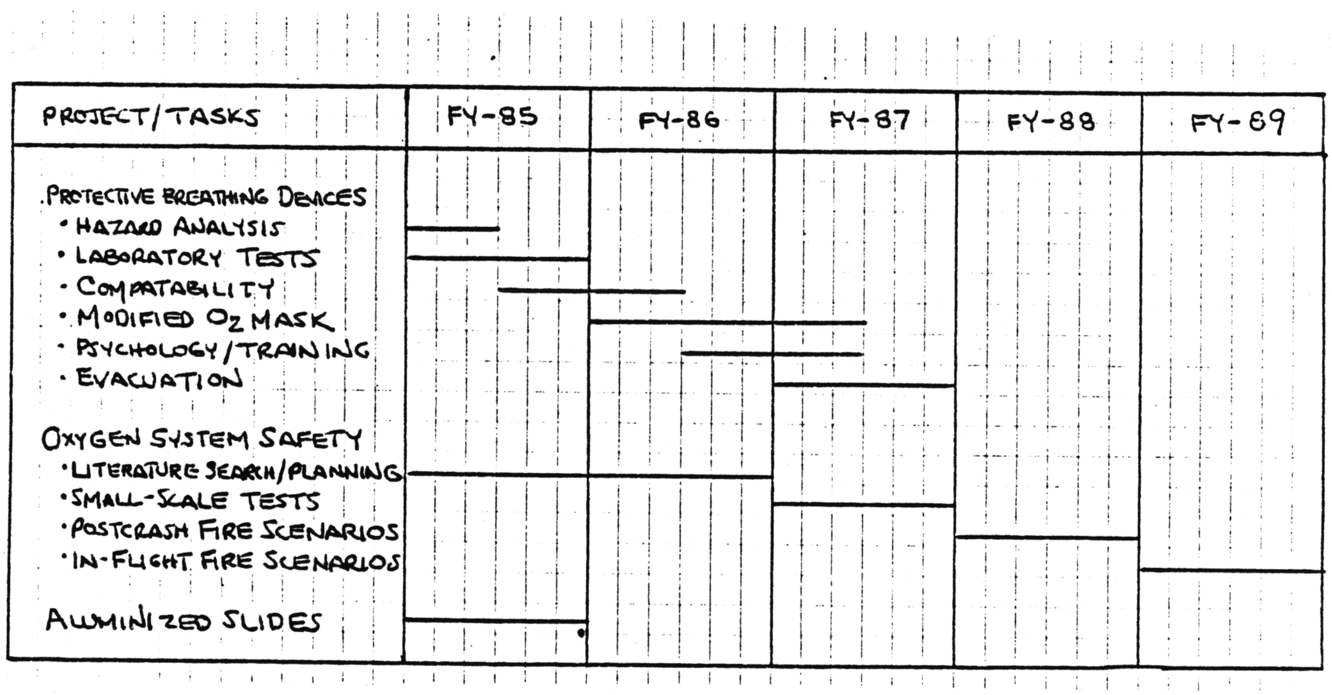

FIGURE 2. SYSTEMS MILESTONE SCHEDULE

2.3 MATERIALS AND TEST METHODS.

2.3.1 Hydraulic Fluid Flammability.

2.3.1.1 Objectives.

The objectives of this project are as follows: (1) determine the adequacy of present fire related regulations with regards to hydraulic fluid; (2) determine the benefits that could be expected from any changes in the regulations.

2.3.1.2 Background.

Hydraulic fluid onboard an aircraft represents both an in-flight and postcrash fire hazard. There have been accidents in the past that indicate there may be a problem with currently used fluids under certain conditions. A postcrash fire on a Korean airlines 747 was the result of the spillage of hydraulic fluid from the struts with sparking as an ignition source. An in-flight fire occured in a Lear Jet when an electrical wire arced through a high pressure hydraulic line, causing a mist which was ignited by the arcing wire. What is not known, however, is if a more fire resistant fluid would have prevented those fires. There has been a great deal of work done on the subject by the U.S.A.F. Reports by the Directorate of Aerospace Safety, Air Force Inspection and Safety Center, Norton AFB, California, indicate the complexity of the problem.

2.3.1.3 Technical Approach.

The project will be conducted in two major phases, with phase I being a paper study to define any problem areas and phase II being the research and testing.

Phase I: This will be a contractual effort designed to define problem areas and determine the state-of-the-art for hydraulic fluids. There will be a study of past accidents and incidents. This will be used to determine possible problem areas and to be able to predict possible benefits from any changes. A second study will look at hydraulic fluids. A report will be generated defining various fluids, their strong points and weak points. Standard test methods for hydraulic fluids will be described. Past research in the area will be outlined and summarized. The state-of-the-art in hydraulic fluids will be defined.

Phase II: This portion of the project will be conducted in-house, with the scope and direction depending on the findings of phase I. This phase will probably need the purchasing and set-up of standard tests for hydraulic fluids. Also realistic full-scale mock-up tests will be designed and conducted as dictated by the results of phase I. These tests can be conducted in building 275 or in the Component Test Laboratory.

2.3.1.4 Resources.

Funding

Accident study contract:	100K
State-of-the-art contract:	150K
Laboratory tests:	50K
Equip. Instrumentation:	50K

Man Power

1 1/4 Engineer man-year
2.0 Technican man-year

2.3.1.5 Schedule.

The two contractual studies will be conducted simultaneously over a period of 12 months. The second phase will also be a 12 month effort, with work beginning after the completion on phase I.

2.3.1.6 Deliverables.

Final reports will be published on the accident study, the state-of-the-art study, and the full- and laboratory-scale testing. Recommendations will be made as to any regulartory changes that are deemed necessary.

2.3.2 Electrical Wiring Insulation Flammability.

2.3.2.1 Objectives.

The objectives of this project are as follows: (1) Determine the adequacy of current aircraft test standards with regards to aircraft electrical wiring insulation, and circuit protection; (2) Determine the benefits that could be expected from any changes in the regulations.

2.3.2.2 Background.

Aircraft electrical wiring poses a threat of being the source of an in-flight fire. A short in the wiring can cause arcing, which could possibly ignite the wire insulation or adjacent materials. Improper circuit protection could lead to overheating of the wiring or electrical components and a possible fire. Electrical wiring may also be exposed to high temperatures that could cause a break-down of the wire insulation and a possible fire. Electrical wiring, in the past, has been the source of some in-flight fires. Electrical fire is being considered as a possible cause in the Air Canada DC9 fire.

2.3.2.3 Technical Approach.

The project will be conducted in two major phases, with phase I being a paper study to define any problem areas, and phase II being the research and testing. Phase I: This will be a contractual effort designed to define problem areas and determine the state-of-the-art for electrical insulation and circuits. There will be a study of past accidents and incidents. This will be used to determine possible problem areas and to be able to predict possible benefits from any changes. A second study will look at electrical wiring. A report will be generated defining various types of wires, insulation and circuits and their strong points and weak points. Standard test methods for electrical wires will be described. Past research in the area will be outlined and summarized. The state-of-the-art in electrical wiring will be defined. Phase II: This portion of the project will be conducted in-house, with the scope and direction depending on the findings of phase I. This phase will probably need the purchasing and set-up of standard tests for electrical wiring. Also, realistic full-scale mock-up tests will be designed and conducted as dictated by the results of phase I. These tests can be conducted in building 275 or in the Component Test Laboratory.

2.3.2.4 Resources.

Funding

Accident study contract:	100K
State-of-art contract:	150K
Laboratory tests:	50K
Equip. Instrumentation:	50K

Man Power

1 1/4 Engineer man-year
2.0 Technican man-year

2.3.2.5 Schedule.

The two contractual studies will be conducted simultaneously over a period of 12 months. The second phase will also be a 12-month effort, with work beginning after the completion of phase I.

2.3.2.6 Deliverables.

Final reports will be published on the accident study, the state-of-the-art study, and the full- and laboratory-scale testing. Recommendations will be made as to any regulartory changes that are deemed necessary.

2.3.3 Chemistry and Toxicity.

2.3.3.1 Objective.

The major objective of this project is to define the toxic threat to cabin occupants resulting from aircraft fires. A secondary objective is to provide support to program and environmental safety activities requiring chemical analyses or expertise in the field of chemistry.

2.3.3.2 Background.

A major threat to the survivability of cabin occupants subjected to in-flight or postcrash fire are the toxic gases produced by burning cabin materials. In the postcrash environment, recent full-scale cabin fire tests indicate that toxic hazards effecting survivability are produced by flashover. Postcrash fires are characteristically intense open fires of short duration with adequate supply of air (before flashover). By contrast, in-flight fires are usually hidden, of longer duration than a postcrash fire, and may have a period of smoldering in oxygen deficient air. This type of incomplete combustion, which tends to form more toxic products than open flaming, will be examined in section 2.1.1.1 under more realistic test conditions than heretofore attempted in order to define the toxic threat created by hidden in-flight fire scenarios.

The effect of toxic gases produced by fire on escape potential is the subject of ongoing research and testing. In the past several years, this effort has undergone a major change in approach, whereas, past work concentrated on the use of rodents and the development of various escape paradigms, the approach now is to utilize primates to develop survival models based on dominant gas species. The contention is that the latter approach is a better representation of human survival.

2.3.3.3 Technical Approach.

2.3.3.3.1 Full-Scale Test Analysis.

The chemistry laboratory and personnel will continue to support full-scale test programs. This will be the collection, identification and quantification of gas samples during fire tests. Reports are submitted in the form of concentration-time profiles, representing the condition of the atmosphere at "that" predetermined point within the aircraft. The bulk of the analyses will be for hidden fire scenarios under the lavatory fire protection project. Additional projects to be supported include smoke ventilation, postcrash cabin firefighting, protective breathing devices and accident investigations. The targeted gas analyses are those toxic gases not monitored by automatic computerized equipment (e.g., HCN, HCl, HF). The present capability is being expanded as required (e.g., measurement of unburned hydrocarbons in the smoke layer).

2.3.3.3.2 Combustion Toxicity Protocols.

Based on past experience and expertise, development of a combustion toxicity test protocol (small-scale material fire test) will be done at CAMI. This work will essentially address two critical areas: animal models and fire exposure conditions. CAMI will also provide technical advice and guidance on survival model studies administered by the Technical Center (section 2.3.3.3.3). The capability exists for setting up a standardized combustion toxicity protocol at the Technical Center, if required.

