Additional Emergency Exit for Flight Tests

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EMBRAER Flight Test
FTSW, Seattle, 05.02.2012
Summary

• Introduction;
• Requirements for acft. exits;
• Emergency Exit: 80s and 90s;
• Additional Emergency Exit: 21st century;
• New products
• Lessons Learned
• Q&A
This presentation covers historical events, the last 20 years learning results on additional emergency exits for EMBRAER flight test prototypes, submitted to a civil certification process (ANAC, FAA, EASA), and the latest features added to the Legacy 500 (001 and 002 prototypes), with its test results.
FAR for Exits

• 25.561
  (a) acft. must be designed to protect each occupant.  
  (b) designed to give chance of escaping in a minor 
  crash landing;  
  (d) Seats and items of mass must not deform, that 
  would impede evacuation of occupants.

• 25.562
  Restraint sys: proper use, performance, Head Impact 
  Criteria...
FAR for Exits

• 25.807
Type of exits (I, II, III, IV, A, B, C...) size, ground clearance....

• 29.783
Doors: latches, locks, access, strenght....

• 29.809
Emergency Exits: works, functions and slides

But...
Identified High Risk Situations

• Ground Egress:
  – $V_{mcg}$, $V_{mu}$, Brake Efficiency, Max. Kinetic Energy, Quick Tourn Around, Landing Perf., Steep Approach, Take Off Perf., Water ingestion;

• Stabilized Flight Bail-out:
  – Deep Stall, Flat spin;

• Uncontroled Flight Bail-out:
  – Structural failure.
FAR for Exits

- FAR 21.35 (d) provision is made for the flight test crew for emergency egress and the use of parachutes.

- Passenger doors, emergency doors or windows commonly supplied for passenger usage are not meant to be used in motion, nor on situations encountered on envelope opening of the compliance demonstration process.

- Regarding the above listed requirements our team asked for additional safety features to be installed on the flight test articles

  “The additional exit for flight test”
EMBRAER history: EMB-110 – Bandeirante

- Early 70s
- FAR 23 req. cert.
- 18 pax, 13000 lb mtow
- Emg. Window & pax door

- No additional exit features!
EMBRAER history: EMB-121 – Xingu

- 8 pax, 12500 lb mtow;
- FAR 23 req. cert.;
- Emg. Window & pax door
- 1st Pressurized acft!

- Bungee actuated emergency window
EMBRAER history: EMB-120 – Brasilia

- Late 80s;
- 30 pax, 25300 lb mtow;
- FAR 25 req. cert.;
- One pax door;
- 2 emg. windows, one right emg. door;

- Bungee actuated emergency window
- Bungee actuated seat rail
EMB-120: Bungee actuated seat rail

- The exit was through the left emergency window (overwing);
- The escape sequence was:
  depressurize acft., trigger bungee, open window and jump through window.
EMBRAER history: CBA-123 – Vector

- Early 90s;
- 19 pax, 17000 lb mtow;
- FAR 25 req. cert.;
- One pax door;
- 2 emg. windows, 1 pax. door;
- Pusher fans

- Ventral Exit
CBA-124: Ventrail Exit

- The exit was through the right ldg enclosure;
- The escape sequence was: lower ldg, depressurize acft., run to the back, jump through hole
EMBRAER history: ERJ-145

• 50 pax, 48500 lb mtow;
• FAR 25 req. cert.;
• Pax, Service, Cargo doors & 2 emg. windows
• 1st jet acft!

Explosive windows
ERJ-145: Bailout Ballistic
ERJ-145: Explosive windows

• The exit was through the cockpit windows and a blown up hole on the right side of the fuselage.
• The escape sequency was: Push trigger, jump out.
Hollow Charge

V or U shaped explosive chord, that focus the explosive energy into a single narrow point, producing a predictive and controlled cut.

Munroe effect or Neumann effect

(not made in Brazil)
ERJ-145: Explosive windows

1st try

2nd try
ERJ-145: Explosive windows

Final conf.
EMBRAER flightline today: E170/ E175

- 70+ pob, 74800lb mtow;
- FAR 25 req. cert.;
- FBW;
- Under cabin Cargo.

