INVESTIGATION TO THE CAUSE OF THE CRASH OF A BOEING 737 NEAR AMSTERDAM SCHIPHOL ON FEBRUARI 25TH 2009
&
LESSONS to be LEARNED

by:
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(Member of Aviation Committee of OvV)

- On februari 25th 2009 a Boeing 737, on a flight from Istanbul to Amsterdam, crashed during the approach to the Polderbaan.

- The Dutch OvV did an investigation to determine the cause of the accident.

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Dutch Safety Board, (OvV)

OnderzoeksRaad voor Veiligheid (OvV), Dutch Safety Board

- The Dutch Safety Board is an independant organisation. Not part of any ministry. Members are appointed by the Crown.
- The organisation consists of a Board with 5 permanent members, in addition to a number of standing committees. The Board is supported by a bureau consisting of investigators and support staff.
- The Board conducts independent investigations to the causes of incidents and accidents.
- Its investigations look for any systematic safety-related shortcomings and issues reports to the parties involved and to the general public.

ICAO Annex 13

ICAO Annex 13 reads:

OBJECTIVE OF THE INVESTIGATION:

- The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents.

- It is not the purpose of this activity to apportion blame or liability.

  . . . . .

2 Introduction

A Boeing 737-800 made a flight from Istanbul Atatürk Airport in Turkey (LTBA) to Amsterdam Schiphol Airport (EHAM) on 25 February 2009.

The aircraft crashed on approach for runway 18R ('Polderbaan') and ended up in a field about 1.5 kilometres from the runway threshold.

4 crew members and 5 passengers died, 3 crew members and 117 passengers were injured.

2 Introduction

2 Introduction, Investigation Questions

Investigation questions

The primary investigation question related to the accident is:

"Why did the aircraft crash?".

This question can be broken down into 3 secondary investigation questions each contributing to one or both objectives of the investigation:

1.1 What is the cause of the accident and which factors played a role in this?
1.2 What are the underlying causes that led to the accident?
1.3 How can such an accident be prevented in future?

3. Relevant systems (Automatic Flight System)

Automatic flight system

The automatic flight system of the Boeing 737-800 consists of the Autopilot Flight Director System (AFDS), consisting of :

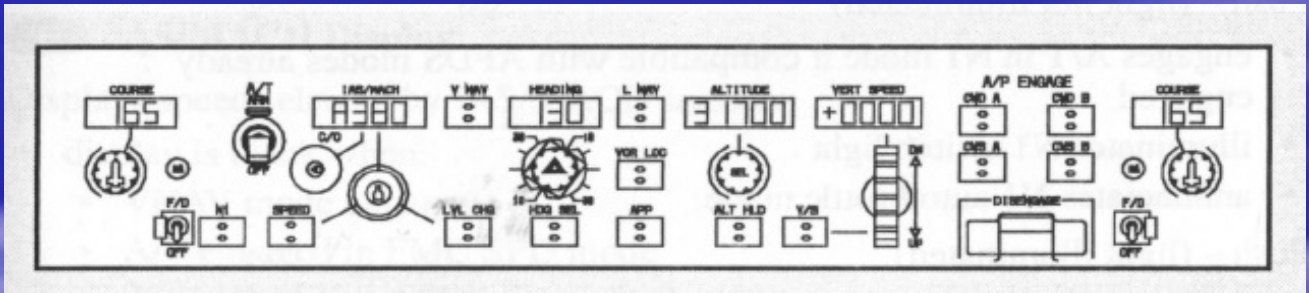
- 2 Flight Control Computers, (Left (A) and Right (B)) and
- 1 computer for the automatic thrustlever operating system (Auto-Throttle).

- The crew makes selections for heading, altitude, speed and other flight path commands on the AFDS Mode Control Panel (MCP).
- The mode selections are transmitted to the Flight Control Computers and AutoThrottle which command the Flight Controls and Throttles in accordance with the selected modes.

3. Relevant systems (Automatic Flight System)

737 Automatic Flight System/Modes:

- Mode selections are made on the Mode Control Panel (MCP) at the Glare shield
- They are shown on the Flight Mode Annunciations (FMA) above the Primary Flight Displays (PFD



3. Relevant systems (Automatic Flight System)

- Vertical or Pitch modes
  - VNAV commands pitch and A/T to fly vertical profiles
  - LVL CHG commands pitch and thrust to make automatic climb and descent to preselected altitudes at selected speed
  - Altitude Hold commands pitch to hold selected altitude
  - Vertical Speed commands pitch to hold vertical speed

3. Relevant systems (Automatic Flight System)

- Lateral or Roll modes
  - Heading Hold commands to turn to and maintain selected heading
  - VOR LOC mode
    - VOR mode: provides roll commands to track selected VOR course
    - LOC mode: Provides roll commands to track selected Localizer course
  - APP mode provides commands to capture and track Localizer and Glideslope

3. Relevant systems (Radio Altimeter)

Radio Altimeter system

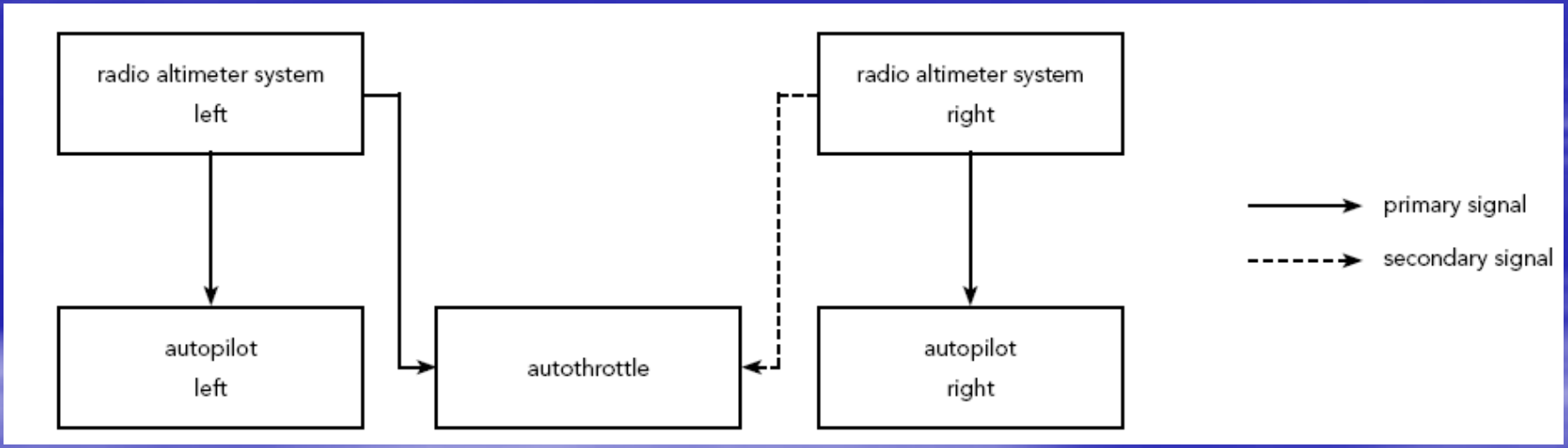
- Comprises 2 independent systems, a left- and a right-hand side system.

- Is used to determine the height above the ground by using radio signals.

(The pressure altimeter determines the altitude by measuring air pressure, wrt a selected pressure level, sea-level)

- The principle of radio height measurement is based on measuring the time that it takes for a signal to be transmitted towards the ground and to be reflected back and received in the aircraft.