2.3.3.3.3 Human Survival Modeling.

The simple human survivable model utilized by FAA is based on two assumptions. The first assumption is that the effect of toxic gases is additive and the second is that a hyperbolic relationship exists between gas concentration and time to incapacitation. The model needs continual revision and updating as better data is generated. FAA will continue to support primate or other studies required to develop a valid human survival model. Whereas, past work included single gases (primarily irritants) in air, future plans include (a) longer exposure times to evaluate the consistancy of the exposure concentration-time-to-effect product (so called "ct" product); (b) gas mixtures composed of narcotic and irritant gases (e.g., CO and HCl) and (c) combustion mixtures to validate the model. A reference library of information on human survival in toxic gas environments will be assembled at the Technical Center.

2.3.3.3.4 Health and Safety.

The chemistry laboratory may perform specified water analyses under a special phase-in provision from the New Jersey Department of Environmental Protection for an interim period of time. This provision is a normal procedural step in the process of full "certification." The laboratory has targeted those tests on potable and waste water required legally by the State agency. The laboratory does work with the Safety Officer toward ensuring a safer work environment. These efforts encompass sampling, identification, and analysis of solids, liquids, and gases from working environments.

2.3.3.4 Resources/Schedule.

It is estimated that 4 man-years at the Technical Center and 3 man-years at CAMI are required to perform this project. Contractual support for the upgrading of the human survival model is estimated at $150K and $200K for FY-1985 and FY-1986, respectively. Support for in-house work at the Technical Center and CAMI is estimated at $50K per year.

2.3.3.5 Deliverables.

The final product of this project is a definition of the toxic threat created by aircraft cabin fires, and improved survival models and toxicity test protocols for addressing this hazard. Documentation will be primarily in the form of a final technical report.

2.3.4 Sustaining Engineering.

2.3.4.1 Objective.

The objectives of this project are as follows: (1) perform cursory fire tests on promising new materials developed by industry and government; (2) participate in organizations developing standards related to aircraft cabin fire safety; and (3) examine the need for permanency requirements for the fire resistance of aircraft materials.

2.3.4.2 Background.

Companies such as DuPont and General Electric and governmental organizations such as NASA and DOD continually support R&D to develop improved polymeric materials. Representatives often visit the Technical Center for an informal appraisal of their product. This is usually made by conducting standardized fire tests in the Materials Test Laboratory (Bldg. 203). In this manner, Technical Center employees become aware of new developments in polymeric materials technology that may have aircraft applications and are better able to assess the need for upgrading FAA standards.

In the past, concensus standards forming organizations such as the American Society of Testing and Materials (ASTM) and the National Fire Protection Association (NFPA) have developed standards related to cabin fire safety with input provided by Technical Center employees. Examples of ASTM fire test standards include the Bunsen burner, NBS smoke chamber, and evacuation slide heat resistance test methods. Participation in round robin test programs are required to establish the repeatability and reproducability of these devices. This type of activity must continue as new products, generated by this program, gain acceptance and require standardization by concensus organizations with consumer, government and industry representation.

Following the Air Canada DC9 accident on June 2, 1983, cabin interior materials from a sistership were tested at the Technical Center in accordance with FAA Standards (FAR 25.853). All materials tested were compliant, except for urethane foam samples cut from the surface of the bottom cushion. Apparently, effects such as abrasion, moisture, or age caused the fire resistance of the cushion surface to depreciate. Work is required to examine whether this poses a problem under realistic fire conditions that justifies the development of test requirements simulating service experience.

2.3.4.3 Technical Approach.

Participation in standards forming organizations and cursory evaluation of promising new polymeric materials will proceed at the current pace. The permanency of the fire resistance of urethane foams will be studied by (1) installing 16 seat bottoms in an airliner, (2) removing 4 seat bottoms every 6 months, and (3) conducting realistic in-flight and postcrash fire tests on seat assemblies and conducting the vertical Bunsen burner test to study the relationship between degradation in standard and realistic fire performance. If notable changes in fire behavior is noted, detailed plans will be developed to address the issue of service aging and wear.

2.3.4.4 Resources.

Approximately one-half man-year effort is required to participate in standard organizations and maintain an awareness of the properties of promising new polymeric materials. One-half man year is also required to examine the fire resistance permanency of urethane seat bottoms. Purchase and service installation of seat bottoms will cost approximately 10K.

2.3.4.5 Schedule.

Studies of seat cushion fire resistance permanency will commence on FY-86 and continue for a 2-year period.

2.3.4.6 Deliverables.

The final products are (1) ASTM and NFPA standards related to aircraft fire safety, (2) knowledge of promising developments in polymeric materials technology, and (3) an assessment of the magnitude of the problem of loss of fire resistance in foam seat bottoms due to airliner service.

2.3.5 Milestone Schedule.

The milestone schedule for the projects and tasks comprising the materials and test methods element of this program is shown in figure 3. The milestone schedule is based on the resouce requirements shown in table 1 and the assumption that the current Cabin Fire Safety Program will be completed completed by October 1, 1984.

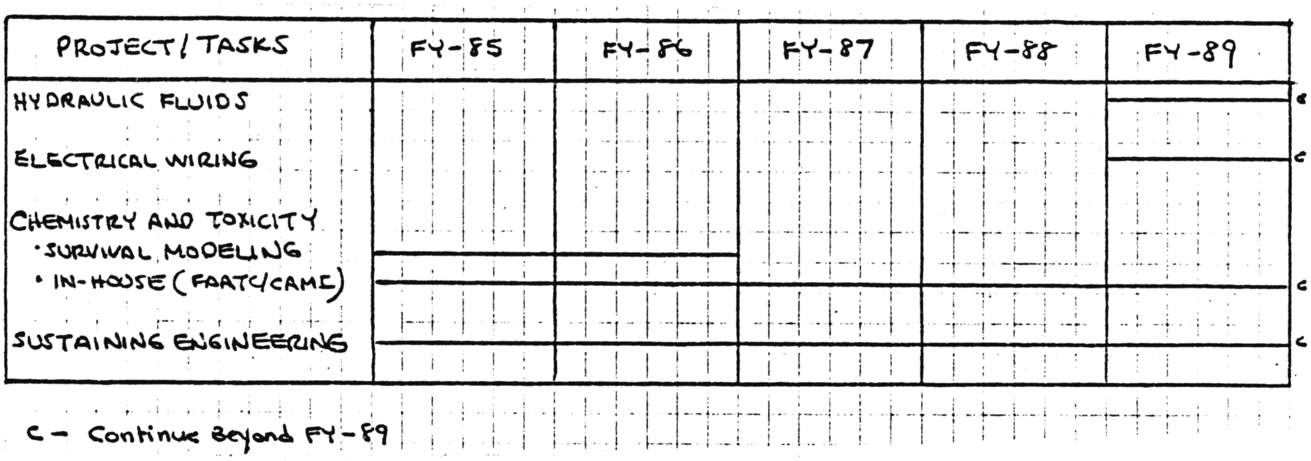

FIGURE 3. MATERIALS AND TEST METHODS MILESTONE SCHEDULE

2.4 POWERPLANT FIRE PROTECTION.

2.4.1 State-of-the-Art Evaluation of Aircraft Fire Protection for Reciprocating and Gas Turbine Engine Installations.

2.4.1.1 Objective.

The objective of this project is the definition of the level of adequency of current practice in powerplant fire detection and extinguishment.

2.4.1.2 Background.

Current design criteria on powerplant fire protection are based primarily on work done at the CAA's Technical Development Center (TDC) in the late 1940's and early 1950's. With the passage of the Federal Aviation Act of 1958, this work was transferred to the FAA's newly established Atlantic City facility. The personnel from TDC continued work with evaluation of the JT3D when they moved to Atlantic City. The JT3C had been done at TDC. The development of the currrently used high rate discharge system (HRD system) was done at TDC. The formula for agent weight requirements as found in the AIA "Design Manual on Aircraft Fire Protection for Reciprocating and Gas Turbine Engine Installations" are based on recommendations from TDC. Thus, the origins of currently used design criteria are quite old. The currently used design criteria may indeed be adequate in spite of the many evolutions in aircraft sstems in the last 30 years. Nevertheless, there is no basis currently for stating the level of adequacy of the requirements. As a result, there is a clear reluctance to reprint the design criteria by either the government or by industry groups.

Consequently, a state-of-the-art review of powerplant fire protection is necessary so that needed documentation can be developed and disseminated for both design and certification efforts.

2.4.1.3 Technical Approach.

A work statement will be prepared for evaluation of the state-of-the-art in powerplant fire detection and extinquishing systems for all current vintage aircraft having requirements. The work statement will include definition of detector types, agent quantities, agent distribution design criteria, and system response times. False alarm frequency as well as fire extinguishing experience will be characterized. Impact of new aircraft materials, nacelle designs, and powerplant designs will be evaluated as to impact on the traditional design criteria for powerplant fire protection systems.

2.4.1.4 Resources.

The in-house technical manpower resources for formulating the work statement, participating in the procurement process, and monitoring the contract is 0.7 man-year. The cost of the procurement is expected to be 280K.

2.4.1.5 Schedule.

The total duration of the effort is anticipated at 24 months.

2.4.1.6 Deliverables.

The final report from the effort will provide either (a) a sound basis for reissuing the material in the AIA "Design Manual on Aircraft Fire Protection for Reciprocating and Gas Turbine Engine Installations" as an Advisory Circular or (b) definition of potential problem areas that must be addressed to maintain past levels of powerplant fire safety.

2.4.2 Effectiveness of State-of-the-art Intumescent/Ablative Coatings.

2.4.2.1 Objective.

The objective of this effort is to assess the effectiveness of current intumescent/ablative materials in aircraft fire scenarios.

2.4.2.2 Background.

In the interest of weight saving in aircraft design, manufacturers are replacing, with increasing frequency, traditionally accepted materials (e.g. stainless steel) in engine nacelle fire zones and resorting to newly developed intumescent/ablative materials applied to light weight substrates such as aluminum. Limited testing of a relatively small sample of these new materials at the FAA Technical Center, conducted for the USAF, has shown some to be inadequate when subjected to the flame of the currently used 2 gph kerosene test burner. This testing has also revealed that intumescent/ablative materials are available which can significantly delay the destructive intrusion of the test flame to the relatively vulnerable substrate. Since these materials are already used extensively on commercial aircraft, testing of a significant number of these materials is required to adequately judge which could be acceptable.

