Supporting Documents

ASOS Special Report In-flight Fires

Aviation Research Group/U.S., Inc.
PO Box 688
Doylestown, PA 18901 USA
Voice: 215-345-6782
Fax: 215-345-8113
Email: argus@aviationresearch.com

“Fire, fire in the cabin!!”

An ASOS Special Report on the History and Horrors of In-Flight Fires.

It is every pilots worst nightmare. What follows in these pages is a chronology of the most significant in-flight fire reports, with Cockpit Voice Recording (CVR) transcripts when they were available.

1983, June 2nd. An Air Canada, DC-9-32, made a successful emergency landing at the Cincinnati airport after discovering smoke in the aft lavatory. The captain’s shirt was on fire when he evacuated. Twenty-three, including all the crew, evacuated and survived. But, 23 passengers were overcome by smoke and died as the plane burst into flames shortly after the doors were opened. Among those killed was Canadian Folk Singer, Stan Rogers.
Compiled by Ed Wandall, ARG/US

1947, October 24th. A United Airlines DC-6 crashed, while attempting to make an emergency landing at Bryce Canyon, Utah. They almost made it, but the fire burned through the controls just short of the airport, killing all 52 on board.

1947, November 11th. An American Airlines DC-6 successfully made an emergency landing at Gallup New Mexico, after fire broke out in that plane’s air-conditioning system. None of the 25 on board was injured, although the plane sustained major fire damage. The investigation of that near tragedy was eventually combined with the United crash above. Both fires were found to have been caused by the same defect in aircraft design: The improper location of the overflow vent for the #3 alternate fuel tank. When fuel was transferred into the #3 tank, it was possible to have some overflow out of the vent for that tank. The airstream then carried the overflow fuel (very high-octane gasoline) directly into the air intake scoop for the cabin heater. The design and testing of the DC-6 fuel system was found to be deficient and in violation of the Civil Aeronautic Board’s existing regulations.

1948, June 17th. A United Airlines DC-6 crashed near Mt. Carmel, Penn. after the crew discharged CO_2, in response to a fire warning, into the cargo compartment. When the nose was lowered, to make an emergency descent to the nearest airport, the CO_2 leaked out of the cargo compartment. Since it was heavier than air, it accumulated in the cockpit, asphyxiating the crew. All 43 on board died. The investigation and subsequent litigation revealed that Douglas Aircraft designed a dangerous fire-fighting system and had reason to know it could render the flight crew unconscious. The fix, to correct that danger, was to install a "dishpan" dump valve that would instantly depressurize the airplane as part of the fire-warning checklist. It was located along side of the First Officer's foot, to allow any CO_2 to flow out of the cockpit before it could accumulate to asphyxiation levels.

1964, July 9th. A United Airlines Vickers Viscount 745D, crashed near Pariottsville, Tennessee, killing all 38 onboard. It suffered an uncontrollable fire in flight, which apparently started below the passenger floor. The ignition source was never determined, but some thought the plane's battery or something in a passenger's luggage the most likely cause. Like the DC-6, the Viscount had a CO_2 fire extinguishing system that proved lethal to the pilots. The CO_2 bottles were located behind the F/O's seat. Testing, after the crash, revealed a lethal amount of CO_2 could be discharged into the cockpit even though it was supposed to go into the lower baggage compartment. The fire eventually burned through the controls, but it is likely that everyone was either unconscious or dead prior to ground contact. The plane was seen, flying erratically for a lengthy period of time, before the final plunge.

1971, August 8th. An Aloha Airlines Vickers Viscount 745D flew a routine flight from Hilo, Hawaii to Honolulu, Hawaii. After taxiing clear of the landing runway, the stewardess informed the captain of smoke in the cabin. The fire trucks were called and the passengers evacuated. As the captain was about to leave the cockpit, he noticed he could move the control wheel to the full aft position, even though the control ground lock had been engaged. The subsequent investigation revealed the left nickel-cadmium battery had suffered an undetected short which lead to a thermal runaway. It melted the metal around it so rapidly that the flight control push rods were burned through in about two minutes time. Had that plane still been flying a few minutes more, none of those on board would have ever seen their loved ones again.

1973, July 11th. A Varig Boeing 707, enroute from Rio de Janeiro to Paris, was forced to land short of the runway at Orly airport, only 5 minutes after reporting a fire in the rear of the cabin. The smoke was so thick in the cockpit that the pilot had to look out the opened side windows to make the crash landing. He could not see his instrument panel o r out the front windshield. Of the 134 on board, only the 3 pilots, 7 cabin crew and 1 passenger survived. All others were asphyxiated and burned. The accident report found the probable cause to be a fire that originated in the washbasin unit of the aft right toilet, either as a result of an electrical fault or by the carelessness of a passenger.

1973, November 3rd. A Pan American 707-321C Cargoliner, crashed, just short of the runway, at Boston Logan International Airport, killing the 3 pilots on board. Only 30 minutes after taking off from New York's JFK Airport, the pilot reported smoke in the cockpit. The smoke became so thick that it "…seriously impaired the flightcrew's vision and ability to function effectively during the emergency." The captain had not been notified that hazardous cargo was aboard. The NTSB said, further, that a ***contributing factor*** was:

…the general lack of compliance with existing regulations governing the transportation of hazardous material which resulted from the complexity of the regulations, the industrywide lack of familiarity with the regulations at the working level, the overlapping jurisdictions, and the inadequacy of government surveillance.

1976, August 6th. An Air Chicago Freight Airlines, Inc., TB-25N (B25 bomber converted to a cargo carrier), crashed while attempting an emergency landing at Chicago's Midway Airport. Both pilots and one person on the ground were killed. The left engine suffered a massive failure in its power section, starting a fire that could not be exti nguished. The NTSB found the probable cause of the accident to be:

…the deterioration of the cockpit environment, due to smoke to the extent that the crew could not function effectively in controlling the aircraft under emergency conditions. The smoke and fire, …propagated into the bomb bay area and then into the cockpit.

1980, August 19th. A Saudi Arabian Airlines, L-1011, returned to Jeddah, Saudi Arabia and made a successful landing, after reporting a fire in its C-3 cargo compartment. However, after landing, no doors opened and no one evacuated. All 301 souls on board perished, including 15 infants, from the inhalation of toxic fumes and exposure to heat. There were no traumatic injuries. Just prior to landing, the captain ordered his crew ***not to evacuate*** and he failed to shut off the engines after the aircraft was stopped. Other findings of the accident investigators:

- There was an extensive history of fires originating in aircraft cargo compartments where loose baggage and cargo are carried.
- The cause of the fire could not be determined.
- The pilots failed to don their oxygen masks.
- The captain failed to understand the seriousness of the situation.
- Both the F/O and the F/E had been dropped from their training programs and/or terminated and reinstated. Their actions, during the emergency, were not helpful to the captain. "Reinstatement in a flight position of terminated crew men is not desirable."

Flight SV163 landed at Riyadh at 16.06h GMT for a scheduled intermediate stop after a flight from Karachi. At 18.08hrs the aircraft took off for the final leg to Jeddah. Six minutes and 54secs. after take-off, while climbing to FL350, visual and aural warnings indicated smoke in the aft cargo compartment C-3. Climbing through FL220 (at 18.20h), a return to Riyadh was initiated. About two minutes later smoke was noted in the aft of the cabin, and passengers were panicking. At 18.25:26h the no.2 engine throttle was stuck. The fire had by then entered the cabin of the TriStar. Because passengers where fighting in the aisles, aft of doors L2 and R2, the captain asked everybody to remain seated (18.27:40). On final approach engine no.2 was shut down, and the captain told the cabin crew not to evacuate. Flight SV163 landed back at Riyadh runway 01 at 18.36:24hrs. The crew continued to a taxiway and told the tower that they were going to shut the engines down and evacuate. The engines were shut down at 18.42:18h. Because no evacuation had been initiated by then, crash, fire and rescue personne l tried to open the doors. At about 19.05 they succeeded in opening door 2R. About three minutes later, the interior was seen to be engulfed in flames.

Legenda
CAM-1 = Voice identified as Captain
CAM-2 = Voice identified as First Officer
CAM-3 = Voice identified as Flight Engineer
CAM-4 = Voice identified as Flight Attendant
RDO-2 = Radio transmission by First Officer
PA = Public address system
TMACC = Riyadh Terminal Area Control Center
TWR = Riyadh Tower
(T) = translated part
Time
(mm:ss) to
landing
GMT Time
(hh.mm:ss) Source Content
28:41 18:07:49 Takeoff
18.14:53 CAM ((Hostess call signal followed by an alternating tone at 14.54)

19 August 1980 Suadi 163

21:32 18.14:58 CAM-3 "B" aft cargo
CAM-1 What?
18.15:01 CAM-3 "B" aft cargo
18.15:04 CAM-2 What's going on?
18.15:10 CAM-3 Smoke detection "B" aft cargo
18.15:14 CAM-1 Stop ventilation
18.15:16 CAM-3 Smoke detection
CAM-3 Smoke detection "B" aft cargo
21:10 18.15:20 CAM-1 In "B" aft cargo
CAM-3 Yes
18.15:32 CAM-1 Did you turn it to the other one?
18.15:37 CAM-3 Just in "B".
CAM-1 What?
18.15:39 CAM-3 Not in "A".
CAM-3 Just in "B".
CAM-1 Just "B".
18.15:42 CAM-3 Yeah, "A" is okay.
CAM-1 Okay, so we can go on
CAM-3 Yes
18.15:51 CAM-1 The ventilation is not working at all in that one
CAM-3 Yeah
CAM ((Alternating tone))
18.15:55 CAM-3 There is "A"
CAM-1 What?
CAM-3 Now it is "A", both of them
20:31 18.15:59 CAM-1 So we got to be returning back right?
CAM-3 Both "A" and "B" aft cargo smoke detection
18.16:06 CAM-1 So we have smoke there
18.16:07 CAM-3 I would say so, yeah
18.16:18 CAM-1 What's the procedure for it in the checklist?

20:10 18.16:20 CAM-1 Yeah I am looking for it now
18.17:10 CAM-1 ((Singing in Arabic))

18.17:16 CAM-1
(T)
See that, what's it's name
18.17:17 CAM-2 Abnormal
18.17:19 CAM-1
(T)
No, no checklist abnormal
18:04 18.18:26 CAM-3 Both "A" and "B"
CAM-3 Yeah. Both "A" and "B"
CAM-3 Shall I test it again and see if it will test?
CAM-1 Yeah
18.18:34 CAM-3 It doesn't test
CAM-1 Doesn't test?
CAM-3 Both off
CAM-1 So that's actual isn't it?
18.18:54 CAM-3 That would ah --- I would say actual, yeah
CAM-1 Uh
CAM-3 I would say so, yeah both of them went
17:30 18.19:00 CAM-1 We have cleared the situation
18.19:17 CAM-1 There isn't anything about it in the abnormal procedures, huh.
18.19:20 CAM-3 Nothing about it, should I just go back there and see if I can find anything or smell anything?
18.19:25 CAM-1 What?
18.19:26 CAM-3 Shall I go back there and see if I can smell anything?
CAM-1 Okay, sure.
CAM-3 Yeah
CAM ((Sound of cockpit door opening))
17:00 18.19:30 CAM-1 Have they seen it
CAM-3 If I can see, smell something I'm think we better go back
18.19:35 CAM-1 Surely check it
CAM-3 We'll see
18.19:40 CAM ((Sound similar to cockpit door slamming))
18.19:41 CAM-2
(T)
Strange no procedure for it
CAM-1 No procedure for it?
18.19:44 CAM-1 Tell them we're returning back
CAM-2 To Riyadh
18.19:48 CAM-1 We are 60 miles out ah ---
18.19:58 CAM-1 We better go, go back to Riyadh
CAM-1

(T)
Look in the abnormal
CAM-1
(T) By the way he's a jackass, in the abnormal it is in the checklist
18.20:16 CAM-3 We've got a fire back there

CAM ((Sound similar to door slamming))
18.20:18 CAM-1 We do?
CAM-3 Yes we do
CAM-1 It's okay call please
18.20:25 CAM-1 Tell him we're coming back
18.20:25 TMACC Go ahead
18.20:27 RDO-2 18.1-6-3, we're coming back to Riyadh
16:00 18.20:30 CAM-3 I would declare an emergency
CAM-1 Yeah
18.20:33 TMACC Cleared to reverse course to Riyadh and request reason
CAM-2 Declare emergency?
18.20:36 CAM ((Door slams))
18.20:37 CAM-? Fire, fire in the cabin
18.20:37 RDO-2 Saudia one six three, we've got fire in the cabin and please alert the fire trucks
CAM ((Noise similar to door slamming))
18.20:45 TMACC Okay and cleared back and if you'd like to descend, you can descend to any altitude you like
18.20:50 CAM-1 Okay
CAM-2 I already asked, I already asked
18.23:07 CAM-3 We definitely want
18.23:10 CAM-3 We definitely, we definitely want preference to land
CAM-1 Huh?
18.23:13 CAM-3 We definitely want preference to land, that's for sure
CAM-1 Yeah
18.23:22 CAM-1 Pressurization set? ---
CAM ((cabin announcement - unintelligible))
13:03 18.23:27 CAM-1 Okay
18.23:32 CAM-2 No smoking sign on
CAM-1 Okay, no smoking sign
18.23:36 CAM-1 Landing preliminary
18.23:40 CAM-3 Okay landing preliminary
18.23:41 CAM-3 18.1-42 on the bug
CAM-1 one fortytwo
18.23:42 CAM-2 one fortytwo
CAM-3 Anti- ice
CAM-1 Off
18.23:50 CAM-3 HSI heading

CAM-1 Set
18.23:51 CAM-3 Seatbelt sign
CAM-1 On
CAM-3 Ah
CAM-3 Logo light
CAM-1 It's okay
18.23:55 CAM-3 Logo light
CAM-1 Checked
12:32 18.23:58 CAM-3 Altimeters
CAM-1 Altimeters is gonna be what it is
CAM-1 It was 1-0-0-2 setting
18.24:03 CAM-3 Okay, and airspeed, groundspeed, airspeed and EPR bugs
18.24:16 CAM-3 Gross weight estimates
18.24:16 CAM ((Sound of alternating tone)) ((Smoke detector aural warning))
18.24:21 CAM-3 What can I say
18.24:22 CAM-1 Okay
CAM-3 I think it's all right now
CAM-1 Okay
12:05 18.24:25 CAM-2 one one zero
CAM-3 Gross weight airspeed and EPR bugs
CAM-1 Set and cross checked, one forty two set here two and one five five check
CAM-2 One five five
CAM-3 Check
18.24:40 CAM-1 Keep the oxygen to be prepared
18.24:41 CAM-3 ((Sound of alternating tone three times simultaneously with above))
CAM-3 There goes "A"
PA (T) # # # #
18.24:49 CAM-1 ((Singing in Arabic))
11:31 18.24:59 PA Would passengers please remain seated
18.25:04 CAM-2 Six point eight
CAM-1 Huh?
CAM-2 Six point eight on the QNH
CAM-2 One zero zero six decimal eight
CAM-? ((Continuous talk by female voice in background))
18.25:12 CAM-1 Okay zero six decima eight
11:04 18.25:26 CAM-1 Okay the throttle in engine number two, it's not returning back --- stuck
CAM-3 Stuck?
18.25:32 CAM-1 Stuck
18.25:36 CAM-3 I would leave it the way it is, Sir
CAM ((Sound of knocking))
CAM-1 Huh?

CAM-3 Just leave it the way it is.
18.25:40 CAM-1 I'm going to shut it down
18.25:41 CAM-4 We tried to, we tried to put it off, at L4 there is a fire
CAM-3 Theres a fire?
CAM-4 Yeah
CAM-3 Well go put it out
18.25:45 TMACC One six three, did you get the message to get us the passengers on board and fuel endurance
CAM-4 How
18.25:47 CAM-3 In the ah, --- the fire extinghuisher
CAM-4 I know I said we will do it
18.25:50 CAM-3 There is a fire back there
CAM-1 Okay
18.25:54 CAM ((Sound similar to door slamming))
18.25:55 CAM-1 Tell them we have actual fire in the cabin
10:31 18.25:59 RDO-2 Riyadh Saudi Arabia one six three, we have an actual fire in the cabin now
18.26:07 CAM-3 Shall I let Jeddah know on HF?
CAM-1 No
18.26:10 TMACC Saudi one six three roger, the fire are in the standby position and they are ready
CAM-3 No?
CAM-1 Not with our situation
18.26:17 RDO-2 One six three
18.26:18 PA L4 and R4 get the fire extinguishers from the galley --- ((repeated))
10:01 18.26:29 CAM-3 Jee's lets go on as fast as we can til we can get to approach
18.26:31 CAM-1 That's it, this is the maximum
CAM-3 Yeah
18.26:34 CAM-1 Now engine number two is stuck there so something is wrong in it, I'm gonna be shut it down
18.26:39 CAM ((Sound similar to cockpit call chime))
18.26:40 CAM-3 Well not yet, not yet, not yet
18.26:42 CAM-4 There is no way I can go to the back * * after L2 R2 because the people are fighting in the aisles
CAM-3 Okay find a way if you can
18.26:53 CAM-4 L4 R4 L3 R3 * * open the cabinet and use all your fire extinguishers and the CO2
9:28 18.27:02 CAM-3 I'll keep your speed up as long as possible
CAM-1 Okay
CAM-1 As soon as possible we're gonna be down
18.27:16 PA (T) (All passengers remain in your seats, etc.)
18.27:21 CAM-3 And your target speed is one forty one
CAM-1 Huh one forty one is set

9:00 18.27:30 CAM-3 Here's the bug card
18.27:32 CAM-1 Thank you
18.27:39 CAM-2 Set on mine
18.27:40 PA
Please, everybody set down, move out of the way, everybody sit down, move out of the aisle, there is no danger from the airplane, everybody should stay in their seats

PA (T)
Sit on your seat, sit on your seat, ladies and gentlemen take your seat --- nothing will happen to aircratf, ladies and gentlemen fasten your seatbelt, don't stand like this set on your seats -- sit down, sit down [in Urdu]
8:27 18.28:03 CAM-3 Piece of cake, piece of cake
18.28:10 CAM-3 As soon as we land, sir, I suggest that we turn off all fuel valves
18.28:14 CAM-1 Okay
CAM-3 As soon as we land
CAM-1 Okay
18.28:17 CAM-3 As soon as we touch down
CAM-1 Okay
18.28:22 CAM-1 Where is the runway?
CAM-1 Can you see the runway?
18.28:27 CAM-2 No not yet, not yet
8:01 18.28:29 CAM-2 Twenty eight miles
CAM-? # # #
18.28:40 CAM-3 Did you tell the fire trucks to go to the back of the airplane as soon as possible
CAM-2 Yeah
CAM-1 Huh
PA (T)
Will all passengers remain seated, will all passengers remain seated, ((Urdu)) --- ladies and gentlemen sit down, sit down (repeated)
CAM-1 Advise them
CAM-1 Huh
CAM-2 Advise them?
18.28:50 CAM-1
(T)
How?
18.28:50 RDO-2 Riyadh one six three
CAM-2 Advise them

18.28:52 TWR Go ahead
CAM ((Sound of two knocks))
CAM-1 Yeah, yeah
18.28:54 RDO-2 Please advise fire trucks to be at tail of the airplane after touch, please.
7:31 18.28:59 TWR Yes, will do
18.29:01 CAM-1
(T)
Where is the airport, I don't see it?
CAM-4 Captain there is too much smoke in the back

CAM-2
(T)
There is the airport road, the yellow lamps are the airport road.
CAM-1 Huh
CAM-2
(T) The yellow lamps are the airport road
CAM-1 That
CAM-2 Yeah
CAM-4 # # #
CAM-1 Are there too much smoke there?
6:56 18.29:34 CAM-3 Okay, I am going to test the system again
18.29:36 CAM ((Sound of alternating tone)) ((Smoke detector))
18.29:38 CAM-3 Okay, there's both "A" and "B" loops working again
18.29:44 CAM-3 And no indication of smoke
18.29:46 CAM-1 Huh
18.29:47 CAM-3 No ah indication of smoke, however, the cabin is filled with smoke in the back
CAM-1 Okay
18.29:53 CAM-1 Now the number two is stuck there the engine
CAM-1 Okay
18.29:56 CAM-3 I suggest we shut it down on short final
18.29:59 CAM ((Sound of alternating tone))
6:31 18.29:59 CAM-1 Yeah, on short final
18.30:01 CAM-3 Okay, there is "A" again
18.30:03 CAM-3 And "A" is going out
18.30:20 CAM ((Sound similar to door movement))
6:03 18.30:27 PA (T) ((Passenger exhorting passengers to sit down))
18.30:35 CAM-3 What is he saying?
CAM-2 Trying to keep them calm, keep the down
18.30:41 CAM-1 Okay flaps four please
18.30:45 CAM-1 Okay, final to the box

18.30:47 CAM-2 Final to the box please
18.30:52 CAM ((Sound similar to seat movement))
18.30:56 PA Everybody sit down please, all passengers
5:30 18.31:00 CAM-1 Okay flaps ten please, correction, it's okay
CAM ((Sound of cough))
CAM-? *
CAM-2
(T) They are the first people
CAM-1
(T)
What?

CAM-2
(T)
They are the first people
CAM-1
(T) Who are they?
18.31:13 CAM-2
(T) They are the people we were talking about
CAM-1 Huh
CAM-2 They are the people we were talking about
18.31:18 CAM-1
(T)
Where is the airport I don't see it
CAM-2
(T)
You see those lights over there, that's the stadium
18.31:22 CAM-2 I got the field in sight
18.31:25 CAM-1 I am just trying to interept this (radial)
CAM-2 Okay
5:00 18.31:30 CAM-4 Shall we evacuate?
CAM-1 What?
18.31:31 CAM-4 Did you say we should evacuate ---
CAM-1 Okay
CAM-4 The passengers
CAM-3 Say again
CAM-4 Can we evacuate all the passengers?
18.31:34 CAM-1 Flaps ten please
CAM-3 When we're on the ground yes
CAM-4 Okay after we are on the ground yes
CAM-2 Flaps ten

CAM-1 Yeah
18.31:38 CAM-1 Final to the box !
18.31:40 CAM-2 Final to the box please
18.31:41 CAM-3 Final to the box
18.31:42 CAM-3 Okay ignition
CAM-2 On
CAM-3 No smoking sign
CAM-2 Say again
18.31:48 CAM-3 No smoking sign
CAM-2 On
18.31:49 CAM-3 Altimeters
CAM-2 Set, cross checked
CAM-3 Brake pressure
CAM-2 Checked
18.31:51 CAM-3 Radio and R NAV selector
CAM-2 Check
18.31:54 CAM-3 Okay complete to the box
18.31:58 CAM-3 Okay, right after landing sir do you want me to turn off all fuel valves?
4:28 18.32:02 CAM-1 No after we have stopped the aircraft
CAM-3 Okay
18.32:05 CAM-1 Okay, I'll tell you
18.32:10 CAM-4 Do you want us to evacuate passengers Captain?
CAM-1 What?
CAM-4 Do you want us to evacuate the passengers as soon as we stop
18.32:16 CAM-1 Take your position
CAM-4 Okay
18.32:19 CAM-3 The area duct overheat
CAM ((Sound similar to door shutting))
CAM-1 Okay
CAM-1 Flaps eighteen please
18.32:23 CAM-2 One eight
18.32:25 PA Flight attendants please take your position
CAM-4 Flight attendants please take your positions
3:59 18.32:31 CAM-2 Got runway in sight?
18.32:33 RDO-2 Riyadh, one six three, we got the runway in sight, are we cleared to land?
CAM-1 Oh yeah, I see it
PA Please take your positions
18.32:36 TMACC Affirmative, you are number one cleared for approach and you can continue tower one eighteen one
18.32:42 RDO-2 Eighteen one, one six three
18.32:44 RDO-2 Riyadh, Saudia one six three ten miles final runway in sight, cleared to land?

CAM-4 All of you sit down
18.32:48 TWR One six three cleared to land, wind three two zero at five
18.32:48 CAM-1 Okay I'm shutting
PA (T) Fasten seatbelts all of you sit down [in Urdu]
18.32:52 CAM-1 Okay, I'm shutting down engine number two
CAM-1 It's stuck, present EPR
18.32:53 RDO-2 One six three, cleared to land, confirm you have alterted the fire trucks
CAM-3 Okay
CAM-1 Okay
CAM-3 Okay
18.32:58 TWR Affirmative, they are ready
18.32:59 CAM-1 Okay, it is coming down
3:29 18.33:01 RDO-2 Thank you
(T)
CAM-3 All right
CAM-1 Okay
18.33:06 CAM-2 Flaps in eighteen
18.33:08 CAM-3 I'll keep our speed up as much as possible
CAM-1 Okay, flaps twenty two
CAM-2 Flaps twenty two
CAM-4 Give me your attention please, be seated ladies and gentlemen,
we are about to land there's no reason to panic
18.33:22 CAM-3 I'll give you a hundred and fifty down, okay
CAM-1 What?
18.22:23 CAM-3 A hundred and fifty on down
CAM-1 Yeah sure
3:01 18.33:29 PA
We're about to land ladies and gentlemen place your hands
behind your head for impact, girls demonstrate impact position,
girls demonstrate impact position
18.33:31 CAM-1 Gear down please
CAM-2 Gear is coming down
18.33:35 CAM-3 Okay, you can go one ninety
CAM-1 Good
18.33:40 CAM-1 There is no, any procedure for the two engine, it's the same as three
CAM-2 Okay
CAM-3 Yeah
18.33:45 CAM-1 I just want to confirm it, I know it God damn it
18.33:52 CAM-1 Tell him that engine number two is should be shut down --- it's stuck
18.33:57 CAM-2 Okay
18.33:58 CAM-1 Tell the tower

CAM-2 Yeah
2:30 18.34:00 CAM-1 Yeah, we just have engine number one
18.34:02 RDO-2 Tower Saudia one six three
18.34:04 PA
The girls have demonstrated impact position, please go down
half a minute before touhdown, it's half a minute before
touchdown, hands behind your head
18.34:06 TWR Go ahead one six three, wind three two zero at five
CAM-1 Number one and number three
18.34:10 RDO-2 One six three is cleared to land, we have engine number two shut
down, we have only one and three
18.34:17 TWR Copied today
PA
Everybody, please sit down, everything's under control, we are
landing back at Riyadh, please it down and fasten your seatbelts,
sit down and fasten your seatbelts, please
CAM-1 Okay
18.34:20 RDO-2 Okay
18.34:25 CAM-1 Complete the final checklist
CAM-2 Complete, flaps
2:04 18.34:26 CAM-3
Okay, your altimeters are one zero zero seven, set and cross
checked three ways, gear and anti-skid is down and checked and
your flaps are at thir- twenty two
18.34:39 CAM-1 Yeah, I know it
18.34:44 CAM-3 Both loops "A" and "B" are out
CAM-1 Thank you
1:37 18.34:53 PA (T) Ladies and gentlemen, no need to panic, place your hands behind
your head for impact position [Urdu]
18.35:06 CAM-3 Aft cargo door is opened sir
18.35:11 CAM-1 Check
CAM-3 No problem
PA Now ladies and gentlement, may I ask you to please put your
hands behind your heads for the impact position
18.35:56 CAM-3 Looking good
18.35:57 CAM-1 Tell them, tell them to not evacuate
0:30 18.36:01 PA Put your hand behind your head and head between your knees,
hands behind your head
CAM ((Sound similar to door opening))
18.36:07 CAM-3 No need for that, we are okay, no problem, no problem
18.36:12 GPWS Minimum --- minimum
18.36:12 CAM-1 One hundred
CAM-3 One hundred
18.36:15 CAM ((Loud squeal begins and continues until end of CVR tape))

18.36:18 CAM-3 Fifty
18.36:19 CAM-3 Forty
18.36:21 CAM-3 Thirty
18.36:22 CAM ((Loud squeal))
((End of CVR tape))
0:00 18.36:30 approximate time of landing

1982, February 21st. A Pilgrim Airlines deHavilland DHC-6-100, (commuter flight) made an emergency landing on a frozen reservoir lake after fire erupted in the cockpit. The fire destroyed the aircraft after impact. One passenger was killed, while the captain, F/O and 8 passengers sustained serious injuries. One passenger escaped with only minor injuries. The fire was caused by the "***deficient design*** of the isopropyl alcohol windshield washer/deicer system and the ***inadequate maintenance*** of the system…The ignition source of the fire was not determined."
NTSB Identification: **DCA82AA016**
Scheduled 14 CFR Part 135: Air Taxi & Commuter
Accident occurred Sunday, February 21, 1982 in PROVIDENCE, RI
Probable Cause Approval Date: 2/21/83
Aircraft: de Havilland DHC-6, registration: N127PM
Injuries: 1 Fatal, 10 Serious, 1 Minor.

