

## REJECTED TAKEOFF



# *Ludo's Brief*

- Some excellent technical briefings are available in the Smartcockpit FLIGHT OPS section!
- The total energy that must be dissipated during an RTO is proportional to the square of the airplane velocity. At low speeds (up to approximately 80 knots), the energy level is low. Therefore, the airplane should be stopped if an event occurs that would be considered undesirable for continued takeoff roll or flight.
- V1 means the maximum speed in the takeoff at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speedbrakes) to stop the airplane within the accelerate-stop distance and V1 also means the minimum speed in the takeoff, following a failure of an engine at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance.
- Refer to the Rejected Takeoff NNM in the QRH for guidance concerning the decision to reject a takeoff below and above 80 knots.  
During takeoff roll the 80kt call has three functions:
  - 1) An incapacitation check.
  - 2) It defines the high and low speed RTO.
  - 3) Airspeed crosscheck.

Again, *RYANAIR* ideally covers the subject while giving a list of reasons to reject (before and after 80 kts):

### Before 80 kts

- System failure
- Unusual noise or vibration
- Tire failure
- Abnormal acceleration
- Engine failure/fire
- Configuration warning
- Predictive windshear warning
- Airplane unsafe or unable to fly
- Significant bird hazard
- Blocked runway.

### Above 80 kts

- Engine failure/fire
- Predictive windshear warning
- Airplane unsafe or unable to fly.

- As the airspeed approaches V1 during a balanced field length takeoff, the effort required to stop can approach the airplane maximum stopping capability. Therefore, the decision to stop must be made before V1.
- Historically, rejecting a takeoff near V1 has often resulted in the airplane stopping beyond the end of the runway. Common causes include initiating the RTO after V1 and failure to use maximum stopping capability (improper procedures/techniques). Effects of improper RTO execution are shown in the diagrams located in the RTO Execution Operational Margins section, of the B737 QRH. They are reproduced below.

737

## Available Runway (DRY)

## Baseline

AFM balanced field length

All-engine RTO, brakes and speedbrakes only, no thrust reverse



1 sec

Go

VR

Lift off



35 ft

Event

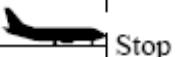
V1

One Engine Acceleration

Transition complete

Brakes

No Go



Stop

## Effect of reverse thrust

Engine-out RTO, brakes, speedbrakes, and 1 thrust reverser

V1

-220 ft / -70 m

## Effect of reverse thrust

All-engine RTO, brakes, speedbrakes, and 2 thrust reversers

V1

-150 ft / -50 m

## Effect of no speedbrakes

All-engine RTO, brakes only, no thrust reverse

V1

60 kts

+430 ft / +130 m

## Effect of no speedbrakes

All-engine RTO, brakes and 2 thrust reversers

V1

35 kts

+120 ft / +40 m

## Effect of late speedbrakes

All-engine RTO, brakes, speedbrake deployment 5 seconds after V1, no thrust reverse

V1

50 kts

+250 ft / +80 m

## Effect of late RTO initiation

All-engine RTO initiated 2 seconds after V1, AFM transition, brakes and speedbrakes only, no thrust reverse

V1

75 kts

+690 ft / +210 m

737

## Available Runway (DRY)

Effect of less than maximum  
braking effort

All-engine RTO, 3/4 brake pressure,  
speedbrakes, and 2 thrust reversers



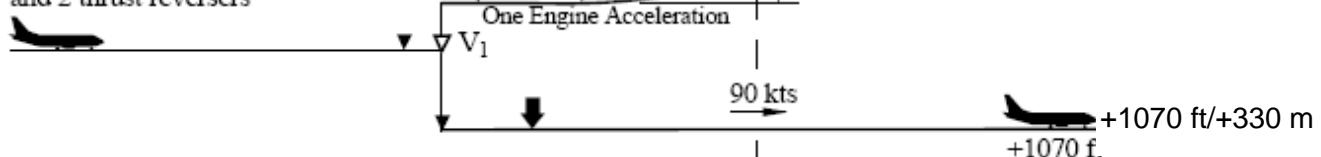
Effect of blown tire

All-engine RTO, brakes, speedbrakes,  
and 2 thrust reversers

## Available Runway (WET)

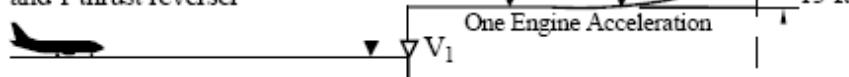
Effect of using dry runway performance  
(limit weight and  $V_1$ ) on wet runway

All-engine RTO, brakes, speedbrakes,  
and 2 thrust reversers



Effect of using wet runway  
performance (reduced  $V_1$  and GW)

Engine-out RTO, brakes, speedbrakes,  
and 1 thrust reverser



- There have been incidents where pilots have missed FMC alerting messages informing them that the takeoff speeds have been deleted or they have forgotten to set the airspeed bugs. If, during a takeoff, the crew discovers that the V speeds are not displayed and there are no other fault indications, the takeoff may be continued.

