Turkish Airlines 1951
25 February 2009, Schipol Airport (EHAM)
SYST 560
Accident Turkish Airlines 1951

Runway 18R

737-800 crashed during approach 1nm from runway
Background

• B737-800
• Turkish Airlines flight from Istanbul Atatürk Airport in Turkey (LTBA) to Amsterdam Schiphol Airport (EHAM)
• 25 February 2009.
• Aircraft crashed while on approach to Runway 18R (the ‘Polderbaan’)
• Crashed in a field 1nm from runway threshold
• Died: 4 crew members and 5 passengers died
  – Injured: 3 crew members and 117 passengers (out of 128)
<table>
<thead>
<tr>
<th>Location</th>
<th>Frequency</th>
<th>MSL Altitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>EHAM/AMS</td>
<td>108.4</td>
<td>132.97</td>
</tr>
<tr>
<td>SCHIPOL Approach</td>
<td>119.05</td>
<td>-</td>
</tr>
<tr>
<td>SCHIPOL Arrival</td>
<td>118.4</td>
<td>131.15</td>
</tr>
<tr>
<td>SCHIPOL Tower</td>
<td>119.22</td>
<td></td>
</tr>
</tbody>
</table>

**ILS Information**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOC VFR</td>
<td>110.1</td>
</tr>
<tr>
<td>Final Apch Crs</td>
<td>184°</td>
</tr>
<tr>
<td>DA(H)</td>
<td>166' / 200'</td>
</tr>
<tr>
<td>RWY Elev</td>
<td>-11'</td>
</tr>
<tr>
<td>RWY</td>
<td>-12'</td>
</tr>
</tbody>
</table>

**Missed Approach**

Turn RIGHT as soon as practicable to intercept R-280 SPL and do not overshoot R-240 SPL. Climb to 2000', cross E1624 at 2000'. Inform ATC.

**Additional Information**

1. Simultaneous approaches on rwy 06, 16C, 24, 27 or 35L may be executed.
2. When established on ILS maintain 140 KT until DA or VFR or as directed.
3. For additional information refer to 10-1P pages.
4. ILS DME reads zero at rwy 18R displaced threshold.
Surrounding Facts

• Flight 1951 was late
• Low visibility
• Flight crew
  – F/O – Trainee (line flying under supervision)
    • 17th flight
  – Captain – Instructor
  – Safety Pilot (1st 20 flights)
• Unstable approach
  – Capture localizer at 5.5 nm from runway threshold
  – High and fast on glideslope
• Radio Altimeter on Captains side malfunctioned
Approach

- **TDZE 12′ MSL**
- **3° Glidepath**
- **DA 188′ MSL**
- **RA** = Radio Altitude
- **Runway**
- **MSL Terrain**
Unstable approach

Preferred Localizer capture point

Capture localizer at 5.5 nm from runway threshold
Unstable Approach

- Glideslope captured from above
- Increased rate-of-descent requires idle-thrust to decelerate to Landing Speed
Equations of Motion

• $M \frac{dv}{dt} = \text{Thrust} - \text{Drag} - W \sin (\text{FPAngle})$
  - $M = \text{mass}$
  - $W = \text{weight} = mg$
  - $\text{FPAngle} = \text{Flight Path Angle}$

• Level flight ($\text{FPA}= 0$), constant speed ($\frac{dv}{dt}=0$)
  Thrust = Drag

• Descending ($\text{FPA} < 0$), constant speed
  Thrust = Drag + $W\sin(\text{FPA})$ : note $W\sin(\text{FPA}) < 0$

• Descending, decelerating ($\frac{dv}{dt} < 0$)
  Thrust = Drag + $W\sin(\text{FPA}) + m \frac{dv}{dt}$ : note $W\sin(\text{FPA})$ & $m\frac{dv}{dt} < 0$

Where is the THRUST LEVER when descending and decelerating?
High and fast V/S mode selected. Throttle lever retards to idle (as it should) through 144 knots (as it should), but throttles remain at Idle (instead of adding thrust).
Conduct Final Approach

- Conduct Final Approach with Autothrottles
  - Task in Progress
  - Complete Task

- Conduct Final Approach without Autothrottles
  - Task in Progress
  - Complete Task

