

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)

EHAM/AMS

Alt Elev -11' (BELOW SEA LEVEL)
 NSD 18.5 8204 45.9

JEPPISEN AMSTERDAM, NETHERLANDS

10-9
 16 Oct 08
 FTL 23 Oct

SCHIPHOL

D-ATIS Departure 122.2	ACARS DL	SCHIPHOL Delivery 121.97	Starup 121.65	ATC Operational Information 131.35	Ground 121.7 121.8 121.9	Tower 119.22	Departure 119.05 121.2
---------------------------	-------------	-----------------------------	------------------	---------------------------------------	-----------------------------	-----------------	---------------------------



Pilot of arriving and departing the landing may
 their contact SCHIPHOL Ground immediately:

LANDING RWY	FREQUENCY
04/22	121.8
06/24	121.7
08/27	121.6
10/25	121.5
12/28	121.4
14/31	121.3
16/33	121.2

- Plots are strongly requested after having
 advanced & read back the erroneous clear
 to switch to ATIS instructions to
 SCHIPHOL Start-up.
- Information about expected RWY combination
 related to SIDs during peak hours, is
 broadcasted on this frequency.

RUNWAY ENCROUSION HOTSPOTS
 (For information only, not to be construed as A.C. instructions.)
 Do not enter NS when instructed to taxi via Taxi B or A14 or A15
 (on standard routing).

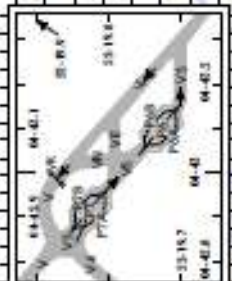
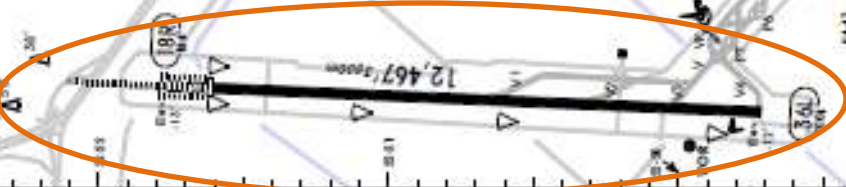
When taxiing on R2 to beginning runway 18L do not turn RIGHT onto
 runway 09. Be sure to have a clearance before crossing runway 09/27.
 When taxiing to runway 18L on R2, do not turn onto R2.
 After landing do not cross red radial on lights of displaced runway
 end 20B. No lights available beyond displaced runway end 20B.

Do not cross red lights at displaced runway end 20B. Inform ATIS in
 advance when additional length is required.

When taxiing from the north on Taxiway 2 via holding point 22,
 do not turn LEFT at W12 or W11.

For AIRPORT SERVICES refer to 10-1P pages

LEGEND
D Ramp
AP Taxi way
H4 Hangar
Rectangles (shaded) Repairs (holding) / De-icing area



EHAM/AMS
SCHIPHOL **JEPPesen AMSTERDAM, NETHERLANDS**
11-4 RNAV POBAN 1 Apch & ILS Rwy 18R

Initial Altitude	SCDHOL Approach (R)	SCDHOL Arrival (APP/R)	SCDHOL Departure	Initial
108.4 132.97	119.05 121.2	118.4 131.15	119.22	121.9

LOC VPS	Final Apch Crs	GS No Altitude published	ILS DA(M)	App Elev
110.1	184°		188' (200')	-11' RWY -12' (Below SEA LEVEL)

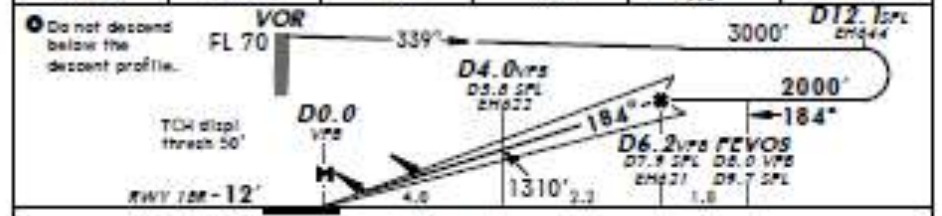


MISSED APCH: Turn RIGHT as soon as practicable to intercept R-280 SPL and do not overshoot R-240 SPL. Climb to 3000', cross EH624 at 2000'. Inform ATC.

Alt Set: hPa Rwy Elev: 0 hPa Trans level: By ATC Trans alt: 3000'
 1. Simultaneous apchs on rwy 06, 18C, 32, 37 or 34R may be executed. 2. When established on ILS maintain 140 KT until DA.0 VPS or as directed. 3. For additional information refer to 10-3F pages. 4. ILS DME reads zero on rwy 18R displaced threshold.



LOC (IGS out)	VPS DME	1.0	2.0	3.0	5.0
	ALTITUDE	320	670	990	1630



Wind speed-kts	70	90	100	120	140	160
ILS GS 3	377	485	539	647	755	862
LOC Descent angle	3.00°					
MAP at DA.0 VPS	1.0					

Standard STRAIGHT-IN LANDING RWY 18R
 ILS LOC (IGS out) CIRCLE-TO-LAND

Licensed to Saveit. Printed on 28 Dec 2008.

NOTICE: PRINTED FROM AN EXPIRED REVISION. Disc 24-2008

JEPPESEN
JeppView 3.6.3.1

EHAM/AMS
SCHIPHOL

2 MAR 09
EHI 12 Mtr



JEPPESEN AMSTERDAM, NETHERLANDS
RNAV **POBAN 1** Apch & ILS Rwy 18R

D-ATIS Arrival	SCHIPHOL Approach (R)	SCHIPHOL Arrival (APP/R)	SCHIPHOL Tower	Ground
108.4 132.97	119.05 121.2	118.4 131.15	119.22	121.9

LOC VPS 110.1	Final Apch Crs 184°	GS No Altitude published	ILS DA(M) 188' (200')	Apch Elev: -11' RWY: -12' (BELOW SEA LEVEL)
----------------------------	----------------------------------	--------------------------------	------------------------------------	---