3. Relevant systems (Radio Altimeter)

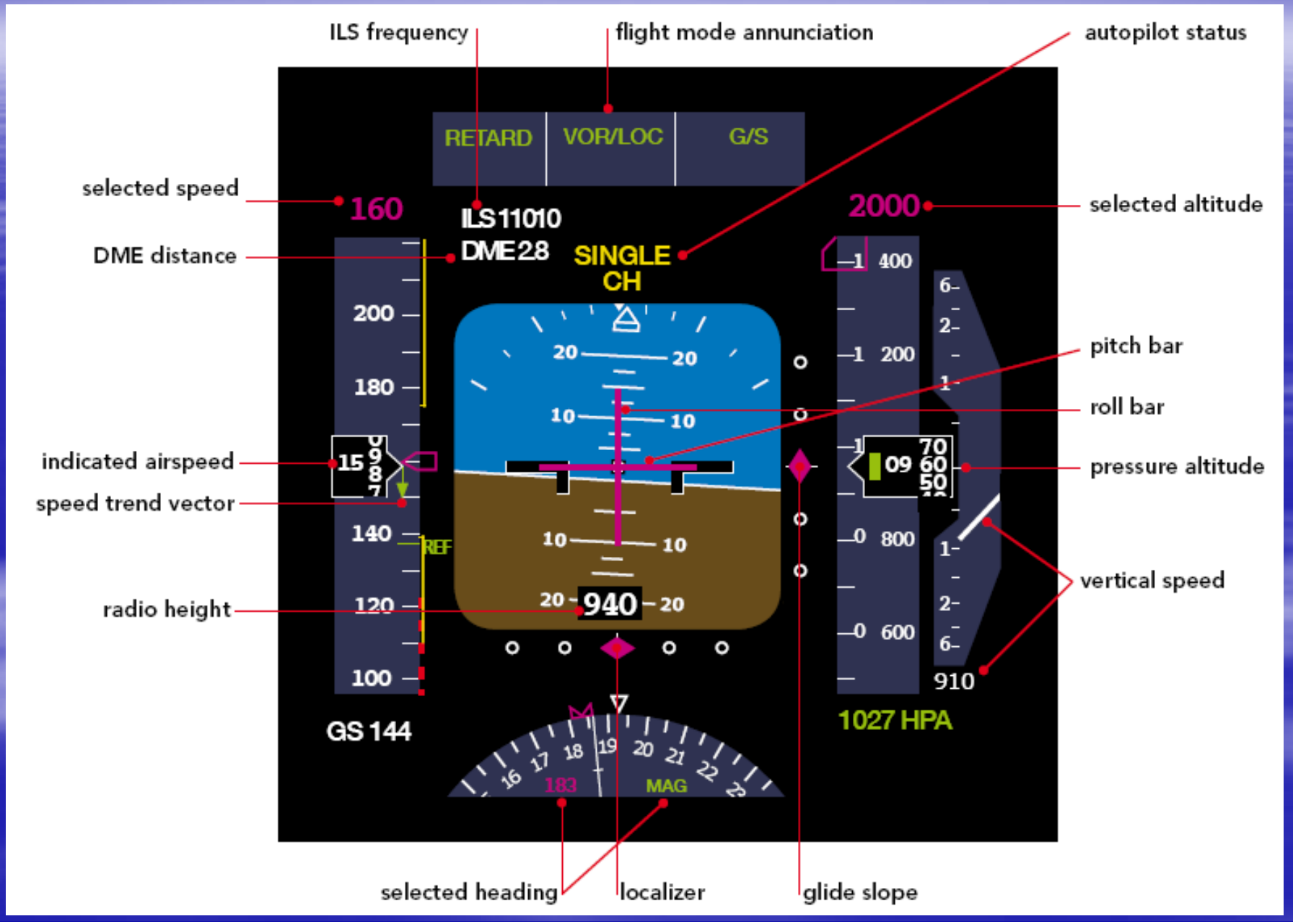


3. Relevant systems (Automatic Flight System)

Auto-Throttle modes: (relevants only)

- MCP Speed
  - Maintains the MCP selected speed
- Retard
  - Thrust goes to Flight idle

3 Relevant systems (Primary Flight Display)

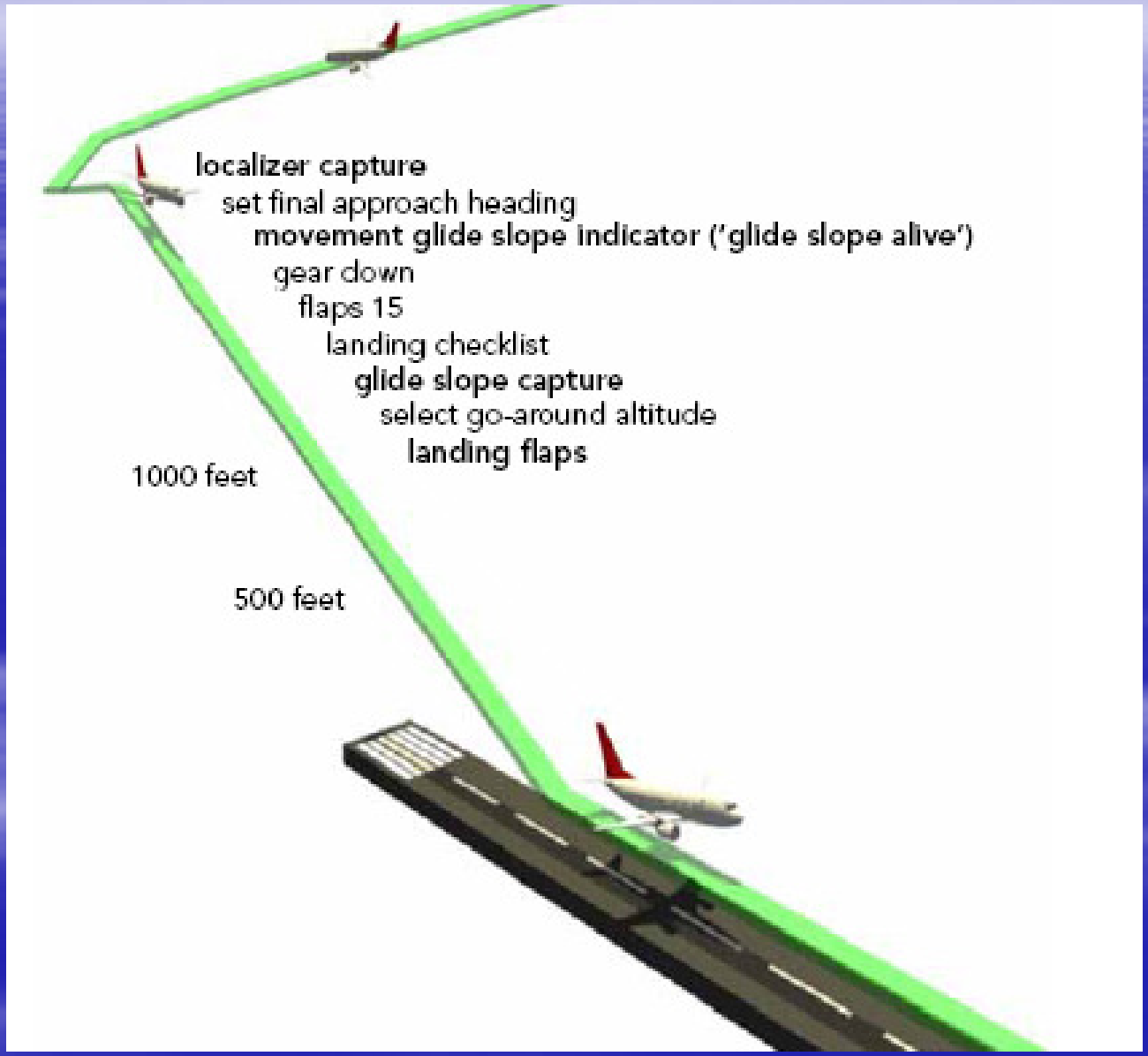


3 Relevant systems, Landing gear warning

Landing gear configuration warning system

- Generates an audible signal to warn the crew, when a landing attempt is being made while the landing gear is not completely down and locked.
- (Sounded during CRZ flight and approach when RadioAltimeter gave wrong signal)