2.4.2.3 Technical Approach.

The proposed project is an in-house effort. This effort will essentially consist of contracting all manufacturers of intumescent/ablative materials and request their cooperation in a test program. Their cooperation will involve the application of their intumescent/ablative material(s) to Government supplied aluminum test panels (approximately 20 inch by 20 inch).

Pretest data will include such items as color, surface texture description curation fluid compatibility, coating weight, coating thickness, panel preparation (if any), application technique, coating flexibility and coating adherence to the substitute before and after flexing. The panels will then be subjected to the FAA 2 gph kerosene test burner in two separate fire tests: 5 minutes to determine acceptability as a fire-resistant material; and 15 minutes for acceptability as a fireproof material. These two fire tests will be conducted on separate panels and at least five of each type will be tested to obtain a statistical base. Post-fire test data will include such items as condition of char, strength of char, thickness of char, flame penetration of intumescent/ablative material, whether or not there was complete flame penetration of test panel, panel weight, temperature history of rear surface of the test panel during testing, and color and amount of smoke generated during testing. Since these materials are intended for use in nonhabitable areas of the aircraft, the latter data item need only be a visual assessment and no toxic gas studies are required.

Since the char of some of these materials is fragile, a suitable shock test and/or vibration is appropriate. In order that these tests (fire/shock/vibration) can be conducted by anyone with the least possible equipment necessary, both tests should be on a small laboratory type scale. The 2 gph torch is a low-cost investment and can be conducted in a suitable fireproof and ventilated room of adequate size. Shock and vibration test gear can be expensive to purchase and install, are generally not portable, can occupy a relatively large area and will be little used by a firm whose only business is the manufacture of intumescent or ablative materials. Therefore the shock test gear should be relatively inexpensive to construct and portable. The test could consist of merely shacking the frame to which the test panel is mounted by such mechanism as striking it from a fixed distance with a pendular weight. This test would not necessarily be representative of a true flight shock or vibration condition (which would vary among different aircraft) but would provide a means to compare char fragility among the various types of materials. The severity of the shock could be varied (up or down) as experience in field use dictates. The initial shock test proposed for this project would be tentative and would be determined at the time of project inception. This project is intended to be an ongoing effort. Materials will continue to be tested for manufacturers as they are submitted and/or assist manufacturers in establishing their own test capability.

2.4.2.4 Resources and Schedule.

Task	MY	Duration	Cost
Contact Manufacturers	1/4	6 months	$35K
Testing	1	1 year	$10K
Ongoing Effort	1/4	continuous	

2.4.2.5 Deliverables.

- o Final report of test effort
- o Test Method
- o Subsequent Reports (ongoing effort)

2.4.3 Burner Standards for Fireproof and Fire-Resistant Certification Testing of Aircraft Components and Systems.

2.4.3.1 Objective.

The objective of this effort is to assess the adequacy of test burners now in use for aircraft component fire testing considering the fire scenarios that can be expected in nonhabitable areas of modern commercial, civil, and military aircraft. The effort will include those burners used by both Government agencies and private industry.

2.4.3.2 Background.

There are at least two distinct types of fire test burners accepted for certification of aircraft components and materials: the 2-gallon-per-hour (gph) kerosene test burner described in SAE ARP 1055 and FAA Powerplant Engineering Report No. 3; and a 6-inch-diameter propane burner per MIL-F-7872. Both burners are used by private industry with the former used by the FAA Technical Center. The earliest document on hand which describes fire test criteria is Department of Commerce Safety

Regulation Release No. 259, dated August 26, 1947. This document states in part that, "the test for demonstrating compliance with criteria for fireproof material or components shall subject the material or unit to a 2000 $\pm$50 degree F flame." Powerplant Engineering Report No. 3A, dated March 1978, states, under Controlling Characteristics of Flame that "temperature measurements through the horizontal centerline should indicate 2000 $\pm$150 degrees F for a distance of not less than 7 inches as measured with the thermocouples described."

From the 1947 issue date of Safety Regulation Release No. 259, there have been no regulation revisions, and this release continues to be accepted as a test standard by Government and industry. With the high airflow of modern aircraft, blow-torch temperature effects have been estimated as high as 3000 degrees F. Differences have been noted between tests conducted at the Technical Center using the 2 gph burner and tests conducted elsewhere using the 6-inch propane burner and/or a standard laboratory propane bunsen burner on identical materials. The test results indicated that when the 2 gph kerosene burner was used, certain materials failed or were marginal at best, and when either of the two propane burners were used, the materials were considered acceptable. The obvious conclusion was that the acceptance or rejection of the same material was a function of the test burner utilized. Defining a fireproof or fire-resistant test by environmental considerations has resulted in multiple regulation interpretations and test fixtures. What is needed in the area of aircraft component and material fireproof and fire-resistant testing for nonhabitable compartments is one test fixture that will be accepted as a "standard" by both Government and industry. The use of a single standardized test burner would reduce or eliminate the controversy surrounding the acceptance or rejection of a material or component which often occurs when different test burners are used.

Since fires within habitable compartments are considered under a separate realm of testing, this proposed project considers areas outside of the habitable compartment where fires can start and pose a threat to the survivability of the aircraft. These include the engine nacelle, wheel well, and wing areas.

2.4.3.3 Technical Approach.

The technical approach will include both contract and in-house efforts. The contractual effort will consist of surveying the field of aircraft fire safety literature and obtaining a list and copy of each reference (FAA, SAE, Military etc.) which refers to fireproof and fire-resistance test criteria of aircraft components and materials outside the habitable compartment (e.g. hoses, fuel lines, firewalls, firewall fittings, void filler foams etc.). Additionally, published documents and photographs, including those available from private industry, will be obtained of test fixtures used by any source for fireproof and fire resistant criteria. The contractor will also identify areas where criteria is not by the use of different fire test fixtures on the same product. The contractor will also through review of reports and personal contact, ascertain as accurately as possible the range of severity of fires within a nacelle, wheel well, or wing during an in-flight fire. Range of severity will include, but which will not necessarily be limited to, range of temperatures, range of heat flux, and fire duration prior to detection and/or extinguishment. Whether in-flight fires were of an oxidizing or reducing nature should also be ascertained, if possible. This information should be obtained for fires aboard military, commercial, and general aviation aircraft whenever possible. A theoretical approach to the severity aspect is also desired.

The resultant study will be documented in a single report. This report will be used to assess the adequacy of the currently used test burners. If, upon completion of this phase, it is determined that the existing burners are inadequate as fire test fixtures, a second contract will be let to design and fabricate a burner to meet proposed revisions to fire test criteria. Burner flame criteria will be based on the first study, and flame characteristics (temperature, heat flux, oxidizing/reducing) will be adjustable within the range determined by this study. This burner will then be tested and checked out extensively in an in-house effort for possible use in laboratory-type tests for fireproof and fire-resistant materials and components testing.

An additional in-house effort will be conducted using a propane torch which was designed and fabricated in-house and which is currently stored at the FAA Technical Center. This propane torch will be used in conjunction with a combustion controller currently at the Technical Center. The combustion controller will be checked out and placed in proper operating condition by the original supplier or other qualified contractor. An effort will be made to match flame characteristics of this propane torch to that of the newly fabricated kerosene torch for a possible dual testing capability. The propane torch would essentially be a stationary test fixture while the kerosene burner is intended to be a portable device as is the currently used 2 gph kerosene burner.

<u>2.4.3.4 Resources and Schedule.</u>

Task	In-House	Contract	Duration
Contractor Study			0.75 yr
Design and Fabrication of kerosene burner		50K	0.5 yr
Testing of kerosene burner	1 MY		0.5 yr
Update of Combustion Controller		10K	0.75 yr
Propane Torch Feasibility study	1 MY		0.5 yr

<u>2.4.3.5 Deliverables.</u>

- o Final Reports
- o New Standard Kerosene Test Burner
- o Propane Torch Feasibility Study
- o Revised Standards for test Criteria and Fixtures

<u>2.4.4 - Development of a Halon Extinguishing Agent Concentration Recorder.</u>

<u>2.4.4.1 - Objective.</u>

The objective of this project is to develop a new generation halon extinguishing agent concentration recorder based upon state-of-the-art technology for use specifically in aircraft powerplant nacelles having high velocity cooling airflow.

<u>2.4.4.2 - Background.</u>

Since 1952, a unique concept airborne extinguishing agent concentration recorder, developed jointly by FAA/USAF and marketed by Statham Laboratories, has been used almost exclusively for powerplant fire extinguishing system certification tests for commercial and military aircraft. This recorder is also used extensively by foreign manufacturers for this purpose. Engine and nacelle design concepts have changed greatly since the introduction of the Statham analyzer in 1952. There are some serious questions being raised about the ability of this analyzer to accurately quantify extinguishing system agent concentrations under the high nacelle cooling airflow conditions that are present in certain existing and design-stage aircraft. If this is the case, there will be increasing difficulty in the future in FAA and military certification of onboard aircraft powerplant fire-extinguishing systems.

2.4.4.3 Technical Approach.

This project will be a combined in-house/contractual effort. Possibly the greatest concentration of expertise in this Country in concept, operation, and in-flight and ground utilization of the currently used Statham analyzer is now in existence at the FAA Technical Center. The majority of this project will, therefore, be conducted at the Technical Center using Center expertise, Statham analyzers, and technical facilities.

The first phase of the project will be an effort to verify that a problem does indeed exist with the current analyzer concept under selected simulated in-flight test conditions. Various Halon agents will be discharged into a high airflow environment using an existing F-111 fuselage/nacelle/engine test bed at the Air Blast Facility, and the resultant concentrations will be recorded and analyzed with FAA-owned Statham instrumentation. A simultaneous and parallel contractual effort will be made to measure and technically verify the concentrations by whatever alternate methods available. The success of this phase depends on the presumption that the contractual expertise and alternate instrumentation exist for rapid and accurate measurement of Halon gas concentrations in a high velocity airstream. The contractual results will then be compared to the Statham analyzer results. If a significant difference exists between the results, a second project phase will be instituted.

The second phase will be contractual effort and will consist of the design and fabrication of two halon agent concentration measurement/recording systems. One system will contain 12 data channels and will be capable of operating in an in-flight environment using aircraft electrical power, and the second system will contain 18 channels and will be a ground-based unit for 115 VAC, 60-Hz electrical power.

