Airbus Americas
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Preventing Runway Excursions

ICAO Runway Excursion Prevention Seminar

Lima, Peru 9-10 October 2014

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Crosswind assessment during Flight Tests

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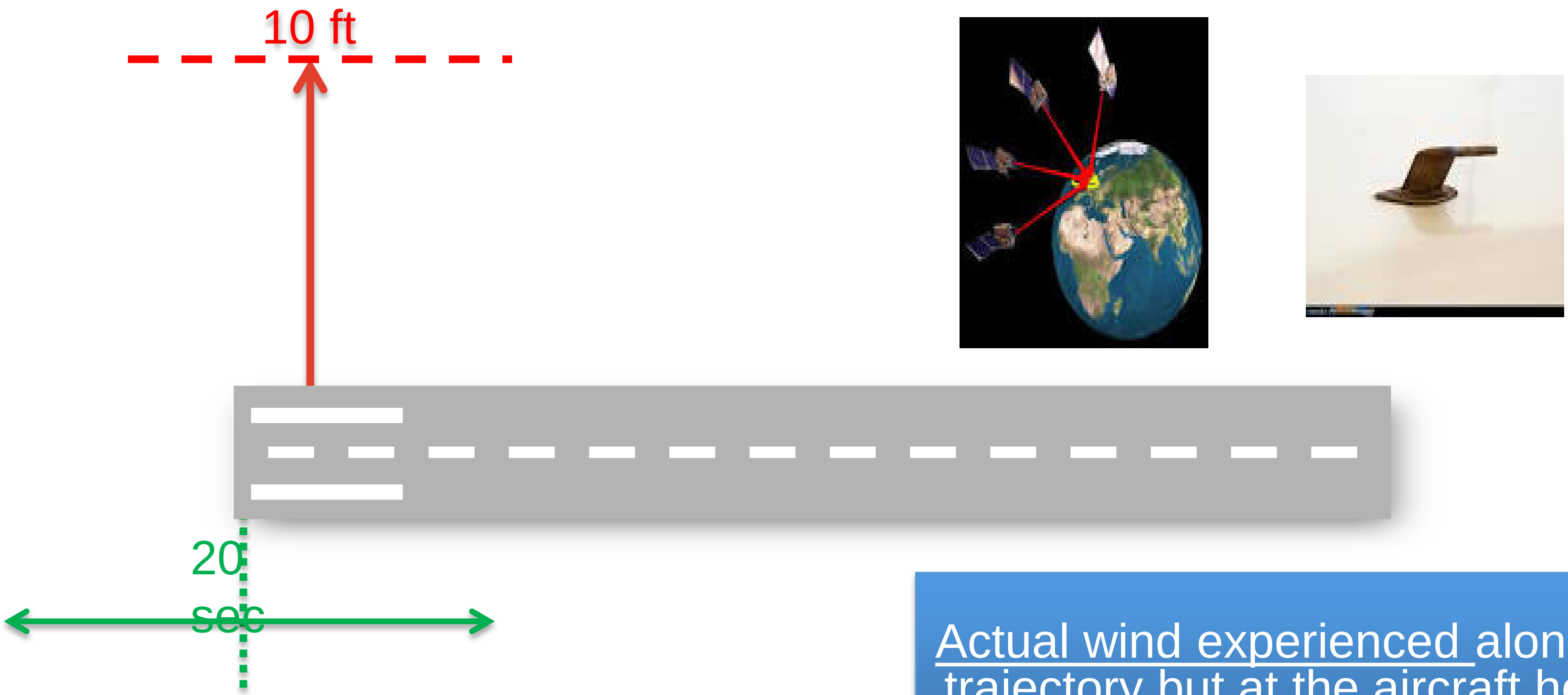
FAA model for computation



Actual wind experienced along the trajectory but at the aircraft height

Experienced wind (steady and gust) is assumed

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

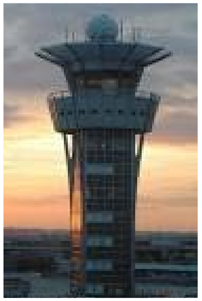
3. REV thrust has a negative impact on the lateral control

- 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

Maximum Demonstrated Crosswind (FCOM – LIM) Flight tests

Maximum Crosswind (FCOM RCAM matrix) Contaminated runways

Maximum Crosswind <u>Engine Limits (AFM A380)</u>

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Crosswind: Maximum Values

WIND LIMITATIONS

MAXIMUM CERTIFIED CROSSWIND FOR TAKEOFF AND LANDING

Maximum certified crosswind at takeoff (gust included) .... 35 kt

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

Maximum demonstrated crosswind .... 40 kt (gust include

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

It is not recommended to take off or land on contaminated runways with a crosswind component higher than the one that appears in the table below.

RUNWAY SURFACE CONDITIONS	[illegible]	...evel ...G	Maximum Crosswind for landing (gust included)
Damp Wet - 3 mm (1/8") or less of water	[illegible]	[illegible]	40 kt
3 mm (1/8") or less of: - Slush - Dry Snow	30 kt		35 kt

Which maximum crosswinds?

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Maximum Crosswind – Airline Policy

WIND FOR TAKEOFF AND LANDING

Maximum certified crosswind at takeoff (gust included)	35 kt
Maximum certified crosswind at landing (gust included)	40 kt

- ***Choose the most restrictive values***
- ***Do not intentionally operate in crosswinds conditions that exceed the maximum values provided by Airbus***

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Crosswind Introduction

Airbus recommendations

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

and remember

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

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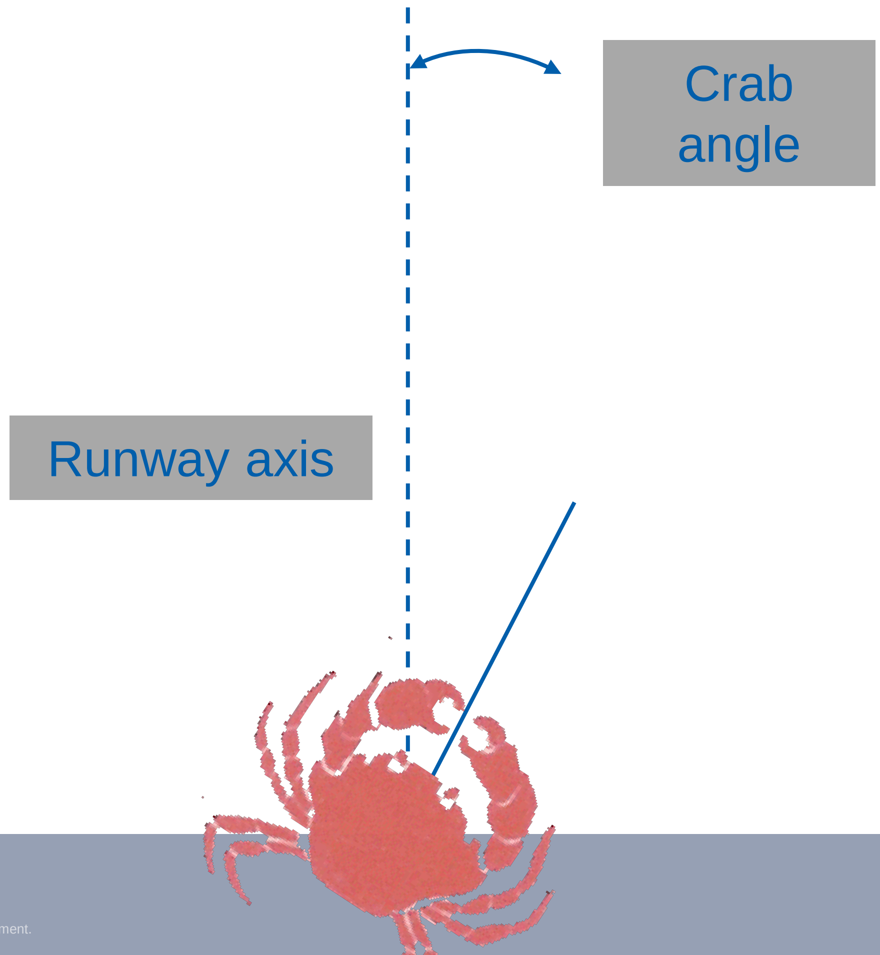
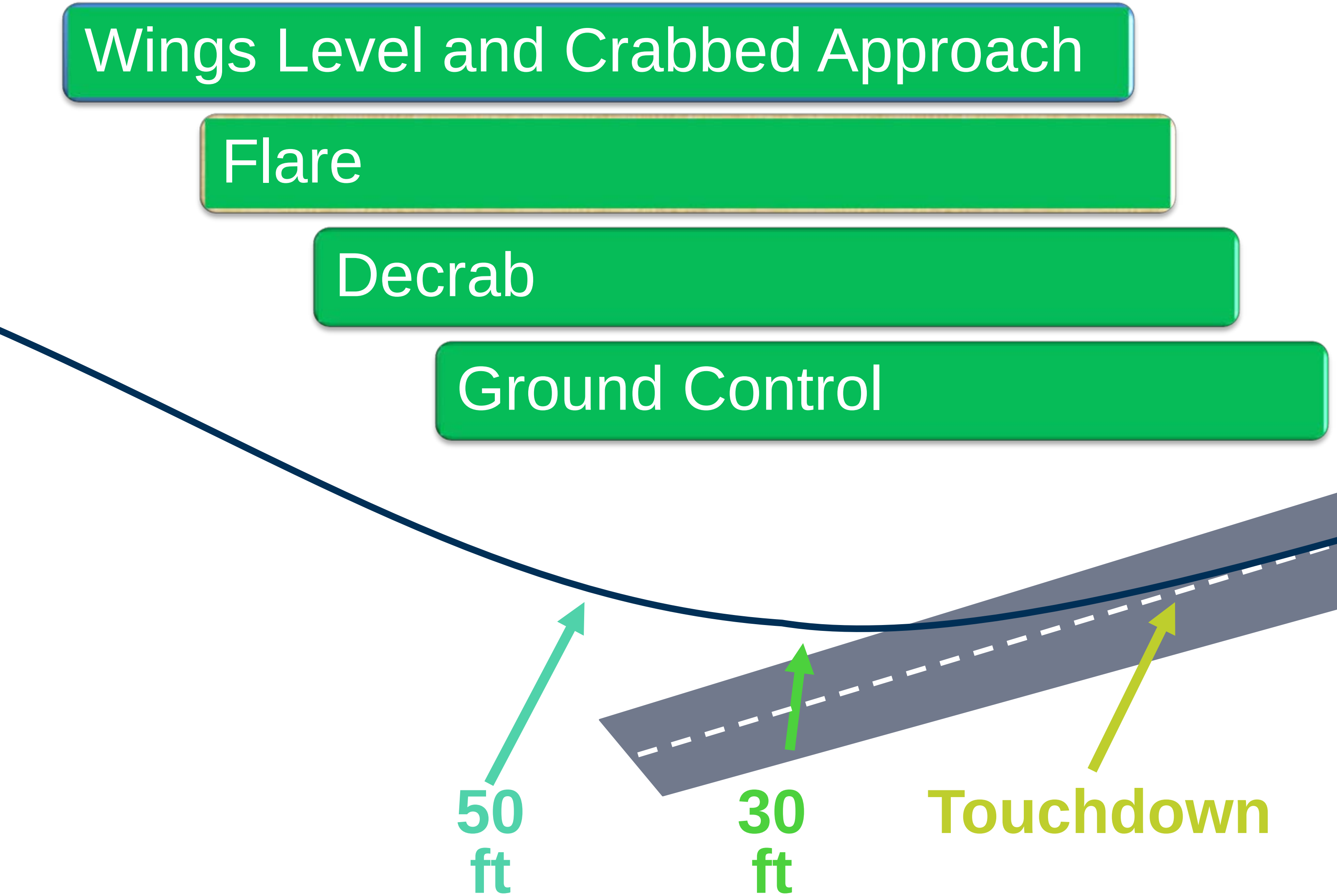
Crosswind Introduction