3 Relevant systems, Actions during ILS approach

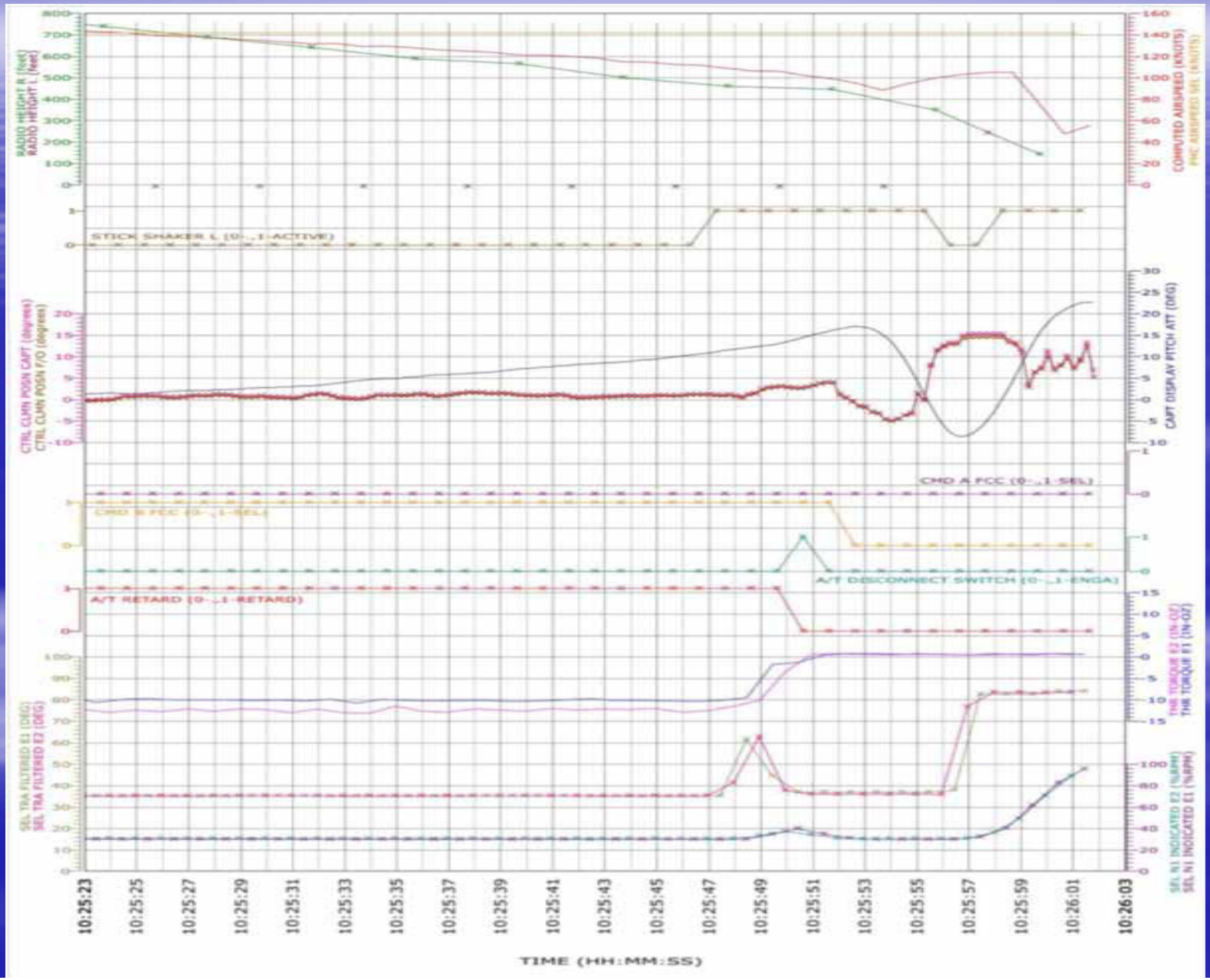


3 Relevant systems, Recorders

Recorders

- Cockpit Voice Recorder (CVR)
- Flight Data Recorder (FDR)

3 Relevant systems, Flight Data Recorder (last 40 sec)



3 Relevant systems, (Safety Pilot)

Safety pilot

- A pilot who is qualified for a specific aircraft type present during LIFUS to be able to take over the role of the captain or of the pilot under supervision when either of the two cannot perform his tasks.

- The role of the safety pilot is observing the flight training and he is responsible for advising the captain in case he detects irregularities.

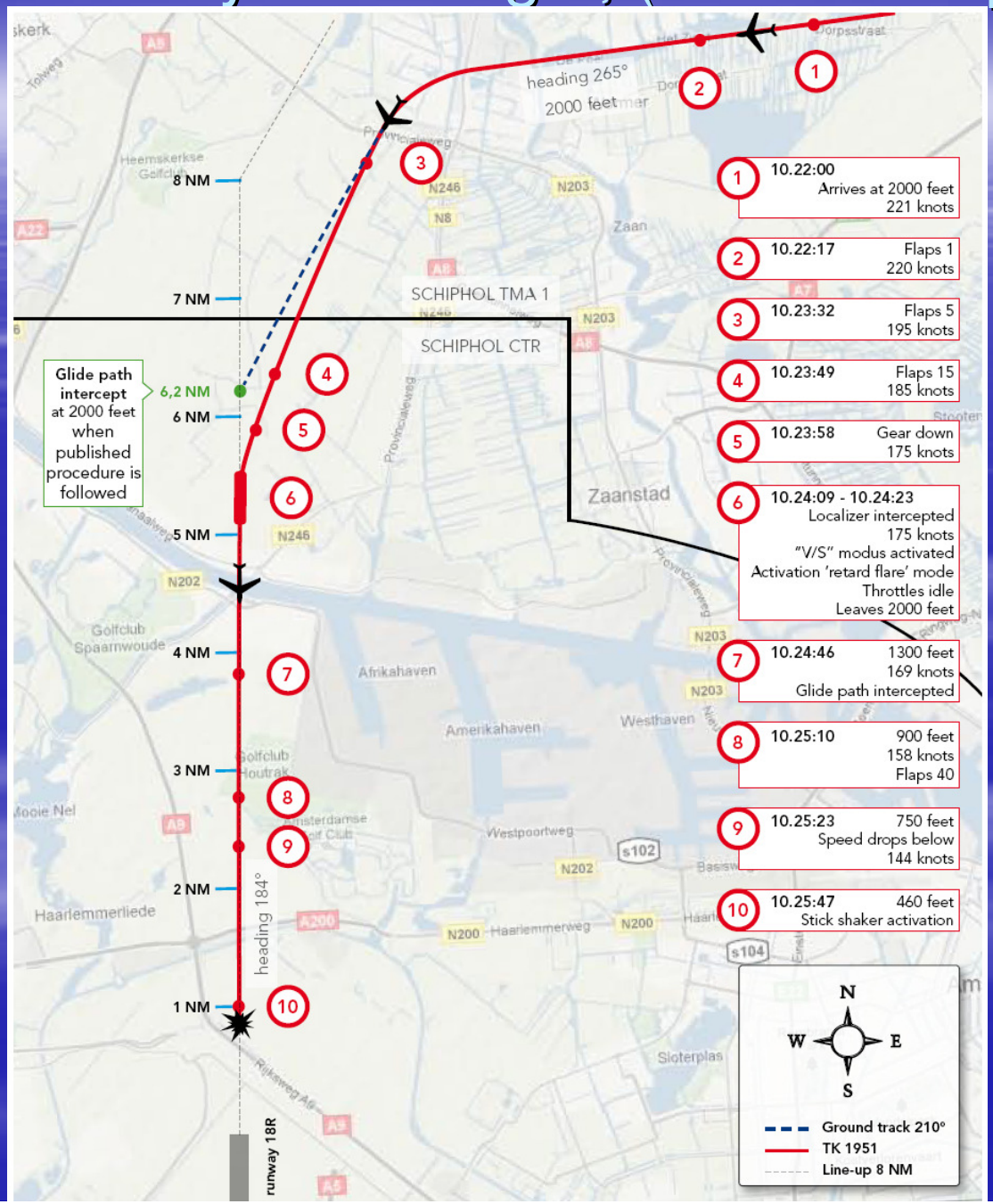
4. History of the flight

- The Boeing 737-800, with registration TC-JGE, took off at 08.23 hours (local time) from Istanbul Atatürk Airport in Turkey to Schiphol airport.
- There were 128 passengers and 4 crew members in the cabin.
- The cockpit crew consisted of 3 pilots.
- The captain, also the instructor occupied the left cockpit seat, the first officer who received 'line flying under supervision' (LIFUS) occupied the right seat.
- The first officer was pilot flying.
- Another pilot was seated in the observer's seat in the cockpit and was acting as safety pilot.
- Intention was to make an coupled ILS cat 1 approach on the right-hand computer .

