TECHNICAL REPORT

ON

Propulsion System and Auxiliary Power Unit (APU) Related Aircraft Safety Hazards

October 25, 1999

A JOINT EFFORT CONDUCTED BY THE

THE FEDERAL AVIATION ADMINISTRATION
AND
THE AEROSPACE INDUSTRIES ASSOCIATION (AIA)

Questions concerning distribution of this report should be addressed to: Manager, Engine and Propeller Directorate

CONTENTS

I. SUMMARY

In 1991, the Aerospace Industries Association (AIA) provided the Federal Aviation Administration (FAA) with a study aimed at the development of more effective methods to identify, prioritize and resolve safety-related problems occurring on commercial aircraft engines. The activity was undertaken as a result of the rapid increase in commercial aircraft entering revenue service, leading to a corresponding increase in the exposure to flight-safety events. The AIA team that developed the study was the Continued Airworthiness Assessment Methodologies (CAAM) Committee. This initial AIA study covered a variety of propulsion system and auxiliary power unit (APU) events. Later, the AIA recognized the need to update uncontained engine events, and prepared a supplemental report.

This FAA report is a compilation of both the initial and supplemental data from the above noted reports, and provides historical safety data that document propulsion system and APU-related aircraft safety hazards. The information provided in this FAA report has been used by the Engine and Propeller Directorate since 1994 to help identify and prioritize responses to potential engine, propeller and APU unsafe conditions.

II. BACKGROUND

In 1991, the Aerospace Industries Association (AIA) produced a study to assist the Federal Aviation Administration (FAA) in developing more effective methods to identify, prioritize and resolve safety-related problems occurring on commercial aircraft engines. This activity was undertaken as a result of the rapid increase in commercial aircraft entering revenue service, leading to a corresponding increase in the exposure to flight-safety events. The AIA team that developed the study was the Continued Airworthiness Assessment Methodologies (CAAM) Committee.

Due to the availability of credible data, the CAAM committee limited the scope of its effort to engines, propellers, and auxiliary power units (APU's) installed on transport airplanes. An event characterization system, termed the hazard level, was developed, based on the observed outcome of the event at the aircraft level (CAAM hazard levels are listed in Appendix 2 of this FAA report). Ten years of engine, propeller and APU events were analyzed and grouped by event cause (i.e., uncontainment, fire, etc.) and hazard level. Historical conditional rates of the most serious events (CAAM hazard levels 3 and 4) were also calculated for each cause.

This initial study was issued by the AIA as a report entitled "Initial Report on Propulsion System and APU Related Aircraft Safety Hazards, 1982 thru 1991" (AIA PC-342), which was released to the FAA on May 1, 1993. Several years later, the AIA reformed a new CAAM committee to update uncontained engine events for the time period of 1992 through November 30, 1996, with the intent of measuring and documenting the relative progress which had been made toward minimizing uncontained turbine engine hazardous events. The AIA issued the second report, entitled "Supplemental Report on Turbine Engine Rotor Uncontained Events, 1 January 1992 through 30 November 1996" (AIA PC-342-1), which was released to the FAA on February 5, 1997.

This FAA report is a compilation of both the initial and supplemental data from the above noted reports, and provides historical safety data that document propulsion system and APU-related aircraft safety hazards. The data provided in this FAA report have been used by the Engine and Propeller Directorate since 1994 as an important part of its efforts to prioritize responses to potential engine, propeller and APU unsafe conditions.

III. DISCUSSION

1. The data contained in this FAA report have been used by the FAA's Engine and Propeller Directorate since 1994, and have become an important part of the safety management process. This report serves as a compilation of the initial and supplemental CAAM data, and includes the relevant definitions and descriptions integral to the analyses. The cover letters of the initial and supplemental reports are also included; ellipses (i.e., "...") indicate the removal of appendix/attachment number references within those AIA reports.

2. The conclusions/recommendations developed in the initial report were as follows:

a. The data may be used to prioritize safety-related industry studies, research and regulatory development activities.

b. The data demonstrate the importance of human factors in propulsion/APU-related flight-safety and the need for early industry consideration of how these issues can best be addressed. Additionally, reduction of multiple-engine powerloss events deserves early industry attention.

c. The data will be beneficial to safety professionals within industry in placing the various powerplant and APU-related flight-safety issues into proper context and in guiding decision making related to potential hazards associated with the defined powerplant and APU malfunctions.

d. Further refinement and development of this initial report should continue and user comments and recommendations for enhancements should be solicited.

e. The process developed under CAAM should be considered for other propulsion applications (i.e., turboshaft engines) and, more importantly, the entire aircraft.

3. The conclusion/recommendation developed in the supplemental report was as follows:

a. The 1992-1996 (5-year) time period uncontained event data indicate a reduced rate for uncontained events when considered against the data from the 1982 through 1991 time period. The reduction in uncontained event rates is approximately 50 percent for "All" events and approximately 66 percent for "Serious" and "Severe" events.

4. The data in this report are organized into the following categories:

a. turboprop,
b. low bypass ratio (LBPR) turbofan engines, and
c. high bypass ratio (HBPR) turbofan engines.

IV. APPENDICES

Appendix 1

CAAM Report Cover Letters
AIA PC-342
COMMITTEE ON CONTINUED AIRWORTHINESS ASSESSMENT METHODOLOGY

INITIAL REPORT
ON
PROPULSION SYSTEM AND APU RELATED AIRCRAFT SAFETY HAZARDS
1982 THRU 1991
1 May 1993

FOREWORD

The material presented in this "Initial Report" has been developed by experts from industry and the FAA under the auspices of the Aerospace Industries Association (AIA) Propulsion Committee (PC). At the request of the FAA, the AIA PC formed the Continued Airworthiness Assessment Methodology (CAAM) Committee "…to work together with the FAA to develop guidance and common methods to be used by the FAA and Industry to identify, prioritize and resolve safety related issues occurring on aircraft propulsion systems and APUs."

This "Initial Report" contains the following material:

1) standardized definitions of safety significant propulsion system and auxiliary power unit (APU) malfunctions,
2) standardized definitions of propulsion system and APU related aircraft hazard levels based on the consequences to the aircraft, passengers and crew,
3) data on safety significant event quantities, hazard ratios, rates and generic summaries for severe and serious events during the period 1982 thru 1991; and
4) Pareto prioritization of safety significant propulsion system and APU malfunctions.

The material presented is not separable and should be considered in its entirety. The safety significant events were gathered and analyzed based on the malfunction and aircraft hazard level definitions. These definitions are fundamental keys to understanding the data presented and they are unique to this activity. The material presented is the first comprehensive propulsion system and APU related safety assessment undertaken by Industry (AIA/FAA) and deserves careful consideration.

The CAAM Committee believed that an early release of an "Initial Report" would be justified based on the need for early Industry consideration of this new material. The CAAM Committee fully expects that review and use of this "Initial Report" will lead to clearly defined needs for clarification, expansion or other enhancements. The CAAM Committee intends to continue developing the material presented and reserves the right to modify or otherwise supersede the current "Initial Report" with an improved version.

CONCLUSIONS/RECOMMENDATIONS

The conclusions/recommendations drawn by the CAAM Committee and which are appropriate to an "Initial Report" are as follows:

1) The data may be used to prioritize safety related Industry studies, research and regulatory development activities.
2) The data demonstrates the importance of "Human Factors" in propulsion/APU related flight-safety and the need for early Industry consideration of how these issues can best be addressed. Additionally, reduction of multiple-engine power loss events deserves early Industry attention.
3) The "data" will be beneficial to safety professionals within Industry in placing the various powerplant and APU-related flight-safety issues into proper context and in guiding decision making related to potential hazards associated with the defined powerplant and APU malfunctions.
4) Further refinement and development of this "Initial Report" should continue and user comments and recommendations for enhancements should be solicited.
5) The process developed under CAAM should be considered for other propulsion applications (i.e., turboshaft engines) and, more importantly, the entire aircraft.

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AIA PC-342-1
COMMITTEE ON CONTINUED AIRWORTHINESS ASSESSMENT METHODOLOGY

SUPPLEMENTAL REPORT
ON
TURBINE ENGINE ROTOR UNCONTAINED EVENTS
1 JANUARY 1992 THROUGH 30 NOVEMBER 1996
5 February 1997

FOREWORD

The material presented in this supplemental report has been developed by experts from the Aerospace Industries Association (AIA) Propulsion Committee (PC). The AIA-PC directed that the PC-342 Committee be recalled for the specific task of updating the uncontained turbine engine rotor event data provided in the Initial Report of 1 May 1993. This action was undertaken based on the Industry need for a measurement of the relative progress made toward minimizing uncontained turbine engine hazardous events.

The material presented in this report is consistent with the definition for "Uncontained" in the Major Propulsion System Malfunction Definitions and the Standardized Aircraft Hazard Levels presented in the earlier report...(t)he data on uncontained turbine engine events and aircraft flights cover the vast majority, but not all, of the turbine engines in commercial transport and commuter airline service, and manufactured in other than the Commonwealth of Independent States (CIS), Eastern Europe, or China. This report covers all multi-engine turbine powered civil/commercial aircraft, i.e.,

* All FAR25 commercial transports;
* All other FAR25 - business jets;
* Small business jets - FAR25 or FAR23 < 12,500 lbs.;
* Commuters - FAR23, SFAR23, 41, etc., up to 19 passenger or 6000 lbs. payload.

Turbine engines for rotorcraft are not included. Specifically, the events which may have occurred on early turboprop, jet, and low bypass turbofan engines (i.e., JT3C, JT4, JT3D, CJ610, CF700, C1805-3, CJ805-23, CT64, Avon, Conway, Proteus, and Tyne) are not included due to absence of reliable reporting. This update continues the same exclusions and maintains consistency with the earlier report.

Appendix 2

Standardized Aircraft Event Hazard Levels and Definitions

This appendix outlines propulsion system and auxiliary power unit (APU) malfunctions or related incidents, in certain cases coupled with crew error or other aircraft system malfunctions, resulting in the following consequences to the aircraft or its passengers/crew.

1. LEVEL 1 - MINOR CONSEQUENCES.

a. Uncontained nacelle damage confined to affected nacelle/APU area.

b. Uncommanded power increase, or decrease, at an airspeed above V1 and occurring at an altitude below 3,000 feet (includes in-flight shutdowns (IFSD) below 3,000 feet).

c. Multiple propulsion system malfunctions or related events, temporary in nature, where normal functioning is restored on all propulsion systems and the propulsion systems function normally for the rest of the flight. Includes common cause environmental hazard-induced events.

d. Separation of propeller/components which cause no other damage.

e. Uncommanded propeller feather.

f. Propulsion system (engine or propeller) malfunctions resulting in a load and frequency spectrum which exceeds the level demonstrated for compliance with §§ 33.23, 25.361, or 25.903(c) or their equivalent (e.g., engine malfunctions resulting in an imbalance exceeding the level of imbalance demonstrated under § 33.94 or its equivalent).

2. LEVEL 2 - SIGNIFICANT CONSEQUENCES.

a. Nicks, dents and small penetrations in aircraft primary structure.

b. Slow depressurization.

c. Controlled fires (i.e., extinguished by on-board aircraft systems).

d. Fuel leaks beyond normal extinguishing capabilities, if fire had resulted. (Note: "All fuel leaks resulting from aircraft fuel cell or fuel line penetrations.")

e. Minor injuries.

f. Multiple propulsion system/APU malfunctions, or related events, where one engine remains shutdown but continued safe flight at an altitude 1,000 feet above terrain along the intended route is possible.

g. Any high-speed takeoff abort (usually 100 knots or greater).

h. Separation of propulsion system, inlet, reverser blocker door, translating sleeve in-flight without level 3 damage consequences to the aircraft structure or systems (separations on the ground are excluded.

i. Partial in-flight reverser deployment or propeller pitch change malfunction(s) which does not result in loss of aircraft control or damage to aircraft primary structure.