APRX 15 MIN AFT TKOF, LGT ICG WAS NOTED ON THE WINDSHIELD. THE AIRCREW ACTIVATED THE WINDSHIELD WASHER/DEICE SYS WHICH USED ISOPROPYL ALCOHOL. HOWEVER, ONLY A LITTLE DEICING FLUID WAS NOTED ON EITHER SIDE. THE SYS WAS ACTIVATED AGAIN. AFT HLDG THE SW SVRL SECONDS, THE ODOR OF ALCOHOL WAS NOTED.DEICING PROC WAS STOPPED, BUT SHORTLY THEREAFTER, GRAY-WHITESMOKE BGN COMING FM BLO THE FLOOR. THE AIRCREW BGN DIVERTING. THICK SMOKE FILLED THE CABIN & FIRE BROKE OUT ON THE FLOORBTN THE PLTS AS THE ACFT DSCNDD BLO THE CLDS. THE CO-PLT TRIED TO USE 1 FIRE EXTINGUISHER, BUT IT WAS TOO HOT. NO ONE ATMTD TO USE THE CABIN EXTINGUISHER. CRSH LNDG WAS MADE ON A FRZN LAKE. ALL BUT 1 OCCUPANT WERE EVCUATED BFR THE PLANE WAS DESTROYED BY FIRE. AN INVESTIGATION REVEALED TYGON TUBING WAS USED IN THE DEICE SYS. AFT CONTACT WITH ALCOHOL, THE TUBING HARDENS, BCMS MISHAPED AT CONNECTION POINTS & OFTEN RESULTED IN LEAKS. LEAKS WERE REPAIRED BY RMVG ENDS & REATTACHING. A REPAIR WAS MADE ON 2/18/82 IAW DEHAVILLAND PROC. FIRE EXT LCTNS NOT SUF MARKED OR NOTED ON SEATBACK SAFETY CRDS.
The National Transportation Safety Board determines the probable cause(s) of this accident as follows:
MAINTENANCE..INADEQUATE..COMPANY MAINTENANCE PERSONNEL
SUPERVISION..INADEQUATE..COMPANY/OPERATOR MANAGEMENT
ACFT/EQUIP,INADEQUATE AIRCRAFT COMPONENT..MANUFACTURER

ANTI-ICE/DEICE SYSTEM,WINDSHIELD..BRITTLE FRACTURE
ANTI-ICE/DEICE SYSTEM,WINDSHIELD..LEAK
FUSELAGE,CREW COMPARTMENT..FIRE

1983, June 2nd. An Air Canada, DC-9-32, made a successful emergency landing at the Cincinnati airport after discovering smoke in the aft lavatory. The NTSB concluded the fire had burned for 15 minutes before the smoke was first detected. Source of the fire could not be determined. Miscommunication, between the captain and the cabin crew, caused a delay in the declaration of an emergency. The NTSB determined the plane could have landed 3 to 5 minutes earlier, at Louisville, if the descent had started as soon as the captain was made aware of the fire. It took only 11 minutes to make the la nding, after the emergency descent was first initiated. The smoke was so thick in the cockpit, they had to depressurize and repeatedly open and close the cockpit windows, to see the instrument panel. The captain's shirt was on fire when he evacuated. Twenty-three, including all the crew, evacuated and survived. But, 23 passengers were overcome by smoke and died as the plane burst into flames shortly after the doors were opened.

Legenda CAM = Cockpit Area Mike voice or sound source
RDO = Radio Communications
-1 = Voice identified as Captain
-2 = Voice identified as First Officer
-3 = Voice identified as male flight attendant
-4 = Voice identified as female flight attendant
-5 = Voice identified as male passenger
CTR = Indianapolis Center
* = Unintelligible word
# = non pertinent word
( ) = Questionable text
--- = pause
Times are in Central Standard Time
18.48:12 CAM [Sound similar to arcing]
18.48:15 CAM [Sound similar to arcing]
18.51:03 CAM [Two sounds similar to arcing]
18.51:04 CAM-
1 How is your sea food, nice?
CAM [Sounds similar to arcing and snapping]
CAM-
2 It's good
CAM-
1 * steak nice?
18.51:09 CAM-
2 Different, a little bit dry but okay
18.51:14 CAM [Sounds similar to arcing and snapping]
CAM-
2 (What was that?)
CAM-
1 #
18.51:19 CAM-
2 It's right here, I see it

CAM-
1 Yeah
CAM-
1 DC bus
CAM-
2 Which one is that?
CAM-
1 DC bus the, ah, left toilet, left toilet flushing
18.51:27 CAM-
1 (I) better try it again, eh, push 'em in
CAM-
2 Push it in one more time, I guess
18.51:41 CAM [Sound of arcing]
CAM-
2 What!
18.51:42 CAM [Sound of arcing and snap]
CAM-
1 That's it
18.51:43 CAM [Sound of arcing and snap]
CAM-
1 Won't take it
CAM-
2 No
CAM-
1 See anything else?
CAM-
1 (There's nothing) on the panel
CAM-
1 Ha
18.52:08 CAM-
1 Like a machine gun
CAM-
2 Yeah, zap, zap, zap
CAM-
1 * put it in the book, there
CAM-
2 Log it
18.52:26 CAM-
1 Now I want to log it, eh
18.53:16 CAM-
1 Somebody must have pushed a rag down the old toilet or something eh?
18.53: 21 CAM-
1 Jammed it, and it overheated
18.53:25 CAM-
2 Is it flushing you pushed?
CAM-
1 It's flushing yeah
CAM-
2 (Motor) *
18.53:30 CAM-
1 Toilet flushing, three breakers banged
18.53:35 CTR Air Canada seven ninety seven, contact Indianapolis on one three three point zero five
18.53:40 RDO-
2 Air Canada seven nine seven, so long

18.53:41 CTR So long
18.53:53 RDO-
1
Indianapolis Center, this is Air Canada seven nine seven maintaining three three zero direct Louisville on course
18.53:59 CTR Air Canada seven ninety seven Indianapolis Center roger
18.54:18 CAM-
1 Don't see the ground too often, today eh?
CAM-
1 No, a lot of, a lotta cloud eh, the whole * * * the whole area
RDO-
? * * *
18.56:56 CAM-
2 Yeah, that feels good
18.57:09 CAM-
1 What the # does this mean
18.57:12 CAM-
1 (Reg a bail)
CAM-
2 I don't know
CAM-
2 Regional examiner, regional * regional
18.57:36 CAM-
1 We may be, I don't know, A.J. would be a three letter code if it was an airport, eh
CAM-
2 I don't know, it might be in the, ah, charts
CAM-
1 Regional --- here's another regional A.J.
CAM-
1 (Well it's)
18.58:16 CAM-
2 That (one) is lettered D.G. *
CAM-
1 Oh I see, oh yeah, yeah *
18.58:27 CAM-
1 Alternate, ah, must be out alternate here
CAM-
1 Ah who gives a #
18.58:43 CAM-
1 Nothing to do with us
CAM [Sound similar to cockpit door]
CAM-
3 Yeah thank you sir
18.59:02 CAM-
? UWX
18.59:30 CAM-
1 Twenty nine U, W, and X twenty nine, those are grid references
18.59:37 CAM-
2 Twenty nine, yeah
18.59:42 CAM-
1 Twenty nine UWX three --- the left toilet flushing
CAM-
2 Left
18.59:47 CAM-

1 Yeah aft left toilet flush, and they wouldn't accept a reset
18.59:58 CAM [Sound of first attempt to reset and sound similar to arcing]
18.59:59 CAM [Sound of second attempt to reset and sound similar to arcing]
19.00:00 CAM [Sound of third attempt to reset and sound similar to arcing]
CAM-
1 Pops as I push it
CAM-
2 Yeah, right
CAM-
1 Yeah
19.00;51 CAM [Sound of cough]
19.01:12 CAM- Zero two seven set for ya Don
2
19.01: 33 CAM-
1 Better --- have dinner here
19.01:42 CAM [Sound of a chime]
CAM-
3 Yes
19.01:49 CAM-
1 Sergio could I try for mine now please
CAM-
3 Sure
CAM-
1 Thank you very much
19.01:59 CAM-
1 Do you want any of that fruit or should we give it to the girls -- as far as I'm concerned
CAM-
2 No
CAM-
1 I don't want it
19.02:13 CAM-
1 There you go
CAM-
2 Thanks
19.02:15 CAM-

1 You're in a left turn here to pick up oh two seven
CAM-
2 So okay twenty seven
CAM-
1 Louisville to Rosewood
19.02:28 CAM-
1 The next chart yeah that's it
CAM-
2 Yeah
19.02:34 CAM-
1 We're just over Louisville here
CAM-
2 [Sound of whistling]
CAM-
2 Louisville --- Rosewood, okay
19.02:40 CAM-
4

Excuse me, there's a fire in the washroom at the back, they're just oh # went back to go to put it out
CAM-
1 Oh yeah
CAM-
4 They're still, well they're just gonna go back now
CAM-
2 Want me to go there
19.02:50 CAM- Yeah go
1
CAM-
2 * the brakers # up
CAM-
1 Leave my, leave my, leave my dinner in the thing there for a minute
CAM-
4 Okay
CAM-
5 (Can I buy you a drink cause there's something going on, drink or a shot)
CAM-
? Ah, wouldn't say that
19.03:06 CAM-
5 Yeah okay
CAM-
? Still there huh?
CAM-
5 Yeah
19.03:10 CAM-
2 Got the, ah, breakers pulled
CAM-
1 It's the motor
19.03:15 CAM-
4 Pardon me
CAM-
2 You got all the breakers pulled out?
CAM-
1 The breakers are all pulled yeah
19.03:21 CAM-

4 (* * make 'em all seat?)
CTR Republic two eighty eight Indianapolis, Memphis one three three point eight fi ve three three eight five, goodbye
19.03:31 CAM-
4 Captain is it okay to move everybody up as far forward as possible
77L * * seven seven lima (Knoxville) * * two none zero --
CTR Seven seven lima (Knoxville) roger
19.03:54 CTR Delta sixteen twenty six continue descent to flight level two four zero, Indianapolis
19.04:00 CTR Center one two eight five five on two four zero at twenty eight fifty five so long
19.04:07 CAM-
2
Okay I eh, you don't have to do it now, I can't go back now, it's too heavy, I think we'd better go down
RDO-
? (Cleared) ah okay

19.04:16 CAM-
3 I got all the passengers seated up front, you don't have to worry I think it's gonna be easing up
19.04:23 CAM-
2 Okay, its starting to clear now
CAM- Okay
1
19.04:25 CAM-
1 Well I want --- hold on then
CAM-
3 (Mike) I just can't go back it too
CAM-
2 I will go back if that's appears better, okay
CAM-
1 Yeah that's okay
CAM-
? That's okay, yeah
CAM-
2 So ---
CAM-
1 Take the, take the smoke mask
CAM-
2 You have control
CAM-
1 Take the goggles
19.04:36 CAM-
1 I'll leave the mask on
CAM-
2 Okay
19.04:46 CAM-
1 Okay go back whenever you can but don't get yourself incapacitated
CAM-
2 No problem, no problem
CAM-
1 Okay
19.05:15 268G Indianapolis good evening Citation two eight six golf, three one oh
19.05:18 CTR Citation two eight six gold Indianapolis
19.05:35 CAM [Electric pulse appears on tape radio channels]

19.05:36 CAM-
4
Captain, your first officer wanted me to tell you that Sergio has put a big discharge of CO2 in the washroom, it seems to be subsiding, all right
268G Okay we're proceeding direct Pocket City
CTR Affirmative sir, direct Pocket City direct Evensville
268G Six gold
19.05:48 B747 Center Poca seven four seven level four three zero
CTR Poca seven four seven Indianapolis roger
RDO-
1 Memphis Center this is Air Canada seven nine seven
19.06:09 CTR Canada seven ninety seven Indianapolis Center, go ahead
19.06:12 RDO-

1 Yeah, we've got an electrical problem here, we may be off communication shortly ah stand by
CAM- (Coming along okay)
1
CAM-
3 Getting mush better, okay
19.06:42 CAM-
3
I was able to discharge half of the CO2 inside the washroom even though I could not see the source but its definitely inside the lavatory
19.06:50 CAM-
1 Yeah, it's from the toilet, it's from the toilet
19.06:52 CAM-
3 CO2 it was almost half a bottle and it now almost cleared
19.06:54 CAM-
1 Okay, thank you
19.06:55 CAM-
3 Okay, good luck
CAM [Sound similar to cockpit door]
CAM-
2 Okay, you got it *
CAM-
1 Yeah
CAM-
1 Okay
19.07:11 CAM-
2 I don't like what's happening, I think we better go down, okay?
CAM-
1 Okay
19.07:14 CAM-
2 Okay, I'll be back there in a minute
19.07:28 P362 Hello Center, Piedmont three sixty two we're level at flight level three three zero
19.07:32 CTR Three sixty two Indianapolis Center roger
19.07:35 P362 We'll take direct Holston Mountain if you can do that
19.07:41 Recorder goes off

1985, December 31st. An in-flight cabin fire forced rock star Rick Nelson's chartered DC-3 to make a forced landing near De Kalb, Texas. Only the pilots survived, with critical burns. Rick Nelson (son of Ozzie and Harriet Nelson), his fiancée, four members of his band and his soundman perished in the fire.

1986, March 31st. A Mexicana Airlines B-727, with 166 onboard, crashed after an overheated tire finally exploded in the wheelwell, tearing through fuel lines and electrical wires. The resulting fire eventually rendered the aircraft uncontrollable. There were no survivors.

1987, November 28th. A South African Airways 747-244B Combi (both a freighter and passenger liner at the same time), while enroute from Taipei to Johannesburg, crashed into the ocean approximately 150 miles northeast of the island of Mauritius, after the pilot reported smoke and the loss of much of the electrical system. All 159 on board were killed. The breakup of the plane was so extensive; only five bodies could be identified. Only the cockpit voice recorder (CVR) was recovered. That, along with the video tape of the wreckage on the ocean floor, and the recovery of a few parts, enabled investigators to conclude the fire had started in the front pallet area of the upper deck cargo hold. They could not determine what started the fire.

Legend
CA = Captain
FE = Flight Engineer
MA = Mauritius ATC

23:49h UTC
CA: Er, good morning, we have, er, a smoke problem and we are doing an emergency descent to level one five, er, one four zero.
MA: Confirm you wish to descend to flight level one four zero?
CA: Ja, we have already commenced, er, due to a smoke problem in the aeroplane.
MA: Eh, roger, you are clear to descend immediately to flight level one four zero.

23:50h UTC
CA: Roger, we will appreciate it if you can alert, er, fire, er, er, er.
MA: Do you request a full emergency please? A full emergency?
CA: Affirmative, that's Charlie Charlie
MA: Roger, I declare a full emergency.
CA: Thank you.

23:51h UTC
MA: (asks for a position report)
CA: Now we have lost a lot of electrics. We haven't got anything on the aircraft now.
MA: (asks for an ETA and positions updates)
CA: (gives both)
MA: (advises that both runways are available)
CA: Er, we'd like to track in er, on, er, one three.
MA: Confirm runway one four?
CA: Charlie Charlie.

00:03h UTC
MA: (gives clearance and asks to report passing FL050)

00:04h UTC
CA: Kay. [Last radio contact with ATC]
...
[fire alarm bell sounds, followed by interphone chime]
FE: What's going on now - cargo?
FE: It came on now afterwards.
[loud click sounds]
??: Say again?
FE: Main deck cargo...then the other one came on as well. I've got two.
CA: (calls for checklist to be read)
[sound of movements with clicks and clunks]

CA: ****. It is the fact that both came on, it disturbs one.
[intercom chime while CA is speaking]
??: Aag!, ****
CA: What's going on now?
[sudden loud sound & rapid changes tape test-tone]

1988, February 3rd. An American Airlines, DC-9-83 captain received a report from a flight attendant that smoke was present in the cabin. The cabin floor, above the midcargo compartment was hot and soft, requiring the flight attendants to move passengers away from the affected area. The captain, aware of a previous flight's problem with the auxiliary power unit, which caused in-flight fumes, was skeptical about her smoke report. Thus, he did not declare a n emergency and completed the flight in a normal manner. However, after landing at Nashville, he called for fire equipment to meet the plane. The flight attendants then evacuated all 126 on board while fire crews extinguished the cargo compartment fire. That compartment was found to contain a 104-pound fiber drum of textile treatment chemicals. The undeclared and improperly packaged hazardous materials included 5 gallons of hydrogen peroxide solution and 25 pounds of sodium orthosilicate-based mixture. The NTSB determined the fire was caused by the hydrogen peroxide, in a concentration prohibited for air transportation.

CO-PILOT [speaks in interphone to back of the aircraft]: hello.

Flight ATTENDANT [calling the cockpit on interphone from back of the aircraft]: Hi. We've got smoke in the cabin.

CO-PILOT: Okay.

FLIGHT ATTENDANT: We don't know where it's coming from. It's past the, ah, exit. [We] got an H2O extinguisher

APPROACH CONTROL: American one thirty-two, descend and maintain two thousand five hundred [feet].

CAPTAIN: Two thousand five hundred, American one thirty-two.

CO-PILOT TO CAPTAIN: We got smoke in the…..AH……..

FLIGHT ATTENDANT: It's a real bad smell.

the passenger cabin] said the floor is getting really soft, and he said we need to land.

CO-PILOT: Okay. Who says the floor is getting soft?

FLIGHT ATTENDANT: Here he is [handing the interphone to the deadheading Co-pilot].

DEADHEAD CO-PILOT: Hey, boss.

CO-PILOT: Yes?

DEADHEAD: You got the floor back here in the middle…. dropping out slightly.

CO-PILOT: Okay.

DEADI-IEAD: You[re] gonna have to land this thing in a hurry.

CO-PILOT: Okay, we're gettin' it down now.

DEADHEAD: Okay, be quick.

Co-PILOT: Okay.

DEADHEAD: Hey, have the [fire] trucks meet us [once we land].

CO-PILOT TO CAPTAIN: [We] have a flight officer back there, says that the floor is getting soft. [We] probably ought to drop the [landing] gear. There's somethin' going on in the, ah, floor board.

CAPTAIN: Put the gear down.

COCKPIT: [Sound of landing gear being lowered]

CO-PILOT TO FLIGHT ATTENDANT: Okay, now how far back is the floor getting soft?

FLIGHT ATTENDANT: Well, ah, the Captain [deadheading Co-pilot] is in the aisle right now. He's about midway through to...

CO-PILOT: About where the [landing] gear might be?

FLIGHT ATTENDANT: Yes.
co-Pilot: Okay. Why don't you go back and buckle in.
FLIGHT ATTENDANT: We're all seated.
CO-PILOT: Okay, fine. [Then to Captain]
Okay, what do you want me to do here? Okay, seatbelt [sign] . .
CAPTAIN: Yes.
CO-PILOT: No smoking sign ….
CAPTAIN: No smoke. Just fumes, right?
CO-PILOT: So far it's just smoke…. Fumes.
CO-PILOT: [to Flight Attendant on interphone] You don't see any smoke. It's just fumes?
FLIGHT ATTENDANT: Bad fumes. Startin' to hurt my eyes.
CO-PILOT: Okay. I'm gonna get off the phone. Call me if anything important changes.
FLIGHT ATTENDANT: Okay.
CAPTAIN TO Co-PILOT: Did you call the Tower?
NASI-IVILLE TOWER: American one thirty-two, Nashville Tower. Wind calm
[on] Runway Two left. Cleared to land.
CAPTAIN: No problems.
CO-PILOT: There's just fumes back there.
CAPTAIN: We've had fumes before, from the APU [Auxiliary Power Unit] is where [it came from] at least initially. Okay, we got [landing] gear.
CO-PILOT: Gear.
CAPTAIN: Spoiler lever, auto brakes. No. Flaps are good. Lights. Are we cleared to land?
CO-PILOT TO TOWER: American one thirty-two, are we cleared to land?
TOWER: Affirmative.
CO-PILOT: Roger. [To Captain] Do you want to call any …. [Emergency] equipment on the ground]?
CAPTAIN: We don't have any problems yet. Just a few fumes.
CO-PILOT: You don't smell it?
CAPTA1N: Yeah, I smell it.
CO-PiLOT: You arc cleared to land. Landing checklist is complete. Five hundred feet, sinkin' a thousand plus five. Four hundred [feet]. Three hundred [feet]. There's two hundred. one hundred. On the tape, fifty, forty, thirty, ten, five .
COCKPIT: Sound of touchdown
CO-PILOT: Reverse [thrust]. Hundred knots. Eighty knots.
TOWER: American one thirty-two, turn right. When able contact ground control.
CO-PILOT: Sixty knots.
GROUND CONTROL: American one thirty-two, Nashville ground. Roger. Your option [is] to enter tango Two [runway exit] or come down to Tango Four. Advise.
CO-PILOT: Tango Two or Tango Four. CAPTAIN: Ah, let's see .
CO-PILOT: This is my first time in here let me look this up.
COCKPIT: [Sound of cabin attendant calling cockpit]
CO-PILOT: I'm here.
DEADHEAD CO-PILOT ON INTERPHONE: You've got a big problem back here, and time in here, so I'm not sure if you…. The problem is, I don't know where the heat is comin' from. It's comin' up through the floor.

CO-I'ILOT: Do you see any smoke?
DEADHEAD: Yeah, there's smoke. Just a little hit.
CO-PILOT: Okay, okay.
DEADHEAD: We better get outta here.
CO-PILOT: Okay.
FLIGHT ATTENDANT TO CAPTAIN: Ah. Captain?
CO-PILOT TO CAPTAIN: There's a crew [man] back there that says we better get outta here. He says there's smoke comin through the floor.
FLIGHT ATTENDANT: I don't see it [the smoke]. We had a first officer here with us. He's the one. He's been checkin' the floor. He's in uniform. That's who you've been talkin' to
CO-PILOT TO CAPTAIN: She don't see [the smoke].
FLIGHT ATTENDANT: He [the deadhead Co-pilot] thinks it's real soft, the floor's real soft.
CO-PILOT TO Captain: The floor is getting very very soft.
CAPTAIN: Okay, let's get out of here. Call ground
CO-PILOT TO FLIGHT ATTENDANT: [evacuation].
CO-PILOT: Ah, stand by.
FLIGHT ATTENDANT: Okay.
CAPTAIN: Give me the checklist.
CO-PILOT TO GROUND CONTROL: Ah, roger, sir, would you call out the fire equipment? We've got the possibility of some fire, some real hot stuff, in the cargo compartment. The floor is real hot. We're gonna get 'em [the passengers] out.
GROUND CONTROL: Okay, we got 'em on the phone, American one thirty-two.
CO-PILOT TO CAPTAIN: Okay, ground evac. Ah, Tower. Called the Tower. Flaps.
CAPTAIN: [Flaps] Forty [fully extended].
CAPTAIN: Spoiler lever .
CAPTAIN: You get out of here. You go help [the Flight Attendants]. Retract brakes. Park fuel levers.
CO-PILOT: Cut-off
END OF TAPE

The Captain ordered the evacuation two minutes and six seconds after Flight 132 touched down, and the inflatable slides were deployed at the two forward cabin doors, the aft galley door and in the tailcone. The over-wing exits were not used. No instructions were given to the passengers over the public address system. Neither were they prepared for the evacuation before landing. During the evacuation, the flight attendants shouted commands at the passengers to 'Unfasten seat belts' and 'Come this way' and 'Remove shoes' and 'Don't take anything with you.'

After the passengers had safely evacuated the airplane, an American Airlines maintenance employee on the ground asked the Captain about the problem. The Captain said there was a fire in the cargo area. They opened the aft cargo compartment and saw little smoke inside. Then they opened the middle cargo compartment. Thick, white/grey smoke poured out.

The Tower's call dispatched 14 firefighters with six vehicles, four crash-fire rescue units and two quick response Units to the aircraft, which had pulled to a stop on the apron beside the runway. The emergency units sprayed about 120 gallons of water into the middle cargo compartment to douse the smoldering fires. Neither aqueous film-forming foam nor dry chemicals to fight fires was used.

None of the 126 crew and passengers was injured seriously; nine passengers and four crew suffered minor injuries.

1988, July 27th. A Peninsula Airways Metro Liner III (commuter flight), took off from the Anchorage, Alaska airport and soon detected a wheelwell fire. The pilot wasted no time in making an emergency landing back at the same airport. All 8 on board escaped injury. It was a very close call. The fire burned through the left aileron control tube and engine nacelle. The left wing flap was damaged and the left fuel tank was severely scorched from excessive heat. "***The flight did not end in a catastrophic explosion because the tank was nearly full of fuel and the fuel-air mixture in the tank was too rich to support combustion at the early stage of the flight***."

1991, July 11th. A Nationair DC-8-61, an international charter flight from Jeddah, Saudi Arabia, to Sokoto, Nigeria, crashed as it attempted to return to Jeddah. All 261 on board died as the in-flight fire burned through the control cables while the plane was on its final landing approach. Some bodies fell out of the plane while it was descending through 2,200 ft. The plane took off with some tires under-inflated. It was not known if the captain was made aware of that situation. A long taxi, combined with a hot day, caused the tires to fail on the takeoff roll. The resulting tire-fire spread into the aircraft after the gear was raised. The captain's delay in turning back to the airport, once he was aware of smoke in the cabin, may have sealed the fate of everyone on board.

1996, May 11th. A Valujet DC-9, crashed only minutes after takeoff from the Miami Airport. It is probable that the fire was burning in the cargo hold, fed by an illegal shipment of oxygen generators, before the plane took off. There was no warning, until the flight attendants yelled to the cockpit that the cabin was on fire, because the plane was not equipped with fire/smoke detectors or a fire suppression system for its cargo compartments. The FAA had refused to act on many previous recommendations, by the NTSB, which would have required smoke detectors and fire suppression systems in all passenger liner cargo compartments. The NTSB said that oxygen generators had been tied to at least 3 previous airline fires. In 1986, an American Trans Air DC-10 in Chicago, was destroyed by the fire that erupted from just one oxygen generator which was still in the back of a seat being shipped in its cargo compartment. Fortunately, the fire occurred while the plane was being serviced, so there were no injuries. The FAA did not disseminate the information, learned from that fire, to the airlines with enough emphasis on how dangerous oxygen generators can be. Nor did the FAA ban them from shipment on passenger liners until after the Valujet crash, which killed all 106 onboard.

14:09:36 PA-2 flight attendants, departure check please.
14:09:44 CAM-1 we're *** turbulence
14:09:02 CAM [sound of click]
14:10:03 CAM [sound of chirp heard on cockpit area microphone channel with simultaneous beep on public address/interphone channel]
14:10:07 CAM-1 what was that?
14:10:08 CAM-2 I don't know.