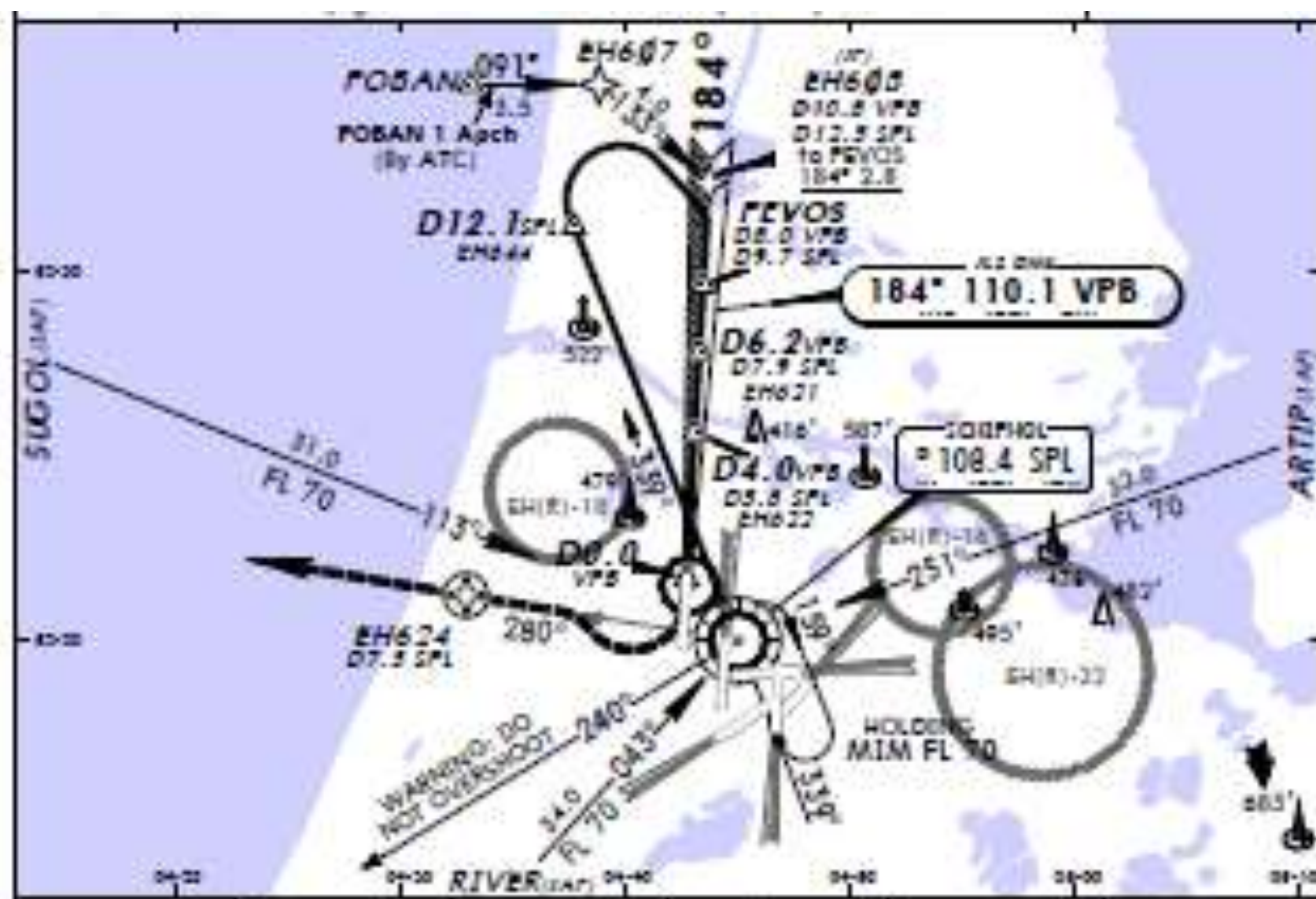
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
-22
-23
-24
-25
-26
-27
-28
-29
-30
-31
-32
-33
-34
-35
-36
-37
-38
-39
-40
-41
-42
-43
-44
-45
-46
-47
-48
-49
-50
-51
-52
-53
-54
-55
-56
-57
-58
-59
-60
-61
-62
-63
-64
-65
-66
-67
-68
-69
-70
-71
-72
-73
-74
-75
-76
-77
-78
-79
-80
-81
-82
-83
-84
-85
-86
-87
-88
-89
-90
-91
-92
-93
-94
-95
-96
-97
-98
-99
-100

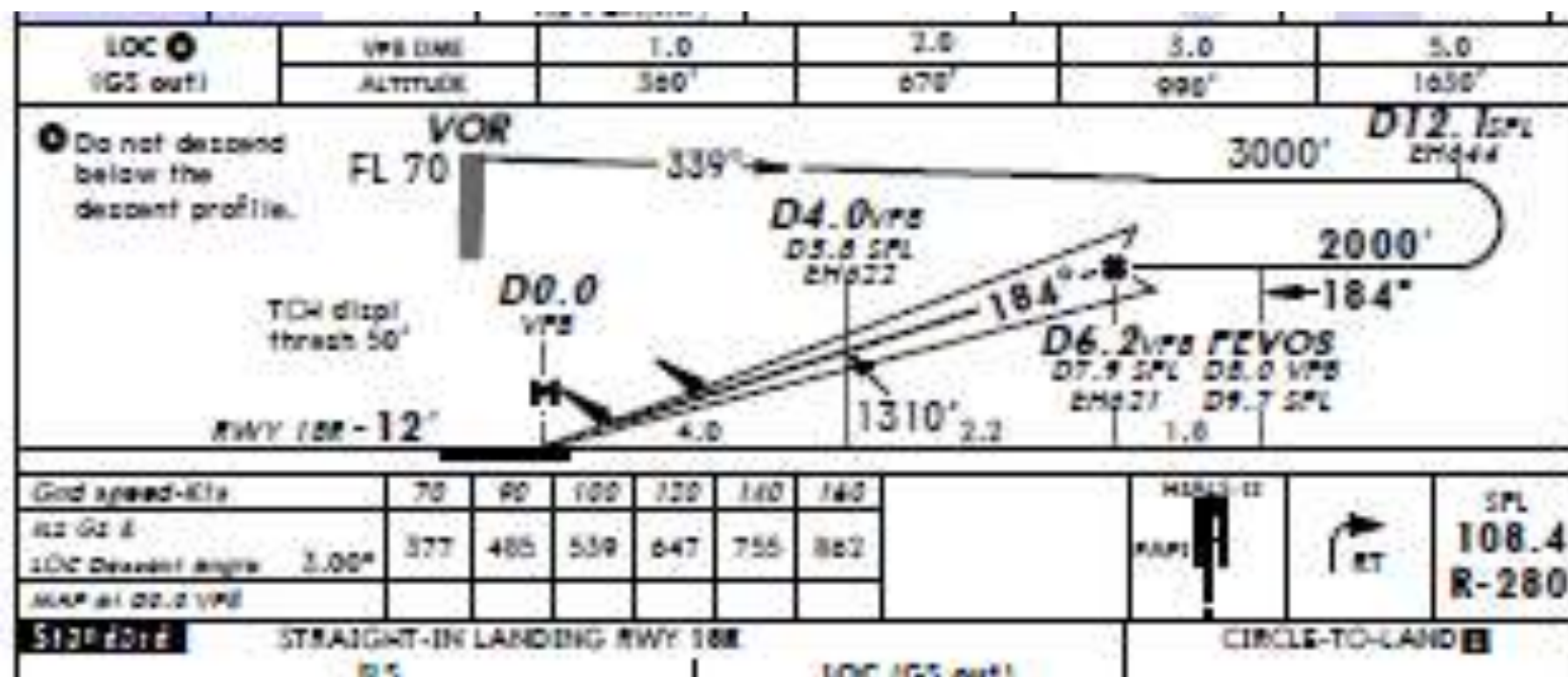
MISSED APCH: Turn **RIGHT** as soon as practicable to intercept R-280 SPL and do not overshoot R-240 SPL. Climb to 2000', cross EH624 at 2000'. Inform ATC.

Alt Set: hPa Rwy Elev: 0 hPa Trans level: By ATC Trans alt: 3000'
1. Simultaneous apchs on rwy 06, 18C, 22, 27 or 36R may be executed. 2. When established on ILS maintain 140 KT until D4.0 VPS or as directed. 3. For additional information refer to 10-1P pages. 4. ILS DME reads zero at rwy 18R displaced threshold.



