Emergency and Abnormal Situations Project

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

Briefing for George Finelli – November 2003
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
# Industry Contacts and Consultants

<table>
<thead>
<tr>
<th>Manufacturers:</th>
<th>Boeing, Airbus Industries, BAe Systems, Bombardier</th>
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</thead>
<tbody>
<tr>
<td>Regulatory and Governmental Agencies:</td>
<td>FAA, CAA (UK), JAA, ICAO, Eurocontrol</td>
</tr>
<tr>
<td>Unions and Trade Groups:</td>
<td>ALPA, APA, SWAPA, ATA, ADF</td>
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<tr>
<td>Accident Investigation Bodies:</td>
<td>NTSB, TSB of Canada, ISASI</td>
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<tr>
<td>Airlines:</td>
<td>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)</td>
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</table>
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
# EAS Project Research Themes: Activities and Studies

<table>
<thead>
<tr>
<th>Research Themes</th>
<th>AvSSP Phase I</th>
<th>AvSSP Phase II (Proposed)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current State of the Industry</strong></td>
<td>• identifying and gathering relevant literature, manuals, and materials</td>
<td>• continue identifying and gathering relevant literature and materials</td>
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<tr>
<td></td>
<td>• sponsored International Symposium on Emergency and Abnormal Situations (June 2003)</td>
<td>• possibly sponsor or co-sponsor additional symposia regarding emergency and abnormal situation issues and concerns</td>
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<tr>
<td></td>
<td>• Emergency and Abnormal Situations: Issues and Concerns (article, many presentations)</td>
<td>• Non-Normal Checklists: Issues in Philosophy, Design, and Use (Technical Memorandum)</td>
</tr>
<tr>
<td><strong>Problems with Procedures</strong></td>
<td>• Emergency and Abnormal Situations: A Review of ASRS Reports (paper and presentation)</td>
<td>• What do Accident Reports Tell Us about Emergencies? (paper and presentation)</td>
</tr>
<tr>
<td><strong>How is a Checklist Born?</strong></td>
<td>• Boeing Checklist Development Process, Design, Functionality, and Philosophy: B777 ECL and QRH, B737 QRH (manuscripts)</td>
<td>• Airbus Checklist Development Process, Design, Functionality, and Philosophy: A320 and A380 ECAMs and QRHs (manuscript)</td>
</tr>
<tr>
<td></td>
<td>• Bombardier Non-normal Checklist Development Process, Design, Functionality and Philosophy: CRJ900 (manuscript)</td>
<td>• Certification and POI Review of Emergency and Abnormal Checklists (paper)</td>
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**Note:**
- Manuscript indicates ongoing research or preliminary work.
- POI stands for Points of Interest.
### EAS Project Research Themes: Activities and Studies

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<tr>
<td><strong>The Non-Normal Checklist</strong></td>
<td>• B737 QRH Comparison Study (Contractor Report or Technical Memorandum)</td>
<td>• Comparison of the Boeing ECL and Airbus ECAM Non-Normal Checklists (manuscript and article)</td>
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<tr>
<td></td>
<td>• The Philosophy, Design, and Structure of Smoke and Fire Checklists (several papers and presentations)</td>
<td>• Paper vs. Electronic Checklists: Error Modes and Design Solutions (technical memorandum and presentations)</td>
</tr>
<tr>
<td><strong>Human Response and Performance</strong></td>
<td>• critical incident interviews with pilots who have been involved in accidents</td>
<td>• continue critical incident interviews with pilots who have been involved in accidents</td>
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<tr>
<td></td>
<td>• Declaring Emergencies: Fact and Fiction (presentation and article)</td>
<td>• Stress on the Flight Deck (several manuscripts – journal articles in peer-reviewed journals, technical memorandum, case studies)</td>
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<td></td>
<td>• Stress and Cognition – A Review of the Scientific Literature (grantee report)</td>
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<tr>
<td><strong>Personnel and Crew Coordination</strong></td>
<td></td>
<td>• Situation Critical: Coordination of Response to Emergency and Abnormal Situations (manuscript, article, and presentations)</td>
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<tr>
<td></td>
<td></td>
<td>• The Influence of Increased Security on Flight and Cabin Crew Communications (contractor report, articles and presentations)</td>
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<tr>
<td>Emergency Training of Flight Crews</td>
<td>• Current Practices in Emergency and Abnormal Training for Flight Crews (analysis of practices, strengths, and limitations - manuscript)</td>
<td>• 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)</td>
</tr>
<tr>
<td>Emergency Training of Cabin Crews</td>
<td>• Current Practices in Emergency and Abnormal Training for Cabin Crews (analysis of practices, strengths, and limitations - manuscript)</td>
<td>• 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</td>
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## Field Guides
Final End Products of the EAS Project
# EAS Research Theme Timeline – AvSSP Phase I