The delivered analyzers will be thoroughly tested in-house at the Air Blast Test Facility in cooperation with the supplier. Any design deficiencies of anomalies will be noted and submitted to the contractor for resolution.

2.4.4.4 - Resources and Schedule.

	In-House M/Y	Duration	Cost
Statham Studies	2	0.5 yr	$ 10K
New Concept Equipment	0.5	1.5 yr	$200K
Evaluation	1	1.0 yr	$ 75K

2.4.4.5 - Deliverables

- o Final report verifying Statham concept
- o Two state-of-the-art Halon concentration recorders
- o New test method

2.4.5 Milestone Schedule.

The milestone schedule for the projects and tasks comprising the powerplant fire protection element of this program is shown in figure 4. The milestone schedule is based on the resouce requirements shown in table 1 and the assumption that the current Cabin Fire Safety Program will be completed completed by October 1, 1984.

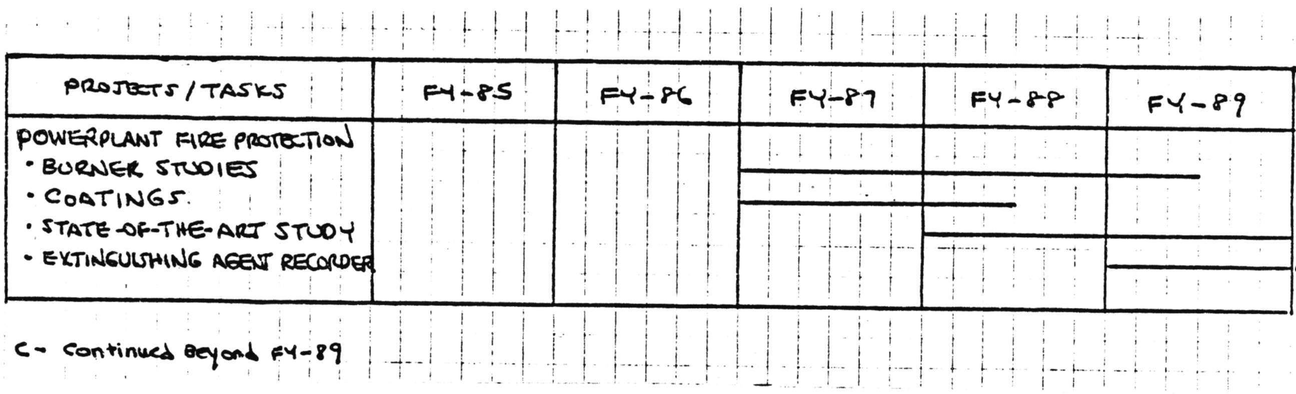

FIGURE 4. POWERPLANT FIRE PROTECTION MILESTONE SCHEDULE

2.5 ADVANCED CONCEPTS.

2.5.1 Theoretical Modeling.

2.5.1.1 Objective.

The objective of this project is to provide computational procedures that can be used to predict growth of fire and its effects in a range of aircraft scenarios.

2.5.1.2 Background.

For over a decade the FAA has supported development and applications of mathematical models of aircraft fires. The original goal was the development of computer codes that could predict the development of aircraft fires when material properties were available from small laboratory tests. Because of the expense of full-scale tests, it was felt that a computer code would play a pivotal role in improved material performance standards by providing an alternative way of determing the role of an individual material in an aircraft fire. In this manner, a material would be characterized in a single small test or in several small tests. The resulant properties along with the material usage in the aircraft would be inputs to a computer program. The contribution of that material alone and through synergistic effects to fire hazards could thereby be determined in an economical fashion. This strategy has proven to be on the optimistic side, and the goal has proven to be elusive, thus far. Nevertheless, the agency sponsored work in this area has resulted in computer programs for aircraft fires equivalent in sophistication and utility to those developed by or for other governmental units. These programs have clearly advanced the basic understanding of enclosure fires and have been useful in selecting practical applications.

It is not at all certain how much more development would be needed to accurately predict the data from a full-scale fire test (postcrash with interior material involvement). Given the initial inflated expectations of mathematical modeling and the actual experience over a 10 year span, no assurances can be made that the original goals of mathematical fire modeling will be attained in the near future. On the other hand, the existing capabilities in this area represent a significant investment and at the very least provide some sound technical underpinnings to the FAA fire safety effort. The prudent course of action, therefore, is to maintain this technology in an active state and enhance the capabilities at a moderate rate. On a routine basis, some of the contractor models developed in the past will be used to support large-scale test efforts in this program. The Cargo Compartment Fire Model which was developed in 1982 will be applied to the Lavatory Fire Protection effort (see 2.1.1.1). DACFIR 3 will be applied to specific scenarios in the Emergency Smoke Venting effort (see 2.1.1.2).

2.5.1.3 Technical Approach.

The technical approach is to utilize existing programs in-house and attempt to interface the models with on-going experimental work. Enhancements will be done on a contractual basis.

2.5.1.4 Resources.

Two man-years per year are required to utilize the computer codes in house. Annual contractual dollars are 250K.

2.5.1.5 Schedule.

This will be a 5-year effort with milestones variable with the change of the state-of-the-art. However, directions will be established through a formal reassessment of the effort in year 1.

2.5.1.6 Deliverables.

The deliverables will be updated versions of DACFIR and UNDSAFE or other zone and field models.

2.5.2 Physical Modeling Pressure.

2.5.2.1 Objective.

The objective of this effort is to maintain existing and develop better techniques of small-scale modeling to guide and support full-scale fire test efforts.

2.5.2.2 Background.

Physical modeling of aircraft fires involves judicious scale-down of fuselages or components so that data can be collected which is equivalent to that obtained from a full-scale test. Initially, in 1977 when the FAA started this effort, the techniques were used to design the currently used full-scale postcrash test configuration. The early work involved exposing a 1/4-scale fuselage to external fuel fires and result in characterization of pool fire radiation as well as effects of wind and door openings. Subsequently, the same 1/4-scale model was used to perform preliminary test on interior materials, advanced windows, and fire blocking curtains. All these preliminary tests were followed by full-scale fire tests. Current model work involves a nominal 1/4-scale enclosure wherein aircraft panels are exposed to an interior fire and the flashover phenomenon is created. This is part of a round-robin series to determine what standard laboratory tests will best correlate with the model flash-over data. The current effort will be followed by full-scale tests to validate the results for rulemaking. This 1/4-scale modeling at atmospheric pressure is generally called Froude modeling. This modeling is used as a working tool to support the full-scale fire test efforts.

Under contract, the FAA has also supported efforts in pressure modeling. In principle, by increasing pressure as scale is reduced, fire phenomena can be modeled in more generality than is possible in Froude modeling. While the Froude modeling has been moved out of the research phase into a working tool for the FAA, pressure modeling like mathematical modeling is very much in the research phases. Like with mathematical modeling, the long range plan with pressure modeling is a less costly alternative to full-scale testing. Also as with mathematical modeling, FAA pressure modeling work provides significant technical underpinning to the overall FAA fire effort.

Because material flammability can be related to either pressure or oxygen mass fraction, the pressure modeling effort not only forces a clearer understanding of material burning process but also naturally leads to description of altitude effects on fire growth.

Froude modeling will continue to be used on a routine basis and pressure modeling technology will continue to be developed at a moderate pace.

2.5.2.3 Technical Approach.

The work on fire modeling will be done primarily in-house. The 1/4-scale fuselage and model pad will continue to be used at the burn site on an "as needed" basis. The enclosure type fire modeling such as the flashover work will be done in the full-scale fire test facility beyond FY-84. (It is currently done in the Froude modeling facility). The 5-foot airflow facility will be used for model tests of in-flight smoke venting and the altitude chamber, along with the pressure modeling facility, will be used to develop the pressure modeling technolog and develop the data base for altitude fire behavior. In particular, Froude modeling will be used for a comprehensive evaluation of the capabilities of various smoke venting procedures. While the Emergency Smoke Venting project (see 2.1.1.2) will focus on the interaction of pressure and ventilation on the development of in-flight fire hazards, the Froude modeling will be used for evaluating the various existing and potential venting techniques from an aerodynamic viewpoint.

Froude modeling will be used to determine the efficiency of static and dynamic port openings (windows, scoops, exits) in enhancing smoke removal.

2.5.2.4 Resources.

This work requires 5 man-years per year and 120K per annum for supplies and equipment.

2.5.2.5 Schedule.

Because of the support role of physical modeling, the effort is considered on-going.

2.5.2.6 Deliverables.

The deliverables are Froude modeling inputs to design of full-scale tests and the development of pressure modelng as a practical testing tool.

2.5.3 Aircraft Command in Emergency Situations.

2.5.3.1 Objective.

The objective of Aircraft Command in Emergenc Situations (ACES) is the development of a prototype software and hardware module that would prompt the crew on the best course of action during an in-flight fire.

2.5.3.2 Background.

Currently, during an in-flight fire situation, the crew can consult an emergency manual on what the should do. There are a number of shortcomings in the current approach.

a. Consulting a manual under emergency conditions is time-consuming and potentially error producing.

b. Instructions in the manual are limited in capability.

c. Instructions are general and not interfaced with minute-by-minute developments.

d. In hidden fires, the crew has no way of knowing the immediate airworthiness state of the aircraft.

The ACES concept involves integrating the procedural findings from the in-flight fire project (2.1.1.1 and 2.1.1.2) with existing sensor determinations in a small computer so that the crew can be prompted on a continuous basis what action to take. Existing sensors are those that already are in place in the aircraft fuselage and provide the warning signal which indicate possible malfunctions.

This would afford the opportunity for the crew to use their sovereignty over the aircraft environment most effectively to control fire and minimize damage to the aircraft and harm to the occupants.

2.5.3.3 Technical Approach.

The technical approach will be that of developing the host computer with the appropriate architecture and using the projects (2.1.1.1 and 2.1.1.2) to provide the software constraints, requirements, and data bases as those project findings become available. At the end, the prototype will be completely demonstrated in the in-flight facility (3.2.2) and partically demonstrated with flight tests.

2.5.3.4 Resources.

The resources per year are identified as to manpower and dollars (contract)

	Manpower (MY)	Dollars
Year 1	2	200K
Year 2	4	200K
Year 3	4	400K
Year 4	6	200K
Year 5	10	1,500K

The manpower needs are primarily in the microprocessor/programming/electronics area.