MSA
5/PL VOR

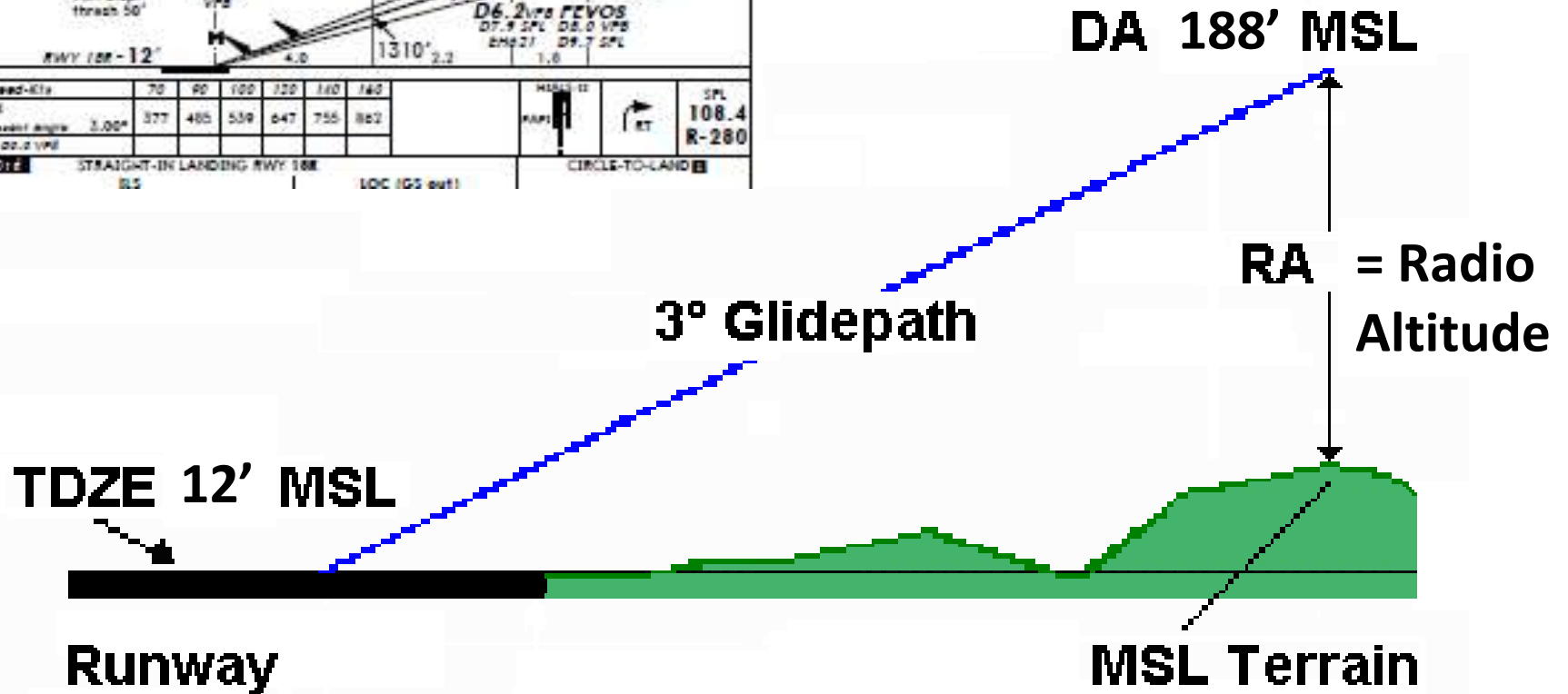
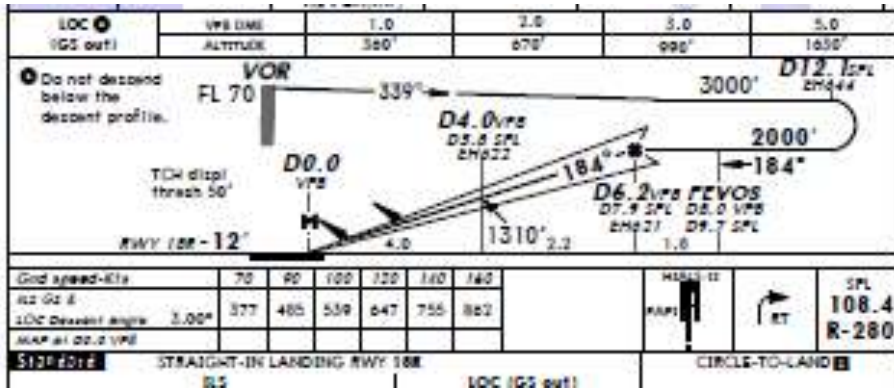




