Lessons Learnt from CFIT

CFIT workshops 15, 16 Dec 2021 - ICAO AFI Region

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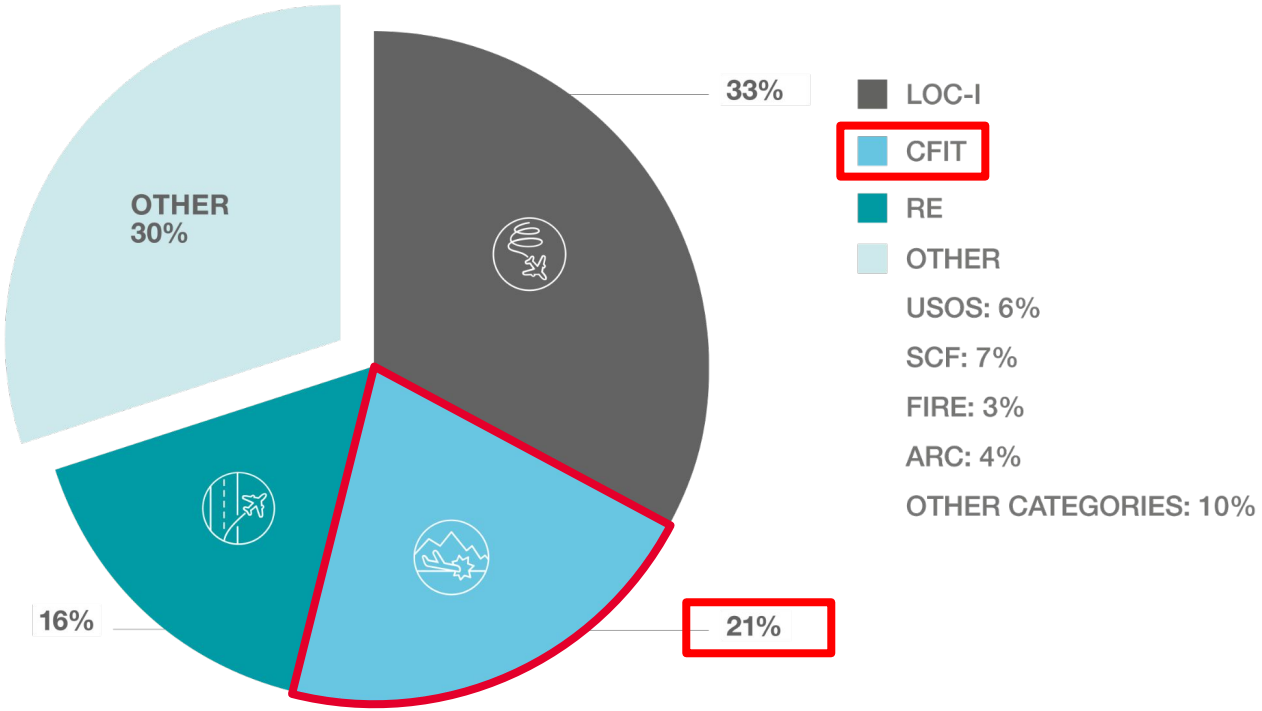
3 Main Accident Categories

- **Runway Excursion (RE)**
- **Controlled Flight Into Terrain (CFIT)**
- **Loss Of Control In-flight (LOC-I)**

Fatal accidents distribution per category 2001-2020



Major Accident Types

The leading cause of fatal accidents over the last 20 years was LOC-I.

Western-built jets above 40 seats

Source: ICAO, Cirium & Airbus databases

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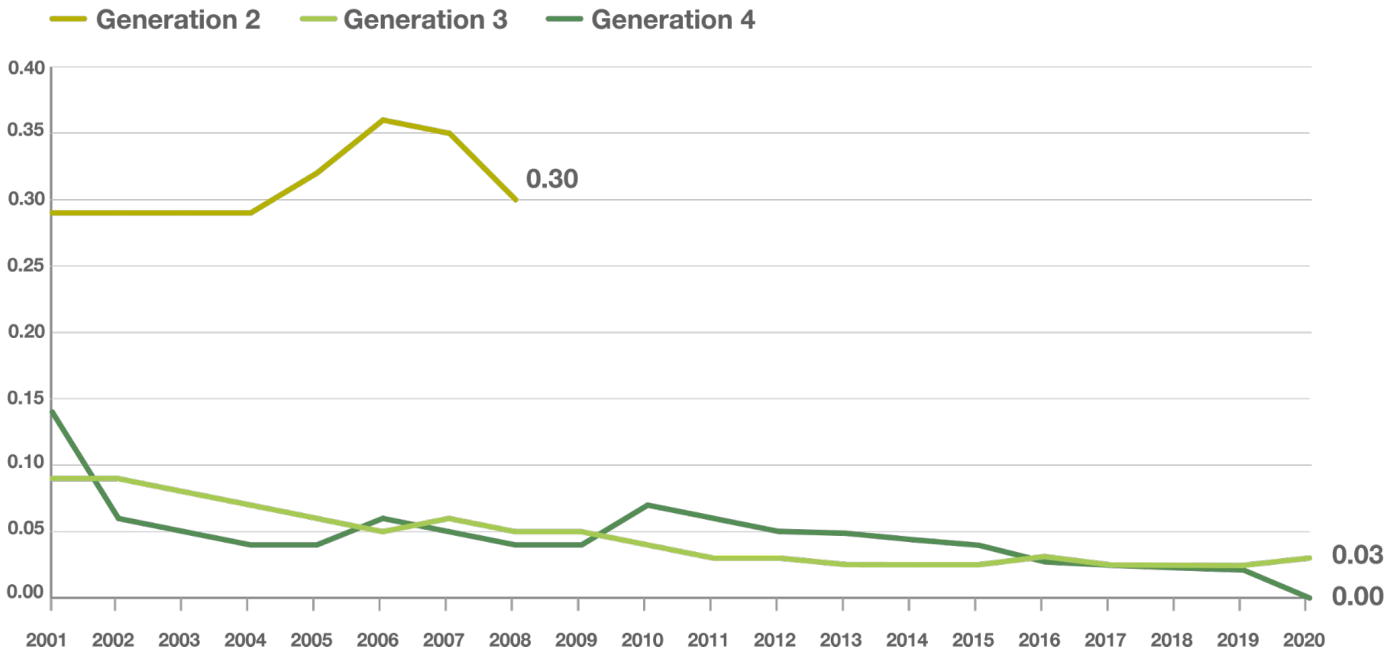
CFIT - Controlled Flight into (or towards) Terrain

- CFIT is used only to refer to occurrences during **airborne phases** of flight
- CFIT includes collisions with **objects extending above the surface** (for example: towers)
- CFIT can occur during **IMC** or **VMC**
- Includes instances when the flight crew is affected by **visual illusions** (e.g. black hole approaches)
- Does **not include** occurrences where the **control of the aircraft is lost**
- Does **not include** occurrences involving **intentional flight into/towards terrain** & low altitude operations

10 year moving average CFIT fatal accident rate (per million flights) per aircraft generation



CFIT fatal accident rates

-89% on CFIT fatal accidents rates from 1999 to 2019 all generations

Western-built jets above 40 seats

Source: ICAO, Cirium & Airbus databases

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CFIT History

1960's : start of studies on CFIT

Early 1970's : First implementation of **reactive TAWS** solutions (GPWS). First NTSB recommendations

1974
First major CFIT B727 @Mt Weather

Mid 1970's : First reactive TAWS mandates by FAA

1979
CFIT - limitations of reactive TAWS DC10 @Mt Erebus

End 1970's : ICAO recommended the installation of the reactive TAWS

1980's : The A310 (1983) is the first Jetliner with Glass cockpit providing **Flight Management System** (FMS) for improved navigation and **Navigation Displays** for improved positional awareness.

