HUMAN FACTORS
BEYOND THE SLOGAN

4º Simpósio de Segurança de Voo (SSV)
Agosto 2011

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Por Que Estamos Aqui?
DADOS DE SEGURANÇA E
ESTATÍSTICAS
BOEING ESTATÍSTICAS

Fatal Accidents and Onboard Fatalities by Phase of Flight

Percentage of total accidents and onboard fatalities

<table>
<thead>
<tr>
<th>Phase</th>
<th>21%</th>
<th>13%</th>
<th>12%</th>
<th>9%</th>
<th>4%</th>
<th>10%</th>
<th>4%</th>
<th>11%</th>
<th>13%</th>
<th>21%</th>
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</thead>
<tbody>
<tr>
<td>Taxi, land</td>
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<td>Climb</td>
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<td>Cruise</td>
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<td>Initial approach</td>
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<td>Landing</td>
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</tbody>
</table>

Percentage of flight time estimated for a 1.25 hour flight

Fatal accidents 13% 12% 9% 4% 10% 4% 11% 13% 21%
Onboard fatalities 0% 14% 13% 11% 20% 4% 14% 13% 11%

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CAST ESTATÍSTICAS: COMERCIAL

1987-2009 Worldwide
Part 121 Hull Loss and Fatal Accidents

Percentage of Total

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CAST ESTATÍSTICAS: COMERCIAL

1987-2009 Latin America & Caribbean Hull Loss and Fatal Accidents

- Fatality Risk
- Accidents

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Maio 2011

CAA TASK FORCE 7 (2009)

- Loss of Control (LOC)
- Runway Overrun or Excursion (RE)
- Controlled Flight into Terrain (CFIT)
- Runway Incursion (RI)
- Airborne Conflict
- Ground Handling
- Airborne and Post-Crash Fire

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### CAA TF 7: LOC

<table>
<thead>
<tr>
<th>Manual Flying</th>
<th>Automation</th>
<th>Type-Rated</th>
<th>Recovery Related</th>
<th>General Aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Flying Skills Assessment and Resency</td>
<td>Automation Design Issues</td>
<td>Dealing with Non-Standard Aircraft Status or Configuration Errors</td>
<td>Stall Prevention / Recovery Technology</td>
<td>Disregard of SOPs</td>
</tr>
<tr>
<td>Monitoring Skills</td>
<td>Maintaining Control When Automation Drops Out</td>
<td>Unestablished Approach Recognition and Action</td>
<td>Altitude Perception</td>
<td>Counterdistraction Strategies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ground Training</td>
<td></td>
<td>Pilot Selection</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fatigue Management</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>% Worldwide Causal Factor</th>
<th>% UK Causal Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>~85%</td>
<td>~40%</td>
</tr>
<tr>
<td>~80%</td>
<td>~57%</td>
</tr>
<tr>
<td>~95%</td>
<td>~48%</td>
</tr>
<tr>
<td>~78%</td>
<td>~8%</td>
</tr>
<tr>
<td>~85%</td>
<td>~40%</td>
</tr>
</tbody>
</table>

### CAA TF 7: CFIT

- **1997 – 2007 Worldwide Fatal Accidents**
  - Aircraft 12,500 lbs+ - all flight operations
  - 57 Fatal Accidents CFIT – 23% of all accidents

- **Top 5 Causal Factors**
  - Lack of positional awareness in air (95%)
  - Omission of action / inappropriate action (56%)
  - Failure in CRM (cross-check/coordinate) (32%)
  - Slow and/or low on approach (32%)
  - “Press-on-it-is” (25%)
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CAA TF 7: RUNWAY EXCURSIONS

[Bar chart showing the number of runway excursions by category]

CAA TF 7: RUNWAY INCURSIONS

- **Light Aircraft – Top 3 Causal Factors**
  - Pilot – Failed to follow clearance
  - Pilot – Failed to follow procedures
  - Pilot – Lack of experience/familiar

- **Heavy Aircraft - Top 3 Causal Factors**
  - Pilot – Failed to follow clearance
  - Pilot – Erroneous Expectation
  - Pilot – Failed to follow procedures
- 68 causal factors identified by AAG
- Top 5 groups present in 83% of fatal accidents

### Table 5: Five most common causal factor groups

<table>
<thead>
<tr>
<th>Causal Factor Group</th>
<th>Percent of accidents with group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight Crew</td>
<td>74%</td>
</tr>
<tr>
<td>Engine</td>
<td>17%</td>
</tr>
<tr>
<td>Aircraft Performance/Control</td>
<td>17%</td>
</tr>
<tr>
<td>Fire</td>
<td>15%</td>
</tr>
<tr>
<td>Aircraft Systems</td>
<td>12%</td>
</tr>
</tbody>
</table>

