Emergency and Abnormal Situations Project

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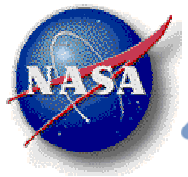
http://human-factors.arc.nasa.gov/eas



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Briefing Outline

1. Introduction: The Challenge of Emergency and Abnormal Situations and Procedures
2. Overview of the Emergency and Abnormal Situations (EAS) Project
3. Introduction to the “Taxonomy of the Domain”
4. A Closer Look at Some of the Issues
5. Conclusion

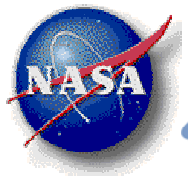
The Challenge

Emergency and abnormal situations:

- are often time critical, complex, and/or ambiguous
- are high stress, high workload, and a great deal is at stake
- require exceptionally high levels of coordination inside and outside of the airplane

Emergency and abnormal procedures:

- are generally focused on aircraft systems rather than on the situation as a whole
- are practiced seldom (twice a year or less) and used rarely
- are often highly dependent on fragile cognitive processes
- when needed, are crucial and must be performed correctly



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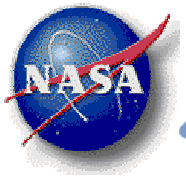
Industry Contacts and Consultants

Manufacturers:	Boeing, Airbus Industries, BAe Systems, Bombardier
Regulatory and Governmental Agencies:	FAA, CAA (UK), JAA, ICAO, Eurocontrol
Unions and Trade Groups:	ALPA, APA, SWAPA, ATA, ADF
Accident Investigation Bodies:	NTSB, TSB of Canada, ISASI
Airlines:	Airborne Express, Air Canada, Alaska, Aloha, American, Atlantic Southeast, Cathay Pacific, Continental, Delta, Fed Ex, Frontier, Hawaiian, Horizon, JetBlue, Southwest, United, UPS, US Airways, TWA (prior to merger)



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Overall Goal of the EAS Project

Develop guidance for procedure development and certification, training, crew coordination, and situation management based on knowledge of the operational environment, human performance limitations, and cognitive vulnerabilities in real-world situations.

Approach

Review: all existing guidelines, handbooks, bulletins, reports, recommendations, documents, and pertinent literature

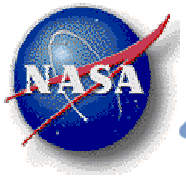
Analyze: ASRS reports, NTSB and FAA accident reports

Study: philosophies, policies, practices, and procedures currently in use by manufacturers and air carriers

Observe: normal air carrier operations, initial and recurrent emergency and abnormal training for flight crews

Interview: manufacturer procedure developers, procedure certifiers, POIs, air carrier management, instructors, pilots, cabin crew, dispatchers, maintenance personnel, air traffic controllers, etc.

Conduct: surveys, field studies, simulator studies, experimental lab studies



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EAS Project Research Themes: Activities and Studies

Research Themes	AvSSP Phase I	AvSSP Phase II (Proposed)
Current State of the Industry	• identifying and gathering relevant literature, manuals, and materials • sponsored International Symposium on Emergency and Abnormal Situations (June 2003) • Emergency and Abnormal Situations: Issues and Concerns (article, many presentations)	• continue identifying and gathering relevant literature and materials • possibly sponsor or co-sponsor additional symposia regarding emergency and abnormal situation issues and concerns • Non-Normal Checklists: Issues in Philosophy, Design, and Use (Technical Memorandum)
Problems with Procedures	• Emergency and Abnormal Situations: A Review of ASRS Reports (paper and presentation)	• What do Accident Reports Tell Us about Emergencies? (paper and presentation)
How is a Checklist Born?	• Boeing Checklist Development Process, Design, Functionality, and Philosophy: B777 ECL and QRH, B737 QRH (manuscripts) • Bombardier Non-normal Checklist Development Process, Design, Functionality and Philosophy: CRJ900 (manuscript)	• Airbus Checklist Development Process, Design, Functionality, and Philosophy: A320 and A380 ECAMs and QRHs (manuscript) • Certification and POI Review of Emergency and Abnormal Checklists (paper)

