Podcast 39 RTO

Hello everyone, and welcome to another episode of the 737 Talk, where we try to help with aircraft technical refreshers, discussing together incidents involving the 737, from which we can all learn. We thought today we'd focus our Talk episodes, in the second in our mini-series, on another of the mandatory items that most of us still need to do to re validate our licence during the Licence/Operator proficiency Check, or LPC/OPC. Today we shall be discussing the Rejected Takeoff Manoeuvre, or RTO and discussing operational points specific to the B737NG when faced with having to perform it.

Our aim today is to familiarise you with what the RTO is, and how to generically perform such a manoeuvre. Although this is an item that is mandated to be tested and checked on your LPC yearly, it is also such a safety critical manoeuvre that there are numerous threats associated with it.

We will understand why the pilot may consider rejecting a take-off and how they would perform it. Together we'll discuss the roles each pilot has, but it is definitely worth mentioning that this is a manoeuvre that is very SOP specific with different operators employing slightly different calls and procedures. We will concentrate on the generic Boeing recommend techniques, but please be sure to check with your operator as to the specific SOPs you will be following. It is also worth highlighting that although most operators require and mandate the Captain or CM1 to make the stop/go decision and be PF for the manoeuvre – both pilots play specific hugely important roles in managing this manoeuvre and it requires excellent team working skills and situational awareness to make sure that it is performed safely and to proficiency.

Firstly, we will look at a bit of background information regarding regulation and definition. As you know we calculate a set of speeds for take-off using the QRH performance section, company paper tables or more likely an electronic performance tool designed to maximise the amount of weight you can lift on a given runway, under given conditions, using the minimum thrust. One of these speeds is known as V1.

Both EASA and the FAA regulation define V1 in the same two ways:

-the maximum speed during the take-off at which the pilot must take the first action to stop the aeroplane within the accelerate-stop distance (ASDA) – with certain assumptions which we discuss for background information and

-V1 is also the minimum speed in the take-off following a failure of the critical engine, at which the pilot can continue the take-off and achieve the required height (screen height 35 dry /15' wet) within the take-off distance.

Referencing a diagram from the FCTM (which we'll put up on the website), you will note that there is a 1 second delay built into the calculations. This is the agreed and regulated time that is given to you to notice the failure, understand the failure, decide to reject, and start to make the first action to stop the aircraft. There is also a further 2 second margin assuming that the aircraft remains at V1 speed built into the calculations to allow the brakes to be applied and reach maximum efficiency. Despite having briefed this prior to every take-off and being fully aware that this 'could' happen on every take-off – such an event will be a shock, and our aim as pilots is to manage this 'startle factor' and build resilience to it to ensure that, should you be part of the crew rejecting a take-off, a safe outcome will result.

It is also worth knowing other assumptions made when thinking about V1. The calculations of your maximum speed at which you can safely stop within the ASDA is also based on you as the pilot timely starting to perform your actions with no more than 1 second thinking time; uniform maximum braking as demonstrated during the flight tests performed computationally and by steely-eyed test pilots; no tyre deposits on the runway to alter the friction coefficient; any headwind is factored at 50% to allow for windspeed variations; and all tyres remain inflated during the reject. It is worth having such ideas in the back of your mind, when approaching that high-speed regime of the take-off, of which we'll discuss later.

From your performance A exam days, you might remember the concept of the balanced field and its significance.

Calculating a V1 speed that equates accelerate-go and accelerate-stop distances defines the minimum field length required for a given weight. This is known as a "balanced field length" and the associated V1 speed is called the "balanced V1". The QRH and FMC provide takeoff speeds based on a balanced V1. If either an ATM or fixed derate reduced thrust takeoff is used, the QRH and FMC, if FMC takeoff speeds are available, will provide a balanced V1 applicable to the lower thrust setting.

Takeoff gross weight must not exceed the climb limit weight, field length limit weight, obstacle limit weight, tire speed limit weight, or brake energy limit. If the weight is limited by climb, obstacle, or brake considerations, the limit weight may be increased by using takeoff speeds that are different from the normal balanced takeoff speeds provided by the QRH or FMC.

Your operator will probably use a policy to determine different V1 speeds, dependant on their requirements.
Different (unbalanced) takeoff speeds can be determined by using:

-improved climb to increase climb or obstacle limited weights
-maximum V1 policy to increase obstacle limited weights
-minimum V1 policy to increase brake energy limited weights
-clearway or stopway to increase field or obstacle limited weights.

If the takeoff weight is not based on normal balanced V1, the QRH and FMC takeoff speeds are not applicable and your operator will provide you with a method to obtain the appropriate takeoff speeds, either electronically, or by paper performance charts.