3. LEVEL 3 - SERIOUS CONSEQUENCES.

A serious incident as defined by the International Civil Aviation Organization (ICAO) is "any event involving the operation of an aircraft other than an accident where the event, or the event coupled with any other reasonably probable second event, has the direct potential to result in an accident."

a. Substantial damage to the aircraft or second unrelated system.

(1) The National Transportation Safety Board (NTSB) definition of "substantial damage" means damage or structural failure that adversely affects the structural strength, performance or flight characteristics of the aircraft, and that would normally require major repair or replacement of the affected components. (Not considered "substantial damage" are engine failure damage limited to the engine, bent fairings or cowlings, dented skin, small puncture holes in the skin or fabric, or damage to landing gear, wheel, tires, flaps, engine accessories, brakes or wing tips).

(2) Damage to a second unrelated system must impact the ability to continue safe flight and landing. Coordination and agreement between the engine/propeller/APU manufacturer and the airframe manufacturer may be required to properly categorize events related to second system damage. In general, aircraft are designed to be dispatched with one part of a redundant system inoperative with no effect on flight-safety. Therefore, an uncontained rotor event which severed an unrelated hydraulic system line without significantly degrading the ability to continue safe flight should not be considered a level 3.a. event.

(3) Small penetrations of aircraft fuel lines or aircraft fuel tanks, where the combined penetration areas exceed two square inches, is a level 3.a. classification. Assistance of the airframe manufacturer should be sought when questions arise.

(4) Damage to a second engine (cross-engine debris) which results in a significant loss of thrust or an operational problem requiring pilot action to reduce power is a level 3.a. event. Minor damage which was not observed by the crew during flight and which did not affect the ability of the engine to continue safe operation for the rest of the flight is a level 2 event.

b. Uncontrolled fires - not extinguished by on-board aircraft systems. Note: internal tailpipe fires that hazard the aircraft are considered uncontrolled fires.

c. Rapid depressurization of the cabin.

d. Permanent loss of thrust or power greater than one propulsion system.

e. Temporary or permanent inability to climb and fly 1000 feet above terrain (increased threat from terrain, inclement weather, etc.) along the intended route which results in restricted capability (i.e., multiple propulsion system malfunctions or single propulsion system malfunctions and/or other aircraft system malfunction or crew error).

f. Any temporary or permanent impairment of aircraft controllability caused by propulsion system malfunction, thrust reverser in-flight deployment, propeller control malfunction, or propulsion system malfunction coupled with aircraft control system malfunction, abnormal aircraft vibration, or crew error.

4. LEVEL 4 - SEVERE CONSEQUENCES.

a. Forced landing. Forced landing is defined as the inability to continue flight due to the consequences of damage, uncontrolled fire or thrust loss where imminent landing is obvious but aircraft controllability is not necessarily lost (i.e., total powerloss due to fuel exhaustion will result in a "forced landing”). The term "emergency landing" may also be used to mean a forced landing if there is an urgent requirement to land. An air turn back or diversion due to a malfunction is not a forced landing, since there is a lack of urgency and the crew has the ability to select where they will perform the landing. However, off-airport landings are almost always forced landings.

b. Loss of aircraft (hull loss).

c. Serious injuries or fatalities. The National Transportation Safety Board (NTSB) definition of "serious injury" means any injury that:

(1) Requires hospitalization for more than 48 hours, commencing within seven days from the date the injury was received;

(2) results in the fracture of any bone (except simple fractures of fingers, toes or nose);

(3) involves lacerations that cause severe hemorrhages, nerve, muscle or tendon damage;

(4) involves injury to any internal organ; or

(5) involves second- or third-degree burns or any burns affecting more than 5 percent of the body surface, and

(6) "fatal injury" is defined as an injury that results in death within 30 days of the accident.

5. GENERAL NOTES APPLICABLE TO ALL EVENT HAZARD LEVELS.

a. The severity of aircraft damage is based on the consequences and damage that actually occurred.

b. Uncontained event damage definitions have been modified from those used in Society of Automotive Engineers (SAE) Aerospace Information Reports (AIR 1537, AIR 4003, and AIR 4770) with respect to a level 3 secondary system damage event. The objective has been to more clearly define and separate those events which had a major impact on continued safe flight and landing from those with lesser consequences.

Appendix 3

Definitions

1. PURPOSE. This appendix outlines the major propulsion system malfunction definitions and the aircraft hazard matrix, as developed by the Aerospace Industries Association (AIA) committee on Continued Airworthiness Assessment Methodologies (CAAM), PC342.

2. MISCELLANEOUS.

a. Hazard level. Levels of unsafe conditions, as defined by their effect on the aircraft. Appendix 2 provides a definition of these established hazard levels.

b. Hazard ratio. The percent of total events of a particular turbine propulsion system or APU malfunction or failure which have serious or severe consequences (i.e., hazard level 3 or 4 from Appendix 2).

c. Malfunction type. A single initiating cause of a failure, defect or other abnormal condition on a type design that can affect one or more parts. One specific cause (such as a melt-related defect leading to fracture) that affects several different parts (5th stage disks and 6th stage disks, for example) within an engine type design is still considered a single malfunction type. However, multiple initiating causes for a single part (e.g., melt-related defect, high-cycle fatigue, corrosion, etc., for 5th stage disks) represent multiple malfunction types.

3. SINGLE PROPULSION SYSTEM EVENT.

a. Uncontained. A significant safety event which initiates from an uncontained release of debris from a rotating component malfunction (blade, disk, spacer, impeller, drum/spool). In order to be categorized as uncontained, the debris must pass completely through the nacelle envelope. Parts which puncture the nacelle skin but do not escape or pass completely through are considered contained. Fragments which pass out of the inlet or exhaust opening without passing through any structure are not judged to be "uncontained."

b. Case rupture. A significant safety event which initiates from a sudden rupture of a high-pressure vessel or case with the resultant release of high-pressure gases into the under-cowl cavity. Case ruptures resulting from uncontained release of debris from a rotating component malfunction are excluded. Case ruptures include those events which propagate from fatigue-type cracks as well as ruptures related to secondary malfunctions (e.g., flame impingement, etc.) (See 2.c. below.)

c. Case burnthrough. Case burnthrough is defined as local case penetrations which initiate from local overtemperature of the case external wall due to an internal engine malfunction (e.g., fuel nozzle leakage, internal bearing compartment fires, titanium fires, etc.) Burnthroughs are distinguished from ruptures by their lack of an explosive release of high-pressure gas. A common cause of case burnthrough is localized penetration due to fuel nozzle malfunction. Events involving accessory component cases also contribute to this category; for example, sump fires which propagate internally and result in burnthrough of piping or which initiate gearbox fires. The key aspect, whether in the primary gas path or accessories, is that fire initiates from an internal malfunction and proceeds to burn through a case, tube or gearbox to reach external regions.

d. Under-cowl fire. A significant propulsion-related fire safety event which initiates due to an external malfunction (external to engine casings). Under-cowl fires are those that occur within the nacelle and on the engine side of the strut or installation fire barrier/wall. Internal pylon fires, including events where fuel leaks from the pylon and initiates a fire under the cowl, are to be excluded. Internal tailpipe fires which do not hazard the aircraft are to be excluded. Starter malfunctions which produce fire warning indications are to be included.

e. High-pressure air leak. Significant safety events initiating from high-pressure air leaks due to casing or high-pressure air duct system malfunctions within the nacelle.

f. Engine separation. In-flight separation of whole engines or major modules (e.g., low pressure turbine, fan rotors, etc.) Separation of nacelle components as the result of engine or engine module separation should be included in this category.

g. Cowl separations. In-flight separation of nacelle components such as inlets, cowls, thrust reverser sleeves, exhaust nozzles, tail plugs, etc. Separation of relatively small sections of skin or other small pieces that are unlikely to hazard continued safe flight and landing are excluded. Events involving only separation of the tail plug are included.

h. Propulsion system and crew error. A significant safety event initiating from a single propulsion system malfunction (excluding propeller system) which, by itself, does not hazard the aircraft, but is compounded by inappropriate crew response (e.g., uncontained disk fracture which did not hazard the aircraft but inappropriate crew response caused the aircraft to stall and crash).

i. Crew error. A significant safety event initiating from inappropriate crew action causing a propulsion system malfunction (excluding propeller system) which results in a hazard to the aircraft, its passengers and crew, or both.

j. Reverser. A significant safety event initiating from a thrust reverser malfunction (including inappropriate operation).

k. Unknown. A significant propulsion-related safety event for which the principal initiating malfunction has not been determined.

l. Other. A significant propulsion-related safety event not included in the categories discussed above and for which the initiating cause(s) is unique to one CAAM level 3 or 4 event in the reporting time period. Tailpipe fires which hazard the aircraft should be included in this category.

4. MULTIPLE PROPULSION SYSTEM EVENT.

a. Common cause - environment. A significant safety event initiating from essentially simultaneous powerloss from multiple propulsion systems for an environmental cause (e.g., bird, ice, rain, hail, or volcanic ash ingestion).

b. Common cause - human. A significant safety event initiating from essentially simultaneous powerloss from multiple propulsion systems for the same human factor-related cause (e.g., servicing errors, maintenance errors, crew error, airport service, Air Traffic Control (ATC) error, etc.)

c. Common cause - other. A significant safety event initiating from essentially simultaneous powerloss from multiple propulsion systems for the same cause other than those listed above (e.g., fuel contamination, fuel exhaustion, unknown).

d. Known/unknown - related causes. A significant safety event initiating from essentially simultaneous powerloss from multiple propulsion systems for similar but not necessarily identical causes. Human error is often associated with these events. For example, engine No. 1 and No. 2 in-flight shutdown (IFSD) at the same time, but cause determined for only one engine; the crew may have inadvertently shutdown the other engine. Engine IFSD for high oil consumption (defect known but engine remained on aircraft due to spare shortage) and another engine IFSD for a different maintenance-related reason.

e. Unrelated causes. A significant safety event initiating from sequential malfunctions of multiple propulsion systems for unrelated causes not related to human error (e.g., turbine blade fracture and oil pump malfunction).

5. PROPELLER SYSTEM EVENT. An event which initiates from a malfunction or misuse of the propeller system as follows:

a. Blade separation. In-flight separation of single or multiple blades due to blade or hub malfunction.

b. Propeller gearbox/attachment. In-flight separation of a propeller assembly as the result of a propeller gearbox or attachment malfunction.

c. Loss of control (negative thrust). Propeller system malfunction leading to negative thrust (high drag).

d. Propeller system and crew error. A significant safety event initiating from a propeller system malfunction which, by itself, does not hazard the aircraft, passengers, or crew, but is compounded by inappropriate crew response.

e. Crew error. A significant safety event initiating from inappropriate crew action related to the propeller system (e.g., operation in beta mode in violation of operating instructions).

f. Other. A significant propeller-related safety event not included in the propeller categories discussed above and for which the initiating cause(s) is unique to one CAAM level 3 or 4 event in the reporting time period.

6. APU SYSTEM EVENT. A significant APU-related safety event as follows:

a. Uncontained. An uncontained rotating component malfunction which allows debris to exit the APU casings/containment.

b. Fire. An APU-related internal or external fire (e.g., tailpipe fire which burns aircraft control or structural elements).

c. Crew error. An inappropriate crew action involving the APU which creates a significant safety hazard to the aircraft (e.g., crew starts a placarded APU which causes damage to the aircraft).

d. Maintenance error. An inappropriate maintenance action which leads to a malfunction which hazards the aircraft (e.g., not placarding a malfunctioning APU).

e. Other. A significant APU-related safety event not included in the APU categories discussed above and for which the initiating cause(s) is unique to one CAAM level 3 or 4 event in the reporting time period.