Airbus recommendations

A Crabbed Approach



Autopilot Logic



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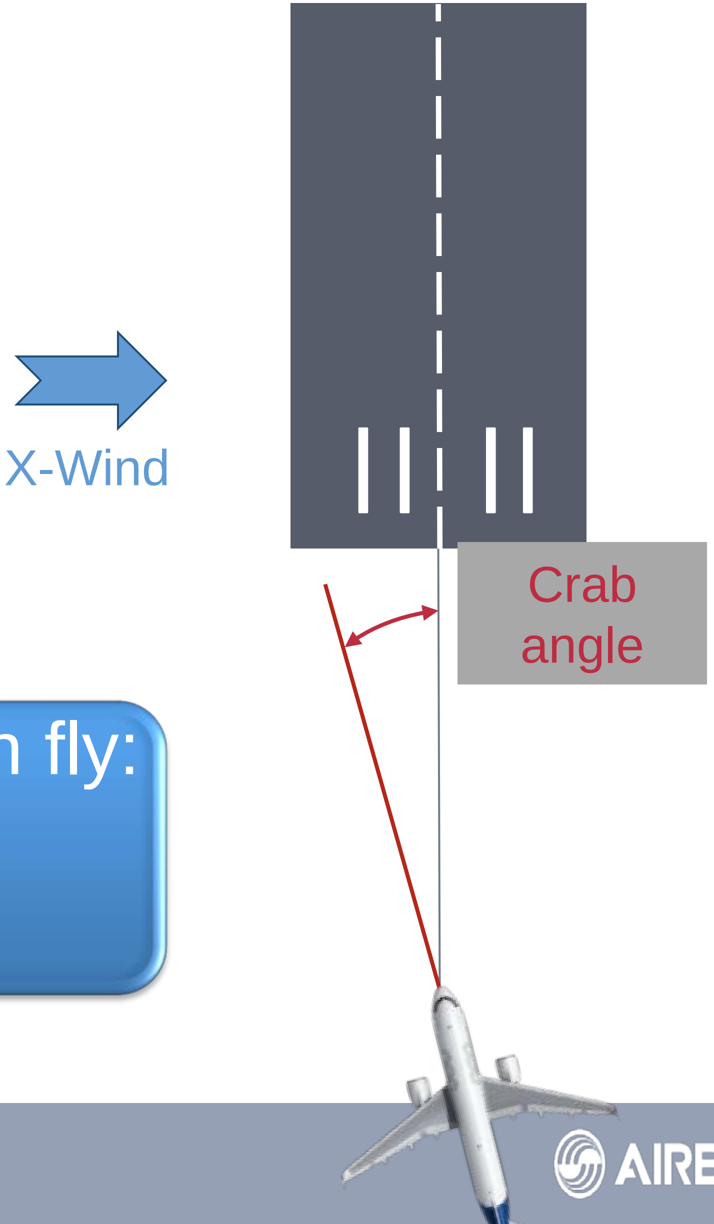
Localizer antenna location

Manual Flying Technique for Final Approach



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:

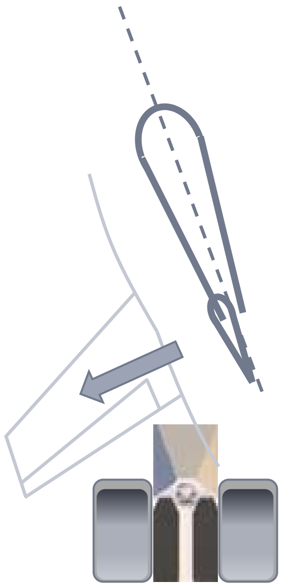
Flare and immediately land the aircraft

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

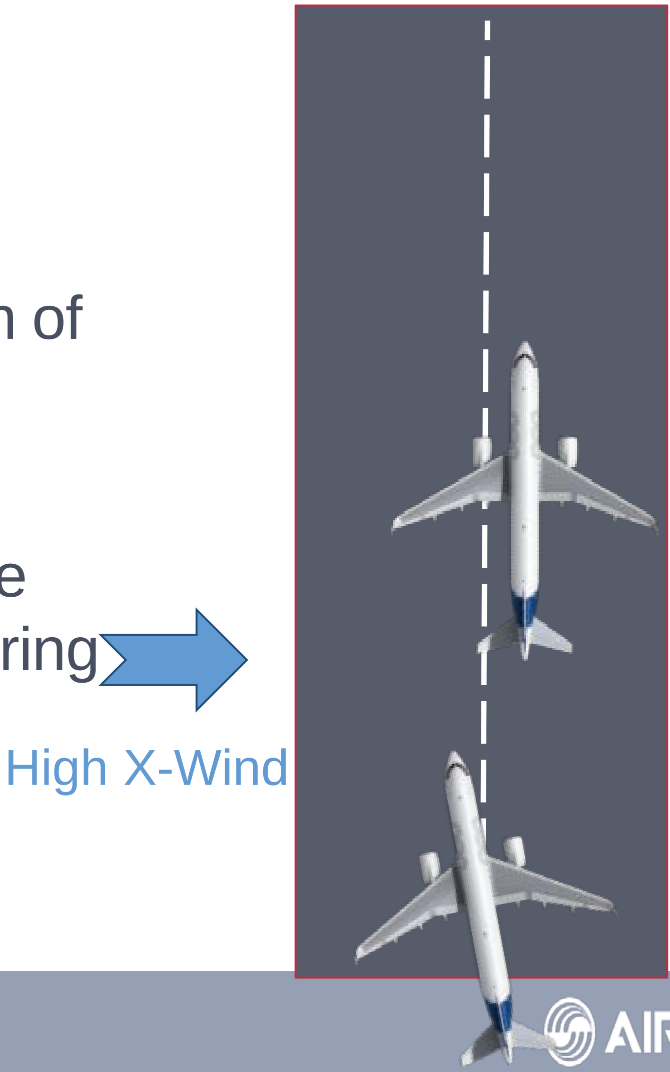
- When the main landing gear touches the ground, a pivoting moment is created around a vertical axis located at the level of the main landing gear by the combined effect of the lateral friction of the tires on the surface and by the inertia force applied at the center of gravity.

- 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

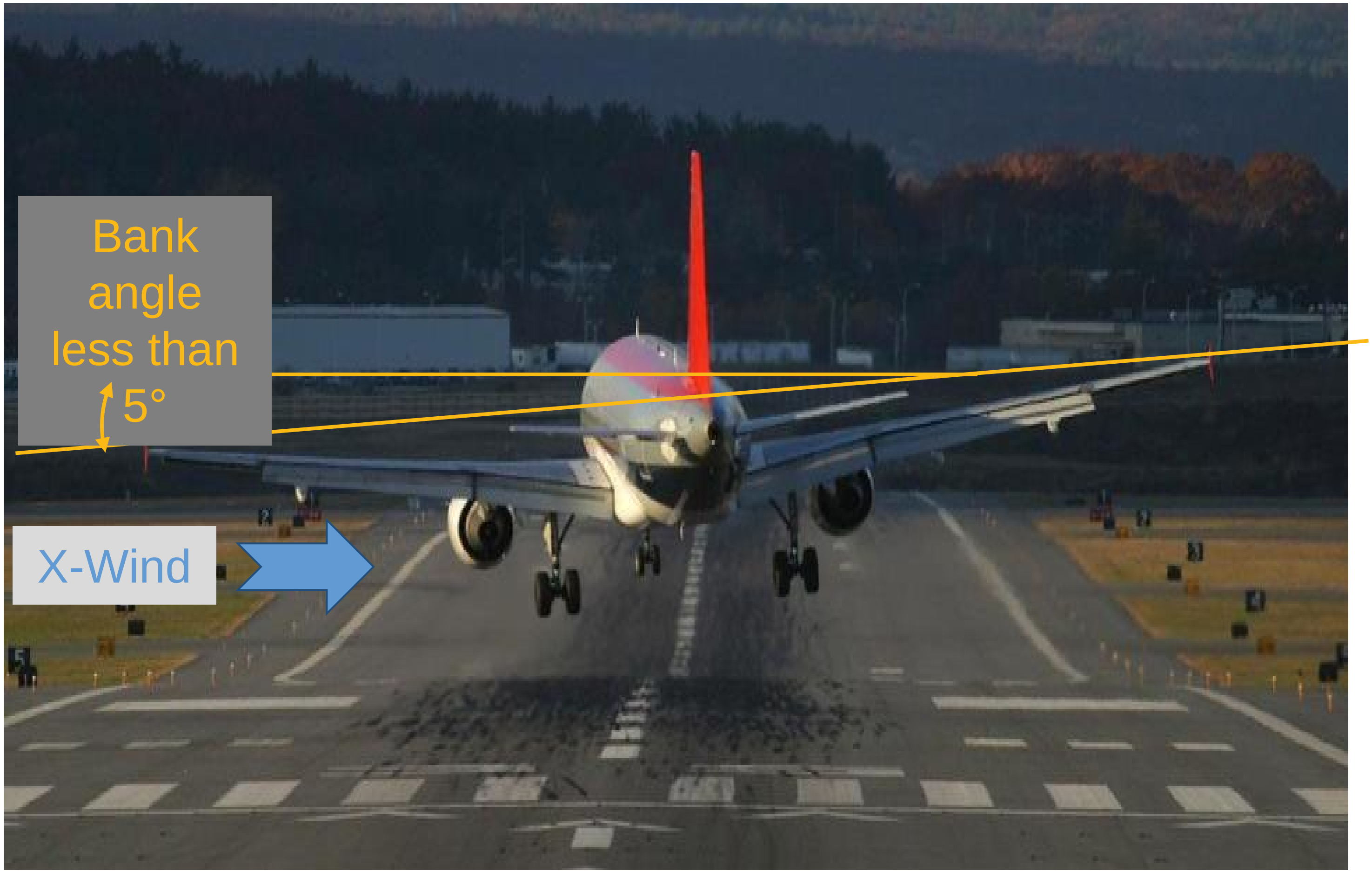
Flying Technique for Landing

- 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

Flying Technique for Landing



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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.

