Take off rotation
Some additional issues

Customer Services
• Why do we talk again about Take Off Rotation?

It has been addressed in 2002 OLMs and in 2003 Performance & Operations Conference in Rome.

Some recent incidents call for some additional explanations.
Reminder of various recommendations

• The Rotation flying techniques are outlined in FCOM SOPs and supplementary techniques

• They address the lateral and the pitch control of the aircraft.
Reminder of various recommendations

• Regarding the lateral control of the aircraft:

? Do not apply large roll inputs in case of crosswind

▷ Since they favor the natural “into the wind turn tendency” of the aircraft

▷ Since spoilers extended increase the pitch required at lift off, thus reduce the tail strike margin (lift reduction)

▷ Since a large lateral stick input may cause a lateral control problem at lift off.
Reminder of various recommendations

- Regarding the pitch control of the aircraft:
  - The T/O normal law is adapted to each aircraft model so as to ensure a similar pitch rotation technique on all FBW models.
Reminder of various recommendations

• Regarding the pitch control of the aircraft:

? At VR initiate rotation – with a positive side stick input for A330/A340, to achieve a continuous rotation of about 3°/sec, towards a pitch attitude of:

- AOE: 15° (12.5° on A340-200/300)
- OEI: 12.5°

NOTE: this pitch target is the average pitch which will be commanded by the FD pitch bar, once A/C is airborne and SRS available
Reminder of various recommendations

• Regarding the pitch control of the aircraft:

  ‣ Avoid aggressive and sharp stick inputs

  ‣ Avoid shy initial stick inputs and further aft stick inputs just prior lift off

  ‣ Avoid chasing FD bar during initial rotation
T/O Rotation some additional issues

• In order to minimize tail strike risks, following recommendations apply:
  
  ‣ Avoid premature rotation
  ‣ Avoid excessive rotation rate, over rotation
  ‣ Apply proper THS setting
  ‣ Avoid improper use of FD pitch bar during rotation
  
  and also
  
  ‣ Properly choose T/O configuration
  ‣ Check Landing Gear shock absorbers
Properly Determine the Take Off Configuration

• CONF 1+F / CONF2 / CONF3 / are available for T/O
As a general rule:

› A low T/O CONF (e.g. 1 + F) is preferable to optimize the 2\textsuperscript{nd} segment climb gradient, more particularly in hot weather

› A high T/O CONF (e.g. 3) is preferable
  – To improve tail clearance at lift off
  – To lower T/O speeds on rough runways
Properly Determine the Take Off Configuration

• The criteria used to determine the best T/O CONF are:
  
  ‣ The configuration allowing the Highest Flex Temp (Engine saving)
  
  ‣ The configuration allowing for Lower Take off Speeds
  
  ‣ The Preferred Configuration for comfortable Aircraft handling (e.g. tail strike)
Properly determine the Take off Configuration

• Some airplanes are more prone to tail strikes due to their geometry (e.g. A321, A340-500/600, …)

• For a given stick input at rotation, the tail clearance is reduced at lower configuration (e.g. 1+F), because the rotation rate is higher

• A compromise is to be done in between Flex Temp, lower T/O speed and preferred configuration for aircraft handling

⇒ Select the highest possible flap configuration, up to CONF3, provided it does not induce a Flex Temp greater than 5°.
Landing gear shock absorbers

- There are 2 types of gears regarding the kinematics of the shock absorbers (oleos) and wheels:
  - The conventional gears with conventional oleos
  - The shock absorbers associated to Rocking Bogie via a Pitch Trimmer
Landing gear shock absorbers

• The A330/A340 are fitted with Rocking Bogies

  ▶ The Rocking Bogie allows a greater pitch attitude at lift off than a conventional gear with the same stroke

  ▶ The shock absorber stroke is physically limited to about 750 mm. A conventional gear would need 1000 mm additional stroke on A340, for the same attitudes at rotation, than with Rocking Bogies

  ▶ The rotation of the bogie around rear wheels added to the oleo extension allows for such max pitch attitude
Comparison Conventional Gear with Rocking Bogie

A340 Rotation Law

A340 Rocking Bogie Characteristics

Conventional Landing Gear

Materializes Additional Stroke Required

Start of Rocking Bogie Mechanism (400 mm shock absorber closure)

Start of Bogie rotation

Landing Gear Fully Extended

Lift Off

Takeoff rotation

Time (sec)
A340 Rocking Bogie Simplified Principle

1) Aircraft at VR+ - Beginning of rotation
Oleo has started to extend
2) Aircraft between VR and VLOF, with pitch increasing and A/C accelerating. Typically when pitch about 5°/6°, shock absorber is 400 mm and pitch trimmer bottomed. Front wheels and MLG leg are mechanically interlocked.
3) The shock absorber cannot extend, the rocking bogie cannot rotate as long as A/C lift has not reached a certain value. Shock absorber remains at 400 mm. Since pitch increases, tail clearance decreases and reaches minimum prior lift off.
4) The lift has increased; the oleo can further extend and the bogie can rotate; the tail clearance slightly decreases, while the A/C pitch increases.
Landing Gear with Rocking Bogie

• The Rocking Bogie allows to fly greater pitch attitude at lift off

• The Rocking Bogie kinematics are such that the minimum tail clearance is actually reached before lift off, at initial bogie rotation

? This is an additional reason to positively initiate rotation, and avoid further aft stick inputs during rotation (Pitch ≈ 8° ...
A340 / A330 Rotation Law Technique

![Diagram showing attitude vs time with 'GOOD' and 'POOR' curves leading to 'LIFT OFF'.]
Landing Gear with Rocking Bogie

• On any type of Landing Gear, servicing shall ensure that oleos are properly pressurized.

• The effects of low pressure in oleos are somehow increased with the Rocking Bogie system, indeed:
  ‣ A low pressure oleo delays the time where pitch trimmer is bottomed
  ‣ A low pressure oleo delays the time where the bogie starts to rotate

? Typically, a 10 bars low pressure in oleo, leading to a 60 mm oleo reduction, decreases the tail clearance by approximately 1 ft (or 1°)
A340 Tail Clearance During Take Off

A340 Rotation Law

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<th>Attitude (°)</th>
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Lift Off

A340 Rocking Bogie Characteristics

- **Maximum Pitch Attitude / Ground (°)**
  - Start of Bogie rotation
- **Landing Gears Fully Extended**
- **Start of Rocking Bogie mechanism (400 mm shock absorber closure)**
- **Tail Clearance (°) (ft)**
  - Lift Off

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<th>Time (sec)</th>
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Nominal pressure

Nominal – 10 bars
Conclusions

• This presentation actually enhances 3 issues:

  ▶ All present recommendations in SOPs and FCOM supplementary techniques are unchanged

  ▶ But configuration must be judiciously determined. Amongst others, higher CONF is preferable provided that FLX TEMP is not penalized by more than 5° C

  ▶ Shock absorbers must be adequately pressurized. Crews shall check consistency in between both MLG shock absorbers length, and report any suspected anomaly.
Takeoff rotation