7. EGRESS INJURY ONLY EVENTS. In CAAM studies of significant propulsion system, propeller system, and APU-related safety events, the injury of passengers or crew members during the act of emergency egress has been noted. At times, the only significant safety aspect to an otherwise benign event was the fact that an egress injury occurred. The CAAM Committee decided to: (1) collect such egress injury events and forward them to the AIA Transport Committee for consideration and disposition, and (2) not consider egress injuries in establishing the top hazard level (e.g., 1, 2, 3 or 4) ranking of any significant safety events under study by CAAM. Direct injuries or fatalities as the result of a malfunction, such as uncontained debris, fire, fuel exhaustion, etc., were considered in establishing the overall hazard level coding.

Appendix 4

Propulsion System and Auxiliary Power Unit (APU) Related Aircraft Safety Hazards (1982 through 1991)

FIGURE 1. UNCONTAINED - BLADES - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LOW BYPASS PRESSURE RATIO (LBPR)			HIGH BYPASS PRESSURE RATIO (HBPR)		
HAZARD LEVEL	**ALL**	**3**	**4**	**ALL**	**3**	**4**	**ALL**	**3**	**4**
NUMBER EVENTS BY MODULE									
FAN	N/A	N/A	N/A	22	2	0	64	1	0
Platforms	N/A	N/A	N/A	0	0	0	3	0	0
LPC	0	0	0	8	0	0	2	0	0
HPC	1	0	0	2	0	0	0	0	0
HPT	5	0	0	2	0	0	1	0	0
IPT	1	0	0	0	0	0	0	0	0
LPT/POWER TURBINE (PT)	10	0	1	36	7	0	38	0	0
BLADE TOTAL	**17**	**0**	**1**	**70**	**9**	**0**	**108**	**1**	**0**

UNCONTAINED BLADE TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 1
UNCONTAINED BLADE TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 11
UNCONTAINED BLADE TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= 195

FIGURE 2. HAZARD LEVEL RATIOS FOR UNCONTAINED BLADES

ENGINE TYPE	TURBOPROP	LOW BYPASS	HIGH BYPASS
LVL.4/ALL	1/17 = 0.06	0/70	0/108
LVL.3+4/ALL	1/17 = 0.06	9/70 = 0.13	1/108 = 0.01

a. Uncontained Blades - Hazard Level 4.

Engine Type	Event Summary
Turboprop	One passenger injured by uncontained power turbine blades shed during overspeed following a power turbine bearing malfunction (hazard level 4.c.)

b. Uncontained Blades - Hazard Level 3.

Engine Type	Event Summary
Low Bypass	Two fan blades fractured; inlet case punctured; nose cowl held on by anti-ice tubes; foreign object damage (FOD) to engines Nos. 2 and 3 (hazard level 3.a.)
	All fan blades fractured; fan section severed, held by cowling rod; hole in flap and fuselage; heavy vibration; FOD to No. 2 engine (hazard level 3.a.)
	High-pressure turbine (HPT) shaft fracture; blades fractured; low pressure turbine (LPT) blades penetrated; debris went through fuselage and No. 1 cowl; punctures to pneumatic/hydraulic/electrical/APU systems (hazard level 3.a.)
	LPT shaft fracture; blades fractured; debris holed fuselage (large) (hazard level 3.a.)
	LPT shaft fracture; blades fractured; aircraft damage to fuselage and vertical stabilizer (hazard level 3.a.)
	Low pressure compressor (LPC) tie rod fracture; LPT blades fractured; fuselage holed in aft stair case; fire extinguished by ground equipment (hazard level 3.b.)
	LPT blades fractured; debris caused damage to No. 2 engine, vertical and horizontal tail (hazard level 3.a.)
	LPT blades fractured; hydraulic lines severed in wing; A and B hydraulic systems lost (hazard level 3.a.)
	LPT blades fractured; debris holed No. 1 fuel tank; fuel leak; no fire (hazard level 3.a.)

High Bypass No. 2 engine blue ice ingestion during cruise. Uncontained fan blade segments separated hydraulic return lines from two systems (hazard level 3.a.)

FIGURE 3. UNCONTAINED - DISKS & IMPELLERS - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS BY MODULE									
FAN	N/A	N/A	N/A	6	1	0	4	2	2
LPC	7	1	0	0	0	0	1	0	0
HPC	3	0	0	8	3	3	4	1	0
HPT	15	1	1	0	0	0	6	1	1
IPT	1	1	0	0	0	0	0	0	0
LPT/PT	4	0	0	7	3	0	3	2	0
DISK/IMPEL. TOTAL	**30**	**3**	**1**	**21**	**7**	**3**	**18**	**6**	**3**

DISK & IMPELLER - NUMBER EVENTS - HAZARD LEVEL 4	= 7
DISK & IMPELLER - NUMBER EVENTS - HAZARD LEVEL 3+4	= 23
DISK & IMPELLER - TOTAL NUMBER EVENT - HAZARD LEVEL ALL	= 69

FIGURE 4. HAZARD LEVEL RATIOS FOR DISK & IMPELLER

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL	1/30 = 0.03	3/21 = 0.14	3/18 = 0.17
LVL.3+4/ALL	4/30 = 0.13	10/21 = 0.48	9/18 = 0.50

a. Uncontained - Disk & Impeller - Hazard Level 4.

Engine Type **Event Summary**

Turboprop Separation of 1st stage HPT assembly; forced landing (hazard level 4.a.)

Low Bypass 13th stage high-pressure compressor (HPC) disk fracture; debris punctured wing fuel tank; aircraft destroyed by fire; minor evacuation injuries (hazard level 4.b.)

	7th stage HPC disk fracture; debris punctured wing fuel tank; aircraft destroyed by fire; fatalities (hazard levels 4.b. and 4.c.)
	9th stage HPC disk fracture due to corrosion; debris severed fuel line; aircraft destroyed by fire; no injuries; cargo flight. (hazard level 4.b.)
High Bypass	Fan disk separation (operated beyond life limit); hull loss; fatal (hazard levels 4.b. and 4.c.)
	No. 2 engine uncontained fan disk separated two hydraulic systems resulting in loss of aircraft control (hazard levels 4.a., 4.b. and 4.c.)
	Uncontained HPT disk punctured wing fuel cell resulting in ground fire. (hazard level 4.b.)

b. Uncontained - Disk & Impeller - Hazard Level 3.

Engine Type	**Event Summary**
Turboprop	LPC impeller uncontained; damage to left-hand engine undercarriage; landed with left-hand wheel retracted. (hazard level 3.a.)
	HPT disk fracture; fragment broke aircraft window. Aircraft landed safely. (hazard level 3.a.)
	Intermediate pressure turbine (IPT) disk uncontained. Right-hand landing gear defective and fuel line cut. Aircraft landed safely. (hazard level 3.a.)
Low Bypass	Fan disk fracture; sheared No. 1 bearing journal; fan containment case liberated; fuel lines severed; uncontrolled fire; cowl and fuselage skin burned; manufacturing related; serious egress injury. (hazard level 3.b.)
	9th stage HPC outer rim fracture; wing slat holed; fuel supply tube broken; no fire; A & B hydraulic systems affected. (hazard level 3.a.)
	10th stage HPC disk fracture; cowling unlatched; high drag; No. 2 engine required high EPR to maintain flight. (hazard level 3.f.)

HPC impeller uncontained at takeoff acceleration with aircraft tail penetration but aircraft still airworthy. (hazard level 3.a.)

LPT 2nd stage disk fracture; debris penetrated fuselage; vertical stabilizer; debris ingestion damage in center engine; serious egress injury. (hazard level 3.a.)

LPT 2nd stage disk fracture; large hole in fuselage; damage to horizontal and vertical tail. (hazard level 3.a.)

LPT 1st stage disk fracture; fire warning; fuselage holed and rapid decompression. (hazard level 3.c.)

High Bypass

2 events. Substantial aircraft damage events due to fan disk separation. (one on takeoff and one during cruise) (hazard level 3.a.)

14th stage HPC disk fracture; takeoff aborted and fire broke out. Fire penetrated into cabin. (hazard level 3.a.)

Uncontained HPT disk during climb punctured wing fuel cell. (hazard level 3.a.)

No. 4 engine uncontained LPT disk resulted in wing fuel cell penetration. (hazard level 3.a.)

No. 4 engine uncontained LPT disk; cables to no. 2 engine severed resulting in in-flight shutdown; no. 3 engine damaged but continued to operate; lost hydraulic power; holes in fuel tank and fuselage. (hazard level 3.a.)

FIGURE 5. UNCONTAINED - SPACERS & OTHER - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER SPACER EVENTS BY MODULE									
HPC	0	0	0	6	1	0	0	0	0
HPT	2	0	0	0	0	0	4	1	0
LPT/PT	0	0	0	0	0	0	5	2	0
SPACER TOTAL	**2**	**0**	**0**	**6**	**1**	**0**	**9**	**3**	**0**
OTHER* TOTAL	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**

SPACER - UNCONTAINED EVENTS - HAZARD LEVEL 4 = 0
SPACER - UNCONTAINED EVENTS - HAZARD LEVEL 3+4 = 4
SPACER - UNCONTAINED EVENTS - HAZARD LEVEL ALL = 17
"*" OTHER UNCONTAINED ROTATING PARTS (NOT BLADE, DISK/IMPELLER OR SPACER) NECESSARY IN COMPLETING TOTAL UNCONTAINED EVENT COUNTS.

FIGURE 6. SPACER HAZARD LEVEL RATIOS

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL	0/2	0/6	0/9
LVL.3+4/ALL	0/2	1/6 = 0.17	3/9 = 0.33

a. Uncontained - Spacer - Hazard Level 3.

Engine Type	**Event Summary**
Low Bypass center	7-8th stage spacer fracture; debris damaged vertical stabilizer; duct penetrated; damaged center engine resulting in power reduction to idle. (hazard level 3.a.)
High Bypass	Wing engine uncontained HPT rotating spacer during climb. Fragments severed wing leading edge slat cable and punctured pylon and wing panels. (hazard level 3.a.)
	LPT 5-6th airseal fracture; case penetrated; pylon skin damaged; debris FOD to adjacent engine causing powerloss. (hazard level 3.a.)
	LPT 5-6th airseal fracture; tailcone liberated. Debris FOD to adjacent engine; fan blade fracture; core damage; not shutdown. (hazard level 3.a.)

FIGURE 7. UNCONTAINED - ALL PARTS - EVENTS - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS TOTAL	50	3	2	97	17	3	136	10	3

FIGURE 8. UNCONTAINED HAZARD LEVEL RATIOS FOR ALL PARTS

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL	2/50 = 0.04	3/97 = 0.03	3/136 = 0.02
LVL.3+4/ALL	5/50 = 0.10	20/97 = 0.21	13/136 = 0.10

AVERAGE LVL. 4/ALL = 8/283 = 0.03 (1:35 EVENTS)
AVERAGE LVL. 3+4/ALL = 38/283 = 0.13 (1:7 EVENTS)

FIGURE 9. UNCONTAINED HAZARD RATES FOR ALL PARTS PER TEN MILLION AIRCRAFT DEPARTURES

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL	0.26	0.37	0.76
LVL.3+4/ALL	0.64	2.46	3.28

FIGURE 10. CASE RUPTURE - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	12	0	0	21	2	2	10	2	0

TOTAL NUMBER EVENTS HAZARD LEVEL 4 = 2
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4 = 6
TOTAL NUMBER EVENTS HAZARD LEVEL ALL = 43

FIGURE 11. HAZARD LEVEL RATIOS FOR CASE RUPTURE

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL	0/12	2/21 = 0.10	0/10
LVL.3+4/ALL	0/12	4/21 = 0.19	2/10 = 0.20

a. Case Rupture - Hazard Level 4.

Engine Type	Event Summary
Low Bypass	Combustor liner fractured; case ruptured. Debris penetrated fuel access panel; fire; hull loss; fatal. (hazard levels 4.b. and 4.c.)
	Combustion case rupture; cowling dislodged; high drag; holes in fuselage; remaining engine overtemperatured to maintain flight; forced landing.(hazard level 4.a.)

b. Case Rupture - Hazard Level 3.