14:10:12 CAM-1 *** ('bout to lose a bus?)
14:10:15 CAM-1 we got some electrical problem.
14:10:17 CAM-2 yeah.
14:10:18 CAM-2 that battery charger's kickin' in. ooh, we gotta.
14:10:20 CAM-1 we're losing e verything.
14:10:21 Tower Critter five-nine-two, contact Miami center on one-thirty-two-forty-five, so long.
14:10:22 CAM-1 we need, we need to go back to Miami.
14:10:23 CAM [sounds of shouting from passenger cabin]
14:10:25 CAM-? fire, fire, fire, fire [from female voices in cabin]
14:10:27 CAM-? we're on fire, we're on fire. [from male voice]
14:10:28 CAM [sound of tone similar to landing gear warning horn for three seconds]
14:10:29 Tower Critter five-ninety-two contact Miami center, one-thirty-two-forty-five.
14:10:30 CAM-1 ** to Miami.
14:10:32 RDO-2 Uh, five -ninety-two needs immediate return to Miami.
14:10:35 Tower Critter five-ninety-two, uh, roger, turn left heading two-seven-zero. Descend and maintain seven-thousand.
14:10:36 CAM [sounds of shouting from passenger cabin subsides]
14:10:39 RDO-2 Two-seven-zero, seven-thousand, five -ninety-two.
14:10:41 Tower What kind of problem are you havin'?
14:10:42 CAM [sound of horn]
14:10:44 CAM-1 fire
14:10:46 RDO-2 Uh, smoke in the cockp ... smoke in the cabin.
14:10:47 Tower Roger.
14:10:49 CAM-1 what altitude?
14:10:49 CAM-2 seven thousand.
14:10:52 CAM [sound similar to cockpit door moving]
14:10:57 CAM [sound of six chimes similar to cabin service interphone]
14:10:58 CAM-3 OK, we need oxygen, we can't get oxygen back here.
14:11:00 INT [sound similar to microphone being keyed only on Interphone channel]
14:11:02 CAM-3 *ba*, is there a way we could test them? [sound of clearing her voice]
14:11:07 Tower Critter five-ninety-two, when able to turn left heading two-five-zero. Descend and maintain five-thousand.
14:11:08 CAM [sound of chimes similar to cabin service interphone]
14:11:10 CAM [sounds of shouting from passenger cabin]
14:11:11 RDO-2 Two-five-zero seven-thousand.
14:11:12 CAM-3 completely on fire.
14:11:14 CAM [sounds of shouting from passenger cabin subsides]
14:11:19 CAM-2 outta nine.
14:11:19 CAM [sound of intermittent horn]
14:11:21 CAM [sound similar to loud rushing air]
14:11:38 CAM-2 Critter five-ninety-two, we need the, uh, closest airport available...
14:11:42 Tower Critter five-ninety-two, they're going to be standing by for you. You

can plan runway one two to dolphin now.
14:11:45 one minute and twelve second interruption in CVR recording]
14:11:46 RDO-? Need radar vectors.
14:11:49 Tower critter five ninety two turn left heading one four zero 14:11:52 RDO-? one four zero
14:12:57 CAM [sound of tone similar to power interruption to CVR]
14:12:57 CAM [sound similar to loud rushing air]
14:12:57 ALL [sound of repeating tones similar to CVR self test signal start and continue]
14:12:58 Tower critter five ninety two contact Miami approach on corrections no you you just keep my frequency
14:13:11 CAM [interruption of unknown duration in CVR recording] 14:13:15 CAM [sounds of repeating tones similar to recorder self-test signal starts and continues, rushing air.]
14:13:18 Tower critter five ninety two you can uh turn left heading one zero zero and join the runway one two localizer at Miami
14:13:25: End of CVR recording.
14:13:27 Tower critter five ninety two descend and maintain three thousand
14:13:43 Tower critter five ninety two Opa Locka airports out at twelve o'clock at fifteen miles
[End of Recording]

1996, September 5th. Federal Express DC-10 Cargoliner. The crew declared an emergency and landed as fast as possible after becoming aware of smoke coming from the cargo hold. They escaped with their lives, but the plane was destroyed by the fire that spread rapidly after they evacuated. The fire came from hazardous material aboard, but the NTSB is still not certain of the ignition source.
The full report, including the CVR transcript can be found at
http://www.ntsb.gov/publictn/1998/AAR9803.pdf
If the above link does not work, cut and paste the entire string into your address bar on your browser.

1998, September 5th. Swissair Flight 111 (a codesharing flight with Delta Airlines) departed New York-JFK for Geneva at 20.18h local time. At 20.58h the flight crew contacted the Moncton High Level Controller for the first time, reporting at FL330. Sixteen minutes later the crew issued a 'Pan'-call reporting smoke in the cockpit and requesting emergency vectoring to the nearest airport, which they thought was Boston. The Moncton controller cleared the flight to descend to FL310 and offered Halifax as the closest airport available, which was accepted by the crew.
At 21.18h the flight was handed over to Moncton Centre and was vectored for a back course approach to Halifax runway 06. At 21.19h HB-IWF was just 30 miles from the threshold, so Moncton Centre vectored the plane for a 360-degree turn to lose some altitude and to dump fuel off the coast. At 21.24h the situation in the cockpit apparently became worse, because the crew decla red an emergency and reported that they were starting the fuel dump and that they had to land immediately.
There were no more radio communications and the aircraft disappeared from radar approximately 35nm from the airport off the Nova Scotia coast.

Legend:
SWR 111 = Radio transmission from Swissair 111.
QM = Moncton High Level Controller
HZ =Halifax Terminal Controller
BAW214 = British Airways Flight Speedbird 214
BAW1506 = British Airways Flight Speedbird 1506
(*) = Word or words unintelligible
( ) = Questionable text
... = Pause
[ ] = Editorial comment
? = Unidentified speaker
Note:
Universal Coordinated Time (UTC) is the time code written on the ATC logging tape.
Source: UTC **RADIO COMMUNICATIONS**
SWR111 0:58:15.8 Moncton Centre, Swissair one eleven heavy good uh evening level three three zero.
QM 0:58:20.4 Swissair one eleven heavy Moncton Centre. Good evening reports of uh occasional light turbulence at all levels.
SWR111 0:58:26.1 Moncton Swissair.
Comment 0:58:26.2 [Extensive communications bet ween Moncton Centre and other aircraft]
SWR111? 1:14:07.9 [Unintelligible squelch covered by United 920]
QM 1:14:12.0 United nine two zero heavy Moncton Centre good evening occasional light turbulence reported at all levels. Other aircraft calling say again.
SWR111 1:14:18.0 Swissair one eleven heavy is declaring Pan Pan Pan. We have uh smoke in the cockpit, uh request (deviate), immediate return uh to a convenient place, I guess uh Boston ***.
QM 1:14:33.2 Swissair one eleven roger ... turn right proceed ...uh ... you say to Boston you want to go?
SWR111 1:14:33.2 I guess Boston ... we need first the weather so uh we start a right turn here. Swissair one one one Heavy.
QM 1:14:45.2 Swissair one eleven roger and a descent to flight level three one zero. Is that okay?
SWR111 1:14:50.3 Three one zero [Unintelligible words obscured by a noise. Possibly the noise associated with donning oxygen masks] Three one zero *** one one heavy.
QM 1:15:03.1 Swissair one eleven Centre.
SWR111 1:15:06.6 Swissair one eleven heavy go ahead.
QM 1:15:08.6 Uh Would you prefer to go into Halifax?
SWR111 1:15:11.6 Uh Standby
Virgin 12 1:15:15.0 Moncton Virgin twelve will be standing by.
QM 1:15:17.3 Virgin twelve roger standby.
SWR111 1:15:38.4 Affirmative for Swissair one eleven heavy. We prefer Halifax from our position.
QM 1:15:43.8 Swissair one eleven roger, proceed direct to Halifax, descend now to flight level two niner zero.
SWR111 1:15:48.7 Level two niner zero to Halifax, Swissair one eleven heavy.
BAW214 1:15:58.3 And uh Swissair one eleven heavy from Speedbird two one four I can give you the Halifax weather if you like?
SWR111 1:16:04.1 Swissair one eleven heavy we have the uh the oxygen mask on go ahead with the weather.
BAW214 1:16:10.4 Okay it's the three hundred zulu weather was one zero zero at niner knots, one five miles, scattered at one two zero, broken at two five zero, plus seventeen, plus twelve,
two niner eight zero, over.
SWR111 1:16:29.6 Roger Swissair one eleven heavy we copy the ah altimeter is two niner eight zero.
QM 1:16:36.5 Swissair one eleven, you're cleared to ten thousand feet and the Hal...altimeter is two

nine eight zero.
SWR111 1:16:41.7 Two niner eight zero, ten thousand feet, Swissair one eleven heavy
QM 1:16:52.5 And Swissair one eleven uh can you tell me what your fuel on board is and the number of passengers?
SWR111 1:16:58.3 Uh roger standby for this.
BAW1506 1:17:15.5 Speedbird one five zero six is at Tusky listening out.
QM 1:17:19.3 Speedbird one five zero six, roger
QM 1:18:19.3 Swissair one eleven you can contact Moncton Centre now one one niner decimal two.
SWR111 1:18:24.4 One one niner point two for the Swissair one one one heavy.
QM 1:18:31.0 Roger
SWR111 1:18:34.3 Moncton Centre good evening. Swissair one eleven heavy flight level two five four descending flight level two five zero on course Halifax. We are flying at the time on track zero five zero.
HZ 1:18:46.8 Swissair one eleven good evening descend to three thousand, the altimeter is two nine seve n nine.
SWR111 1:18:51.8 Ah we would prefer at the time around uh eight thousand feet, two nine eight zero, until the cabin is ready for the landing.
HZ 1:19:00.9 Swissair one eleven uh you can descend to three, level off at an intermediate altitude if you wish. Just advise.
SWR111 1:19:07.2 Roger. At the time we descend to eight thousand feet. We are anytime clear to three thousand. I keep you advised.
HZ 1:19:14.5 Okay. Can I vector you uh to set up for runway zero six at Halifax?
SWR111 1:19:19.4 Ah say again latest wind, please.
HZ 1:19:22.1 Okay, active runway Halifax zero six. Should I start you on a vector for six?
SWR111 1:19:26.3 Yes, uh vectors for six will be fine Swissair one eleven heavy.
HZ 1:19:31.0 Swissair one eleven roger, turn left heading of ah zero three zero.
SWR111 1:19:35.1 Left ah heading zero three zero for the Swissair one eleven.
HZ 1:19:39.5 Okay, it's a back course approach for runway zero six. The localizer frequency one zero niner decimal niner. You've got thirty miles to fly to the threshold.
SWR111 1:19:53.3 Uh we need more than thirty miles, please ah say me again the frequency of the back beam.
HZ 1:19:59.5 Swissair one eleven roger, you can turn left heading three six zero to lose some altitude, the frequency is one zero niner decimal niner for the localizer, it's a back course approach.
SWR111 1:20:09.5 One zero niner point niner roger, and we are turning left to heading ah north. Swissair one eleven heavy.
HZ 1:21:23.1 Swissair one eleven when you have time could I have the number of souls on board and your fuel onboard please for emergency services.
SWR111 1:21:30.1 Roger, at the time uh fuel onboard is uh two three zero tons. We must uh dump some fuel. May we do that in this area during descent? [Note: Two three zero tons represents the current gross weight of the aircraft not the amount of fuel on board]
HZ 1:21:40.9 Uh okay, I am going to take you... Are you able to take a turn back to the south or do you want to stay closer to the airport?
SWR111 1:21:47.0 Uh, standby short, standby short.
SWR111 1:21:59.1 Okay we are able for a left or right turn towards the south to dump.
HZ 1:22:04.2 Swissair one-eleven uh roger, uh turn to the ah left heading of ah two zero zero degrees and ah advise me when you are ready to dump. It will be about ten miles before you are off the coast. You are still within about twenty five miles of the airport.
SWR111 1:22:20.3 Roger, we are turning left and ah in that case we're descending at the time only to ten thousand feet to dump the fuel.
HZ 1:22:29.6 Okay, maintain one zero thousand. I'll advise you when you are over the water. It will be very shortly.
SWR111 1:22:34.4 Roger
SWR111 1:22:36.2 (Du bisch i dr) emergency checklist (fr) air conditioning smoke? [Translation: (You are in the) emergency checklist for air conditioning smoke?]

HZ 1:22:42.9 Uh Swissair one eleven say again please.
SWR111 1:22:45.3 Ah, sorry it was not for you Swissair one eleven was asking internally. It was my fault, sorry about.
HZ 1:22:50.8 Okay
HZ 1:23:33.1 Swissair one-eleven continue left heading one-eight zero you'll be ah off the coast in about ah fifteen miles.
SWR111 1:23:39.2 Roger, left heading one eight zero. Swissair one eleven ah and maintaining at ten thousand feet.
HZ 1:23:46.3 Roger.
HZ 1:23:55.7 You will ah be staying within about ah thirty five, forty miles of the airport if you have to get to the airport in a hurry.
SWR111 1:24:03.9 Okay, that's fine for us. Please tell me when we can start ah to dump the fuel.
HZ 1:24:08.8 Okay.
SWR111 1:24:28.1 [Background tone] Ah Swissair one eleven. At the time we must fly ah manually. Are we cleared to fly between ah ten thou..eleven thousand and niner thousand feet? [Sound of Autopilot disconnect warbler]
HZ 1:24:38.7 Swissair one eleven you can block between ah five thousand and twelve thousand if you wish.
SWR111 1:24:45.1
1:24:46.4
Swissair one eleven heavy is declaring emergency
[Second voice overlap] (Roger) we are between uh twelve and five thousand feet we are declaring emergency now at ah time ah zero one two four. [Possible intercom sound toward the end of the transmission.]
HZ 1:24:56.0 Roger.
SWR111 1:24:56.5 Eleven heavy we starting dump now we have to land immediate.
HZ 1:25:00.7 Swissair one eleven just a couple of miles I'll be right with you.
SWR111 1:25:04.1 Roger. [Sound - Probable Autopilot disconnect warbler]
SWR111 1:25:05.4 And we are declaring emergency now Swissair one eleven.
HZ 1:25:08.6 Copy that.
HZ 1:25:19.2 Swissair one eleven you are cleared to ah commence your fuel dump on that track and advise me ah when the dump is complete.
HZ 1:25:43.0 Swissair one eleven check you're cleared to start the fuel dump.
SWR111 1:25:49.3 (***) End of recording.
End of recording.

Although each of these accidents and incidents is tragic, we can learn from the experiences of others. ***The fatality count on many of these accidents could have been reduced or even eliminated by a quick decision on the part of the aircrew to get the aircraft down.*** In most situations where an in-flight fire occurs, ***the blaze has developed to the point where the resources available to extinguish the fire are insufficient.***
Your hope and salvation rely on your flying ability and the fire equipment on the ground.
Get the aircraft on the ground and get the passengers out.
Don’t end up in the next ARG/US *Special Report.*

Summary of In-flight Smoke Accidents

Summary of In-Flight Smoke Accidents

Swiss Air 330 21 Feb 1970
CFIT following in-flight fire and cockpit smoke. Otherwise flyable aircraft flew past airport while attempting to return for landing. Flight crew unable to see due to heavy continuous smoke (transcript attached)

Varig 11 July 1973
Aircraft lost after off airport forced landing. Report specifies crew unable to see instruments due to smoke (excerpts attached).

Pan Am 3 November 1973
CFIT following in-flight fire and cockpit smoke. Otherwise flyable aircraft crash landed in water short of the runway. Flight crew unable to see due to heavy continuous smoke (report excerpt attached)

Cubana de Aviacion 6 October 1976
CFIT following in-flight fire and cockpit smoke. Otherwise flyable aircraft crash landed in water short of the runway. Flight crew unable to see due to heavy continuous smoke (report excerpt attached)

Air Canada 2 June 1983
This aircraft was nearly lost in-flight due to smoke and fire. The aircraft was destroyed by fire post landing. Flight crew reported loss of vision on final approach, continued flight would have been impossible (excerpts attached).

Gulf Air 23 September 1983
Aircraft lost in-flight. Report specifies Crew unable to see instruments due to smoke (excerpts attached).

Private Operator 31 December 1985
CFIT following in-flight fire and cockpit smoke. Flight crew unable to see due to heavy continuous smoke (pilot report attached)

South African Airways 28 November 1987
Aircraft lost in-flight. Report specifies probable cause "A" reduced cockpit visibility in smoke (excerpts attached).

SAS 2 February 1989
This aircraft was nearly lost in-flight due to smoke and fire. Flight crew reported loss of vision on final approach, continued flight would have been impossible (excerpts attached).

Air Europe 17 December 1989
This aircraft was nearly lost in-flight due to smoke and fire. Flight crew reported loss of vision on final approach, continued flight would have been impossible (excerpts attached).

Swiss Air 551 16 October 1993
This aircraft was nearly lost in-flight due to smoke and fire. Flight crew reported loss of vision on final approach, continued flight would have been impossible (excerpts attached). Final German FUS report recommends the EVAS system.

Swiss Air 330 21 Feb 1970

CFIT following in-flight fire and cockpit smoke. Otherwise flyable aircraft flew past airport while attempting to return for landing. Flight crew unable to see due to heavy continuous smoke (transcript attached)

Protokoll uber den Funkverkehr swischen Swissair 330

Und den Dienststellen der Flugsicherung Zurich-Kloten

Auszug aus der Tonbandaufnahme vom 21. Februar 1970

Zeiten: GMT in Stunden, Minuten und Sekunden

Rufzeichen:	330	=	SR 330
	GND	=	Zurich Ground
	TWR	=	Zurich Tower
	DEP	=	Zurich Departure
	CTL	=	Zurich Control
	APP	=	Zurich Approach
	RAD	=	Zurich Approach Radar

GMT:	To:	From:	Text:
12 18 40	CTL	330	good afternoon
	330	CTL	good afternoon squawk alfa 01 report 150
	CTL	330	squawking alfa 01 will check passing 150
	330	CTL	roger
19 50	CTL	330	now intercepting radial 172 from Trasadingen turning to Monte Ceneri
20 00	330	CTL	roger
21 00	CTL	330	(schwach horbares Gesprach aus dem Cockpit: … returning ….. Gepack) we have trouble with the Cabin Compression we have to return to Zurich
	330	CTL	roger what is your actual level?

GMT:	To:	From:	Text:
	CTL	330	140 request reverse course
21 10	330	CTL	roger then make a right turn Swissair 330 back to Koblenz
	CTL	330	roger turning right back to Koblenz maintaining 140?
21 20	330	CTL	that is correct for the time beeing
	CTL	330	roger
	330	CTL	you are just east of Brunnen
	CTL	330	thank you
21 50	330	CTL	you may stop your turn onto heading 335 for positioning on the ILS runway 16
22 00	CTL	330	roger will stop turning on 335 and request descend
	330	CTL	roger I call you back
22 50	CTL	330	We suspect an explosion in the aft compartment of the aircraft every thing is ok at the moment but we request descend clearance immediately and fire fighting equipment on the ground for landing
23 10	330	CTL	roger descend to flight level 100 you are
			coming back to Brunnen
23 20	330	CTL	(Anruf)
23 30	CTL	330	roger we descend say again the level?
	330	CTL	100
	CTL	330	100? and we are leaving 140 for 100
	330	CTL	roger
24 00	330	CTL	what is your heading?
12 24 00	330	CTL	your heading?
24 10	CTL	330	is now 060

GMT:	To:	From:	Text:
	330	CTL	roger but do not turn back towards the south please
24 20	CTL	330	roger we are on 060 maintaining
24 30	330	CTL	turn left please on to heading 330
	CTL	330	oh roger now turning left to 330
	330	CTL	roger
25 30	CTL	330	reaching 100
	330	CTL	roger
25 40	CTL	330	we also request a police to investigate the
	330	CTL	say again please
	CTL	330	we also request a police to investigate the Incident
26 00	CTL	330	we have fire on board request an immediate landing
	330	CTL	that is understood descend to flight level 60
26 10	CTL	330	we descend to 60 as quickly as possible we have fire on board in the aft
	330	CTL	understood
26 20	CTL	330	this is an emergency Zurich from 330
	330	CTL	all understood
26 50	330	CTL	you are now 5 miles south east of inter-section ALFA
	CTL	330	roger we are leaving 80
	330	CTL	roger
27 20	330	CTL	continue heading 330 further instructions with approach on 118.0
27 30	CTL	330	ah GCA appro ah we have fire on board we have speed and request GCA approach our navigation is not ok
27 40	330	CTL	ok understood

GMT:	To:	From:	Text:
	CTL	330	aah
	330	CTL	you may expect it Swissair 330
28 00	CTL	330	main ah descending now to ah 60 heading 330
	330	CTL	correct just east of ALFA
	330	CTL	approach on 118.0
28 10	CTL	330	118.0

118.0 MHz Approach

GMT:	To:	From:	Text:
12 28 20	APP	330	(ruft mit 338) we have electrical power failure (Kommandant und Copilot sprechen gleichzeitig) 330 330
	APP	330	go ahead
28 30	330	APP	we no delay for radar vector ILS runway 16 check wind 220 degrees 20 knots
29 00	330	APP	altitude?
29 40	330	APP	you are cleared to descend to 4000 SR 330 cleared to descend to 4000
30 10	330	APP	I can not read you any more I can not read any more please continue heading 330 …… zero (Pfeifton zufolge Doppelbe-aprechung)
12 30 50	TWR	330	on 118.1 how do you read?
31 00	330	TWR	read you three
	330	RAD	do you read here
	RAD	330	loud and clear come in we are 6000 feet We are think we are on heading 329
31 10	330	RAD	roger make your heading 330 descend to 4000 heading 330 4000

GMT:	To:	From:	Text:
	RAD	330	ok 4000 feet heading 330
31 40	330	RAD	according radar you are going off track turn to the right until I say stop
	330	RAD	(Anruf)
32 00	RAD	330	roger 330
	330	RAD	roger turn to the right until I say stop you are fully off track now
	RAD	330	we are turning to the right 330
	330	RAD	roger
32 10	RAD	330	can you give me my position about?
	330	RAD	you are passing Buden and stop your turn now
	RAD	330	…….. possible (Pilot and Verkehrs-Leiter sprechen gleichzeitig)
	330	RAD	roger what is your heading you are going through now
32 20	RAD	330	passing now 330 335
	330	RAD	thank you turn right 360
	RAD	330	360
	330	RAD	descend to 3500 feet (Pilot and Verkehrs-leiter sprechen gleichzeitig, Pilot unver-standlich)
32 30	RAD	330	say again say again
	330	RAD	descend to 3500 feet on QNH 1013
	RAD	330	3500 1013
32 40	330	RAD	do you wish a short final to be final over Rhine or a normal line up (Pilot and Ver-kehrsleiter sprechen gleichzeitig, Pilot Unverstandlich)

GMT:	To:	From:	Text:
32 50	330	RAD	do you wish a normal line up or a short line up?
33 00	RAD	330	…….. emergency we have …. Smoke on board I can't see anything
12 33 10	330	RAD	right heading 080 330 right 080
33 20	ORI	RAD	(Sabena RI) there is an aircraft below you on emergency can you see it? (Keine Antwort)
	RAD	330	is crashing
33 30	330	RAD	roger
	RAD	330	good bye everybody
	RAD	330	good bye everybody
33 40	RAD	330	………. Reducing power we cannot see anything can you give me a low altitude?
34 00	330	RAD	you are making a threesixty (Pfeifton zu-folge Doppelbesprechung) you are making a threesixty left hand side maintain at least 3500 feet and if possible set course heading 080 stop your turn heading 080 if possible
35 00	330	RAD	you are now you are now on heading 080 please stop turn on heading 080 this is direct to Rhine beacon
35 30	330	RAD	heading 080 please
	330	RAD	please open the window SR 330 open your window please

GMT:	To:	From:	Text:
35 40	330	RAD	heading 080 I can not read you any more please open your window
36 00	330	RAD	on 3500 feet you are now heading Rhine I say again open the window please
36 10	330	RAD	you are very very low speed now
36 30	330	RAD	you are at very low speed could you increase speed to a heading east please increase speed to heading east and open your window
36 40	330	RAD	you are still circling you are still circling continue a heading east if possible
37 50	330	RAD	continue you are proceeding now direction field maintain if possible 3500 feet

Varig 11 July 1973

Aircraft lost after off airport forced landing. Report specifies crew unable to see instruments due to smoke (excerpts attached).

RECREATION FROM ORIGINAL DOCUMENTS
ALPA article

One of the most ignored truisms is that the ability to fly an aircraft has to be complemented by the ability to crash it competently.

In July 1973, the crew of a four-engine jet transport asked the approach controller for an emergency descent since they had "a problem of fire on board." The flight had completed an 11-hour transatlantic crossing and had routinely descended to 8,000 feet. Five minutes after the emergency was declared, smoke in the cockpit made the situation so intolerable that the captain decided to make a forced landing. He had to open the sliding cockpit window to maintain ground reference. The aircraft was skillfully landed in open farm land, about three miles from the destination runway. Unfortunately, by that time most of the cabin occupants had already been incapacitated by the in-flight smoke and were unable to leave the intact fuselage which was subsequently destroyed in the ground fire.

RECREATION FROM ORIGINAL DOCUMENTS

FAA Statement:

July 11, 1973 – Boeing 707 (Varig) A fire which apparently started in one of the aft lavatories created dense smoke in the passenger cabin. The fire was not controlled and smoke eventually reached the cockpit. In spite of oxygen masks and goggles, the crew found it necessary to make a forced landing while using the openable side windows for vision. 123 fatal, 11 injured (both pilots survived)

Pan Am 3 November 1973

CFIT following in-flight fire and cockpit smoke. Otherwise flyable aircraft crash landed in water short of the runway. Flight crew unable to see due to heavy continuous smoke (report excerpt attached)

1973, November 3rd. A Pan American 707-321C cargoliner, crashed, just short of the runway, at Boston Logan International Airport, killing the 3 pilots on board. Only 30 minutes after taking off from New York's JFK Airport, the pilot reported smoke in the cockpit. The smoke became so thick that it "…seriously impaired the flightcrew's vision and ability to function effectively during the emergency."

Cubana de Aviacion 6 October 1976

CFIT following in-flight fire and cockpit smoke. Otherwise flyable aircraft crash landed in water short of the runway. Flight crew unable to see due to heavy continuous smoke (report excerpt attached)

RECREATION FROM ORIGINAL DOCUMENTS

Aircraft Accident

Cubana de Aviation

DC8-43 Aircraft

CUT-1201

which crashed into the sea northwest of

Bridgetown, Barbados on October 6, 1976

with the loss of all on board

The Commission determines that the accident was due to the effects of an explosive device placed within the passenger compartment of the aircraft

REPORT OF THE COMMISSION OF ENQUIRY

PART ONE

Bridgetown, Barbados
March 1977

2.3 Events in the Flight Compartment

The following analytical reconstruction of probable events during the flight is based on assessment of evidence detailed elsewhere in this report and on related technical studies.

The take-off and climb-out from Seawell were normal. The First Officer was at the flight controls and the Captain was handling the radio communications. At 1723 the aircraft had reached an altitude of about 16,000 feet.

A few seconds later the crew heard violent explosive sounds which appeared to come from the rear of the aircraft. The Captain pressed his microphone button and shouted "cuidado" (be careful) as he assumed control. The First Officer then reported an explosion and fire to air traffic control.

The Captain commenced an emergency descent and at 1723:43 started a right turn toward Seawell Airport. During the rapid descent the crew carried out emergency procedures to effect smoke removal.

The flight compartment door had been locked in accordance with regulations. During the emergency a crew member opened the door**. Heavy smoke and noxious fumes entered the flight compartment causing the Captain to shout "Close the door! Close the door!"**

In the passenger cabin, an uncontrollable fire had started in the aft cabin making it impossible to reach the wall-mounted fire extinguisher or to open the galley access door to remove the smoke. Some occupants of the cabin died within minutes from the effects of noxious gases produced by burning plastic materials. They were still strapped to their seats. The cabin flight attendants were similarly affected. The fire was intensified by oxygen escaping from shattered supply lines in the rear.

The pilots continued to attempt to reach Seawell airport. They reduced speed and altitude, lowered flap and extended the landing gear. During the descent they flew through rain showers**. Heavy black smoke ad choking fumes continued to enter the flight compartment and the pilots had great difficulty seeing the flight instruments.** Nevertheless they managed to guide the aircraft almost to the extended centre-line of runway 09 at Seawell.