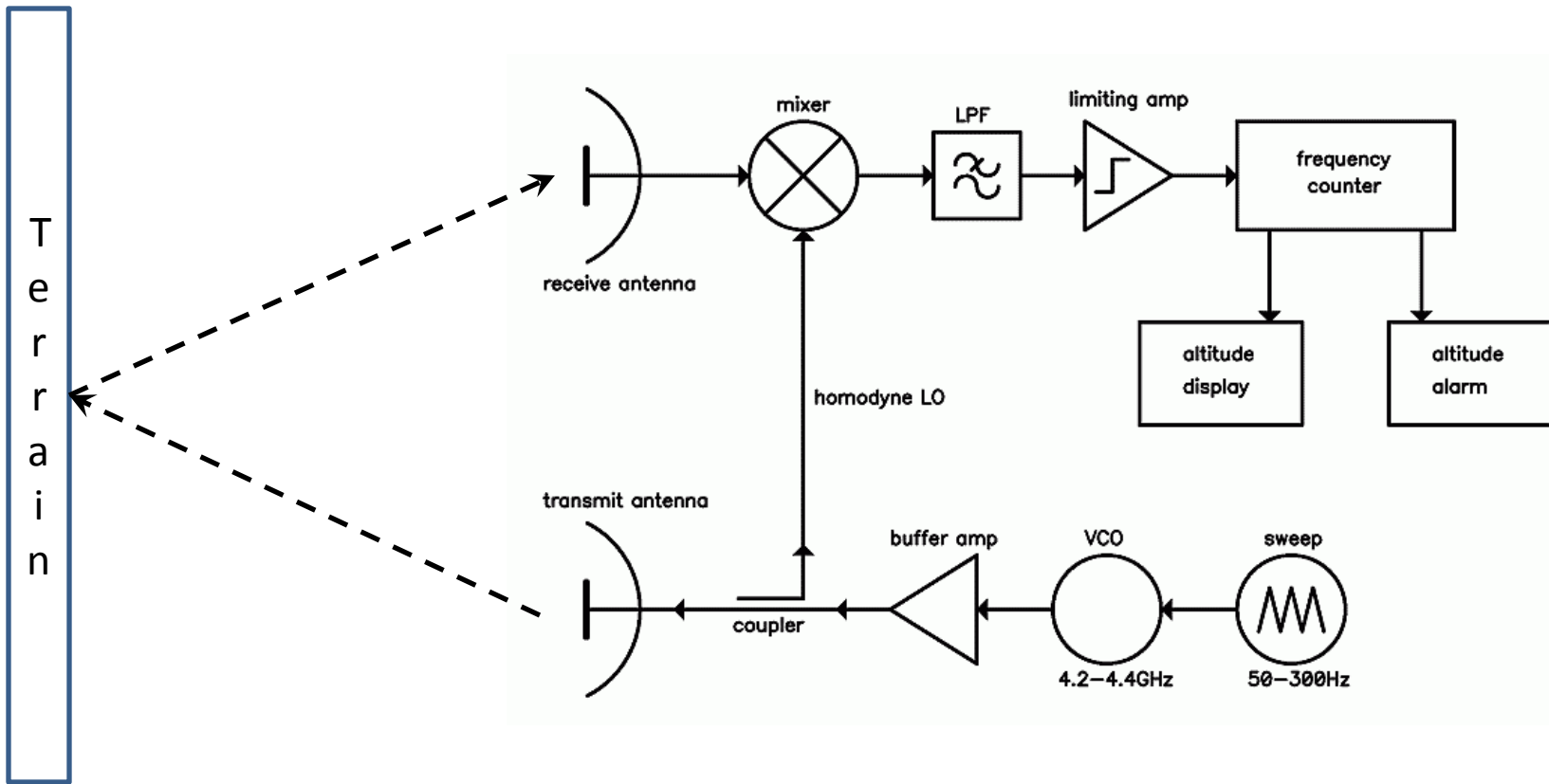
Surrounding Facts

- 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

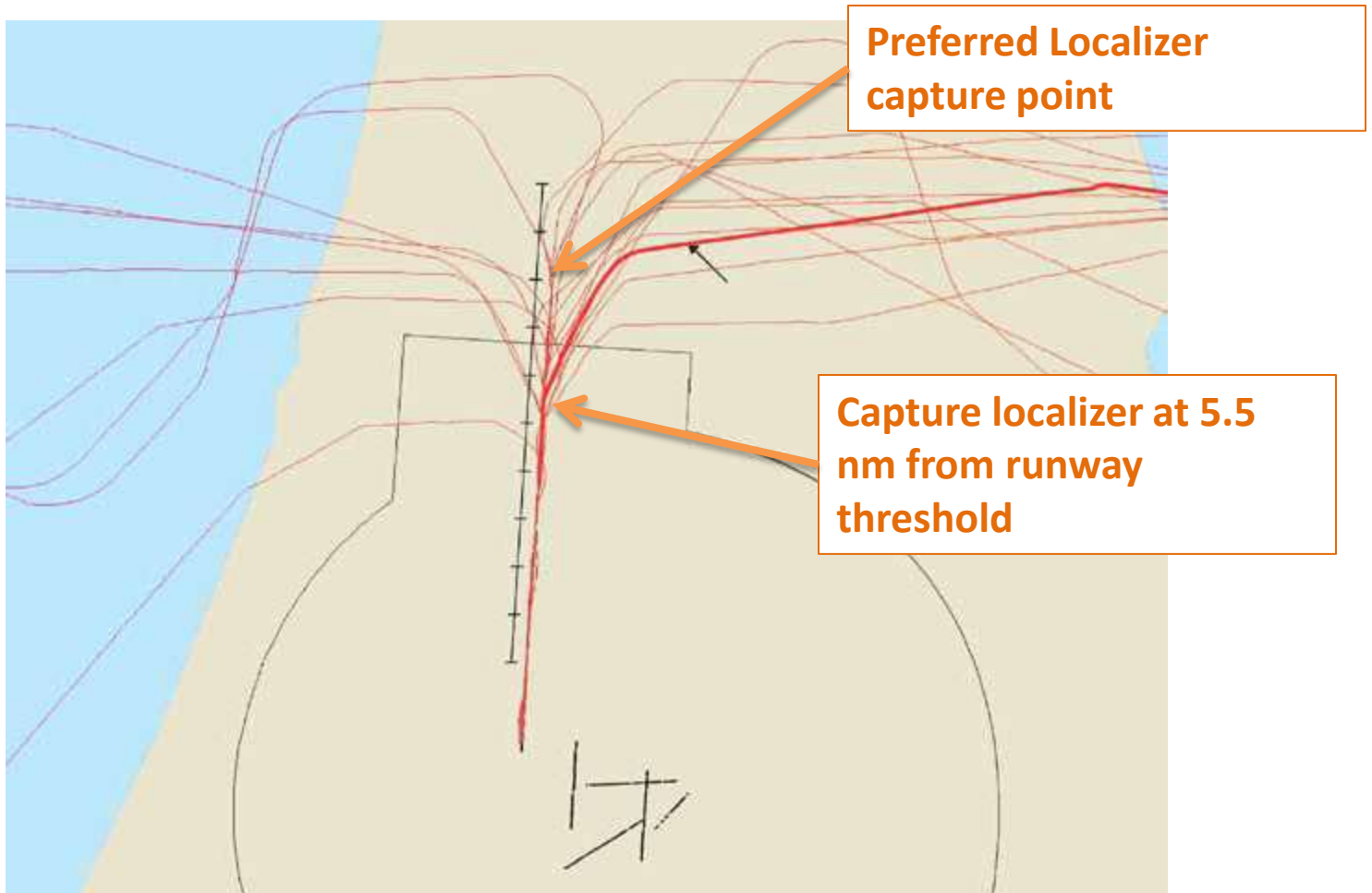
Approach



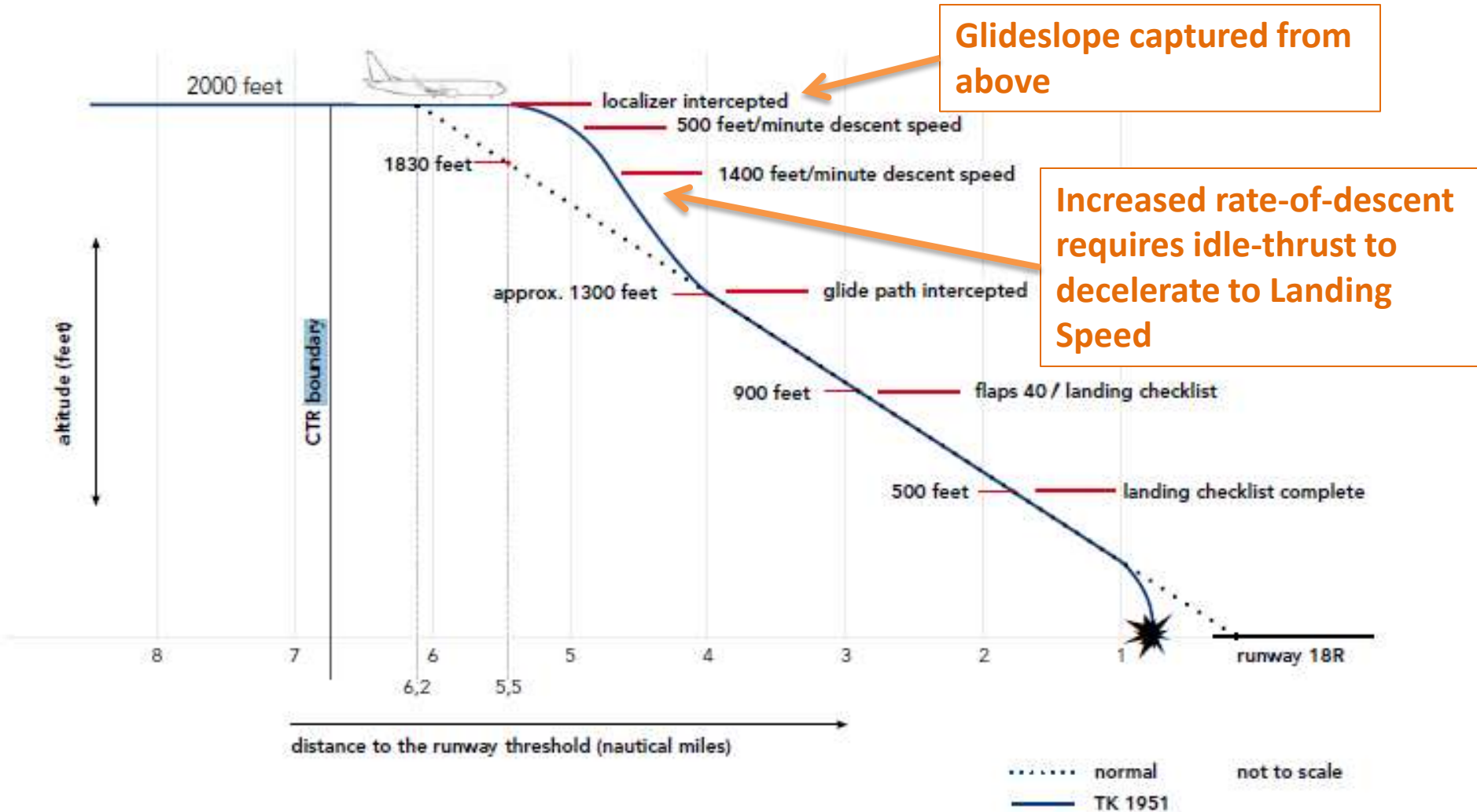
Radio Altimeter



Unstable approach



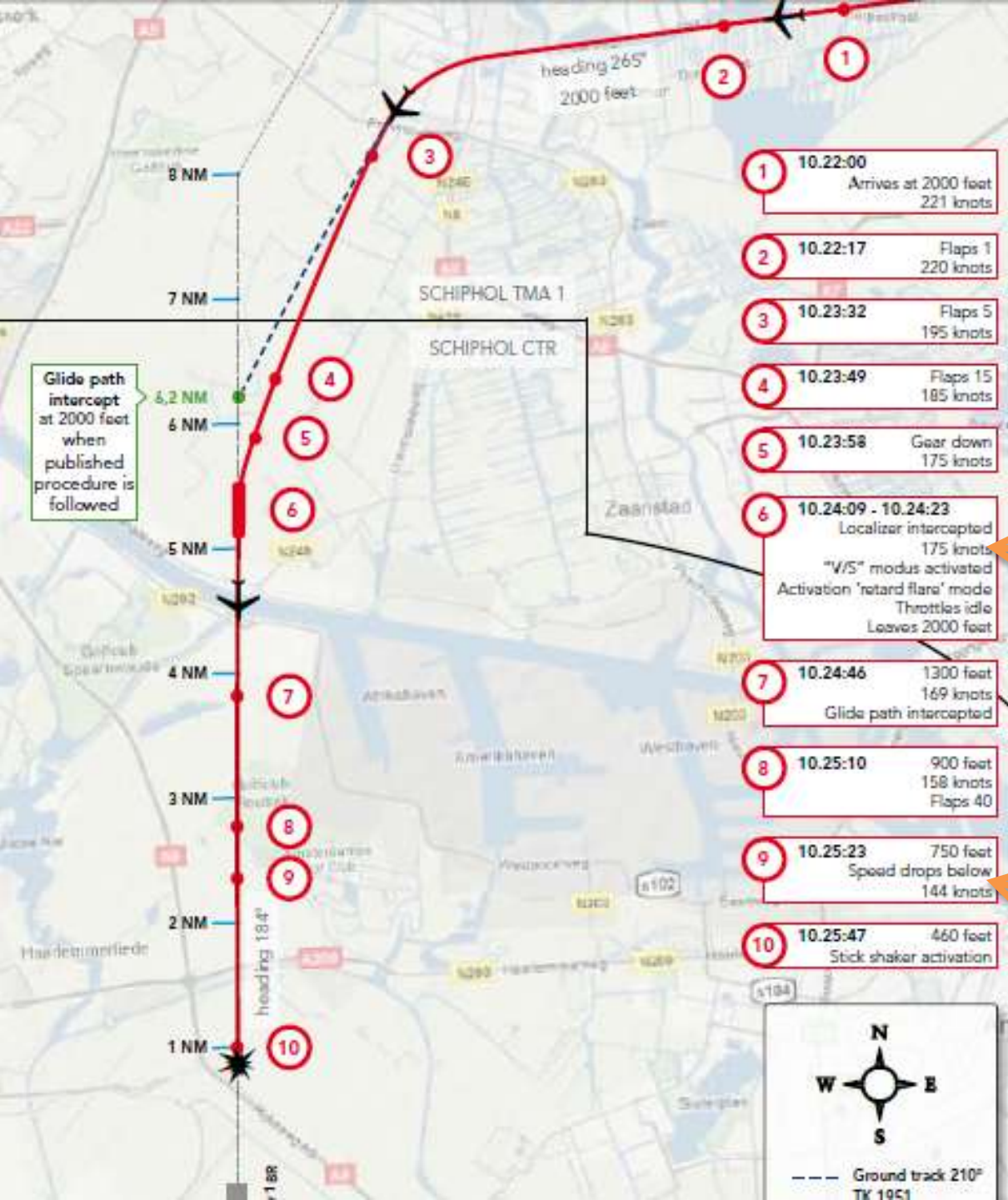
Unstable Approach



Equations of Motion