Engine Type	Event Summary
Low Bypass "A"	Combustion chamber fractured; case ruptured; hydraulic line to system severed. (hazard level 3.a.)
	Combustion case ruptured; cowling, pylon, wing penetrations. (hazard level 3.a.)
High Bypass	Compressor rear frame rupture during takeoff resulting in separation of core cowl and short-duration uncontrolled fire. (hazard level 3.b.)
	Combustion case rupture; fire warning. Cowls separated; abort; fire extinguished by ground fire brigade. (hazard level 3.b.)

FIGURE 12. CASE BURNTHROUGH - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	6	1	0	6	0	0	44	0	0

TOTAL NUMBER HAZARD LEVEL 4	= 0
TOTAL NUMBER HAZARD LEVEL 3+4	= 1
TOTAL NUMBER HAZARD LEVEL ALL	= 56

FIGURE 13. HAZARD LEVEL RATIOS FOR CASE BURNTHROUGH

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL	0/6	0/6	0/44
LVL.3+4/ALL	1/6 = 0.17	0/6	0/44

a. Case Burnthrough - Hazard Level 3.

Engine Type	Event Summary
Turboprop	No. 4 combustion flame tube and casing penetrated. Fire had to be extinguished by ground fire brigade. (hazard level 3.b.)

FIGURE 14. FIRE - UNDER COWL - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	17	2	1	18	1	0	88	3	0

TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 1
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 7
TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= 123

FIGURE 15. HAZARD LEVEL RATIOS FOR FIRE - UNDER COWL

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL	1/17 = 0.06	0/18	0/88
LVL.3+4/ALL	3/17 = 0.18	1/18 = 0.06	3/88 = 0.03

a. Fire - Under cowl - Hazard Level 4.

Engine Type	Event Summary
Turboprop	Improper assembly of high-pressure fuel filter cover led to fire; air turn back and emergency landing; substantial damage and serious injuries. (hazard level 4.c.)

b. Fire - Under Cowl - Hazard Level 3.

Engine Type	Event Summary
Turboprop	Fire fed by engine oil when four-day inoperative generator failed; damaged accessory gearbox pad seal (maintenance related). (hazard level 3.b.) Total blockage of No. 5 burner due to incorrect assembly caused uncontrolled fire. (hazard level 3.b.)
Low Bypass of	Contained fan blade fracture; abort. Vibration caused separation fuel control unit and fuel pump; fire required ground equipment to extinguish. (hazard level 3.b.)
High Bypass level	Fire warning; air turn back; bleed signal manifold broken; angle gearbox housing burned; fire extinguished on ground. (hazard 3.b.) Gearbox fire from bearing failure spread to accessory zone; uncontrolled fire. (hazard level 3.b.) Gearbox fire required ground equipment to extinguish. (hazard level 3.b.)

FIGURE 16. HIGH-PRESSURE AIR LEAK - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	7*	0	0	*	0	0	203	0	0

TOTAL NUMBER EVENTS HAZARD LEVEL 4 = 0
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4 = 0
"*" TOTAL NUMBER EVENTS HAZARD LEVEL ALL IS INCOMPLETE
NO EVENTS GREATER THAN HAZARD LEVEL 2 REPORTED OR UNCOVERED.

FIGURE 17. ENGINE SEPARATION - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	0	0	0	2	0	0	2	0	2

TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 2
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 2
TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= 4

FIGURE 18. HAZARD LEVEL RATIOS FOR ENGINE SEPARATION

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL. 4/ALL	0/0	0/2	2/2 = 1.00
LVL. 3+4/ALL	0/0	0/2	2/2 = 1.00

a. Engine Separation - Hazard Level 4.

Engine Type	Event Summary
High Bypass	Mount pin failure; engine fell nose down; fire initiated; pylon burned; canoe, flaps, wing damaged beyond repair; hull loss. (hazard level 4.b.) Two-engine separation on right wing; control lost; crashed; hull loss; fatal.(hazard levels 4.b. and 4.c.)

FIGURE 19. COWL SEPARATION - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	0	0	0	28	0	0	78	1	0

TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 0
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 1
TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= 106

FIGURE 20. HAZARD LEVEL RATIOS FOR COWL SEPARATION

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL	0/0	0/28	0/78
LVL.3+4/ALL	0/0	0/28	1/78 = 0.01

a. Cowl Loss - Hazard Level 3.

Engine Type	**Event Summary**
High Bypass	Wing engine core cowl separation during climb; impacted fuselage resulting in rapid depressurization. (hazard level 3.c.)

FIGURE 21. PROPULSION SYSTEM AND CREW ERROR - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	*	4	14	*	2	5	*	5	2

TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 21
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 32
"*" NO UNIFORM REPORTING OF LESSER CATEGORY 1 & 2 EVENTS	

a. Propulsion System + Crew Error - Hazard Level 4 Events.

Engine Type	**Event Summary**
Turboprop fuel	Oil indication led crew to in-flight shutdown right-hand engine; mismanagement led to flameout of left-hand engine; further crew error led to inability to restart either engine; forced landing on dirt road. (hazard level 4.a.)
	Lost one engine and crew inadvertently feathered other engine; forced landing. (hazard level 4.a.)
	Left-hand engine lost power during takeoff; landed straight ahead with aircraft striking tree; serious injuries. (hazard level 4.c.)
fatal	On descent, crew shutdown right-hand engine but inadvertently shutdown left-hand engine also; aircraft struck electrical lines; (hazard level 4.c.)

	On approach in low ceiling (fog), reported engine surging; aircraft was 200 feet too low and struck tree, electrical lines and a house; fatal (hazard level 4.c.)
	After lift-off, left-hand engine lost power; wing contacted ground on left turn; serious injuries (hazard level 4.c.)
	Aircraft crashed shortly after takeoff following powerloss on one engine; fatal (hazard level 4.c.)
	Crew shutdown left-hand engine for fuel leak. Aircraft stalled 1 kilometer (km) from runway and crashed; fatal (hazard level 4.c.)
	Fluctuating engine parameters; late aborted takeoff; over run; struck fence and dump truck (hazard level 4.c.)
	No. 2 engine fuel pump failure; engine out; crew actions were incorrect; struck power cable and crashed into building (hazard level 4.b.)
	Port engine quit in cruise; overweight aircraft; forced landing (hazard level 4.a.)
	45-degree turn made too close to runway after unspecified engine problem; crashed (hazard level 4.b.)
	Engine fire and inadequate operational decision; unauthorized change in power setting; crashed (hazard level 4.b.)
	Overloaded aircraft crashed into sea; probable powerloss; fatal (hazard level 4.c.)
Low Bypass aircraft;	High-pressure compressor spacer uncontained; crew stalled
	crashed; hull loss; fatal (hazard level 4.b. and 4.c.)
	Takeoff conducted in snow and icing conditions; crew failed to use engine anti-ice or abort when acceleration slow. Ice blocked PT2 probes gave false engines pressure ratio (EPR) indication; hull
loss;	fatal (hazard levels 4.b. and 4.c.)
	Engine failed and turn back at low height. Collision with ILS
mast.	Crash landed (hazard level 4.b.)

Engine failed and abort after rotation speed (Vr). Aircraft overran and crashed into ravine (hazard level 4.b.)

	Engine fire and touched down short of runway. Crashed through stone wall causing fire (hazard level 4.a.)
High Bypass	Birdstrike at Vr; aborted takeoff; departed runway; hull loss (hazard level 4.b.)
	Left-hand engine experienced fan blade separation during climb; crew shutdown wrong engine resulting in forced landing short of runway; hull loss fatal (hazard levels 4.b. and 4.c.)

b. Propulsion System and Crew Error - Hazard Level 3.

Engine Type	**Event Summary**
Turboprop	Engine surged and takeoff aborted late. Aircraft ran off runway and damaged (hazard level 3.a.)
	Engine fire during takeoff; aborted. CAP 479 Volume two stated engine and crew related (hazard level 3.b.)
	No. 2 engine shutdown for fire warning. No. 1 engine incorrectly operated. Aircraft landed with collapsed undercarriage (hazard level 3.a.)
	No. 2 engine accessory gearbox drive (AGB) shaft sheared. Crew shutdown No. 1 engine in error; suspect noise was a factor. Emergency landing made on No. 2 engine (hazard level 3.f.)
Low Bypass	No 1 engine exhaust gas temperature and fan speed dropped. Aircraft had just become airborne and the crew elected to put it back on runway. Substantial damage (hazard level 3.a.)
	No. 2 engine shutdown in error. No. 1 engine had T1 sensor failure (hazard level 3.e.)
High Bypass	High-pressure turbine case cracked; hot air leak produced fire warning; crew aborted above V1 speed; aircraft departed runway; substantial damage (hazard level 3.a.)
	Engine overtemperature condition caused by high-pressure turbine blade retainer fracture; pilot aborted takeoff above V1 speed resulting in runway departure and substantial damage (hazard levels 3.a. and 3.f.)

Tailpipe fire caused by loose P4 connector/overfueling; flaps damaged; airport crew extinguished fire (hazard levels 3.a. and 3.b.)

Takeoff at max gross weight; one engine lost power; crew over rotated; stick shaker sounded for 30 seconds; throttles firewalled (hazard levels 3.f.)

High vibration from turbine blade and bearing failure when aircraft rotated for takeoff. Crew aborted and nose gear collapsed into fuselage (hazard level 3.a.)

FIGURE 22. CREW ERROR - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	*	0	5	*	1	0	*	2	1

TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 6
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 9
"*" NO UNIFORM REPORTING OF LESSER CATEGORY 1 & 2 EVENTS	

a. Crew Error - Hazard Level 4.

Engine Type	Event Summary
Turboprop	Unable to start No. 2 engine; elected to three-engine ferry. Got airborne with insufficient flight speed for control and crashed; fatal (hazard level 4.c.)
	Both engines lost power from ice ingestion. Crew procedures not followed (hazard level 4.a.)
	Crew unfamiliar with ferry tank system (fuel exhaustion). Attempted emergency landing; hull loss (hazard level 4.b.)
	During aborted takeoff engines were feathered instead of ground fine pitch. Aircraft aquaplaned off runway and into field; hull loss (hazard level 4.b.)
	Crew didn't detect that No. 4 engine was at idle when distracted by weather conditions. Drag from No. 4 engine created handling problems leading to forced landing (hazard level 4.a.)

High Bypass	Thrust reverser not activated on No. 4 engine on thrust reverse cancel; No. 4 went to high power; aircraft veered off runway; nose gear collapsed into cargo bay; cargo displaced cabin floor; hull loss (hazard level 4.b.)

b. Crew Error - Hazard Level 3.

Engine Type	**Event Summary**
Low Bypass	Excessive rate of descent; high-speed landing in blowing snow; asymmetric thrust; weathervaned off runway; fuselage split (hazard level 3.a.)
High Bypass	Aircraft stalled at high altitude due to engine powerloss and inappropriate autoflight control system configuration (altitude hold but no speed hold). Crew recovered after rapid descent with permanent deformation to wing and stabilizer structure (hazard level 3.a.) Aircraft overran end of runway; thrust reversers locked out; damage to nose gear support structure; FOD to engines (hazard level 3.a.)

FIGURE 23. REVERSER - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	N/A	N/A	N/A	15	1	1	20	5	1

TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 2
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 8
TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= 35

a. Reverser - Hazard Level 4.

Engine Type	**Event Summary**
Low Bypass	Lower clamshell links sheared; clamshell deployed; high drag; forced landing (hazard level 4.a.)
High Bypass	Reverser deployed in-flight; control lost; crashed; hull loss; fatal (hazard levels 4.b. and 4.c.)

b. Reverser - Hazard Level 3.