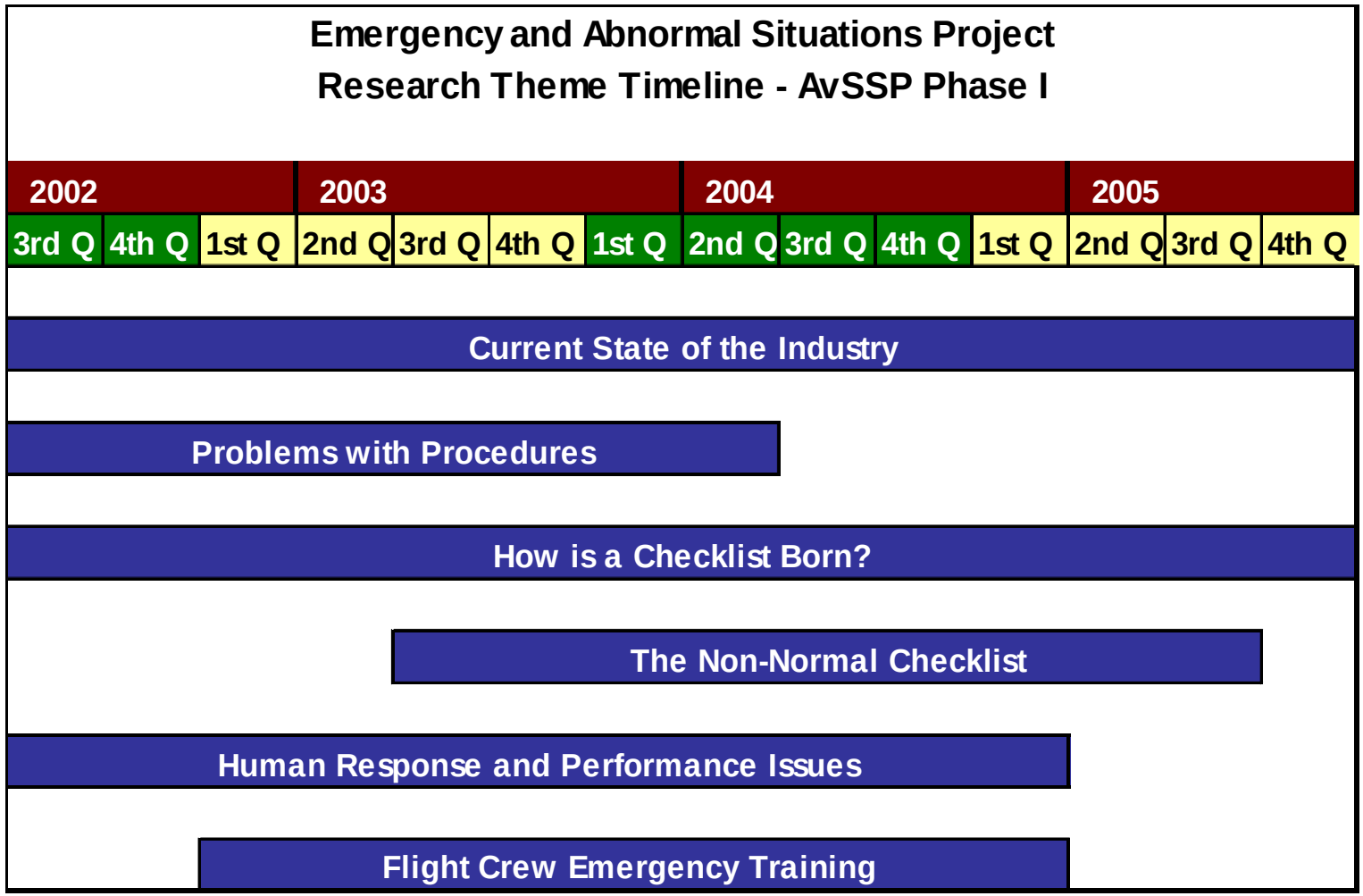
EAS Project Research Themes: Activities and Studies

Research Themes	AvSSP Phase I	AvSSP Phase II (Proposed)
The Non-Normal Checklist	• B737 QRH Comparison Study (Contractor Report or Technical Memorandum) • The Philosophy, Design, and Structure of Smoke and Fire Checklists (several papers and presentations)	• Comparison of the Boeing ECL and Airbus ECAM Non-Normal Checklists (manuscript and article) • Paper vs. Electronic Checklists: Error Modes and Design Solutions (technical memorandum and presentations) • The Role and Use of Automation During Emergency and Abnormal Situations: Perceptions and Practices (technical memorandum and article)
Human Response and Performance	• critical incident interviews with pilots who have been involved in accidents • Declaring Emergencies: Fact and Fiction (presentation and article) • Stress and Cognition – A Review of the Scientific Literature (grantee report)	• continue critical incident interviews with pilots who have been involved in accidents • Stress on the Flight Deck (several manuscripts – journal articles in peer-reviewed journals, technical memorandum, case studies)
Personnel and Crew Coordination		• Situation Critical: Coordination of Response to Emergency and Abnormal Situations (manuscript, article, and presentations) • The Influence of Increased Security on Flight and Cabin Crew Communications (contractor report, articles and presentations)