Finally it became impossible to see the flight instruments because of the smoke. Irritation from the chemical fumes made wearing the oxygen masks uncomfortable**. One pilot opened a cockpit window but the only effect was to draw more smoke; the other shouted "That's worse! Go near the water! Go near the water!".**

4.0 RECOMMENDATIONS

The Commission of Enquiry recommends that the Government of Barbados brings the following items formally to the attention of the International Civil Aviation Organization for dissemination to member states:

(a) Flight crew members in large Commercial aircraft should be provided with an adequate number of effective portable devices to protect the eyes and respiratory tract, for use in emergencies related to fire and toxic gases.

(b) Research and regulatory action should be expedited to develop and require the use of materials in aircraft cabins that do not support combustion and do not produce toxic gases when exposed to high temperatures.

(c) The criteria for the certification of large Commercial aircraft should include requirement for a positive means of smoke removal, particularly from the cockpit area.

For reasons of security, other recommendations are being made in a separate document.

By the Commission of Enquiry

Denys Ambrose Williams
Chairman

Thomas Edwin Went
Member

William Maurice Howes
Member

Bridgetown Barbados March 1977.

Air Canada 2 June 1983

This aircraft was nearly lost in-flight due to smoke and fire. The aircraft was destroyed by fire post landing. Flight crew reported loss of vision on final approach, continued flight would have been impossible (excerpts attached).

RECREATION FROM ORIGINAL DOCUMENTS

AVIATION SAFETY
(Aircraft Passenger Survivability and Cabin Safety)

(98-64)

HEARINGS

BEFORE THE

SUBCOMMITTEE ON INVESTIGATIONS AND

OVERSIGNT

OF THE

COMMITTEE ON PUBLIC WORKS AND

TRANSPORTATION

HOUSE OF REPRESENTATIVES

NINETY-EIGHTH CONGRESS

FIRST SESSION

JULY 12, 13, 14, 1983 – AIRCRAFT PASSENGER SURVIVABILITY
NOVEMBER 1, 2, 1983 – CABIN SAFETY

(text unintelligible) for the use of the Committee on Public Works and Transportation

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON: 1985

In order to simplify procedures for the flightcrew, arrival control maintained control of communication with Flight 797 throughout the approach and this procedure was coordinated with the tower. Arrival control then provided the flightcrew with range calls during the final approach.

The flight attendants had dispensed one tray of wet towels to the passengers. The flight attendants also selected able-bodied passengers to sit near overwing exits and instructed them to open these exits after the airplane was stopped. According to the cabin crew, the smoke remained in the aft portion of the cabin until the start of descent, **thereafter it increased and spread throughout the cabin. The smoke was described as heavy, and black and the cabin visibility decreased to a few feet.**

A maximum rate of descent was made at 310 knots and the airplane was leveled off initially at 3,000 feet and thereafter a descent was made to 2,000 feet**. Smoke was now entering the cockpit and both pilots donned oxygen masks and smoke goggle**s. The flaps and the landing gear were extended**. The smoke in the cockpit had by this time become so thick that the captain had difficulty seeing his airspeed indicator during the final approach.** After touchdown, a maximum effort stop was made. Since the electrical system had failed and had rendered the antiskid system inoperative, the main wheel tires blew out during the stop. After the airplane was stopped, the flightcrew executed emergency shut-down procedures. They then attempted to enter the cabin to assist the cabin crew with the passenger evacuation; however, the heat and smoke in the cabin were so intense they were not able to enter the cabin, and they exited the airplane through the cockpit windows.

Gulf Air 23 September 1983

Aircraft lost in-flight. Report specifies Crew unable to see instruments due to smoke (excerpts attached).

RECREATION FROM ORIGINAL DOCUMENTS

3737 CRUISE NR ABU DHABI 23 SEP 83 8302756D S

FOREIGN ACC AC CRASHED IN DESERT NEAR ABU DHABI CAUSE UNDERTERMINED NO SURVIVORS

AC CRASHED IN DESERT NEAR ABU DHABI. ALL PASSENGERS AND CREW WERE KILLED. INVESTIGATION BEING CARRIED OUT TO DETERMINE THE CAUSE OF THE ACCIDENT. POSSIBILITY OF SABOTAGE. EYEWITNESS REPORTED "HEAVY SMOKE SUDDENLY CAME FROM THE "PLANES FRONT AND REAR. IT MADE SEVERAL TURNS BEFORE IT EXPLODED AND CRASHED". PILOT REPORTED AN ENGINE MALFUNCTION JUST BEFORE CONTACT WAS LOST WHEN AC WAS 20 MINUTES FROM ABU DHABI AIRPORT. TWO DISTRESS SIGNALS SENT BELIEVED THAT AN INCENDIARY DEVICE HAD BEEN PLACED IN THE FORWARD FREIGHT HOLD**. CVR INDICATES CREW UNABLE TO SEE INSTRUMENTS DUE SMOKE**. ALL OCCUPANTS APPEARED TO HAVE DIED FROM SMOKE INHALATION.

Private Operator 2 October 1992

CFIT following in-flight fire and cockpit smoke. Flight crew unable to see due to heavy continuous smoke (pilot report attached)

RECREATION FROM ORIGINAL DOCUMENTS

31 Dec 85 DC-3 Rickie Nelson – Texas – 7 dead

Pilot's account (on US network TV):

2 October, 1992 **–** What Happened (NBC) IN their investigative report, they recreated the circumstances involving Rickie **Nelson's death following a smoke in the cockpit air disaster. The pilot and co-pilot were the only survivors. "Pilot - - had to make a life or death choice, he needed to see the ground to land, but he knew if he opened the window he would risk fanning the flames" Pilot: "I'm going to pop my window." Co-Pilot: "It drew flames up around my seat and my body, however there wasn't any option."**

CNN/Headline News Report (7/12/91), Pilot's Final words prior to crash landing, "We have smoke in the cockpit, we have smoke in the cockpit!"

South African Airways 28 November 1987

Aircraft lost in-flight. Report specifies probable cause “A” reduced cockpit visibility in smoke (excerpts attached).

RECREATION FROM ORIGINAL DOCUMENTS

173

smoke from the occupied compartments using criteria for testing which had been developed from years of transport experience”. In the Board’s view, however, the effects of thermal expansion were not adequately demonstrated in the tests.

4.11 The fire/smoke detection systems in the Boeing 747-244D Combi main deck cargo compartment were inadequate. Although the evidence indicates that the fire/smoke detection systems functioned, the extent to which the fire developed and the fact that smoke penetrated the passenger cabin suggest that the fire was not discovered early enough to prevent these consequences.

4.12 The fire fighting facilities provided for the main deck cargo compartment were inadequate.

4.13 The aircraft crashed into the sea some three minutes after the last transmission from the captain, acknowledging clearance for a further descent to flight level 50.

4.14 The aircraft was not under control when it crashed into the sea.

4.15 The only possible causes for the loss of control were one or more of the following:

(a) pilot incapacity from carbon monoxide and carbon dioxide poisoning, and/or smoke inhalation, or disorientation consequent on reduced cockpit visibility in smoke, or pilot distraction;

(b) damage to the structure and/or to the control systems of the aircraft directly or indirectly caused by the fire.

4.16 Irrespective of which of these causes might have been operative in the crash itself, there is a strong possibility that the quantity of carbon monoxide and carbon dioxide released by the fire caused loss of consciousness in or the death of some, if not all, of the occupants before the aircraft crashed into the sea.

4.17 There was no connection between the accident and the omission of Station ZUR to communicate with the Helderberg at the pre-arranged time. Nor is there any significance in the fact that the ZUR tape covering that time was mislaid or wiped out by later use.

4.18 The Board agrees with and supports the findings and conclusions of the FAA Review Team (in its Report of June 1st 1988 (Appendix F Volume 2 pp 25-51).

4.19 Despite intensive investigation the Board was unable to find or conclude that fireworks or any other illegal cargo were carried in the aircraft.

SAS 2 February 1989

This aircraft was nearly lost in-flight due to smoke and fire. Flight crew reported loss of vision on final approach, continued flight would have been impossible (excerpts attached).

RECREATION FROM ORIGINAL DOCUMENTS

SAS		**Incident Investigation Report** (Major Incident)		No. DC989013
Prepared by Tore Hultgren	Date 01 Dec 89	A/C Type DC-9-41	A/C Reg. SE-DAK	ATA No. 24.5

Title

Emergency Landing at Trondheim Airport, Norway after electrical fire.

Reference and Enclosures

FOR DC989013 date 89-02-02

Investigation team

Conny Boholm, STOMD Ulla Bolter, STOOK
Magne Naesbakken, OSLOA, Randi Kile, OSLOK
Tore Hultgren, STOOF Chairman

Summary

On 02FEB89 Flight SK378, a DC-9-41, SE-DAK carrying 103 passengers and a crew of 5, experienced an electrical fire with heavy smoke generation both on flight deck and in cabin, 70 NM North of Trondheim (TRD) Norway.

The flight was at FL 310 normal cruise at night IMC when the incident started.

Emergency descent and return to TRD was initiated and preparations for emergency landing at TRD was started in cabin.

The engine driven generators were switched off line and emergency power selected. The descent, approach and landing was performed on emergency battery power only.

Smoke intensity on flight deck seriously impaired the Pilot's ability to see the flight instrumentation.

After landing an emergency evacuation was performed without delay.

No injury to passengers or crew.

Primary cause was an electrical short circuit in the Acx-tie Relay.

Air Europe 17 December 1989

This aircraft was nearly lost in-flight due to smoke and fire. Flight crew reported loss of vision on final approach, continued flight would have been impossible (excerpts attached).

RECREATION FROM ORIGINAL DOCUMENTS

CAA Report

Date 1989	Aircraft	Regn	Operator	Location	Nature of Flight	Total Aboard		Injury to Occupants F	S	M/N	Damage to Aircraft
17.12	Pokker 100	PH-ZCL	Air Europe	Copenhagen	Scheduled Passenger	88	Crew	0	0	7	Substantial
							Pass	0	0	81	

Some 8 (text unintelligible) before landing, the autopilot disconnected and multiple cautions were announced. Smoke began appearing from the electrical panel behind the co-pilot's seat. **The crew donned oxygen masks and in seconds thick smoke severely impaired vision on the flight deck.** The 'ESS and emergency power only button was pushed to isolate the electrics and **by this time neither pilot could see each other.** An emergency was declared and a visual landing was carried out with very limited visibility. The aircraft was brought to a halt and both engines shut down. The public address system did not appear to work so the flight deck door was opened and the order to evacuate was given and was successfully accomplished. The manufacturer issued an all operator's message concerning sequence of events and maintenance instructions on torque values to generator contractors and terminals. (ICAO Summary 5/89)

Originals on file – Aircraft Services Group - Ramsey, New Jersey - www.yourjet.com

Swiss Air 551 16 October 1993

This aircraft was nearly lost in-flight due to smoke and fire. Flight crew reported loss of vision on final approach, continued flight would have been impossible (excerpts attached). Final German FUS report recommends the EVAS system

Recently Translated German Investigation of In-flight Fire Underscores Need to Land and Evacuate

June 14, 1999

although smoke from a smoldering electrical fire was filling the DC-9's cockpit, at first the crew did not declare an emergency. Rather, after deciding it would be prudent to return to the departure airfield, at this point some 10 minutes into the flight, the flightcrew donned their oxygen masks and smoke goggles. The captain informed the passengers: "Ladies and gentlemen: due to a small technical fault we are returning to Munich for investigation...For the time there is no reason for concern..."

About 4 minutes later, the captain radioed air traffic control, "The smoke is becoming heavier. We are declaring an emergency now." Moments later, the captain told the first officer, "I can't fly any more. Have no instruments. Your controls!"

After the right generator was restored, the captain resumed command. But the density of smoke in the cockpit increased, obscuring the instrument panel. The first officer tried to clear the view by "wagging" the emergency checklist. As the stricken airplane approached for landing, the captain thought the speed indicator was at the 4 o'clock position, which would correlate with 150 knots. He asked the first officer to flap the checklist more vigorously to clear the smoke.

Unable to see anything outside the airplane during rollout, the captain applied emergency braking to stop as quickly as possible. An emergency evacuation was conducted.

This Oct. 16, 1993 case involving Swissair Flight 551 nearly ended in disaster. According to the Oct. 24, 1995 report of the German Aircraft Accident Investigation Branch (FUS), a report which is not well known in the industry because it is in German, the source of the smoldering fire was traced to the emergency power switch. The switch, as it turned out, had a history of short-circuits and malfunctions. Indeed, Swissair had reported problems to the manufacturer. The German investigators found that unfastened screws and connectors, and damage to the switch's "roll contacts," could lead to short circuits.

The fire wiped out the overhead panel. A life-limit of 10,000 activations was recommended and the manufacturer issued a service bulletin to this effect. The German investigators went further, though, expressing dismay over the toxicity of the smoke and the intensity of the fire which, if prolonged, could have had fatal results. They also expressed dismay at the design: "High current from the Emergency DC bus going to the Emergency Power Switch... (and) relays and wire, which are subject to high current, should not be installed in the overhead panel..."

They also suggested the use of an "inflatable view channel between the crew, their instruments and the cockpit windows," which sounds remarkably like the Emergency Vision Assurance System mentioned recently in this publication (see ASW, Dec. 21, 1998).

The case is presented here for its remarkable similarities to salient issues raised in the more recent Swissair Flight 111 accident, including: the swift passage from concern to emergency, smoke in the cockpit, emergency procedures, adequacy/logic of checklists, electrical system design and installation, and the imperative in the face of an uncontrollable fire to land quickly. Indeed, a 1986 article on this last point was suggested as required reading for the Canadian investigators of the Flight 111 tragedy -- to which, we might suggest, the FUS report of this 1993 near-disaster could be added (see ASW, May24). (Note, our thanks to aviation journalist Tim van Beveren for translating the FUS report)

FAA AC25.9a Excerpts

AC Number: AC 25-9A **Date:** 01/06/94

Subject:
Smoke Detection, Penetration, and Evacuation Tests and Related Flight Manual Emergency Procedures

Related Regulation(s):
Part 25, Part 121

Section Number(s):
Sec. 121.221, Sec. 25.831, Sec. 25.854, Sec. 25.855, Sec. 25.857, Sec. 25.858, Sec. 25.869, Sec. 25.1359, Sec. 25.1301, Sec. 25.1309, Sec. 25.1439, Sec. 25.1585

Cancels:

Initiating Office:
ANM-111

AC Document in PDF Format:

AC Document: EXCERPTS

6. BACKGROUND

c. This revision of the Advisory Circular (AC) addresses the following issues:

(8) Continuous Smoke in the Cockpit. Although the FAR does not require the consideration of continuous smoke generation/evacuation, the FAA recommends that the airframe design address this situation. Accordingly, paragraphs 12a(1) and 12e(3) recommend addressing continuous smoke generation/evacuation in the cockpit

7. SUBJECTS AND DEFINITIONS. For purposes of this AC, the following are applicable:

d. On-board smoke sources.

(1) On board smoke or fire may occur due to several reasons. Probable causes are—failure of electrical equipment (shorted wires), overheating of equipment (loss of thermostats or controlling devices), leakage of hot air from pneumatic ducts or spillage of combustible fluid (hydraulic oil, glycol) on a hot surface. Incidents of on-board fire (excluding engine fires) are extremely rare but they do occur and can compromise safety. Smoke sources should be considered in all airplane compartments which contain combustible materials and potential ignition sources (baggage, cargo, passenger, equipment bay, crew rest area, galley, lavatory, etc.). Fires in inaccessible areas (e.g., equipment bays, Class C cargo compartments) should be assumed to be continuous, i.e., capable of continuously generating products of combustion until it can be visually verified that the fire has been extinguished. This is required for the development of fire suppression procedures and to show compliance with the control and containment (as well as continued safe flight and landing) requirements specified in Sections 25.831, 25.869, and 25.1309. The adequacy of the smoke control and containment means should be demonstrated during airplane flight tests, see Section 25.855.

(2) Failures that cause fire and smoke should be included in the failure assessment conducted under Sections 25.831, 25.869 (previously 25.1359), and Section 25.1309. It should be determined, for each failure condition considered for this assessment, whether smoke detectors and specific fire or smoke procedures are warranted and whether the failure or secondary effects should be prevented through the use of isolation, containment, extinguishers, etc. The likelihood of a continuous exposure to smoke may be based on a failure evaluation which would include the sources of failure, contributing materials, failure preventative measures, and smoke control or containment means. The adequacy of the smoke control and the containment means should be verified by smoke tests.

12. SMOKE EVACUATION TESTS.

a. Background.

(1) Cockpit smoke evacuation tests verify that smoke, from sources within or contiguous with the cockpit, can be readily evacuated as required by Section 25.831(d). Typical commercial large transport airplanes are capable of evacuating dense cockpit smoke within approximately 90 seconds after the AFM fire and smoke emergency procedures are initiated. Three minutes is an acceptable maximum time to evacuate smoke from any transport category airplane cockpit. In the case of a cargo conversion supplemental type certificate, the cognizant ACO may accept the original cockpit smoke evacuation test provided it is substantiated by compartment airflow analysis.

The cockpit smoke evacuation test procedure is intended to measure the capability of the smoke clearance procedures against a standard condition, i.e., to clear the cockpit of smoke after the pilot’s view is obscured, without any further smoke being generated.

Although the FAR does not require it, it is recommended that the capability to evacuate continuously generated smoke from the cockpit be demonstrated. Equipment and means designed beyond what is prescribed in the regulations may only be used if those means are readily usable and enable the pilot to see all the instruments, switches, working panels/lights, and mechanisms necessary to safely land the airplane in all weather conditions.

e. Test Procedures. The smoke evacuation tests should be conducted with smoke generated in the cockpit as follows:

(1) The cockpit door or curtain, if installed, should be closed for the test. The crew should don protective breathing equipment as soon as the smoke is evident.

(2) When the cockpit instruments are obscured (dial/panel indicator numbers or letters become indiscernible), smoke generation should be terminated, and the appropriate AFM and operations manual (if applicable) fire and smoke procedures should be initiated. The smoke should be reduced within three minutes such that any residual smoke (haze) does not distract the flightcrew or interfere with flight operations.

(3) Although not mandatory, if the applicant wishes to demonstrate protection from smoke generated by a continuous source in the cockpit, smoke should be generated continuously. The crew should don protective breathing equipment and initiate smoke evacuation procedures as soon as smoke becomes evident and, activate any optional vision enhancement devices, if approved.

/s/ RONALD T. WOJNAR
Manager, Transport Airplane Directorate,
Aircraft Certification Service, ANM-100

Probability Analysis

PROBABILTY ANALYSIS (Based in part on AC 120-42A Appendix 1)

The Author*: Paul Halfpenny has 33 years experience with Lockheed aircraft in the design and testing of Lockheed aircraft, systems, and components beginning with the C-130 and the P2V, Navy Patrol Aircraft in 1952 and ending with the L-1011 in 1985. While employed he served on the AC-9 committee of the SAE and was chairman of that committee in 1983*
84. After retiring he was the vice chairman of the National Academy of Sciences (NAS) Committee on Airline Cabin Safety, and a member of the NAS committee on Contamination Limits for Space Station Freedom. He has served as an expert witness in various aircraft accidents involving contamination in the flight station. Included were the Air Canada accident at Cincinnati, the L-1011 Fire at Riyahd, Saudi Arabia and most recently, the Value Jet Accident at Miami.

SUMMARY

This analysis has been made in an attempt to compare the ETOPS probabilities with the probability of cockpit smoke and subsequent loss of an aircraft due to interference with the crew to the extent that they cannot successfully follow Manual procedures to locate the source and apply corrective action to eliminate the smoke. Failure to promptly apply effective corrective action to eliminate the smoke would exacerbate the situation and could subsequently lead to an inability to control the aircraft.

The ETOPS probability resulting in loss of the aircraft due to ditching or crash is the probability of the first engine failing in the scheduled flight segment followed by the failure of the second engine during the diversion. Since these are independent events, the combined probability is obtained by multiplying the IFSD probability for each event. The combined probability falls within the FAA Extremely Remote range.

The probability of smoke in the cockpit causing diversions is found from available incident reports. The probability of the cockpit smoke causing subsequent loss of the aircraft through crew inability to correct the situation is real; the probability number is inferred. The assumption is that the combined probability of smoke AND subsequent loss of the aircraft must fall in the range of Extremely Remote. The inferred probability of the second event spans the range of Frequent to Reasonably Probable.

The conclusion is that smoke in the cockpit, from whatever cause, is Reasonably Probable. The probability of subsequent loss of an aircraft due to the smoke is inferred to be in the range of Frequent to Reasonably Probable. Smoke in the cockpit is a serious matter—and it could lead to loss of the aircraft—or to the hazards of a less than normal landing and the risks associated with passenger emergency evacuation.

PROBABILITY ANALYSIS

The probability of an IFSD of a single engine based on .02/1000 hrs is equal to 2×10^{-5} for the maximum ETOPS category of 180 minutes and the special category of 207 minutes. (Note: Per AC120-42A, 0.02/1000 hrs is the threshold value to be used in the analysis of a 180 minute ETOPS.) This would require diversion to a 180-minute airport under max *normal* ETOPS. For a complete loss of the aircraft (or ditching in the open seas) the second engine would have to fail with the same probability as the first. Since these are unrelated events the total probability is the product of the two independent probabilities.

For the sample case of a seven hour flight **and** a 3 hour diversion to the nearest airport, the combined probability would be $(7 \times 2 \times 10^{-5}) \times (3 \times 2 \times 10^{-5})$ or 0.084×10^{-7}. This would be within the FAA guidelines for an Extremely Remote probability of 10^{-7} to 10^{-9}.

SIMULTANEOUS LOSS OF THRUST

The probability of simultaneous loss of two engines due to a common cause (e.g. fuel mismanagement) can be derived from equation (1) of Sec 2 (d) of the AC, where the total probability of complete thrust loss is the sum of the probability of complete loss of thrust due to independent causes plus the probability of complete loss of thrust due to common causes.

Using the value of 0.084×10^{-7} and subtracting from 1×10^{-7}, the loss due to common causes mus t be less than 0.916×10^{-7}, again falling within the Extremely Remote Category. The AC does not attempt to analyze the likelihood of this common cause.

COCKPIT SMOKE

To relate to the probability of a diversion due to cockpit smoke, the probability of such an event was determined from available incident reports. The frequency of diversions was based on 7 diversions per 100,000 flts. With a flight duration of 1.75 hours (assumed) the probability of a diversion is 4×10^{-5} per hour. This would make the probability of a diversion due to cockpit smoke just beyond the FAA range of 10^{-3} to 10^{-5} per hr. or a Reasonably Probable event as classified by the FAA, and in the range of Remote. The other data given were that there were 350 diversions in a10 month period. Basing a probability calculation on these data and 15000 flights a day of 1.75 hours, the probability of a smoke-caused diversion is 350 divided by the total hours which are equal to (10/12 x 365 x 15000 x 1.75) or 8×10^{-6}, which yields a probability of 4.4×10^{-5} which again would put it just above the upper limit of the Reasonably Probable Range 10^{-3} to 10^{-5} and again in the range of Remote

Based on flights rather than hours, the data used give values of 7 and 7.7×10^{-5} as the probability of a smoke diversion per flight.

To directly compare the hazard of a smoke caused diversion with that of an ETOPS ditching or accident, the probability of a crash as a result of the cockpit smoke can be calculated using FAA guidelines for probability of an event. To reach the lower limit of extremely remote probability (1×10^{-7}) the probability of the smoke induced diversion causing the second failure, the crash, must be combined with the incident probability. The total probability of the two events, smoke in the cockpit and eventual crash must reach 1×10^{-7} to 1×10^{-9}. The calculations have been based on a per hour exposure in accord with the FAA guidelines. Given that the probability of event A, (P_A)

smoke in the cockpit, is 4.4 x 10^{-5}, to find the probability of event B, ($P_{B,}$), subsequent loss of the aircraft, which when combined will equal P_{AB}, (1 x 10^{-7}) we divide P_{AB} by P_B. Thus (1 x10^{-7})/(4.4 x 10^{-5}) = 2.27 x 10^{-3}. The lower probability of 1 x 10^{-9} when divided by P_B yields 2.27 x 10^{-5}. These inferred probabilities of a subsequent loss of aircraft due to cockpit smoke fall in the range of Frequent (2.27 x $10^{-3)}$ to Reasonably Probable (2.27 x 10^{-5}) (Ref) Paul F. Halfpenny 30 Sept .2002

Ref. **FAA Probability Guidelines**

Probability Occurrence

10^{-3} Frequent

10^{-3} to 10^{-5} Reasonable Probable

10^{-5} to 10^{-7} Remote

10^{-7} to 10^{-9} Extremely Remote

ALPA Smoke Report 1999

00ASC-93

A Review of Smoke and Potential In-flight Fire Events in 1999

Jim Shaw
Air Line Pilots Association

ABSTRACT

Data from 1999 regarding events involving smoke, fumes, and in-flight fire was analyzed. It suggests that these events are sometimes unreported or under-reported. Many of these events resulted in unscheduled landings. Fire or high temperature events frequently occur in areas of the aircraft that present a high hazard potential and indicates that current designs and procedures do not give the crew the ability to locate the source of the smoke. There is a need for further effort in the areas of incident data collection, improved prevention efforts, and means to quickly detect and isolate the ignition sources involved.

INTRODUCTION

The Air Line Pilots Association (ALPA) is addressing the issue of inflight fire because of the extremely serious consequences that can result from the occurrence of these events. A fire inflight can result in catastrophe if not promptly and completely extinguished. It is the Association's view that all inflight fires must be prevented or rapidly found and fought in order to prevent a catastrophic loss of control of the aircraft, serious injury, or loss of life.

This paper reviews data from 1999 regarding events involving smoke, fumes, and inflight fire events. Available data was analyzed for the level or completeness of reporting, the location of fire or high temperature events, what components were causing the events, and the accessibility to the crew of where the initiating event occurred. It was further analyzed for the resultant crew action from the event of smoke or fire (e.g. did the crew make an unscheduled landing?)

We found a high number of smoke and fire events that resulted in unscheduled landings or were not controllable or accessible by the crew. We also found the reporting of serious events to be poor and haphazard.

The particular fire detection and protection methods to mitigate these potentially serious events are beyond the scope of this paper. In general, such methods might include changes to fire detection and suppression systems, as well as changes to materials used in aircraft construction to minimize the fuel material available to propagate an inflight fire.

The reader must understand that pilots experiencing events such as those identified in this report must consider them to be potentially catastrophic events, requiring immediate emergency action. Designers, operators, and flight crews must also appreciate the fact that these emergency actions can be relatively drastic and, if not properly planned and executed, can lead to a chain of events that is potentially hazardous and could lead to an incident or accident itself. Thus, prevention is by far the preferred solution to this problem.

SDR AND INCIDENT DATABASE SUMMARY

The following is a summary of data extracted from the FAA Service Difficulty Report (SDR) database for the period Jan 1, 1999 to November 2, 1999. The reports were extracted based on a word search for records satisfying the following parameters: (Smoke and not False Warning) as the *Nature of Condition* and (insulation or wiring) and (char or burn or short) in the *Summary*.

This produced 1,089 records. Even with the parameters, set as listed above, there are still a few engine events and other events involving false alarms.

The reader must be made aware of the limitations to the databases used. The largest database, and the one most used in this analysis, was the SDR. It has many limitations. As shown in the data below there is at least one write-up that shows that not all events are recorded. The database itself must be treated in its entirety, as was done for this paper. A simple word search for "smoke" using only the text fields may give you only a fraction of the events involving smoke.

Also included are reports derived from the FAA Incident database for the period of 1 January 99 to 23 July 99 that had similar search parameters as the SDR download but only resulted in 21 records pertaining to commercial aviation.

LESSONS LEARNED

Several points of interest were learned by reviewing the data. These items are listed below and each is described in detail in the following sections.

1. There appears to be an under reporting of significant events in the FAA incident database.
2. The data in the SDR database under reports the significance of the problem.
3. There is an average of more than one unscheduled landing a day due to smoke or fire based only on SDR data.
4. There are a very high number of smoke or fire events occurring on transport category aircraft in the US and Canada.
5. Approximately 82% of the high temperature events were related to aircraft electrical systems or components.
6. In most cases the crew had limited ability to recognize or control the malfunction, or have access to the area of the malfunction.
7. SDR reports involving tripped circuit breakers being reset for systems with internal or external short circuits indicate that resets can be extremely hazardous.