Your input

Feet position on pedals feedback

0

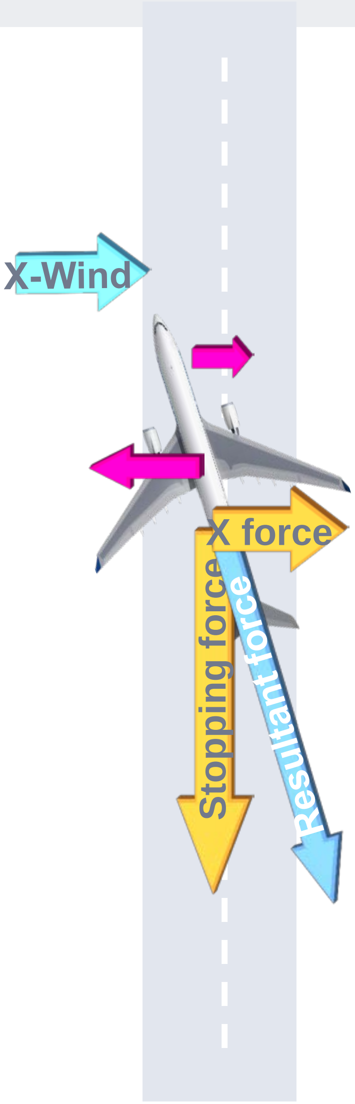
Question – One answer per airline “Does your airline encourage”:

1		2		3
TO & LDG	TO	LDG	TO	LDG

Airbus Recommendations - Touchdown and Rollout

- 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



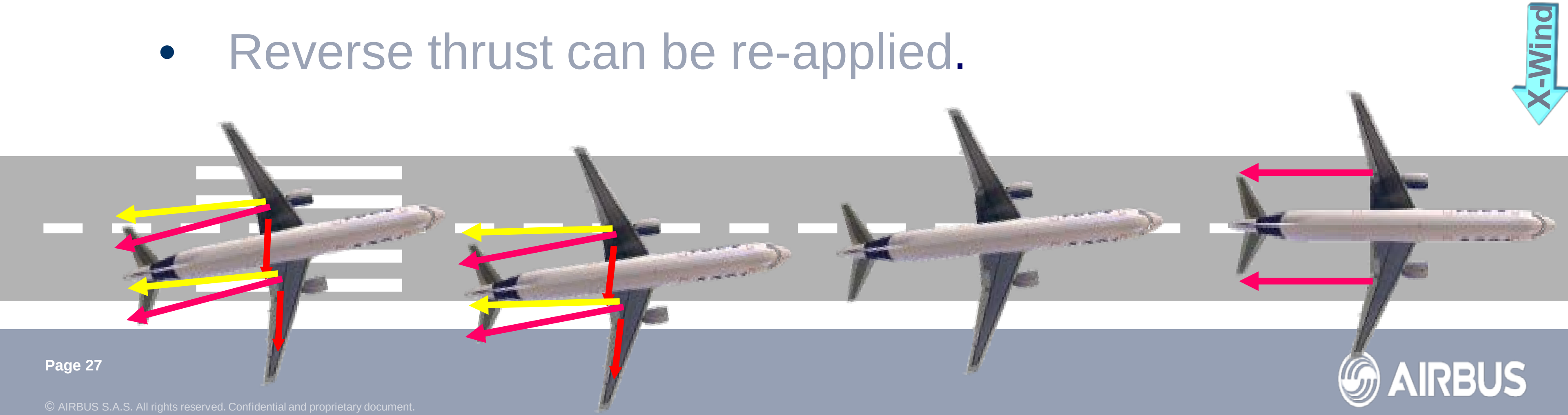
Airbus Recommendations - Touchdown and Rollout

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 runaways

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.

Flying Technique – Published Information

Flight Operations Briefing Notes — Landing Techniques / Crosswind Landings

Flight Operations Briefing Note
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 handli…

This Flight … factors inv… conditions…

The Flight … expanded …

II Statistics

Adverse w… involved in…

Crosswind … of runway …

83 % of cr…

(Source: Flight…

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.

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Flight Operations Briefing No…
Landing Techniqu…
Crosswind Landings

- From Matter
- Preliminary Pages
- IN Introduction
- OP Operational Philosophy
- NO Normal Operations
  - Preliminary Pages
  - NO-010 GENERAL
  - NO-020 PRE START
  - NO-030 START
  - NO-040 TAXI
  - NO-050 TAKEOFF
  - NO-060 CLIMB
  - NO-070 CRUISE
  - NO-080 DESCENT
  - NO-090 HOLDING
  - NO-100 APPROACH GENERAL
  - NO-110 ILS APPROACH
  - NO-120 NON PRECISION APPROACH
  - NO-130 CIRCLING APPROACH
  - NO-140 VISUAL APPROACH
  - NO-150 PRECISION APPROACH
  - NO-160 LANDING
    - PREFACE
    - MAIN GEAR CLEARANCE
    - FLARE
    - CALL OUT
    - DEROTATION
    - ROLL OUT
    - BRAKING
    - FACTORS AFFECTING LANDING DISTANCE
    - CLEARANCE AT TOUCH DOWN

the aircraft touches down, the pilot flies the nose down conventionally, varying sidestick input as required, to control the derotation rate.
After touch down, when reverse thrust is selected (on at least one engine) and one main landing gear strut is compressed, the ground spoilers partially extend to establish ground contact. The ground spoilers fully extend when both main landing gears are compressed. A small nose down term on the elevators is introduced by the control law, which compensates the pitch up tendency with ground spoiler extension.
It is not recommended to keep the nose high in order to increase aircraft drag during the initial part of the roll-out, as this technique is inefficient and increases the risk of tail strike. Furthermore, if auto brake MED is used, it may lead to a hard nose gear touch down.

ROLL OUT

Applicable to: ALL

NORMAL CONDITIONS

During the roll out, the rudder pedals will be used to steer the aircraft on the runway centreline. At high speed, directional control is achieved with rudder. As the speed reduces, the Nose Wheel Steering (NWS) becomes active. However, the NWS tiller will not be used until taxi speed is reached.

CROSSWIND CONDITIONS

The above-mentioned technique applies. Additionally, the pilot will avoid setting stick into the wind as it increases the weathercock effect. Indeed, it creates a differential down force on the wheels into the wind side and differential drag due to spoiler retraction.
The reversers have a destabilizing effect on the airflow around the rudder and thus decrease the efficiency of the rudder. Furthermore they create a side force, in case of a remaining crab angle, which increases the lateral skidding tendency of the aircraft. This adverse effect is quite

CROSSWIND

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

Reported Braking Action	Reported Runway Friction Coef…	Maximum Cros…	Equivalent Runway Condition
			n/(2)
			1
			1
			2/3
			2/3
			3/4
			4/5

2. Runway covered with Slush.
3. Runway covered with Dry Snow.
4. Runway covered with Standing Water, with risk of hydroplaning or Wet Snow.
5. Icy runway or high risk of hydroplaning.

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

Reported Braking Action	Reported Runway Friction Coefficient	Maximum Crosswind (kt)
Good	≥ 0.4	40 kt(1)
Good/Medium	0.39 to 0.36	27 kt
Medium	0.35 to 0.3	20 kt
Medium/Poor	0.29 to 0.26	20 kt
Poor	≤ 0.25	15 kt
Unreliable		5 kt

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

// END

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

Contents

Forewords

Operational Review of Go-Around Survey

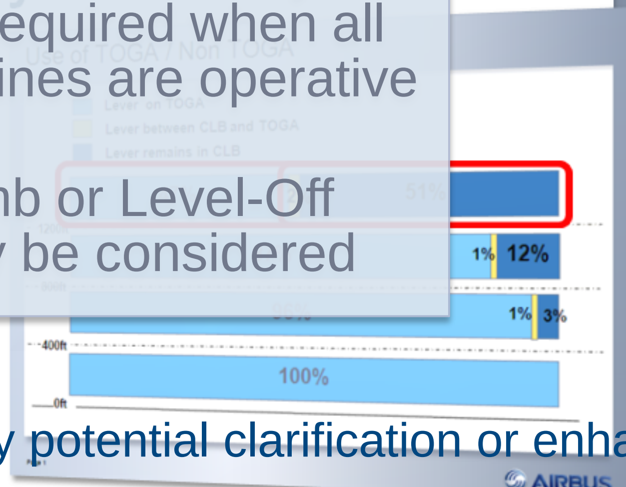
At Low Height

- 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

- Amongst these Go-Arounds, **more than 96%** are performed **with thrust levers left in CLIMB**

