NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

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Attachment 11 – Airbus Material – Avoiding Tail Strike

OPERATIONAL FACTORS

DCA17LA145

Operational Liaison Meeting FBW aircraft

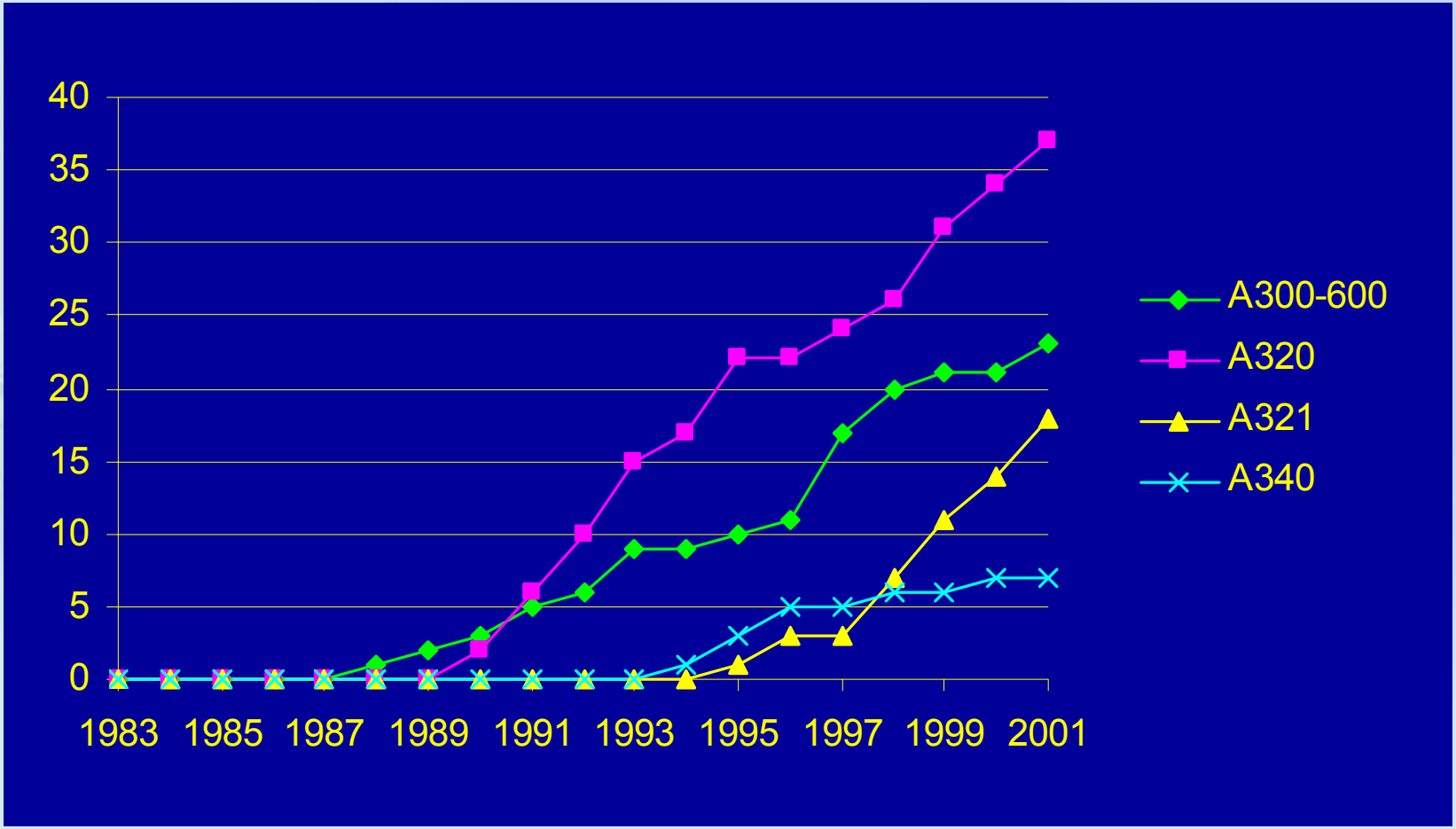
Avoiding Tail Strike

Content

- Statistics
- Most common causes
- Factors affecting the margins
- Aircraft design features
- Operational recommendations
- Conclusions

