Podcast 31, Talk, Performance

Hello and welcome to another episode of the 737 Talk where this week we'll be looking at a very complex subject; Aircraft performance. Now this one is far too tricky for Mark and me to handle alone so we've brought in reinforcements. We're going to have a chat with, once we've explored some of the area ourselves, a performance expert. Some of you may know his name but for those who don't it's Thiago Brenner. Thiago has been kind enough to offer as a prize a digital copy of his excellent performance book titled "Aircraft Performance Weight and Balance" which is a must have for you performance enthusiasts out there with over 300pages of in-depth and useful information. This digital copy will only be available on ipad and Macbook so please only enter if you have those devices. More on how to enter later. For those who don't win the prize you can get either a digital or paperback copy from Amazon and I'm sure elsewhere too. More from Thiago later and no doubt he'll pull Mark and I up on any mistakes we make here!

We'll start the journey at take-off which is the most complex of flight phases performance wise. Most of us are now in possession of OPT and TODC which make the calculation straightforward for us, if we put the right information in of course. But what lies behind that nice user interface is quite complex and worth a delve in to.

Our software will first make sure we're within the AFM environmental envelope and then start looking at other factors such as the performance limited take-off weight, which we'll get into shortly, and declared distances. Brace yourself for acronym bingo now.

Our declared distances are the length of the runway declared usable for take-off and landing for the purpose of our performance calculations. They involve the TORA or Take-Off Run Available, TODA or Take-off Distance Available, ASDA Accelerate Stop Distance Available and LDA or Landing Distance Available.

TORA is the length of the runway declared available by the appropriate authority and suitable for the ground run of the airplane taking off. The TORA is literally defined as from the beginning of the take-off run to a point halfway between lift-off and where the aircraft reaches screen height.

TODA is TORA + the length of any clearway available. The maximum length of this clearway may not exceed half of the TORA and the use of clearway is limited to one half the distance from lift-off to screen height on a dry runway, only. If the runway is wet or contaminated, the clearway can be used to compute the all-engine take-off distance, but not the one engine out take-off distance.

ASDA is TORA + the length of stopway available, if such stopway is declared available by the appropriate authority and can bear the weight of the 737 under the prevailing conditions. ASDA can in fact be shorter than the length of the runway if the runway end lacks appropriate runway end safety area (RESA).

LDA is simply the length of the runway which is declared available by the authority and suitable for the ground run of an airplane landing.

Something to bear in mind is TORA TODA and ASDA distances start from the beginning of the runway, or taxiway edge that will be behind you in the case of an intersection take-off. As I'm sure you can imagine this puts us at a line-up disadvantage to begin with. EASA regs require operators to take this into account for performance calculations with 90° runway entries and 180° turnarounds but no other type.

I briefly mentioned performance limited take-off weight before. To put some more meat on dem bones this will be the lowest weight of the following:

- Max Certified weight
- Climb limited weight
- Obstacle limited weight
- Field length limited weight
- Brake energy limited weight
- Tire speed limited weight and
- Radius restricted weight which is simply a max V2 for a turn
- There's also the RETURN TO LAND limited weight, also called Fuel Jettison Limited weight, but it only applies to the 737MAX family. The NG is excused to comply with this one because it is a quite new regulation.

Starting with the simple one our max certified weight is the weight we can easily extract from the AFM.

Climb limit weight is a little more complicated to explain, where's Thiago when you need him! Put simply we must achieve a minimum mandatory climb gradient. Less simple is that we like to split the take-off into 4 segments and have different requirements in each one. Let's quickly review those 4 segments then.

Segment 1 is from lift-off to gear fully retracted and here we must achieve just a positive climb gradient.

Segment 2 is from gear up to acceleration altitude which must be at least 400ft AAL. In this segment our mandatory minimum gradient is 2.4%. This is a "snap shot requirement", that is, it is a gradient that must be met at the exact moment the gear has finished retracting, and it is natural to decrease as the airplane climbs through the second segment.

Segment 3 is from the beginning of acceleration to flaps up. Here we are expected to accelerate is approximately level flight but a climb gradient of 1.2% is stipulated to ensure the aircraft has the excess energy to accelerate during retraction.

Segment 4 is flaps up to 1500ft AAL and here we need to achieve a minimum of 1.2%

These are all mandatory gradients and don't consider obstacles. We have another limit weight for that of course!

The obstacle limited take-off weight allows the 737 to clear all obstacles in the departure route with an engine failure at VEF. It will be calculated to at least 1500ft AAL or until 1.18VSR, otherwise known as the en-route climb speed, is reached.