2.5.3.5 Schedule.

6 months	Detailed project plan
24 months	Complete contract on sensor availability in aircraft
36 months	Hardware modules with basic architecture and sample programing
48 months	Integration of results from projects (2.1.1.1 and 2.2.2.2)
10 months	Final prototype

2.5.3.6 Deliverables.

Prototype device and equipment specifications.

2.5.4 Milestone Schedule.

The milestone schedule for the projects and tasks comprising the advanced concepts element of this program is shown in figure 5. The milestone schedule is based on the resouce requirements shown in table 1 and the assumption that the current Cabin Fire Safety Program will be completed completed by October 1, 1984.

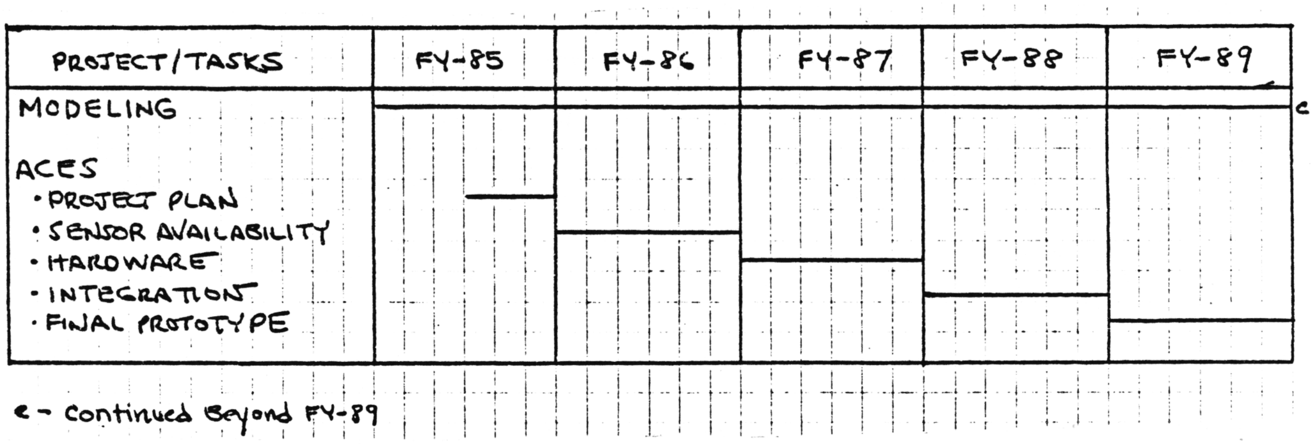

FIGURE 5. ADVANCED CONCEPTS MILESTONE SCHEDULE

2.6 ACCIDENT INVESTIGATION, SITE INVESTIGATION.

2.6.1 Accident Investigation, Site Investigation.

2.6.1.1 Objectives.

The objectives of this project are as follows: (1) Provide technical expertise on aircraft fires to the National Transportation Safety Board during the field investigative phase of aircraft accidents involving fire; (2) Obtain first hand information concerning aircraft accidents for input into R&D projects in the fire safety area.

2.6.1.2 Background.

Due to the unique nature of the work performed by the Fire Safety Branch, technical expertise exists in that Branch that is not available anywhere else. The NTSB has, in the past, regularly called upon the Fire Safety Branch for support and technical advice during the field phase of many aircraft accident investigations. This association has not only benefited the NTSB in their investigations but also the FAA, leading to more realistic and timely R&D projects. Two prime examples of timely R&D projects generated by the participation in an accident investigation are the evacuation slide work (Continental DC10 at LAX) and the cargo fire work (Saudia L1011 Ryaid, Saudi Arabia).

2.6.1.3 Technical Approach.

Provide technical expertise, upon request by ASF-100, during the field phase of aircraft accident investigations.

Resoures

Funding

Travel Funds	10K per year
Miscellaneous Funds	2K per year

Man Power

1/4 Engineer man-year per year
1/12 Technican man-year per year

2.6.1.4 Schedule.

The project will be in effect the full 5 years of this plan. Work each year will depend on the number of fire related aircraft accidents.

2.6.2 Accident Investigation, Experimental Analysis.

2.6.2.1 Objectives.

The objectives of this project are as follows: (1) Provide technical expertise and facilities at the request of NTSB, through ASF-100 (AVS), for the purpose of conducting tests to determine the cause or propagation of fire during an aircraft accident; (2) Conduct experimental testing in conjunction with an aircraft accident that may result in recommendations, through ASF-100 (AVS), that could improve aircraft fire safety.

2.6.2.2 Background.

In the past, the NTSB has requested the Fire Safety Branch to conduct various tests in conjunction with the investigation of an aircraft accident. The Technical Center's unique technical expertise and facilities (such as full-scale and laboratory fire test facilities and a chemistry lab.), make it the ideal location for the conduct of tests that may lead to finding the cause of an accident and/or the improvement of aircraft fire safety. The analytical chemistry lab has performed analysis on various fluids from accident investigations. These materials were analyzed per ASTM and MIL spec's. Examples of materials analyzed are: water from toilet flush tanks, kerosene fuels, hydraulic fluids, and deicing fluids.

2.6.2.3 Technical Approach.

Provide technical expertise and facilities, upon request by ASF-100, for the conduct of experimental tests in conjunction with an aircraft accident investigation.

2.6.2.4 Resources

Funding

Travel Funds	3K per year
Miscellaneous Funds	5K per year

Man Power

1/12 Engineer man-year per year
1/6 Technican man-year per year

2.6.2.5 Schedule.
The project will be in effect the full 5 years of this plan. Work each year will depend on the number of fire related aircraft accidents.

2.6.2.6 Deliverables.

A report of each test will be supplied to NTSB, through ASF-100.

2.6.3 Accident Investigation, Course Lectures.

2.6.3.1 Objective.

Provide guidance to aircraft accident investigators in fire related areas.

2.6.3.2 Background.

In many cases, R&D programs and the implementation of safety changes are dependent on having enough statistical data available to support them. For this information to be there, investigators must know what to look for, what is important and how to make it available to researchers. General accident investigation knowledge is usually obtained through courses given by the Transportation Safety Institute.

That organization has requested that a member of the Fire Safety Branch lecture on in-flight and ground fire patterns at each of their advanced aircraft accident investigation courses.

2.6.3.3 Technical Approach.

Provide the Transportation Safety Institute with a fire safety expert to lecture on accidents and aircraft fire safety at each of their advanced aircraft accident investigation courses.

2.6.3.4 Resources.

Funding

Travel Funds	3K per year
Miscellaneous Funds	1K per year

Man Power

1/24 Engineer man-year per year

2.6.3.5 Schedule.

The project will be in effect the full 5 years of this plan. Work each year will depend on the scheduling of the Transportation Safety Institute.

2.6.3.6 Deliverables.

Better educated accident investigators in the area of aircraft fires.

2.7 REIMBURSABLE AGREEMENTS.

2.7.1 FAA/USAF Aircraft Fire Protection Program.

2.7.1.1 Objective.

The objectives of this program are to evaluate new concepts for the prevention, detection, and control of aircraft fires; to establish the effectiveness of various fire protection measures; and to establish advanced aircraft engine/nacelle/fuel and flammable systems simulation test criteria.

2.7.1.2 Background.

In the early 1950's, the Air Force and the FAA (then CAA) decided that since both military and civilian in-flight fire protection fields were similar in nature, a joint pooling of resources, expertise, and effort would best serve the interests of the aviation community. The benefits derived from this mutual approach have been significant, and, in recognition of this fact, the program has continued in an uninterrupted fashion for over 30 years. Although originally designed to address in-flight fire protection for the engine and nacelle, the program has expanded over the years and now includes both ground and in-flight fire protection of the entire aircraft and of the systems and components contained thereon.

Though now sponsored directly by the U.S. Air Force under the direction of the Wright-Aeronautical Laboratories at Wright-Patterson Air Force Base, Ohio, the program has included participation and funding by the U.S. Army and the U.S. Navy. Other direct beneficiaries of the program have included Governmental agencies such as NASA, U.S. Marine Corps, Bureau of Mines, Coast Guard, and the Royal Canadian Air Force.

The current FAA/USAF program, as developed over the past 30 years and projected through 1990, defines specific areas of cooperation. The USAF transferred six DOD positions to the Technical Center for accomplishment of this effort. These positions are not included in the FAA Technical Center authorized personnel ceiling. The Air Force provides P, C, and B funding, limited travel money, and project requirements in the form of a 1-year renewable Military Interdepartmental Purchase Request, which is subject to a 10 percent FAA administrative charge. The Air Force also supplies special test articles, materials, and components. The FAA, in turn, agrees to supply project personnel, full-scale and component test facilities, instrumentation, fire expertise, and associated project support such as photography, report processing, test article buildup, and facility upkeep.

As users of aircraft, the Air Force benefits through rapidly improved fire protection, direct application of state-of-the-art fire protection technology, and data inputs for military aircraft accident investigations. The FAA benefits from the availability of a sound data base for regularoty and advisory actions, and from advanced information on military fire protection technology which is generally adapted from the original military concept to utilization in new generation commercial aircraft and, finally, joint benefits are derived from the existence of a common proving ground for advanced concepts in fire safety for military/commercial/general aviation aircraft.

2.7.1.3 Technical Programs.

Two broad technical programs areas are addressed under this agreement. Although military oriented in their original conception, it is clear that these programs have direct application and benefit to the entire aviation community.

2.7.1.3.1 Aircraft Systems/Components Fire Protection.

The overall program goals are to test, evaluate, and develop state-of-the-art and advanced concepts for the prevention, detection, and control of aircraft fires external to the engine/nacelle installation; to provide test facilities and data for fire related accident investigations and manuals, and to define and establish fire test methodology and standards. Examples of proposed fire safety studied in this area include intumescent and ablative materials, fire retardant void filler foams, advanced fire extinguishers for aircraft habitable compartments, fuel tank filler materials, wheel-well fire protection, and composite and advanced structural material fire testing.