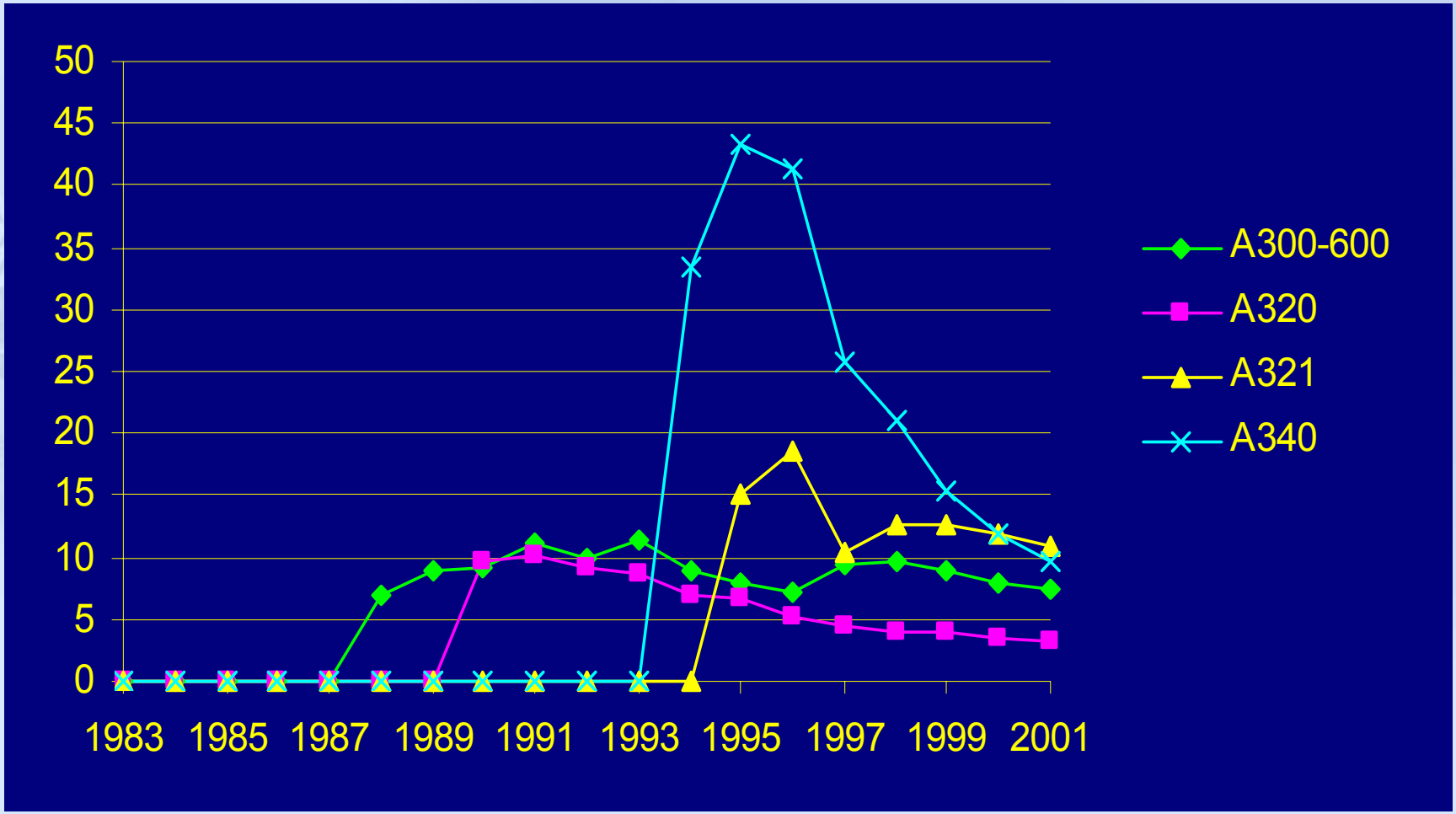
Statistics

Total number of events



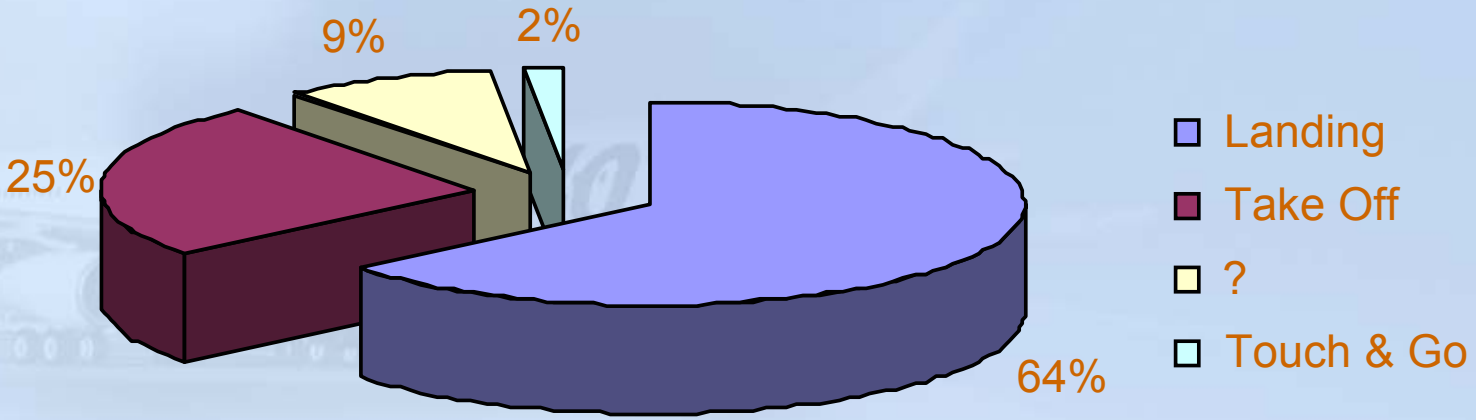
Statistics