The lack of displayed V speeds with no other fault indications does not fit any of the published criteria for rejecting a takeoff (refer to the Rejected Takeoff NNM in the QRH). In the absence of displayed V speeds, the PM should announce  $V_1$  and  $V_R$  speeds to the PF at the appropriate times during the takeoff roll.

The  $V_2$  speed should be displayed on the MCP and primary airspeed indicators. If neither pilot recalls the correct rotation speed, rotate the airplane 5 to 10 knots before the displayed  $V_2$  speed.

- The maximum braking effort associated with an RTO is a more severe level of braking than most pilots experience in normal service.
- The decision to reject the takeoff is the responsibility of the Captain (except during Captain's incapacitation), and must be made before V1 speed. If the captain is the PM, he should initiate the RTO and announce the abnormality simultaneously.
- According to Boeing, « *A successful rejected takeoff at or near V1 is dependent upon the captain making timely decisions and using the proper procedures* ». I would add that First Officer's role is also important because he verifies all items for the reject have been actioned by the Captain and the First Officer also calls any omissions.
- With RTO selected:
  - if the takeoff is rejected prior to wheel speed reaching 90 knots autobraking is not initiated, the AUTO BRAKE DISARM light does not illuminate and the RTO autobrake function remains armed.
  - If the takeoff is rejected after reaching a wheel speed of 90 knots, maximum braking is applied automatically when the forward thrust levers are retarded to IDLE.



- Read the REJECTED TAKEOFF PROCEDURE presented at the end of this briefing.
- Think fast.
- The RTO maneuver is initiated during the takeoff roll to expeditiously stop the airplane on the runway. The PM should closely monitor essential instruments during the takeoff roll and immediately announce abnormalities, such as "ENGINE FIRE", "ENGINE FAILURE", or any adverse condition significantly affecting safety of flight.
- If the Captain does make the decision to reject the takeoff, the Captain should announce the decision in a loud clear statement such as,
  - "Abort" **SOUTHWEST AIRLINES**
  - "Abandon" **RYANAIR**
  - "Stop" (chosen by a majority of operators for CRM reasons because the word STOP is easy to say in a very high emotional situation such as a RTO)

This announcement leaves no doubt, or indecision for the First Officer and will help maintain situational awareness. If the First Officer is making the takeoff, the Captain should make a statement such as: "**Abort / Abandon / Stop / I have the aircraft**" or "**Abort / Abandon / Stop / I have control**"

- If the takeoff is rejected before the THR HLD annunciation, the autothrottles should be disengaged as the thrust levers are moved to idle. If the autothrottle is not disengaged, the thrust levers advance to the selected takeoff thrust position when released. After THR HLD is annunciated, the thrust levers, when retarded, remain in idle. For procedural consistency, disengage the autothrottles for all rejected takeoffs.
- If rejecting due to fire, in windy conditions, consider positioning the airplane so the fire is on the downwind side.
- After an RTO, comply with brake cooling requirements before attempting a subsequent takeoff (see QRH Brake Cooling Schedule).
- In case of takeoff on a narrow runway (< 45m), perform a reduced thrust, when performance permits: it will minimize thrust asymmetry following an engine failure and increase crosswind capability. Remember that the greatest deviation from centerline will occur with engine failure at low speed combined with a crosswind
- The most critical conditions during an RTO are:
  - Low speed (before the rudder becomes effective – see Note)
  - Crosswind (remember VMCG is determined in zero wind)
  - High thrust (large thrust asymmetry in case of an engine failure)
  - Light weight (less momentum)
  - Aft CG (directional control)
  - Max takeoff flap (lower speed, VMCG does not change with flaps setting but the takeoffs speeds will be lower and closer to VMCG)