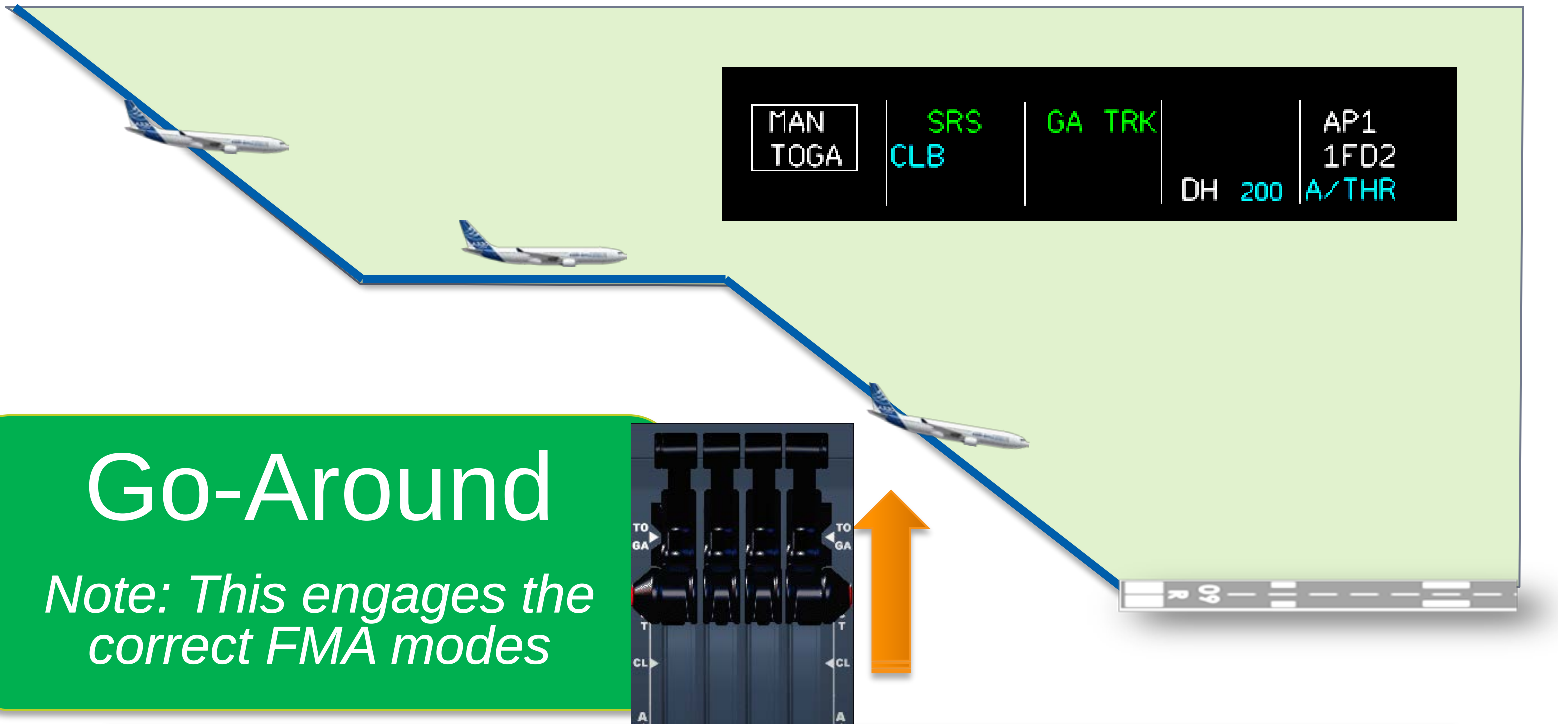


➔ Internal Airbus Review to identify potential clarification or enhancements

Drivers

- Simple
- Straightforward
- Intuitive

Go-Around: Airbus SOP



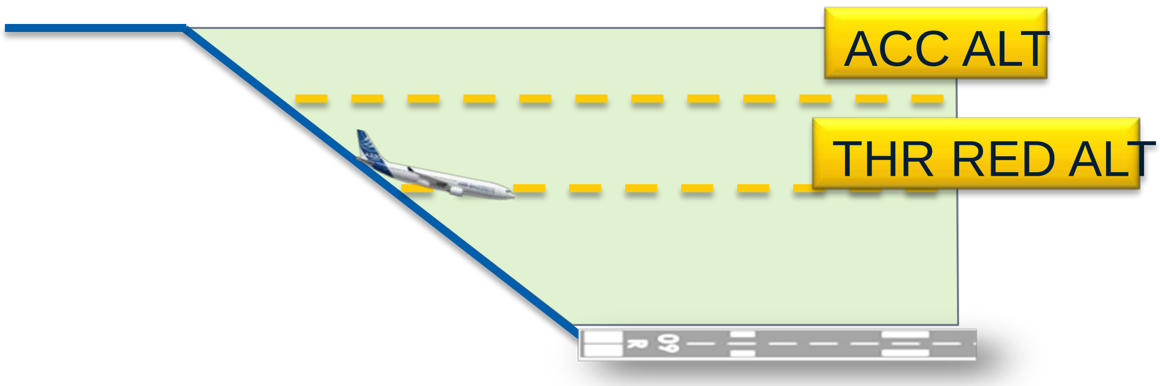
Go-Around

Note: This engages the correct FMA modes

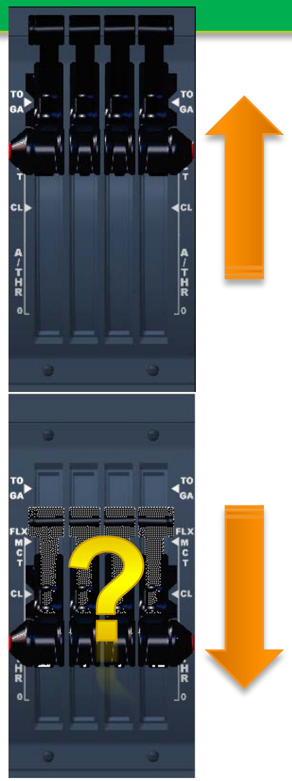
SOPs extract

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



Go-Around



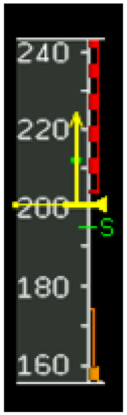
Set the thrust levers to TOGA

But….

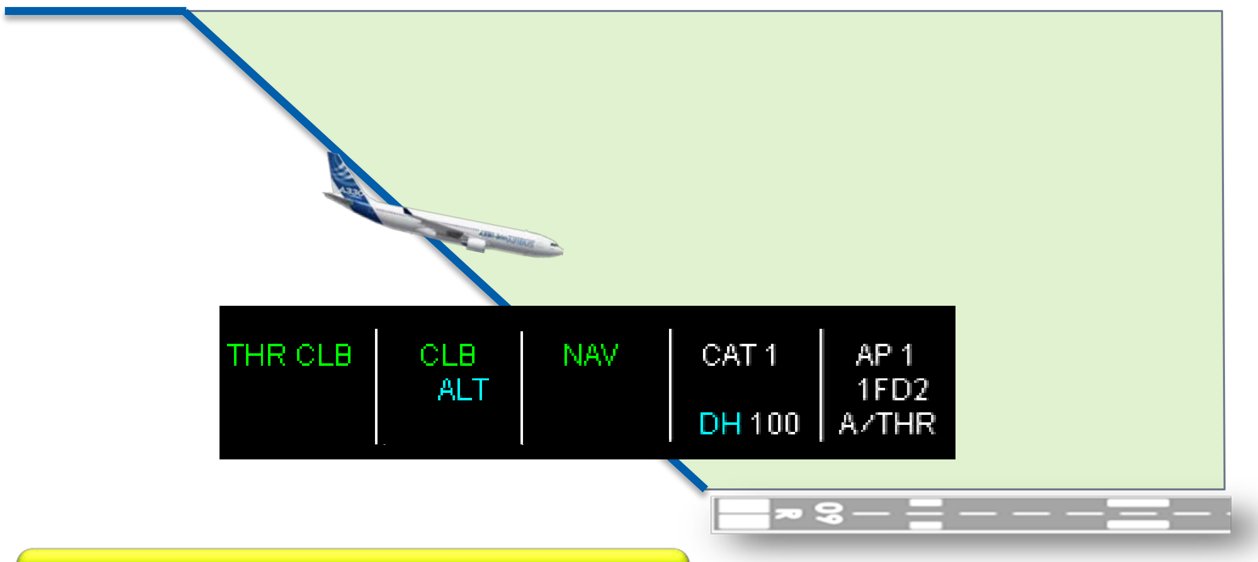
MAN TOGA	SRS OP CLB	GA TRK	CAT 1 DH 100	AP 1 1FD2 A/THR

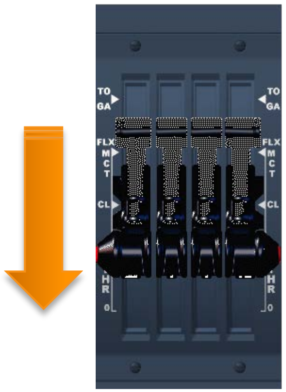
THR CLB	CLB ALT	NAV	CAT 1 DH 100	AP 1 1FD2 A/THR