THERE APPEARS TO BE AN UNDER REPORTING OF SIGNIFICANT EVENTS IN THE FAA INCIDENT DATABASE

NOTE: The reporting of an incident is dependent on the definition used for 'incident'. According to the U.S. NTSB rules (49 CFR 830), an incident is defined as "an occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operations." 49 CFR 830.5 on Immediate Notification requires inflight fires to be reported by the airline (operator) regardless of the outcome. Smoke without fire is not a reportable event under US NTSB rules, but is reportable in Canada.

769 of the 1,089 SDRs fell in the same period as the Incident reports from the FAA, allowing a rate comparison to be made for identical time periods. In the SDR database, there were 412 events during the reporting period that we classified as 'High Temperature' events. There were 155 events that necessitated an Unscheduled Landing, Emergency Descent, Return to the Block, or Aborted Takeoff. However, there are only 21 FAA Incident reports for this same time frame.

Below are three typical write-ups from the FAA Incident database and four from the SDR database that were not included in the Incident database. Note the absence of clear discriminators that could be used to classify an event as belonging in one dataset or the other. Clearly, significant events are being captured by one system but not the other and no definable method is in place to categorize events.

<u>From the FAA Incident Database</u>
"19990106008729C Date 1/[redacted]/99

(-5) VERY STRONG SMELL, LIKE BURNING MATCHES, BECAME VERY PRONOUNCED THROUGH-OUT THE AIRCRAFT AND THEN DISSAPATED. MAINTENANCE INSPECTED ENTIRE AIRCRAFT AND WAS UNABLE TO DETECT ANY ODOR OR ABNORMALITIES. NO PREVIOUS HISTORY OF SAME IN PAST 90 DAYS."

"19990210013029C Date 2/[redacted]/99

[redacted] FLIGHT [redacted], BOEING 757-232, ENROUTE FROM LAX TO DFW REPORTED SMOKE IN THE CABIN COCKPIT AT 0517 (CST).THE FLIGHT CREW DECLARED AN EMERGENCY AND DIVERTED THE FLIGHT TO LBB. THE LBB AIRPORT FIRE EQUIPMENT WAS ON THE SCENE WHEN THE FLIGHT LANDED WITHOUT INCIDENT AT 0530 (CST). UPON INSPECTION PERSONNEL FOUND THE RIGHT RECIRCULATION FAN DAMAGE, ISOLATED THE UNIT AND THE FLIGHT WAS DISPATCHED AT 1100 (CST) PER MEL PROCEDURES."

"19990429015209C Date 4/[redacted]/99

AIRCRAFT WAS TAXIING FOR TAKEOFF AT WICHITA MIDCONTINENT AIRPORT, WICHITA, KANSAS WHEN SMOKE WAS REPORTED ABOVE SEATS 3B AND 3C. PASSENGERS WERE OFF LOADED WITHOUT INCIDENT. AIRCRAFT RETURNED TO MAINTENANCE WHERE IT WAS DISCOVERED THAT THE CONNECTOR FOR THE LIGHT WAS FOUND ARCED. THE BALLEST FOR THE LIGHT WAS DISCONNECTED AND CIRCUIT BREAKER PULLED PER MEL 33-03 AND AIRCRAFT WAS THEN DISPATCHED WITH NO FURTHER INCIDENT."

<u>From the SDR Database:</u>
"1999061800624 Date 4/[redacted]/99

NAS - FLT [redacted] - ROUTINE FLIGHT AT FL 150 APPROX 50 NM WEST OF NAS SMOKE WAS NOTICED IN THE MAIN CABIN AIR CONDITIONING SYSTEM. DECLARED EMERGENCY AND DESCENDED TO 5000 FT DIRECT TO NAS. FOLLOWED EMERGENCY PROCEDURES FOR COCKPIT AND ELECT RICAL SMOKE. ONCE THE NR 1 RECIRC FAN WAS TURNED OFF, THE SMOKE DISSIPATED.

NORMAL LANDING, TAXI AND DEPLANING OF PASS ENGERS. CONTRACT MAINTENANCE FOUND THE NR 1 RECIRC FAN AS THE SOURCE OF THE SMOKE AND IT WAS MEL'D. SUBSEQUENTLY, THE NR 1 RECIRC FAN WAS REMOVED, REPLACED AND OPERATIONAL CHECKED. THE MEL ITEM WAS RESTORED AND THE AIRCRAFT WAS RETURNED TO SERVICE. (M)"

Note the similarity of this event to the second FAA incident event described above.

"1999050700108 Date 4/[redacted]/99

NR 3 UNPARELLED LIGHT CAME ON AFTER LANDING. TOTAL ELECTRICAL FAILURE APPROX 1-2 MIN. THEN DETECTED SMOKE IN COCKPIT, EVACUATED A/C. REF L/P 183785 ITEM 2. FOUND WIRE W103-T1-5X2 (WDM 24-20-03) INSIDE NR 3 GEN CURRENT X-FORMER CHAFFING WITH COVER MOUNTING SCREW EXPOSING STRAND OF WIRE. ALSO, FOUND TERMINAL LUG OF ABOVE WIRE HAS NO CLEARENCE WITH FWD LOW ER NUT. REPAIRED CHAFED AREA OF WIRE REMOUNTED CLIP NUT 180 FOR CLEARENCE. ACFT POWER SYSTEMS, OPS CK OK."

"1999052800547 Date 4/[redacted]/99

MIA - FLT [redacted] - AFTER TAKEOFF, SEAT WIRING HARNESS AT ROW 2AB SHORTED OUT CAUSING AN ARC AND SMOKE IN FIRST CLASS CABIN. FLIGHT AIR INTERRUPTED AND RETURNED TO MIA AND LANDED WITHOUT FURTHER INCIDENT. MAINTENANCE FOUND SEVERAL WIRES SHORT ED TO GROUND ADJACENT TO PASSENGER SEAT 3A FOOT REST. MAINTENANCE INSTALLED A GROUND GROMMET AND REPAIRED SHORTED WIRIN G TO POWER FOOT RESTS AT SEAT ROWS 2AB THROUGH 4AB. SYSTEM GROUND CHECKED NORMAL OPERATION. (M)"

"1999081200899 Date 5/[redacted]/99

LHR - FLT [redacted] - AFTER TAKEOFF LHR WHILE EN ROUTE TO MIA, CREW SMELLED SMOKE IN FORWARD GALLEY AREA. FORWARD CABIN TEMPER ATURE LIGHTS ILLUMINATED, PASSENGER 02 LIGHT ILLUMINATED AND DROPPED 02 MASKS, VARIOUS CIRCUIT BREAKERS POPPED. CREW DE CLARED AN EMERGENCY AND AIR INTERRUPTED BACK TO LHR AND LANDED WITHOUT INCIDENT. CHAFED WIRE BUNDLE ABOVE FIRST CLASS C ENTRAL CLOSET AREA WAS REPAIRED ACCORDING TO AIRCRAFT WIRING MANUAL CHAPTER 20. ALL RELEVANT CIRCUITS TESTED NORMAL. O 2 MASKS RESTOWED, AND MANUAL 02 TEST PERFORMED NORMAL. FORWARD TEMPERATURE CONTROL OPERATION CHECKS NORMAL. SYSTEM GRO UND CHECKED NORMAL OPERATION. (M)"

This last event was a very serious one. The "chafed wire bundle" involved multiple circuit failures and if fuel had been available at the event site the results could have been extremely serious.

A close examination of the SDR database shows hundreds of similar incidents that appear to be of a serious enough nature that they should be included in the incident database.

THE DATA IN THE SDR DATABASE UNDER REPORTS THE SIGNIFICANCE OF THE PROBLEM

The following was extracted from the SDR Database:

"SEVERAL AIR RETURNS WITH SMOKE ODOR AND 'LAV SMOKE' LIGHT ON EICAS. FINAL FIX WAS REMOVED AND REPLACED NR 2 ENGINE FAN DRIVE SEAL AND CARBON SEAL ASSY. NO FURTHER ODORS OR 'LAV SMOKE LIGHTS' ON EICAS. (M)"

This was the only entry for this aircraft; even though it mentions "several air returns with smoke odor". This is one report that demonstrates under reporting of events in the database. The accuracy of any database is only as good as the information that goes in. In the case of SDRs there appears to be a wide variation on the level of participation among the various reporters. The thoroughness of the person making the entry can also cause understatement of the problem by not fully filling in all fields, by entering incomplete information, and by not even submitting a report.

Thus, a review and analysis of SDR data can only state that these are minimum numbers and that the total number of occurrences can reasonably be presumed to be greater than that listed.

THERE ARE A VERY HIGH NUMBER OF SMOKE OR FIRE EVENTS OCCURRING ON TRANSPORT CATEGORY AIRCRAFT IN THE US AND CANADA

As an aid to the analysis, the events were codified based on the nature of the condition reported. Of the 1,089 SDR events, 964 were coded as smoke or fire as shown in the table below. It is important to recognize that the condition noted was what the crew could see and again depends on how the SDR form was completed. Thus, it would be incorrect to conclude that because 12 events mentioned "fire" that there were only

12 fire events. An event involving fire in a hidden area (behind a panel, under the floor) could easily be recorded as a "smoke" event if the smoke was the only indication of a malfunction available to the crew. Results of a subsequent investigation (i.e. that the smoke was caused by a fire unseen by the crew) might not ever be recorded in the database. Sixteen events were entered more than once, but were not deleted due to additional data that some of the fields offered.

Code	Count	Nature of Condition
A	12	FLAME
B	952	SMOKE

SDR events were further grouped under the following failure categories in order to make the many non-standardized failure modes in the original reports more manageable. The groups were defined as follows:

A-High Temperature situation,
B-Air contamination situation (possibly combustible),
C-Out of tolerance situation (e.g. bulb out or a false alarm)
D-Not pertinent situation (e.g. blown tire).

The following subjective judgments were used as definitions for categories A & B:

A-High Temperature situation: Any reference to smoke from a solid material was considered to be a high temperature event, or any case of a motor failing and popping a circuit breaker, due to bearing seizure or an internal failure, like a short circuit.
B-Air contamination situation (possibly combustible): If the event referred to smoke that also included mist or it appeared to be a leakage of oil or hydraulic fluid into the air duct system, then it was called an air contamination event.

Total Occurrences per Failure Category:

Failure Category	Occurrences
A - High Temperature	578
B - Air contamination situation (possibly combustible)	367
C - Out of tolerance	102
D - Not pertinent situation	42

For the ten-month period there were almost 3 smoke events per day even allowing for some duplication of entries.

THERE IS AN AVERAGE OF MORE THAN ONE UNSCHEDULED LANDING A DAY DUE TO SMOKE OR FIRE BASED ONLY ON SDR DATA

The following table summarizes precautionary procedures employed by a flight crew following a malfunction recorded in the SDR database. There is more than one entry for some events.

Code	Precautionary Procedure	Total Count
A	UNSCHED LANDING	359
O	OTHER	264
K	NONE	246
H	DEACTIVATE SYST/CIRCUITS	129
D	RETURN TO BLOCK	85
E	ENGINE SHUTDOWN	17
F	ACTIVATE FIRE EXT.	15
C	ABORTED TAKEOFF	11
B	EMER. DESCENT	8
G	MANUAL O2 MASK	6
I	INTENTIONAL DEPRESSURE	1
J	DUMP FUEL	1
L	ABORTED APPROACH	1

Recall that the data is based on a ten-month sampling period (approximately 300 days). Therefore, there is an average of more than one unscheduled landing a day due to smoke or fire based only on SDR data. Given the limitations of the data collection and recording process highlighted above, it is clear that even more events are occurring than are being recorded.

APPROXIMATELY 82% OF THE HIGH TEMPERATURE EVENTS WERE RELATED TO AIRCRAFT ELECTRICAL SYSTEMS OR COMPONENTS

The analysis of SDR data also lead to significant conclusions about the components that failed. Each component identified in the SDR entry was classified (subjectively) based on the likelihood of the malfunction being electrical in nature. For example, a light ballast that overheats and begins to smoke can logically be presumed to be an electrical problem, whereas smoke emanating from an air duct could not be presumed to be electrical. In the table below, in the column labeled "Electrical Component?" and entry of "Yes" would be a component likely to fail electrically in the context of the recorded event. "No" would not be the converse, "N/A" indicates non-applicable for the study purpose and "Unk" shows a component whose status was too varied to easily categorize.

Wire or wiring accounts for approximately 11% of the events. Other electrical components such as connectors, circuit breakers, switches, and Line Replaceable Units (LRUs) account for the vast majority of the rest.

The group of SDR events coded as High Temperature events (Code "A") showing the most frequent component occurrences, listed in order from highest to lowest is presented below:

Location Description	Electrical Component?	Count
FAN	Yes	68
WIRE	Yes	48
LIGHT	Yes	27
BALLAST	Yes	23
SWITCH	Yes	22
OVEN	Yes	22
AIR DIST	No	19
COFFEEMAKER	Yes	17
CONNECTOR	Yes	12
ENGINE	No	10
APU	No	9
MOTOR	Yes	8
CIRCUIT BREAKER	Yes	8
VALVE	No	8
ACM	No	8
RELAY	Yes	7
BULB	Yes	7
WIRING	Yes	7
CONTROLLER	Yes	6
POWER SUPPLY	Yes	5
HARNESS	Yes	5
INVERTER	Yes	5
GCU	Yes	5
VIDEO UNIT	Yes	5
SMOKE DETECTOR	N/A	5
BLOWER	Yes	4
PSU	Yes	4
BEARING	No	4
RESISTOR	Yes	4
BATTERY CHARGER	Yes	4
PDU	Unk	3
PROJECTOR	Yes	3
DUCT	No	3
PACK	No	3
CHARGER	Yes	3
CONTROL PANEL	Yes	3
RMI	Yes	3
HEATER	Unk	3
PANEL	Yes	3
SOCKET	Yes	3
AIR DISTR	No	3
BATTERY	Yes	3
TRANSFORMER	Yes	3
WINDSHIELD	Yes	3
STARTER	Unk	3

Sorting the same data on the "electrical" field shows the prevalence of electrical components involved in High Temperature events. The data are summarized below and reveal that 82% of the High Temperature failures can be attributed to electrical type components (occurrences of less than 3 for a component were not tallied).

Category	Totals
Electrical	314
Non-electrical	67
Not Applicable	5
Unknown	6

A similar component-based analysis was performed on wires and wire-related components as shown below:

Count	Part Name
51	WIRE
7	WIRING
3	WIRE HARNESS
2	WIRES

Of the 578 High Temperature events 63, or 11%, were associated with wiring faults. Based on informal interviews the writer has had with maintenance personnel this number could be higher as some technicians will enter the problem as related to the Line Replaceable Unit (LRU) as opposed to the wire in or into the LRU that may have actually caused the event.

A LARGE MAJORITY OF THE "HIGH TEMPERATURE" EVENTS OCCUR IN OR NEAR THE CABIN OR COCKPIT

Continuing the analysis of High Temperature events and focusing on the location of the malfunction reveals the following information:

Location	Number of Events
PASSENGER CABIN	195
COCKPIT	115
GALLEY	62
ACM AREA	53
EE BAY	50
ENGINES	40
CARGO COMPARTMENT	10
LAVATORY	10
LANDING GEAR	9
APU	9
WING	7
TAIL	5
PITOT SYSTEM	5
FUEL TANKS	4
RADAR SYSTEM	3
HYDRAULIC SYSTEM	1

382 of 578 High Temperature events or 66% occurred in the Passenger Cabin, Cockpit, Galley, or Lavatory areas. Of course it should be noted that these areas contain a majority of the components that cause smoke and fire events, so these greater numbers are not surprising.

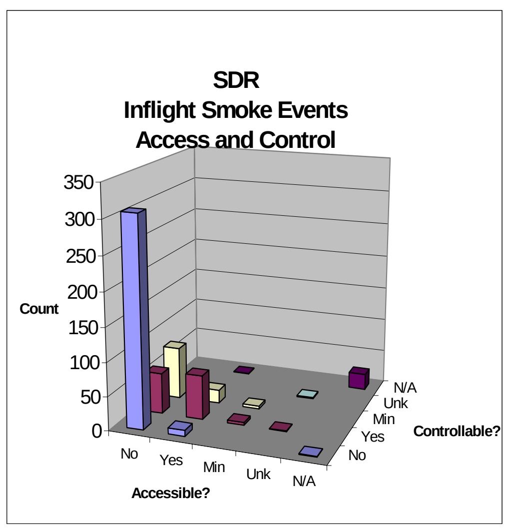
IN MOST CASES THE CREW HAD LIMITED ABILITY TO RECOGNIZE, OR CONTROL THE MALFUNCTION, OR HAVE ACCESS TO THE AREA OF THE MALFUNCTION

Below is a chart of High Temperature occurrences and a subjective judgment by the author as to whether or not the event was accessible or controllable by the crew based on what the crew knew at the time. In most events, the crew faced a situation of smoke of indeterminate origin. In such instances, accessibility of the source and controllability of the event were impossible because they did not know the source of the smoke. Subjectively, it appears that many of the events might have been controllable by the crew if they had had additional information.

Categorizations for "Crew Accessibility" and "Crew Controllable" were made as follows:

No	Crew had no access or control over the situation.
Yes	Crew clearly had access or control over the situation.
Min	Crew had some access or control over the situation. Typically a C/B that tripped on its own would fall into this category.
N/A	The event was not applicable. This would be true for a malfunctioning smoke detector during a smoke event, an engine failure, and hot brakes.
UNK	Could not determine from the information given.

Count	Crew Accessibility?	Crew Controllable?
308	No	No
77	No	Min
65	Yes	Yes
60	No	Yes
24	N/A	N/A
20	Yes	Min
9	Yes	No
4	Min	Min
4	Min	Yes
2	No	Unk
2	Unk	Unk
1	N/A	No
1	Unk	Yes
1	Yes	N/A



It is significant to note that with current designs and procedures, the crew had neither access nor control in over half the High Temperature events captured in the database. Control of the event, even at a minimal level, was possible by the crew in less than 40% of the events and access of some kind was possible in less than 20%. Further analysis of the data shows that even the high occurrence items, such as the passenger cabin or cockpit, a majority of those incidents were not accessible by the crew either. This may suggest that from a cost benefit analysis point of view that the best locations for inflight smoke and fire detection and suppression are in the inaccessible areas of the fuselage.

SDR REPORTS INVOLVING CIRCUIT BREAKERS BEING RESET FOR SYSTEMS WITH INTERNAL SHORT CIRCUITS INDICATE THAT RESETS CAN BE EXTREMELY HAZARDOUS

There were 12 cases where the crew or the maintenance technician reset a tripped C/B and in 8 of those cases additional smoke, arcing, or damage occurred. In the remaining four a serious malfunction had taken place and there existed the possibility for further damage upon reset.

One of the more hazardous practices revealed by analysis of the SDR data was that of resetting tripped circuit breakers before complete corrective action or analysis of the system was performed. Two write-ups that are indicative of this are shown below:

> "INSTRUMENT LIGHTS FAILED. TWO MINUTES LATER, THE INSTRUMENT LIGHTS CIRCUIT BREAKER TRIPPED. PILOT RESET THE CIRCUIT BREAKER. APPROXIMATELY FOUR MINUTES LATER, THE SMELL OF SMOKE WAS OBSERVED. AIRCRAFT WAS ON FINAL APPROACH AT THIS TIME AND SAFE LANDING WAS ACCOMPLISHED. NO EVIDENCE OF FLAME INSIDE OR AROUND LIGHT CONTROL UNIT. APPARENT INTERNAL SHORT OF CIRCUIT BOARD CAUSED ODOR OF BURNING WIRES AND SMOKE."

This demonstrates a case where the pilot felt justified to reset the C/B. The instrument lights had failed and the pilot likely felt he or she needed them for the approach. Re-setting them exacerbated the situation and re-introduced smoke into the cockpit while on final approach.

> "LEFT COFFEEMAKER POPPED. RESETTING CENTER C/B CAUSES ARCING IN AFT COFFEEMAKER. ISOLATED PROBLEM TO NR 2 C/M IN LEFT AFT GALLEY. PULLED AND COLLARED POWER C/B FOR NR 2 C/M. FWD TO MCO AND PLACARD. C/M NASI LGW."

This demonstrates a case where resetting a tripped C/B would clearly not be necessary for continued safe flight and could have serious consequences if attempted in flight. It was not clear from the write-up if the initial reset was attempted on the ground or in the air.

CONCLUSION

The data summarized in this paper suggests that there are likely to be a number of actual smoke or potential fire events that are unreported or under-reported. The data further suggests that fire or high temperature events frequently occur in areas of the aircraft that present a high hazard potential (e.g. the cockpit) and indicates that current designs and procedures do not give the crew the ability to locate the source of the smoke. We found a large number of potentially serious events, many of which resulted in unscheduled landings. The data also supports the need for further effort in the areas of incident data collection, improved prevention efforts, and more efficient means to quickly detect and isolate the ignition sources involved.

The analysis provided has shown a significant number of events are occurring that could lead to serious in-flight fires. Efforts must be undertaken to prevent these events from occurring and to prevent any events that do occur from propagating to catastrophic levels, by appropriate changes to aircraft system design standards, aircraft construction materials, and appropriate use of fire detection and suppression systems.

ACKNOWLEDGMENTS

I would like to thank the Air Line Pilots Association (ALPA) Engineering Staff and a variety of colleagues for their review and editorial input.

CONTACT

This study was conducted by Jim Shaw a type rated 767 First Officer with over 23 years of flying experience both in the US Air Force and Commercial Aviation. He is the Project manager for the ALPA Inflight Fire Project Team and the Chief Accident Investigator for the ALPA team at Delta Air Lines.

ADDITIONAL SOURCES

The data used in this paper was extracted from the FAA Service Difficulty Report (SDR) database for the period Jan 1, 1999 to November 2, 1999. The reports were

extracted based on a word search for records satisfying the following parameters: (Smoke and not False Warning) as the *Nature of Condition* and (insulation or wiring) and (char or burn or short) in the *Summary*.
This produced 1,089 records.

The Aviation Incident Database System (AIDS) was also utilized. The databases were then analyzed extensively using the database program Microsoft Access.

APPENDIX

The following pages contain additional reduction of the same data used in the preceding analyses and are included as an additional reference.

Air contamination situation (possibly combustible). The most frequent component occurrences are listed in order from highest to lowest:

Location Description	Total Occurrences
AIR DIST	67
COALESCER	36
ACM	23
OVEN	20
COALESCER BAG	19
APU	17
VALVE	16
ENGINE	13
PACK	12
BATTERY	10
SEAL	9
DUCT	8
AIR DISTRIBUTION	8
LINE	8
INLET	6
FILTER	5
SMOKE DETECTOR	4
BATTERY PACK	4
BALLAST	3
CONTROLLER	3
CONNECTOR	2
COMPRESSOR	2
LT PACK	2
COFFEEMAKER	2
O-RING	2
GASKET	2
FUEL TANK	2
OIL SYST	2
HEATER	2
OIL SYSTEM	2
BEARING	2
BATTERY CHARGER	2
SWITCH	2
ACTUATOR	2
ENERTAINMENT SYS	1
ENTERTAIN SYST	1
FAN	1
COOLING DOOR	1

Out of tolerance (bulb out, false alarm). The most frequent component occurrences are listed in order from highest to lowest:

Location Description	Occurrences
SMOKE DETECTOR	17
LIGHT	5
WIRE	3
WINDOW	3
CABLE	3
CLAMP	2
SEAL	2
DETECTOR	2
COALESCER	2
CARBON SEAL	2
GYRO	2
VALVE	2
HEAT EXCHANGER	1
GEARSHAFT	1
FUEL LINE	1
FITTING	1

Non-pertinent situation. The most frequent component occurrences are listed in order from highest to lowest:

Location Description	Total Occurrences
ENGINE	10
SMOKE DETECTOR	3
SEAL	2
SWITCH	2
BLADE	1
BRAKE	1
BRAKES	1
LOCK WASHER	1
BEARING	1
APU	1
COALESCER	1
COALESCER BAG	1
CSD OIL COOLER	1

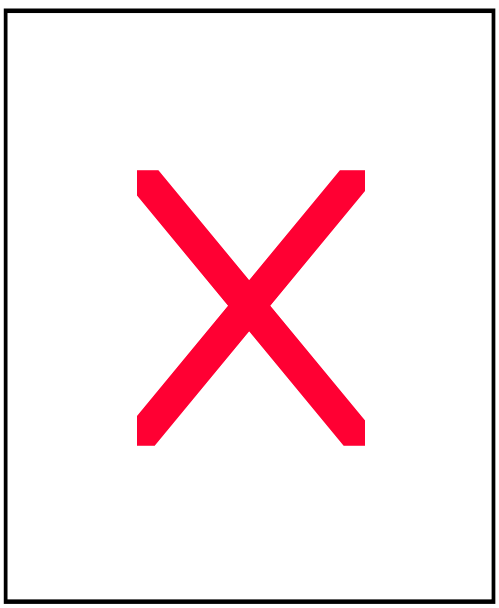
This chart contains the 4 failure modes and normalized locations. This results in 51 combinations of location and failure mode. They are sorted by location then failure mode. The same information is then sorted only by failure mode.

Location Description	Failure Category Text	Occurrences
PASSENGER CABIN	HIGH TEMPERATURE	195
PASSENGER CABIN	AIR CONTAMINATION	107
PASSENGER CABIN	OUT OF TOLERANCE	23
PASSENGER CABIN	N/A TO FUSELAGE	4
COCKPIT	HIGH TEMPERATURE	115
COCKPIT	AIR CONTAMINATION	34
COCKPIT	OUT OF TOLERANCE	10
COCKPIT	N/A TO FUSELAGE	2
GALLEY	HIGH TEMPERATURE	62
GALLEY	AIR CONTAMINATION	28
GALLEY	OUT OF TOLERANCE	3
LAVATORY	HIGH TEMPERATURE	10
LAVATORY	AIR CONTAMINATION	4
LAVATORY	OUT OF TOLERANCE	6
LAVATORY	N/A TO FUSELAGE	2
EE BAY	HIGH TEMPERATURE	50
EE BAY	AIR CONTAMINATION	8
EE BAY	OUT OF TOLERANCE	6
CARGO COMPT	HIGH TEMPERATURE	10
CARGO COMPT	AIR CONTAMINATION	7
CARGO COMPT	OUT OF TOLERANCE	16
CARGO COMPT	N/A TO FUSELAGE	2
ACM AREA	HIGH TEMPERATURE	53
ACM AREA	AIR CONTAMINATION	83
ACM AREA	OUT OF TOLERANCE	9
ACM AREA	N/A TO FUSELAGE	4
ENGINES	HIGH TEMPERATURE	40
ENGINES	AIR CONTAMINATION	43
ENGINES	OUT OF TOLERANCE	21
ENGINES	N/A TO FUSELAGE	22
APU	HIGH TEMPERATURE	9
APU	AIR CONTAMINATION	34
APU	OUT OF TOLERANCE	2
APU	N/A TO FUSELAGE	3
TAIL	HIGH TEMPERATURE	5
TAIL	AIR CONTAMINATION	3
HYDRAULIC SYSTEM	HIGH TEMPERATURE	1
HYDRAULIC SYSTEM	AIR CONTAMINATION	4

Location Description	Failure Category Text	Occurrences
HYDRAULIC SYSTEM	OUT OF TOLERANCE	2
LANDING GEAR	HIGH TEMPERATURE	9
LANDING GEAR	AIR CONTAMINATION	6
LANDING GEAR	OUT OF TOLERANCE	2
LANDING GEAR	N/A TO FUSELAGE	3
PITOT SYSTEM	HIGH TEMPERATURE	5
RADAR SYSTEM	HIGH TEMPERATURE	3
FUEL TANKS	HIGH TEMPERATURE	4
FUEL TANKS	AIR CONTAMINATION	4
FUEL TANKS	OUT OF TOLERANCE	1
WING	HIGH TEMPERATURE	7
WING	AIR CONTAMINATION	2
WING	OUT OF TOLERANCE	1

The following chart presents the same data in a cross tabulation format with a chart of the results.