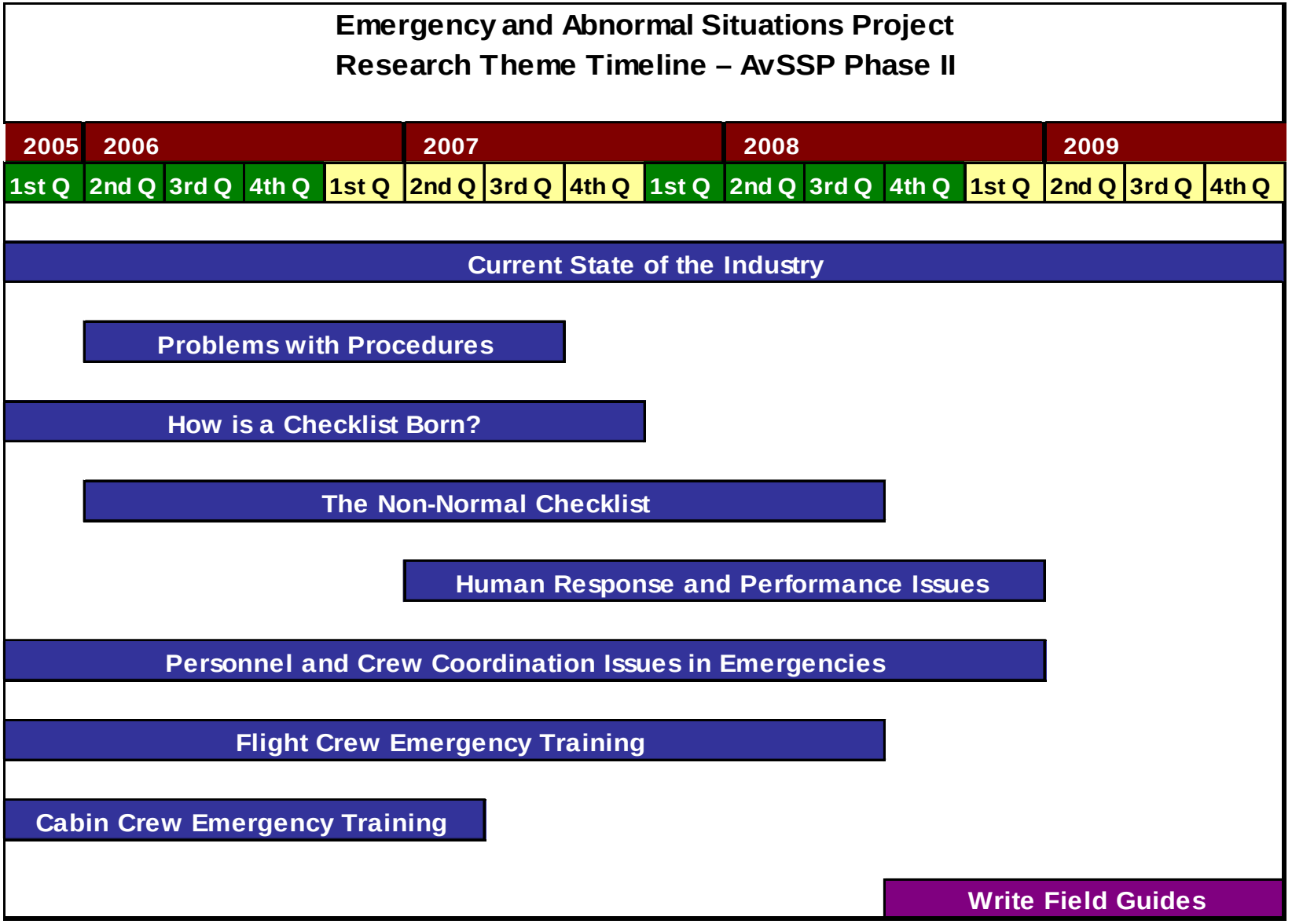
EAS Project Research Themes: Activities and Studies

Research Themes	AvSSP Phase I	AvSSP Phase II (Proposed)
Emergency Training of Flight Crews	• Current Practices in Emergency and Abnormal Training for Flight Crews (analysis of practices, strengths, and limitations - manuscript)	• Emergency Checklists Used by Flight and Cabin Crews: Consistency and Complementariness (paper, article, and presentation) • Non-Standard Emergencies and Real-World Demands: Challenges in Training Flight Crews (manuscript, articles, and presentations)
Emergency Training of Cabin Crews		• Current Practices in Emergency and Abnormal Training for Cabin Crews (analysis of practices, strengths, and limitations - manuscript)
Field Guides Final End Products of the EAS Project		• Field Guides on Emergency and Abnormal Situations for various user groups: – manufacturers – checklist designers and developers – certification and regulation groups – airline safety managers – instructors and trainers – line pilots and cabin crew – accident investigators

EAS Research Theme Timeline – AvSSP Phase I



EAS Research Theme Timeline – AvSSP Phase II



Feedback about our Work from Industry

The International Symposium on Emergency and Abnormal Situations in Aviation Participant Comments:

"Thanks so much for conducting this gathering. It was very worthwhile."

"I found the Symposium very interesting and I will certainly use the material for inclusion in our training"

"Seems like you are doing all the right things to identify the problems and issues, Good project. Please distribute findings after project is complete!"

"All sounds very good. I'm very interested in seeing the end results. My main area of interest is in the development of checklists for our maintenance control group (who assist pilots with an emergency). I'm wondering how we can stay in touch to assist each other in this effort."