Engine Type	Event Summary
Low Bypass	Driver links broken due to corrosion; upper door deployed; substantial vibration; power reduced (hazard level 3.f.)
High Bypass	Outboard left-hand reverser uncommanded deployment during climb resulted in temporary loss of aircraft control. Crew performed in-flight shutdown (hazard level 3.f.)
	Actuator valve failed in deploy mode; fan reverser deployed; aircraft pitched down; recovered (hazard level 3.f.)
	Drive unit extend port capped; fan reverser deployed; vibration;
roll	
	and yaw; in-flight shutdown (hazard level 3.f.)
	Defective unlock switch; fan reverser deployed; severe yaw
(hazard	
	level 3.f.)
	Fan reverser deployed; severe yaw and vibration (hazard level 3.f.)

FIGURE 24. UNKNOWN - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	*	0	2	*	0	1	*	0	0

TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 3
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 3
"*" NO UNIFORM REPORTING OF LESSOR HAZARD LEVEL 1 & 2 EVENTS	

a. Unknown - Hazard Level 4.

Engine Type	Event Summary
Turboprop	No. 2 engine failed during approach and aircraft crashed. No other information available; presume other factors involved (hazard level 4.b.)
	Left engine lost power on takeoff; belly landed; slid into trees. Suspect crew error; fatal (hazard level 4.c.)

Low Bypass Shortly after takeoff aircraft reportedly had engine problems and crashed into village during attempted air turn back (hazard level 4.a.)

FIGURE 25. OTHER - 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	12	1	1	11	1	0	25	4	0

TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 1
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 7
TOTAL NUMBER EVENTS ALL HAZARD LEVELS	= 48

a. Other - Hazard Level 4.

Engine Type	Event Summary
Turboprop	Training flight. Student poor landing; captain took over but two engines on same side did not respond; crashed; fatal; compressors extremely dirty causing failure to respond (hazard level 4.c.)

b. Other - Hazard Level 3.

Engine Type	Event Summary
Turboprop	No. 1 engine exhaust gas temperature to 1100 degrees centigrade and torque pressure to zero; engine shutdown; fire in rear of pylon/hydraulic area damaged main wiring bundle (hazard level 3.b.)
Low Bypass	Malfunction of ignitor boxes allowed excess fuel leading to fire put out by fire brigade (hazard level 3.b.)
High Bypass	After engine fuel check "loose fuel" ignited and fire damaged the wing and pylon. Fire put out by ground fire equipment (hazard level 3.b.) Tailpipe fire from ignition of leaking fuel/main shutoff valve not fully closed together with blocked drain. Passenger and airport reaction with full fire brigade and aircraft evacuation (hazard level 3.b.)

Tailpipe fire put out by fire brigade (hazard level 3.b.)

Power drop from reverse thrust to sub-idle not noticed. Tailpipe fire; put out by fire brigade. Passengers evacuated with serious injuries (hazard level 3.b.)

FIGURE 26. MULTIPLE-ENGINE POWERLOSS - COMMON CAUSE-ENVIRONMENT 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	*	2	2	21	3	2	44	9	1

TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 5
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 19
TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= *
"*" THE REPORTING OF HAZARD LEVEL 1 & 2 EVENTS FOR TURBOPROPS SUSPECTED TO BE UNRELIABLE.	

FIGURE 27. HAZARD LEVEL RATIOS FOR COMMON CAUSE - ENVIRONMENT

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL		2/21 = 0.10	1/44 = 0.02
LVL.3+4/ALL		5/21 = 0.24	10/44 = 0.23

a. Common Cause - Environment - Hazard Level 4.

Engine Type	**Event Summary**
Turboprop	In descent; heavy turbulence; both engines flameout; forced landing short of runway. Investigation could not duplicate problem (hazard level 4.a.)
	After departure flew through flock of birds; both engines flamed out; hit wires and chain link fence on impact; hull loss (hazard level 4.b.)
Low Bypass	Multiple birds (pigeons) ingested in both engines; continuous surging; powerloss; crashed; hull loss; fatal (hazard level 4.b. and

4.c.)

	Wing ice shed into both engines causing damage; surging; powerloss; forced landing; hull loss (hazard level 4.b.)
High Bypass	Both engines flamed out during descent in severe hail. Unsuccessful restart attempts resulted in forced landing in field (hazard level 4.a.)

b. Common Cause - Environment - Hazard Level 3.

Engine Type	**Event Summary**
Turboprop	Light icing when descending through 9000 feet; double engine flameout but both successfully restarted (hazard level 3.e.)
	Double engine flameout in light icing; no other details (hazard level 3.e.)
Low Bypass	Abort; dual engine surging due to ingestion of water on runway; two inches deep; aircraft hydroplaned; off side of runway; damage to nose gear (hazard level 3.a.)
	Abort at 60 to 90 knots due to slush; water; snow ingestion; both engines flamed out and damaged (hazard level 3.d.)
	Wing ice shed during takeoff and ingested by both engines; No. 1 surged at rotation and power reduced to idle; No. 2 surge in climb; throttle pushed on both engines successfully (hazard level 3.e.)
High Bypass	No. 1 and No. 2 engine birdstrike on takeoff. No. 2 engine uncontained transverse blade separation. No. 1 engine stalled with significant powerloss (hazard level 3.d.)
	While cruising at FL290 in icing conditions pilot put on anti-icing. Aircraft entered a "hot cell" and stability bleeds opened; three of four engines ran down. Aircraft landed with only one engine running. All engines suffered ice damage (hazard level 3.d.)
	Birdstrike to all engines (four); three lost power and one shutdown. Continued to climb to 1000 feet and air turn back and overweight landing. 57 strikes from Mediterranean herring gulls. All engines damaged (hazard level 3.d.)
	Volcanic ash ingested; three engine flameout; one restarted; two engine landing (hazard level 3.d.)

3 events: Dual engine birdstrike on four-engine aircraft with fan damage to both engines; one event with two engines in-flight shutdown; other two events had one engine in-flight shutdown and the other engine at idle (hazard level 3.d.)

2 events: No. 1 and No. 3 engine birdstrikes resulting in permanent loss of power greater than one engine (hazard level 3.d.)

FIGURE 28. MULTIPLE-ENGINE POWERLOSS - COMMON CAUSE - HUMAN 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	*	2	9	9	1	3	19	6	1

TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 13
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 22
TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= *

"*" THE REPORTING OF HAZARD LEVEL 1 & 2 EVENTS FOR TURBOPROPS SUSPECTED TO BE UNRELIABLE.

FIGURE 29. HAZARD LEVEL RATIOS FOR COMMON CAUSE - HUMAN

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL		3/9 = 0.33	1/19 = 0.05
LVL.3+4/ALL		4/9 = 0.44	7/19 = 0.37

a. Common Cause - Human - Hazard Level 4.

Engine Type	**Event Summary**
Turboprop	On test flight after maintenance right-hand engine flamed out; restart unsuccessful. Then left-hand engine flamed out; landed in open field (maintenance related) (hazard level 4.a.)
	On ferry flight after 6 months non-preserved storage, both engines flamed out. Most probable cause fuel icing of fuel tank vent blockage (hazard level 4.a.)
	Crew training at low altitude; instructor pulled power on one engine; student shutdown good engine (hazard level 4.a.)

	Aircraft recently purchased and had just received major fuel system maintenance. Aircraft was reportedly at 8000 feet when it had one or more engine failures and it crashed (hazard level 4.c.)
	Powerloss on both engines when changing from main to wing tip fuel tanks; forced landing; pilot ditched aircraft (hazard level 4.a.)
	Water methanol tanks filled with Avgas. Both engines failed; forced landing (hazard level 4.a.) Fuel mismanagement; crashed (hazard level 4.b.)
	Fuel contaminated with water and dirt after being parked a long time; forced wheels-up landing; (hazard level 4.a.)
	Water in fuel and subsequent crew error mishandling (hazard level 4.b.)
Low Bypass (hazard	**2 events**: Fuel exhaustion due to crew error; hull loss; fatal levels 4.b. and 4.c.)
	Aircraft exhausted fuel waiting for airport lights to be turned on (hazard level 4.c.)
High Bypass	Fuel exhaustion caused by human error (error in converting/understanding fuel quantity as kilograms when given in pounds); forced landing (hazard level 4.a.)

b. Common Cause - Human - Hazard Level 3.

Engine Type	**Event Summary**
Turboprop	Takeoff aborted due to dual engine powerloss; fuel in water methanol tanks (hazard level 3.d.)
	Loss of power on both engines due to fuel in water methanol tanks (hazard level 3.d.)
Low Bypass	Two of three engines would not accelerate due to fuel contamination of fuel controls (hazard level 3.d.)
High Bypass	Both engines inadvertently shutdown by flight crew after takeoff. Engines restarted and aircraft leveled off at 500 feet (hazard level 3.e.)

Three of four engines failed to accelerate due to fuel starvation; all fuel in No. 2 fuel tank (hazard level 3.d.)

Two of four engines in-flight shutdown due to oil loss; oil caps left off (hazard level 3.d.)

Both engines inadvertently shutdown in initial climb due to fuel shutoff rather than EEC enable (hazard level 3.e.)

All engines low oil and shutdown; 'O'-rings omitted from chip detectors; one engine restarted (hazard level 3.d.)

Two engines lost oil quantity due to 'O'-rings omitted (hazard level 3.d.)

FIGURE 30. MULTIPLE-ENGINE POWERLOSS - COMMON CAUSE -OTHER 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	*	0	5	1	1	0	9	1	2

TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 7
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 9
TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= *
"*" ALL FOR TURBOPROPS SUSPECTED TO BE UNRELIABLE.	

FIGURE 31. HAZARD LEVEL RATIOS FOR COMMON CAUSE - OTHER

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL		0/1	2/9 = 0.22
LVL.3+4/ALL		1/1 = 1.00	3/9 = 0.33

a. Common Cause - Other - Hazard Level 4.

Engine Type	**Event Summary**
Turboprop	Pilot reported left-hand engine surging and shut it down. Then the right-hand engine began surging. Forced landing; substantial aircraft damage; investigation revealed fuel exhaustion (hazard level 4.a.)

	Lost power on both engines on approach; landed gear up on residential road; fuel exhaustion (hazard level 4.a.)
	On approach both engines flamed out; suspect fuel system problem (hazard level 4.a.)
	On approach both engines flamed out; landed in river bed (hazard level 4.a.)
	Flew six hours and 18 minutes; both engines stopped and aircraft crashed one mile short of runway; fuel exhaustion; hull loss (hazard level 4.b.)
High Bypass	Forced landing due to fuel exhaustion; official investigation report (hazard level 4.a.)
	Cargo door torn off in-flight; No. 3 and No. 4 engine ingested debris; shutdown; fatality (hazard level 4.c.)

b. Common Cause - Other - Hazard Level 3.

Engine Type	**Event Summary**
Low Bypass	Aborted due to tire ingestion; No. 1 engine lost power; and No. 2 engine lost 50 percent power; ran off end of runway (hazard level 3.d.)
High Bypass	No. 1 and No. 3 engine experienced high-pressure turbine blade fractures (hazard level 3.d.)

FIGURE 32. MULTIPLE-ENGINE POWERLOSS - KNOWN/UNKNOWN - RELATED 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	*	0	0	1	0	0	25	1	0

TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 0
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 1
TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= 26
"*" THE REPORTING OF HAZARD LEVEL 1 & 2 EVENTS NOT EXPECTED TO BE COMPLETE ON TURBOPROPS.	

FIGURE 33. HAZARD LEVEL RATIOS FOR COMMON CAUSE - KNOWN/ UNKNOWN - RELATED

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL		0/1	0/25
LVL.3+4/ALL		0/1	1/25 = 0.04

a. Multiple - Known/Unknown - Related - Hazard Level 3.

Engine Type	Event Summary
High Bypass	Wear in fuel control caused fuel scheduling drifts and two engines to run down (hazard level 3.d.)

FIGURE 34. MULTIPLE-ENGINE POWERLOSS - UNRELATED CAUSES 1982 THROUGH 1991

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS	2	1	1	3	3	0	6	4	0

TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 1
TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 9
TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= 11

FIGURE 35. HAZARD LEVEL RATIOS FOR COMMON CAUSE - UNRELATED

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL	1/2 = 0.50	0/3	0/6
LVL.3+4/ALL	2/2 = 1.00	3/3 = 1.00	4/6 = 0.67

a. Multiple - Unrelated - Hazard Level 4.