1980's: Worldwide generalization of Reactive TAWS

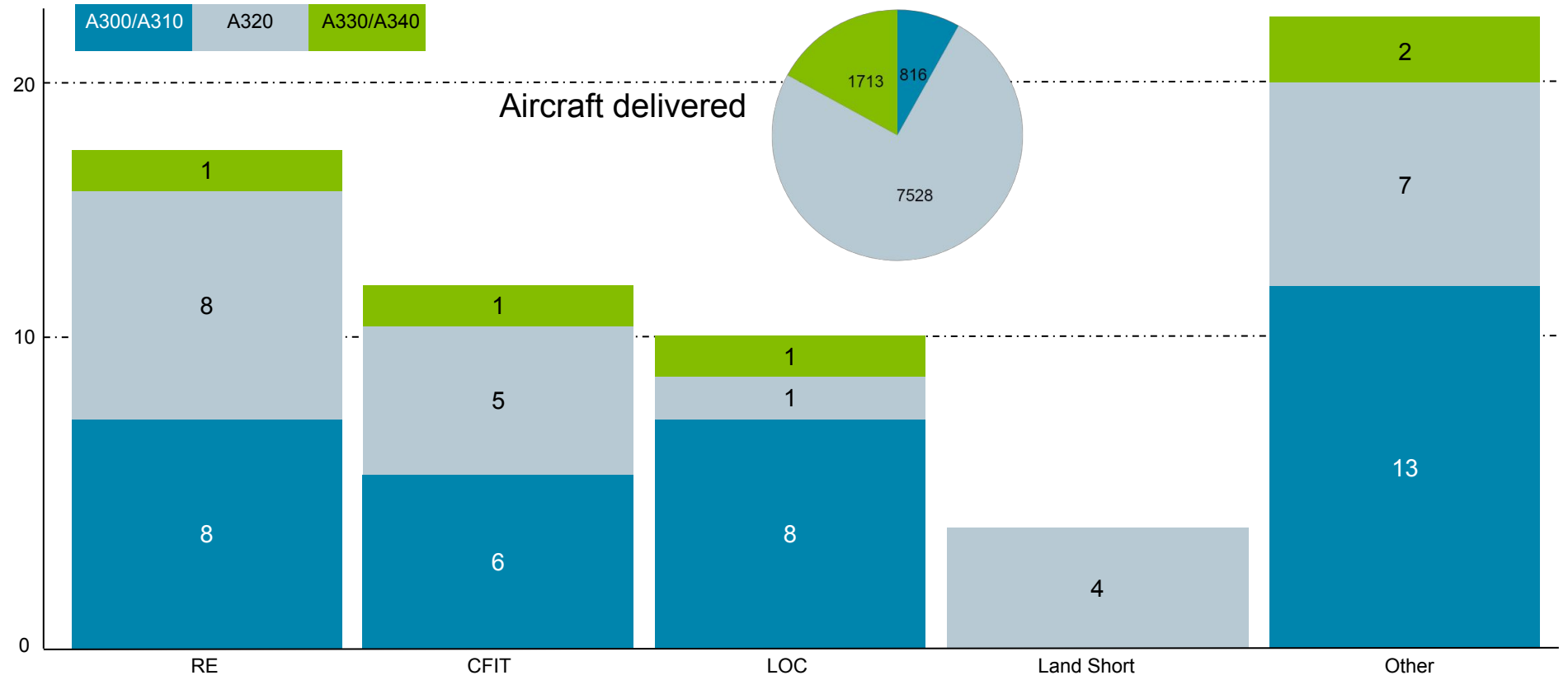
Early 1990's : Introduction of **predictive TAWS /** Enhanced GPWS (EGPWS) comparing the **aircraft position vs a terrain database**

Mid 1990's : the last few countries mandate **reactive TAWS**

2000's : Worldwide generalization of **predictcve TAWS**

FMS, Navigation Displays and TAWS have helped to reduce the CFIT fatal accident rate by 86%

Airbus Accidents Involving Hull Loss or Fatalities



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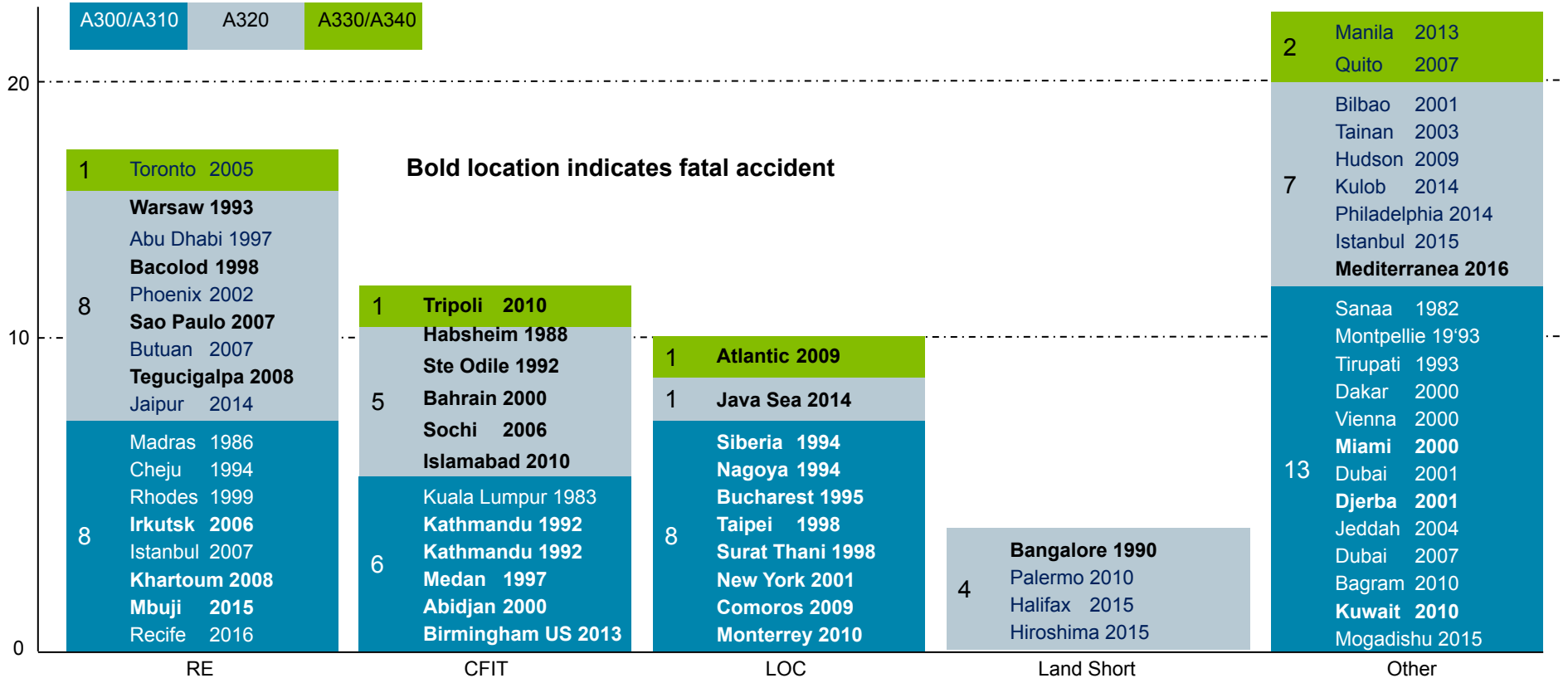
Airbus Accidents Involving Hull Loss or Fatalities