	Failure Code Category				
Location Code	A	B	C	D	Grand Total
A	195	107	23	4	329
B	115	34	10	2	161
C	62	28	3		93
D	10	4	6	2	22
E	50	8	6		64
F	10	7	16	2	35
G	53	83	9	4	149
H	40	43	21	22	126
I	9	34	2	3	48
J	5	3			8
L	1	4	2		7
M	9	6	2	3	20
P	5				5
R	3				3
T	4	4	1		9
W	7	2	1		10
Grand Total	578	367	102	42	1089



Now the same data is sorted by number of occurrences, in decreasing order.

Loc	Location Text	Failure Category Text	Count
A	PASSENGER CABIN	HIGH TEMPERATURE	195
B	COCKPIT	HIGH TEMPERATURE	115
A	PASS CABIN	AIR CONTAMINATION	107
G	ACM AREA	AIR CONTAMINATION	83
C	GALLEY	HIGH TEMPERATURE	62
G	ACM AREA	HIGH TEMPERATURE	53
E	EE BAY	HIGH TEMPERATURE	50
H	ENGINES	AIR CONTAMINATION	43
H	ENGINES	HIGH TEMPERATURE	40
B	COCKPIT	AIR CONTAMINATION	34
I	APU	AIR CONTAMINATION	34
C	GALLEY	AIR CONTAMINATION	28
A	PASSENGER CABIN	OUT OF TOLERANCE	23
H	ENGINES	N/A TO FUSELAGE	22
H	ENGINES	OUT OF TOLERANCE	21
F	CARGO COMPT	OUT OF TOLERANCE	16
D	LAVATORY	HIGH TEMPERATURE	10
B	COCKPIT	OUT OF TOLERANCE	10
F	CARGO COMPT	HIGH TEMPERATURE	10
G	ACM AREA	OUT OF TOLERANCE	9
M	LANDING GEAR	HIGH TEMPERATURE	9
I	APU	HIGH TEMPERATURE	9
E	EE BAY	AIR CONTAMINATION	8
F	CARGO COMPARTMENT	AIR CONTAMINATION	7
W	WING	HIGH TEMPERATURE	7
E	EE BAY	OUT OF TOLERANCE	6
M	LANDING GEAR	AIR CONTAMINATION	6
D	LAVATORY	OUT OF TOLERANCE	6
P	PITOT SYSTEM	HIGH TEMPERATURE	5
J	TAIL	HIGH TEMPERATURE	5
A	PASSENGER CABIN	N/A TO FUSELAGE	4
L	HYDRAULIC SYSTEM	AIR CONTAMINATION	4
T	FUEL TANKS	AIR CONTAMINATION	4
T	FUEL TANKS	HIGH TEMPERATURE	4
D	LAVATORY	AIR CONTAMINATION	4
G	ACM AREA	N/A TO FUSELAGE	4
C	GALLEY	OUT OF TOLERANCE	3
M	LANDING GEAR	N/A TO FUSELAGE	3
R	RADAR SYSTEM	HIGH TEMPERATURE	3
I	APU	N/A TO FUSELAGE	3

Loc	Location Text	Failure Category Text	Count
J	TAIL	AIR CONTAMINATION	3
B	COCKPIT	N/A TO FUSELAGE	2
W	WING	AIR CONTAMINATION	2
M	LANDING GEAR	OUT OF TOLERANCE	2
F	CARGO COMPT	N/A TO FUSELAGE	2
L	HYDRAULIC SYSTEM	OUT OF TOLERANCE	2
I	APU	OUT OF TOLERANCE	2
D	LAVATORY	N/A TO FUSELAGE	2
T	FUEL TANKS	OUT OF TOLERANCE	1
L	HYDRAULIC SYSTEM	HIGH TEMPERATURE	1
W	WING	OUT OF TOLERANCE	1

Primary Precautionary Procedure Crew Utilized

Primary Precautionary Procedure	Count
UNSCHED LANDING	352
EMER. DESCENT	8
ABORTED TAKEOFF	10
RETURN TO BLOCK	70
ENGINE SHUTDOWN	12
ACTIVATE FIRE EXT.	9
MANUAL O2 MASK	2
DEACTIVATE SYST/CIRCUITS	118
NONE	246
OTHER	262

Secondary Precautionary Procedure Crew Utilized

Secondary Precautionary Procedure	Count
N/A	1037
UNSCHED LANDING	7
EMER. DESCENT	3
ABORTED TAKEOFF	1
RETURN TO BLOCK	15
ENGINE SHUTDOWN	5
ACTIVATE FIRE EXT.	6
MANUAL O2 MASK	4
DEACTIVATE SYST/CIRCUITS	9
ABORTED APPROACH	1
OTHER	1

Tertiary Precautionary Procedure Crew Utilized

Tertiary Precautionary Procedure	Count
N/A	1084
DEACTIVATE SYST/CIRCUITS	2
INTENTIONAL DEPRESSURE	1
DUMP FUEL	1
OTHER	1

High Temperature Events Sorted Location and Accessibility Count

Part Location	Crew Accessibility?	Count
PASSENGER CABIN	NO	106
COCKPIT	NO	63
GALLEY	YES	28
PASSENGER CABIN	YES	26
COCKPIT	NO	24
GALLEY	NO	20
PASSENGER CABIN	NO	17
PASSENGER CABIN	NO	17
PASSENGER CABIN	YES	14
COCKPIT	NO	13
COCKPIT	YES	10
PASSENGER CABIN	YES	8
PASSENGER CABIN	N/A	5
LAVATORY	NO	5
GALLEY	NO	4
GALLEY	NO	4
COCKPIT	YES	3
GALLEY	YES	3
PASSENGER CABIN	MIN	2
COCKPIT	MIN	1
COCKPIT	NO	1
GALLEY	MIN	1
GALLEY	N/A	1
GALLEY	UNK	1
LAVATORY	MIN	1
LAVATORY	N/A	1
LAVATORY	NO	1
LAVATORY	YES	1
LAVATORY	YES	1

Tripped Circuit Breaker Resets

Report Number	Remarks
1999031200820	WHILE EN ROUTE TO YIP FROM IND, THE FLIGHT ENGINEER FOUND THE NR 1 ENGINE FIRE DETECTION CIRCUIT BREAKER HAD TRIPPED. A TTEMPTED ONE RESET, BUT THE CIRCUIT BREAKER WOULD NOT RESET. THERE WAS A BUNRING RUBBER SMELL NOTED IN THE COCKPIT. DE CLARED AN EMERGENCY INTO YIP. THE PLANE LANDED WITHOUT FURTHER INCIDENT. MAINTENANCE TRACED THE BURNING SMELL BACK TO THE CIRCUIT BREAKER. THE CIRCUIT BREAKER WAS REPLACED AND AN OPERATIONAL TEST OF THE SYSTEM WAS CARRIED OUT OK. THE AIR CRAFT WAS THEN RETURNED TO SERVICE. (M)
1999031200906	CIRCUIT BREAKER L20 POPPED, SMOKE ODOR PRESENT ON RESET. MAINTENANCE REPLACED CONVERTER 12LL, OPS CHECK GOOD.
1999051400699	[redacted] - IMMEDIATELY AFTER TAKEOFF NOTICED ELECTRICAL SMELL IN COCKPIT. SMELL WENT AWAY IN A FEW MINUTES. DURIN G CLIMB-OUT NOTICED LEFT IGNITION C/B TRIPPED. RESET C/B PER QRH, WOULD NOT RESET. GOT A BEEP NOISE AND SPARKS CAME OU T OF OVERHEAD PANEL NEAR IGNITION SWITCH. REPLACED IGNITION SWITCH. OPS CHECK NORMAL. (M)
1999081400135	[redacted]- EN ROUTE FROM PHL TO MIA, CREW REPORTED THE RIGHT PACK TEMPERATURE INDICATION READ 200 DEGREES ALL THE TIME. CREW ALSO REPORTED THE UPPER ANTI-COLLISION BEACON CIRCUIT BREAKER WAS FOUND OPEN AND WHEN AN ATTEMPT TO RESET TH E BREAKER WAS ACCOMPLISHED, THE BREAKER RE-OPENED CAUSING SMOKE TO APPEAR IN THE PASSENGER MID-CABIN. FLIGHT DIVERTED T O JAX AND LANDED WITHOUT FURTHER INCIDENT. MAINTENANCE REMOVED AND REPLACED THE RIGHT PACK TEMPERATURE BULB (P/N MS5280 34-1). OPERATIONAL CHECK OF RIGHT PACK NORMAL. MAINTENANCE DETERMINED THE SMOKE TO COME FROM A FAILED UPPER ANTI-COLLI SION BEACON. OPERATIONAL CHECK NORMAL. (X)
1999061800252	WHILE EN ROUTE, THE EMERGENCY CABIN LIGHTS ILLUMINATED EMERGENCY LIGHTS ARM AND CHARGE CIRCUIT BREAKER WAS POPPED BUT DI D RESET. REPAIRED CHAFFED WIRE ABOVE RIGHT LAV.
1999062500101	FOUND C/B FOR 2R DOOR ELECTRIC MOTOR POPPED, WOULD NOT RESET. FWD TO MCO AND PLACARD.
1999062500709	MID AND AFT CARGO C/B'S POPPED AND WOULD NOT RESET. ALSO, THE ORD LIGHTS C/B AT 3C11. THIS HAPPENED WHEN STARTING TO C LOSE CARGO DOOR FOR DEPT BOS. MTC IN PROGRESS TO REPAIR BURNT WIRING TO 2 WIRE BUNDLES IN MESC LT O/B CEILING AREA BUND LE M911 AND M915.
1999071600020	PILOT NOTED THE RIGHT LANDING LIGHT CIRCUIT BREAKER TRIPPED. PILOT RESET BREAKER AND IT TRIPPED AGAIN. INVESTIGATION R EVEALED THE RIGHT MAIN FUEL TRANSFER PUMP WAS SHORTING THIS CIRCUIT. (NOTE: BOTH THE LANDING LIGHT AND TRANSFER PUMP A RE ON THE SAME CIRCUIT). THIS PUMP SHOWS SIGNS OF ARCING AND BURN MARKS AT THE POINT THE SHIELDED POWER WIRE ENTERS THE PUMP.
1999102200848	WHILE CHECKING INOPERATIVE VIDEO ENTERTAINMENT SYSTEM PROBLEM, FOUND BUFFER BOX NR 2 AND NR 3 CIRCUIT BREAKERS POPPED. ATTEMPTED RESET RESULTED IN SPARKS IN VIDEO CLOSET BEHIND VIDEO EQUIPMENT. SUBSEQUENT INVESTIGATION UNCOVERED BURNED WI RES AT CONNECTOR P3-D9030, P3-D9032 AND P3-D9031.
1999102200780	INSTRUMENT LIGHTS FAILED. TWO MINUTES LATER, THE INSTRUMENT LIGHTS CIRCUIT BREAKER TRIPPED. PILOT RESET THE CIRCUIT BR EAKER. APPROXIMATELY FOUR MINUTES LATER, THE SMELL OF SMOKE WAS OBSERVED. AIRCRAFT WAS ON FINAL APPROACH AT THIS TIME AND SAFE LANDING WAS ACCOMPLISHED. NO EVIDENCE OF FLAME INSIDE OR AROUND LIGHT CONTROL UNIT. APPARENT INTERNAL SHORT O F CIRCUIT BOARD CAUSED ODOR OF BURNING WIRES AND SMOKE.

Tripped Circuit Breaker Resets (Cont.)

1999110500446	[redacted] - EN ROUTE FROM PHL/MSP, CAPTAIN REPORTED THE NR 2 AND NR 3 TRANSFORMER RECTIFIERS HAD TRIPPED AND THE C APTAIN'S WINDOW OVERHEAT LIGHT WAS ON. CAPTAIN RESET T/R'S, BUT THEY BOTH TRIPPED AGAIN. LOSS OF ELECTRIC TRIM, AUTOSP EED BRAKE AND RIGHT GENERATOR WAS NOTED. AN ELECTRICAL SMELL IN THE COCKPIT WAS ALSO NOTED. FLIGHT DIVERTED TO ORD AND LANDED WITHOUT FURTHER INCIDENT. NO EMERGENCY WAS DECLARED. MAINTENANCE REMOVED AND REPLACED THE NR 2 ENGINE GENERATO R FEEDER HARNESS. RAN ENGINE. OPERATIONAL CHECK NORMAL. (X)
1999110500697	LEFT COFFEEMAKER POPPED. RESETTING CENTER C/B CAUSES ARCING IN AFT COFFEEMAKER. ISOLATED PROBLEM TO NR 2 C/M IN LEFT A FT GALLEY. PULLED AND COLLARED POWER C/B FOR NR 2 C/M. FWD TO MCO AND PLACARD. C/M NASI LGW.

Smoke and Fire Events 2001

Smoke and Fire Events for 2001

In April of 2000 I presented a paper at the SAE Conference in Daytona Florida. This paper was later published by the SAE. The general conclusions of this paper were as follows:

1. There appears to be an under reporting of significant events in the FAA incident database.
2. The data in the SDR database under reports the significance of the problem.
3. There is an average of more than one unscheduled landing a day due to smoke or fire based only on SDR data.
4. There are a very high number of smoke or fire events occurring on transport category aircraft in the US and Canada.
5. Approximately 82% of the high temperature events were related to aircraft electrical systems or components.
6. In most cases the crew had limited ability to recognize or control the malfunction, or have access to the area of the malfunction.
7. SDR reports involving tripped circuit breakers being reset for systems with internal or external short circuits indicate that resets can be extremely hazardous.

Since the publication of this paper there has been numerous questions as to the whether the data was anomalous or if it is still current. To answer these questions I undertook to do another analysis of SDR data for the year 2001. The results were very similar. The following is a compilation of that analysis.

FAA SDR records produced 1093 records of smoke and fire sans duplicates for 2001. Of these events 991 actually had smoke or fire related to them. As in my earlier paper I sorted out the events with subjective descriptors as to whether the event would be considered High Temperature or Air Contamination, Crew Accessibility to the event location, and whether the component was Electrically Related or not.

4. There are a very high number of smoke or fire events occurring on transport category aircraft in the US and Canada.

The following table gives an overview of all the events. Of significant note is that there were 991 events involving “High Temperature” or “Air Contamination” in the SDR database for the 2001 year. This equates to 2.72 smoke or fire events per day. Forty-one percent of theses events were of the high temperature condition and electrically related.

2001 SDR Smoke and Fire Event Count

Electrical?	Part Condition	Count	Percentage
TRUE	HIGH TEMPERATURE	452	41%

FALSE	AIR CONTAMINATION	362	33%
FALSE	HIGH TEMPERATURE	130	12%
FALSE	N/A TO FUSELAGE	64	6%
TRUE	AIR CONTAMINATION	47	4%
TRUE	OUT OF TOLERANCE	15	1%
FALSE	OUT OF TOLERANCE	14	1%
TRUE	N/A TO FUSELAGE	9	1%
	Total	1093	100%
	High Temperature/Air Contamination	991	91%
	Duplicates (Not included above)	45	
Per day		2.72	

1. There appears to be an under reporting of significant events in the FAA incident database.

I will not be addressing this here. In the earlier paper I noted that there were only 21 reports relating to smoke or fire in the FAA Incident database when there were well over 700 in the SDR database.

2. The data in the SDR database under reports the significance of the problem.

This was my opinion based on numerous reports from operators on what the criteria they used to send in an SDR. Since this time the FAA has moved to improve SDR reporting. The jury is still out on its effectiveness.

3. There is an average of more than one unscheduled landing a day due to smoke or fire based only on SDR data.

The following table shows the precautionary procedure utilized by the crew. Of note is that 24% of the procedures were “None”. This means there was not an entry for this in the report. The Secondary and Tertiary Precautionary Procedures were not analyzed for this report. If quantified this would have increased the numbers slightly. Even with this there were 342 flight interrupts for the year, or nearly one per day due to smoke/fire/fumes. The rate for un-scheduled landings was 0.7 per day due to smoke/fire/fumes.

Flight Interrupts in Bold

Precautionary Procedure Used For All Events

Precautionary Procedure	**Count**	**Percentage**
OTHER	280	26%
NONE	267	24%
UNSCHED LANDING	**258**	24%
DEACTIVATE SYST/CIRCUITS	147	13%
RETURN TO BLOCK	**71**	6%
ENGINE SHUTDOWN	27	2%
ACTIVATE FIRE EXT.	18	2%
ABORTED TAKEOFF	**13**	1%

EMER. DESCENT	6	1%
MANUAL O2 MASK	3	0%
DUMP FUEL	2	0%
INTENTIONAL DEPRESSURE	1	0%
	1093	
Flight Interrupts	342	31%

Of greater significance is that about a third of the flight interrupts mentioned above were of a high temperature nature as depicted in the table below as a Part Condition "A". This equates to about one flight interruption with a cause suggesting a higher level of risk every three days.

5. Approximately 82% of the high temperature events were related to aircraft electrical systems or components.

As shown in the following table the numbers for 2001 are very similar with 78% of the high temperature events being related to electrical systems.

HIGH TEMPERATURE	582	
High Temp Electrically Related	452	78%
High Temp Not Electrically Related	130	22%

6. In most cases the crew had limited ability to recognize or control the malfunction, or have access to the area of the malfunction.

The determination as to whether the crew had access was first dependent on if they knew what the problem or source of the smoke/fire was. If they did not know the source or the location of the generation of the smoke/fire or this location was not accessible to the crew in-flight so they could have "No Access". If the source would allow them to isolate the generator of the smoke/fire, but they did not know the source then the control was "Possible". From the following table it can be seen that in the large majority of cases the crew had neither "Access" nor "Control" over the event. For the most part they did not know what was causing the generation of the smoke/fire.

Crew Access?	Crew Control?	Count	
N	N	701	64%
N	Y	114	10%
Y	Y	109	10%
N	POS	63	6%
N/A	N/A	42	4%
N	MIN	12	1%
MIN	N	11	1%

MIN	Y	10	1%
MIN	POS	9	1%
Y	N	5	0%
MIN	MIN	4	0%
Y	POS	4	0%
UNK	UNK	3	0%
N	UNK	2	0%
UNK	N	1	0%
N/A	Y	1	0%
Y	MIN	1	0%
N	N/A	1	0%
		1093	

7. SDR reports involving tripped circuit breakers being reset for systems with internal or external short circuits indicate that resets can be extremely hazardous.

No numerical data was collected on the earlier report as to how many times crews were resetting CBs in-flight, but the frequency seemed much too high to this investigator. Because of that conclusion, work was initiated in cooperation, with the ATSRAC and the FAA to educate the pilot force. The education process was at least a partial success. Subjectively there are less of these events, but they are still there, and with too great of a frequency. I found several instances during the reporting period where crews reset tripped CBs in-flight. In no case was the item that was being re-powered critical, or even needed, for continued flight.

Jim Shaw

Former Vice-Chairman of the ATSRAC and Manager of ALPA Inflight Fire Team

LROPS Unscheduled Landings

EROPS and Unscheduled Landings

Questions have arisen over the causes of unscheduled landings on long-range type aircraft. This study was undertaken to determine what the causes were for these unscheduled landings and to analyze what effect these causes might have on risk to Extended Range Operations (EROPS). Service difficulty reports (SDRs) were examined for 2000-2002 for the following aircraft Airbus 310 and 330, the Boeing 747, 757, 767, and 777, and the MD-11. All these aircraft are used to varying degrees in EROPS operations. Duplicate reports were removed and the remaining data was analyzed.

Disclaimer: Because of differing levels of participation of carriers in the SDR program no overall rates can be calculated from this data. Because of this the total numbers of these events can be misleading. The actual numbers must be at lease equal or greater than that indicated by SDRs. However, the rates calculated herein are an accurate assessment of the causes of unscheduled landings as expressed as a percentage instead of total numbers. It must also be noted that these rates are for the type of aircraft that are often used in EROPS, but the operation where the divert occurred was not necessarily during the EROPS portion of the flight.

EROPS flights typically operate over oceans, Polar Regions, or desolate areas for hours on end. So they have additional risk factors when the aircraft is not within a suitable range to an alternate field. This is different from most non-EROPS flights that have an alternate or emergency field readily available. So an EROPS flight must operate for extended periods of time with whatever condition that caused the crew to begin the divert.

1. The most common condition for unscheduled landings are “Warning Indications” and the most common defined cause was “Smoke”.
2. When looking only at cruise operations the percentage for “Smoke” conditions leading to an unscheduled landing was 20.3% of the events.
3. Most unscheduled landings initiating events occur during climb, but a large number, 39%, occur in cruise.
4. A majority of smoke related events occur during cruise. Fully 54% of all smoke events that cause an unscheduled landing occur during cruise.
5. During cruise operations “Smoke” is more than twice as likely to cause an unscheduled landing than an engine problem.

The most common condition for unscheduled landings are “Warning Indications” and the most common defined cause was “Smoke”.

A number of conditions will trigger a “Warning Indication” event. These numbers add up to more than 100% because of this. An example would be “Cargo Smoke”. This condition could be listed as both as “Warning Indication” and “Smoke”. An oil quantity loss could be indicated by “Fluid Loss”, “Engine Stoppage”, and “Warning Indication”. So “Warning Indication” does not by itself differentiate the actual cause of the unscheduled landing. Keeping this in mind the most common cause for unscheduled landings is “Smoke” with a 15% rate with “Fluid Loss” and “False Warning” following close behind at 12% and 11% respectively.

Total Condition Qualifications		
WARNING INDICATION	871	53%
SMOKE	238	15%
FLUID LOSS	195	12%
FALSE WARNING	180	11%
OTHER	153	9%
FLT CONT AFFECTED	99	6%
PARTIAL RPM/PWR LOSS	76	5%
VIBRATION/BUFFET	71	4%
ELECT. POWER LOSS-50 PC	40	2%
OVER TEMP	42	3%
MULTIPLE FAILURE	30	2%
ENGINE FLAMEOUT	26	2%
ENGINE STOPPAGE	28	2%
FLAME	20	1%
INFLIGHT SEPARATION	12	1%
F.O.D.	10	1%
INADEQUATE Q C	11	1%
NO WARNING INDICATION	6	0%
OTHER AFFECTED SYSTEMS	3	0%
SIGNIFICANT FAILURE REPORT	2	0%
FLT. ATTITUDE INST.	1	0%
AFFECT SYSTEMS	1	0%
ENGINE CASE PENETRATION	1	0%
SYSTEM TEST FAILURE	1	0%
Note: Adds up to greater than 100% do to multiple conditions		

It is only during cruise operations that the risk factors increase for EROPS because of their extended divert times.

When looking only at cruise operations the percentage for “Smoke” conditions leading to an unscheduled landing increases to 20.3% of the events.

Cruise Total Condition Qualifications		
WARNING INDICATION	313	48.9%
SMOKE	130	20.3%
FLUID LOSS	94	14.7%
FALSE WARNING	70	10.9%
OTHER	65	10.2%
VIBRATION/BUFFET	26	4.1%
PARTIAL RPM/PWR LOSS	26	4.1%
FLT CONT AFFECTED	28	4.4%
ELECT. POWER LOSS-50 PC	19	3.0%
MULTIPLE FAILURE	12	1.9%
ENGINE FLAMEOUT	14	2.2%
OVER TEMP	11	1.7%
ENGINE STOPPAGE	8	1.3%
INADEQUATE Q C	4	0.6%
FLAME	3	0.5%
INFLIGHT SEPARATION	2	0.3%
AFFECT SYSTEMS	1	0.2%
F.O.D.	1	0.2%
OTHER AFFECTED SYSTEMS	1	0.2%
FLT. ATTITUDE INST.	1	0.2%
AFFECT SYSTEMS	0	0.0%

Most unscheduled landings initiating events occur during climb, but a large number, 39%, occur in cruise

All Events Stage of Flight

Stage of Flight	Count		
CLIMB		826	50%
CRUISE		640	39%
NOT REPORTED		99	6%
TAKEOFF		39	2%
UNKNOWN		13	1%
APPROACH		12	1%
DESCENT		9	1%
TAXI		1	0%
		1639	

A majority of smoke related events occur during cruise. Fully 54% of all smoke events that cause an unscheduled landing occur during cruise.

The following chart shows the phase of flight where the greatest chance to have a smoke related event that results in an unscheduled landing. Surprisingly most of these events occur in cruise.

Smoke Events with Unscheduled Landings During Cruise		
Stage of Flight	Count	
CLIMB	89	38%
CRUISE	129	54%
DESCENT	2	1%
NOT REPORTED	14	6%
TAKEOFF	1	0%
UNKNOWN	2	1%
	237	

During cruise operations "Smoke" is more than twice as likely to cause an unscheduled landing than an engine problem.

Much time in risk mitigation for ETOPS (twin engine EROPS) operations have concentrated on engine failures. While this is an important issue this investigator has found that while looking at all engine related unscheduled landings versus smoke related unscheduled landings during cruise the results show that smoke is more than twice as likely to be the cause of an unscheduled landing as compared to engine problems.

Cruise Only Engine versus Smoke

SMOKE	130	20.3%
ENGINE	59	9.2%

What this suggests is that there is a real dilemma posed to crews by smoke. Current regulations only require that once the smoke generation stops that the air system be able to clear the cockpit of smoke within a preset time limit. AC25-9A admits that the regulations do not require this test to be performed. It then offers the suggestion that a continuous smoke test be employed, but caveats their suggestion with requirements that would require numerous additional performance criteria on a certifier if they were to do this test. Current regulations do not deal adequately with the problem of continuous smoke generation that often happens during the most serious of smoke and fire events such as the Swissair 111 and Valuejet accidents.

In summary, this investigator has found that the most common defined cause for unscheduled landing for EROPS type aircraft to be "Smoke" and occurs most frequently during cruise operations. "Smoke" also occurs twice as often in cruise than engine problems. With current smoke design criteria concentrating on the removal of smoke after the generation of the smoke ends, crews and passengers on EROPS aircraft are placed in the difficult position of trying to operate and survive for long periods of time in a smoke filled aircraft. Obviously the most important issue is to not allow events to occur that generate smoke, but as long as electronic equipment and flammable materials are in our transport aircraft smoke will always be a real threat to all aircraft operations, but a more significant threat to EROPS because of the time required to stay airborne before reaching an alternate field.

To mitigate these risks there are several options. First is to reduce the risk of the fire or smoke generation through more rigorous wiring and flammability standards. Next is to get the fire or smoke generation stopped as soon as possible with improvements in fire detection and suppression in inaccessible areas such as the fuselage and cockpit overheads. And finally devices to improve instrument visibility, cockpit smoke procedures, and an adequate oxygen supply so the pilots have at least a chance of completing the divert when all else fails.

Captain Jim Shaw

Bio: Captain Shaw is a long time aviation safety volunteer and activist. He is type rated on the B-707, B-737, B-757, and B-767 aircraft. He has held numerous positions as an ALPA safety volunteer: Chief Accident Investigator, head of the ALPA Inflight Fire Team, participant on the ALPA ETOPS committee, and on Flight Operations Quality Assurance teams. He has also been honored to be the Vice-Chairman of the Aging Transport Rulemaking Advisory Committee, work for a long period of time on the SWR 111 accident and has received international recognition for his aviation safety work.

NTSB Letter Jan 1, 2002

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: January 4, 2002

In reply refer to: A-01-83 through -87

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

Recent In-Flight Fires

Delta Air Lines Flight 2030

On September 17, 1999, about 2230 eastern daylight time, a McDonnell Douglas MD-88, N947DL, operated by Delta Air Lines as flight 2030, experienced an in-flight fire and made an emergency landing at the Cincinnati and Northern Kentucky International Airport in Covington, Kentucky.[1] After landing, an emergency evacuation was performed. The airplane sustained minor damage, and none of the 2 flight crewmembers, 3 flight attendants, 3 off-duty flight attendants, or 113 passengers were injured.

