Preventing Runway Excursions

ICAO Runway Excursion Prevention Seminar
Lima, Peru 9-10 October 2014
Contents

1. Flight Tests to Determine Maximum Crosswind
2. Flare and Landing Technique
3. Go-Around Decision and Execution
4. Runway Overrun Protection
5. Securing the Takeoff
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Crosswind assessment during Flight Tests

Initial step to assess Flight Control performance and Power

Using simulation and flight test data

Incremental approach to crosswind
Crosswind assessment during Flight Tests

Wind reference
FAA model for computation

Experienced wind (steady and gust) is assumed

Actual wind experienced along the trajectory but at the aircraft height

10 ft

20 sec
Crosswind assessment during Flight Tests

1. CS25 only requires:
   - Crosswind certification on a dry runway
   - Theoretical analysis for wet or contaminated runway

2. No flight test on Wet or Contamination
   - Wet or Contaminated runway: reduced friction. The more slippery the RWY, the less crosswind component is acceptable

3. REV thrust has a negative impact on the lateral control
   - Not taken into account

4. Crosswind experienced
   - Not considered as the limit: published as a demonstrated crosswind.
Crosswind assessment

Wind values from tower:
• May be different due to local effects

ND provides wind indication
• A rough guide - but errors can be up to 5-7kts

Always be prepared for a Go-Around if necessary
## Maximum Crosswind – 3 Types of Values

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Demonstrated Crosswind (FCOM – LIM)</td>
<td>Flight tests</td>
</tr>
<tr>
<td>Maximum Crosswind (FCOM RCAM matrix)</td>
<td>Contaminated runways</td>
</tr>
<tr>
<td>Maximum Crosswind Engine Limits (AFM A380)</td>
<td></td>
</tr>
</tbody>
</table>
Crosswind: Maximum Values

**WIND LIMITATIONS**

**MAXIMUM CERTIFIED CROSSWIND FOR TAKEOFF AND LANDING**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Maximum certified crosswind at takeoff (gust included)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>35 kt</td>
</tr>
</tbody>
</table>

*Note: The maximum certified crosswind value is an AFM limitation. It is an engine limitation.*

<table>
<thead>
<tr>
<th>Condition</th>
<th>Maximum demonstrated crosswind (gust included)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40 kt</td>
</tr>
</tbody>
</table>

*Note: The maximum demonstrated crosswind value is not an Airplane Flight Manual (AFM) limitation: It is the maximum crosswind condition experienced during the aircraft certification campaign. Airbus recommends that operators should not intentionally operate.*

**MAXIMUM RECOMMENDED CROSSWIND ON CONTAMINATED RUNWAYS**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Maximum Crosswind for landing (gust included)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damp</td>
<td>40 kt</td>
</tr>
<tr>
<td>Wet - 3 mm (1/8&quot;) or less of water</td>
<td>40 kt</td>
</tr>
<tr>
<td>3 mm (1/8&quot;) or less of: Slush</td>
<td>35 kt</td>
</tr>
<tr>
<td>3 mm (1/8&quot;) or less of: Dry Snow</td>
<td>30 kt</td>
</tr>
</tbody>
</table>

Which maximum crosswinds?
Maximum Crosswind – Airline Policy

Choose the most restrictive values

Do not intentionally operate in crosswinds conditions that exceed the maximum values provided by Airbus
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Always ensure the pilots seats and rudder pedals are in the correct position, so as to allow full and immediate control movement to be exercised over all flight controls, and the brakes.