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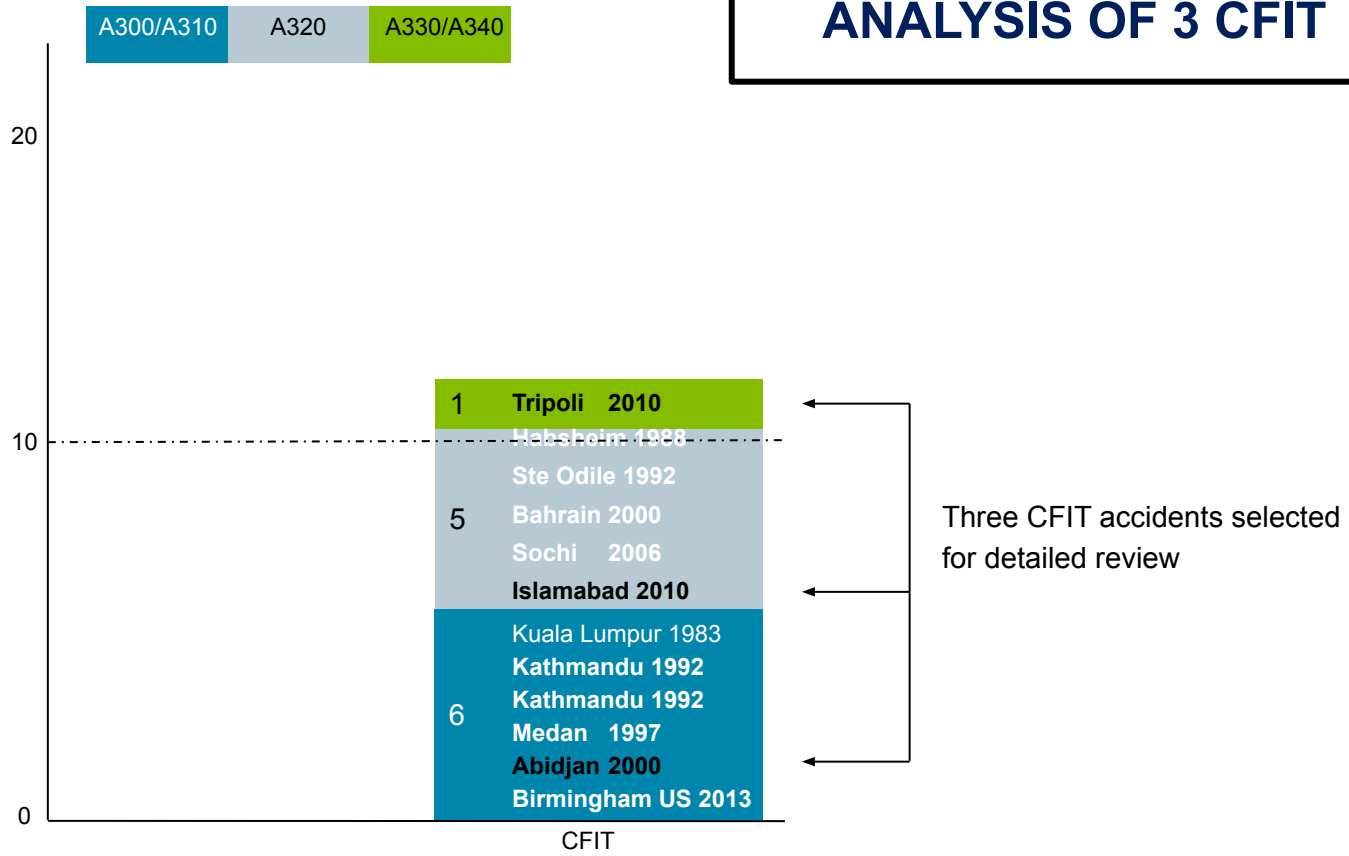
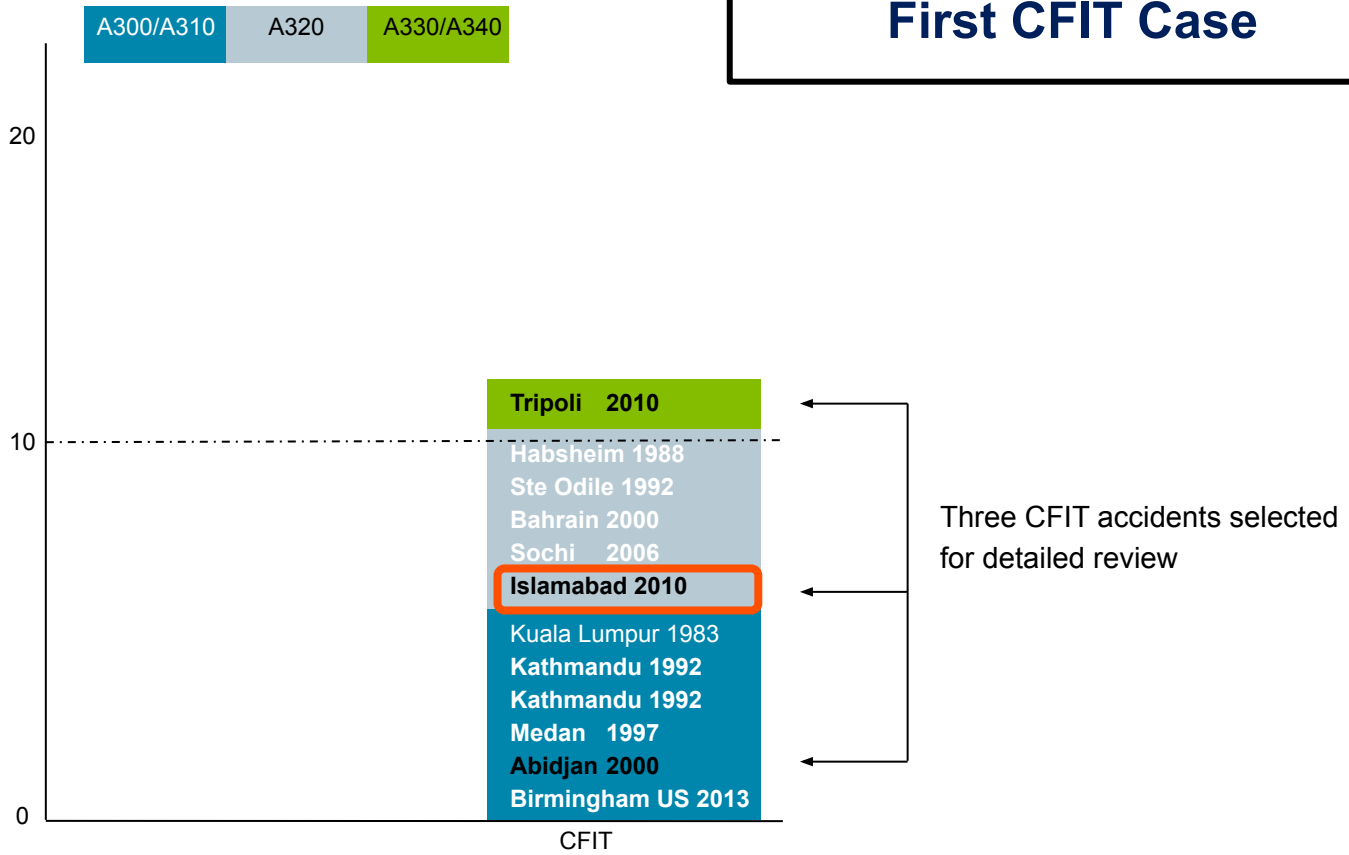
ANALYSIS OF 3 CFIT



Three CFIT accidents selected for detailed review

First CFIT Case



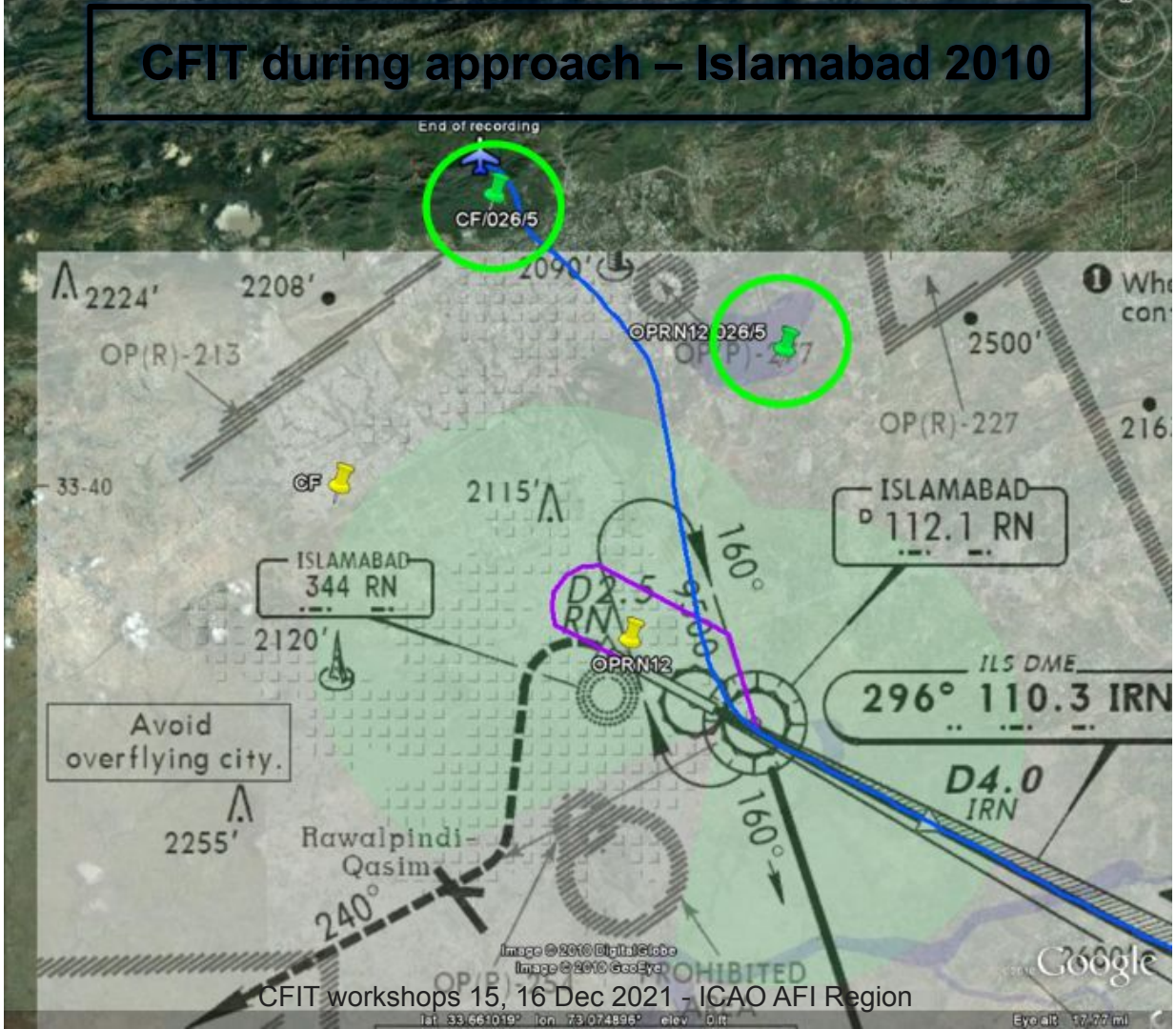
Three CFIT accidents selected for detailed review

CFIT during approach – Islamabad 2010

Event Description

- The aircraft was to perform a circling approach procedure for runway 12.
- Before starting the approach, the flight crew created FMS waypoints that did not match the published approach procedures.
- Weather reports indicated rain, poor visibility, and low clouds. The aircraft descended **below the MDA** (i.e. 2 300 ft instead of maintaining 2 510 ft).
- The approach was **continued despite low visibility** and insufficient visual ground references.
- As configured in the FMS, the aircraft flew toward the waypoints inserted by the flight crew, away from the published approach path, toward the hills.
- As the aircraft neared the hills, air traffic control sent calls to the flight crew and the **TAWS** triggered **TERRAIN** and **PULL-UP** warnings with increasing severity **for more than one minute**.
- The **flight path was not corrected**. The aircraft impacted the hilly terrain 9.6 NM from the airport.