High energy



TOGA then CL detent is an option

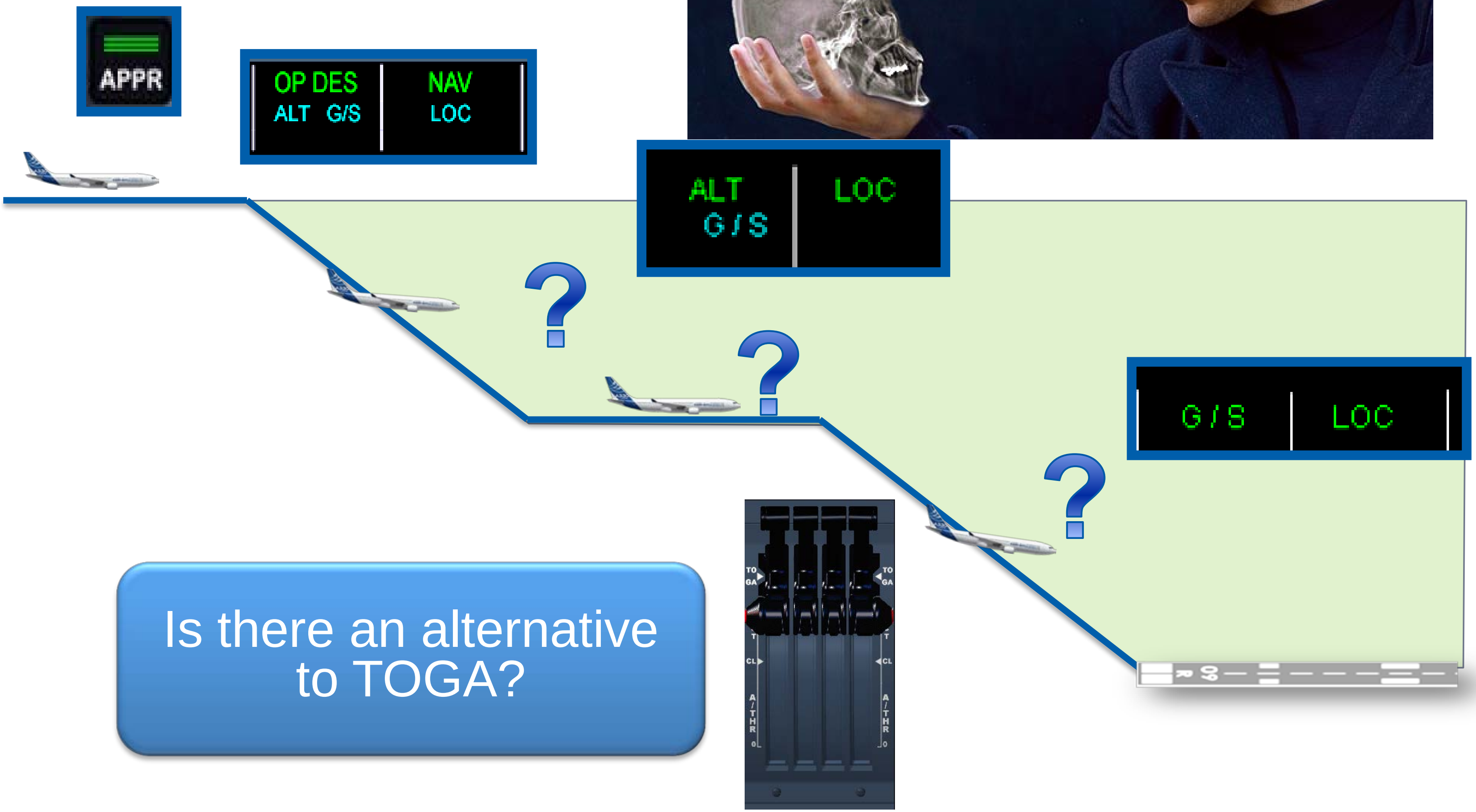




When conditions permit

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)**

TOGA or not TOGA?



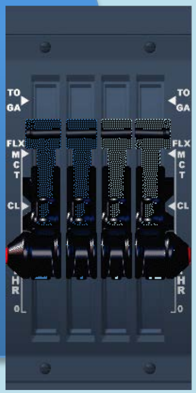
Is there an alternative to TOGA?