Additional EAS Presentation Invitations as a result of the Symposium:

- ALPA Operations Committee Meeting at the ALPA Safety Week Forum (August 2003)
- ISASI 2003 Symposium (International Society of Air Safety Investigators - August 2003)
- Air Line Dispatcher's Federation Annual Safety Conference (October 2003)
- Abnormal Situation Management Consortium (petrol-chemical industry - October 2003)
- Cabin Safety Symposium (sponsored by the Southern California Safety Institute - February 2004)
- ALPA Safety Week 2004

Feedback about our Work from Industry

Excerpt from a letter from Dan Boorman (from Boeing) regarding my work on the B777 ECL and QRH document:

Barbara,

In my opinion your document is remarkable. You have taken a wide variety of often sketchy sources and created a clear, coherent, comprehensive treatment of how Boeing creates ECL and QRH non-normal checklists.

Your understanding of the ECL authoring material blew me away. You are now, without a doubt, the worlds' third leading expert on 777 ECL authoring considerations. Only Brad and I know more about it. You would teach the Authoring Course much more effectively than Roger, who has been authoring checklists for years.

The organization is VERY good. The examples are excellent. We will make great use of this document for both the paper and the ECL world, and for all Boeing models, not just 777.

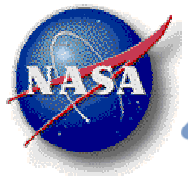
You did what we couldn't do for the last 10 years.

THANK YOU!!!!!

Dan

Taxonomy of the Domain

- Philosophies
- Economic and Regulatory Pressures
- Definitions and Perspectives
- Development of Checklists and Procedures
- Checklist Structure and Design
- Checklist Type and Availability
- Crew Coordination and Response
- Checklist Use
- Human Performance
- Personnel Issues
- Roles and Behavior of Others
- Critical Aircraft Systems
- Automation Issues
- Training
- Selected Equipment and Evacuation Issues



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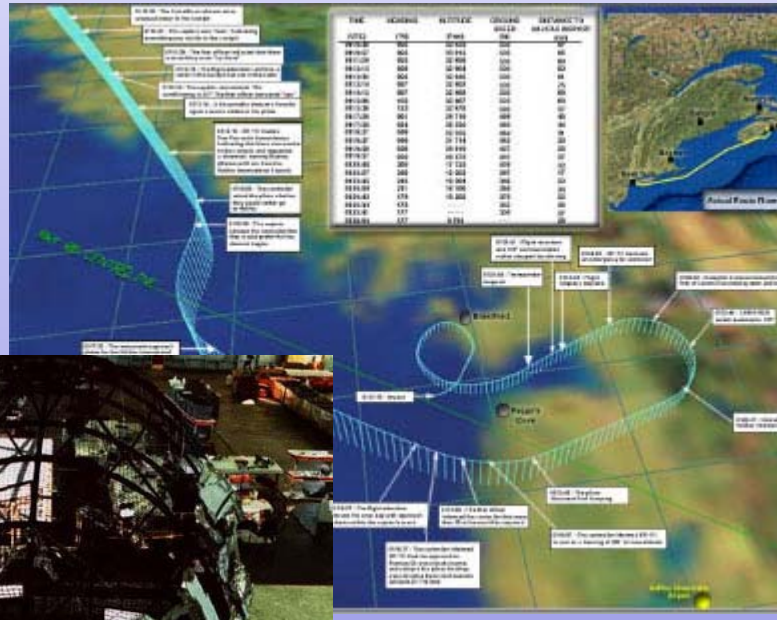
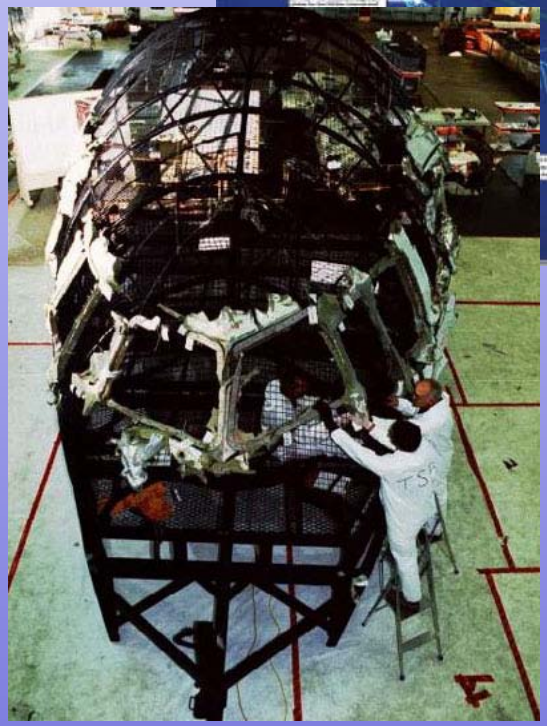
A Closer Look at Some of the Issues

Philosophy of Response to Emergencies – Checklist Design

In a study of 15 in-flight fires that occurred between January 1967 and September 1998, the TSB of Canada determined that the average amount of time between the detection of an on-board fire and when the aircraft ditched, conducted a forced landing, or crashed was 17 minutes.

