Avoiding Tail Strike
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Statistics

Total number of events

A300-600
A320
A321
A340
Statistics

Cumulative number of events per million departures

[Graph showing cumulative events per million departures for A300-600, A320, A321, and A340 from 1983 to 2001.]
Statistics

Per flight phases:

- 64% Landing
- 25% Take Off
- 9% Touch & Go
- 2% "?

Avoiding Tail Strike

AIRBUS
Statistics

Events at landing per million of departures

- A320
- A321
- SA
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

<table>
<thead>
<tr>
<th>Main gear position</th>
<th>A319</th>
<th>A320</th>
<th>A321</th>
<th>A340-300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully extended</td>
<td>15,5°</td>
<td>13,5°</td>
<td>11,2°</td>
<td>14,2°</td>
</tr>
<tr>
<td>Fully compressed</td>
<td>13,9°</td>
<td>11,7°</td>
<td>9,7°</td>
<td>10,1°</td>
</tr>
</tbody>
</table>
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
Avoiding Tail Strike

Factors affecting the margin (Landing)

- The airspeed at touchdown
- The flare technique

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Geometry limit at touchdown</th>
<th>Pitch attitude at touchdown (Vapp - 8) *</th>
<th>Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A319</td>
<td>15.5°</td>
<td>7.7°</td>
<td>7.8°</td>
</tr>
<tr>
<td>A320</td>
<td>13.5°</td>
<td>7.6°</td>
<td>5.9°</td>
</tr>
<tr>
<td>A321</td>
<td>11.2°</td>
<td>6.6°</td>
<td>4.6°</td>
</tr>
</tbody>
</table>

* 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
Avoiding Tail Strike

Aircraft design features

- Direct law
- Gain
- Tail distance protection
- Gain integrator

The protection can be surpassed

Pitch rate

A320
A319/321
A330/340
A340-500
A340-600
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.
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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!

Thank you for your attention