Cumulative number of events per million departures

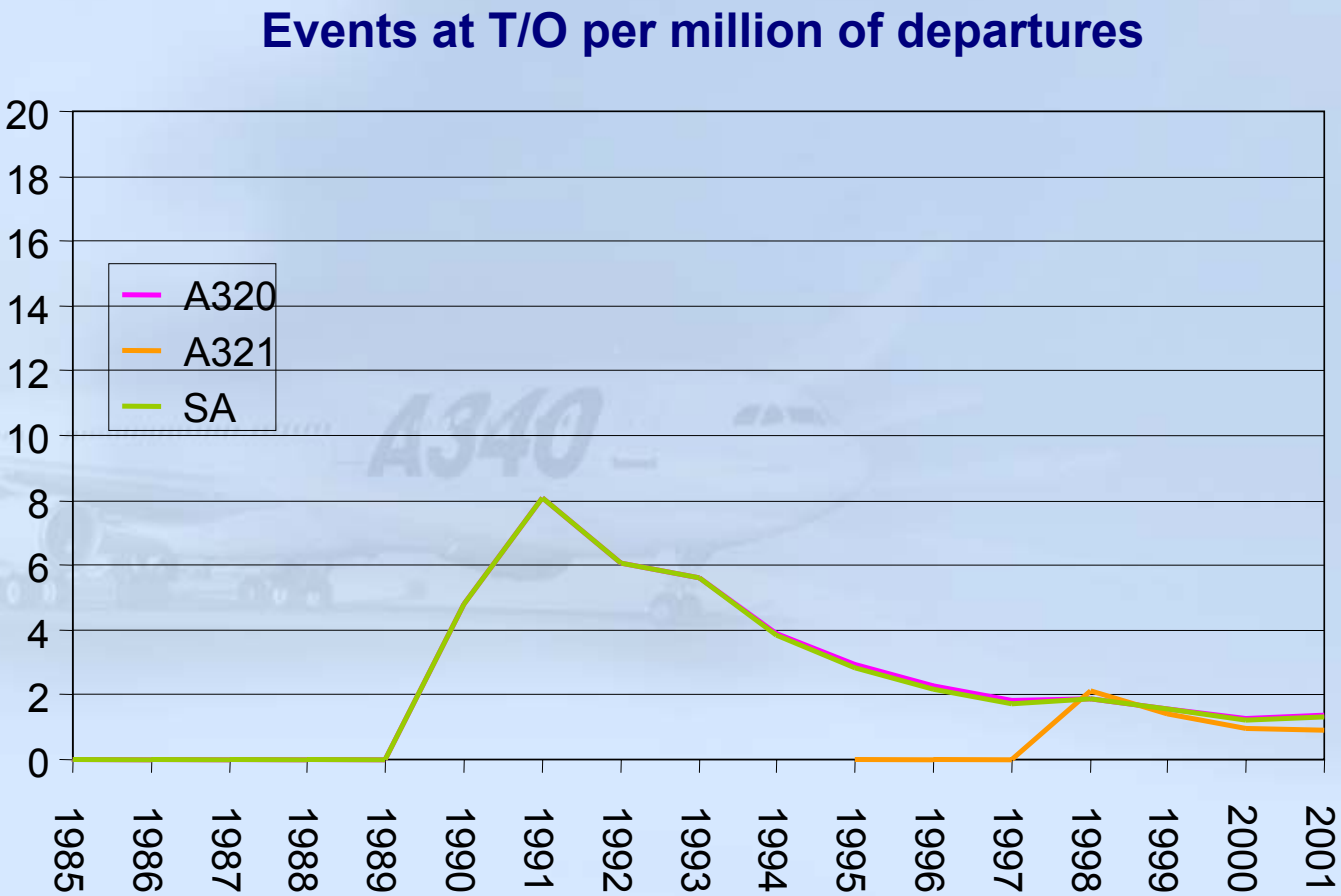


Statistics

Per flight phases:

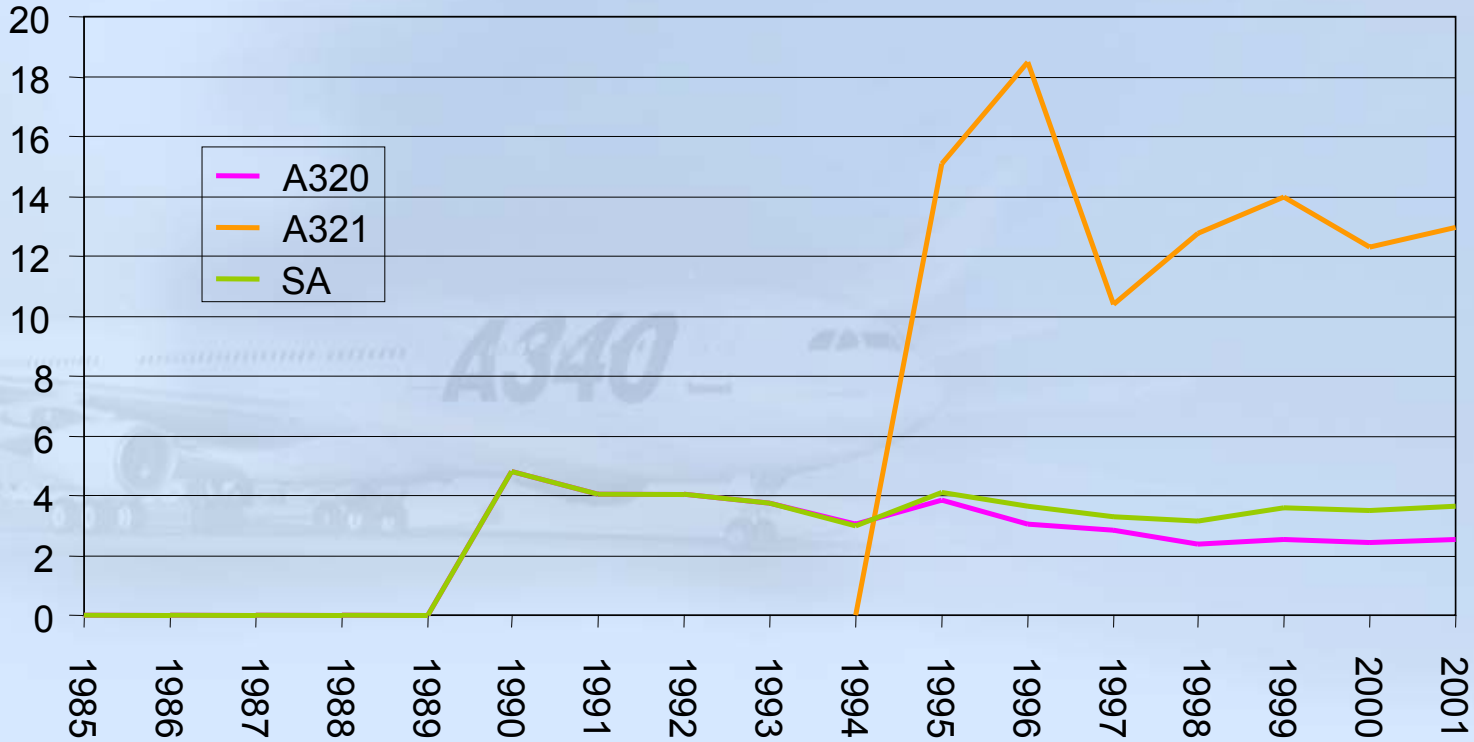


Statistics


Events at T/O per million of departures
20
18
16
14
12
10
8
6
4
2
0
A320
A321
SA
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001

Statistics

Events at landing per million of departures



Most Common Causes

- At takeoff
  - Excessive rotation rate
    - Increasing rotation rate, rotation in two steps
  - Premature rotation
    - V_R computation error
  - Over-rotation
  - Improper use of FD pitch command bar
    - Aggressive rotation into FD pitch bar
  - Improper pitch trim setting
  - Rotation with large roll input
  - Improper shock absorber servicing
  - Turbulence, wind shear/downburst

Most of the time, more than one cause is involved!