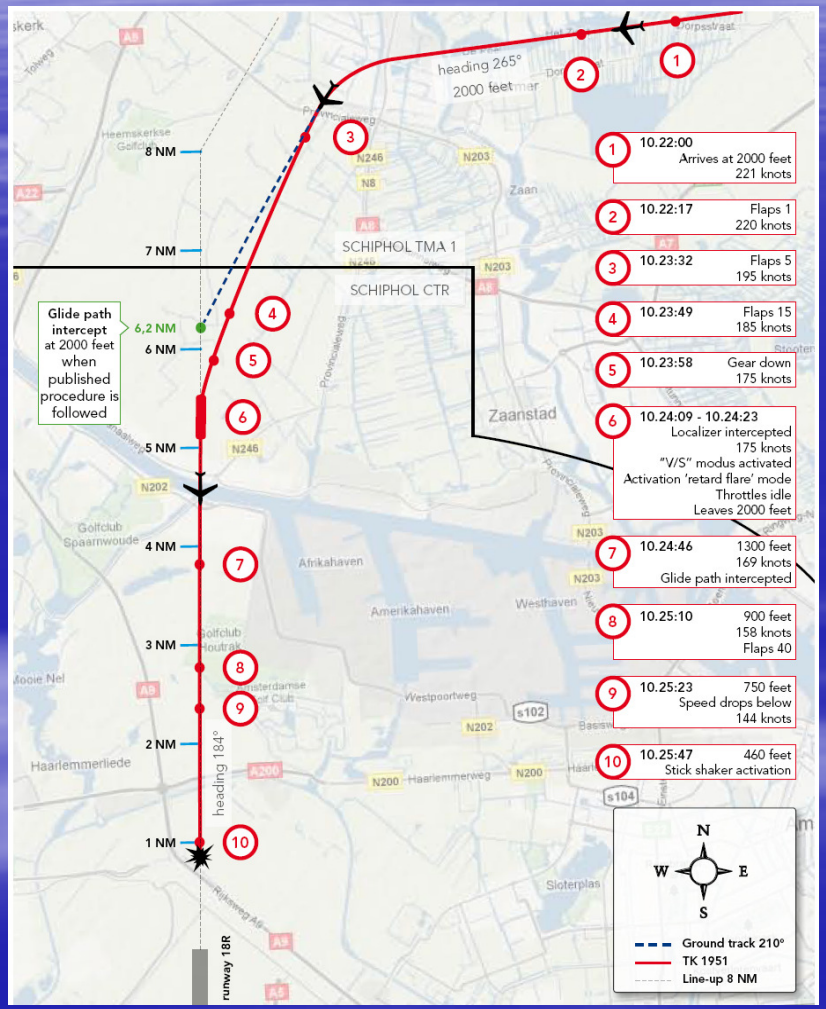
4. History of the flight

- The right autopilot B) was selected and active, the first officer acted as pilot flying.
- The flight data recorder recorded that the left radio altimeter system provided erroneous readings, beginning shortly after take-off as the aircraft climbed through approximately 400 ft.
- It is not known if the pilots were familiar with those readings.

4. History of the flight, (short line-up)



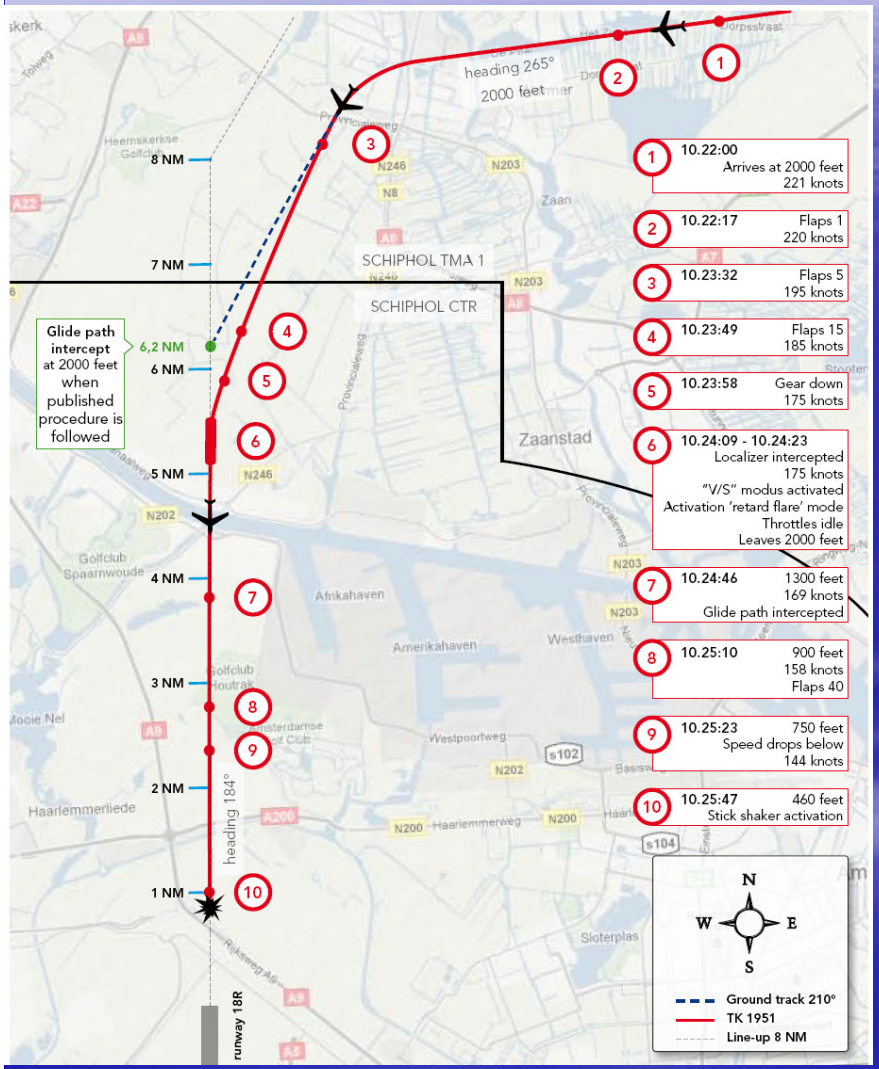
4. History of the flight (approach phases)



2-3. Landing gear warnings

- This time segment (10.15:02 - 10.22:37 hours) starts with radio contact with Schiphol approach.
- 4 times an audio warning regarding the landing gear can be heard during this period.
- TK1951 is on a 265 degrees heading at 2000 ft and the flaps are selected in position 1 at the end of this time segment.

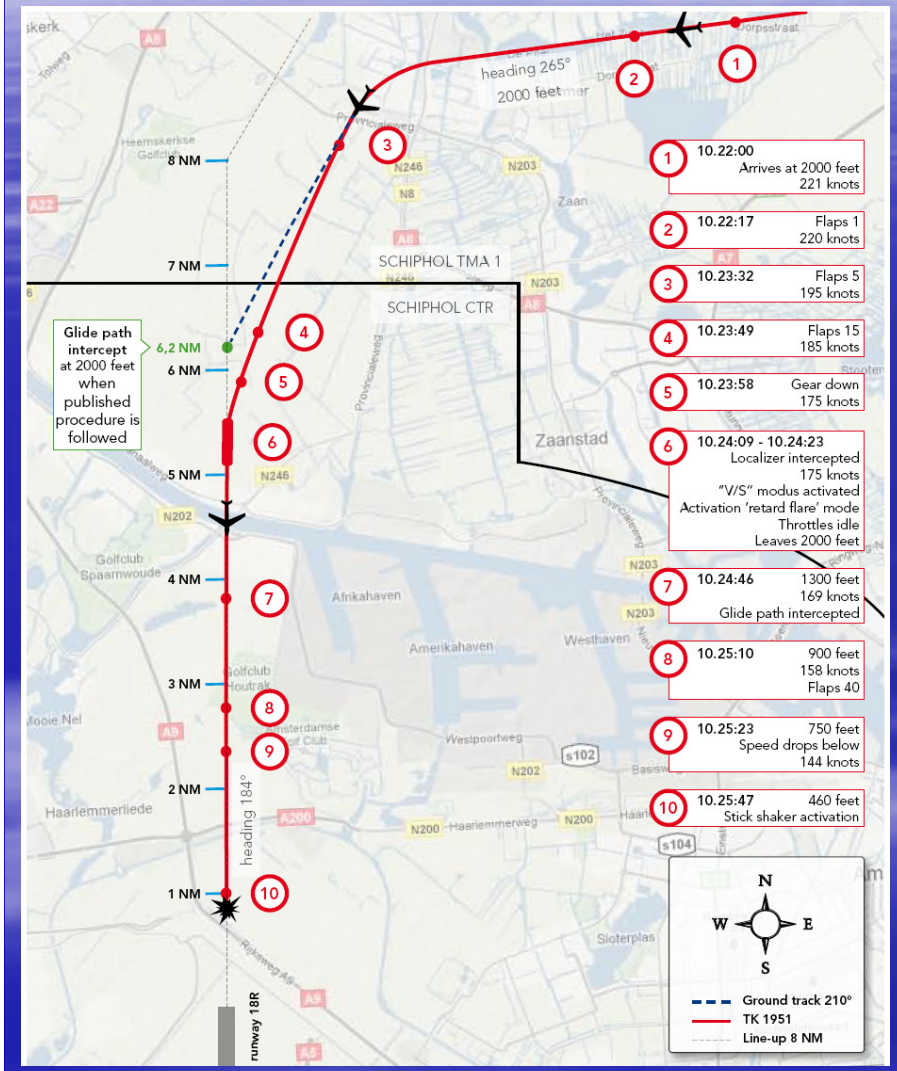
4. History of the flight (approach phases)



3-4. Aligning for the final approach and landing gear configuration warning

- This phase (10.22:38 - 10.24:08 hours) starts with the instruction to fly heading 210 degrees and permission to start the approach.
- The audio warning with regard to the landing gear can be heard again.
-
- The landing gear is selected down and the flaps are in position 15 by the end of this time segment. Landing gear warning stops!