Discontinuing the approach

At or above the FCU altitude

It is possible to discontinue the approach without TOGA

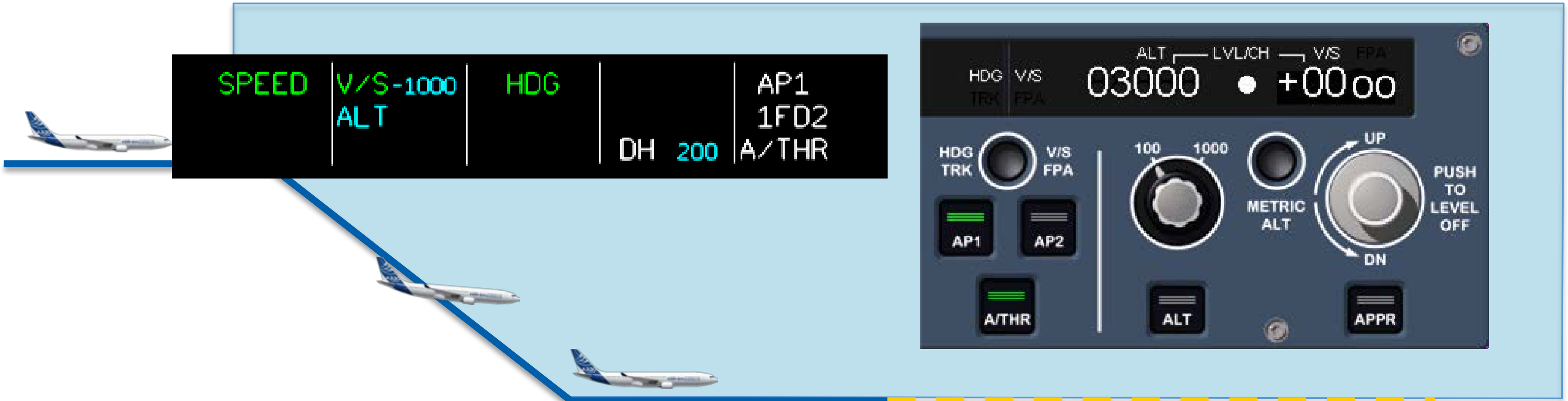
Note: all engines operative, no RNP AR…

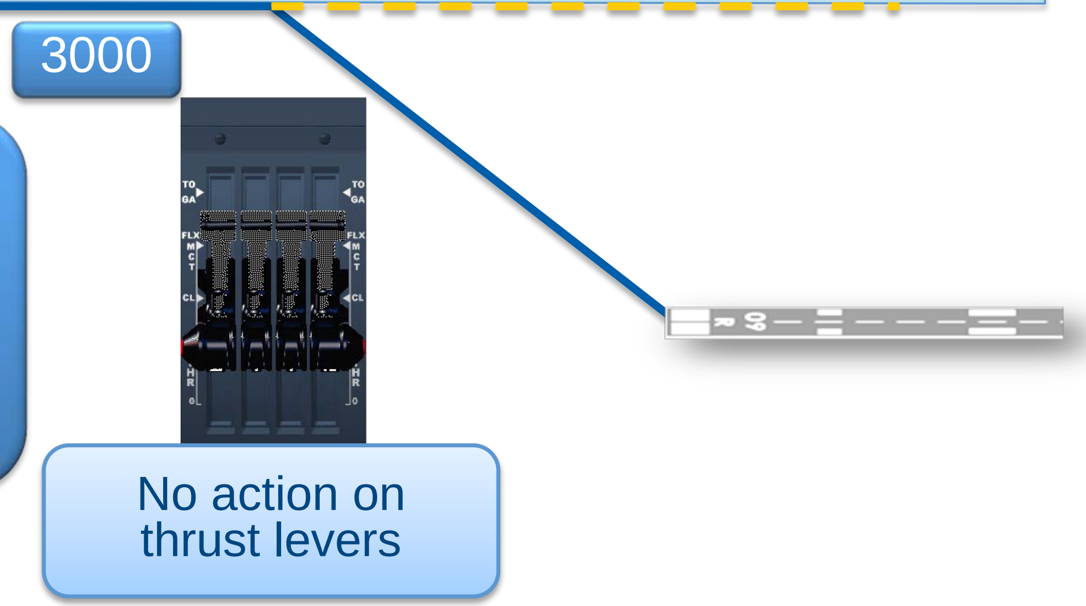


Below the FCU altitude

<u>TOGA</u>

Discontinuing the approach without TOGA

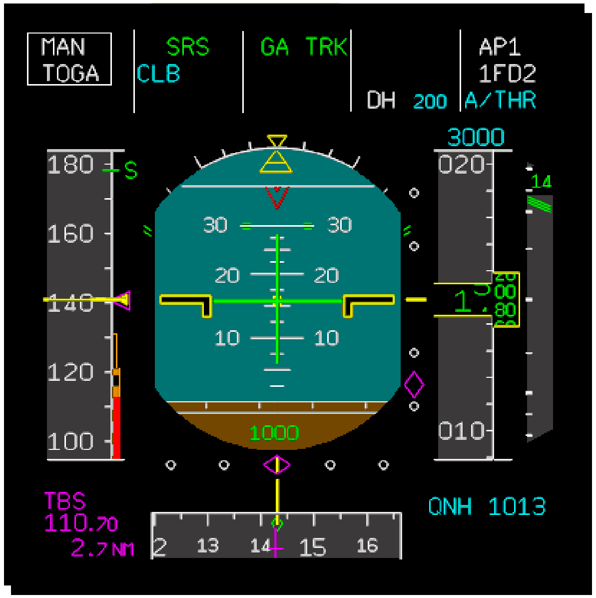


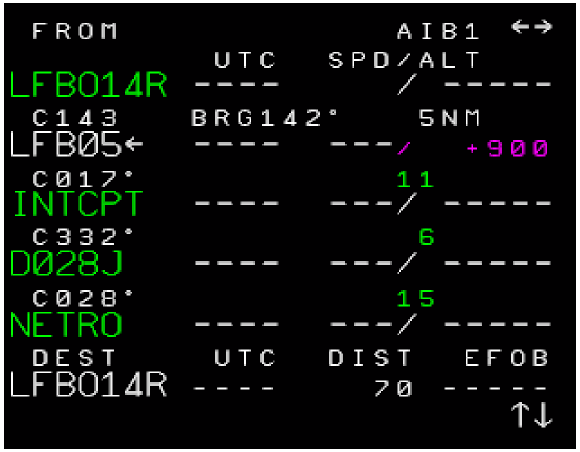


1. Deselect APPR mode(s)
2. Select a heading or NAV
3. Select a V/S, or level off
4. Adapt the speed
5. Enter a new DEST

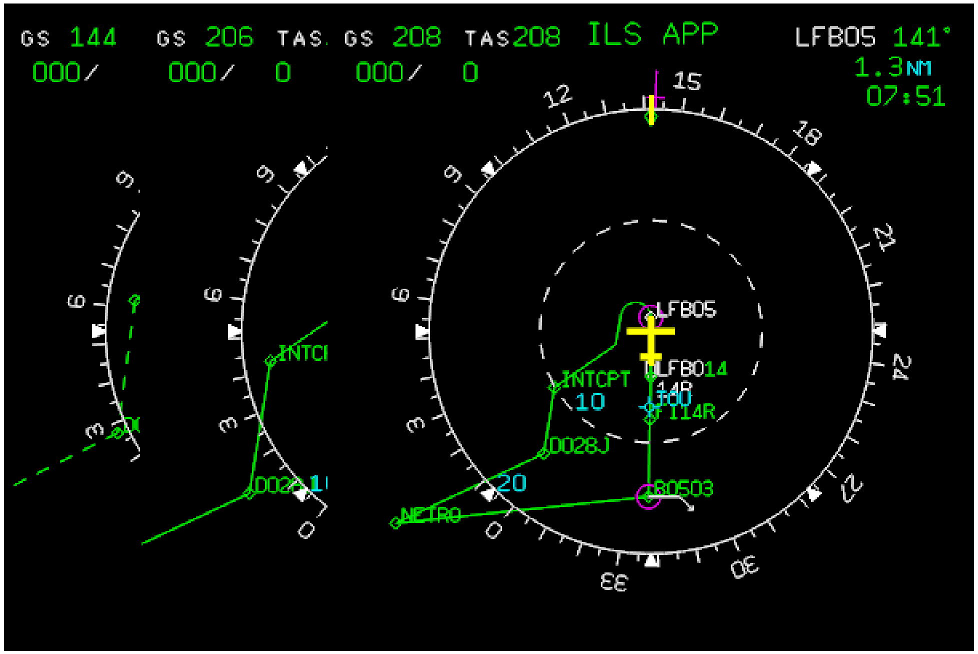
"Classic" Go-Around

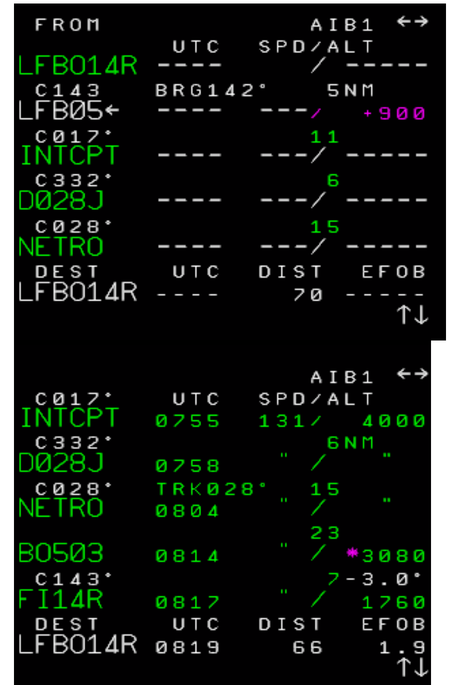
Thrust levers on TOGA





“Classic” Go-Around



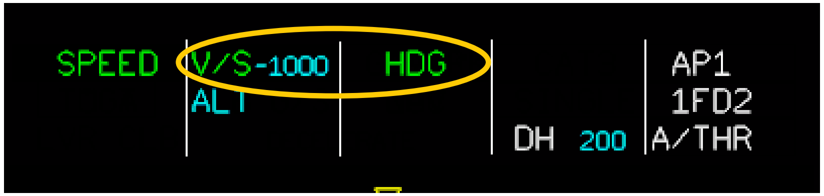


- When the FMS transitions to the GO AROUND flight phase, the missed approach is sequenced
- If a published missed approach exists, it is followed by a flight plan discontinuity and then the original approach
- In some cases, the previous approach can be automatically selected and sequenced

Discontinuing the approach

Thrust levers NOT ON TOGA

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



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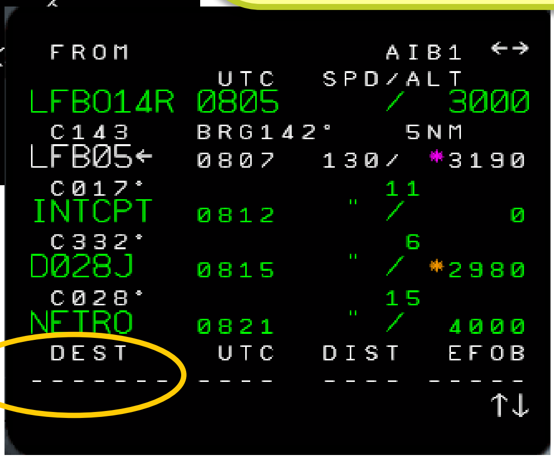
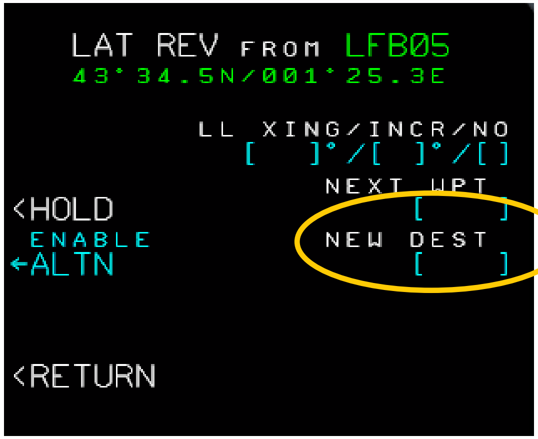
Discontinuing the approach





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

Conclusion

Go-Around:

1. Select TOGA thrust,
2. Then, if TOGA thrust not necessary, select CL detent

OR

Discontinued Approach:

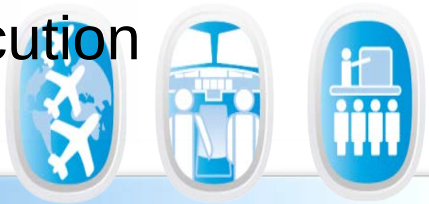
1. Press again APPR pb
2. Select appropriate Vertical & Lateral guidance
3. Adapt the speed
4. Enter a new DEST

Detailed in the Training and Operational materials since end of 2013

Go-Around:

1. Select TOGA thrust,
2. Then, if TOGA thrust not necessary, select CL detent

Content



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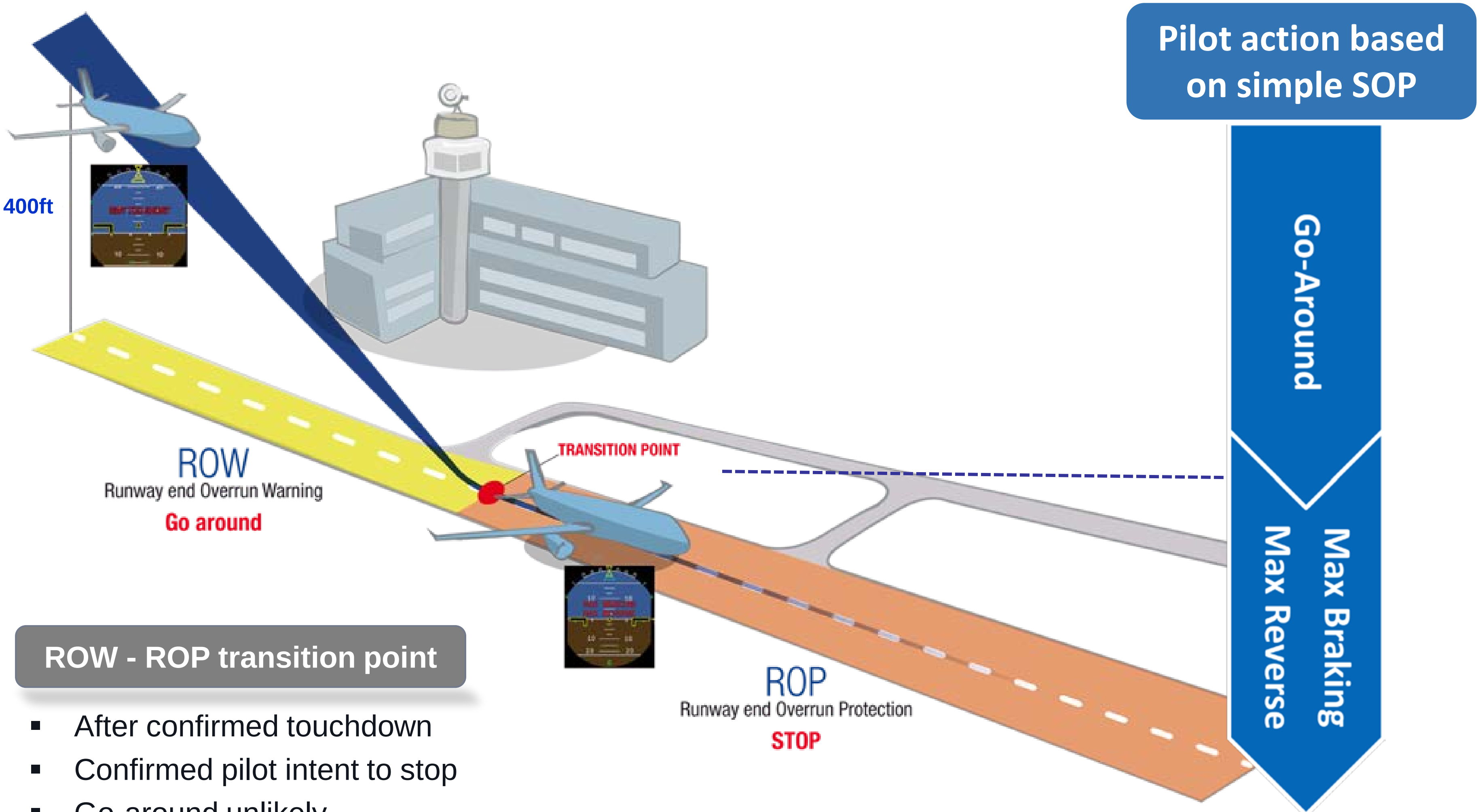
Review of ROPS Design

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.