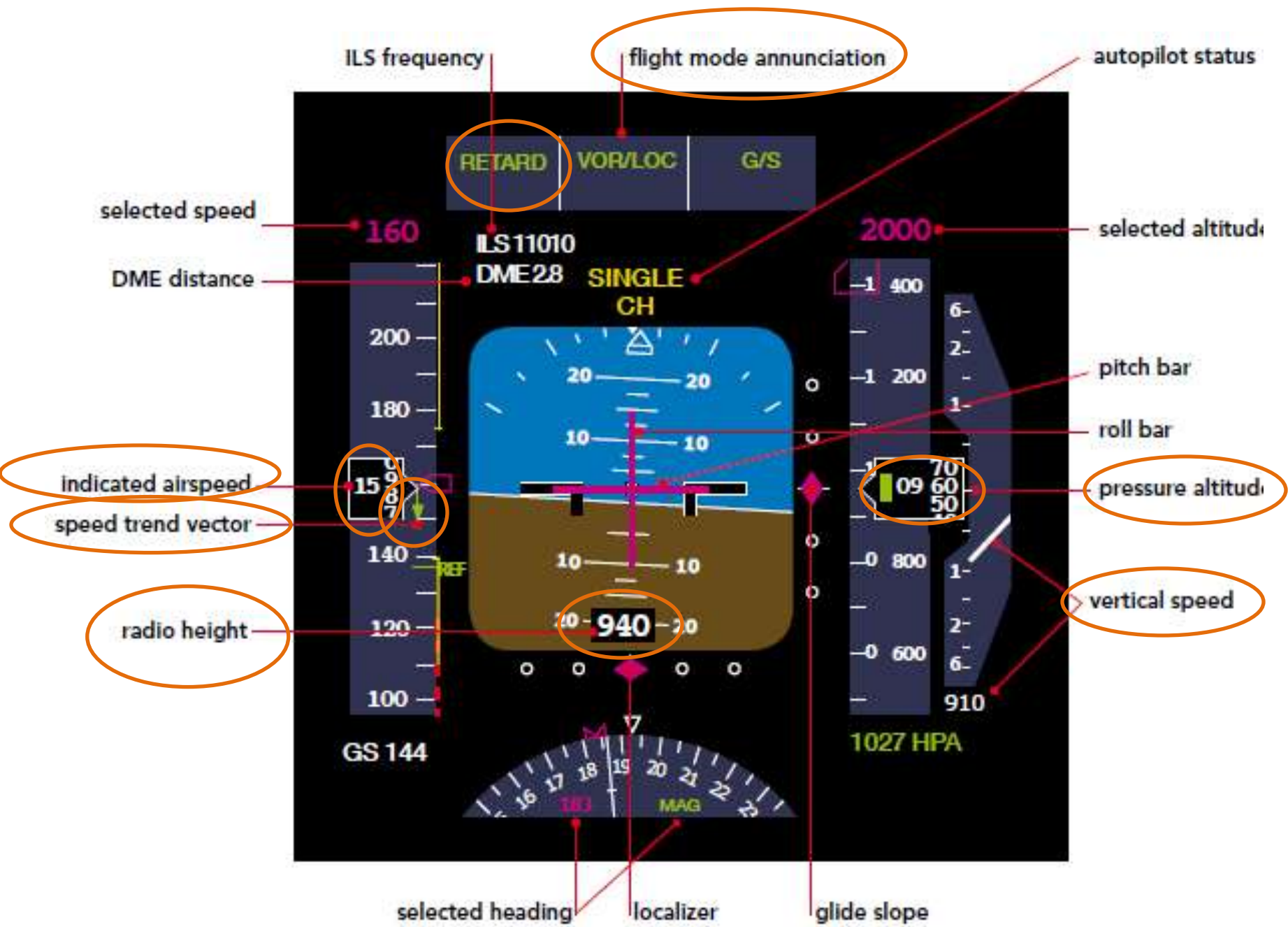
- $M \, dv/dt = \text{Thrust} - \text{Drag} - W \sin(\text{FPAngle})$
 - $M = \text{mass}$
 - $W = \text{weight} = mg$
 - $\text{FPAngle} = \text{Flight Path Angle}$
- Level flight ($\text{FPA} = 0$), constant speed ($dv/dt = 0$)
Thrust = Drag
- Descending ($\text{FPA} < 0$), constant speed