Engine Type	Event Summary
Turboprop	One engine ran down and was feathered. Shortly thereafter, the other engine caught fire; forced landing (hazard level 4.a.)

b. Multiple - Unrelated Hazard Level 3.

Engine Type	Event Summary
Turboprop	No. 2 engine seized accessory gearbox and then powerloss on No. 1 engine; No. 1 engine cause not reported (hazard level 3.d.)
Low Bypass	No. 3 engine flamed out due to sheared fuel pump shaft; No. 2 engine no response to throttle (hazard level 3.d.)
	No. 1 strut overheat light and power reduced; No. 2 oil pressure light and shutdown (hazard level 3.d.)
	No. 2 engine turbine damage and shutdown; No. 3 engine low oil pressure due to bearing failure and power reduced (hazard level 3.d.)
High Bypass 3	No. 2 engine oil pressure fluctuations due to chafed vent line; No.
	engine low oil quantity due scavenge line leak from epoxied; mismachined hole in main gearbox (hazard level 3.d.)
	No. 1 engine surged due to boost pumps not turned on; restart attempts unsuccessful; two hours later, No. 2 engine stalled; shutdown; not restarted; engine vane and bleed control (EVBC) adjusted (hazard level 3.d.)
	No. 1 engine fire warning due to broken bleed pipe shutdown; No. 3 engine exhaust gas temperature high; shutdown and restarted but only 50 percent power; metal in tailpipe (hazard level 3.d.)
	No. 3 engine high-pressure turbine blade fracture on takeoff roll; shutdown; No. 4 engine shutdown in climb due to reported fuel flow dropping (unconfirmed by flight data recorder); unknown if No. 4 engine restarted prior to landing (hazard level 3.d.)

FIGURE 36. APU-RELATED AIRCRAFT HAZARD MATRIX
1982 THROUGH 1991

HAZARD LEVEL	ALL	3	4
APU SYSTEM MALFUNCTION	NUMBER EVENTS		
UNCONTAINED	21	0	0
FIRE	47	7	0
CREW ERROR	1*	1	0
MAINTENANCE ERROR	1*	1	0
OTHER	8*	0	0
TOTAL EVENTS	**78***	**9**	**0**

APU EVENTS HAZARD LEVEL 4	= 0
APU EVENTS HAZARD LEVEL 3+4	= 9
APU EVENTS ALL HAZARD LEVEL	= 78
"*" THE EVENT COUNT FOR ALL EVENTS MAY BE INCOMPLETE.	

a. APU - Hazard Level 3.

MALFUNCTION	**Event Summary**
FIRE	Ground fire due to fuel leak; APU exhaust possible ignition source; substantial aircraft damage (hazard level 3.a.)
	2 events. Tailpipe fire due to clogged drain; wind blew flames onto fuselage; trim tabs damaged (hazard level 3.a.)
	3 events. Torching start; wind blew flames onto fuselage; elevator surface damage reported (hazard level 3.a.)
	Torching start; no aircraft damage; nine (9) injured due to toxic effects of fire agent (hazard level 3.b.)
CREW ERROR	APU placard inoperative. APU was started. A torching start with 30 knot tailwind resulted in aircraft elevator damage (hazard level 3.a.)
MAINTENANCE ERROR	APU was written up but not placarded. APU was started with tail into wind; elevator and stabilizer were damaged (hazard level 3.a.)

FIGURE 37. PROPELLER SYSTEM-RELATED AIRCRAFT HAZARD MATRIX 1982 THROUGH 1991

HAZARD LEVEL	ALL	3	4
PROPELLER SYSTEM MALFUNCTION	**NUMBER EVENTS**		
PROPELLER SEPARATION	*	7	2
PROPELLER GEARBOX\ATTACHMENT SEPARATION	*	3	0
LOSS OF CONTROL (NEGATIVE THRUST)	*	3	1
PROPELLER SYSTEM & CREW ERROR	*	0	5
CREW ERROR	*	0	3
OTHER	*	0	1
TOTAL EVENTS	*****	**13**	**12**

PROPELLER SYSTEM EVENTS HAZARD LEVEL 4 . = 12

PROPELLER SYSTEM EVENTS HAZARD LEVEL 3+4 . = 25

"*" THE REPORTING OF HAZARD LEVEL 1 & 2 EVENTS IS BELIEVED TO BE INCOMPLETE AND THEREFORE MISLEADING

a. Propeller Separation - Hazard Level 4.

One blade separated; engine mounts shook loose and engine hung Down below wing. Crew unable to maintain flight (high drag); forced landing (hazard levels 4.a. and 3.f.)

No. 3 Propeller blade sheath fractured, releasing propeller assembly, which struck No. 4 propeller; No. 4 subsequently broke away, hit fuselage and damaged No. 2 engine. No. 4 propeller damage to fuselage included severing hydraulic lines and control cables. Emergency declared and flight diverted landing safely without brakes and with limited control (hazard level 4.a.)

b. Propeller Separation - Hazard Level 3.

2 events: One propeller blade separated; unbalance twisted engine from mounts and remaining propeller blades penetrated cabin (hazard level 3.a.)

One propeller blade separated and engine cocked outboard and aircraft depressurized rapidly (hazard level 3.c.)

One propeller blade separated; substantial damage (hazard level 3.a.)

One blade fragment (23 inches long tip section) separated and deflected away from fuselage but aircraft had substantial damage; abort (hazard level 3.a.)

Blade separated during takeoff roll penetrated fuselage (structural damage) (hazard level 3.a.)

No.2 Propeller hub fracture; released blade which struck No. 1 propeller resulting in release of No. 1 propeller due to vibration. Both engines shutdown; divert and two-engine landing (hazard level 3.a.)

c. Propeller Gearbox/Attachment Separation - Hazard Level 3.

Propeller assembly separated and struck fuselage making 3 foot by 1.5 foot hole due to foreign object lodged in pinion input and main drive gear causing gearbox and propeller separation (hazard level 3.a.)

Propeller separated; struck fuselage, depressurizing the cabin and jamming the flight controls and throttles, but landed safely using autopilot for control over direction and gear extension for controlling altitude (hazard level 3.a.)

No. 1 propeller and front of gearbox released; slight damage to No. 2 (hazard level 3.a.)

d. Loss of Control - Hazard Level 4.

Fire warning on both engines; both engine propeller systems cruise lockup; forced landing (hazard level 4.a.)

e. Loss of Control - Hazard Level 3.

Engine malfunction above V1; propeller auto-coarsened; then went to flat pitch. Pilot manually feathered propeller and IFSD (hazard level 3.e.)

Engine malfunction above V1; propeller auto-coarsened; then went to flat pitch. Pilot recovered aircraft control after GPWS and stick shaker over water. Pilot manually feathered propeller and IFSD (hazard levels 3.e. and 3.f.)

Propeller system cruise lockup; engine autofeathered and turbine burned out (hazard level 3.f.)

f. Propeller and Crew Error - Hazard Level 4.

Crew inadvertently placed power lever below flight idle during approach. Beta Lock Out System (to preclude P/L below idle) malfunctioned. Unable to recover; crashed; hull loss; fatal (hazard levels 4.b. and 4.c.)

Propeller system cruise lock hang up and late overshoot together with inappropriate crew action; crashed; hull loss (hazard level 4.b.)

Both propeller systems cruise lockup. Withdrawal solenoid-related defect together with inappropriate crew action. Wheels-up landing in a field (hazard level 4.a.)

Propeller/aircraft electrical fault caused cruise pitch lock. Crew did not take appropriate action; forced landing (hazard level 4.a.)

Propeller system fault; sudden and complete loss of power resulting from inappropriate crew action; crashed; hull loss (hazard level 4.b.)

g. Crew Error - Hazard Level 4.

Crew placed power levers into reverse range during final approach aircraft stalled; crashed; hull loss; fatal (hazard levels 4.b. and 4.c.)

Both propellers oversped simultaneously due to operation in Beta Mode in-flight. One auto-recovered but other did not; crashed; hull loss; fatal (hazard levels 4.b. and 4.c.)

Failure of crew to select propeller lockout for stall maneuvers resulted in turbine burn out and fire, leading to engine separation. Remaining engine also caught fire and was shutdown; forced landing (hazard level 4.a.)

h. Other - Hazard Level 4.

Under investigation. Crew lost control (loss of propeller pitch control) and airplane crashed; hull loss; fatal (hazard levels 4.b. and 4.c.)

FIGURE 38. AIRCRAFT HAZARD EVENT COUNT MATRIX - SUMMARY
1982 THROUGH 1991
EXCLUDING PROPELLER AND APU-RELATED EVENTS

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR			TOTAL	
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4	3	4
MALFUNCTION TYPE	MALFUNCTION TYPE EVENT COUNTS										
UNCONTAINED SUBTOTAL	**50**	**3**	**2**	**97**	**17**	**3**	**136**	**10**	**3**	**30**	**8**
Blades	17	-	1	70	9	-	108	1	-	10	1
Disk/Impeller	30	3	1	21	7	3	18	6	3	16	7
Spacer	2	-	-	6	1	-	9	3	-	4	-
Other	1	-	-	-	-	-	1	-	-	-	-
CASE RUPTURE	12	-	-	21	2	2	10	2	-	4	2
CASE BURNTHROUGH	6	1	-	6	-	-	44	-	-	1	-
HP AIR LEAK	7*	-	-	*	-	-	203	-	-	-	-
ENGINE SEPARATION	-	-	-	2	-	-	2	-	2	-	2
COWL SEPARATION	-	-	-	28	-	-	78	1	-	1	-
PROP. SYS. +\ CREW ERROR	*	4	14	*	2	5	*	5	2	11	21
CREW ERROR	*	-	5	*	1	-	*	2	1	3	6
FIRE-U/COWL	17	2	1	18	1	-	88	3	-	6	1
REVERSER	N/A	N/A	N/A	15	1	1	20	5	1	6	2
UNKNOWN	*	-	2	*	-	1	*	-	-	-	3
OTHER	12	1	1	11	1	-	25	4	-	6	1
MULTIPLE PROPULSION SYSTEM EVENTS SUBTOTAL	*****	**5**	**17**	**35**	**8**	**5**	**103**	**21**	**4**	**34**	**26**
Common - Environmental	*	2	2	21	3	2	44	9	1	14	5
Common - Human	*	2	9	9	1	3	19	6	1	9	13
Common - Other	*	-	5	1	1	-	9	1	2	2	7
Known/Unknown	*	-	-	1	-	-	25	1	-	1	-
Unrelated	2	1	1	3	3	-	6	4	-	8	1
GRAND TOTAL	*	16	42	*	33	17	*	53	13	102	72

NOTE: "*" TOTAL NUMBER OF EVENT COUNTS NOT COMPLETE

"-" DASH USED INSTEAD OF ZERO TO FACILITATE SPEED READING

FIGURE 39. SUMMARY PROPULSION SYSTEM AND APU-RELATED FIXED WING COMMERCIAL AIRCRAFT FLEET HAZARD RATES - 1982 THROUGH 1991

RATES PER 10 MILLION AIRCRAFT FLIGHTS

a. Turboprop Powerplants (78.331 million aircraft flights).

ENGINE HAZARD LEVEL 4	5.36
PROPELLER HAZARD LEVEL 4	1.53
POWERPLANT - HAZARD LEVEL 4	6.89
ENGINE HAZARD LEVEL 3+4	7.40
PROPELLER HAZARD LEVEL 3+4	3.19
TOTAL POWERPLANT HAZARD LEVELS 3+4	10.59

b. Low Bypass Ratio Powerplants (81.431 million aircraft flights).

POWERPLANT HAZARD LEVEL 4	2.09
POWERPLANT HAZARD LEVELS 3+4	6.14

c. High Bypass Ratio Powerplants (39.60 million aircraft flights).