- Go Around

- Stall Recovery
  - Conduct Final Approach without Autothrottles

- Flare
Non-intuitive Automation Configuration

Captain’s
Radio Altimeter

Left Autopilot

Autothrottle

Right Autopilot

F/O
Radio Altimeter

Captain’s
PFD

F/O
PFD
Accident Report – “Probable Cause”

• Primary cause:
  – faulty radio altimeter (had failed 2x in previous 25 hours) triggered incorrect automation reaction

• Contributing factor:
  – Crew noticed too late to take appropriate action to increase the throttle and recover aircraft (before stalled and crash)

• Solution:
  – Boeing issued a bulletin to remind pilots of all 737 series aircraft
    • “... importance of monitoring airspeed and attitude,”
    • “.. advising against the use of autopilot or autothrottle while landing in cases of radio altimeter discrepancies”
What did the PF (F/O) Know?

(1) Faulty radio altimeter on Captain’s side reads “-8” when aircraft on approach starting at 2000’

(2) Autothrottle reduces thrust for deceleration
   Autothrottle switches to RETARD Mode to reduce thrust for landing (< 27ft AGL) and engine noise decreases.

(3) Throttle levers move and engine noise decreases.

(4) Speed decays from 210 knots through landing speed until stall. Throttles have no intention to hold desired speed 160 knots.

(5) Need to override Autothrottles in RETARD
What did the PM (Captain) Know?

1. Faulty radio altimeter on Captain’s side reads “-8” when aircraft on approach starting at 2000’

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5. Need to override Autothrottles in RETARD
### What the Pilot Flying (F/O) Saw

<table>
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<tr>
<th>Mission Task - Stage</th>
<th>Mission Task - Operator Actions</th>
<th>Prompts and Cues (Competing Cues listed)</th>
<th>Hidden Knowledge to complete the task</th>
</tr>
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</table>
| Id Task              | Recognize need to conduct the approach with the autothrottles off. | 1. Primary - Speed decaying below reference landing speed  
2. Secondary - FMA Retard  
3. Throttle Levers retard early (may occur if aircraft high and fast)  
Competing - Everything in the cockpit and out the window including TOO LOW! GEAR! aural alert which was obviously wrong. | The autothrottle mode logic uses only one of the radio altimeters as input (in this case the Captain’s side). The TOO LOW! GEAR! aural alert above a threshold AGL is an indication of a loss of radio altimeter |

| Select Function      | Decide to use...  
A/T Disengaged button  
OR  
Autothrottle ARM to OFF  
Manually hold throttles at full power position | None.  
Note: infrequent task to over-ride automation | Override Autothrottle by pressing either the A/T *disengage* buttons or switching off the autothrottle "ARM" switch, or to manually hold throttles at full power position. |
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<tbody>
<tr>
<td>Access</td>
<td>Locate Throttle Levers</td>
<td>High frequency input devices (no cues required)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Locate MCP A/T Arm Switch</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Locate MCP A/T Engage Button</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enter</td>
<td>Push throttles forward and hold at firewall, or Turn A/AT ARM switch to OFF and push throttle levers to firewall, or push A/T Engage button and push throttle levers to firewall</td>
<td>High frequency input devices (no cues required)</td>
<td>Override Autothrottle by pressing either the A/T disengage buttons or switching off the autothrottle &quot;ARM&quot; switch, or to manually hold throttles at full power position.</td>
</tr>
<tr>
<td>Confirm &amp; Verify</td>
<td>FMA Throttle Lever Position</td>
<td>No verification action required.</td>
<td></td>
</tr>
<tr>
<td>Monitor</td>
<td>FMA Throttle Lever Position</td>
<td></td>
<td></td>
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Task/HCI Viewpoint?

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- Did automation alert the crew to this failure?
- Did automation provide guidance on how to complete procedure in presence of this failure?
- Did automation alert the crew to this stall scenario?
- Did automation provide guidance on how to complete procedure in presence of this stall scenario?
Homework

1. Describe in your own words **what** happened to Turkish Airlines 1951 (hint: sequence of events)
2. Describe in your own words **how** the accident happened
3. What information did the pilots have and when?
4. Do agree/disagree with the findings of the accident report? Explain.
5. What role did each of the following stakeholders have in the accident? Explain

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