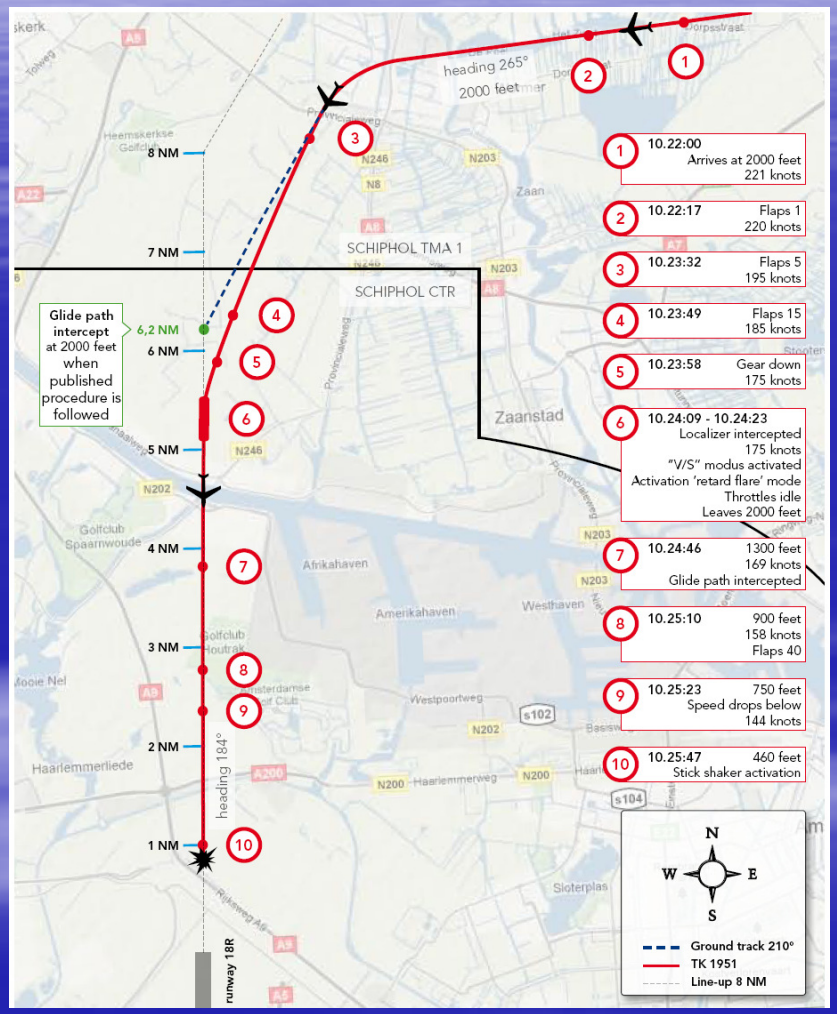
4. History of the flight (approach phases)



4-6. Interception of the localizer signal and activation of the retard mode

- This time segment (10.24:09 - 10.24:23 hours) starts with the interception of the localizer signal.
- The glide path is, subsequently, approached from above from an altitude of 2000 ft, using V/S mode.
- The thrust levers automatically go to idle.
- The autothrottle flight mode annunciation changes to 'RETARD'.

4. History of the flight (approach phases)

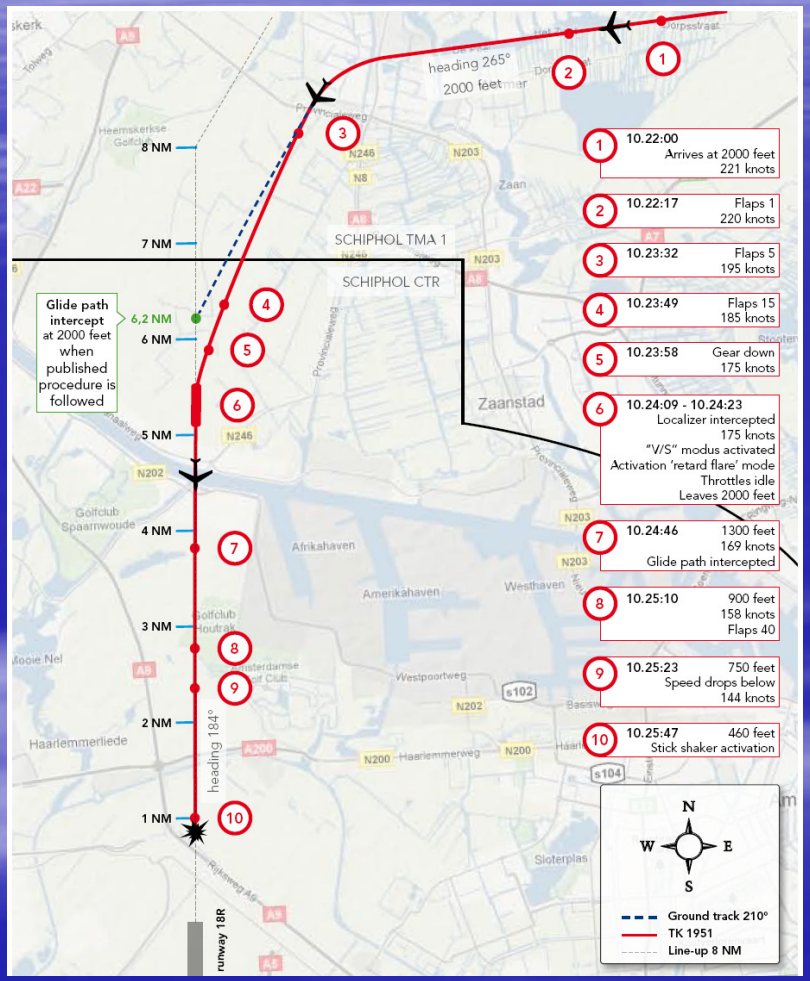


6-7 Interception of the glide slope signal and execution of the landing checklist

This phase (10.24:24 - 10.25:22 hours) starts with radio contact with Schiphol Tower.

- The aircraft intercepts the glide path.
- The flaps are in position 40.
- A landing speed of 144 knots is selected at the end of this phase.

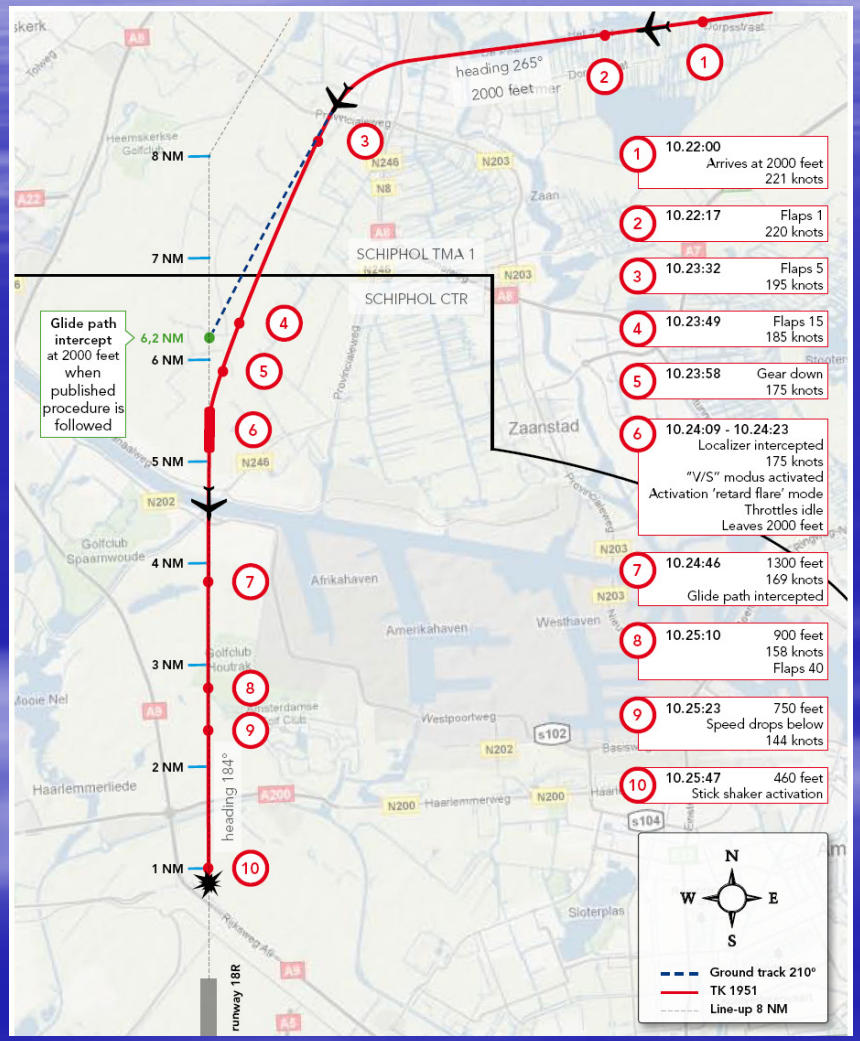
4. History of the flight (approach phases)



8-9 Air speed drops below the selected value

- In this phase the speed drops below the selected speed of 144 knots.
- The aircraft descends to 500 ft.
- The distance to the runway threshold is about 2,5 NM.