CFIT during approach – Islamabad 2010



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CFIT during approach – Islamabad 2010

The flight crew did not respond to multiple TAWS alerts:

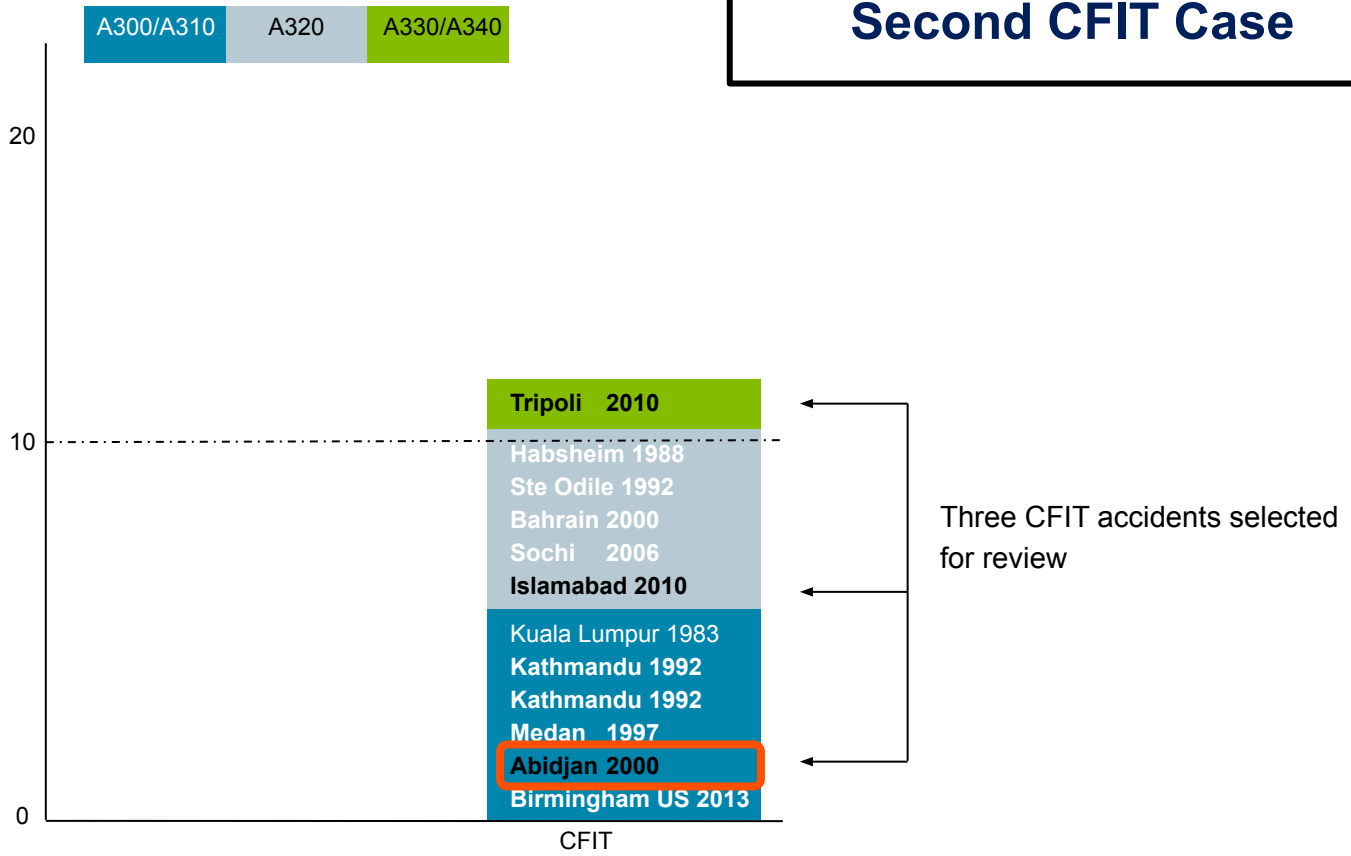
- 70 seconds before the impact, the crew received the first TAWS warning **TERRAIN HEAD**
- During these last 70 seconds, the TAWS sounded **21 times** as:
  - **TERRAIN AHEAD**,
  - **PULL UP** & **TERRAIN AHEAD PULL UP** (**15 times**).
- Despite calls from ATC and the FO (FO informed the Captain 4 times about the terrain and asked him at least 3 times to pull up), the Captain did not react to these warnings

Safety Enhancement

- **Design aspect**
  Some ideas to be further matured

- **Operational aspect**
  CRM reinforcement

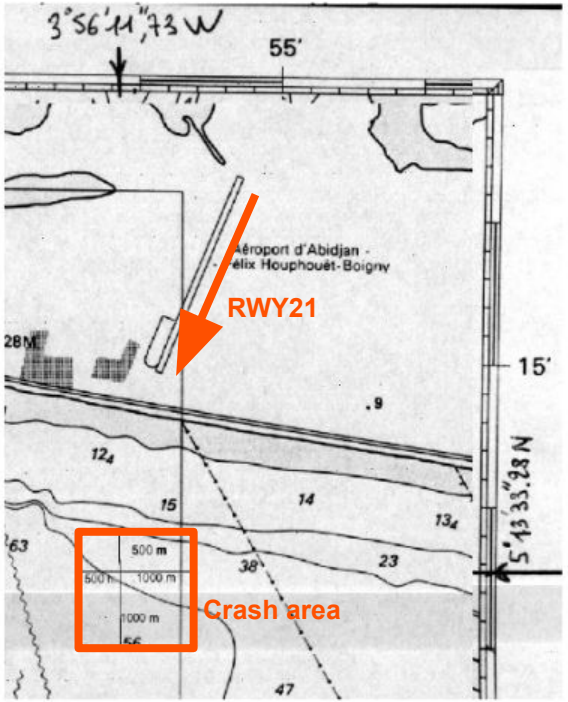
Second CFIT Case



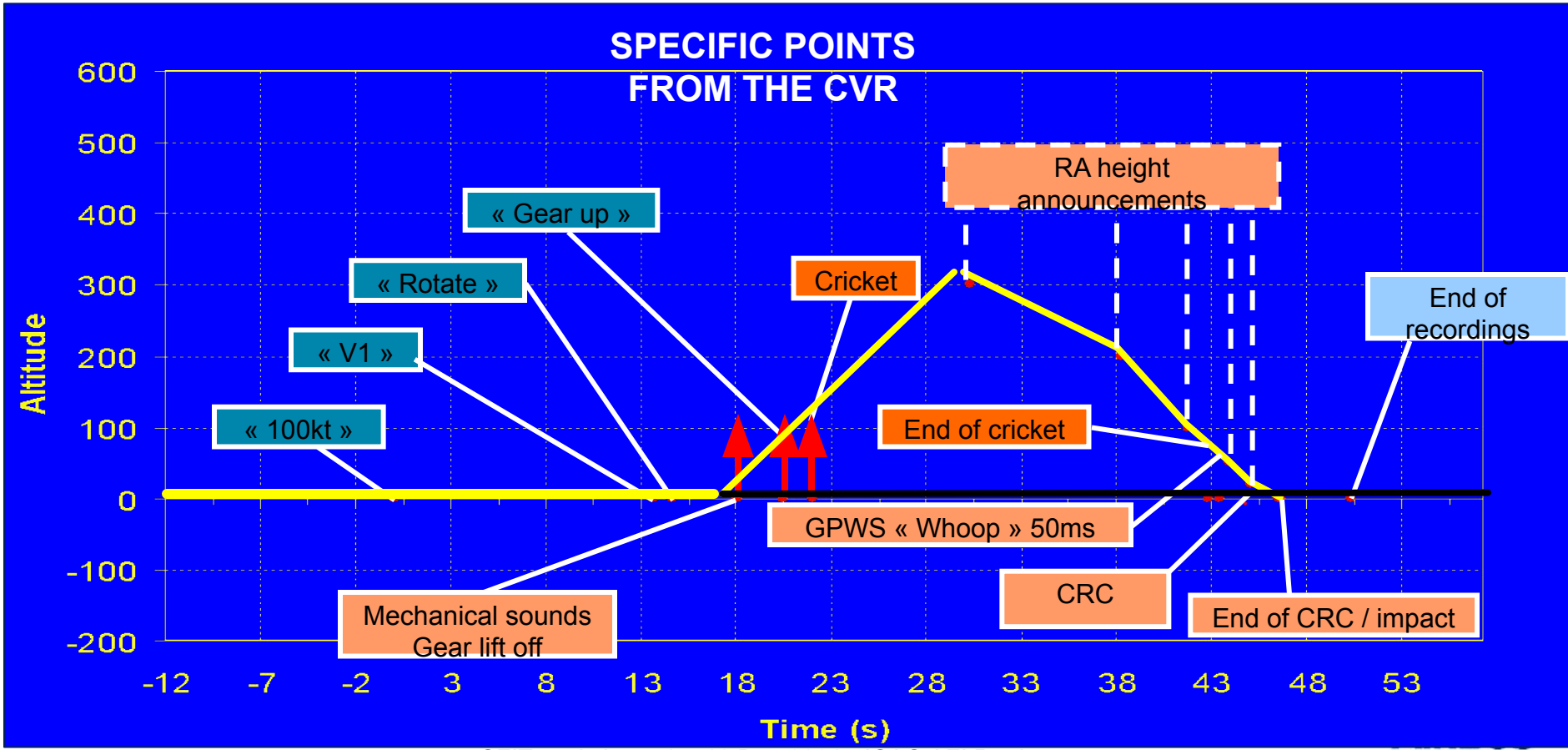
Three CFIT accidents selected for review