2.7.1.3.2 Aircraft Engine/Nacelle Fire Protection.

The overall program goals are to test, evaluate, and develop state-of-the-art and advanced concepts for the prevention, detection, and control of engine/nacelle fires; to establish the effectiveness of various fire protection measures; and to establish advanced aircraft fire scenarios and simulated in-flight test criteria. A full-scale F-111 aircraft with an operating TF-30 turbine engine, considered representative of an advanced high-performance aircraft installation, is currently being used for simulated in-flight fire safety studies. Examples of proposed engine/nacelle investigations include bleed-air duct leak detectors, fire detector systems, extinguishing systems and agents, fuels and lubricants, hydraulic oils, hot surface ignitions, construction and structural materials, cooling airflow patterns, fire isothermal mapping, and fire hardening methods.

2.7.1.4 Resources.

The primary facility used to support the AIRCRAFT ENGINE/NACELLE FIRE PROTECTION program, Section 2.7.1.3.2, is the existing AIR BLAST TEST FACILITY, Section 3.1.6. A proposed facility, the AIRCRAFT COMPONENT FIRE TEST FACILITY, Section 3.2.1., is considered essential to the accomplishment of the AIRCRAFT SYSTEMS/COMPONENTS FIRE PROTECTION program, Section 2.7.1.3.1. All work done on these programs will be accomplished in-house with positions supplied by the DOD. The estimated level of effort and budgeted Air Force monies are as follows:

FY	Estimated EY	Authorized AF Funds (P,C,&B)
1984		
1985	4.5	$220K
1986	4.5	$220K
1987	4.5	$220K
1988	5	$220K
1989	5	open
1990	6	open

In addition to these yearly staffing funds, the AF has provided test articles, turbine engines, FAA facility air supply engines, and specialized equipment and materials valued in excess of 4.5 million dollars for accomplishment of this effort.

2.7.1.5 Schedule.

The schedules for the many individual projects in the two major program areas are based upon mutual agreement between FAA and AF. The priorities for the individual projects, however, are based upon Air Force requirements. The scheduling, consequently, must remain flexible and is difficult to unilaterally project over a 5-year period.

2.7.1.6 Deliverables.

The major deliverables will be formal final reports leading to advances in the state-of-the-art for fire test standards, test simulation criteria, fire prevention measures, fire and overheat detection systems, and fire extinguishment and control techniques for in-use and new generation aircraft.

2.7.2 Reimbursable Agreements - Potential Areas.

The resources of the Aircraft Systems Fire Safety Program and Fire Safety Branch — experienced personnel and extensive facilities — could be employed in fire safety studies for applications other than civil or military aircraft. As described in section 2.7.1, a continuing program exists with the Air Force covering a broad range of fire safety topics. A small interagency agreement with the Transportation Systems Center provides standardized testing of urban mass transit vehicles. These examples illustrate this capability. Moreover, as exemplified by test work to support accident investigations by NTSB (section 2.6), the equipment and experience is readily available to expeditiously set up and instrument novel experiments. In terms of scope, the fire test facilities at the FAA Technical Center may be unsurpassed anywhere in the world. The Full-Scale Fire Test Facility is the second largest enclosed fire test bay in the United States, designed to withstand a large fuel fire. Hundreds of measurements may be taken of temperature, heat flux, smoke density, oxygen and numerous toxic gases under realistic fire test conditions. The Materials Fire Test Laboratory houses numerous small-scale fire tests standardized by FAA, ASTM, SAE, and NFPA, and two new test methods developed by Technical Center employees which are the basis for recently issued regulatory notices for seat cushion fire blocking layers and cargo liners. The Analytical Chemistry Laboratory contains instrumentation for the measurement of toxic gases and animal handling (rodents) capability for combustion toxicity studies. The Air Flow Facility has a broad range of capabilities, including simulating flight conditions in small aircraft or engine nacelles, pressure modeling, theoretical fire modeling using a VAX 750 computer and fuselage smoke venting. Finally, the Froude Modeling Facility contains a number of reduced scale models for various fire related applications.

Over 30 years of FAA experience exists in aircraft fire safety. The following is a generalized list of past work which can be brought to bear on any fire problem or fire study:

- o Engine fire detection and extinguishment
- o Detection of combustion chamber failure
  Flammability, smoke and toxic gas test method development
- o Full-scale fire tests
- o Total flooding systems
- o Compartmentation
- o Fire burn-through
- o Flame spread
- o Theoretical and physical fire modeling
- o Cargo compartment fire safety
- o Emergency lighting
- o Portable fire extinguishers
- o Flashover and flash fire
- o Smoke venting
- o Fuel tank inerting with liquid nitrogen
- o Postcrash, in-flight and ramp fire tests
- o Pool fire impact on aircraft fuselages
- o Seat cushion fire blocking layers
- o Seat cushion fire blocking layers
- o Heat resistant evacuation slides
- o Toxicity
- o Correlation of small- and large-scale fire tests
- o Window burn-through
- o Measurement of toxic gases
- o Investigation of major aircraft fire accidents
- o Flight recorder fire protection
- o In-flight measurement of discharged extinguishing agent concentrations

- o Combined hazard analysis
- o Fuel tank explosion hazards
- o Hazards of burning materials

The fire technology accumulated in the past few years in aircraft fire safety represents a significant advance in the state-of-the-art and contains a wealth of technical information that is transferable to not only other modes of transportation but also to the building industry.

3. FACILITY REQUIREMENTS.

3.1 EXISTING FACILITIES.

3.1.1 Material Fire Test Laboratory, Building 203.

Building 203 contains a number of small-scale fire test methods frequently used to evaluate the performance of aircraft cabin materials. Many of the test methods are standardized by the American Society of Testing and Materials (ASTM). Some of the test methods are in the process of being standardized, while others are used for research purposes only. The test methods are located in test cells equipped with smoke ventilation equipment. Building 203 also contains a shop area, material conditioning (temperature and humidity) chambers and a buildup area required for test apparatus maintenance and modification and sample preparation. Office space exists in the front of the building.

Improved methods of testing were the result of research and testing in this facility. FAA flammability requirements are contained in FAR 25.853 (a&b); the basis is the vertical test apparatus (ASTM-F-501). At present, the following additional test methods are in building 203: (1) the radiant panel (ASTM E-162), (2) horizontal test method (ASTM F-776), (3) evacuation slide test method (ASTM F-828), (4) OSU rate of heat release apparatus (ASTM E-906), (5) seat blocking fire test (undergoing evaluation), (6) NBS smoke chamber (ASTM F-814), (7) flooring radiant panel (ASTM E-648), (8) cargo liner test (undergoing evaluation application), (9) limiting oxygen index (ASTM D-2863), (10) setchkin burner (ASTM F-777). The OSU apparatus has been extensively modified for toxic gas analysis and computerized data acquisition to calculate the combined hazard index (CHI) of a burning material.

3.1.2 Airflow Facility (Building 204).

The airflow facility, until 1981, consisted of one capability which was a 5-foot diameter test section with velocity capabilities up to a Mach number of 0.85. This test section is part of an induction-type airflow facility driven by two J57 turbojets. The facility was originally used for powerplant fire protection testing.

This facility has now been modernized and expanded to include a number of new capabilities and test beds. A low speed test section of 10-foot diameter was added to the inlet section so that light aircraft could be tested at simulated flight conditions. This new section currently contains a Cessna 210 used for hand fire extinguisher studies. A high pressure (1000 psi) air capability consisting of a 120 cfm compressor and storage tank has been added to the existing 100 psi facility compressed air capability. The high pressure system is configured to feed both the high pressure fire test vessel (see 2.5.2.) as well as a B707 fuselage on the facility for in-flight smoke venting certification procedure development. Data acquisition capabilities have been enhanced by installation of a DEC VAX-750 computer and by a centralized video data acquisition system. The facility in its current configuration and final configuration (see 3.2.3.) represents an Environmental Complex unique in the Government for simulating the wide range of conditions that influence in-flight fires.

3.1.3 Froude Modeling Facility (Building 204).

The Froude Modeling Facility is a warehouse-type building, 102 feet long and 39 feet wide. The buildings' sidewalls are 20 feet high, and a 26-foot high peak runs the length of the building. The building has a series of modifications that make it suitable for fire tests (see 2.5.2). These include large-volume, low-pressure fans for smoke removal, an attached control room housing a DEC MIVC 11 computer for data acquisition, louvered lighting sources to keep the building illuminated during tests resulting in deep smoke layers, and a 64-square-foot hood for evacuating toxic products during specialized material tests.

The Froude Modeling Facility currently houses a wide range of models ranging in size from a 48-cubic-foot flashover model to a 1/5 scale model of the Full-Scale Fire Test Facility.

In addition to the current active work on flashover phenomena with aircraft interior materials, the facility has recently been used for a wide range of tests. A partial listing includes the following:

a. Evaluation of intumescent coatings on hose assemblies
b. Characterization of aviation fuel fire radiation
c. Comparison of the relative effectiveness of the halons 1011, 1211, and 1301
d. Verification testing for the Harvard model on fire penetration into fuselage doorways

3.1.4 Full-Scale Fire Test Facility (Building 275).

The function of this facility is to provide a controlled environment in which to conduct full-scale aircraft fire test programs. The test area is 180 feet long, 70 feet wide and 40 feet high, and is capable of withstanding localized temperatures of over 2000° F, indefinitely. The center 70-foot by 70-foot section of the test area ceiling is constructed of 2-inch thick refractory plaster and can tolerate a constant temperature of 2200° F. Two vents in the test area ceiling allow smoke to exit the area during and after test fires. All exposed electrical wiring in the test area are ceramic-insulated wires inside a copper sheathing.

The facility consists of the test area, office and operation areas, buildup shop, computer room and electrical and mechanical rooms that contain the facility operating equipment (boiler, generators, vacuum pump, etc.). The buildup area allows project personnel to fabricate and assemble all types of test furnishings and equipment.

The test bay currently houses a surplus USAF C133 aircraft modified to resemble a wide-bodied passenger aircraft. This test article is used for simulating postcrash and in-flight fires. The bay also contains a fuselage section of a DC10, and DC30, that is being used for the cargo compartment fire test program.

The facility computer room contains a Data General Nova 3 computer that collects and records data from various test instrumentation that is located both inside and adjacent to both test articles. This instrumentation includes Beckman Instrument Company infrared carbon monoxide, carbon dioxide, and Halon 1301 analyzers and polarographic oxygen analyzers. Also, temperatures, smoke density, and heat flux is recorded directly by the computer. A Texas Instrument 99/4A computer system is also used in the facility to assist in recordkeeping, report writing, etc.