POWERPLANT HAZARD LEVEL 4	3.28
POWERPLANT HAZARD LEVELS 3+4	16.67

d. Overall Grand Total (199.362 million aircraft flights).

POWERPLANT + APU - HAZARD LEVEL 4 (84 EVENTS)	4.21
POWERPLANT + APU - HAZARD LEVELS 3+4 (208* EVENTS)	10.43

NOTE: *" 9 HAZARD LEVEL 3 APU EVENTS INCLUDED IN GRAND TOTAL

FIGURE 40. PROPULSION SYSTEM-RELATED AIRCRAFT HAZARD MATRIX TURBOPROP TRANSPORT AND REGIONAL AIRCRAFT 1982 THROUGH 1991

EVENTS, HAZARD RATIO AND RATES PER 10 MILLION AIRCRAFT FLIGHTS

	EVENTS			HAZARD RATIOS		RATES	
HAZARD LEVEL	**ALL**	**3+4**	**4**	**(3+4) /ALL**	**4/ALL**	**3+4**	**4**
MALFUNCTION TYPE							
UNCONTAINED SUBTOTAL	**50**	**5**	**2**	**0.10**	**0.04**	**0.64**	**0.26**
Blades	17	1	1	0.06	0.06	0.13	0.13
Disk/Impeller	30	4	1	0.13	0.03	0.51	0.13
Spacer	2	-	-	-	-	-	-
Other	1	-	-	-	-	-	-
CASE RUPTURE	12	-	-	-	-	-	-
CASE BURNTHROUGH	6	1	-	0.17	-	0.13	-
HP AIR LEAK	7*	-	-	-	-	-	-
ENGINE SEPARATION	-	-	-	-	-	-	-
COWL SEPARATION	-	-	-	-	-	-	-
PROPULSION SYSTEM + CREW ERROR	*	18	14	*	*	2.30	1.79
CREW ERROR	*	5	5	*	*	0.64	0.64
FIRE-UNDERCOWL	17	3	1	0.18	0.06	0.38	0.13
UNKNOWN	*	2	2	*	*	0.26	0.26
OTHER	12	2	1	0.17	0.08	0.26	0.13
MULTIPLE PROPULSION SYSTEM SUB-TOTAL	*****	**22**	**17**	*****	*****	**2.81**	**2.17**
Common - Environmental	*	4	2	*	*	0.51	0.26
Common - Human	*	11	9	*	*	1.40	1.15
Common - Other	*	5	5	*	*	0.64	0.64
Known/Unknown	*	-	-	-	-	-	-
Unrelated	2	2	1	1.00	0.50	0.26	0.13
GRAND TOTAL	*****	**58**	**42**	*****	*****	**7.40**	**5.36**

NOTE:
- "*" TOTAL EVENT COUNTS NOT COMPLETE
- "-" DASH USED INSTEAD OF ZERO TO FACILITATE SPEED READING
- 1982 THROUGH 1991 ESTIMATED 78.331 MILLION AIRCRAFT FLIGHTS

FIGURE 41. PROPULSION SYSTEM-RELATED AIRCRAFT HAZARD MATRIX JET AND LOW BYPASS RATIO ENGINES 1982 THROUGH 1991 (JT3C/D, JT4 EXCLUDED)

EVENTS, HAZARD RATIOS AND RATES PER 10 MILLION AIRCRAFT FLIGHTS

	EVENT			HAZARD RATIOS		RATES	
HAZARD LEVEL	**ALL**	**3+4**	**4**	**(3+4)/ALL**	**4/ALL**	**3+4**	**4**
MALFUNCTION TYPE							
UNCONTAINED SUBTOTAL	**97**	**20**	**3**	**0.21**	**0.03**	**2.46**	**0.37**
Blades	70	9	-	0.13	-	1.11	-
Disk/Impeller	21	10	3	0.48	0.14	1.23	0.37
Spacer	6	1	-	0.17	-	0.12	-
Other	-	-	-	-	-	-	-
CASE RUPTURE	21	4	2	0.19	0.10	0.49	0.25
CASE BURNTHROUGH	6	-	-	-	-	-	-
HP AIR LEAK	*	-	-	-	-	-	-
ENGINE SEPARATION	2	-	-	-	-	-	-
COWL SEPARATION	28	-	-	-	-	-	-
PROPULSION SYSTEM + CREW ERROR	*	7	5	*	*	0.86	0.61
CREW ERROR	*	1	-	*	-	0.12	-
FIRE-UNDERCOWL	18	1	-	0.06	-	0.12	-
REVERSER	15	2	1	0.13	0.07	0.25	0.12
UNKNOWN	*	1	1	*	*	0.12	0.12
OTHER	11	1	-	0.09	-	0.12	-
MULTIPLE PROPULSION SYSTEM SUB-TOTAL	**35**	**13**	**5**	**0.37**	**0.14**	**1.60**	**0.61**
Common - Environmental	21	5	2	0.24	0.10	0.61	0.25
Common - Human	9	4	3	0.44	0.33	0.49	0.37
Common - Other	1	1	-	1.00	-	0.12	-
Known/Unknown	1	-	-	-	-	-	-
Unrelated	3	3	-	1.00	-	0.37	-
GRAND TOTAL	*	**50**	**17**	*	*	**6.14**	**2.09**

NOTE: "*" TOTAL EVENT COUNTS NOT COMPLETE

"-" DASH USED INSTEAD OF ZERO TO EHANCE SPEED READING

1982 THROUGH 1991 ESTIMATED 81.431 MILLION AIRCRAFT FLIGHTS

FIGURE 42. PROPULSION SYSTEM-RELATED AIRCRAFT HAZARD MATRIX HIGH BYPASS RATIO ENGINES – 1982 THROUGH 1991

EVENTS, HAZARD RATIOS AND RATES PER 10 MILLION AIRCRAFT FLIGHTS

	EVENTS			HAZARD RATIOS		RATES	
HAZARD LEVEL	**ALL**	**3+4**	**4**	**(3+4)/ALL**	**4/ALL**	**3+4**	**4**
MALFUNCTION TYPE							
UNCONTAINED SUBTOTAL	**136**	**13**	**3**	**0.10**	**0.02**	**3.28**	**0.76**
Blades	108	1	-	0.01	-	0.25	-
Disk/Impeller	18	9	3	0.50	0.17	2.27	0.76
Spacer	9	3	-	0.33	-	0.76	-
Other	1	-	-	-	-	-	-
CASE RUPTURE	10	2	-	0.20	-	0.51	-
CASE BURNTHROUGH	44	-	-	-	-	-	-
HP AIR LEAK	203	-	-	-	-	-	-
ENGINE SEPARATION	2	2	2	1.00	1.00	0.51	0.51
COWL SEPARATION	78	1	-	0.01	-	0.25	-
PROPULSION SYSTEM + CREW ERROR	*	7	2	*	*	1.77	0.51
CREW ERROR	*	3	1	*	*	0.76	0.25
FIRE-UNDERCOWL	88	3	-	0.03	-	0.76	-
REVERSER	20	6	1	0.30	0.05	1.52	0.25
UNKNOWN	-	-	-	-	-	-	-
OTHER	25	4	-	0.16	-	1.01	-
MULTIPLE PROPULSION SYSTEM SUB-TOTAL	**103**	**25**	**4**	**0.24**	**0.04**	**6.31**	**1.01**
Common - Environmental	44	10	1	0.23	0.02	2.53	0.25
Common - Human	19	7	1	0.37	0.05	1.77	0.25
Common - Other	9	3	2	0.33	0.22	0.76	0.51
Known/Unknown	25	1	-	0.04	-	0.25	-
Unrelated	6	4	-	0.67	-	1.01	-
GRAND TOTAL	*****	**66**	**13**	*****	*****	**16.67**	**3.28**

NOTE:

"*" TOTAL EVENT COUNTS NOT COMPLETE

"-" DASH USED INSTEAD OF ZERO TO EHANCE SPEED READING

1982 THROUGH 1991 - ESTIMATED 39.6 MILLION AIRCRAFT FLIGHTS

FIGURE 43. PARETO OF ALL HAZARD LEVEL 4 EVENTS
1982 THROUGH 1991

MALFUNCTIONS		NUMBER EVENTS	RATE PER 10 MILLION A/C FLIGHTS
PROPULSION SYSTEM & CREW ERROR		21	1.05
MULTIPLE - COMMON - HUMAN		13	0.65
PROPELLER		12	0.60
Blade Separation	2		
Gearbox/Attachment Separation	0		
Loss of Control	1		
Propeller & Crew Error	5		
Crew Error	3		
Other	1		
UNCONTAINED		8	0.40
MULTIPLE - COMMON - OTHER		7	0.35
CREW ERROR		6	0.30
MULTIPLE - COMMON - ENVIRONMENT		5	0.25
UNKNOWN		3	0.15
REVERSER		2	0.10
ENGINE SEPARATION		2	0.10
CASE RUPTURE		2	0.10
OTHER		1	0.05
MULTIPLE - UNRELATED		1	0.05
FIRE - UNDER COWL		1	0.05
TOTAL		**84**	**4.21**

FIGURE 44. PARETO OF ALL HAZARD LEVEL 3 & 4 EVENTS
1982 THROUGH 1991

MALFUNCTIONS		NUMBER EVENTS	RATE PER 10 MILLION A/C FLIGHTS
UNCONTAINED		38	1.91
PROPULSION SYSTEM & CREW ERROR		32	1.61
PROPELLER SYSTEM		25	1.25
Blade Separation	9		
Gearbox/Attachment Separation	3		
Loss of Control	4		
Propeller & Crew Error	5		
Crew Error	3		
Other	1		
MULTIPLE - COMMON - HUMAN		22	1.10
MULTIPLE - COMMON - ENVIRONMENT		19	0.95
CREW ERROR		9	0.45
MULTIPLE - COMMON - OTHER		9	0.45
MULTIPLE - UNRELATED		9	0.45
APU		9	0.45
Fire	7		
Crew Error	1		
Maintenance Error	1		
REVERSER		8	0.40
FIRE - UNDER COWL		7	0.35
OTHER		7	0.35
CASE RUPTURE		6	0.30
UNKNOWN		3	0.15
ENGINE SEPARATION		2	0.10
COWL SEPARATION		1	0.05
CASE - BURNTHROUGH		1	0.05
MULTIPLE KNOWN/UNKNOWN - RELATED		1	0.05
HIGH-PRESSURE AIR LEAK		0	-
TOTAL		**208**	**10.43**

Appendix 5

Turbine Engine Rotor Uncontained Events
(1 January 1992 through 30 November 1996)

FIGURE 45. UNCONTAINED - BLADES - 1992 THROUGH 30 NOV. 1996

ENGINE TYPE	TURBOPROP			JET/LOW BYPASS PRESSURE RATIO (LBPR)			HIGH BYPASS PRESSURE RATIO (HBPR)		
HAZARD LEVEL	**ALL**	**3**	**4**	**ALL**	**3**	**4**	**ALL**	**3**	**4**
NUMBER EVENTS BY MODULE									
FAN	N/A	N/A	N/A	4	0	0	26	0	0
Platforms	N/A	N/A	N/A						
LPC				1	0	0			
IPC									
HPC				2	0	0			
HPT				2	0	0	1	0	0
IPT	1	0	0						
LPT/PT				12	0	0	26	0	0
BLADE TOTAL	**1**	**0**	**0**	**21**	**0**	**0**	**53**	**0**	**0**

UNCONTAINED BLADE TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 0
UNCONTAINED BLADE TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 0
UNCONTAINED BLADE TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= 75

FIGURE 46. HAZARD LEVEL RATIOS FOR UNCONTAINED BLADES

ENGINE TYPE	TURBOPROP	LOW BYPASS	HIGH BYPASS
LVL.4/ALL	0/1	0/21	0/53
LVL.3+4/ALL	0/1	0/21	0/53

a. Uncontained Blades - Hazard Level 4.

Engine Type **Event Summary**

None for the period.