Thrust = Drag + $W \sin(\text{FPA})$: note $W \sin(\text{FPA}) < 0$
- Descending, decelerating ($dv/dt < 0$)
Thrust = Drag + $W \sin(\text{FPA}) + m \, dv/dt$: note $W \sin(\text{FPA})$ & $m \, dv/dt < 0$

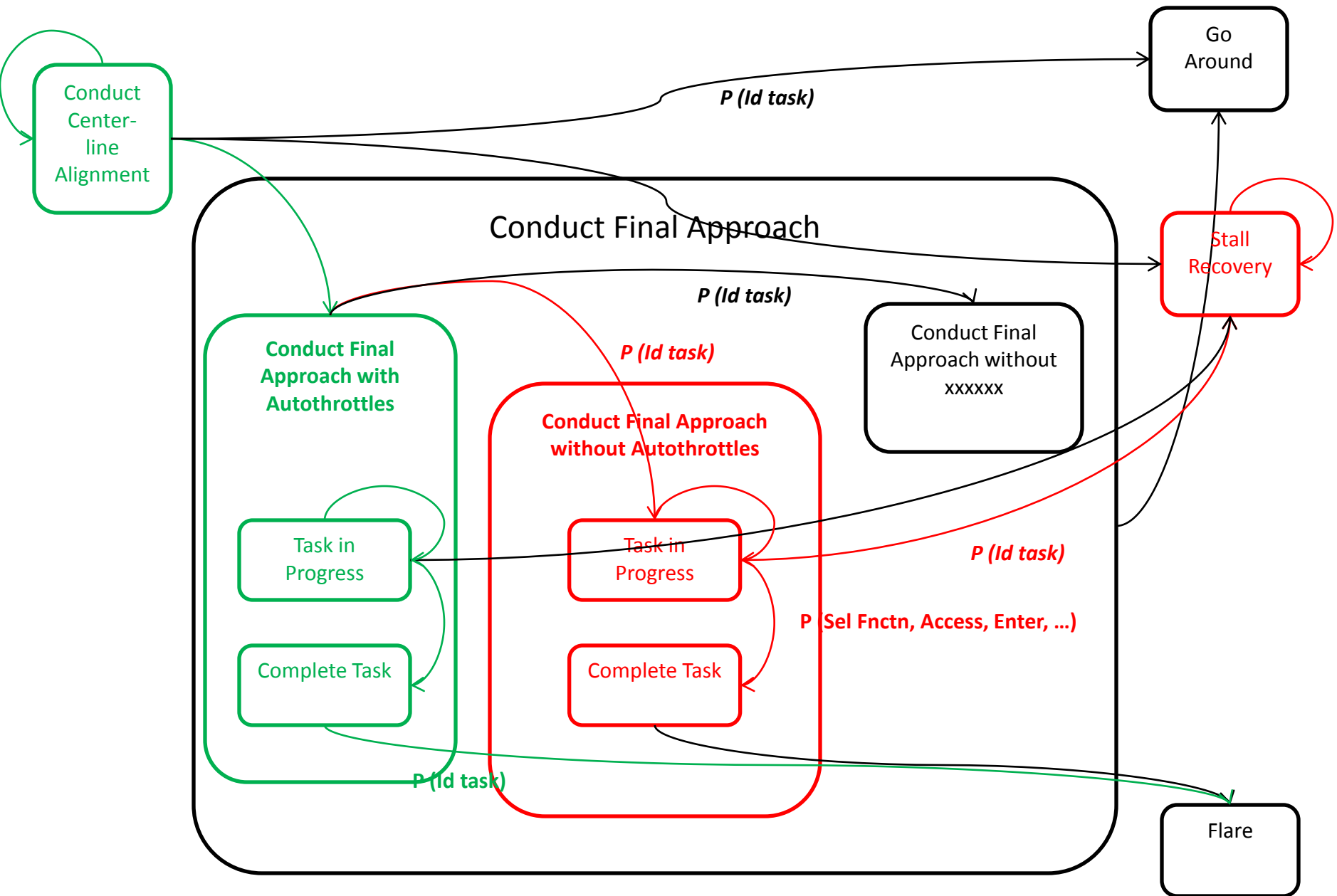
Where is the THRUST LEVER when descending and decelerating?