## Emergency and Abnormal Situations Project

<table>
<thead>
<tr>
<th>Year</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
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<tbody>
<tr>
<td>Q1</td>
<td>3rd Q</td>
<td>4th Q</td>
<td>1st Q</td>
<td>2nd Q</td>
</tr>
<tr>
<td>Q2</td>
<td>2nd Q</td>
<td>3rd Q</td>
<td>4th Q</td>
<td>1st Q</td>
</tr>
<tr>
<td>Q3</td>
<td>2nd Q</td>
<td>3rd Q</td>
<td>4th Q</td>
<td>1st Q</td>
</tr>
<tr>
<td>Q4</td>
<td>2nd Q</td>
<td>3rd Q</td>
<td>4th Q</td>
<td>1st Q</td>
</tr>
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</table>

### Current State of the Industry

### Problems with Procedures

### How is a Checklist Born?

#### The Non-Normal Checklist

### Human Response and Performance Issues

### Flight Crew Emergency Training
### EAS Research Theme Timeline – AvSSP Phase II

<table>
<thead>
<tr>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Q</td>
<td>2nd Q</td>
<td>3rd Q</td>
<td>4th Q</td>
<td>1st Q</td>
</tr>
</tbody>
</table>

#### Current State of the Industry

- Problems with Procedures
- How is a Checklist Born?
- The Non-Normal Checklist
- Human Response and Performance Issues
- Personnel and Crew Coordination Issues in Emergencies
- Flight Crew Emergency Training
- Cabin Crew Emergency Training
- Write Field Guides
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)
• 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 world's 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
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

EMERGENCY CHECKLIST

AIR CONDITIONING SMOKE

ECON P/B

SMOKE DECREASES

NO

No further action required.

END

AIR SYSTEM P/B
ECON P/B
PACK 1
OFF

17
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

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>OXYGEN MASKS AND SMOKE GOGGLES</td>
<td>ON/100%</td>
</tr>
<tr>
<td>RADIO RACK Switch</td>
<td>VENTURI</td>
</tr>
<tr>
<td>CABIN PRESSURE Control</td>
<td>MANUAL</td>
</tr>
<tr>
<td>EMER PWR Switch</td>
<td>ON</td>
</tr>
<tr>
<td>GEN Control and APU Bus Switch</td>
<td>OFF</td>
</tr>
</tbody>
</table>

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
- R & L GEN or APU BUS Switches
- F/O FLT INSTRUMENTS
- EMER PWR Switch
- AC EMERG FEED C/B’s (K10 & L11)

NOTE: If smoke disappears, fault is on AC emergency bus. If smoke continues:
- AC EMERG FEED C/B’s (K10 & L11)
- DC EMERG FEED C/B (M36)
  [930, 960 Series A/C (N37)]

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)]
- [A/C #960 (M36)]

B. If smoke stops or decreases, at Captain’s discretion:
- BATT Switch
- BATT DIRECT BUS C/B’s (Overhead)

NOTE: If smoke continues:
- BATT DIRECT BUS C/B’s (Overhead)
- DC TRANSFER BUS FEED C/B (M36)
  [930, 960 Series A/C (N37)]

-END-
Crew followed QRH procedures that were incomplete. This caused the aircraft to fall from 100 ft agl on final approach. The nosewheel separated from the aircraft.

The missing information was included in the AOM expanded checklists but was never transferred to the QRH checklists.
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.
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.
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
Sean Belcher, M.A.* ‡
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