Swissair 111 - In-flight Fire, Nova Scotia, Canada September 2, 1998





OCT/25.JAN.96 | EMERGENCY CHECKLIST ALERT AND NON-ALERT | MD-11 | 41.1 Page 9

AIR CONDITIONING SMOKE

ECON P/B ---------- OFF

SMOKE DECREASES

NO

No further action required.

END

AIR SYSTEM P/B ---------- MANUAL
ECON P/B ---------- ON
PACK 1 ---------- OFF

SMOKE DECREASES

NO

BLEED AIR 1 ---------- OFF
1 - 3 ISOL ---------- ON

DO NOT activate BLEED AIR 1 or PACK 1 for remainder of flight.

END

PACK 1 ---------- ON
PACK 3 ---------- OFF

SMOKE DECREASES

NO

BLEED AIR 3 ---------- OFF
1 - 3 ISOL ---------- ON

DO NOT activate BLEED AIR 3 or PACK 3 for remainder of flight.

END

PACK 3 ---------- ON
PACK 2 ---------- OFF

SMOKE DECREASES

NO

BLEED AIR 2 ---------- OFF
1 - 2 ISOL ---------- ON

DO NOT activate BLEED AIR 2 or PACK 2 for remainder of flight.

END

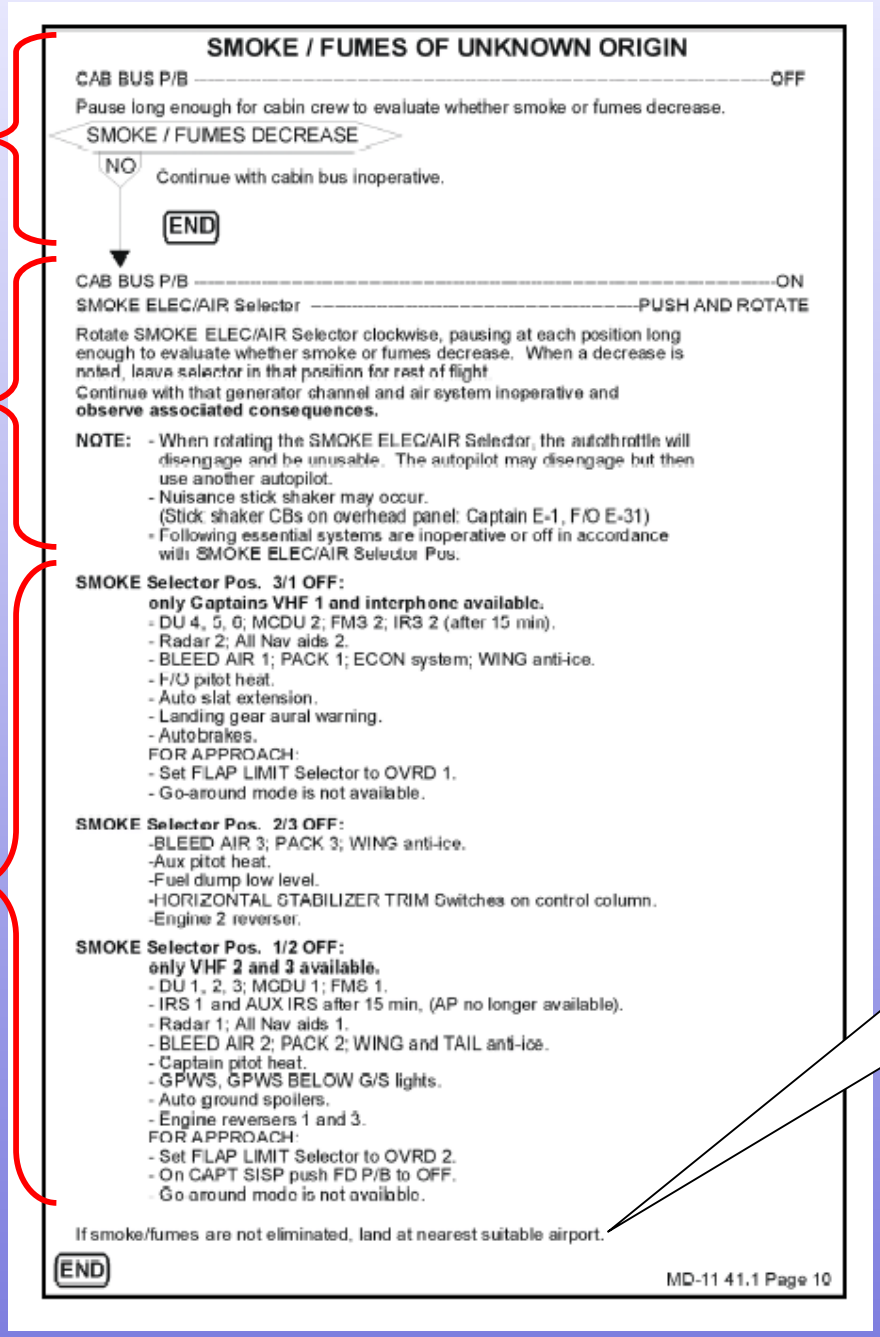
PACK 2 ---------- ON

Smoke is not of air conditioning origin.