CFIT after Liftoff – A310 Abidjan 2000

- The aircraft flew into the sea after takeoff
- Stall warning triggered continuously after takeoff
- Investigation identified a broken angle-of-attack (AOA) vane
  - High AOA data sent to the Flight Warning System
- Crew applied the stall warning procedure in response to the spurious alert



Flight Profile from CVR



STALL WARNING PROCEDURE

A310 FLIGHT CREW OPERATING MANUAL	PROCEDURES and TECHNIQUES	2.02.09
		PAGE 1 / 2
	FLIGHT CONTROLS	REV 27 / SEQ 001

RECOVERY FROM STALL WARNING (STICK SHAKER)

Whenever a stall warning (i. e. Stick Shaker activation) is experienced at low altitude, this should be considered as an immediate threat to maintaining a **safe flight path.**

Indications :

Stick Shaker activation

Speed symbol in the red and black strip on PFD speed scale

At the first indication of an impending stall or upon stick shaker activation, perform simultaneously the following actions :

THRUST LEVERS . . . . . TOGA

PITCH ATTITUDE . . . . . REDUCE

- If a risk of ground contact exists, do not reduce the pitch attitude more than necessary to allow airspeed to increase.
- After initial recovery, maintain the speed close to the stick shaker speed until it is safe to accelerate (closely monitor both the speed and the speed trend arrow).

BANK ANGLE . . . . . WINGS LEVEL

SPEED BRAKES . . . . . CHECK RETRACTED

- **If below 20000ft and in clean configuration :** R

  SLATS . . . . . EXTEND R

- **When out of stall and if no threat of ground contact :**

  LANDING GEAR (If DOWN) . . . . . UP

  Recover normal speed and select flaps as required.

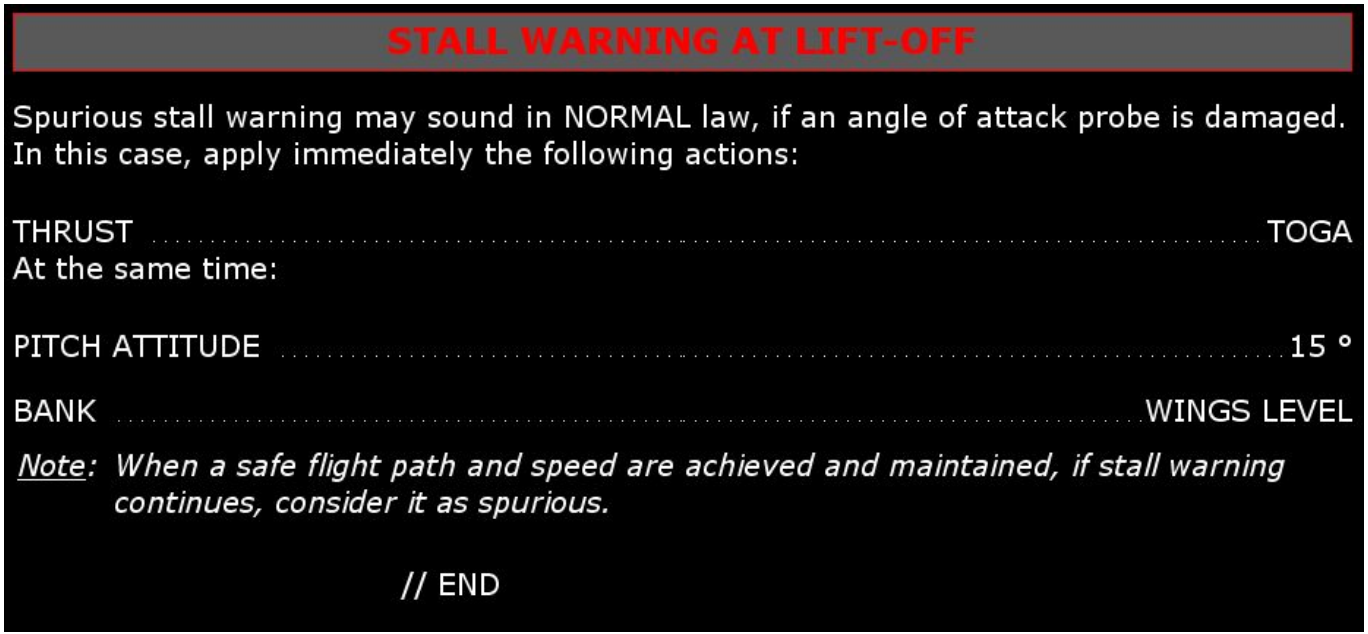
  - **If one engine inoperative :**

    POWER AND RUDDER . . . . . USE WITH CARE

Safety Enhancement – Angle-of-Attack Monitoring at Takeoff

- **Broken probe monitoring**
  - [0, +8°] domain between 90 kt and 110 kt
  - Any sensor out of domain is rejected
- **At higher airspeed, the triplex monitoring takes over**
  - If one source goes away from the others, it is rejected by the system

Safety Enhancement – Operational Considerations



STALL WARNING AT LIFT-OFF

Spurious stall warning may sound in NORMAL law, if an angle of attack probe is damaged.
In this case, apply immediately the following actions:

THRUST ..... TOGA
At the same time:

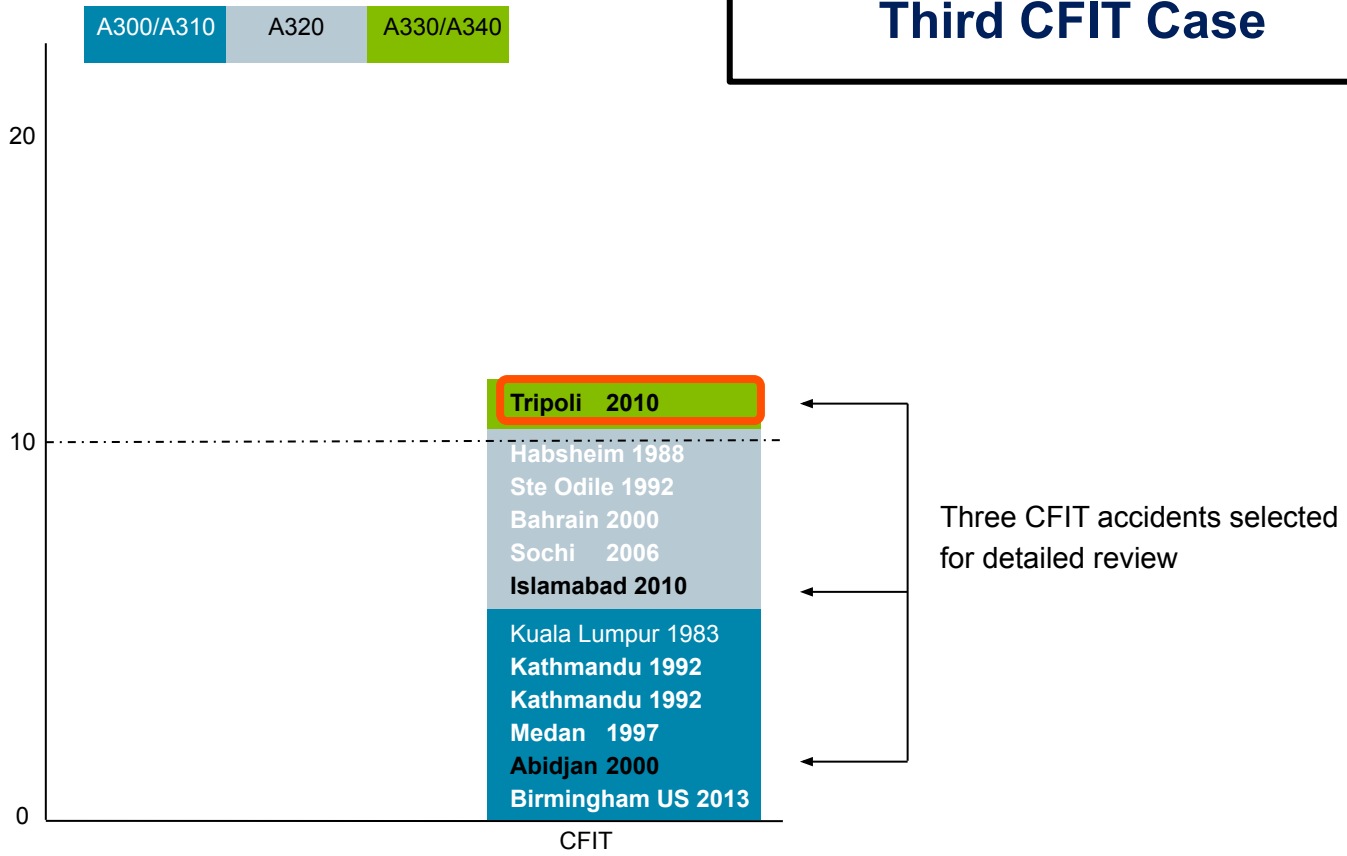
PITCH ATTITUDE ..... 15 °

BANK ..... WINGS LEVEL

Note: When a safe flight path and speed are achieved and maintained, if stall warning continues, consider it as spurious.

// END

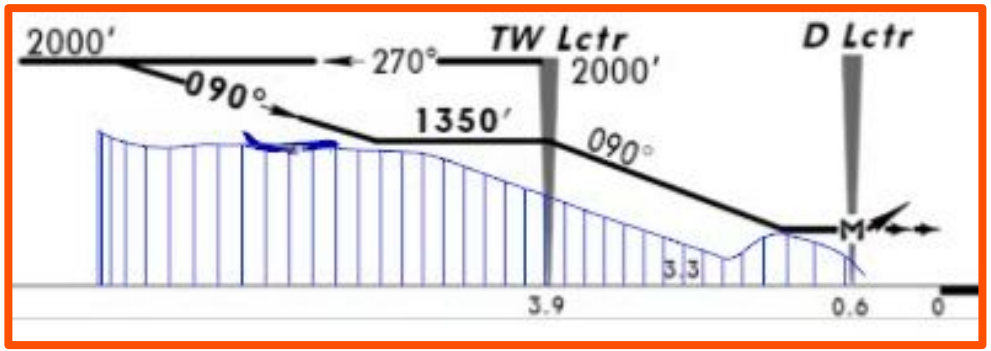
Third CFIT Case



Three CFIT accidents selected for detailed review

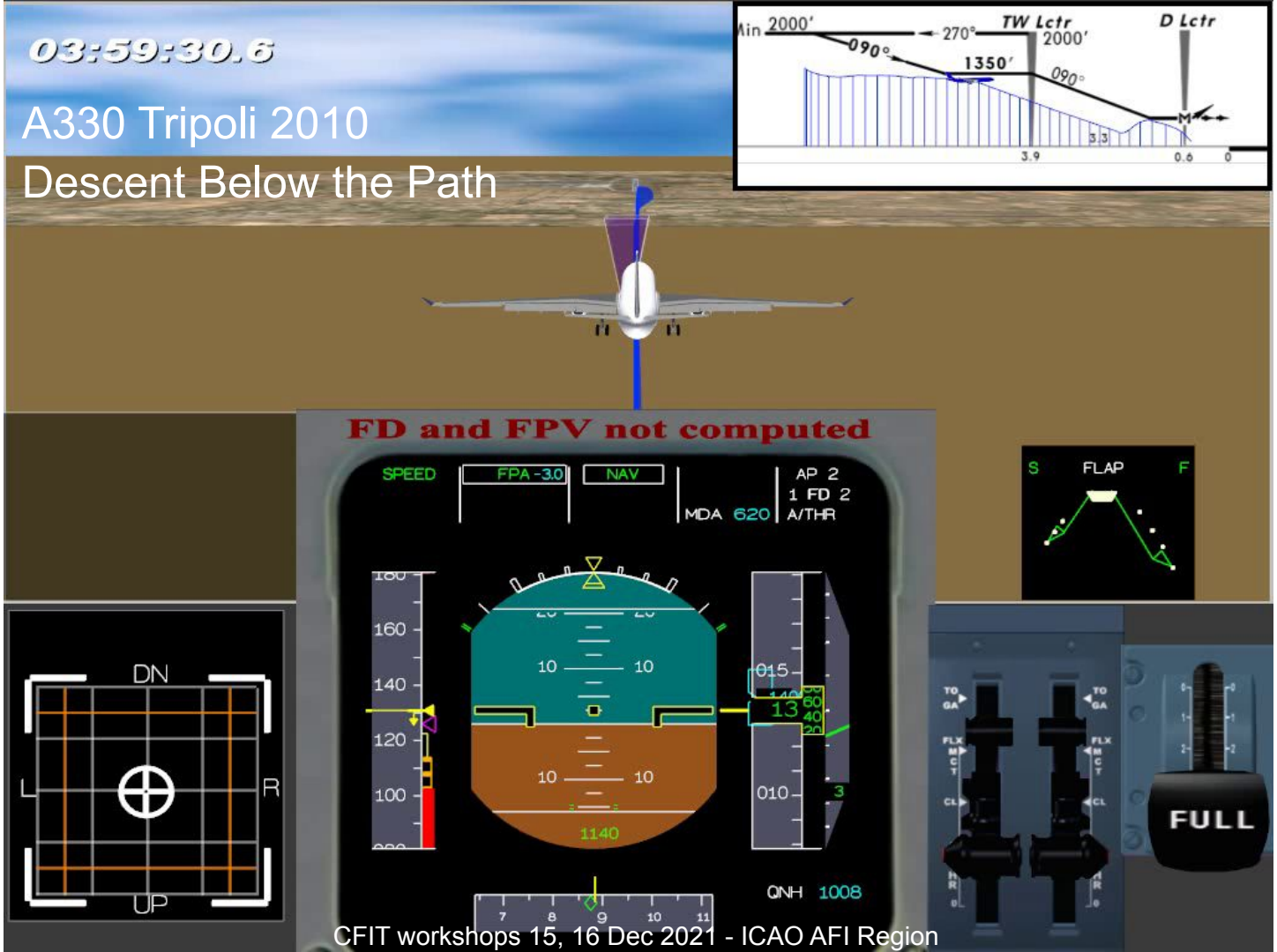
CFIT during Go-Around – A330 Tripoli 2010

- No precision locator approach
- Fog forming over the airport before sunrise
- No visual reference with runway below minimum
- Go-around upon **TOO LOW TERRAIN**
  - AP disconnected / TOGA / CONF 3 / Gear UP
- Go-around pitch not flown / FD bars not followed
- Nose down inputs due to spatial disorientation
- A/C started to descent
- Late response to increasing TAWS alerts
  - **DON'T SINK**
  - **TOO LOW TERRAIN**
  - **PULL UP**