Most Common Causes

- At landing
  - Unstable approach
    - Large thrust and pitch attitude variations
    - Too high sink rate close to the ground
    - Too low airspeed and high pitch attitude
  - Flare/landing technique
    - Improper flare initiation height
      - Too high, leading to significant speed drop
      - Too low, leading to high pitch rate
      - improper anticipation of aircraft inertia
    - Improper thrust reduction coordination
    - Uncontrolled high pitch rate at touch down
      - high touch down vertical speed leading to bounce
    - Prolonged hold off during flare
    - Nose gear kept high after touchdown

Most Common Causes

- At landing (cont'd)
  - Turbulence, wind shear/downburst
  - Bouncing at landing
    - Pitch rate not stopped after touchdown
    - Aft stick order not released
    - Pitch up effect at spoiler extension not controlled
    - Pitch increase, attempting to smooth the second touchdown

Most of the time, more than one cause is involved!

Factors affecting the margins

- Ground Clearance Geometry

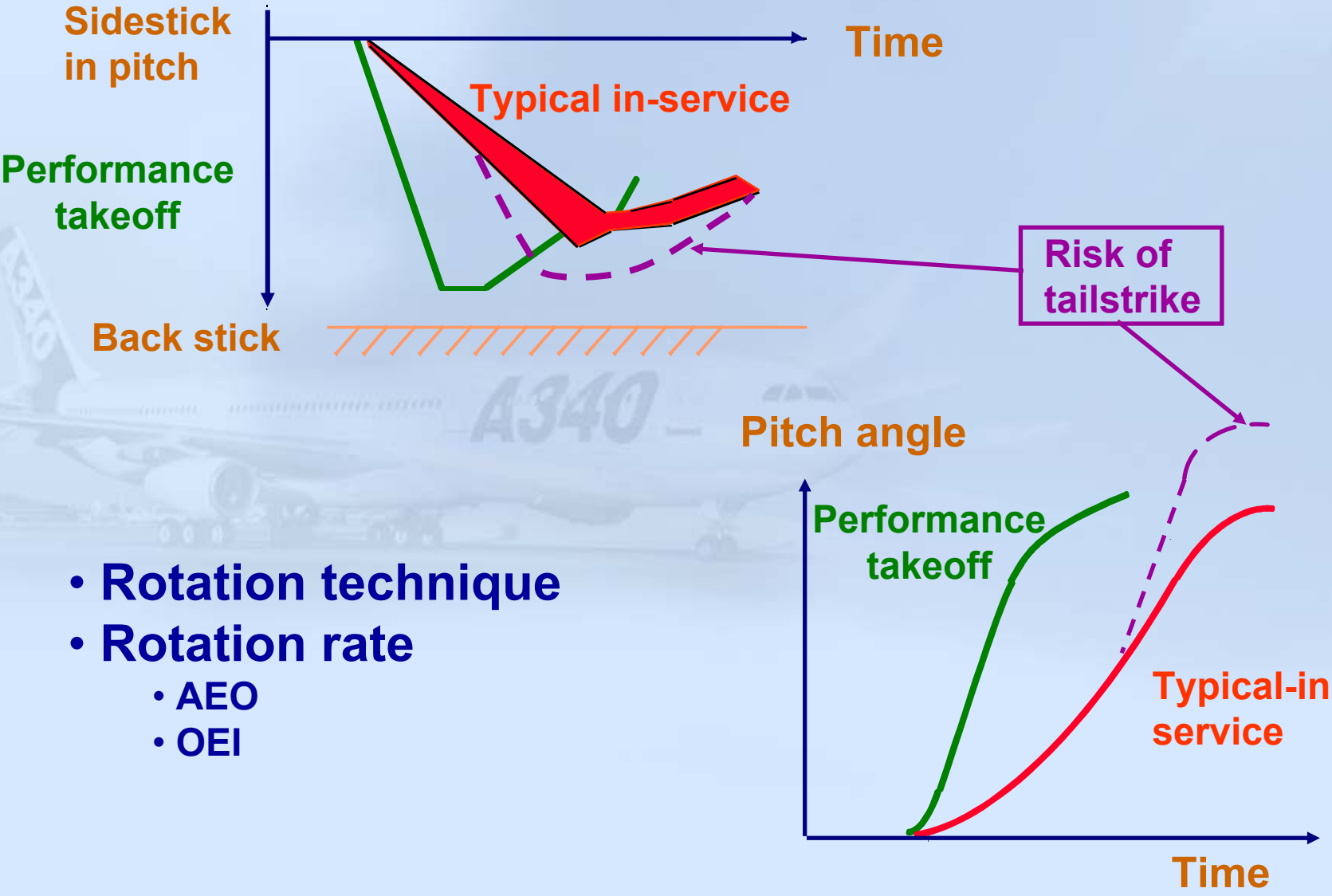
	Pitch attitude to ground contact			
Main gear position	A319	A320	A321	A340-300
Fully extended	15,5°	13,5°	11,2°	14,2°
Fully compressed	13,9°	11,7°	9,7°	10,1°