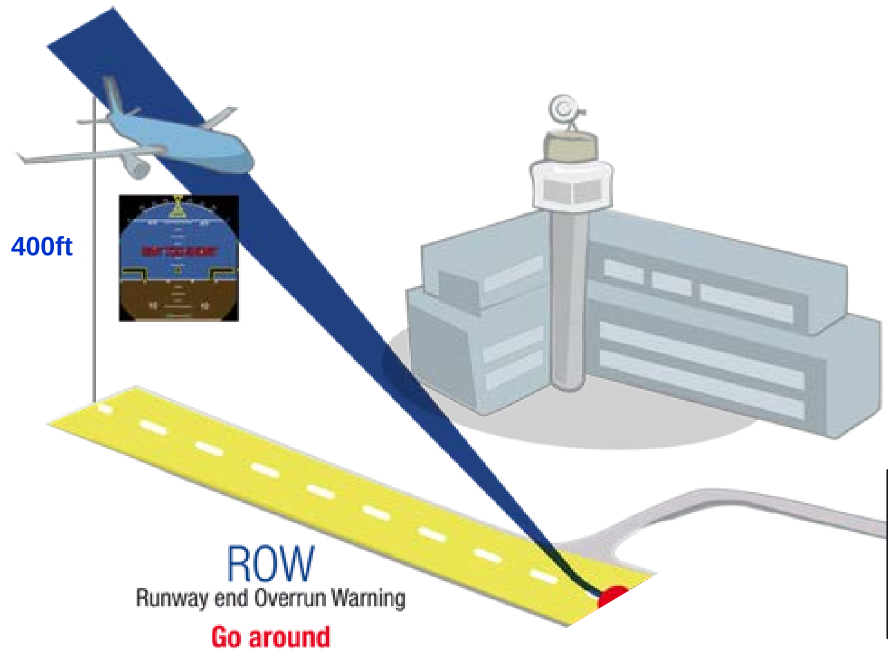
ROPS = ROW + ROP



ROW - ROP transition point

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

ROW – Runway End Overrun Warning



ROW

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

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

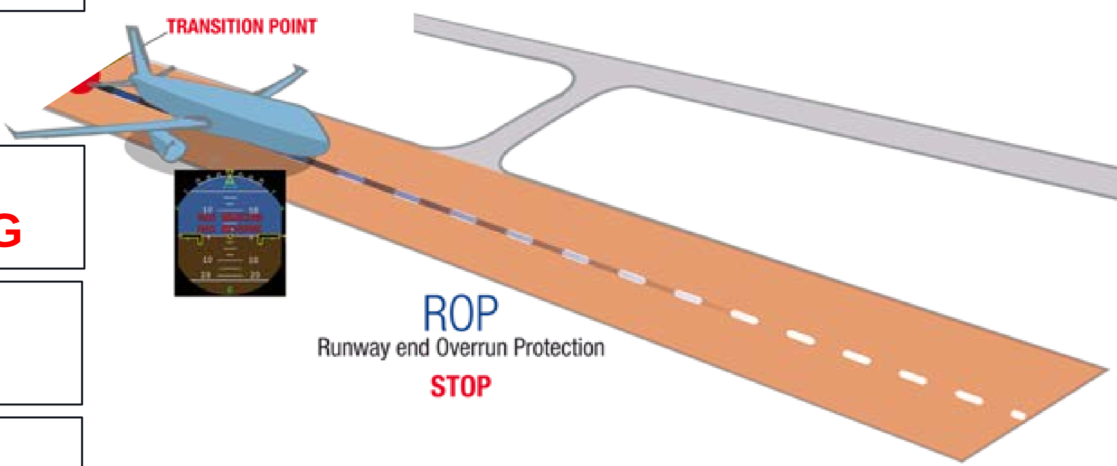
Visual Alert: **MAX BRAKING**
MAX REVERSE

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

Content

Take-Off Securing

Objectives of TOS function:

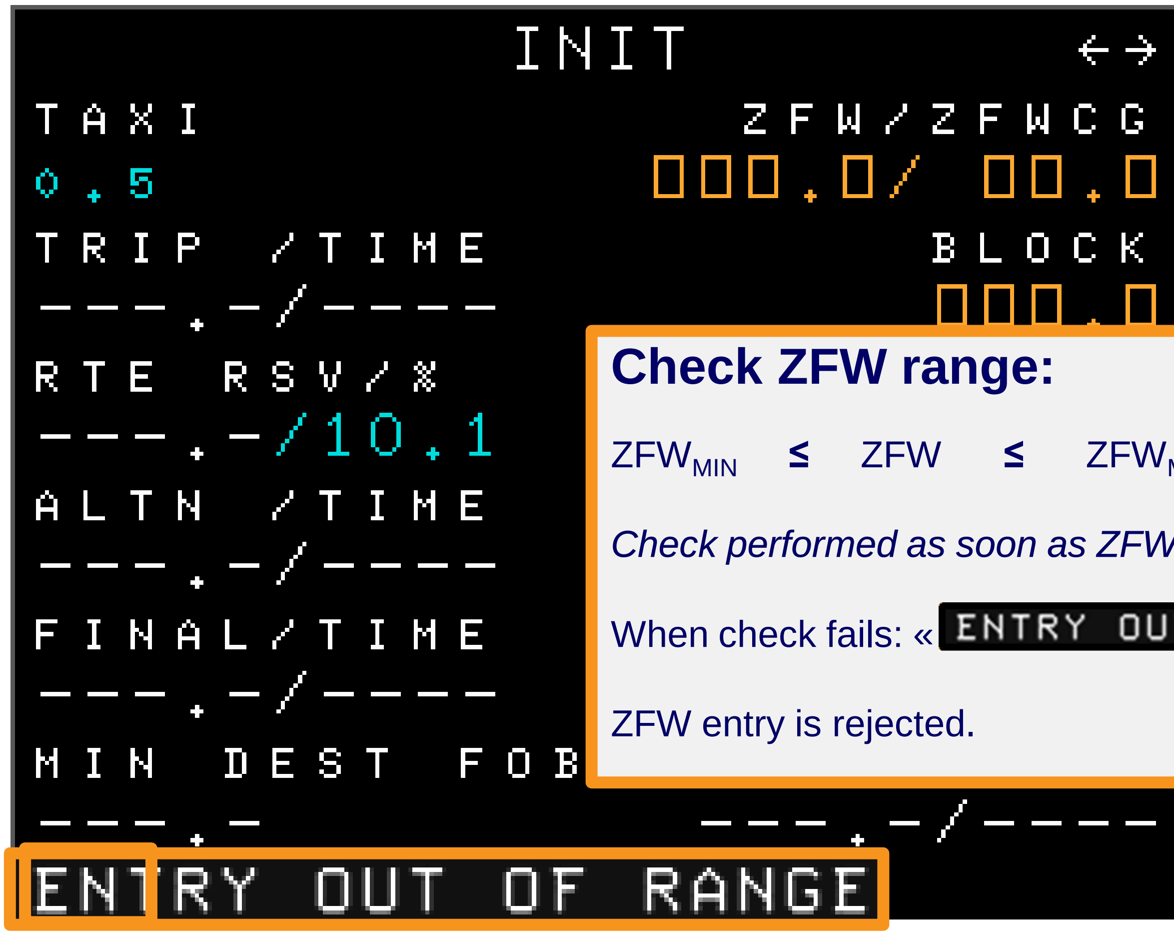
- ✓ To provide a safety net within avionics regarding erroneous takeoff parameters.
- ✓ To reduce risks of tail strike and runway overrun due to erroneous takeoff parameters.
- ✓ Detect gross inconsistency between takeoff parameters inserted in FMS.

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

Take-Off Securing

Detection of erroneous weight initialization in the FMS



Check ZFW range:

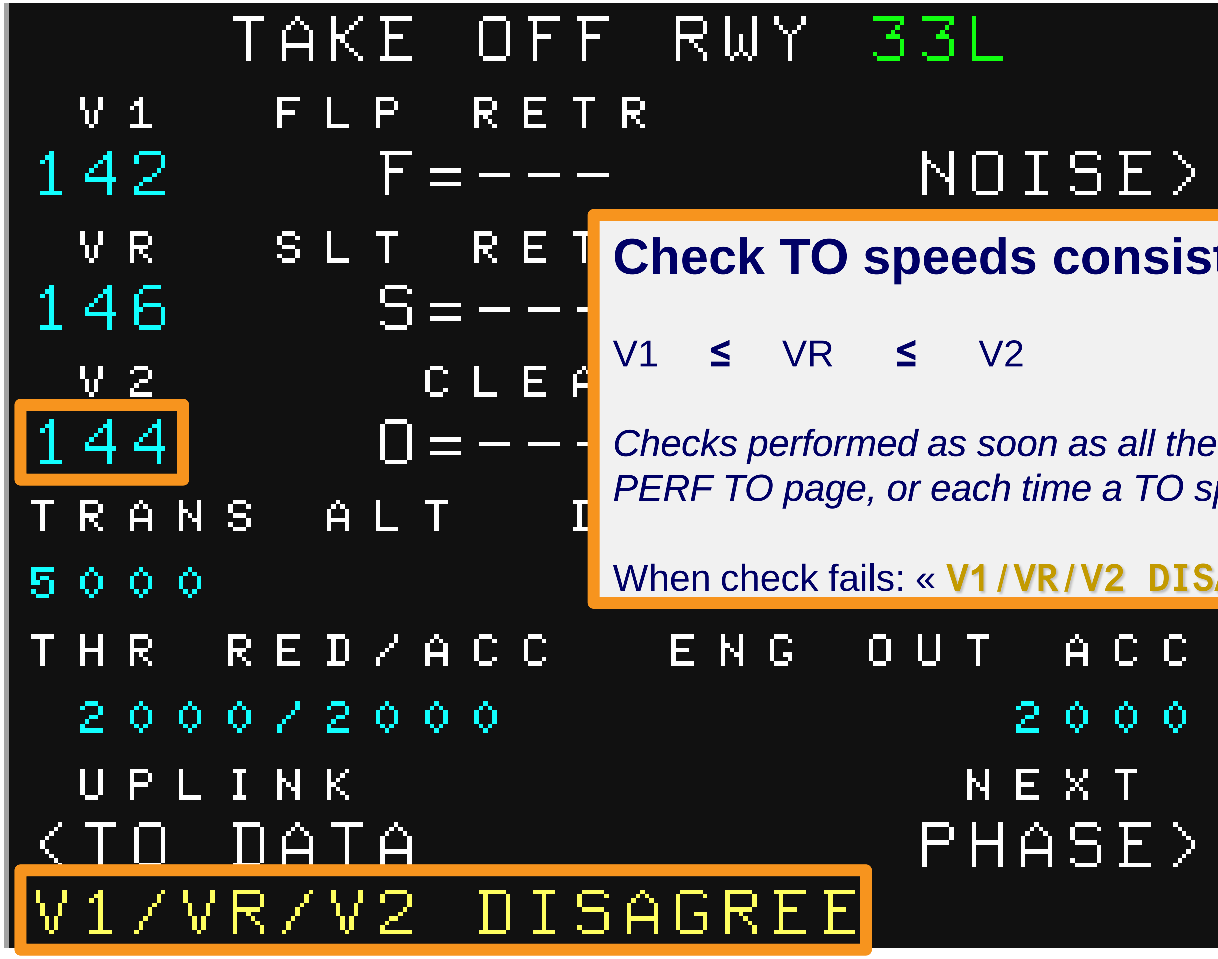
$ZFW_{MIN} \leq ZFW \leq ZFW_{MAX}$

Check performed as soon as ZFW is entered or modified.