4. History of the flight (approach phases)



10. Activation stick shaker

- This time segment starts with the activation of the stick shaker and ends with the aircraft's accident.

4. Flight Mode Annunciations during approach

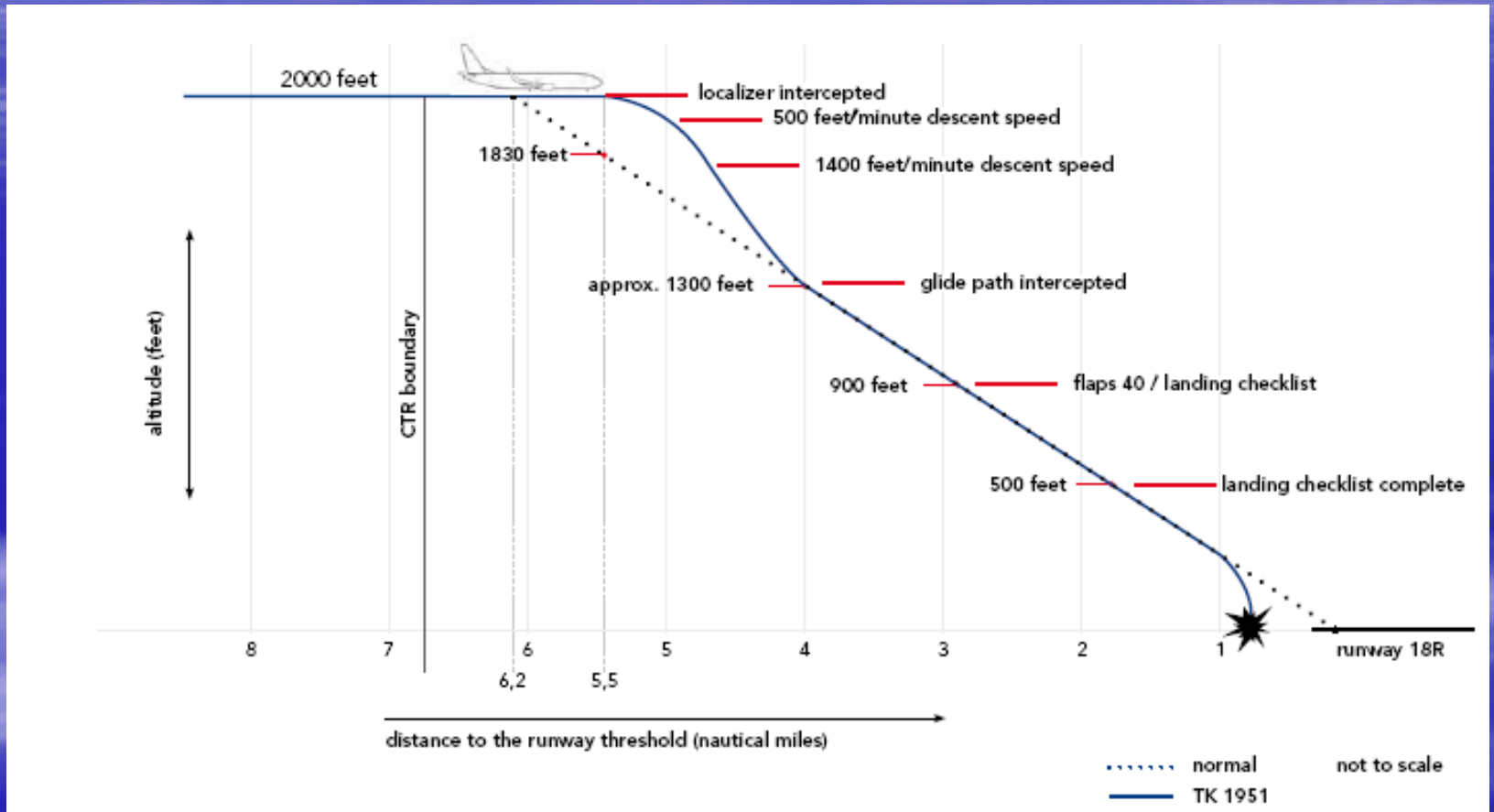
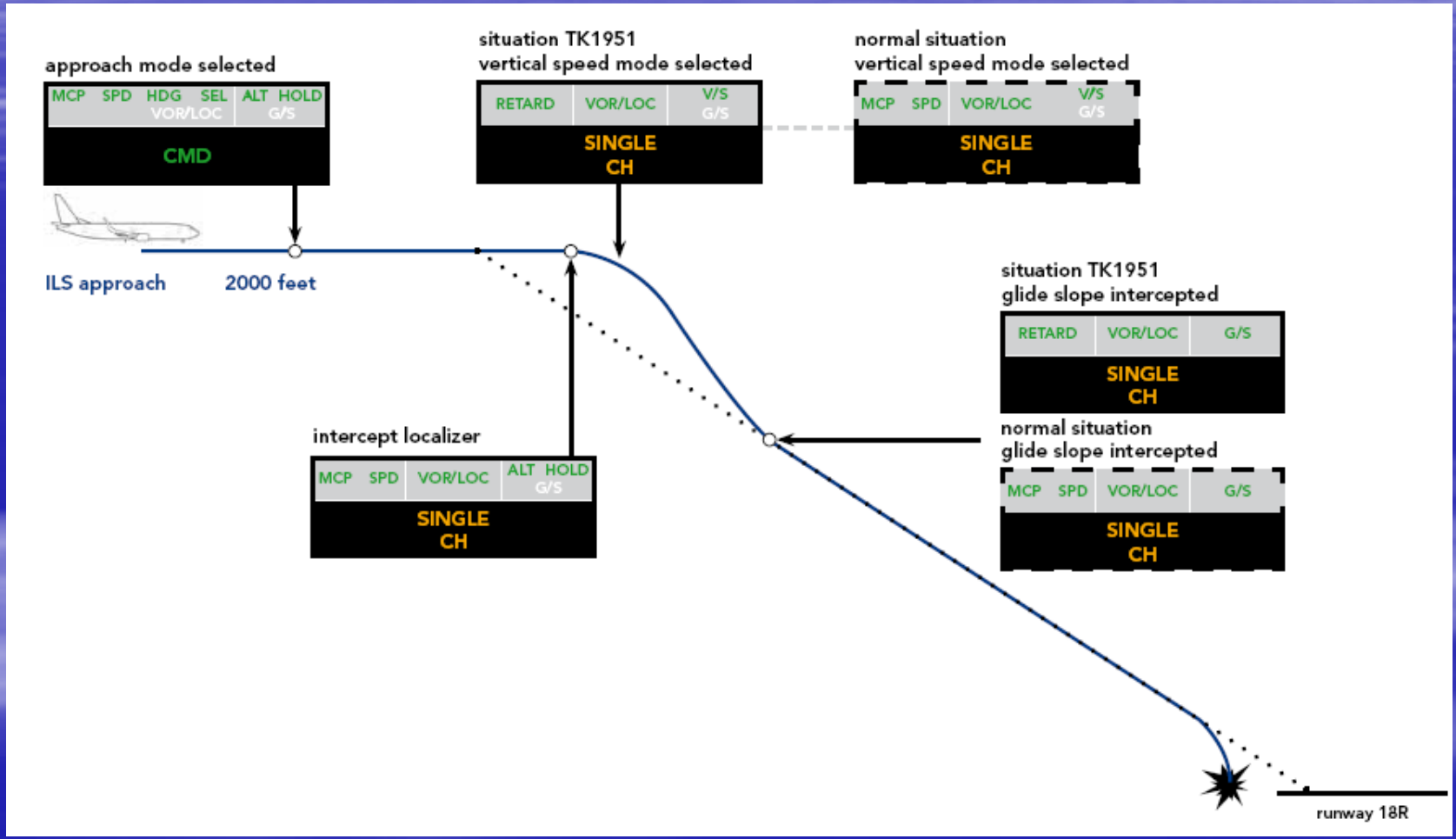
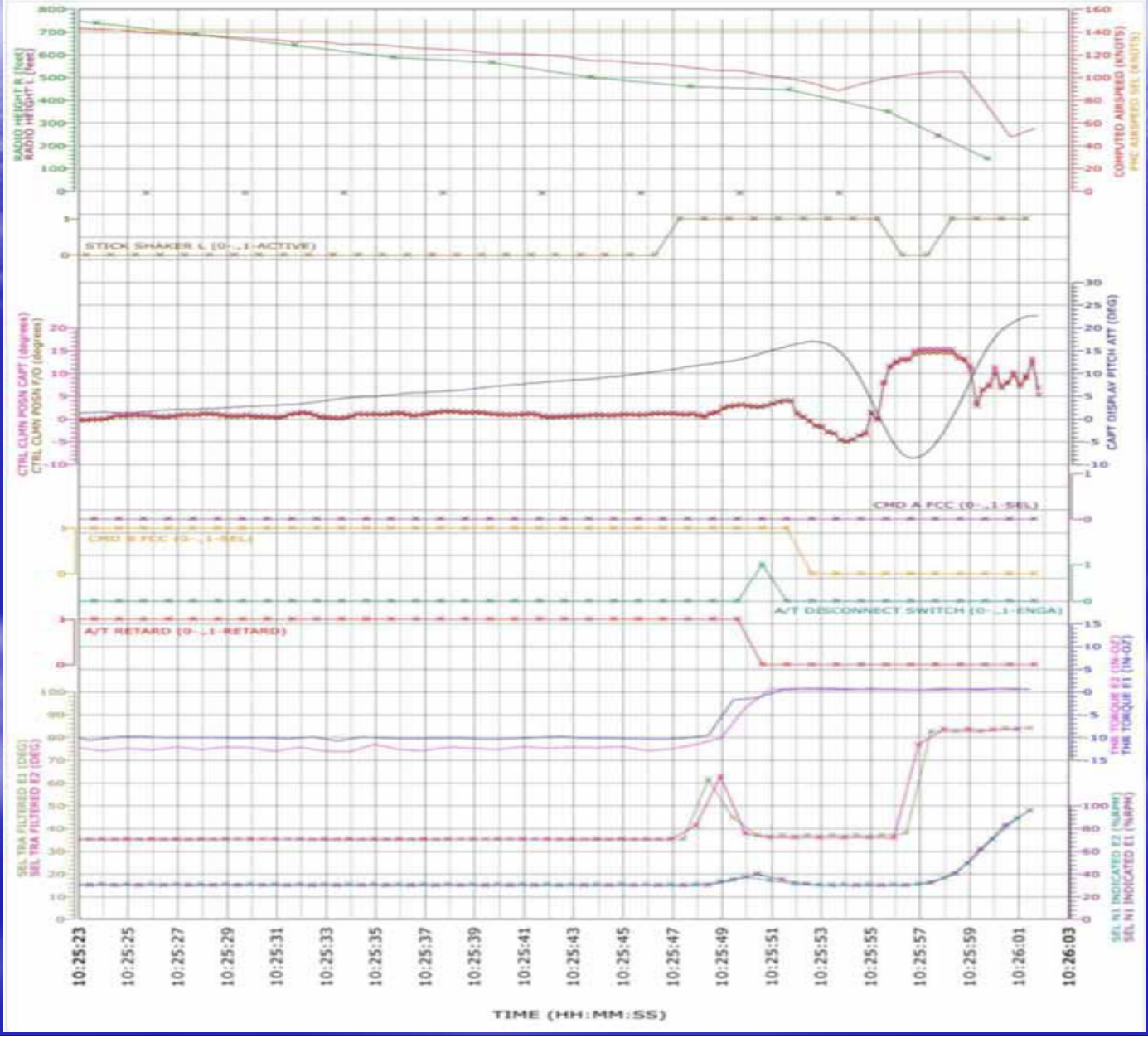