Obstacles with obstacle accountability are inserted into databases, another reason to make sure your database is up to date but beware temporary obstacles are accounted for too as you may have to insert these yourself.

Vertical clearance is a minimum of 35ft from the Net Flight Path. This is figured out by doing the calculation of gross flight path minus 0.8%. As you can see this isn't a huge amount of potential clearance and emphasis the need for accurate flying.

Horizontal clearance considers 90m either side of the centreline + 0.125 times the distance from the end of the TODA. In other simple words the cone widens the further away from the runway you get, reaching a maximum with of 1,200m for a straight out departure or 1,800m if analysing a departure that requires more than 15° change of track.

To maximise obstacle limited weight, we will often have an engine failure procedure that doesn't follow the SID but avoids the most limiting obstacles.

The field length limited weight is the maximum weight for the available runway that allows us to meet all the following.

1st the all-engine take-off distance required to screen height times 1.15 must not exceed TODA. As a reminder screen height is 35ft dry and 15ft, for one engine inoperative take-off, only, wet and contaminated. All engine take-off keep the 35ft screen height.

2nd the engine out take-off distance required to screen height must not exceed TODA

3rd the accelerate stop distance required with an engine failure must not exceed the ASDA and

4th the accelerate stop distance required with an RTO caused by an event other than an engine failure must not exceed ASDA. All brakes must be fully available in this scenario.

The engine failure in these requirements is assumed to be one second prior to V1 with braking underway 2 seconds after V1. However, pilot action must have been taken by V1.

Reverser wise, we get no credit on a dry runway but on a wet or contaminated we get credit for the number of operational engines.

Our brake energy limited weight looks at the possibility of a high energy RTO. Our brakes are limited by the maximum speed at a given mass at which an RTO may ne initiated without exceeding the maximum absorption capabilities of the brakes, or VMBE as its referred too. It is based on groundspeed, maximum manual braking and no credit for reverse. Brake energy limited weight is when V1 equals VMBE as V1 may not exceed VMBE.

Tire limited weight is based on the maximum allowable speed to limit tire stress and prevent failure. On the 737 this is 195kts for BIAS tires. For RADIAL tires – 737MAX is default and 737NG is optional – it is 204kt. It is based on groundspeed at liftoff and can come into play at high-density altitudes, low flap settings and tailwind take-offs.

We'll now look at some more factors effecting take-off performance. Firstly, a note on the effects of a displaced threshold which can sometimes see some confusion. When operating from a runway with a displaced threshold TORA, TODA and ASDA still start from the beginning of the runway but the LDA starts at the displaced threshold.

Aircraft centre of gravity also affects take-off performance with a movement of the CofG aft improving it. Our take-off performance however is always based on the CofG at its forward limit. There is an option for the operator to purchase an alternate forward CofG limit to improve performance limited take-off weights but as it's to do with aircraft it would no doubt cost the CEO his shirt. There is no need for the extra purchase when referring to the 737MAX. It is default for any costumer to have 2 alternate forward limits on AFM. The operator just has to choose which value. Check your AFMs to see if you have this option and it can be used as long as the actual CofG is aft of the Alternate forward limit.

Now it wouldn't be a discussion about performance without having a delve into those fabled V speeds. We'll do these in chronological order and start with VMCG.

VMCG is our minimum control speed on the ground. It is the speed at which, when the critical engine fails, we can maintain directional control using rudder alone. Just to mention here, the 737 does not normally have a critical engine although Thiago did point out to us that, believe it or not, sometimes it does. When taking off with an inoperative bleed, for example, you will have two engines producing different amount of thrust, so you will have a critical engine. Max deviation from the centreline is assumed at 30ft or just over 9m using normal piloting skills. Consideration for crosswinds is not applied.

V1 can never be lower than VMCG (in fact is V1(MCG), and it is just a bit higher speed than VMCG), but what is V1? V1 is the maximum speed in the take-off at which point we must take the first action to stop within the ASDA. It is also the minimum speed in the take-off, following a failure of the critical engine at which we can continue the take-off and achieve screen height within the TODA. Regulations apply a 1 reaction gap between V1 and the first stop action. That's also why VEF is 1 second before V1 giving us that 2 second time to transition from acceleration to deceleration.