A330 Tripoli 2010

Descent Below the Path



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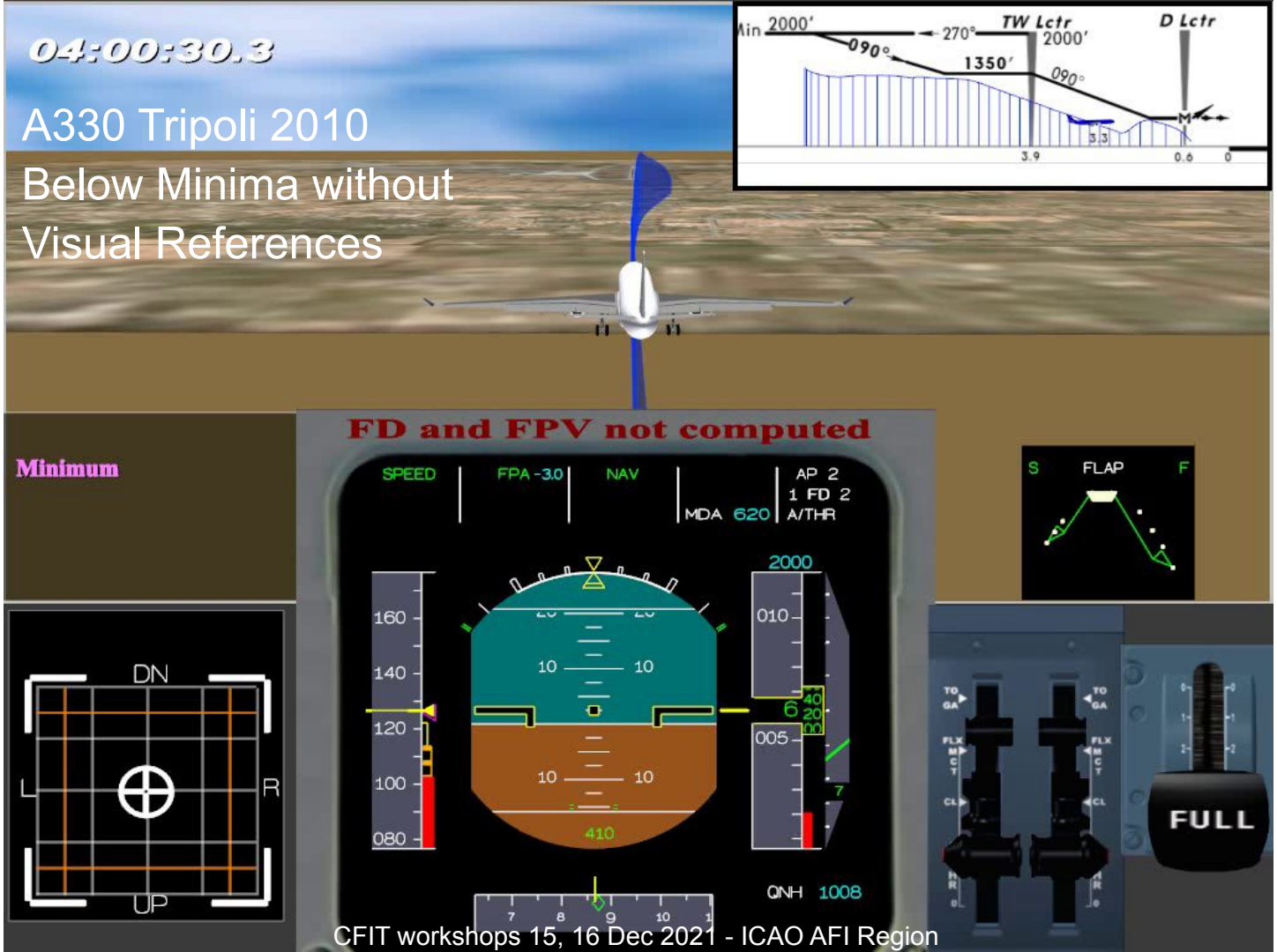
04:00:30.3
A330 Tripoli 2010
Below Minima without
Visual References
Min 2000'
090°
270°
TW Lctr
2000'
D Lctr
1350'
090°
3.9
3.3
0.6
0
Minimum
FD and FPV not computed
SPEED
FPA -3.0
NAV
AP 2
1 FD 2
A/THR
MDA 620
2000
160
140
120
100
080
010
005
10
10
10
10
410
QNH 1008
S
FLAP
F
DN
L
R
UP
FULL

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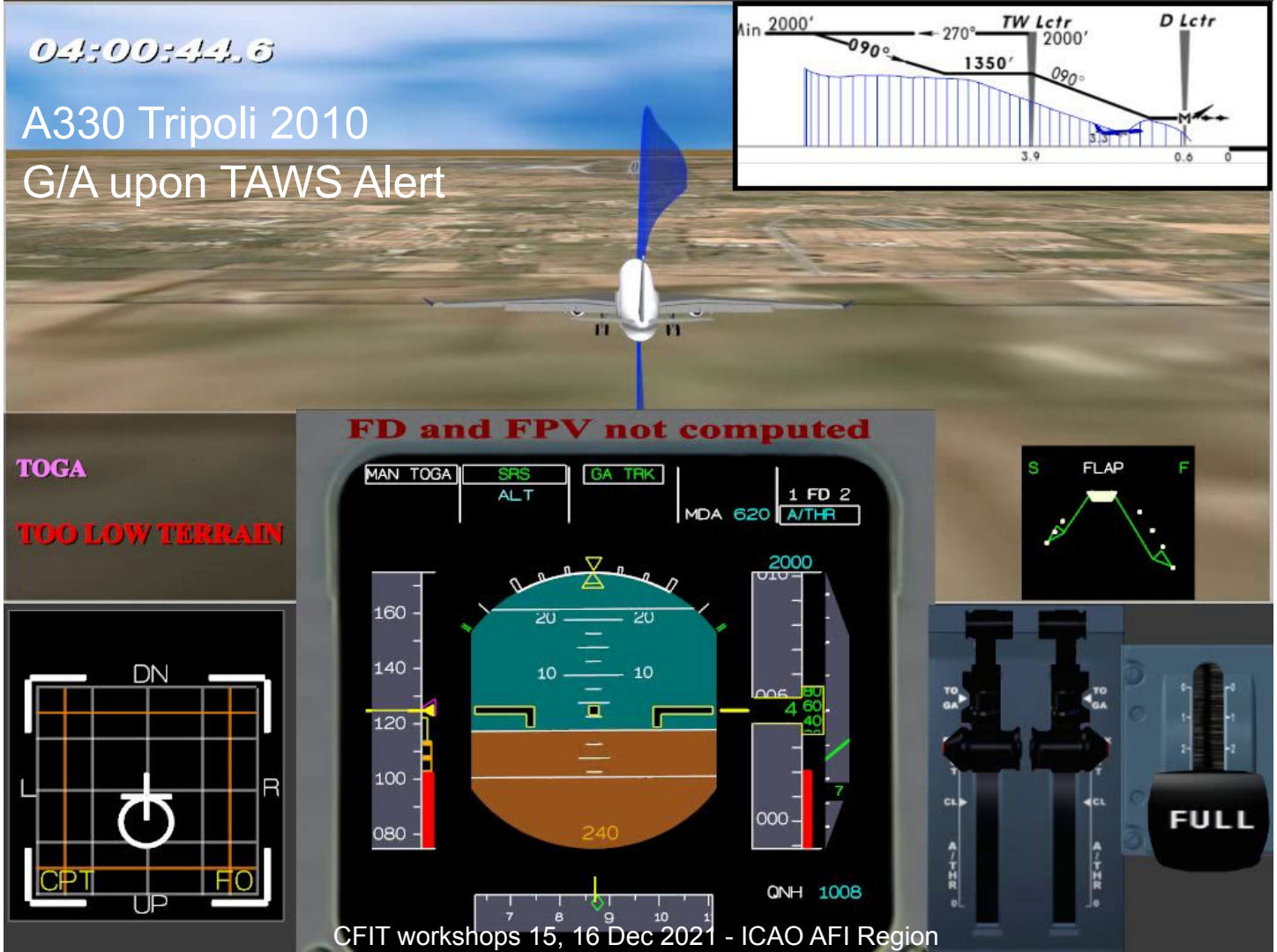
04:00:44.6
A330 Tripoli 2010
G/A upon TAWS Alert
Min 2000'
090°
270°
TW Lctr
2000'
D Lctr
1350'
090°
M
3.9
0.6
0
TOGA
TOO LOW TERRAIN
FD and FPV not computed
MAN TOGA
SRS
ALT
GA TRK
MDA 620
1 FD 2
A/THR
S
FLAP
F
2000
160
140
120
100
080
20
20
10
10
4
60
40
240
000
7
DN
L
R
CPT
FO
UP
QNH 1008
FULL

AIRBUS


04:00:52.3
A330 Tripoli 2010
Pitch G/A not flown
FD Bars not followed
Min 2000'
090°
270°
TW Lctr
2000'
D Lctr
1350'
090°
3.3
3.9
0.6
0
MAN TOGA
SRS
ALT
GA TRK
MDA 620
1 FD 2
A/THR
S
FLAP
F
180
160
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20
20
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7
8
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TO GA
CL
A/THR
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A330 Tripoli 2010
Late Response to TAWS Alerts