During rollout in high crosswinds, asymmetric braking may be required, if full rudder is insufficient for directional control.
Airbus recommendations

A Crabbed Approach

Crab angle

Runway axis
Autopilot Logic

Wings Level and Crabbed Approach

Flare

Decrab

Ground Control

50 ft

30 ft

Touchdown
Localizer antenna location
During a crosswind approach fly: Wing Level and Crabbed Approach
Manual flight – final approach

• In crosswind conditions
  • Fly a stabilized approach
  • Keep the aircraft on the correct lateral flight path, localizer centered
  • When disconnecting the AP for a manual landing, avoid the temptation to make large inputs on the side-stick
  • Do not align the longitudinal axis of the aircraft with the center line when initially becoming visual.
• Remember AP logic:

  Wing Level and Crabbed Approach
Manual flying technique for the Flare

• Flare the aircraft at a normal height

  A high, or an extended flare significantly increases the landing distance

  During an extended flare the crosswind will move the aircraft away from the centerline

• Remember AP logic:

  Flare and immediately land the aircraft
Flying Technique for De-Crab

Use the rudder to align the aircraft with the runway centerline during the flare. The aircraft will rotate around a vertical axis close to the center of gravity due to the yaw moment by deflecting the rudder.

This will induce a lateral force.
Flying Technique after the De-Crab

• When the main landing gear touches the ground, a pivoting moment is created around a vertical axis located at the level of the main landing gear by the combined effect of the lateral friction of the tires on the surface and by the inertia force applied at the center of gravity.

• This moment tends to turn the aircraft so as to align the aircraft longitudinal axis with the ground speed vector.

• Simultaneously, the sideslip created by this rotation creates an opposite moment tending to yaw the aircraft towards the wind by weather cock effect and must be counteracted by the rudder.
Flying Technique for Landing

• In high crosswind conditions and especially on contaminated runways

• A partial de-crab may be required prior to touchdown, using a combination of bank angle and crab angle

• Avoid downwind drift.

• Use roll control only to maintain the aircraft on the centerline before flaring

• Use appropriate lateral inputs
Flying Technique for Landing

X-Wind

Crab angle less than 5°
Flying Technique for Landing

Bank angle less than 5°

X-Wind
Flying Technique for Rollout

Be prepared for wind effect

- Large and immediate inputs on the rudder pedals may therefore be necessary to maintain the centerline.

- Be ready to use **differential braking** if needed.

- Have your **feet in a position** so that **full rudder deflection combined with full braking, even differential, can be applied instinctively and without any delay.**

- **Use of Auto Brake** is highly recommended.
Feet position on pedals feedback

Question – One answer per airline “Does your airline encourage”:

<table>
<thead>
<tr>
<th>TO &amp; LDG</th>
<th>TO</th>
<th>LDG</th>
<th>TO</th>
<th>LDG</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
• During a crosswind landing, or aborted takeoff, cornering force is the primary means to maintain the aircraft on the runway.

• Reverse thrust resultant force is resolved in 2 components:
  - parallel to the runway, actually stopping the aircraft
  - perpendicular to the runway, increasing crosswind effects
Airbus Recommendations - Touchdown and Rollout

If a directional control problem occurs

- Consider reducing reverse thrust
- If braking manually, consider reducing braking temporarily or use differential braking

After directional control has been recovered and the runway centerline has been regained:

- Manual braking can be re-applied
- Reverse thrust can be re-applied.
Flying Technique for Rollout

Take care of the destabilizing effect of reversers

Rudder effectiveness reduces with decreasing speed
Training – Crosswind landing

• Demonstrate de-crab and flare with auto pilot
  • Gradually increase to maximum crosswind limit for auto land

• Demonstrate de-crab and flare in manual flight
  • As the instructor demonstrate, if necessary, the manual handling of the aircraft during crosswind landings

• Trainee training for crosswind landings
  • Gradually increase to the maximum crosswind limit
  • Respect the maximum crosswind limits on contaminated runways
  • Pay attention to the simulator friction models on contaminated runways
Training – Feet position

• Use rudder pedals to steer aircraft on the ground.
  • Taxi with small turns, rapid runway exits

• PM rest his feet on the pedals.
• PF apply brake pedals inputs and PM should call out the input during ground manoeuvres.
  • During training exercises only.