Refer to EMERGENCY Procedure - SMOKE / FUMES OF UNKNOWN ORIGIN.

END

MD-11 41.1 Page 9



SMOKE / FUMES OF UNKNOWN ORIGIN

CAB BUS P/B ---------- OFF

Pause long enough for cabin crew to evaluate whether smoke or fumes decrease.

SMOKE / FUMES DECREASE

NO — Continue with cabin bus inoperative.

END

CAB BUS P/B ---------- ON

SMOKE ELEC/AIR Selector ---------- PUSH AND ROTATE

Rotate SMOKE ELEC/AIR Selector clockwise, pausing at each position long enough to evaluate whether smoke or fumes decrease. When a decrease is noted, leave selector in that position for rest of flight.

Continue with that generator channel and air system inoperative and **observe associated consequences.**

NOTE:
- When rotating the SMOKE ELEC/AIR Selector, the autothrottle will disengage and be unusable. The autopilot may disengage but then use another autopilot.
- Nuisance stick shaker may occur. (Stick shaker CBs on overhead panel: Captain E-1, F/O E-31)
- Following essential systems are inoperative or off in accordance with SMOKE ELEC/AIR Selector Pos.

SMOKE Selector Pos. 3/1 OFF:
only Captains VHF 1 and interphone available.
- DU 4, 5, 6; MCDU 2; FM3 2; IRS 2 (after 15 min).
- Radar 2; All Nav aids 2.
- BLEED AIR 1; PACK 1; ECON system; WING anti-ice.
- F/O pitot heat.
- Auto slat extension.
- Landing gear aural warning.
- Autobrakes.

FOR APPROACH:
- Set FLAP LIMIT Selector to OVRD 1.
- Go-around mode is not available.

SMOKE Selector Pos. 2/3 OFF:
- BLEED AIR 3; PACK 3; WING anti-ice.
- Aux pitot heat.
- Fuel dump low level.
- HORIZONTAL STABILIZER TRIM Switches on control column.
- Engine 2 reverser.

SMOKE Selector Pos. 1/2 OFF:
only VHF 2 and 3 available.
- DU 1, 2, 3; MCDU 1; FMS 1.
- IRS 1 and AUX IRS after 15 min, (AP no longer available).
- Radar 1; All Nav aids 1.
- BLEED AIR 2; PACK 2; WING and TAIL anti-ice.
- Captain pitot heat.
- GPWS, GPWS BELOW G/S lights.
- Auto ground spoilers.
- Engine reversers 1 and 3.

FOR APPROACH:
- Set FLAP LIMIT Selector to OVRD 2.
- On CAPT SISP push FD P/B to OFF.
- Go around mode is not available.

If smoke/fumes are not eliminated, land at nearest suitable airport.

END

MD-11 41.1 Page 10

Swissair 111 - In-flight Fire, Nova Scotia, Canada September 2, 1998

If smoke/fumes are not eliminated, land at nearest suitable airport

ValueJet 592 - In-flight Fire, Florida Everglades, May 11, 1996

ELECTRICAL SMOKE OR FIRE

OXYGEN MASKS AND SMOKE GOGGLES	ON/100%
RADIO RACK Switch	VENTURI
CABIN PRESSURE Control	MANUAL
EMER PWR Switch	ON
GEN Control and APU Bus Switches	OFF

NOTE: Wait a reasonable time to determine whether to follow step A or B below.

A If smoke continues:

AC and DC BUS X TIE Switches	OPEN
R & L GEN or APU BUS Switches	ON
F/O FLT INSTRUMENTS	CHECK
EMER PWR Switch	OFF
AC EMERG FEED C/B's (K10 & L11)	PULL

NOTE: If smoke disappears, fault is on AC emergency bus. If smoke continues:

AC EMERG FEED C/B's (K10 & L11)	RESET
DC EMERG FEED C/B (M36) [930, 960 Series A/C (N37)]	PULL

NOTE: If smoke disappears, fault is on DC emergency bus. If smoke continues:

DC EMERG FEED C/B (M36) [930, 960 Series A/C (N37)]	RESET
BATT Switch	OFF

NOTE: If smoke disappears, fault is on battery bus. If smoke continues:

BATT Switch	ON
BATT DIRECT BUS C/B's(Overhead)	PULL

NOTE: If smoke continues:

BATT DIRECT BUS C/B's(Overhead)	RESET
DC TRANSFER BUS FEED C/B(M35) [930, 960 Series A/C (N37)] [A/C #960 (M36)]	PULL

B If smoke stops or decreases, at Captain's discretion:

AC & DC X-TIE Switches	OPEN
LEFT GEN Switch	ON

NOTE: If smoke reappears, fault is on left gen bus, left AC bus, left DC bus, or AC X-tie is shorted:

L GEN Switch	OFF
R GEN Switch	ON
F/O FLT INSTRUMENTS	CHECK
EMGNCY POWER Switch	OFF

NOTE: If smoke reappears, fault is on right gen bus, right AC bus, right DC bus, ground service AC bus, battery charger, or AC X-tie is shorted:

[END]

Valujet 558 - DC-9 Hard Landing – Nashville, Tenn., January 7, 1996

Crew followed QRH procedures that were incomplete. This caused the aircraft to fall from100 ft agl on final approach. The nosewheel separated from the aircraft.