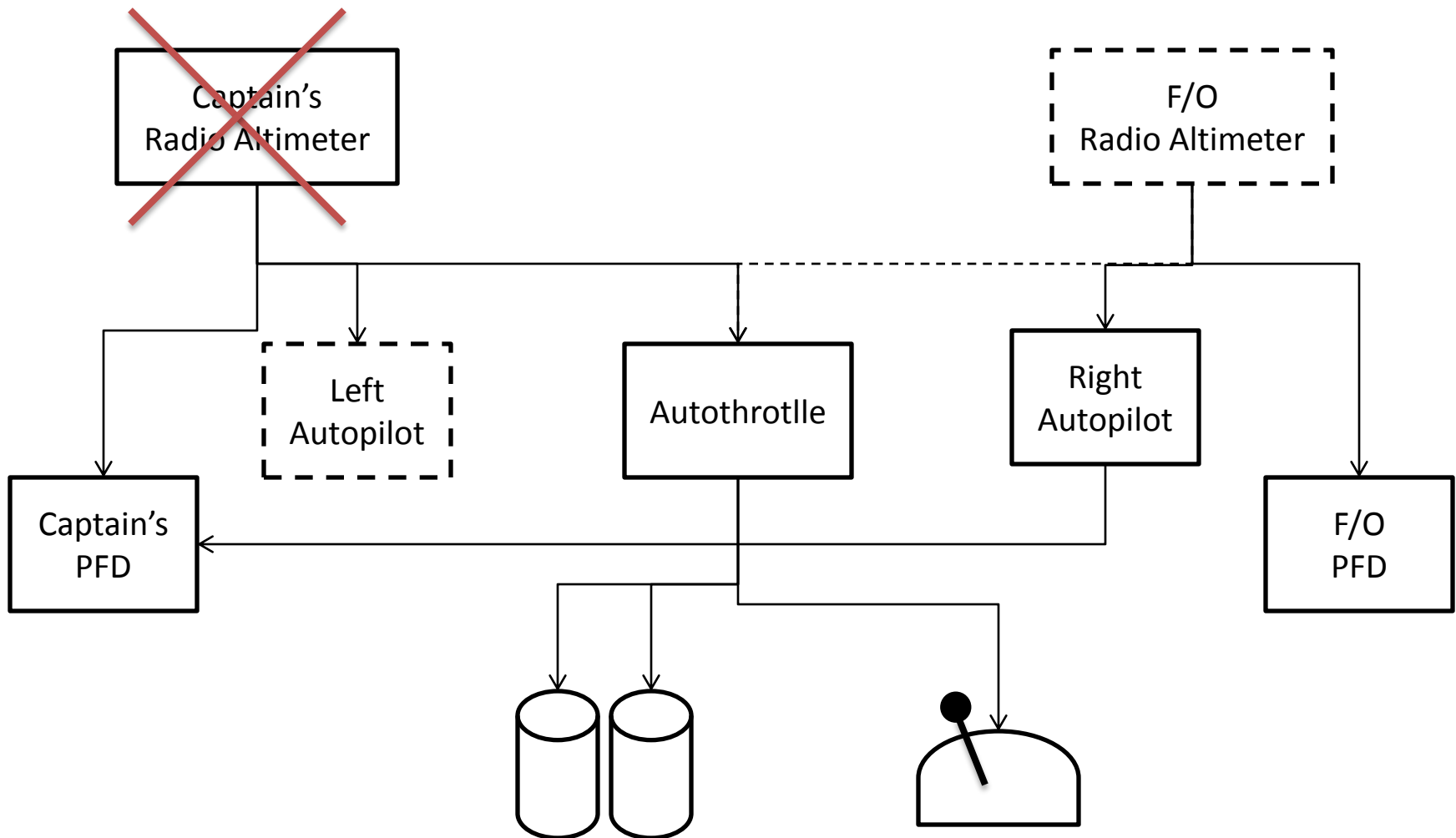
High and fast
V/S mode selected
Throttle lever retards to
idle (as it should)

Continued deceleration
through 144 knots (as it
should), but throttles
remain at Idle (instead of
adding thrust)





Non-intuitive Automation Configuration



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?

(3) Throttle levers move and engine noise decreases.

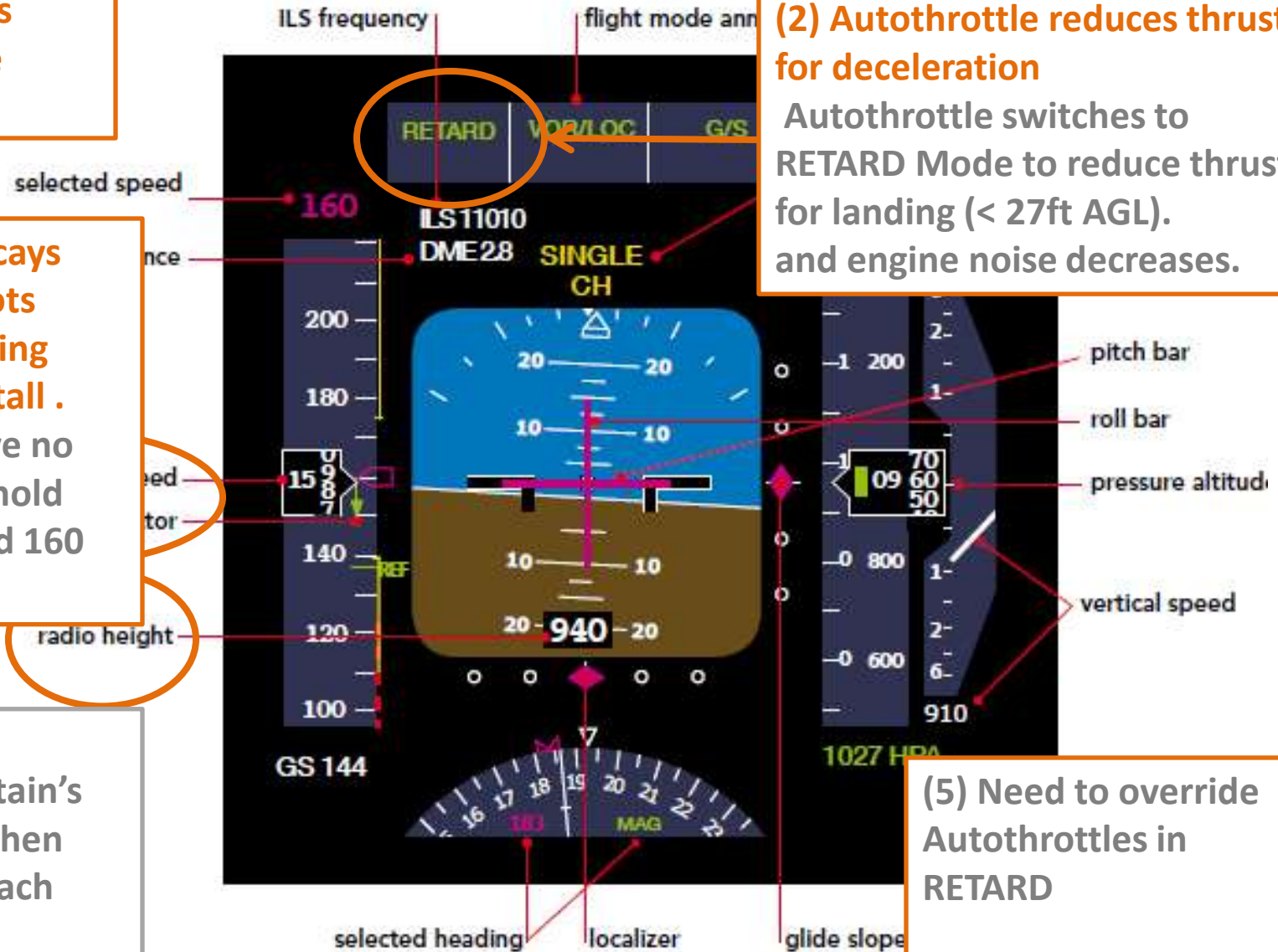
(4) Speed decays from 210 knots through landing speed until stall. Throttles have no intention to hold desired speed 160 knots