Due to the large amount of dirt and carbon residue generated by the test fires, two washdown hoses are installed in the test area for cleaning purposes. The waste water from the cleaning operation is directed to a 3000-gallon underground hold tank for proper disposal. Test article fire protection is provided by both a 900-gallon water/foam tank installed in the test area and a 7.5-ton carbon dioxide tank located externally at the rear of the facility. There is no installed fire extinguishing equipment for the facility itself, however every room in the building contains thermal detectors with both local alarms and hookup to the central fire dispatch center on the Technical Center.

Both the test area and the shop have electrical outlets which supply 28 VDC, 115 VAC, 60 Hz, and single phase 115 VAC, 400 Hz power. Also, a large movable fan in the test area can provide velocities as high as 10.5 mph to simulate wind conditions during C133 pool fire tests.

3.1.5 Analytical Chemistry Laboratory.

The Chemical Analysis Laboratory is located adjacent to the Full-Scale Fire Test building in the R&D area of the Technical Center. It is staffed with four chemists and a technician.

The prime responsibility for this support effort is the sampling and analysis of toxic gases from full-scale fire tests run in building 275. Time/concentration analytical profiles are produced for specific points within a test article. These graphic reports are produced for acid gases and cyanide gas, using ion and gas chromotographic methods of analysis, respectively. These reports are combined with other reports of gases that are automatically analyzed, (i.e. oxygen) and information on smoke and temperatures. The combination of all information is analyzed for impact on survivability. A second effort is the development of laboratory sized testing devices that can be used to comparatively rank materials for their contribution to fire hazards. A prime example is the adaptation of the OSU apparatus to measure a series of toxic gas emissions in order to generate a Combined Hazard Index (CHI). The laboratory is also equipped to perform toxic gas exposure tests on rats, for example the CAMI ranking test. The laboratory analytical devices are supported by computers, hardware and software. The chemists are trained to write and modify software programs to adapt them to changing demands.

A third effort conducted in the laboratory is in the area of fuel testing. The laboratory has the ability to perform half of the ASTM tests required for aviation kerosene (jet A). The laboratory also runs other tests in support of the program to develop and introduce antimisting kerosene to the civil fleet.

The fourth effort is the conducting of special analytical tests for the National Transportation Safety Board in their investigations of the causes of aircraft accidents.

A fifth effort is the analyses of materials within the environment of the Technical Center in the support of Health and Safety Programs. The chemical laboratory is well equipped with state-of-the-art analytical tools to perform analysis on fire gases, fuels, potable water, waste water, and a variety of solid, liquid and gas samples of unknown materials.

3.1.6 Air Blast Test Facility.

3.1.6.1 Function.

This unique fire test facility is designed to provide high mass, high velocity airflow for simulated in-flight fire safety studies of full-scale aircraft engine/nacelle installations, components, and external aircraft surfaces.

3.1.6.2 Description.

Facility operation is accomplished by in-house personnel. The simulated in-flight airflow for the facility is generated by a single Pratt-Whitney YTF-33 turbofan engine. The uncontaminated bypass fan air is collected at the fan exit and delivered to the test article through a 30-inch diameter duct. The ducting is branched, and a series of movable duct gates allow supply and control of air to one or more test articles, simultaneously. The test article(s) can be situated on either of two abutting reinforced concrete test pads. The first test pad is 25 feet by 25 feet in size and is used for component testing. The second test pad is 75 feet by 100 feet in size and is used primarily for full-scale aircraft testing. The larger test pad incorporates a water deluge system capable of washing the pad with 3400 gallons of water in less than 1 minute in the event of a large fuel spill fire emergency. Any burning fuel/water mixture is diverted to a remote 6000 gallon holding tank for personnel safety and to minimize fire damage to the full-scale test article. The test pads are lighted for night work and have ample power outlets located around their perimeters.

Facility instrumentation and operation are controlled within a large trailer protected by a steel barrier structure. A second adjoining trailer is used for machining, component buildup, and storage.

The facility has additional buildings for extinguishing agent container filling; electrical power generation and transmission; and flammable fluid pumping, mixing, heating, and distribution to any desired test article. The facility also contains three large capacity underground fuel tanks and a complex buried system of instrumentation conduit and hydraulic, pneumatic, and flammable fluid lines.

The only other facility in this Country of similar design and utilization is the U.S. Navy DASH facility located at the Naval Weapons Center, China Lake, California.

3.1.6.3 Capability.

The major capabilities provided by this facility are:

1. Variable mass airflows from 0 to 200 pounds per second exiting a 30-inch diameter duct.

2. Variable airspeeds from 0 to 400 + knots exiting a 30-inch diameter duct.

3. Heated flammable aviation fluids variable to 200° F (fuel, engine oil, hydraulic fluid, etc.)

4. Variable boundary layer generation to 8 inches for external fire pattern/ignition/spread studies.

5. Remotely operated motion picture and video camera coverage.

6. Three types of aviation test fuels from buried tanks of 5000/1000/1000 gallon capacities.

7. Total facility intercommunications system for use in high noise level environments.

8. Protected enclosure for instrumentation and personnel during hazardous testing.

9. Wheeled, 150-pound capacity Halon 1211 auxiliary fire protection unit.

10. Steel tiedown fixtures embedded throughout the test pads for adequate securing of test articles using 1-inch diameter bolts.

11. Comprehensive data acquisition utilizing DEC PDP 11/34A computer, data logger, oscillographs, strip-chart recorders, manometer banks, pressure transducers, thermocouples, gas analyzers (extinguishing agent, Co, CO_2, O_2, boundary layer probes, pitot-static probes, flowmeters, strain gages, and closed circuit video/recording system.

12. A weapon mounting pad and protective backstop for conducting military ballistic fire protection studies.

13. Varied electrical power including 115/220 VAC, 60 hertz; 115 VAC, 400 hertz; and 28 VDC.

3.1.6.4 Upgrading Requirements.

The 10+ year old trailers and other temporary buildings comprising this facility should be replaced with a single permanent structure capable of housing project personnel, instrumentation, a computer, a machining and buildup area, a storage area, and facility control consoles. Cost for this structure and associated site improvements (parking, grading, etc.) is estimated to be \$350K. If the proposed AIRCRAFT COMPONENTS FIRE TEST FACILITY, described in Section 3.2.1 were constructed adjacent to the AIR BLAST TEST FACILITY as approved by the Center Master Planning and Siting Board, the two facilities could be combined into a single structure, thus eliminating the estimated \$350K.

3.2 PLANNED FACILITIES.

3.2.1 Aircraft Component Fire Test Facility.

3.2.1.1 Function.

This facility is a building designed and constructed specifically for the purpose of conducting fire and environmental testing of aircraft sections, components, systems, and materials.

3.2.1.2 Requirement.

The fire test facilities of the FAA Technical Center and the in-house expertise are nationally and internationally recognized. However, currently there exists a distinct gap in the facility capability. Full-scale and laboratory tests can be adequately undertaken but a facility is needed to conduct component test. Component parts, sections, or systems of aircraft require fire testing before testing as a complete integrated aircraft fuselage, engine or total aircraft. Also, there is a need for a test cell which has high ventilation rates for evacuating smoke and toxic gases for personnel protection and an ability to control environmental factors such as temperature and humidity. This proposed facility would provide the required capability and allow FAA to maintain our leadership in this area which has been established over the past years.

The current long range fire safety plan (Red Book, chapter III, pages 40/41, 70/71) and, more specifically, the FY-84 budget submission calls for an assessment of current aircraft design deficiencies to identify parts or systems that need updating to the current sate-of-the-art in fire protection methods and materials. The long range plan calls for looking at the whole aircraft and systems as a fireworthy vehicle beyond that currently emphasized — cabin and cargo compartments. Specific aircraft systems and components have already been identified in the Aircraft Systems Fire Safety Technical Program Plan, 1985-1990, which require the aircraft component fire test facility for timely and efficient testing. These identified items, as well as several other suggested fire study areas, are as folllows:

1. Conduct a system test on the current oxygen system used in aircraft today to determine its vulnerability to fire and its ability to perpetuate a fire.

2. Evaluate the effectiveness of curent an anticipated advanced fire detection and extinguishing systems — cargo and engine.

3. Evaluate advanced concepts in hand-held extinguishers.

4. Test the fireworthiness of current hydraulic systems and their potential as a fire source.

5. Test the fireworthiness of electrical systems and their potential as a fire source.

6. Conduct component fuselage fire tests to determine resistance to burn-through from external pool fire. An important item as we extend survival time inside the cabin by increasing survival time through improved cabin materials.

7. Conduct fire tests on galley and lavatory components for improved fireworthiness.

8. Conduct fire tests on component parts such as engine cowling which are now being designed to use composites. There is a large trend in aviation towards replacing current metals with composites.

9. Test system component hoses and tubing fire resistance under simulated in-flight aircraft vibration.

10. Fireproof testing for nacelle construction materials and methods, including engine firewalls.

11. Test new fire ablative, intumescent, and void filler materials requiring high ventilation rates in test cell.

12. Test fireworthiness of strategic controls such as flight cables when located in vulnerable areas such as near a cargo compartment.

13. Evaluate new extinguishing agent concentration analyzer instrumentation for engine compartment certification testing.

14. Establish burner standards for aircraft component fire testing.

In an effort to continue urgently needed work in the component fire test field, certain past and present projects have had to adapt and utilize alternate facilities not specifically suited for this purpose. In most cases, compromises have resulted in project delays, interference with ongoing work, space limitations, safety concessions, decreased quality of test results, and extended planning and test preparation. Therefore, this proposed facility is considered a necessity to insure rapid response to FAA, military, and industry requests for component tests. Component testing is a dynamic field with new technological advances occurring at a constantly increasing rate. Component testing generally leads to definable and rapidly implemented results. We know of no other facility that has the component and systems test capability and versatility that are planned for the subject facility.

Mr. R. Kirsch, AVS, and Mr. T. Horeff (AWS) verbally suport the construction and utility of this facility.

3.2.1.3 Resources.

Based upon past justifications, budget approval, and congressional authorization, a $44K A&E study was completed in FY-82. This study includes complete plans, drawings, and specifications, and the package is ready for immediate construction bid advertising. The estimated construction costs have escalated from an A&E study projection of $500K in the original authorized FY-82 implementation year to $762K in the FY-85 budget year.