Escape Hatch
Additional exit (BAC-111 2nd prototype)
E170, E190: Escape Hatch

“Potty”
E170, E190: Escape Hatch

- Subcontracted to European Supplier

IMPORTED
(not made in Brazil)
E-170: “Potty” hole

- The exit was through the aft hatch;
- The escape sequence was: depressurize acft., run all the way to the back, blow the door, jump through hole
E-175, E-195

“Fast” opening door for pressurized situations.
Phenom 100 / 300

- 6+ pob, 17500 lb mtow
- FAR 23 req. cert.
- Pax door, emg. window

Extraction Markings
Phenom 300: Extraction Markings

- Small if compared to E-jets;
- Tight schedule;
- Low budget;
Phenom 100 / 300: extraction markings
Upcoming EMBRAER Flightline

- 14 pob, 41800lb mtow
- FAR 25 req. cert.
- Pax door, 1 emg. Window
- M 0.83
- Full FBW

Legacy 500 / 450
Identified High Risk Test Situations

• Ground Egress:

• Stabilized Flight Bail-out:
  – Deep Stall, Flat spin; Flight controls malfunction,

• Uncontroled Flight Bail-out:
  – Structural failure; Flight Controls Departure, Flight Controls Inop.
Legacy 500: Additional Exit Options

- Overwing Emergency window
- Cockpit side window
- Position 1
- Position 2
- Position 3
- Position 4
Legacy 500: Additional Exit Options

-2 frames
-5 stringers

-1 frames
-3 stringers
Legacy 500: Bailout Ballistic
## Legacy 500: Additional Exit Options

<table>
<thead>
<tr>
<th>position</th>
<th>description</th>
<th>ground egress</th>
<th>stabilized flight bail out</th>
<th>project and implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>high speed</td>
<td>flat spin</td>
</tr>
<tr>
<td>1</td>
<td>rh lateral 4h</td>
<td>may be obstructed in ground</td>
<td>possible wing hit</td>
<td>possible engine hit</td>
</tr>
<tr>
<td>2</td>
<td>rh lateral 3h</td>
<td>not obstructed in ground</td>
<td>clear bail out</td>
<td>possible tail hit</td>
</tr>
<tr>
<td>3</td>
<td>rh lateral 5h</td>
<td>obstructed on ground</td>
<td>possible wing hit</td>
<td>possible engine hit</td>
</tr>
<tr>
<td>4</td>
<td>front floor</td>
<td>obstructed in ground</td>
<td>possible belly hit</td>
<td>possible belly hit</td>
</tr>
<tr>
<td>5</td>
<td>cabin door (lh)</td>
<td>obstructed on ground</td>
<td>clear bail out</td>
<td>possible tail hit</td>
</tr>
<tr>
<td>6</td>
<td>rh lateral emerg. window</td>
<td>not obstructed on ground</td>
<td>clear bail out</td>
<td>possible engine hit</td>
</tr>
<tr>
<td>7</td>
<td>cockpit side window</td>
<td>not obstructed on ground</td>
<td>not enough space to bail out with parachute</td>
<td></td>
</tr>
</tbody>
</table>
Legacy 500: Additional Exit Options

Pax Door

Additional Emergency Exit

Emergency Window
Legacy 500: Emerg. Window Handle

17kg @ 9.6 psid (45000 ft)
Legacy 500 Additional Emergency Exit

708mm wide x 740mm tall
Legacy 500: Explosive Trigger Positions

- Cockpit trigger
- External trigger
- Aft trigger
Legacy 500: Explosive frame

708mm wide x 740mm tall
Explosive charge test #1 - before

Made in Brazil
Explosive charge test #1
Explosive charge test #1 - after
Explosive charge test #2 - before
Explosive charge test #2
Explosive charge test #2 - after
Lessons Learned

- Gvmt. (safety) requirements are not enough for envelope opening flight tests;
- Extra safety devices may require structural changes;
- Extra safety devices may not interfere with tests and its conformity;
- Development Schedule and tight budget may easily push a Corporate No-Go decision;
- Almost the same recipe may turn out in almost a different cake;
- Do not produce a safety device that results in more danger than if you did not have it!
Questions?
Thank You!