• PM monitors and advises PF of inadvertent brake pedals input during take off roll.
Flight Operations Briefing Notes
Landing Techniques
Crosswind Landings

I. Introduction
Operations in crosswind conditions require strict adherence to applicable crosswind limitations or maximum recommended crosswind values, operational recommendations, and handling procedures. These factors may affect conditions in the following:
- The flight
- The pilot

II. Statistics
Adverse wind occurrences are
- Crosswinds
- 99% of events

III. Runway Condition and Maximum Recommended Crosswind
The maximum demonstrated crosswind and maximum computed crosswind, discussed in Flight Operations Briefing Note Understanding Forecast/ATC/Aircraft Wind Information, are applicable only on dry or wet runway.

It is not recommended to land with a crosswind component higher than the one that appears in the table below:

<table>
<thead>
<tr>
<th>Reported Braking Action</th>
<th>Reported Runway Friction</th>
<th>Maximum Crosswind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equivalent Runway Friction Coefficient</td>
<td>n/a</td>
<td>40 kt</td>
</tr>
</tbody>
</table>

Good: 0.4
Good/Medium: 0.39 to 0.36
Medium: 0.35 to 0.3
Medium/Poor: 0.29 to 0.26
Poor: 0.25
Unreliable: 0.15

(1) This is the maximum crosswind for dry and wet runway gust included.

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Conclusion – Airbus recommended flying technique

**Approach**
- Stabilize the Aircraft for the approach
- Fly a Wings level Crabbed approach
- No important changes at AP disconnection

**Flare**
- Use a coordinated drift angle reduction through out the flare
- Prompt landing after flare

**Ground roll**
- Be ready to correct with the rudder and asymmetric braking
- Be aware of reverser destabilization
- Ensure you can achieve full rudder AND full asymmetric braking
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Forewords

At Low Height
- TOGA thrust required
- Climb always necessary

At Higher Height
- TOGA thrust may not be required when all engines are operative
- Climb or Level-Off may be considered

Drivers
- Simple
- Straightforward
- Intuitive
Go-Around: Airbus SOP

Note: This engages the correct FMA modes

If TOGA thrust is not required, set the thrust levers to TOGA detent then retard the thrust levers as required. This enables to engage the GO-AROUND phase, with associated AP/FD modes.
TOGA gives high energy

Set the thrust levers to TOGA

But….  

Go-Around

High energy
TOGA then CL detent is an option

When conditions permit

1. Set the thrust levers to TOGA,
2. Check your FMA (MAN TOGA/SRS/A/THR blue)
3. Then immediately to CL (A/THR white)
Is there an alternative to TOGA?
Discontinuing the approach

At or above the FCU altitude
It is possible to discontinue the approach without TOGA

Note: all engines operative, no RNP AR...

Below the FCU altitude
TOGA
Discontinuing the approach without TOGA

1. Deselect APPR mode(s)
2. Select a heading or NAV
3. Select a V/S, or level off
4. Adapt the speed
5. Enter a new DEST

No action on thrust levers
“Classic” Go-Around

Thrust levers on TOGA
"Classic" Go-Around

- When the FMS transitions to the GO AROUND flight phase, the missed approach is sequenced
- If a published missed approach exists, it is followed by a flight plan discontinuity and then the original approach
- In some cases, the previous approach can be automatically selected and sequenced
Discontinuing the approach

Thrust levers **NOT ON TOGA**

1. Deselect APPR mode(s)
2. Select a V/S, or level off

Missed Approach is available
Discontinuing the approach

1. Select a heading or NAV
2. Adapt the speed
3. Enter a new DEST

- The FMS sequences the missed approach
- The FMS remains in Approach phase

When overflying the runway threshold
- The FMS does not sequence the previous approach
- The FMS has no DEST
Go-Around:
1. Select TOGA thrust,
2. Then, if TOGA thrust not necessary, select CL detent

Discontinued Approach:
1. Press again APPR pb
2. Select appropriate Vertical & Lateral guidance
3. Adapt the speed
4. Enter a new DEST

Detailed in the Training and Operational materials since end of 2013
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Runway Overrun Prevention System (ROPS) is a safety enhancement function that helps the flight crew to anticipate an overrun risk during the landing phase by computing in real time braking distances and comparing them to the Landing Distances Available (LDA) or remaining runway length.