Engine Type **Event Summary**

None for the period.

FIGURE 47. UNCONTAINED – DISKS, SPOOLS & IMPELLERS – 1992 THROUGH 30 NOV. 1996

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS BY MODULE									
FAN	N/A	N/A	N/A	2	1	1			
LPC									
IPC							1	1	0
HPC				2	0	1	4	1	0
HPT	2	0	0						
IPT									
LPT/PT	1	0	0				8	2	0
TOTAL	**3**	**0**	**0**	**4**	**1**	**2**	**13**	**4**	**0**

DISK, SPOOL & IMPELLER TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 2
DISK, SPOOL & IMPELLER TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 7
DISK, SPOOL & IMPELLER TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= 20

FIGURE 48. HAZARD LEVEL RATIOS FOR DISKS, SPOOLS & IMPELLERS

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL	0/3	2/4 = 0.50	0/13
LVL.3+4/ALL	0/3	3/4 = 0.75	4/13 = 0.31

a. Uncontained – Disk, Spool & Impeller - Hazard Level 4.

Engine Type **Event Summary**

Low Bypass Fan hub fracture during takeoff roll, liberating the hub. Accompanying fan blade fragments penetrated the fuselage (passenger cabin). Two fatalities (hazard level 4.b.)

High-pressure compressor disk fragment fractured during takeoff roll. Disk fragment penetrated through fuel line in fuselage. Aircraft destroyed by the internal fuselage fire. One injury (hazard level 4.b.)

b. Uncontained – Disk, Spool & Impeller - Hazard Level 3.

Engine Type	Event Summary
Low Bypass	Fan hub fractured during takeoff after liftoff, releasing 2 and 4 adjacent fan blades. Engine was fuselage-mounted. Substantial damage to the fuselage at the engine installation; fire continued after discharge of both bottles (hazard level 3.b.)

Engine Type	Event Summary
High Bypass	LPT disk release from No. 2 engine caused hole in wing (approx. 1 sq. ft.) and consequential damage to wiring and pneumatic duct. Loss of indications on No. 1 engine caused crew to IFSD the No. 1 engine. FOD damage to No. 1 engine was minor (hazard level 3.a.) IPT disk release occurred at start of takeoff roll during power set. Minor impact damage to wing and fuselage. Ricocheting debris from ground damaged engine on opposite wing; compressor case punctured, causing it to surge. Low speed abort (hazard level 3.d.) HPC rear spool fractured and a piece of the compressor case punctured the left hand wing fuel tank, opening a 0.4 by 2.0 inch irregular hole. There was another lower wing-side tear 0.2 by 8 inches long (hazard level 3.a.) LPT Disk fractured. One disk piece went out vertically, missing the aircraft, and the other fragment passed through the lower fuselage, rupturing hydraulic lines with the loss of all fluid. Drag chute access door separated. Landing gear manually extended (hazard level 3.a.)

FIGURE 49. UNCONTAINED - SPACERS & OTHERS - 1992 THROUGH 30 NOV. 1996

ENGINE TYPE	TURBOPROP			LBPR			HBPR		
HAZARD LEVEL	**ALL**	**3**	**4**	**ALL**	**3**	**4**	**ALL**	**3**	**4**
NUMBER EVENTS BY MODULE									
FAN	N/A	N/A	N/A						
Platforms	N/A	N/A	N/A						
LPC									
HPC							1	0	0
HPT									
IPT									
LPT/PT									
SPACER TOTAL							1	0	0
OTHER TOTAL	1	0	0				2	1	0
SPACER & OTHER* TOTAL	**1**	**0**	**0**				**3**	**1**	**0**

UNCONTAINED SPACER TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 0
UNCONTAINED SPACER TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 0
UNCONTAINED SPACER TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= 1
UNCONTAINED OTHER TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 0
UNCONTAINED OTHER TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 1
UNCONTAINED OTHER TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= 3
"*" OTHER FOR TURBOPROP IS AN UNKNOWN PART.	
"*" OTHER FOR HBPR TURBOFAN IS A FAN SPINNER FRACTURE.	

FIGURE 50. HAZARD LEVEL RATIOS FOR HBPR SPINNER

ENGINE TYPE	HIGH BYPASS
LVL. 4/ALL	0/2
LVL. 3+4/ALL	1/2 = 0.50

a. Uncontained Spacer - Hazard Level 4.

Engine Type	Event Summary
	None reported for this period.

b. Uncontained Spacer - Hazard Level 3.

Engine Type	Event Summary
	None reported for this period.

c. Uncontained Other - Hazard Level 3.

Engine Type	Event Summary
High Bypass	Spinner fractured on No. 2 engine, releasing spinner and secondary fan blade leading edge fragments through the inlet cowl. Uncontained fragments FODed No. 1 engine. Crew shutdown both left-wing engines. FOD damage to No. 1 engine was minor (hazard level 3.d.)

FIGURE 51. TURBINE POWERED AIRCRAFT FLEET UTILIZATIONS
(Aircraft Flight - Millions)

ENGINE TYPE	1992 THROUGH 11/30/96	1982 THROUGH 1991
TURBOPROPS	40.050	78.331
LOW BYPASS	36.915	81.431
HIGH BYPASS	49.669	39.600
PERIOD TOTALS	**126.634**	**199.362**

FIGURE 52. UNCONTAINED EVENT RATES PER 10 MILLION AIRCRAFT FLIGHTS
1992 THROUGH 30 NOV. 1996 (1982 through 1991)

ENGINE TYPE	HAZARD LEVEL 3+4		HAZARD LEVEL 4	
TURBOPROP				
Blades	0	(0.13)	0	(0.13)
Disk, Spool & Impeller	0	(0.51)	0	(0.13)
Spacer	0	(0)	0	(0)
Other	0	(0)	0	(0)
ALL PARTS	**0**	**(0.64)**	**0**	**(0.26)**
LOW BYPASS				
Blades	0	(1.11)	0	(0)
Disk, Spool & Impeller	0.81	(1.23)	0.54	(0.37)
Spacer	0	(0.12)	0	(0)
Other	0	(0)	0	(0)
ALL PARTS	**0.81**	**(2.46)**	**0.54**	**(0.37)**
HIGH BYPASS				
Blades	0	(0.25)	0	(0)
Disk, Spool & Impeller	0.81	(2.27)	0	(0.76)
Spacer	0	(0.76)	0	(0)
Other	0.20	(0)	0	(0)
ALL PARTS	**1.0**	**(3.28)**	**0**	**(0.76)**
ALL ENGINE TYPES				
Blades	0	(0.55)	0	(0.05)
Disk, Spool & Impeller	0.55	(1.15)	0.16	(0.35)
Spacer	0	(0.20)	0	(0)
Other	0.08	(0)	0	(0)
ALL PARTS	**0.63**	**(1.91)**	**0.16**	**(0.40)**

FIGURE 53. TOTAL FLEET UNCONTAINED EVENT COUNTS AND RATES PER 10 MILLION AIRCRAFT FLIGHTS

	1992 THROUGH 11/30/96		1982 THROUGH 1991	
	NUMBER	RATE	NUMBER	RATE
ALL EVENTS	99	7.82	283	14.20
HAZARD LEVEL 4	2	0.16	8	0.40
HAZARD LEVEL 3+4	8	0.63	38	1.91

Appendix 6

Combined Turbine Engine Rotor Hazard Ratios (1982 through 30 November 1996)

FIGURE 54. UNCONTAINED - BLADES - 1982 THROUGH 30 NOV. 1996

ENGINE TYPE	TURBOPROP			LBPR			HBPR		
HAZARD LEVEL	ALL	3	4	ALL	3	4	ALL	3	4
NUMBER EVENTS BY MODULE									
FAN	N/A	N/A	N/A	26	2	0	90	1	0
Platforms	N/A	N/A	N/A				3	0	0
LPC				9	0	0	2	0	0
IPC									
HPC	1	0	0	4	0	0			
HPT	5	0	0	4	0	0	2	0	0
IPT	2	0	0						
LPT/PT	10	0	1	48	7	0	64	0	0
BLADES TOTAL	**18**	**0**	**1**	**91**	**9**	**0**	**161**	**1**	**0**

UNCONTAINED BLADE TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 1
UNCONTAINED BLADE TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 11
UNCONTAINED BLADE TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= 270

FIGURE 55. HAZARD LEVEL RATIOS FOR UNCONTAINED BLADES

ENGINE TYPE	TURBOPROP	LOW BYPASS	HIGH BYPASS
LVL.4/ALL	1/18 = 0.06	0/91	0/161
LVL.3+4/ALL	1/18 = 0.06	9/91 = 0.10	1/161 = 0.006

FIGURE 56. UNCONTAINED – DISKS, SPOOLS & IMPELLERS – 1982 THROUGH 30 NOV. 1996

ENGINE TYPE⇒	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	**ALL**	**3**	**4**	**ALL**	**3**	**4**	**ALL**	**3**	**4**
NUMBER EVENTS BY MODULE									
FAN	N/A	N/A	N/A	8	2	1	4	2	2
LPC	7	1	0				1	0	0
IPC							1	1	0
HPC	3	0	0	10	3	4	8	2	0
HPT	17	1	1				6	1	1
IPT	1	1	0						
LPT/PT	5	0	0	7	3	0	11	4	0
TOTAL	**33**	**3**	**1**	**25**	**8**	**5**	**31**	**10**	**3**

DISK, SPOOL & IMPELLER TOTAL NUMBER EVENTS HAZARD LEVEL 4 = 9
DISK, SPOOL & IMPELLER TOTAL NUMBER EVENTS HAZARD LEVEL 3+4 = 30
DISK, SPOOL & IMPELLER TOTAL NUMBER EVENTS HAZARD LEVEL ALL = 89

FIGURE 57. HAZARD LEVEL RATIOS FOR DISKS, SPOOLS & IMPELLERS

ENGINE TYPE	TURBOPROP	JET/LOW BYPASS	HIGH BYPASS
LVL.4/ALL	1/33 = 0.03	5/25 = 0.20	3/31 = 0.10
LVL.3+4/ALL	4/33 = 0.12	13/25 = 0.52	13/31 = 0.42

FIGURE 58. UNCONTAINED - SPACERS & OTHERS - 1982 THROUGH 30 NOV. 1996

ENGINE TYPE	TURBOPROP			JET/LBPR			HBPR		
HAZARD LEVEL	**ALL**	**3**	**4**	**ALL**	**3**	**4**	**ALL**	**3**	**4**
NUMBER OF SPACER EVENTS BY MODULE									
HPC				6	1	0	1	0	0
HPT	2	0	0				4	1	0
LPT/PT							5	2	0
SPACER TOTAL	**2**	**0**	**0**	**6**	**1**	**0**	**10**	**3**	**0**
OTHER TOTAL	**2**	**0**	**0**				**3**	**1**	**0**
SPACER & OTHER TOTAL	**4**	**0**	**0**	**6**	**1**	**0**	**13**	**4**	**0**

UNCONTAINED SPACER TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 0
UNCONTAINED SPACER TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 4
UNCONTAINED SPACER TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= 18
UNCONTAINED OTHER TOTAL NUMBER EVENTS HAZARD LEVEL 4	= 0
UNCONTAINED OTHER TOTAL NUMBER EVENTS HAZARD LEVEL 3+4	= 1
UNCONTAINED OTHER TOTAL NUMBER EVENTS HAZARD LEVEL ALL	= 5

FIGURE 59. HAZARD LEVEL RATIOS FOR SPACERS

ENGINE TYPE	TURBOPROP	LBPR	HBPR
LVL.4/ALL	0/2	0/6	0/10
LVL.3+4/ALL	0/2	1/6 = 0.17	3/10 = 0.30

FIGURE 60. HAZARD LEVEL RATIOS FOR OTHER

ENGINE TYPE	TURBOPROP	LBPR	HBPR
LVL.4/ALL	0/2		0/3
LVL.3+4/ALL	0/2		1/3 = 0.33