Shortly after takeoff, several flight attendants detected a sulphurous or “lit match” smell and reported it to the flight crew. Following the captain’s instructions, flight attendants checked the lavatories, but were unable to locate the cause of the smell. Two off-duty flight attendants retrieved Halon fire extinguishers when flight attendants noticed smoke in the forward section of the coach cabin.[2] Flight attendants reseated a passenger in row 11 to another row when he stated that his feet were hot. This individual’s carry-on bag, which had been on the floor beside him, next to the right sidewall and above the floor vent, was scorched. Flight attendants also reported seeing an orange or red, flickering glow beneath the vent at that location.

Flight attendant No. 1 went to the cockpit to inform the flight crew of these observations and asked the captain whether to spray Halon into the vent where she had seen the glow. The captain instructed her not to use the Halon extinguisher, indicating he was concerned about spraying Halon in the cabin. Meanwhile, another flight attendant had already discharged a Halon fire extinguisher into the vent and observed that the glow was no longer visible. Thereafter, the smoke began to dissipate and did not return, indicating that the fire had been extinguished by the Halon.

When flight attendant No. 1 returned from the flight deck, she became alarmed that a Halon fire extinguisher had been discharged because the captain had instructed her not to do so. During its investigation of this incident, Safety Board staff discovered that the source of the smoke in the cabin was a smoldering insulation blanket in the cargo compartment adjacent to a static port heater. Electrical arcing from the heater ignited the blanket, and the smoldering became a self-sustaining fire that grew in size.

AirTran Flight 913

On August 8, 2000, about 1544 eastern daylight time, a McDonnell Douglas DC-9-32, N838AT, operated by AirTran Airways (AirTran) as flight 913, experienced an in-flight fire and made an emergency landing at the Greensboro Piedmont-Triad International Airport in Greensboro, North Carolina.[4] An emergency evacuation was performed. The airplane was substantially damaged from the effects of fire, heat, and smoke. Of the 57 passengers and 5 crewmembers on board, 3 crewmembers and 2 passengers received minor injuries from smoke inhalation, and 8 other passengers received minor injuries during the evacuation.

Shortly after takeoff, flight attendants No. 1 and No. 2, who were seated on the forward jumpseat, both smelled smoke. Flight attendant No. 1 went to the cockpit, where she saw smoke “everywhere” and noticed that the crew had donned their oxygen masks. The captain told her that they were returning to Greensboro. She closed the cockpit door and returned to the cabin. She and flight attendant No. 2 reseated themselves in empty seats in business class because of the rapidly accumulating smoke in the galley area around their jumpseats.

Flight attendant No. 1 reported that the smoke became so dense she could no longer see the forward galley. However, neither flight attendant made any effort to locate the source of the smoke or to use any of the firefighting equipment available to them. Flight attendant No. 1 saw a large amount of electrical “arcing and sparking” and heard “popping noises” at the front of the cabin. She told investigators that she “debated whether to use the Halon” fire extinguisher but was unsure where to aim it. She decided not to use the Halon fire extinguisher because she “did not see a fire to fight.” As discussed later in this letter, AirTran’s flight attendant training program does not include any drill involving hidden fires but does include a drill that uses a visible, open flame. An off-duty AirTran pilot seated in first class considered using a Halon fire extinguisher but decided against it because he was concerned that the Halon “would take away more oxygen.”

The Safety Board investigation of this accident is ongoing, but preliminary findings indicate that the smoke in the forward cabin was caused by electrical arcing in the bulkhead behind the captain’s seat. The arcing ignited interior panels, which continued burning after the airplane landed and the passengers were evacuated. The fire was eventually extinguished by airport rescue and firefighting personnel.

American Airlines Flight 1683

On November 29, 2000, about 1753 eastern standard time, a McDonnell Douglas DC-9-82 (MD-80), N3507A, operated by American Airlines as flight 1683, was struck by lightning and experienced an in-flight fire that began shortly after takeoff from Reagan National Airport in Washington, D.C.[5] The flight crew performed an emergency landing and ordered a passenger evacuation at Dulles International Airport. The airplane sustained minor damage. None of the 2 pilots, 3 flight attendants, or 61 passengers were injured.

After takeoff, the three flight attendants saw a flash of light and heard a boom on the right side of the airplane. Flight attendant No. 1, who was seated on the forward jumpseat, saw white smoke coming from a fluorescent light fixture in the forward entry area. She shut the light off and called the cockpit. The captain told her to “pull the breaker” for the fluorescent light. She pulled the circuit breaker, and smoke stopped coming out of the fixture.

When flight attendant No. 1 went aft to check on the passengers, she observed "dark, dense, black" smoke coming from the ceiling panels above rows 7 and 8. She went to the cockpit and notified the flight crew while the other two flight attendants retrieved Halon fire extinguishers and brought them to the area near rows 7 and 8. The smoke detectors in the aft lavatories sounded. The smoke worsened in the midcabin area, and a ceiling panel above row 9 began to blister and turn yellow.

A flight attendant began discharging a Halon extinguisher toward the blistered ceiling panel. Flight attendant No. 1 asked the passengers if anyone had a knife that could be used to cut the ceiling panel. A passenger produced a knife and cut a circular hole in the blistered area of the ceiling panel. Flight attendant No. 1 then fully discharged a Halon fire extinguisher into the hole, assessed the results, and found that the smoke appeared to be diminishing. Before taking her seat for the emergency landing, another flight attendant gave the passenger in seat 9E a Halon fire extinguisher, instructed him on its use, and told him to "use it if it was needed." However, the smoke did not recur.

The Safety Board investigation of this incident is ongoing, but preliminary findings indicate that a lightning strike caused arcing in the airplane wiring above the cabin ceiling panels, which ignited adjacent materials.

1983 In-Flight Fire on Air Canada Flight 797

On June 2, 1983, about 1920 eastern daylight time, a McDonnell Douglas DC-9, C-FTLU, operated by Air Canada as flight 797, experienced an in-flight fire and made an emergency landing at the Greater Cincinnati International Airport (since renamed Cincinnati and Northern Kentucky International Airport) in Covington, Kentucky.[6] The fire was initially detected when a passenger noticed a strange smell and a flight attendant saw smoke in one of the lavatories. Another flight attendant saw that the smoke was coming from the seams between the walls and ceiling in the lavatory. Although neither flight attendant saw any flames, the second flight attendant discharged a CO_2 fire extinguisher into the lavatory, aiming at the paneling and seams and at the trash bin. He then closed the door. When the first officer came back to assess the situation, he found that the lavatory door was hot, and he instructed the flight attendants not to open it. The first officer then informed the captain that they "better go down," and an emergency descent was initiated.

During the descent, the smoke increased and moved forward in the cabin. After the airplane landed, flight attendants initiated an emergency evacuation. Of the 41 passengers and 5 crewmembers on board, 23 passengers were unable to evacuate and died in the fire. The airplane was destroyed.

In its final report, the Safety Board determined that the flight attendant's discharge of fire extinguishing agent into the lavatory "had little or no effect on the fire," noting that "[i]n order for the extinguishing agent to be effective, it must be applied to the base of the flames." The Board determined that the probable cause of the accident was "a fire of undetermined origin, an underestimate of fire severity, and conflicting fire progress information provided to the captain. Contributing to the severity of the accident was the flight crew's delayed decision to institute an emergency descent."[7]

As a result of the Air Canada accident, the Safety Board issued several recommendations to the Federal Aviation Administration (FAA), including Safety Recommendation A-83-70, which asked the FAA to expedite actions to require smoke detectors in lavatories; Safety Recommendation A-83-71, which asked the FAA to require the installation of automatic fire extinguishers adjacent to and in lavatory waste receptacles; and Safety Recommendation A-83-72, which asked the FAA to require that the hand-operated fire extinguishers carried aboard transport category airplanes use a technologically advanced agent, such as Halon.

Recommendations A-83-70 and -72 were classified "Closed – Acceptable Action" and A-83-71 was classified "Closed – Acceptable Alternate Action" on January 15, 1986, after the FAA completed rulemaking to require that all airplanes operated under 14 *Code of Federal Regulations* (CFR) Part 121 be equipped as follows: each lavatory and galley has a smoke or fire detector system that provides a warning light in the cockpit or an audio warning in the passenger cabin that would be readily detected by the flight attendant; each lavatory trash receptacle is equipped with a fire extinguisher that discharges automatically if a fire occurs in the receptacle; and, of the required hand-held fire extinguishers installed in the airplane, at least two contain Halon 1211 or equivalent as the extinguishing agent.

In its final report on the Air Canada accident, the Safety Board also issued Safety Recommendation A-84-76, which recommended that the FAA:

Require that air carrier principal operations inspectors [POIs] review the training programs of their respective carriers and if necessary specify that they be amended to emphasize requirements: for flight crews to take immediate and aggressive action to determine the source and severity of any reported cabin fire and to begin an emergency descent for landing or ditching if the source and severity of the fire are not positively and quickly determined or if immediate extinction is not assured; for flight attendants to recognize the urgency of informing flight crews of the location, source, and severity of fire or smoke within the cabin; for both flight crews and flight attendants to be knowledgeable of the proper methods of aggressively attacking a cabin fire by including hands-on-training in the donning of protective breathing equipment, the use of the fire ax to gain access to the source of the fire through interior panels which can be penetrated without risk to essential aircraft components, and the discharge of an appropriate hand fire extinguisher on an actual fire.

In its November 2, 1984, response to the Safety Board, the FAA explained that 14 CFR 121.417 required crewmembers to be trained for fire emergencies and further required them to perform emergency drills and "actually operate the emergency equipment during initial and recurrent training for each type aircraft in which the crewmember is to serve." The FAA concluded that the regulations were adequate, stating that "the safety record of U.S. carriers is a testimony to the adequacy of the current regulations." In its April 12, 1985, letter, the Board disagreed, stating that "current firefighting training is directed primarily toward 'exposed' fires which are relatively easy to control. This does not prepare crews to assess effectively the hazard of or to fight hidden fires." The Board also reiterated its belief that crew training programs should emphasize that if the source of a fire cannot be immediately identified or cannot be extinguished immediately, the aircraft should be landed immediately. In its March 7, 1986, letter, the FAA responded that "due to requirements of 14 CFR 121.417, the various Air Carrier Operations Bulletins (ACOBs), and the guidance in the Air Carrier Operations Inspector's Handbook,"[8] further action by the FAA was unwarranted. The Safety Board disagreed and on May 12, 1986, classified Safety Recommendation A-84-76 "Closed – Unacceptable Action," stating that, "[a]lthough we have closed this recommendation, our concern for the safety issue involved has not diminished and we will continue to voice our concern in future accident investigations."

The Safety Board recognizes that the FAA's response to the Air Canada recommendations resulted in some changes that improved aircraft fire safety; in particular, requirements for smoke detectors and Halon-type fire extinguishers have provided crewmembers with better methods of locating and suppressing fires. However, the recent in-flight fires cited in this letter renew the Safety Board's interest in this issue and its concern that the FAA has not issued additional advisory material emphasizing the importance of training crewmembers to recognize, locate, and fight hidden fires on airplanes.

Safety Issues

Training

Title 14 CFR 121.417 requires that crewmembers receive training on firefighting equipment and procedures for fighting in-flight fires. The regulation specifies that airlines must provide individual instruction on, among other things, the location, function, and operation of portable fire extinguishers, with emphasis on the type of extinguisher to be used for different classes of fires and instruction on handling emergency situations, including fires that occur in flight or on the ground. As part of their initial training, each crewmember must accomplish a one-time emergency drill while fighting an actual fire[9] using the type of fire extinguisher that is appropriate for the type of fire being demonstrated in the drill.

Although 14 CFR 121.417 also requires crewmembers to perform certain drills biannually during recurrent training, including one that demonstrates their ability to operate each type of hand-operated fire extinguisher found on their airplanes, the regulation does not require recurrent training in fighting an actual or simulated fire. As a result, crewmembers are required to fight an actual or simulated fire during initial training only.

Further, although the emergency training requirements specified in 14 CFR 121.417 require instruction in fighting in-flight fires, they do not explicitly require that crewmembers be trained to identify the location of a hidden fire or to know how to gain access to the area behind interior panels. The Safety Board has evaluated the firefighting training programs of several air carriers and found that the actual "fire" crewmembers fight during initial training is typically an open flame that requires little effort to extinguish and that does not demonstrate the problems inherent in fighting a hidden fire on an airplane. AirTran's initial training program for flight attendants, for example, includes a firefighting drill in which students are required to extinguish an actual fire consisting of a visible, open flame. The accident and incident descriptions in this letter demonstrate that in-flight fires on commercial airplanes can present themselves not as visible, localized flames, but in less obvious ways, such as smoke or heat from hidden locations. Crewmembers must be trained to quickly identify the location of the fire, which may require removing interior panels or otherwise accessing the areas behind the panels before they can use fire extinguishers effectively.

The results of a series of experiments conducted by the FAA Technical Center[10] to evaluate the ability of flight attendants to extinguish cargo fires in small Class B cargo compartments also demonstrate that the FAA's current training requirements are inadequate. Technical Center staff conducted 13 tests in which trained crewmembers attempted to extinguish cargo fires located in a cabin-level compartment using firefighting equipment identical to the types on which they had been trained. The report noted that, although the fires could have been extinguished using proper techniques, in most cases the crewmembers did not act quickly or aggressively enough to successfully extinguish the fires. The report concludes that "improved and more realistic training procedures would better prepare flight attendants to more effectively fight in-flight fires."

The Safety Board is concerned that as a result of limited training, crewmembers may fail to take immediate and aggressive action in locating and fighting in-flight fires, as demonstrated in the events cited in this letter. In the Delta flight 2030 incident, the flight attendant asked for the captain's permission before discharging a fire extinguisher. This delayed an immediate firefighting response. Further, if the captain's order not to use the fire extinguisher had been carried out, the fire would likely have progressed and could have resulted in death or serious injury, as well as possible loss of the airplane. In the AirTran flight 913 accident, flight attendants made no effort to locate the source of the smoke or to use any of the firefighting equipment available to them. In the American flight 1683 incident, a flight attendant, working with a passenger, successfully extinguished the fire by cutting a hole in the overhead panel and applying extinguishing agent. Although this action was successful, the Board notes that the flight attendant took the action on her own initiative, not because she was trained to do so. In the Air Canada accident, flight attendants did not apply extinguishing agent directly to the flames, either because they had not been trained to do so or because they could not access the area behind the interior panels.

The Safety Board concludes that current training programs still do not adequately prepare crewmembers to fight the type of hidden in-flight fires likely to occur on airplanes. Therefore, the Board believes that the FAA should issue an advisory circular (AC) that describes the need for crewmembers to take immediate and aggressive action in response to signs of an in-flight fire. The AC should stress that fires often are hidden behind interior panels and therefore may require a crewmember to remove or otherwise gain access to the area behind interior panels in order to effectively apply extinguishing agents to the source of the fire. Further, the Board believes that the FAA should require POIs to ensure that the contents of the AC are incorporated into crewmember training programs. Finally, the Board believes that the FAA should amend 14 CFR 121.417 to require participation in firefighting drills that involve actual or simulated fires during crewmember recurrent training and to require that those drills include realistic scenarios on recognizing potential signs of, locating, and fighting hidden fires.

Access to Areas Behind Interior Panels

The Safety Board is also concerned that the interior panels of airplanes are not designed so that crewmembers are able to easily and quickly locate and extinguish hidden in-flight fires. The Board addressed this problem in 1983 after the Air Canada accident, in which one flight attendant discharged a CO_2 extinguisher into the lavatory, aiming at the seams between the walls and the ceiling where smoke had been observed. The Board found that this action had little effect on the fire because the extinguishing agent was not applied to the source of the fire. In the American incident, the flight attendant did access the area behind the ceiling panel, but the method used (that is, having a passenger cut a hole in the ceiling) risked damage to electrical wiring and other cables that may have been covered by the paneling. In addition, although the flight attendant's action successfully extinguished the fire, access to the area behind the panel should not have been dependent on the actions of a passenger, either to provide a sharp instrument for cutting or to cut the hole itself.

Therefore, the Safety Board believes that the FAA should develop and require implementation of procedures or airplane modifications that will provide the most effective means for crewmembers to gain access to areas behind interior panels for the purpose of applying extinguishing agent to hidden fires. As part of this effort, the FAA should evaluate the feasibility of equipping interior panels of new and existing airplanes with ports, access panels, or some other means to apply extinguishing agent behind interior panels.

Properties of Halon and the Merits of Halon Extinguishers in Fighting In-Flight Fires

The Safety Board is concerned that, in two of the occurrences described in this letter, crewmembers hesitated to use Halon extinguishers. In the Delta incident, the captain specifically ordered a flight attendant not to use the Halon extinguisher because he was concerned about Halon being sprayed in the cabin. In the AirTran accident, an off-duty crewmember chose not to use the Halon extinguisher because of his concern that it "would take away more oxygen" from the cabin.

FAA AC 20-42C, *Hand Fire Extinguishers for Use in Aircraft*, states that Halon-type extinguishers are three times as effective as CO_2 extinguishers with the same weight of extinguishing agent, have a gaseous discharge and therefore a more limited throw range, leave no chemical residue to contaminate or corrode aircraft parts or surfaces, have fewer adverse effects on electronic equipment, and do not degrade visual acuity. However, AC 20-42C also states the following:

> Tests indicate that human exposure to high levels of Halon vapors may result in dizziness, impaired coordination, and reduced mental sharpness. . . . Exposure to undecomposed halogenated agents may produce varied central nervous system effects depending upon exposure concentration and time. Halogenated agents will also decompose into more toxic products when subjected to flame or hot surfaces at approximately 900º F (482º C). However, unnecessary exposure of personnel to either the natural agent or to the decomposition products should be avoided.

The AC also specifies maximum concentration levels for Halon agents under various conditions that should not be exceeded in ventilated and non-ventilated passenger compartments on aircraft. It appears that air carrier training programs may not be placing enough emphasis on the importance of using Halon extinguishers to fight in-flight fires and may not make it clear that the maximum allowable levels of Halon vapors cannot be achieved by discharging a single handheld extinguisher in a transport-sized cabin.

Although the AC also states, “generally, the decomposition products from the fire itself, especially carbon monoxide, smoke, heat, and oxygen depletion, create a greater hazard than the thermal decomposition products from Halon,” the Safety Board is concerned that the potential hazards posed by Halon gas are over-emphasized in the AC, especially when compared to the potentially devastating effects of an in-flight fire. Indeed, the statement quoted above is buried in the paragraph warning against exposure to Halon gas.

The Safety Board therefore believes that the FAA should issue a flight standards handbook bulletin to POIs to ensure that air carrier training programs explain the properties of Halon and emphasize that the potential harmful effects on passengers and crew are negligible compared to the safety benefits achieved by fighting in-flight fires aggressively.
Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Issue an advisory circular (AC) that describes the need for crewmembers to take immediate and aggressive action in response to signs of an in-flight fire. The AC should stress that fires often are hidden behind interior panels and therefore may require a crewmember to remove or otherwise gain access to the area behind interior panels in order to effectively apply extinguishing agents to the source of the fire. (A-01-83)
Require principal operations inspectors to ensure that the contents of the advisory circular (recommended in A-01-83) are incorporated into crewmember training programs. (A-01-84)
Amend 14 *Code of Federal Regulations* 121.417 to require participation in firefighting drills that involve actual or simulated fires during crewmember recurrent training and to require that those drills include realistic scenarios on recognizing potential signs of, locating, and fighting hidden fires. (A-01-85)
Develop and require implementation of procedures or airplane modifications that will provide the most effective means for crewmembers to gain access to areas behind interior panels for the purpose of applying extinguishing agent to hidden fires. As part of this effort, the FAA should evaluate the feasibility of equipping interior panels of new and existing airplanes with ports, access panels, or some other means to apply extinguishing agent behind interior panels. (A-01-86)
Issue a flight standards handbook bulletin to principal operations inspectors to ensure that air carrier training programs explain the properties of Halon and emphasize that the potential harmful effects on passengers and crew are negligible compared to the safety benefits achieved by fighting in-flight fires aggressively. (A-01-87)

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred with these recommendations.

By: Marion C. Blakey
Chairman
Original Signed

1 The description for this accident, NYC99IA231, can be found on the Safety Board’s Web site at <http://www.ntsb.gov>.

2 In comparison, on March 17, 1991, a Delta Air Lines L-1011 experienced a fire below the aft cabin floor that produced visible flames in the cabin. According to an August 14, 1991, Safety Board letter, "a flight attendant promptly discharged a Halon fire extinguisher into an opening in the base of the sidewall from which the flames appeared to originate. The fire was extinguished and a precautionary landing was made at Goose Bay."

3 As a result of this incident, on February 6, 2001, the Safety Board issued to the FAA three recommendations (A-01-003, A-01-004, and A-01-005) regarding the inspection and design of static port heaters and the possible replacement of existing insulation blankets with an alternate that would be less likely to propagate a fire. The FAA response is currently under Safety Board review.

4 The description for this accident, DCA00MA079, can be found on the Safety Board’s Web site at <http://www.ntsb.gov>.

5 The description for this accident, IAD01IA017, can be found on the Safety Board’s Web site at <http://www.ntsb.gov>.

6 The description for this accident, DCA83AA028, can be found on the Safety Board’s Web site at <http://www.ntsb.gov>.

7 National Transportation Safety Board, *Air Canada Flight 797, McDonnell Douglas DC-9-32, C-FTLU, Greater Cincinnati International Airport, Covington, Kentucky, June 2, 1983,* Aircraft Accident Report NTSB/AAR-84/09 (Washington, D.C.: NTSB, 1984).

8 See FAA Order 8430.6, *Air Carrier Operations Inspector’s Handbook*.

9 Title 14 CFR 121.417 provides a definition of an actual fire: “An *actual fire* means an ignited combustible material, in controlled conditions, of sufficient magnitude and duration to accomplish the training objectives.”

10 See U.S. Department of Transportation, Federal Aviation Administration, *Effectiveness of Flight Attendants Attempting to Extinguish Fires in an Accessible Cargo Compartment*, DOT/FAA/AR-TN99/29 (April 1999).

NTSB A97-61 Value Jet 592

NTSB RECOMMENDATIONS TO FAA

Data Source: NTSB Recommendations to FAA and FAA Responses
Report No: A-97-61
Subject: VALUJET/EVERGLADES
Letter Date:07/23/1999

[O]

On May 11, 1996, a McDonnell Douglas DC-9-32, N904VJ, crashed into the Everglades swamp shortly after takeoff from Miami International Airport, Miami, Florida. The airplane was operated by ValuJet Airlines, Inc., as ValuJet Flight 592.

[Recommendations]

A-97-61. Evaluate the cockpit emergency vision technology and take action as appropriate.

MBA report – Smoke Elimination

MORTEN BEYER & AGNEW

AVIATION CONSULTING FIRM

2107 WILSON BOULEVARD
SUITE 750
ARLINGTON, VA 22201

Washington, D.C.

2107 Wilson Blvd.

Suite 750

Arlington, Virginia 22201

United States

Phone +703 276 3200

Fax +703 276 3201

Europe

12/14 Rond Point des Champs Elysees

Paris 75008

France

Phone +33 1 5353-1664

Fax +33 1 5353-1400

Pacific Rim

3-16-16 Higashiooi

Shinagawa-ku

Tokyo 140-0011

Japan

Phone +81 3 3763 6845

EXECUTIVE SUMMARY

MORTEN BEYER & AGNEW's (MBA) mission is to analyze those events that occur on a frequent basis with a high potential for the catastrophic loss of an aircraft. In this report MBA assess the smoke elimination procedures in transport category aircraft and comments on the adequacy of the standards, systems, and procedures. The assessment was led by L. Nick Lacey, former head of the Federal Aviation Administration (FAA), Flight Standards Service and an experienced pilot, and Niels Brix Andersen, who has an extensive background in airline flight deck technology and is an Aeronautical Engineer.

The FAA, National Aeronautics and Space Administration, Department of Defense, trade organizations, manufacturers, and airlines, along with many organizations with an interest in aviation safety have done research, established standards, and developed procedures for coping with in-flight fires. Our approach was to review the work of these organizations to see if cost effective safety benefits can be gained through the application of current smoke displacement technology, an alteration of design philosophy, or improved operational training and procedures.

- We have found that in-flight smoke and fires continue to occur largely in inaccessible areas and compartments of transport aircraft, leading to unscheduled landings and, in some situations, have been a primary causal factor leading to the loss of an aircraft.

- We have found that actions by regulatory agencies and manufacturers to prevent, detect, and suppress various types of in-flight fires are in most instances effective; however, much remains to be done.

- We have found that transport category aircraft certification procedures DO NOT require the manufacturer to test for smoke dispersal and evacuation during CONTINUOUS dense smoke.

- Fires can rapidly progress to a level of serious aircraft damage and/or system impairment before aircrew reaction for detection and suppression. Fire Detection is only provided for engines, lavatories, and cargo compartments, yet avionics bays, flight deck center instrument consoles, instrument panels, and the passenger cabins do not have detection and/or automatic suppression capability. Fire and smoke can also occur in difficult to access areas such as wire harnesses, circuit breaker panels, electrical motors, and in aircraft insulation.

- We found that existing flight deck smoke elimination procedures can be effective, but they are convoluted and depend upon precise identification of the source of the fire by the entire flight crew—unfortunately, the crews are very often hindered by a serious inability to precisely detect the location and cause of the smoke.

- Currently, aircrew training does not provide flight crews with sufficient training and simulator "experience" in the identification, elimination, and suppression of smoke and fires; therefore, the subsequent actual in-fight decision-making has resulted in errors which in many cases have led to accidents.

- We have found that aircrew responses to in-flight fires in some events do not follow established procedures and often lack a sense of urgency, resulting in smoke migration, confusion, and occasional conflagrations with catastrophic results.

- The time taken for fire identification and suppression, while simultaneously maneuvering to land the aircraft (on the order of about 15-30 minutes), can result in obscured pilot vision inside and outside of the flight deck; thereby, greatly increasing the risks of a serious degradation in situational awareness, communications, and crew coordination.

- We concluded that a significant redesign of aircraft electrical systems, ventilation systems, fire detection, and suppression systems or the certification methods is not likely to be undertaken by regulatory agencies in the foreseeable future. (Efforts are now focused on preventative maintenance practices, wiring insulation, and circuit protection.)

- We believe it would always be in an air carrier's interests to discuss with and seek guidance from the aircraft manufacturer for the anticipated flight deck conditions under circumstances of continuous smoke on the flight deck before the aircraft type is introduced into operation, as well as to seek assistance from the manufacturer in developing effective emergency procedures for fire and smoke for all phases of flight, including polar and oceanic routes.

Overall, MBA believes that responsible air carriers should take a proactive approach to safety by formally and systematically analyzing events that could lead to a catastrophic loss and assessing the benefits of cost effective technologies, training, and procedural interventions. Our team believes that this report brings together data and ideas in a form that offers value to those airlines that wish to advance aviation safety–to do otherwise is to abrogate responsibility for safety to the "wisdom" of federal regulators.

In-Flight Fire and Smoke Events Statistical Information and Expert Judgments

Some accidents represent scenarios that continue to occur repeatedly in airline operations. We calculate from current safety reporting channels that the industry experiences over 1,000 in-flight smoke events a year, which averages out to more than three events a day. The industry also experiences over 350 unscheduled landings due to in-flight smoke or fire. The estimated rates of occurrence are as follows:

In-flight smoke events:	1 in 5,000 flights
In flight smoke diversions:	1 in 15,000 flights

An analysis done in 1999 by Captain Jim Shaw for the Airline Pilots Association shows that approximately 80% of the smoke or fire events were related to electrical systems or components. According to Paul Halfpenny, an engineer with 33 years experience with Lockheed aircraft in the design and testing of aircraft systems concludes that the probability of a fire that creates smoke dense enough to obscure pilot vision in the cockpit is not high; however, "the probability is there and it must be considered. The results of loss of visual acuity by the crew can be disastrous as shown in the Air Canada, Varig, and ValueJet accidents." It is the combination of the frequency of in-flight fires and the "potential" for disastrous consequences that we are concerned with in this analysis.