**Note:** If it happens, decrease thrust on operating engine as quickly as possible to remove asymmetric thrust



## DON'Ts !

- Do not start or continue a takeoff when any warning horn or bell sounds before the aircraft attains 80 knots.
- Do not initiate a stop after V1 unless the aircraft is incapable of flight.
- Do not forget to deploy the speedbrake **prior to** reverse thrust

## REJECTED TAKEOFF PROCEDURE

According to RYANAIR procedures

| CAPTAIN   | FIRST OFFICER  | REMARKS  |
|---|--|--|
| 1 Call "ABANDON" and take control of the aircraft.  |  | The PM should closely monitor essential instruments during the takeoff roll (especially before 80 kt) and immediately announce abnormalities, such as "ENGINE FIRE", "ENGINE FAILURE", or any adverse condition significantly affecting safety of flight.  |
| 2 Close thrust levers and disengage simultaneously autothrottle.  | <ul style="list-style-type: none"> <li>- Verify thrust levers close &amp; autothrottle disengaged.</li> <li>- Call out omitted action items.</li> </ul>  | A/T must be disengaged to prevent A/T from restoring takeoff thrust.   |
| 3 Verify automatic RTO braking or take max manual braking as required if deceleration is not adequate or if AUTOBRAKE DISARM light is illuminated.  | <ul style="list-style-type: none"> <li>- Note the brakes on speed.</li> <li>- Call "AUTOBRAKE DISARM"</li> <li>- Call out omitted action items.</li> </ul>   | <u>Speed conditions:</u> <ul style="list-style-type: none"> <li>- RTO not activated below 60 kts wheel speed. (A/T FMA window indicates N1).</li> <li>- No auto braking below 90 kts wheel speed. (A/T FMA indicates THR HLD).</li> </ul> <p>Brake on speed knowledge is important for the further calculation of the Brake Cooling Schedule - brake cooling time and precautions (refer to QRH)</p> |
| 4 Raise speed brake lever.  | <ul style="list-style-type: none"> <li>- Call "SPEEDBRAKES UP" or</li> <li>- Call "SPEEDBRAKES NOT UP"</li> <li>- Call out omitted action items.</li> </ul>  | Although speedbrakes move automatically at reversers application, they must be extended manually to prevent any delay in spoilers extension, necessary for an efficient wheel braking.   |
| 5 Apply maximum reverse thrust consistent with runway conditions and continue maximum braking until certain the airplane will stop on the runway.   | <ul style="list-style-type: none"> <li>- Verify thrust reverser</li> <li>- Call out: "100 KNOTS, 80 KNOTS, 60 KNOTS"</li> </ul>  | Field length permitting, initiate movement of the reverse thrust levers to reach the reverse idle detent by taxi speed.  |
| 6 Stop aircraft on runway heading or consider turning into wind if the takeoff was rejected due to fire warning.  | <ul style="list-style-type: none"> <li>- Alternating red and white runway lights call "900 METERS"</li> <li>- Steady red lights call "300 METERS" of runway remaining</li> </ul>                       |  |
| 7 Set parking brake   | <ul style="list-style-type: none"> <li>- Select Flaps 40 when parking brake is set</li> <li>- Inform ATC including information on airplane position and alert if necessary the fire brigade</li> </ul> |  |
| <u>When the airplane is stopped, perform procedures as required and consider the following:</u> <ul style="list-style-type: none"> <li>- The need to proceed to an emergency evacuation (assess quickly the situation)*</li> <li>- The possibility of wheel fuse plugs melting (see Brake Cooling Schedule for brake cooling time and precautions before attempting a new takeoff)</li> <li>- The need to clear the runway and the requirement for remote parking.</li> <li>- Advising the ground crew of the hot brake hazard.</li> <li>- Completion of Non-Normal checklist (if appropriate) for conditions which caused the RTO</li> </ul> |  |  |

\* Once the aircraft has come to a complete stop, The CSS (Cabin Service Supervisor = Purser) picks up the interphone and calls the captain and says: **"CABIN TO THE FLIGHT DECK STANDING BY"**.

As the flight crew are extremely busy carrying out their own rejected-takeoff drill, there may be a time delay before the captain answers the call. While the CSS is on the interphone, he/she is assisting the cabin for any potential hazards, i.e. fire inside or outside the cabin. (...) Cabin crew can be checking conditions inside and outside the cabin while awaiting instructions.

The Captain will then give the CSS instructions thru the intercom.

If the CSS is unable to establish contact with the flight deck he/she will, after some time, gain access to the flight deck.

Some airlines like **Continental Airlines** have also a special check-list dedicated to the RTO.