As Ian mentioned at the start, it is usually within most operator's SOPs for the CM1 or Captain to make the decision to stop/go, and perform the reject as PF.
Boeing recommend a call of 80kts during the take-off roll by PM.
There are several reasons for this call, and we'll discuss them:

-You should be keeping forward pressure on the control column up until this point; this is because the rudder becomes effective around the 40-60 kts region, and up until that you are primarily maintaining aircraft directional control by the nose wheel steering, and thus you want weight on the nose wheel to achieve this.

-Secondly, this 80 kts is an incapacitation check, requiring a response from the PF.

-Thirdly it is a suitable point to perform an ASI crosscheck. With unreliable airspeed having caused many incidents in the past, it is imperative to check your speed indications with a view to reject if an anomaly is detected.

-And lastly, this 80 kts is an arbitrary number which approximates to the low and high-speed regimes of the take-off roll and is suitable point at which to alter your decision making. Remember that the amount of energy needed to be dissipated is proportional to the square of the velocity, you can see as the speed increases, as does the energy exponentially. There is nothing special about 80 kts, it is just chosen for us as pilots to consider the 4 items above.

Once you press one of the TO/GA buttons on the take-off, the auto throttle will drive the thrust levers to the calculated take-off thrust. At 84 kts, Throttle Hold will engage, and the thrust clutch will disengage. Up until 84 kts, the system will attempt to move the thrust levers back to the determined take-off thrust despite any movement on them. It is therefore imperative that the auto throttle is disengaged as part of the RTO actions, more of which later.

We mentioned the 80-knot call and its significance in differentiating between the low/high speed regimes of the take-off roll. Different operators will have different SOP guidance of what to reject for before and after 80 knots. This is guidance only, and there are many other factors when making this big decision; runway length, weather conditions, aircraft weight etc.

Before 80 knots the FCTM gives guidance which many operators will simplify and advise their pilots to reject for ANYTHING abnormal below 80 knots. Just because this is the low-speed regime of a possible RTO, it would be wrong to assume the risks of runway excursion are lower. It is worth training and asking your TRI/TRE to give you a low-speed RTO, with a low-speed severe engine malfunction or seizure below VMCG. Controllability will be an issue, and different operators will have different techniques, but it is suggested you may need to apply a tiller input to stop an excursion after timely retardation of the thrust levers.

Above 80 knots, but before V1, it is a harder and more critical decision to make as we have seen the assumptions and margins involved.

Again, different operators will offer differing guidance as to what to reject for above 80 knots, but operators tend to suggest the following which I'll mention here:

- Any fire or Fire warning
- Engine failure, confirmed by 2 parameters
- Predicative Windshear Warning
- Aircraft unsafe or unable to fly which could be something such as a Control Malfunction or a Blocked runway

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.

With such tight margins and a need to execute this manoeuvre timely and accurately, it is imperative that both pilots know their roles and can perform them using 'muscle memory', which will come with training, practice and a knowledge of your role and procedures. As we've mentioned on a previous pod, some pilots may find the technique of 'arm chair' flying useful to practice and visualise what they are going to do, when and where.

Boeing recommends that the CM1 or Captain, will make the decision and assume the PF role for the reject. Some operators are approved that the FO can decide and reject, but it is usually the CM1. Early detection and timely decision making are critical to ensure a safe outcome. It is suggested that when making this decision, your mindset changes around this arbitrary 80 kts, and you become more 'go-minded' as you approach V1, with the call of V1 being the point at which a take-off is assumed.

Rejecting the takeoff after V1 is not recommended unless the captain judges the aircraft incapable of flight. Even if excess runway remains after V1, there is no assurance that the brakes have the capacity to stop the airplane before the end of the runway.

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 take-off mentioned earlier. In the absence of displayed V speeds, the PM should announce V1 and VR speeds to the PF at the appropriate times during the takeoff roll.

The V2 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 V2 speed.

It is generally assumed that the CM1 will perform the reject. If the FO is PF for the take-off, and the CM1 decides to reject it is assumed they will take control, announce their intention to stop with an SOP call of usually 'STOP' or 'REJECT', while initiating the RTO. The FO will relinquish control and assume the PM role and carry out the equally important actions of monitoring during this manoeuvre.

This is assuming the CM1 has not become incapacitated, either mentally/physically, gradually, or suddenly. It is then in the FOs or CM2s remit to perform the reject and the UK CAA will train and test this as part of a 3 yearly training programme. I.e. it should always be in both pilots minds that they may need to reject the take-off at such a critical phase of flight.

Assuming there is no incapacitation of the CM1, we will now discus the actions, and the order in which Boeing recommend the RTO is performed.