UNABLE TO RAISE GEAR LEVER

NOSE STEERING WHEEL ..... OPERATE (C)

If steering wheel does NOT turn and centering indices are aligned:

Indicates a malfunction of the anti–retraction mechanism.

If desired, retract landing gear:

GEAR HANDLE RELEASE BUTTON ..... PUSH (PNF)

GEAR LEVER ..... UP (PNF)

If steering wheel turns:

DO NOT RETRACT THE GEAR

Indicates ground shift mechanism is still in the ground mode.

No auto–pressurization, and takeoff warning horn will sound when flaps/slats are retracted.

The ground control relay electrical circuits can be placed in the flight mode by pulling the Ground Control Relay circuit breakers (H20 and J20).

Do not exceed VLE (300 kts/M.70).

Approach and landing:

If landing gear was not retracted prior to landing, ground spoilers must be operated manually.

AIRPLANE ..... DEPRESSURIZE (PNF)

ANTI–SKID SWITCH (before 30 kts) ..... OFF (PNF)

GROUND CONTROL RELAY C/Bs (if pulled)
(H20 and J20) ..... RESET (C or FO)

The missing information was included in the AOM expanded checklists but was never transferred to the QRH checklists.

Approach and landing:

If landing gear was not retracted prior to landing, ground spoilers must be operated manually.

AIRPLANE ..... DEPRESSURIZE (PNF)
– Ensure airplane is depressurized prior to landing.

ANTI–SKID SWITCH (before 30 kts) ..... OFF (PNF)
– During landing rollout and prior to 30 kts, momentarily release brakes and place Anti–skid switch to OFF.

GROUND CONTROL RELAY C/Bs (if pulled)
(H20 and J20) ..... RESET (C or FO)
– Reset Ground Control Relay circuit breakers during taxi and verify that circuits are in the ground mode.

ATA 406 - B727 Rapid Decompression – Indianapolis, Indiana May 12, 1996

PACK REINSTATEMENT FOLLOWING AUTO PACK TRIP

ELECTRONIC PRESSURIZATION

After 1000 Feet AFL:

Both Pack Switches ..... OFF
Pack Reset Button ..... PUSH
Auto Pack Trip Switch ..... CUT OUT

If in AUTO mode:

One Pack Switch ..... ON

Do not reinstate second pack unless flaps are retracted.

When ready to reinstate second pack:
Second Pack Switch ..... ON

If in STANDBY mode:

– Cabin ALT Selector ..... SET 2000 FEET ABOVE *AIRPLANE'S* ALTITUDE
– Cabin Rate Switch ..... FULL INCREASE
– One Pack Switch ..... ON
After initial pressure surge and as rate of climb returns to zero:
Cabin ALT Selector ..... SET CRUISE CABIN PRESSURE ALTITUDE
– Cabin Rate Knob ..... SET AT INDEX OR AS REQUIRED
Adjust as required to maintain desired rate of change.