Factors affecting the margins (Takeoff)

- The rotation speed V_R :
  Margin increases with $V_R / V_{R\,min}$, and V_2/V_S ratio

V_{MU} tests to set minimum takeoff speed, $V_{R\,min}$

Factors affecting the margins (Takeoff)



- Rotation technique
- Rotation rate
  - AEO
  - OEI

Factors affecting the margins (Takeoff)

- Other factors to be considered at TO
  - Thrust to weight ratio
    - margin is decreasing with more FLEX
  - Configuration is not a factor for same rotation rate
    - But for the same side stick input, the margin increases with more flaps
  - Large lateral side stick input
    - Spoilers extension modify the lift to AOA ratio, thus reducing the margin

Factors affecting the margin (Landing)

- The airspeed at touchdown
- The flare technique

Aircraft	Geometry limit at touchdown	Pitch attitude at touchdown (Vapp - 8) *	Clearance
A319	15.5°	7.7°	7.8°
A320	13.5°	7.6°	5.9°
A321	11.2°	6.6°	4.6°

* Typical value

A good IAS at touch down is obtained with:

- Properly stabilized approach (pitch, IAS, flight path) at flare initiation
- Smooth and repetitive flare technique

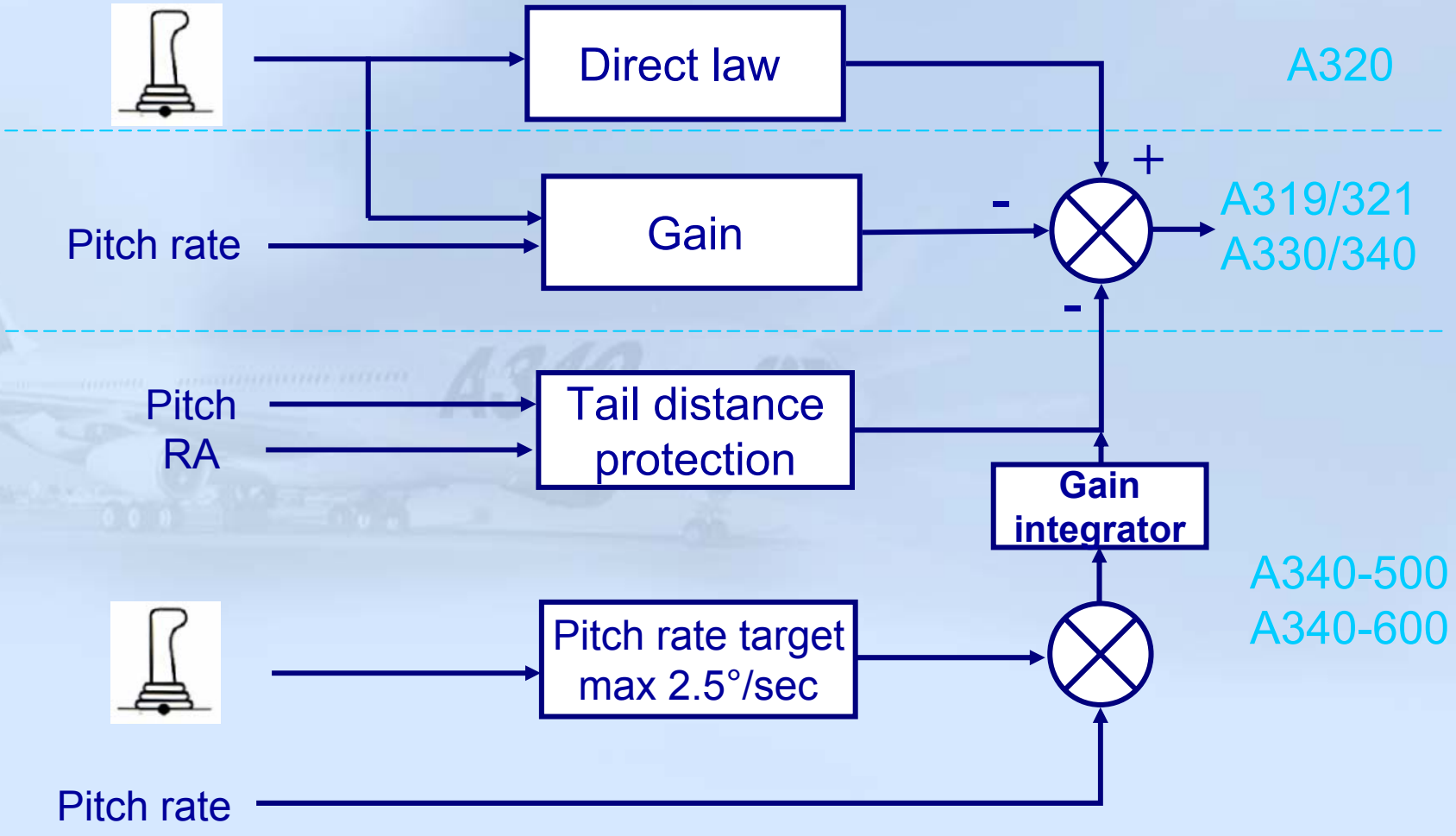
Factors affecting the margin (Landing)