Aircraft Environmental Systems

The design principles of aircraft environmental systems in jet aircraft have not changed since the mid 1960s--they are designed to create an artificial environment within the cabin of the aircraft to achieve a balanced, healthy, fresh airflow to maintain the cabin altitude at a level where supplemental breathing equipment is not required and at a comfortable temperature. The designs of most such installations provide the flight deck with additional airflow to compensate for the heat generated by the electronics equipment, greenhouse effects of the windshield, and to evacuate smoke and fumes if and when detected.

The air flowing into the aircraft interior is sourced from the compressors of the engines. Before it flows into the cabin, it is processed through air-conditioning units called "Packs" (air-conditioning packages), which combine the required proportions of hot and cold air to obtain the desired air temperature to be delivered to the aircraft cabin interior.

Controlling the rate of airflow through cabin areas and flight deck to maintain the desired cabin altitude is crucially important. Pressure within the cabin is maintained by controlling the flow of air out from the cabin through the valves referred to as the “outflow valves”. The flight deck crew controls the positions of the outflow valves by setting the desired cabin altitude and rate of climb/descend altitude controller.

In the current generation of two-pilot aircraft, the operation of the entire environmental system is highly automated, and is designed to recirculate cabin air to save fuel by reducing the demand for engine bleed air. For example, the B747-400 can recirculate up to 50% of air supplied to the cockpit. In this type of recirculating installation, the environmental systems can be come a source of flight deck smoke.

Smoke Elimination Procedures for Transport Category Aircraft

The basic pilot actions for smoke and fumes removal are universal for all transport category aircraft, regardless of aircraft manufacturer or airline:

- Fly the Airplane
- Confirm the Emergency
- Oxygen Masks “On” and Oxygen Regulators to “100%”
- Establish Crew Communications
- Smoke Goggles (if required)

These steps are then followed by further specific checklist procedures designed to ventilate the cockpit, eliminate the source of the smoke, and/or suppress the fire. For example, if the pilots conclude that the smoke source is electrical, they would accomplish the Electrical System Fire/Smoke/Fumes checklist. If they believe the source is the air-conditioning system, then they would accomplish the Air Conditioning Smoke checklist. A galley fire would require the use of another checklist, and so on.

If the smoke source cannot be determined, the pilots would then accomplish the generic checklist--the Smoke Removal checklist. This checklist sets the environmental systems for maximum flight deck ventilation, followed by a descent to an altitude where the aircraft can be safely depressurized–below 10,000 feet for passenger aircraft (25,000 feet for cargo).

If the smoke persists, the crew would proceed to LAND AT THE NEAREST SUITABLE AIRPORT. Unfortunately, it is under this set of circumstances–unidentified (or misidentified) source of smoke-that crews have found themselves in circumstances leading to disaster. There have also been fire and smoke situations that unfolded so rapidly that the flight crew never got beyond the "fly the aircraft step."

Flight Crew Training

Pilot training for smoke in the cockpit is limited to a classroom or computer-based study of the bleed air and air conditioning systems. The crews practice the emergency procedures in the simulator by accomplishing the checklist actions while flying the aircraft. During these simulator sessions, pilots are never exposed to the actual smoke or to the migration patterns they are likely to experience, nor are they required to deal with potential compound emergencies–such as a cargo bay explosion–that caused not only a rapid decompression, but also a partial electrical and instrumentation failure, along with smoke emanating from multiple sources.

While it would be impossible to train for every combination of in-flight emergencies, it is our opinion that dense smoke could accompany many such situations that may be survivable–if the pilots are able to see well enough to continue to fly the aircraft:

- Detonation of an Explosive Device
- Uncontained Engine Failures
- Mid-Air collision
- Wheel-Well Explosion
- Missile Attack
- Smoke Used to Commandeer an Aircraft During a Hijacking
- Sabotage of the Aircraft Environmental Systems

- Hazardous Cargo or Baggage
- Countless Sources of Electrical Malfunctions

We have first hand experience with the United States Air Force (USAF) simulator training for in-flight fires on tanker and transport aircraft. Because of its combat mission, the USAF takes the training of pilots in a "dense smoke" environment to a higher level of realism. For example, the USAF simulator training routinely puts crews through a cockpit electrical fire situation during a descent into a mountainous area. As the USAF crews accomplish their electrical fire checklist, they inevitably would become over-tasked and begin to make serious navigation and procedural errors or bungle the crew coordination necessary to combat the fire. We believe airline flight crews could benefit from guided discussions of some of these scenarios during their classroom and simulator training.

Flight Crew Response to Actual Smoke Emergencies

Established procedures and training cannot guarantee that crews will always act in accordance with what they have been taught. Systems are not infallible–sensors fail, systems generate nuisance alerts, and the logic imbedded in software may not adequately respond to all conditions that may occur in flight. Pilots sometimes miss warning signals, misinterpret data, or choose the course of action, which, in retrospect, appears to have been incorrect.

Pan Am B707 Freighter

An event that brought attention to the problem of smoke and fumes happened in the 1970s on a Pan Am 707-321C freighter enroute to Europe from JFK. The crew declared an emergency somewhere over Maine or New Hampshire with an uncontrolled fire and resultant smoke on the flight deck. The crew attempted to make an emergency landing at Logan Airport, but crashed on final approach. Among other things, in an attempt to gain cockpit visibility during the approach, the crew opened the cockpit windows, which only made visibility on the flight deck worse, ending in the loss of the aircraft and crew. This accident led to the development of procedures for dealing with continuous cockpit smoke.

Air Canada DC-9

A cabin fire forced the flight crew to make an emergency landing on June 2, 1983, at the Greater Cincinnati Airport. The interior materials of the airplane's cabin continued to burn after the landing. Five crew members and 18 passengers were able to evacuate the burning cabin; the remaining 23 passengers died in the fire. As a result of its investigation of that accident, the Safety Board issued Safety Recommendation A-83-77 on October 31, 1983. The safety recommendation asked the FAA to do the following: **Evaluate and change as necessary the procedures contained in the FAA-approved Airplane Flight Manuals (AFM) of transport category airplanes relating to the control and removal of smoke to assure that these procedures address a continuing smoke source and are explicit with regard to the presence of fire and the optimum use of cabin pressurization and air-conditioning systems.**

Valujet Flight 592

Valujet's Flight 592 crashed during an uncontrolled descent from 10,000 feet. Shortly after takeoff, the first officer radioed Miami Approach and requested an immediate return to the airport because of "smoke in the cockpit, smoke in the cabin."

The National Transportation Safety Investigation showed that an intense in-flight fire in the forward cargo compartment was caused by more than 100 expired, but still active, chemical oxygen generators that had been improperly prepared and loaded as cargo.

Among the 27 recommendations issued in the final report, one urged the FAA to expedite rulemaking to require smoke detection and fire suppression in all Class D cargo containers. Other recommendations addressed equipment; training, and procedures for handling in-flight smoke and fire aboard air carrier airplanes, including recommendation **A-97-61 to evaluate the cockpit emergency vision technology and take action as appropriate.**

Transport Safety Board Canada Summary of Swiss Air Flight 111

Swissair Flight 111, a McDonnell Douglas MD-11 aircraft, departed JFK Airport, New York, en route to Geneva, Switzerland. Approximately 53 minutes after take-off, as the aircraft was cruising at Flight Level 330, the crew noticed an unusual smell in the cockpit. Within about three and a half minutes, the flight crew noted visible smoke and advised the air traffic services controller of smoke in the cockpit. While the aircraft was maneuvering in preparation for landing, the crew advised air traffic that they had to land immediately, and that they were declaring an emergency. A short time later, the aircraft struck the water near Peggy's Cove, Nova Scotia, fatally injuring all 229 occupants.

The investigation has revealed heat damage consistent with a fire in the ceiling area about one meter forward and several meters aft of the bulkhead that separates the cockpit flight deck from the cabin area. Numerous wires from this area exhibit charring and burnt insulation. Seventeen examples of arcing damage have been found to date. It has not been determined whether the arcing was the origin of the heat that resulted in the fire or whether arcing was the secondary result of a fire that originated elsewhere and damaged the wiring insulation to the extent that arcing occurred. The source and fuel for the fire are still being evaluated. One significant source of the materials that propagated the fire was the thermal acoustical insulation blanket material.

Aircraft Certification Process and Standards

The FAA is responsible to ensure the safety of transport category aircraft. Each aircraft goes through a type certification process, which makes sure that each new type of aircraft complies with the design standards and production requirements of *FAR Part 25, Airworthiness Standards for Transport Category Airplanes.*

FAR Part 25.1309 Equipment, Systems and Installations governs many, if not most, design features of modern transport airplanes. It requires aircraft to be designed “so that the occurrence of any failure condition which would prevent the continued safe flight and landing becomes extremely improbable.” According to Hugh Waterman, an expert on

FAA Certification standard, an “extremely improbable” event is not expected to happen during the entire lifetime of all airplanes of a type. Another measure of that time interval is 1x10-9, or once in a billion flight hours. Thus you could argue that the entire fleet has not yet flown enough flights to warrant the first catastrophic accident due to fire/smoke in the cockpit, per the regulations. Waterman, however, goes on to point out that Boeing alone had lost at least seven jets where “smoke in the cockpit” was the suspected cause.

Among other things, FAR Part 25, section 831, provides broad “standards” for smoke detection, suppression, and evacuation.

> If accumulation of hazardous quantities of smoke in the cockpit area is reasonably probable, smoke evacuation must be readily accomplished, starting with full pressurization and without depressurizing beyond safe limits.

In addition to the regulations, the FAA provides the industry with advisory material in the form of circulars, notices, and bulletins, which provide detailed guidance on procedures for complying with the rules. *Advisory Circular 25-9A Smoke Detection, Penetration, and Evacuation Tests and Related Flight Manual Emergency Procedures* of January 1994 provides guidance for the conduct of test procedures for testing the ability of the emergency fire and smoke procedures to clear the flight deck of smoke.

- Fires in inaccessible areas (e.g., equipment bays, Class C cargo compartments) should be assumed to be continuous; e.g., capable of continuously generating products of combustion. The adequacy of smoke control and containment means should be demonstrated during airplane flight tests.

- During testing of and certification for an aircraft’s ability to remove dense smoke, the FAA guidance says, “smoke generation should be terminated.” Once the instruments are obscured, the smoke evacuation procedure should restore visibility within three minutes–a long time to fly an airplane without reference to the instruments or the horizon.

- The possibility of continuous smoke is addressed by the FAA as follows: "Although not mandatory, if the applicant wishes to demonstrate protection from smoke generated by a continuous source in the cockpit, smoke should be generated continuously."

To our knowledge, FAA-certified aircraft have never demonstrated the ability to disperse dense continuous smoke. This has been a safety concern of airline pilot safety committees for over 30 years.

The FAA and the Role of the Airframe and Engine Manufacturers

In the United States there is close collaboration between the airframe manufacturers and the FAA during the development of aviation safety and certification standards. FAA rules and standards are established through a committee and public comment process. The FAA receives information and advice from the airframe, engine, and equipment manufacturers through an Aviation Rule Making Advisory Committee (ARAC). The manufacturers assign only their most experienced and knowledgeable experts to the ARAC.

The manufacturers can also influence the process through the "public comments" process. New rules, or significant, non-emergency changes to existing rules, are open to public comment. The FAA is required to address, consider, and respond to these public comments.

Finally, FAA standards all undergo a rigorous cost/benefit analysis under procedures developed for all Federal Regulations by White House Office of Management and Budget. Here again, the manufacturers can have strong influence on the shape of the standards and their implementation by providing essential cost data. The FAA's inability to justify the benefits of their standards can also result in a watered-down rule in some cases.

Advisory Circular 25-9A Smoke Detection, Penetration, and Evacuation Tests and Related Flight Manual Emergency Procedures is an example of the evolution of the application of a rule. The FAA staff began writing a draft revision to the July 1986 advisory circular to address the problem of loss of pilot vision during incidents involving continuous smoke. The 1992 draft incorporated the sections of the Advisory Circular regarding reasonably probable sources of smoke. It emphasized the existence of a continuing problem, "incidents of fire or smoke that cannot be extinguished continue to occur." Accordingly, the draft Advisory Circular added the requirement to generate continuous smoke:

> To demonstrate protection from smoke generated by a continuous source in the cockpit, smoke should be generated continuously. The crew should don protective breathing equipment and initiate smoke evacuation procedures and/or activate smoke displacement devices, if needed, as soon as smoke becomes evident. The ability of the crew to safely operate the airplane should not be impaired by loss of vision due to smoke from a continuous source in or contiguous with the cockpit.

When the revision to the July 1986 Advisory Circular emerged in its final form, the requirement to demonstrate the pilots ability to "see" in the presence of continuous smoke became a function of the manufacturer's discretion.

> Although not mandatory, if the applicant wishes to demonstrate protection from smoke generated by a continuous source in the cockpit, smoke should be generated continuously. The crew should don protective breathing equipment and initiate smoke evacuation procedures as soon as smoke becomes evident and activate any optional vision enhancement devices, if approved.

In trying to strengthen the procedures for testing and certifying aircraft systems for smoke elimination as per Advisory Circular 25-9A, we surmise that the manufacturers were conscious of the potential for costly redesign of bleed air systems, air conditioning packs, and outflow valves.

Once again, it is essential for the air carriers to not lose sight of the FAA rulemaking process--aviation safety and certification standards are based on expert opinion, informed public opinion, operational experience, R&D results, accident experiences, perceived cost, and perceived benefits.

Because of the nature of the U.S. rulemaking process, the FAA considers its rules as the minimum standard for air carrier operations. An FAA final rule becomes mandatory and enforceable–unlike the "recommended" standards of Joint Aviation Authority or ICAO. The advisory material associated to a rule provides the industry with guidance, but is considered only "one means of compliance," thus permitting the industry the discretion of finding more effective methods.

Where safety is an immediate concern, the FAA has the authority to bypass the rulemaking process by issuing an *Airworthiness Directive* (AD) when an unsafe condition exists in an aircraft and the condition is likely to develop in other products of the same type design. For in-flight fires, the FAA has exercised its Airworthiness Directive authority on one particular source: the inspection and maintenance of aircraft wiring.

The FAA has also initiated a combination of regulatory and research activity to develop a set of rules requiring more frequent inspections and procedures for enhancing aircraft wiring system maintenance. These potential rules are years away from implementation.

The Federal Aviation Act requires all U.S. air carriers to operate to the highest standards. For operators to be proactive in preventing accidents, they should continually review all safety standards and, where feasible, apply cost-effective technologies, refined standard operating procedures, and improved training techniques.

The lean air carriers of today do not generally have the in-house engineering staff to review the certification basis for the aircraft they operate, and thus are quite dependent on the certification standards as set by the FAA. Because of the potential for the loss of an aircraft as the result of an in-flight fire, we believe operators should inquire with the manufactures about the performance of their "systems" in a "continuous smoke" situation. This would simply be a part of an overall aircraft acquisition process. Furthermore, operators could use this information in developing their standard and emergency operating procedures and training programs.

In operations that follow routes over an extended distance from a "suitable airfield", we would expect the air carrier's operational decision-making processes to include contingency plans based on the knowledge of their aircrafts' capability to dissipate smoke and fumes--How long can we see to fly the aircraft? How long will it take to land at a suitable airfield?

Conclusion

The fundamental priority of the airline executive has never changed: to identify and manage safety risks. Not just primary risks–the obvious threats such as pilot mistakes, maintenance errors, or inadequate training programs—but also contributing risks, everything from weak regulatory standards to poor corporate safety culture. The foundation of good risk management is information. But getting the right kind of information–objective, relevant and actionable—can be difficult. This study is for airlines that desire to go above and beyond the conventional approach to safety. Airline disasters can significantly diminish an airline's reputation and erode traveler confidence.

This report has determined that in-flight smoke and fires continue to occur. In spite of the frequent occurrence of these events, the fundamental design and certification of transport category aircraft environmental systems has remained unchanged since the introduction of jet transport aircraft. While measures are being taken to reduce the chances of fire and smoke by addressing circuit breaker protection, maintenance procedures, wiring, and insulation materials, we can hardly conclude that the problems have been remedied.

Airline executives should direct their operations and safety staff to evaluate and implement the practical and feasible interventions—technical solutions, training initiatives, and improved standard operating procedures—that can mitigate the chances of an in-flight smoke or fire leading to the loss of an aircraft.

This report has been prepared by:

(Signature on File)

L. Nick Lacey
Executive Vice President
MORTEN BEYER & AGNEW

(Signature on File)

Niels Brix Andersen
Senior Associate

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ALPA Letter to FAA re: AC25.9a

THIS DOCUMENT IS A RE-CREATION OF THE ORIGINAL

December 11, 1992

Federal Aviation Administration
Transport Standards Staff, ANM-110
1601 Lind Avenue, S.W.
Renton, WA 98058-4056

Re: Draft Advisory Circular (AC) 25-9A

Ladies and Gentlemen:

The Air Line Pilots Association, representing 42,000 pilots flying for 44 airlines, would like to comment on the proposed changes to the subject AC. We support the proposed changes and make further suggestions for change as outlined below.

Section 9.b, Airplane Test Conditions, should be revised to require that the lavatory smoke detectors be tested at a pressure altitude up to the pressure altitude approved for the cabin. Some smoke detector designs are negatively affected (less sensitive) at high pressure altitudes, and need to be specially calibrated for those conditions. Unfortunately, these smoke detectors will be too sensitive at low pressure altitudes. Therefore, we recommend that the units be tested to be effective at both altitudes, of sea level and maximum cabin pressure altitude.

We specifically submit comments on the change to the AC for the continuous production of smoke in evaluating the cockpit smoke evacuation capability. ALPA is very concerned that aircraft cockpits must be able to evacuate smoke effectively, so the crew can safely land the aircraft. We agree that this change will result in the test being more conservative and realistic. It is important to be able to evacuate continuous smoke if the source cannot be immediately identified. New aircraft use significantly more power in their systems, both the electrical and pneumatic/air conditioning systems. These systems have correspondingly more smoke generation capability and should thus be protected sufficiently. The continuous smoke test as proposed in the AC should accomplish this.

Accident experience supports the change to using continuous smoke in the cockpit smoke evaluation test. While the majority of the cockpit smoke incidents we have reviewed were controllable by disconnecting the damaged system, there appeared to be several failure modes where it was not possible to disconnect the damaged system. Therefore, there is a need for the continuous smoke evacuation capability. Examples of this include the leaking of hydraulic lines onto hot components, some electrical compartment failures, bombs, illegal cargo, and engine failures.

Our final comment upon review of the revisions to the AC addresses smoke evacuation, or venting, from the cabin. Specifically, the AC should provide more information on the need for evacuating smoke from post-crash and inflight fires from the aircraft cabin. This is the next best way to prevent fire propagation, second only to cooling the fire with water. Smoke evacuation in the cabin removes the combustible and hot gasses before they can be completely burned in a flashover. This AC should present methodologies to test the cabin smoke evacuation using continuous smoke generation. Only by providing the capability to evacuate continuous smoke can the cabin survivability be prolonged.

Smoke venting in the cabin should assist the natural convective currents of hot air. It would be beneficial to have the AC address the design of aircraft air conditioning systems and their effort on fire and smoke control. Most air conditioning systems provide fresh air from the ceiling and the air collection ducts are at the floor sidewall region. This is directly opposite to the direction of a fire's convective currents. For smoke evacuation purposes, it would appear more beneficial to provide fresh air at the floor and collect waste air near the ceiling. We would like to see this addressed further in the subject AC.

Thank you for the opportunity to comment. Please feel free to call us to discuss this further; please contact Pierre Huggins at (703) 689-4211.

Sincerely,

Captain Ricky R. Davidson, Chairman
Assistant Survival Committee

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AIR LINE PILOTS ASSOCIATION

535 HERNDON PARKWAY □ P.O. BOX 1169 □ HERNDON, VIRGINIA 22070 □ (703) 689-2270

703-689-4100

December 11, 1992

CC: G. ROEUSTRA
JOHN WELLS

FAXED 8-31-99

Federal Aviation Administration
Transport Standards Staff, ANM-110
1601 Lind Avenue, S.W.
Renton, WA 98055-4056

Re: Draft Advisory Circular (AC) 25-9A

Ladies and Gentlemen:

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Sincerely,

Captain Ricky R. Davidson, Chairman
Accident Survival Committee

RRD:jag

bcc: D. Haddad
T. Kraemer
Accident Survival Comm
HAZCO
Dangerous Goods Comm.
Accident Invest. Bd.
Accident Invest. Dept.
B. Hall
R. Kessel

User List

Cockpit Emergency Vision Technology Operators

Abbott Labs
AIG
Air Color, LLC
Air Group
Allstate Insurance Company
American Financial Group
American General
American Industries
Air Products & Chemicals, Inc.
American Standard
AOL
AON Flight Operations
Atlantic Aviation
Bank of America
Bank One
Becton Dickinson & Co.
BellSouth
Bombardier
Borg-Warner
Bosch
Boulder Aviation
Bristol-Myers Squibb Co.
CAE Simuflite
Cafaro Company
Carnival Corp.
Carter Wallace
Chamarac
Chevron-Texaco Corp.
Cigna Corp.
Citigroup, Inc.
Citizen's
Cox Aviation
Dassault Falcon Jet Corp.
Delmar Jets LLC
Dornair
Dow Chemical
Dream Works, LLC
East-West Air, Inc.
Executive Fliteways
Executive Jet Aviation
Executive Jet Management
Executive Jet Services
Exxon Mobil Corp.
Federal Aviation Administration (FAA)
FedEx
FL Aviation
FlightSafety International
General Dynamics
General Electric Capital Corp.
GTC
Genuine Parts Co.
GTECH Corp.
Gulfstream Aerospace
Harsco
Hartvig Aviation, LLC
Hawker Pacific Pty. Ltd.
High Tech Aircraft Corp.
Honeywell, Inc.
IBM
IMS Health
Intellectual Ventures
Interjet
International Paper
ITT Industries
J.D. Melvin, Co.
Jet Aviation
Jet Aviation AG, Basel
Jet Aviation Business Jets, Inc.
Jet Blue Airways
Kal-Aero
KB Systems, Inc.
Key Corp.
Kingdom, Eleven: 767
Knight Ridder
Learjet, Inc.
Leeson Electric Corp.
Lockheed Martin
Loew's Corp.
Lowe's Companies, Inc.
Lucent Technologies
Magic Carpet Aviation
Markin Aviation
McCormick & Co., Inc.
MCI Worldcom
Melvin Simon Aviation
Merck & Co.
Merrill Lynch
Metromedia Co.
MIT Lincoln Labs
Mutual of Omaha
National Beverage Corp.
Nauthiz Pty. Ltd.
Nestle-Purina
Nextel
Office Depot
P.P.G. Industries
P&R Trading, Inc.
Paramount
PE Corp.
Penobscot Properties, LLC
Perkin-Elmer Corp.
Peterson Aviation
Pfizer, Inc.
Phillip Morris (Altria)
Planet Hollywood
Polo Wings II
PPG
PrivatAir SA
R.O.P. Aviation, Inc.
Raytheon Corp.
Raytheon Travel Air Co.
Richardson Aviation
Royal Australian Air Force
Raytheon Travel Air Co.
Sabrina Fisheries
Saudi Arabian Oil Co.
Schering-Plough Corp.
Shell Oil Co.
Siegel-Robert
Simon Aviation
Smuckers
Snowbird Aviation
Sony Aviation, Inc.
Sprint
Stockwood, Inc.
TAG Aviation
Teal Aviation
Tech Air Service
Tenet HealthCare Corp.
Tessler Aviation Leasing Corp.
Texas Instuments
The Air Group, Inc.
The Limited Stores
The Lupton Co., LLC
The Richards Group, Inc.
35-55 Partnership
Timco
Time Warner
Tisdale & Nicholson
Trans Canada Pipelines
Raytheon Corp.
Trans Meridian Aviation
Tudor Investment Corp.
Tyson Foods, Inc.
Union Carbide Corp.
U.S. Army
U.S. Coast Guard
U.S. Navy
United Technologies Corp.
Universal Studios
Vivendi Universal
Walter H. Annenberg
Warner-Lambert Co.
Wham Leasing
Whitewind Company
Wyeth
Xerox Corp.
XTO Energy

FAA Contract Excerpts

Relevant excerpts from FAA contract for the purchase of EVAS
SIR DTFA-02-02-R-15425

PART I - SECTION C
SCOPE OF WORK

EMERGENCY VISION ASSURANCE SYSTEM (EVAS) STATEMENT OF WORK

1. GENERAL

1.1 This Statement of Work (SOW) outlines the requirements for an Emergency Vision Assurance System (EVAS) for the FAA aircraft fleet. The EVAS will be operated and maintained in accordance with Aviation System Standards (AVN), policies and the Code of Federal Regulations (CFR), Title 14, Aeronautics and Space, Part 135.

2. EMERGENCY VISION ASSURANCE SYSTEM

2.1 The EVAS is a patented flight deck smoke displacement system. EVAS is the only safety system available which has been FAA tested and certified to ensure flight crew vision in the presence of dense continuous smoke. When an aircraft is equipped with EVAS the flight crew has an unobstructed view of the flight path and primary instruments as well as read approach plates and emergency procedures.

2.2 EVAS is self-contained with an internal power supply, and is certified to operate for at least two continuous hours. The system displaces cockpit smoke using an inflatable vision unit (IVU). The IVU is filled with a clean filtered air supply by the power unit. Clear panels in the IVU are secured against the windshield, and primary flight instruments. The IVU extends back from the instrument panel to the flight crew. The flight crew member's simply place their protective smoke goggles for full face mask against the clear panel on the IVU to view the aircraft instruments and to see outside the aircraft through the windshield. The ability to perform these functions in an environment of continuous smoke is critical to mission safety.

3. CONCEPT OF SUPPORT

3.1 It is the FAA's intent to purchase two, (2) EVAS units for each aircraft in the FAA's fleet as identified in Appendix 1.

4. EVAS INSTALLATION

4.1 The FAA shall be responsible for installation/removal of the EVAS units into FAA aircraft. Prior to the FAA installing units into aircraft the Contractor shall provide the FAA with a Supplemental Type Certificate (STC) for each aircraft type in the FAA's fleet (See Attachment 1). The contractor shall view each aircraft type to identify the appropriate location to attach the EVAS units. The FAA understands that the Contractor currently has an STC for the Gulfstream G-IV, Challenger 600, Hawker 800A, and Cessna 560. The Contractor shall be responsible for obtaining additional STC as necessary to allow for installation of EVAS units in all FAA fleet aircraft. After receipt of the approved STC the FAA will schedule installation and order the appropriate number of EVAS units.

4.2 EVAS may be utilized as loose equipment on some aircraft types. Some aircraft may be equipped with EVAS as loose equipment initially and converted to installed equipment as STC's are developed.

5. TRAINING

5.1 Initial EVAS training on the use of the equipment and required checks will be provided by the Contractor for approximately 118 Pilots. Training will be provided during the first available scheduled recurrent ground school at each of the FAA field offices in Oklahoma City OK, Sacramento CA, Atlantic City N.J., Atlanta GA, Anchorage Alaska, and Battle Creek MI.

5.2 New-hire initial training will be accomplished by the FAA on an as needed basis, using the inflatable cockpit trainer provided by Contactor.

5.3 Annual recurrent training will be provided by the FAA utilizing a Training Demonstration Unit provided by the Contractor

6. WARRANTY

6.1 EVAS Worldwide warranties each new and re-certified EVAS unit to function as designed and in accordance with EVAS Certification, Compliance and Technical Specifications. The FAA will conduct a receiving inspection of all incoming unit(s) IAW TI 4100.24, General Maintenance Manual, Chapter III, Section 41 and Chapter V. Any unit(s) received in a damaged condition or without proper certification documentation will be identified, recorded, and returned to the Contractor for disposition at the Contractor's expense.

6.2 Any EVAS that fails a 30 day system check will be returned for re-certification by the Contractor.

6.3 The Contractor shall employ personnel who possess the necessary skills to effectively accomplish the requirements of the contract and who possess the necessary training to perform biennial inspections and re-certifications