Firstly the CM1 or Captains actions.

Simultaneously,

Close the Thrust Levers, Disengage auto throttles (in case the reject occurs before 84kts and THR HOLD) and apply maximum manual wheel brakes or verify RTO autobrake. Monitor the auto braking if used, and if AUTO BRAKE DISARM light illuminates, apply manual maximum brakes

As you monitor this, Raise SPEED BRAKE lever and Apply Reverse thrust, up to maximum, consistent with conditions, and keep this max braking until stopping is assured.

When it is clear that you will safely stop, the CM1 will start moving the thrust reverse levers to reach reverse idle detent before taxi speed. And when they are reverse idle, continue to move them to the full down position.

As described earlier the FO or CM2 has an equally important role in monitoring. Because there is a tendency for the startle factor, it is not uncommon for the CM1 to forget items, and thus critically important that the FO monitors and announces SOP deviance in a clear and concise manner.

The FO will effectively Verify, monitor or check the CM1 actions:

- Thrust Levers Closed.
- Auto throttles disengaged
- Maximum manual wheel brakes or RTO autobrake applied

They will Monitor the Speed brake lever and call:

- 'SPEEDBRAKES UP' or 'SPEEDBRAKE NOT UP'

They will monitor the reserve thrust application and when both REV indications are green:

Announce 'REVERSERS NORMAL'

- Or if no REV, or indication stays amber

-'NO REVERSER ENGINE NUMBER 1 or 2' respectively

Once again, when it is clear that the aircraft will safely stop: They will announce 60knots and communicate when appropriate with the ATS unit that they are stopping. The communication with the passengers and cabin is a very company specific thing, but Boeing recommend that the FO does this.

Performing the initial actions and safely bringing the aircraft to a halt within the ASDA, is only the initial part of your workload. Once the aircraft is stopped, good teamwork and effective decision making is vital to ensure a safe outcome. The crew need to come together now to diagnose the reasons for the RTO, and if necessary, any non-normal checklists are to be actioned. There are now many things to consider, and the workload is high.

Some of those things may be:

- The possibility of Wheel Fuse plugs melting (around 600 deg C)
- Are you able to vacate the active runway? Do you want to?
- Wind direction if you have a fire, and possibly turning the aircraft so that the fire is not blown over it.
- Communicating with Fire services, on their discrete frequency. Many UK airports use 121.6.
- NOT setting the parking brake unless there is to be an evacuation – a Boeing recommendation in case the brakes bind.
- Setting Flap 40, to aid passenger evacuation from the overwing exits.
- Passenger and crew communications
- And any possible Evacuation

Over the years many LPCs have combined the RTO with an evacuation. This is done for time and logistical reasons in the simulator. There is an argument that it is leading to negative training because of the perceived risk that you will always associate an evacuation with an RTO and in the heat of the moment order an unnecessary evacuation. This is fraught with many risks and is why we are not combining and discussing the RTO and evacuation together, because it is a separate non-normal, and should be considered thus in our opinion.

Finally, we would like to discuss the effects of incorrectly applying the actions of an RTO on your stopping distance. 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 or techniques). There is a graphic from the FCTM, which we'll put on the website which shows the effects of improper RTO execution.

The baseline distance is shown and then the other graphics illustrate the effects of improper techniques. Remember that reverse thrust is not considered on a dry runway, and no credit is given for it, but on a wet runway with wet figures, reverse thrust is critical.

It is worth knowing and trying to prepare for the fact that the maximum braking effort associated with an RTO is a more severe level of braking than most pilots experience in normal service. Again, very difficult to simulate in a FSTD, and will come as a shock if ever faced on the line with a high-speed RTO.

To summarise, the RTO is a manoeuvre that will occur at a critical phase of flight and requires good knowledge of the procedure and excellent flight path management, coupled with good early decision making.

Both pilots play a very important monitoring role during the manoeuvre, monitoring the aircraft, and the environment. This is key to ensuring a safe outcome.

Having witnessed many RTOs in the simulator before, with crews under check, the thing that most jumps out is that, despite crews' knowledge of what they are trying to do, the common error is there is a tendency to rush and complete the initial actions as quick as they can. Our advice is that as slow as you think you are going, with the adrenaline coursing through you, be aware that the risk is that you are going faster than your colleague, and then team working will break down and items and actions will get missed.

So that's about it, the second in our series of mandatory check items, with training inputs and suggested techniques to fly the manoeuvre to the required standard. We discuss this, and the other mandatory items in more detail, on our subscription-based service b737training.org, where you can watch interactive presentations, visualise these manoeuvres and full flight sim manoeuvre demonstrations, together with TEM briefs and de-briefs.

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