3.2.1.4 Schedule.

Bid advertising procedure — 3 mos.
Construction — 12 mos.

3.2.2 In-flight Fire Test Facility.

3.2.2.1 Definition.

The In-flight Fire Test Facility is a large metal enclosure capable of containing an aircraft fuselage and being evacuated to altitude pressure conditions.

3.2.2.2 Requirements.

The characteristics of in-flight fires are quite different from postcrash fires. The postcrash fire generally involves an external pool fire which can penetrate the fuselage through open doors or ruptures depending on ambient wind conditions. Fuselage fire safety considerations are primarily aimed at preventing interior fire hazards from developing for a long enough period so that occupants have enough time to escape. The fire test conditions are so dominated by a large pool fire, that improvements can be aimed at major phenomena such as fuselage burn-through and flashover prevention under a relatively limited range of parameters.

The in-flight fire, lacking such a strong ignition source as an external fuel fire, tends to be characterized by much longer development times. Additionally, the in-flight fire can occur in many different parts or systems of the aircraft. Forced ventilation rates and altitude/pressure have a strong bearing on the nature of the fire growth (both rate and direction). Handling a non-extinguished in-flight fire in reality is an attempt to land and evacuate an aircraft before the fire grows to a point where it disables the aircraft or the occupants.

Two major control features that can slow fire growth or modify it are the ventilation in the fuselage and the pressure in the fuselage. The only way to develop sound recommendations for manipulating ventilation and pressure is by full-scale fire tests in a fuselage where these two parameters can be varied. Because of the systems nature of such in-flight fires, they are extremely difficult to model. Model tests can only yield a data base on burning rates of materials *per se* but not of real-life configurations of there materials.

Thus, a facility is required that would be approximately 100 feet long and 40 feet in diameter that could accommodate an aircraft and be evacuated to cover a range of altitudes and aircraft ventilation rates.

The chamber will be evacuated with an ejector system driven by turbojet action. The test article ventilation will be fed by a metering system from the atmosphere outside the chamber. The facility will accommodate projects 2.1.1.2 (Emergency Venting), 2.2.2 (Oxygen System Safety), and 2.5.3 (ACES). All of these projects require altitude simulation for definitive results. The 10 B707 fuselages identified under 2.1.1.2 will be used in a sequential and destructive progression and the fuselages will be salvaged as they are damaged beyond further test application.

3.2.2.3 Resources.

Construction of the facility will cost 1,400K.

3.2.2.4 Schedule.

The construction of this facility will take 2 years with the following major milestones.

Month 3	Site selection and design requirements
Month 6	Design complete for foundation and services
Month 9	Contract let for foundation
Month 9	Metal orders
Month 18	Assembly contract let
Month 24	Assembly completed

3.2.3 Environmental Laboratory.

3.2.3.1 Definition.

The existing low-speed wind tunnel and altitude chamber will be moved into a new wing at the Airflow Facility. The resultant complex will also include the Pressure Modeling Facility and will be reidentified as the Environmental Facility.

3.2.3.2 Requirements.

Reconfigurations of buildings from lab or shop purposes to offices have displaced two significant capabilities at the Technical Center. One is the low-speed calibration wind tunnel and the other is the altitude chamber. Both are needed for calibration of sensors, and the altitude chamber is further needed for developing a data base on altitude material burning as related to in-flight fires. A host of other near-term needs for these two entities come from fuel safety (high altitude, low-temperature soaking as well as outgassing in fuel), powerplant fire safety (Statham sensor calibration), and postcrash fire testing (anemometer calibration).

By adding these devices to the present Airflow/Pressure Modeling complex, significant improvements in manpower and equipment utilization will occur. This addition has already been requested and approved and is expected to be on-line at the start of the 5-year program.

3.2.3.3 Resources.

The cost of this modification is approximately 160K.

3.2.3.4 Schedule.

The Environmental Facility is projected to be complete at the start of the 5-year program.

4.0 RESOURCE REQUIREMENTS.

Contact funding and in-house manpower requirements to meet the objectives set forth in this technical program plan are identified in table 1. This information is presented for each of the 17 planned projects through fiscal years 1985 to 1989. Resources are committed — almost entirely — to in-flight fire or related activities. Fiscal year 1985 manpower requirements are consistent with present staffing levels; however, in FY-1986 and beyond, additional manpower is required as shown in table 1, to undertake the complete program.

5. PROGRAM MANAGEMENT.

5.1 GENERAL.

The overall conduct of this program will be accomplished by the Fire Safety Branch, ACT-350, Federal Aviation Administration (FAA) Technical Center. The Fire Safety Branch contains the following four subelements of activity supervised by a "project manager" reporting directly to the Technical Program Manager (TPM):

a. Full-scale and small-scale testing.
b. Modeling and advanced concepts.
c. Chemical analysis and toxicity.
d. Fire management and suppression.

Each project or activity under the four major tasks described in this program plan is assigned to a project manager, or to the TPM for some contractual efforts, who is then responsible for its accomplishment. Projects or activities related generally to medical or human aspects of cabin fire safety, such as toxicity, human survival limits, and protective breathing devices, are usually performed by appropriate groups within the FAA's Civil Aeromedical Institute (CAMI).

Another major subelement - reimbursable (Air Force Fire Protection Program) is supervised by a technical program manager (TPM) reporting directly to the Manager, Fire Safety Branch.

5.2 PARTICIPATION ON TECHNICAL OR ADVISORY COMMITTEES.

Individuals working in the program participate on various fire safety and aircraft safety technical committees to assure maximum integration and benefit from related activities. These committees include the following:

a. NBS Ad Hoc Committee on Mathematical Fire Modeling
b. ASTM E-5 Committee on Fire Standards, and F-7 Committee on Aerospace Industry Methods
c. NFPA Aviation Committee
d. SAE S-9 Cabin Safety Provisions
e. SAE A-20C Aircraft Interior Lighting
f. SAE G-3 Aerospace Fittings, hose and tubing assemblies

The FAA program adheres to the major recommendations of the SAFER Advisory Committee.

5.3 TECHNICAL PROGRAM INTERFACE.

The effectiveness of the Aircraft Systems Fire Safety Technical Program will be enhanced and maintained at a high level by continual interface not only internally within FAA and DOT, but also with National and International organizations prominent in the aircraft fire safety field. Figure 7 illustrates the many interfaces that have led to FAA's worldwide prominence in aircraft fire safety in the past and will continue under this 5-year program.

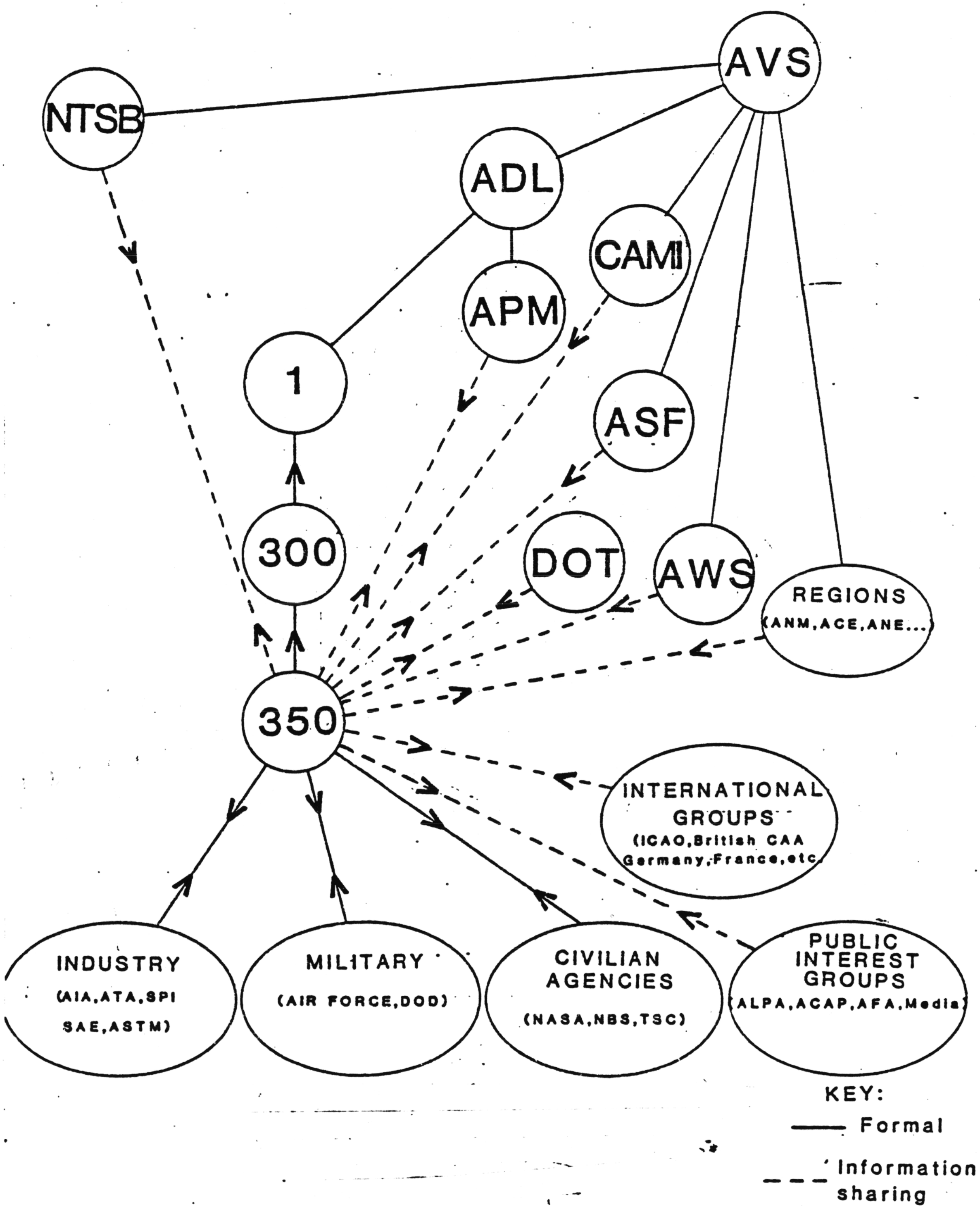

FIGURE 7. AIRCRAFT SYSTEMS FIRE SAFETY TECHNICAL PROGRAM INTERFACE