### Table 4: Five most common causal factor categories

<table>
<thead>
<tr>
<th>Causal factor</th>
<th>Percent of accidents with factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew - Omission of action/inappropriate action</td>
<td>36%</td>
</tr>
<tr>
<td>Crew - Flight handling</td>
<td>28%</td>
</tr>
<tr>
<td>Crew - Lack of positional awareness – in air</td>
<td>25%</td>
</tr>
<tr>
<td>Crew - Failure in CRM (cross check/co-ordinate)</td>
<td>22%</td>
</tr>
<tr>
<td>Crew - Poor professional judgement/airmanship</td>
<td>20%</td>
</tr>
</tbody>
</table>

- 68 causal factors identified by AAG
- Top 5 groups present in 67% of fatal accidents
U.S. Air Carrier Part 121 Accident Causal Factors

- Aircraft
- Environment
- Personnel

U.S. Part 91 Accident Causal Factors for 2005

- Aircraft: 25%
- Environment: 39%
- Personnel: 91%

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U.S. Part 91 Accident Human Factors Causal Factors for 2005

<table>
<thead>
<tr>
<th>Human Performance Issues</th>
<th>All Accidents</th>
<th>Fatal Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft handling/control</td>
<td>1,372</td>
<td>275</td>
</tr>
<tr>
<td>Planning/decision</td>
<td>489</td>
<td>106</td>
</tr>
<tr>
<td>Use of aircraft equipment</td>
<td>148</td>
<td>22</td>
</tr>
<tr>
<td>Maintenance</td>
<td>87</td>
<td>14</td>
</tr>
<tr>
<td>Communications/ATC</td>
<td>69</td>
<td>8</td>
</tr>
<tr>
<td>Meteorological service</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Airport</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Dispatch</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Underlying Explanatory Factors</td>
<td>116</td>
<td>57</td>
</tr>
<tr>
<td>Qualification</td>
<td>41</td>
<td>18</td>
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<tr>
<td>Physiological condition</td>
<td>31</td>
<td>25</td>
</tr>
<tr>
<td>Psychological condition</td>
<td>25</td>
<td>8</td>
</tr>
<tr>
<td>Aircraft/equipment inadequate</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Institutional factors</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Procedure inadequate</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Material inadequate</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Information</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Facility inadequate</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

CENIPA ESTATÍSTICAS: CIVIL

Incidência de Fatores Contribuintes 2000 a 2009

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Fatores Humanos

EXEMPLO DE ACIDENTES

RESUMO DE ACIDENTE

- Southwest Flight 1248
  - December 8, 2005
  - Time: 1914 CST
  - Boeing 737-7H4
  - Overran Runway 31 Center
  - 1 fatality, several minor injuries
RESUMO DE ACIDENTE

- Environmental Conditions
  - Steady snowfall
  - 25 degrees F (~ -4 C)
  - 200 foot ceiling
  - 8-9 knot tailwind

- Runway plowed 27 minutes prior
  - Worst runway friction reported by previous pilots landing = “Poor”
INVESTIGAÇÃO DE SISTEMAS

- Sistemas da Aeronave
  - Flap system
  - Spoiler system
  - Brake system
  - Anti-skid system
  - Thrust reverser (TR) actuation components
- Tudo estava funcionando sem problemas

AÇÕES DOS PILOTOS

- Captain set autobrakes at maximum setting
  - Crew overrode autobrakes after touchdown
- Captain reported having difficulty deploying Thrust Reversers
  - FO deployed TRs 18 seconds after touchdown
- Airplane departed pavement 7 seconds later
Fatores Humanos

- Factors ruled out
  - Certificated / qualified / trained
  - No accidents or violations
  - Medical and behavioral
  - Fatigue

- Relevant Factual Information
  - Decision to land
    - Mixed braking action reports
    - Performance calculations
  - Inability to stop the aircraft
    - Use of reverse thrust

Condição da Pista

<table>
<thead>
<tr>
<th>Report</th>
<th>Braking Deceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOOD</td>
<td>Normal...</td>
</tr>
<tr>
<td>Good to Fair</td>
<td></td>
</tr>
<tr>
<td>FAIR</td>
<td>Noticeably Reduced</td>
</tr>
<tr>
<td>Fair to Poor</td>
<td></td>
</tr>
<tr>
<td>POOR</td>
<td>Significantly Reduced</td>
</tr>
</tbody>
</table>

FAIR  Arrival End  POOR  Departure End
CONDIÇÃO DA PISTA

- SWA policy:
  - Defer to the “more critical term”
  - E.G., FAIR to POOR ➔ POOR

- SWA policy:
  - POOR: 5kt tailwind component limit

- Crew unaware of mixed report policy

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CONDIÇÃO DA PISTA

- How to Categorize Mixed Reports:
  - Written Guidance: Limited
  - Training: Inconsistent