Illustration 10: side view of the approach of flight TK1951

4. Flight Mode Annunciations during approach

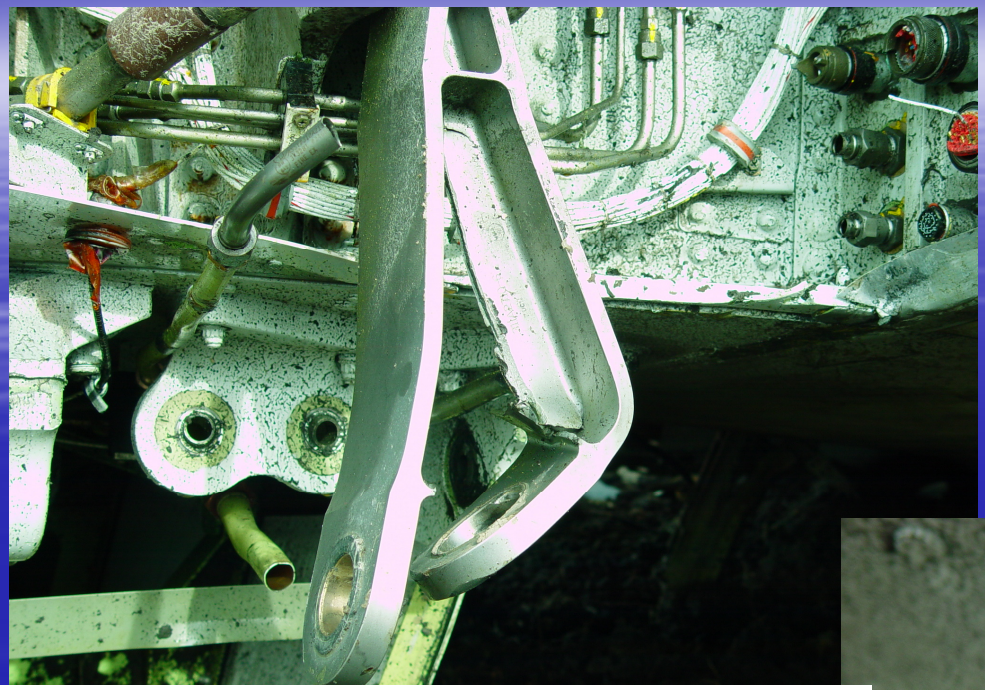


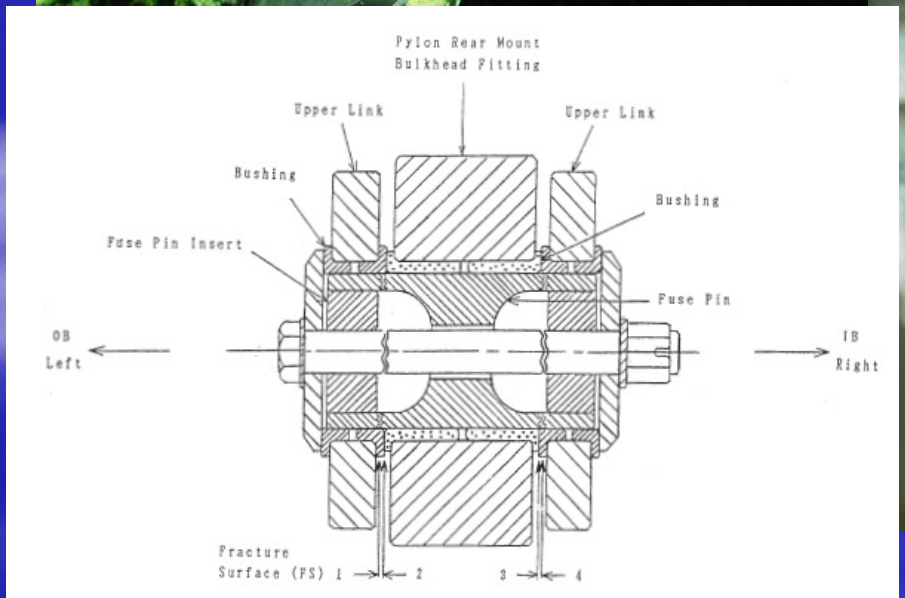
4. History of the flight (last 40 seconds FDR)