This enhanced feature provides:

- an automatic detection of the landing runway
- and, in case of detection of runway overrun risk, it triggers visual and/or aural alerts to the flight crew during final approach and landing.
**ROPS = ROW + ROP**

- After confirmed touchdown
- Confirmed pilot intent to stop
- Go-around unlikely

Pilot action based on simple SOP

Go-Around
Max Braking
Max Reverse

ROW - ROP transition point
ROW – Runway End Overrun Warning

ROW uses the current energy and position of the aircraft to predict the distance necessary to stop the aircraft.

Row alert is triggered when the distance necessary to stop the aircraft is longer than the remaining runway length.

If predicted stop distance on a WET runway is longer than remaining runway length

Visual Alert - IF WET : RWY TOO SHORT

If predicted stop distance on a DRY runway is longer than remaining runway length

Visual Alert - RWY TOO SHORT

Aural Alert - “RUNWAY TOO SHORT”
ROW – Runway End Overrun Warning

ROW prediction of distance necessary to stop is based on TALPA hypotheses and consistent with Airbus In-Flight Landing Distances

- Threshold crossing at 50ft
- Air Phase of 7 seconds
- Application of Max Braking two seconds after touchdown
- Thrust Reverse Assumption
  - Idle Reverse on DRY runways
  - Max Reverse on WET runways
- 15% safety margin
ROW – Runway End Overrun Warning

The strength of ROW is the ability to continuously monitor aircraft **position** and **energy** with regards to the remaining runway length.

Consequently, any changes during the approach are immediately captured and the resulting distance to stop is updated.

For example:
- Changing winds affect the ground speed and thus the predicted touchdown speed.
- Above glide-slope may affect the predicted threshold crossing point.
- Long flares affect the predicted touchdown point.
ROP = Runway Overrun Protection

ROP uses the current *deceleration* and *position* to determine if the *current aircraft predicted stopping distance* is sufficient to stop on the remaining runway length.

ROP provides alerts in case of runway overrun risk.

- **Visual Alert:** MAX BRAKING
  - MAX REVERSE

And contextual aural alerts in order of priority:

- If brake pedals not deflected to maximum
  - **Aural Alert:** BRAKE, MAX BRAKING

- If max reverse not set
  - **Aural Alert:** SET MAX REVERSE

- At reverse cut-off speed
  - **Aural Alert:** KEEP MAX REVERSE
ROP Runway State Selection

The ROP system for Single Aisle has no explicit selection of the runway state. Therefore the system makes an implicit selection at touchdown:

- **IF** the predicted **WET** stopping distance is less than LDA
  - The system makes the hypothesis that the runway could be WET. Therefore ROP protection is based on a **WET** runway

- **IF** the predicted **WET** stopping distance is greater than LDA
  - **IF WET RWY TOO SHORT** visual alert is on the PFD
  - If pilot continues the landing the hypothesis is that the runway must be **DRY**
  - Therefore ROP protection is based on a **DRY** runway
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Objectives of TOS function:

✓ To provide a safety net within avionics regarding erroneous takeoff parameters.

✓ To reduce risks of tail strike and runway overrun due to erroneous takeoff parameters.

✓ Detect gross inconsistency between takeoff parameters inserted in FMS.
Take-Off Securing

✓ 1 check to catch entry errors on ZFW range

✓ 3 checks to catch entry errors on TO speeds

✓ 1 check to detect TO speed not inserted

✓ 1 check to detect inappropriate trim setting

✓ 1 check to detect inappropriate high lift configuration setting
Detection of erroneous weight initialization in the FMS

Check ZFW range:

\[ ZFW_{\text{MIN}} \leq ZFW \leq ZFW_{\text{MAX}} \]

Check performed as soon as ZFW is entered or modified.