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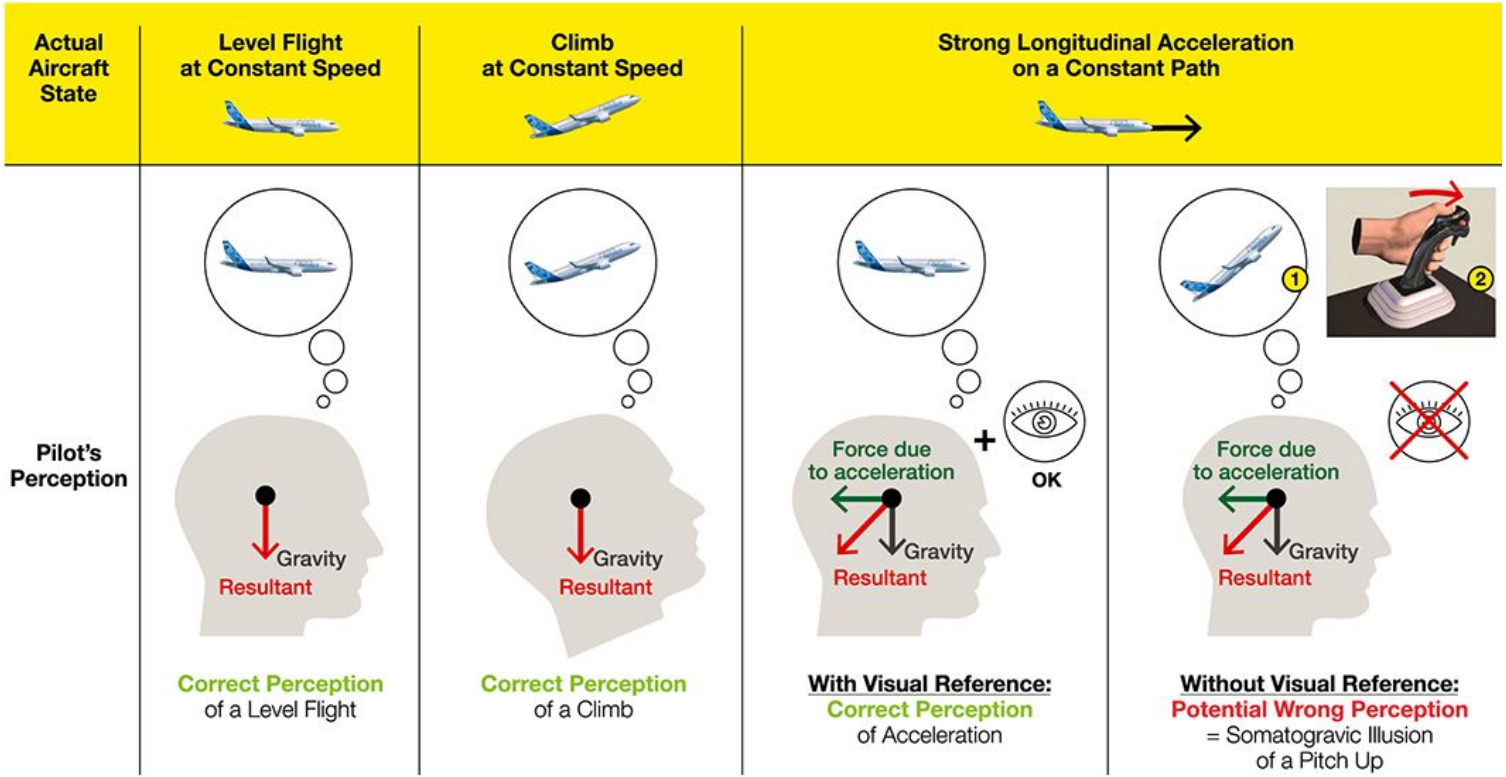
SOMATOGRAVIC ILLUSION



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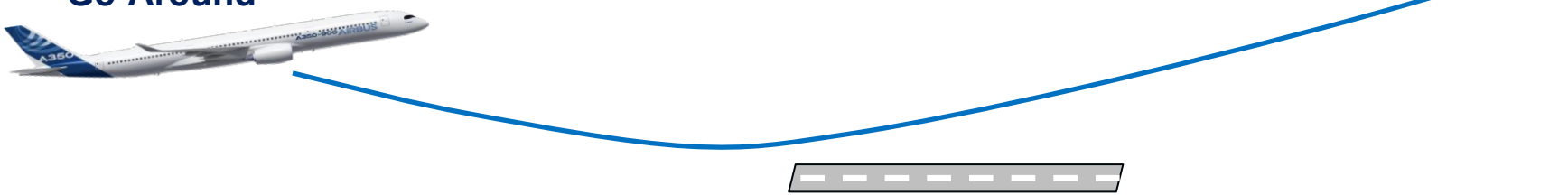
CFIT during Go-Around – A330 Tripoli 2010

- First TAWS alert **TOO LOW TERRAIN** was followed by a GO-AROUND
- When subsequent TAWS alerts **DON'T SINK** & **TOO LOW TERRAIN** & **PULL UP** were triggered the flight crew did not respond in time

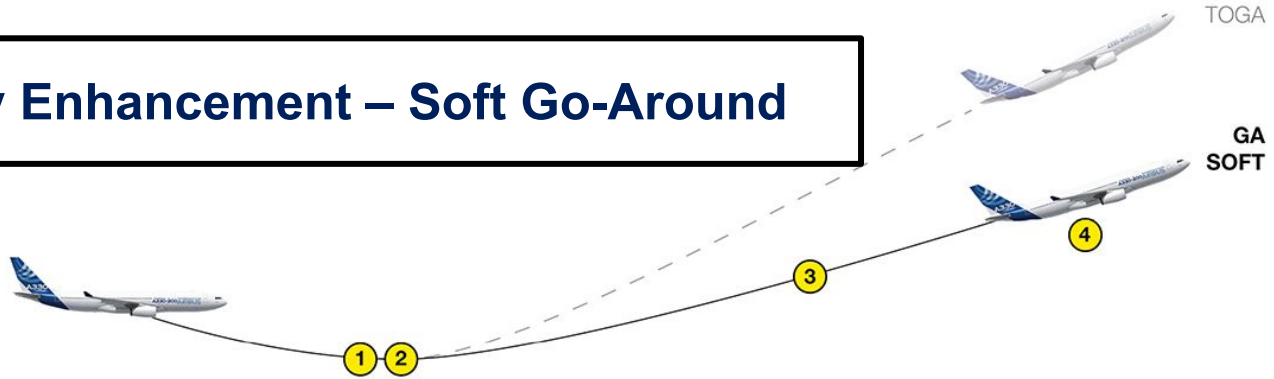
Safety Enhancement – Soft Go-Around

- **Classical go-around with TOGA power at light A/C weight**
  - Strong airspeed acceleration
  - High V/S
  - High pitch angle in some cases

- **Soft Go-Around**



Safety Enhancement – Soft Go-Around

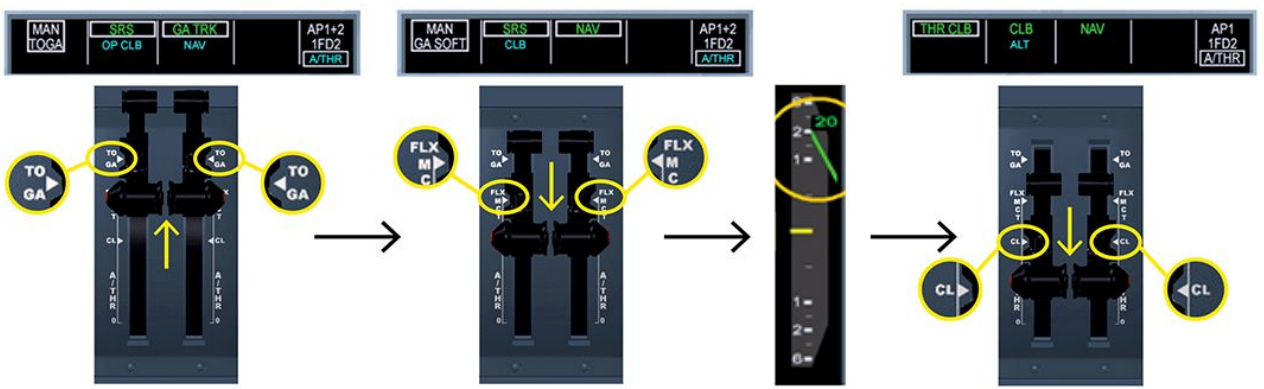


1 TOGA (Go-Around Initiation)
- SRS Guidance Mode Engagement
- Approach Mode Disengagement
- FMS Go-Around Phase Activation

2 FLX/MCT
- Soft Go-Around Activation

3
AP/FD Orders for 2000 ft/mn or 2300 ft/mn

4 CLB
- Soft Go-Around Disengagement
- CLB Guidance Mode Engagement
- A/THR Activation



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Safety Enhancement – Soft Go-Around

- Enables the flight crew to have an “appropriate” Go-Around thrust to reach a 2000ft/min V/S
- Prevents overspeed or high pitch angle increase, and reduce somatogravic illusions

CONCLUSION

- CFIT remains one of the main accident categories
- TAWS has proven to be efficient, significantly reducing the number of CFIT
- CFIT are still happening where responding to TAWS alerts would prevent the accident
- Absolute need to respond to TAWS alerts
- There are “non classical” CFIT, but TAWS is also designed for these cases