(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.

(5) Need to override Autothrottles in RETARD



What did the PM (Captain) Know?

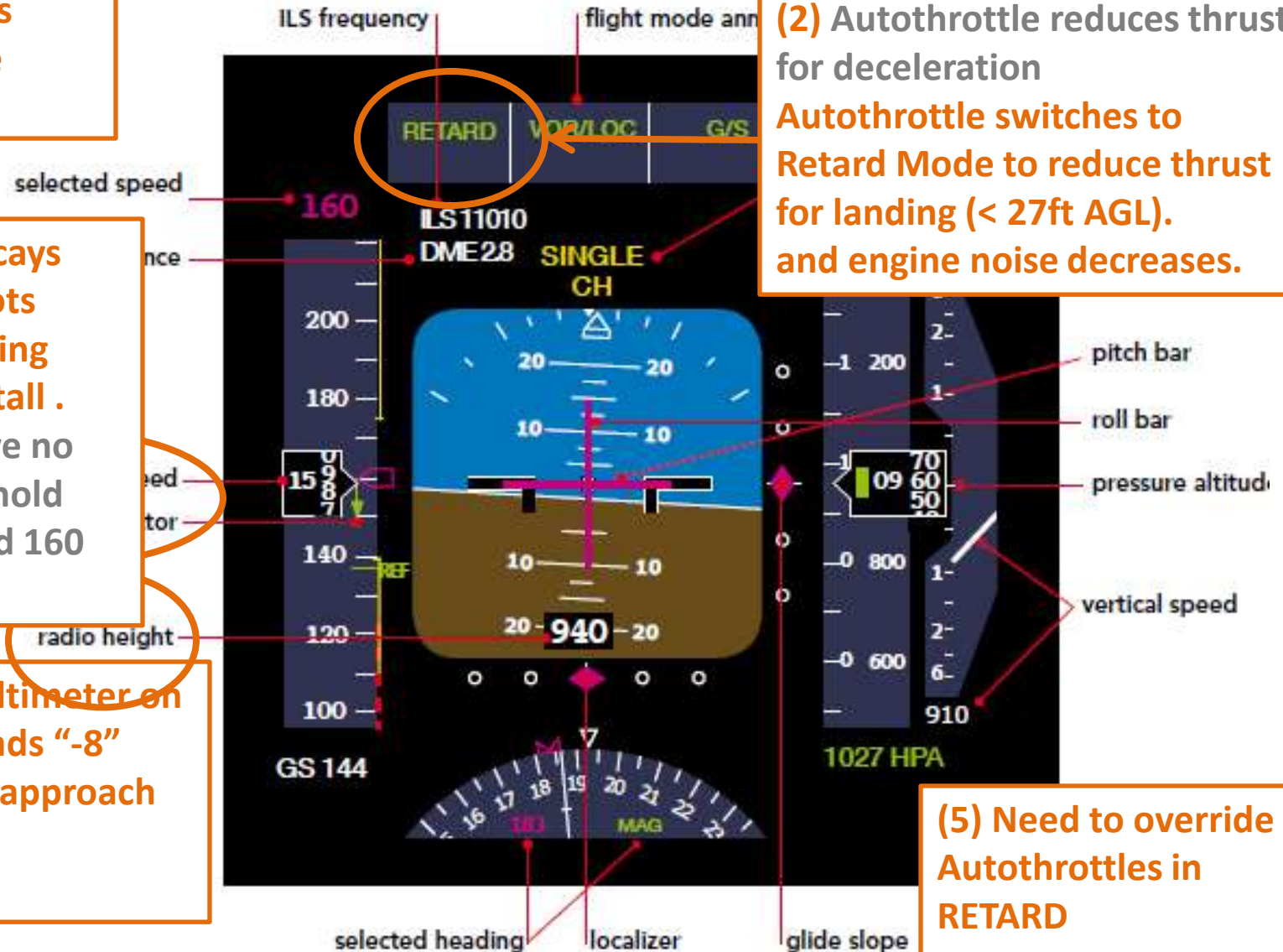
(3) Throttle levers move and engine noise decreases.

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

(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.

(5) Need to override Autothrottles in RETARD



What the Pilot Flying (F/O) Saw

Mission Task - Stage	Mission Task - Operator Actions	Prompts and Cues (Competing Cues listed)	Hidden Knowledge to complete the task
Id Task	Recognize need to conduct the approach with the autothrottles off.	<p>1.Primary - Speed decaying below reference landing speed</p> <p>2.Secondary - FMA Retard</p> <p>3.Throttle Levers retard early (may occur if aircraft high and fast)</p> <p>Competing - Everything in the cockpit and out the window including TOO LOW! GEAR! aural alert which was obviously wrong.</p>	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 Autthrottle ARM to OFF Manually hold throttles at full power position	None. Note: infrequent task to over-ride automation	Override Autothrottle by pressing either the <i>A/T disengage</i> buttons or switching off the autothrottle "ARM" switch, or to manually hold throttles at full power position.

What the Pilot Flying (F/O) Saw

Mission Task - Stage	Mission Task - Operator Actions	Prompts and Cues (Competing Cues listed)	Hidden Knowledge to complete the task
Access	Locate Throttle Levers Locate MCP A/T Arm Switch Locate MCP A/T Engage Button	High frequency input devices (no cues required)	
Enter	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	High frequency input devices (no cues required)	Override Autothrottle by pressing either the <i>A/T disengage</i> buttons or switching off the autothrottle "ARM" switch, or to manually hold throttles at full power position.
Confirm & Verify	FMA Throttle Lever Position	No verification action required.	
Monitor	FMA Throttle Lever Position		

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”



Task/HCI Viewpoint?

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”

- 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

Pilots, Airline Training, Airline management, Aircraft Manufacturer, Aircraft Avionics Equipment Manufacturers, Regulatory Authorities for Aircraft Certification, Regulatory Authorities for Airline Training Certification, Regulatory Authorities for Airline Procedure Certification, Air Traffic Control, Air Traffic Control Procedures, Air Traffic Control Training, Regulatory Authorities for ATC Training and Procedures