- Other factors to be considered at landing
  - High and increasing pitch rate at touch down
  - Large lateral side stick inputs
  - Excessive vertical speed
  - Aircraft inertia
  - Thrust reduction height

Aircraft design features

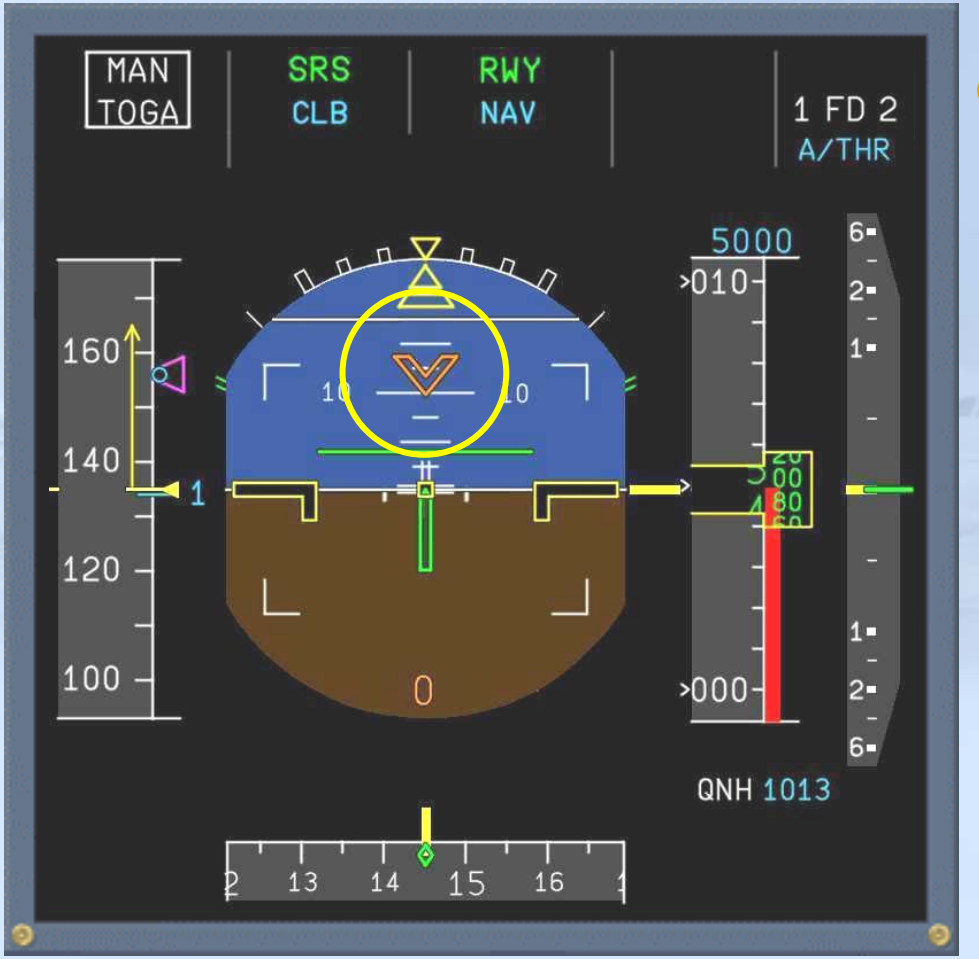
- Properly designed direct law for TO:
  - Pitch rate damping on all Airbus FBW except A320
- In addition for A340-600:
  - Take-off Rotation Law
  - Automatic pitch trim setting, function of CG, after engine start and for touch-and-go
  - TRIM SETTING DISAGREE ECAM message at TO CONFIG (comparison of MCDU PERF T/O trim value with actual pitch trim setting and CG from FCMC).
  - TAIL STRIKE ECAM warning when a tail strike is detected
  - “PITCH” auto call out for landing

Aircraft design features



The protection can be surpassed

Aircraft design features



- Pitch limit indication is provided:
  - At take-off
    - From power application to 3 sec after lift off
    - Maximum pitch altitude: optimized between 9°5 and 14° (for A340-600)
  - At landing:
    - 8.4° below 400 feet /AGL.