- Other pilots also were unaware

- Three previous SWA aircraft landed
  - All four landings were in violation of guidance

- SWA amended training and guidance
CÁLCULOS DE DESEMPENHO

Onboard Performance Computer (OPC)

Output: Stopping Distance
- Margin = Remaining Pavement

Crew performed several assessments:
- "FAIR" = margin of 560’
- "POOR" = margin of 40’

Crew uncomfortable with 40’
- Expected conditions better than POOR
  - Expected a margin between the two values
- Expected increased margin with reverse thrust
CÁLCULOS DE DESEMPENHO

- OPC assumptions:
  - Reverse thrust use assumed (unless MEL)
  - Tailwind component limit (5kt)

- Stopping Margins not based on information entered or displayed
  - Presented 8kt tailwind (represents actual)
  - Used 5kt maximum instead

- Stopping margin based on 8kt: -260

CÁLCULOS DE DESEMPENHO

- Programming
  - Inconsistent programming across fleet

- Training / guidance / presentation
  - Limited training of assumptions
  - Incorrect in some cases
  - Assumptions could not have been determined by reviewing the display output

- SWA updated programming
CÁLCULOS DE DESEMPENHO

- Flight Operations Manual:
  - “Landing authorized with any positive stopping distance with max auto brake setting”

- Crew deliberated their level of comfort with this guidance
  - Captain was uncomfortable with landing, but did not follow through with his initial position
  - Assertive First Officer

INVERSOR DE PROPULSÃO

Stowed

Deployed
**INVERSOR DE PROPULSAO**

- **Policy required reverse thrust immediately**
  - All landings
  - Emphasized: Conditions less than GOOD
  - Crew and other pilots aware of protocol

- **Delay in command of reverse thrust**
  - No delay: Would have been able to stop

- **Other SWA pilots landing at MDW**
  - All used reverse thrust immediately

---

**INVERSOR DE PROPULSAO**

- **New autobrake procedure**

- **Pilot actions upon touchdown in conditions less than GOOD:**
  - Prior: Manual reverse thrust and manual brakes
  - New: Manual reverse thrust only

- **Learning new procedures**
  - Additional cognitive demands
  - Requires practice
INVERSOR DE PROPULSAO

- **Automatic Task Sequences**
  - Absence ➔ Absence
  - Activation ➔ Activation

- **Accident Sequence:**
  - Refrained from manual brakes
    
    *Failed to deploy reverse thrust*
  - Manual brakes applied
    
    *Thrust reverse within 3 sec*

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INVERSOR DE PROPULSAO

- **Operator Trials in Development of Auto Brake Policy**
  - Other company pilots demonstrated delay during first use of autobrakes
  - There were two trials; same outcome

- **Captain of Accident Aircraft**
  - Captain stated being distracted
  - Post-accident familiarization period
CAUSA PROVÁVEL

- “The *pilots’ failure* to use available reverse thrust in a timely manner to safely slow or stop the airplane after landing, which resulted in a runway overrun.”

- “This *failure occurred because* the pilots’ first experience and lack of familiarity with the airplane’s auto brake system *distracted* them from thrust reverser usage during the challenging landing.”

FATORES QUE CONTRIBUÍREM

- “Southwest *Airlines’*

  1. *failure* to provide its pilots with *clear and consistent guidance* and *training* regarding company policies and procedures related to arrival landing distance calculations;

  2. *programming and design* of its on board performance computer, which did not present inherent assumptions in the program critical to pilot decision-making;

  3. *plan to implement new* auto brake *procedures* without a familiarization period; and

  4. *failure to include a margin of safety* in the arrival assessment to account for operational uncertainties.”
“The pilots’ failure to divert to another airport given reports that included poor braking actions and a tailwind component greater than 5 knots.”

“Contributing to the severity of the accident was the absence of an engineering materials arresting system, which was needed because of the limited runway safety area beyond the departure end of runway 31C.”

**Fatores que contribuírem**

- Aircraft
  - Handling/Service
  - Systems
  - Structures
  - Propeller/Rotor
  - Power Plant
  - Performance/capability
  - Fluids/Misc. Hardware

- Environment
  - Operating environment
  - Physical environment
  - Conditions/weather
  - Task environment

- Personnel
  - Physical
  - Psychological
  - Experience/knowledge
  - Action/Decision
  - Task Performance
  - Miscellaneous

- Organizational
  - Development
  - Management
  - Support/oversight
FATOES QUE CONTRIBUÍRAM

Equipment Design
- Display of Information
- MFG Certification Data and Recommendations

Pilot/Crew
- Decision-Making
- Information Processing
- SOP Knowledge / Adherence
- Automatic Behaviors
- Distraction
- Workload

Oversight (FAA)
- Guidance, Policies, Procedures
- Advanced Technologies

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Intervalo para Café

TEMPO PARA DESCANSAR

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