5. Damage to the aircraft

5. Damage to the aircraft, Structural fuses





6. Facts: Malfunction of the Radio altimeter

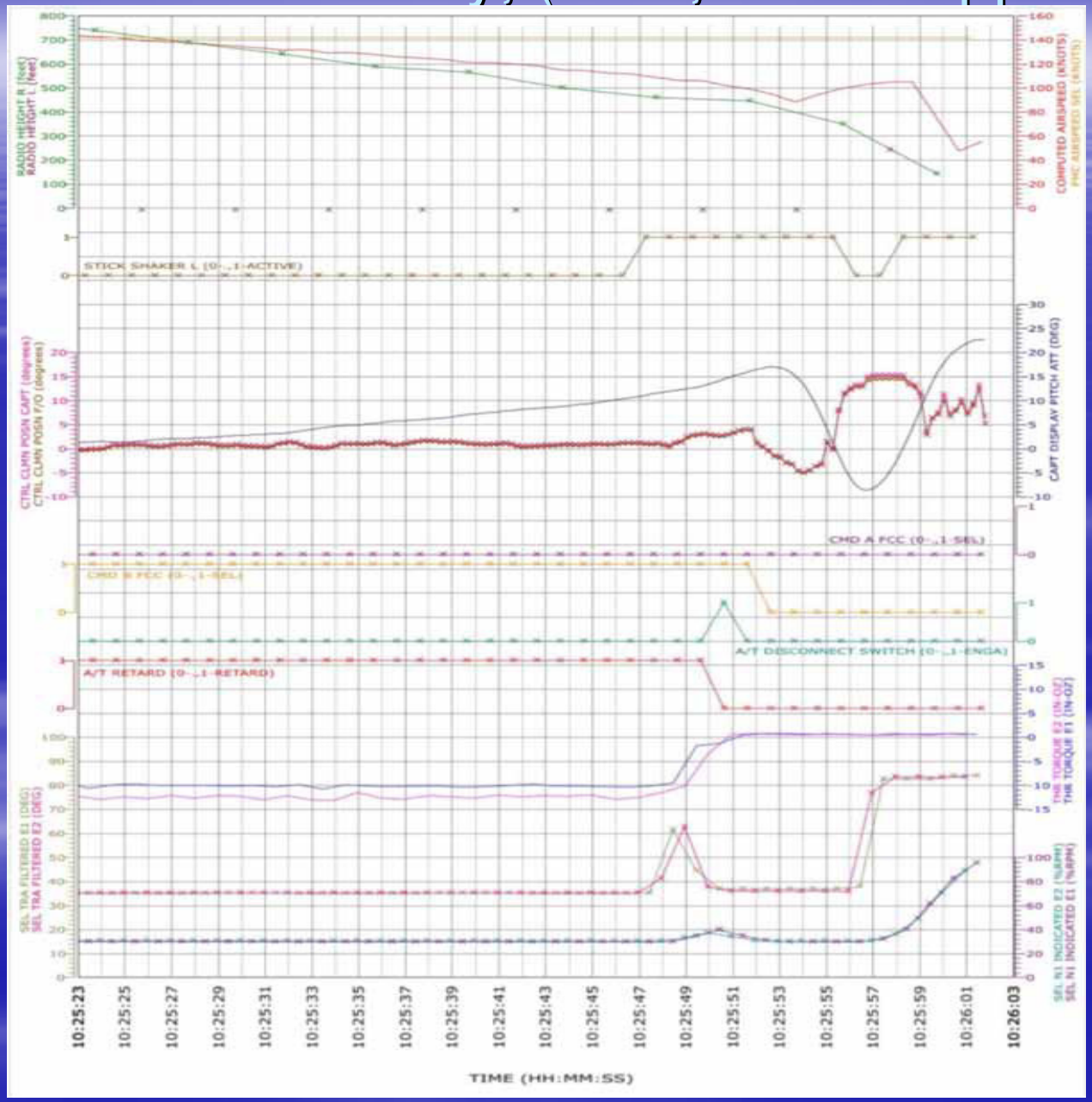
The autothrottle ‘Retard flare’ mode

- The ‘vertical speed’ mode was selected to intercept the G/S from above.
- Usually, when this mode is selected, the corresponding ‘MCP speed’ mode will be activated for the autothrottle. However the ‘Retard flare’ mode of the autothrottle was activated.
- With this ‘RETARD’ appeared on the Flight Mode Annunciation of both Primary Flight Displays.
- With regard to the Boeing 737 NG series the ‘Retard flare’ mode is activated when the autothrottle is in use and certain conditions have been met, under which, a radio height less than 27 ft.

6. Facts: Malfunction of the Radio altimeter

- This (RETARD) mode should normally only be activated during the landing and is automatically de-activated after the wheels of the aircraft touch the ground.
- During flight TK1951, the left radio altimeter system specified a height of -8 ft at a given moment.
- The system did not switch to the right radio altimeter system.
- The autothrottle activated the 'Retard flare' mode and the thrust levers were closed to take the position for Flight Idle thrust based on this input and the system logics.
- Intercepting the glide slope from above as a result of the localizer interception on 5.5 NM at 2000 ft has masked the incorrect operation of the auto-throttle.

6. Facts: Stall recovery, (FDR, Thrust application



6. Facts, Stabilised at 1000 ft

According to the TA standard operating procedures an approach must be stabilised at 1000 feet (in IMC) and at 500 feet (in VMC).

An approach is stabilised when it meets amongst others:

- • The airplane is on the correct flight path.
- • The aircraft is in the proper landing configuration.
- • The sink rate is not greater than 1000 feet/minute.
- • The power setting is appropriate for the configuration.
- • All briefings and checklists have been performed.
- • Only small changes in heading/pitch are required to maintain the correct flight path.
- • The airplane speed is not more than Vref + 20 knots indicated airspeed and not less than Vref (Boeing).

7. String of events

This accident was not caused by one event, but it was a string of events that led to the crash:

1. LIFUS flight
2. Malfunction of Radio alt
3. Crew unaware of consequence of Radalt malfunctioning
4. Short turn in, without descent, non-requested, but accepted
5. RETARD mode not remarked by crew, crew did not take action on reducing airspeed, or on the throttles remaining closed
6. High workload (LIFUS, Short turn in, Intercept of G/S from above)
7. No Go-around at 1000 ft as not stabilized
8. Inadequate stall recovery, No full thrust, Auto throttle was disconnected after applying thrust, too late.

8. Main conclusions

Main Conclusions

- During the approach with the ILS, right autopilot engaged, the left radio altimeter system showed an incorrect height of -8 ft on the left primary flight display.
- This incorrect value of -8 feet resulted in activation of the 'RETARD FLARE' mode of the Autothrottle, thrust of both engines was reduced to Flight idle.
- Due to the approach heading and altitude provided by ATC, the localizer signal was intercepted at 5.5 NM from the runway threshold with the result that the Glide slope had to be intercepted from above.
- This obscured the fact that the Autothrottle had entered the "Retard flare" mode.
- It also increased the crew's workload.

10. Lessons Learned (1)

From the accident lessons can be learned for the private/GA pilot:

- 1. De kist vliegen gaat voor alles (A.., N.., C..) Monitor your (flight) instruments during (final) approach en laat je niet afleiden!
- 2. Ken de werking en presentaties van je systemen (AP, ATS)
- 3. Accepteer niet zonder meer voorstellen/opdrachten van ATC. Ga eerst na wat de consequenties zijn voor het vervolg van de flight.

10. Lessons Learned (2)

- 4. Denk vooruit,
- Wat zijn de consequenties voor verloop van de vlucht/approach als ik dit accepteer?
- Handel niet van: Ik ben een ervaren/goede vlieger, dus dat lukt me wel. (10.000+ hrs captains maakten deze fout!)

- 5. Zorg dat je niet in een tijdnood-situatie terecht komt. Denk vooruit.

- 6. Voer je (abnormal) handelingen uit als in checklist, ook voor de:
- “by head” procedures.

10. Lessons Learned (3)

7. Brief voor je zelf/mede vlieger hoe je aanvlieg/approach procedure uitvoert (route, hoogtes, speeds, configuratie, RPM enz).

   Vlieg deze vervolgens zo, hou je vervolgens aan je briefing.

   Spreek voor de vlucht met je medevlieger af dat hij/zij je handelen monitort en afwijkingen meldt. (rol pilot-monitoring)

8. Zorg dat je in de approach een altitude bepaalt, waar je gestabiliseerd moet zijn.
   Als niet gestabiliseerd op die hoogte: Go-Around!

9. Voer je (abnormal) handelingen uit als in checklist aangegeven, ook de “by head” procedures.

Thank you for your attendance