Operational recommendations

- For takeoff
  - Cross check TO speeds and trim setting
  - Be aware of turbulence
  - Initiate rotation at V_R (not before)
  - Make a positive side stick input to initiate a proper rotation rate
    - it is always better to release the stick if the rotation rate is too high
    - never add pitch up input when the rotation rate is established
  - Adapt the rotation rate to circumstances
    - lower the rate with OEI
  - Do not apply large roll corrections during rotation
  - Do not chase FD pitch bar orders before airborne
    - Follow smoothly FD orders once airborne to fly SRS

Operational recommendations

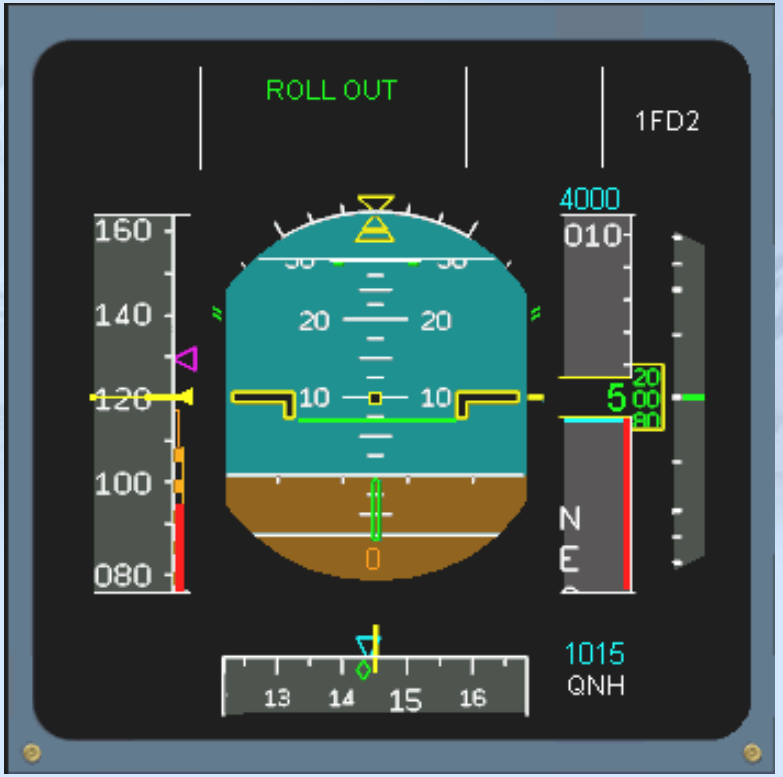
- For landing
  - Fly a stabilised approach (pitch, thrust, flight path, IAS)
  - Do not chase the G/S close to the ground
    - Progressively give priority to the pitch and the sink rate
  - Adapt the flare height to the aircraft inertia
    - Monitor the global energy
    - Co-ordinate thrust reduction with speed, vertical speed and height; touchdown with thrust at idle
  - Zero the pitch rate prior touch down
    - Even attempting to avoid a firm landing
  - Do not hold it off to make an “extra smooth” landing
  - Do not wait to fly the nose wheel to the ground
    - Initiate and control derotation just after MLG touchdown

Operational recommendations

- Bouncing
  - "Freeze" the pitch attitude
    - pitch up effect of spoiler extension may have to be counteracted
  - Do not attempt to soften the second touch down by:
    - Increasing the pitch
    - Adding thrust
  - If the bounce is too large:
    - Initiate a go around maintaining the pitch attitude
    - Do not attempt to avoid a temporary touch down

Operational recommendations

- Reinforcement of PNF specific call outs for excessive pitch attitude on take off and landing



Conclusions

- Apply proper rotation technique at take off
- Fly a stabilized approach
- Avoid excessive sink rate close to the ground
- Control the pitch in case of bounce

Enhance pitch awareness

Include tail strike awareness in the TO and approach briefings

Conclusions

- During transition training course (standard or CCQ) and recurrent training, outline the following factors:
  - Specific geometry limits
  - Specific TO rotation technique
  - Specific flare and derotation technique
  - PNF pitch attitude monitoring
- Refer to SOP and FCOM Bulletins


I hope it will not
happen to me!
A340
A340
Thank you for your attention