to 1/2 OPEN
..... ON
O MAINTAIN
E OF CLIMB

..... CLOSE
..... ON

..... NORMAL

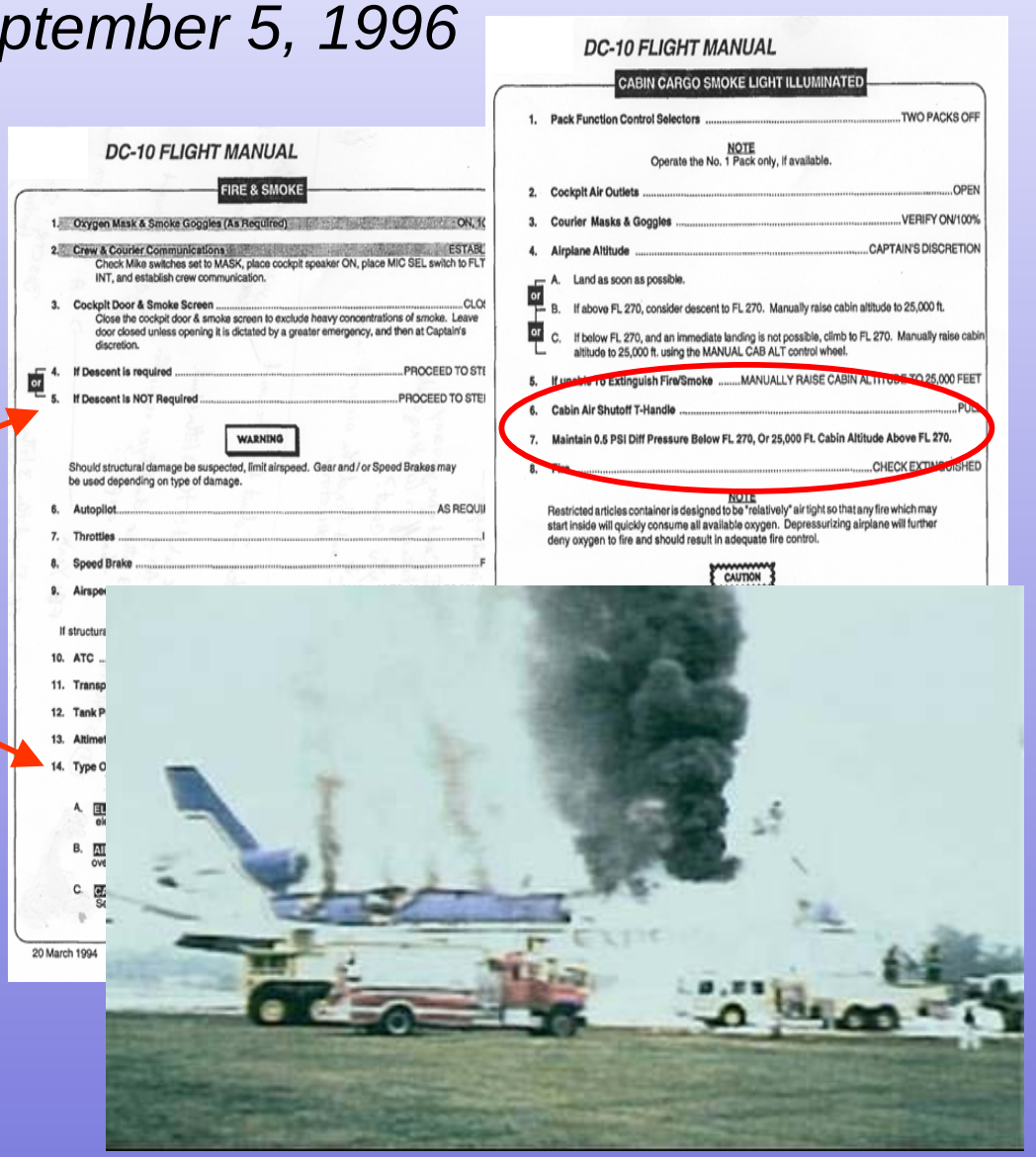
Without referring to a checklist to reinstate a pack that had automatically tripped off, the flight engineer opened the outflow valve by mistake (instead of closing it) and caused the aircraft to rapidly decompress.

The captain, flight engineer, and a flight attendant, who had been on the flight deck, each lost consciousness during the event.

FedEx 1406, DC-10 In-flight Fire – Newburgh, New York September 5, 1996

In a rapidly deteriorating situation under high stress and workload, some checklist steps were not completed which resulted in the aircraft being partially pressurized after making an emergency landing.

The crew and two passengers barely escaped the burning aircraft.



SAS 751 - MD-81 Dual Engine Failure – Gottrora, Sweden – December 27, 1991

On takeoff, ice was ingested into the engines which damaged the fan stages and caused the engines to surge – all power was lost 77 seconds later.

During the event engine power was increased automatically by the Automatic Thrust Restoration (ATR) feature, which increased the intensity of the surging and contributed to the failure of the engines.

Neither the crew nor the company knew that the ATR feature existed on the airplane.

Birgenair ALW 301 - B757 Loss of Control – Puerto Plata, Dominican Republic – February 2, 1996

Erroneous information was sent to the captain's airspeed indicator and center autopilot by the left air data computer because a pitot tube was blocked.

The crew members were tremendously confused by contradictory warnings (overspeed and stall warnings) and conflicting airspeed indications on the three displays.

The center autopilot and autothrottles contributed to their problems. The crew did not attempt to fly the aircraft manually and tried to use automation in a way that did not help them.

The aircraft crashed into the ocean. All onboard perished.

ATA 356 - 717-200 – Flushing, New York – March 26, 2003
NTSB Preliminary Report

While on final approach the forward flight attendant noticed a burning smell and discovered that the handset to call the cockpit was not working.

After landing she pounded on the cockpit door and yelled to get the flight crew's attention.

The flight crew never heard the flight attendant pounding or yelling.

EAS Project Team

Immanuel Barshi, Ph.D.* ‡ - Civil Servant

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Ben Berman, A.B.* ‡

Barbara Burian, Ph.D.

Key Dismukes, Ph.D.* ‡ - Civil Servant

Captain Richard Fariello (Ret.), B.S.*

Colleen Geven, A.A.* ‡

Richard Geven, M.A.* ‡

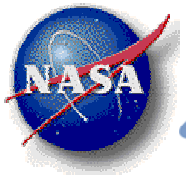
Todd Kowalski, B.S. ‡

Chris Reed, B.S.* ‡

All are licensed pilots

* Licensed Airline Transport Pilots

‡ Certified Flight Instructors



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