When check fails: « ENTRY OUT OF RANGE » message and ZFW entry is rejected.

Take-Off Securing

Detection of erroneous take-off speeds initialization in the FMS



Check TO speeds consistency:

V1 ≤ VR ≤ V2

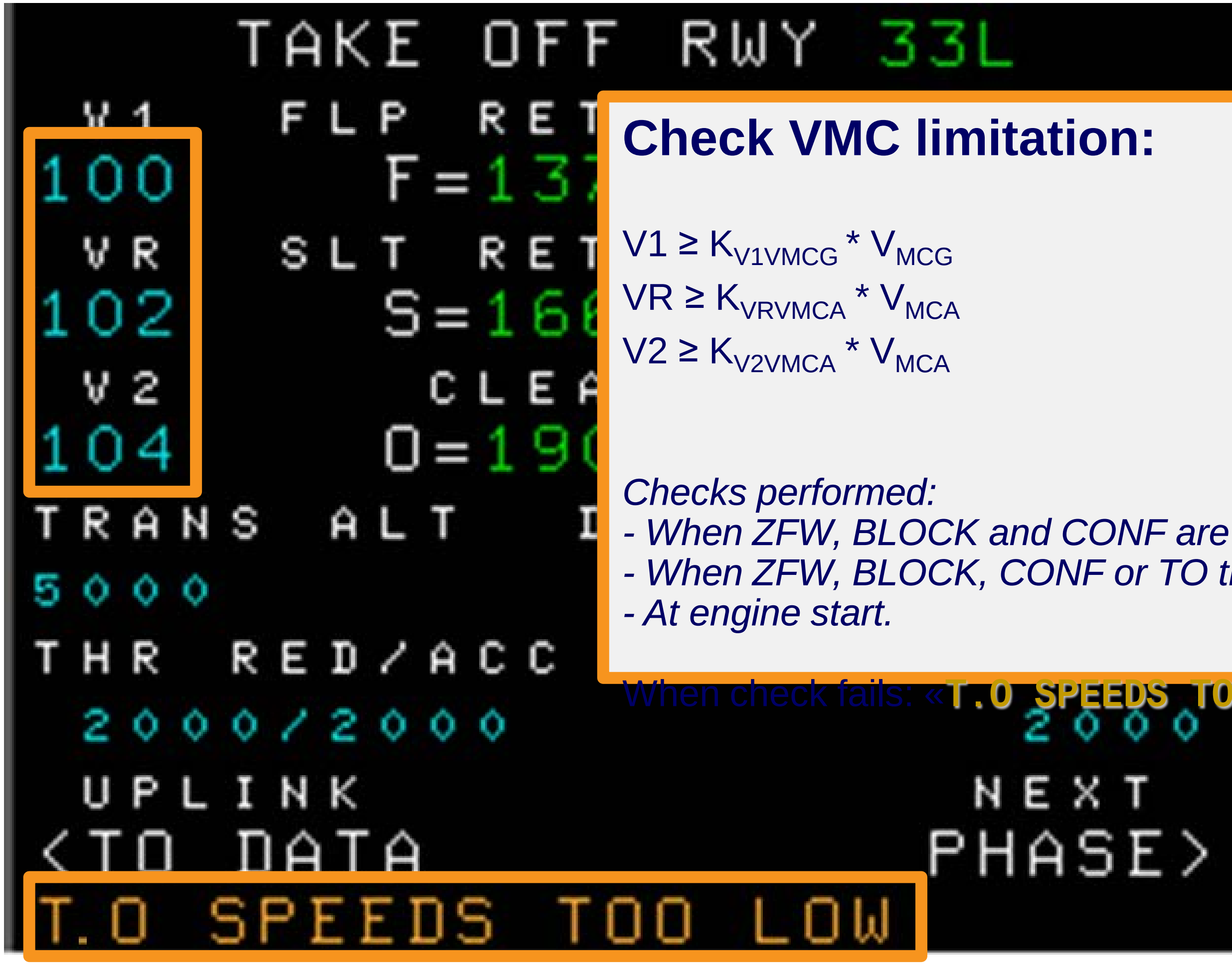
Checks performed as soon as all the 3 TO speeds are inserted in the PERF TO page, or each time a TO speed is modified.

When check fails: « **V1/VR/V2 DISAGREE** » message.

- ✓ *Available on FMS / MCDU*
- ✓ *Enhancement under development to provide ECAM alert for A320, A330/A340 and A380 programs*

Take-Off Securing

Detection of erroneous take-off speeds initialization in the FMS



Check VMC limitation:

$V1 \geq K_{V1VMCG} * V_{MCG}$

$VR \geq K_{VRVMCA} * V_{MCA}$

$V2 \geq K_{V2VMCA} * V_{MCA}$

Check Vs1G/VMU limitation:

$VR \geq K_{VR} * V_{RMIN}$

$V2 \geq K_{V2} * V_{S1G}$

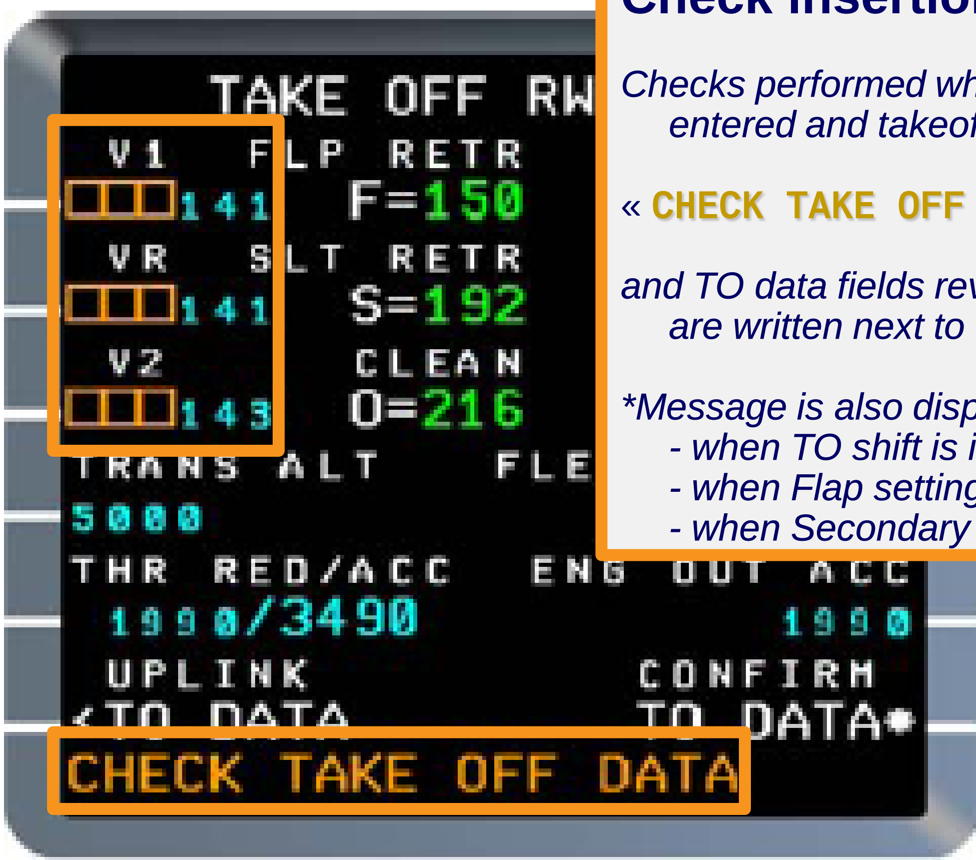
Checks performed:
- When ZFW, BLOCK and CONF are inserted on the MCDU.
- When ZFW, BLOCK, CONF or TO thrust setting are modified.
- At engine start.

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*

Take-Off Securing

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 change d*
- *when Secondary Flight Plan is activated*

✓ *Available on FMS / MCDU*

✓ *Enhancement under development to provide ECAM alert for A320 and A330/A340 programs*

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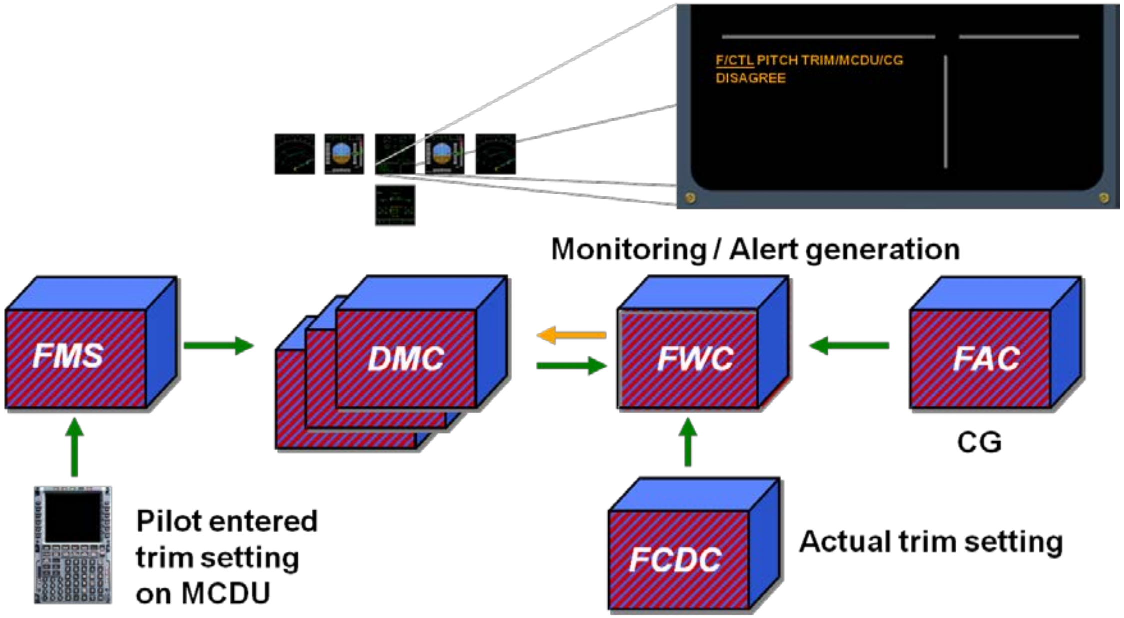
Take-Off Securing

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

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

** Enhancement under development to provide ECAM alert*

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Thank You !