When check fails: «ENTRY OUT OF RANGE» message and ZFW entry is rejected.
Detection of erroneous take-off speeds initialization in the FMS

Check TO speeds consistency:

\[ V_1 \leq V_R \leq V_2 \]

Checks performed as soon as all the 3 TO speeds are inserted in the PERF TO page, or each time a TO speed is modified.

When check fails: « \textbf{V1/VR/V2 DISAGREE} » message.

- Available on FMS / MCDU
- Enhancement under development to provide ECAM alert for A320, A330/A340 and A380 programs
Detection of erroneous take-off speeds initialization in the FMS

**Check VMC limitation:**

\[
V_1 \geq K_{V_1 VMCG} \times V_{MCG}
\]

\[
V_R \geq K_{V_R VMCA} \times V_{MCA}
\]

\[
V_2 \geq K_{V_2 VMCA} \times V_{MCA}
\]

**Check Vs1G/VMU limitation:**

\[
V_R \geq K_{VR} \times V_{RMIN}
\]

\[
V_2 \geq K_{V_2} \times V_{S1G}
\]

Checks performed:
- When ZFW, BLOCK and CONF are inserted on the MCDU.
- When ZFW, BLOCK, CONF or TO thrust setting are modified.
- At engine start.

When check fails: «T.O SPEEDS TOO LOW» message.

- Available on FMS / MCDU
- Enhancement under development to provide ECAM alert for A320, A330/A340 and A380 programs
Detection of take-off speeds not inserted:

Check insertion of take-off speeds:

Checks performed when V1, V2, VR or FLX TO data have been entered and takeoff runway is changed:

« CHECK TAKE OFF DATA » MCDU message*

and TO data fields revert to amber boxes and previously entered values are written next to the amber boxes.

*Message is also displayed (but TO speeds not invalidated)
- when TO shift is inserted
- when Flap setting is changed
- when Secondary Flight Plan is activated

✔ Available on FMS / MCDU

✔ Enhancement under development to provide ECAM alert for A320 and A330/A340 programs
Take-Off Securing

Detection of inappropriate **trim setting**

- The monitoring compares pilot inserted value with flight controls computations and the actual trim setting.
- Checks performed when pushing TO CONFIG pb and at T.O. power.
- When check fails, ECAM alert is triggered:
  
  **F/CTL PITCH TRIM/MCDU/CG DISAGREE**

A320 Family design:
Take-Off Securing

Detection of inappropriate high lift configuration setting

• The monitoring compares pilot inserted value on MCDU and actual high lift configuration setting
• Checks performed when pushing TO CONFIG pb and at T.O. power.
• When check fails, ECAM alert is triggered: F/CTL FLAPS/MCDU DISAGREE

• Under development for A320 program and available for other programs
## Take-Off Securing

### Availability per program and systems impacted

<table>
<thead>
<tr>
<th>Checks</th>
<th>Message</th>
<th>Systems impacted</th>
<th>A320 Family</th>
<th>A330/A340 Family</th>
<th>A380</th>
<th>A350</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZFW refined range</td>
<td>ENTRY OUT OF RANGE</td>
<td>FMS</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Take Off speed order</td>
<td>V1/VR/V2 DISAGREE</td>
<td>FMS</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Take Off Speed too low</td>
<td>T. O SPEEDS TOO LOW</td>
<td>FMS</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Take Off Speed not inserted</td>
<td>CHECK TAKE OFF DATA</td>
<td>FMS</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>TRIM settings consistency checks</td>
<td>F/CTL PITCH TRIM/MCDU/CG DISAGREE</td>
<td>FMS FWS EIS FAC(A320Fam)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>CONF settings Consistency check</td>
<td>F/CTL FLAPS/MCDU DISAGREE</td>
<td>FMS FWS EIS</td>
<td>Under development</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* Enhancement under development to provide ECAM alert
Thank You!