You will sometimes here the terms balanced V1 and Balanced field length. When your accelerate GO distance = your accelerate stop distance this is called a balanced field length. The V1 at which this occurs is your balanced V1. If your actual take-off weight is less than the field length limited weight, then you will have a range of V1 speeds available. Using the balanced V1 will maximise your performance margins or give you the greatest thrust reduction. It's not quite as black and white as that as with most things' performance. It's been pointed out to us, and rightly so that Unbalancing V1 may maximise your performance in some situations, such as when taking off from runways with stopways, clearways or close-in obstacles.

The next speed to look at is VR or the speed at which we rotate. VR is based on requirements for minimum unstick speed or VMU. For all engines it will be 1.1 VMU and for single engine 1.05VMU. Using VR and a correct rotation will ensure minimum tail clearance. The next speed we'll look will be reached by screen height after an engine failure when using the correct VR and rotation technique. Did you guess it? Yes, that's right our take-off safety speed, otherwise known as V2.

V2 is the minimum speed to be maintained with an engine failure in the 2nd climb segment up to acceleration as we are all well aware of with our 6 or 12monthly V1 cut practise. Maintaining V2 ensures we meet required climb gradients and as V2 is always above VMCA, more on that in a minute, the aircraft will be controllable. V2s mathematical requirements are that it must be at least 1.13VSR and 1.1 VMCA.

As we just mentioned it twice let's define VMCA or minimum control speed airborne. It is the speed at which, after the failure of the critical engine, it is possible to maintain directional control using rudder and bank angles of up to 5° toward the operating engine. Configuration for VMCA is assumed as most critical for take-off but with the gear retracted.

Before we leave our V speeds and head into the engine derates one last one to think about toward the end of our flight is VMCL or minimum control speed airborne in the landing configuration. Conditions for VMCA apply here with some differences being that the aircraft is in the most critical landing configuration at the most unfavourable weight with GA thrust selected on the remaining engine.

On the 737 we have two ways in which we can decrease thrust settings for take-off. These are the fixed derate and the Assumed Temperature method or ATM. We can use these methods separately or together. Those regulators step in again here and state we may not reduce thrust by more than 25% of the maximum.

So why do we do this. Well, it saves money in maintenance of course but it also has other advantages. Lowering our EGT has the benefits of reducing stresses on the engine due to lower pressures and temperatures as well as RPMs. These lower stresses also decrease the probability of an engine failure occurrence.

Our fixed derate is selectable in the FMC once we have done our performance calculation and is considered a take-off operating limit since minimum control speeds and stabiliser trim settings are based on it. We should not advance thrust levers passed this point or we would compromise controllability. The caveat here is unless conditions during take-off are encountered that require additional thrust on both engines such as windshear. Derated take-offs may be used on a wet runway too as well as when contamination includes standing water, slush, snow or ice. When using a derate on a contaminated runway it may even allow a higher take-off weight due to the reduction in VMCG. Using a derate is not permitted if the EECs are in alternate.

The Assumed Temperature Method is not considered an operating limit as VMCG, VMCA and stabiliser setting are not based upon it. If used alone without the derate thrust may be increased to full rated take-off thrust.

The thrust reduction is achieved by selecting an assumed temperature higher than the actual ambient temperature. The maximum allowable ATM accepted by the FMC is 70°C which is our 25% thrust reduction in standard conditions. Differences in OAT, field elevation and thrust rate, often mean the limiting temperature is lower than 70ºC. ATM is not permitted on contaminated runways, when anti-skid is inop, or when the EECs are in alternate. During ATM take-offs slightly more back pressure may be required during rotation and initial climb on the 737NG, but not for 737MAX as this takes into consideration the ATM to give you the stab trim setting for take-off.

You may well have noticed the option for improved climb performance on the company software. Improved climb will increase the take-off climb gradient by using higher V speeds thus increasing the Climb limit weight if that was your limiting factor. If we have an excess field length, we can trade this off using a longer ground run to improve our climb performance once airborne. For close in obstacles this method may not work due to the longer take-off distance required. For a long runway we can use this method up to the point where our tire limiting speed comes into play.

Before we move into enroute performance we just want to look briefly at the new GRF or Global Reporting Format. This is an ICAO standardisation, based on the FAAs Take-off and Landing Performance Assessment or TALPA, for the reporting of runway conditions. EASA countries have already introduced it on 12th August with the UK following suit on November 4th which is the deadline for introduction by all ICAO countries.

Trained and competent aerodrome personnel will now assess the runway condition using a Runway Condition Assessment Matrix or RCAM from which they will give a Runway Condition Report through a SNOWTAM or ATIS, or even by voice. Either way we get a Runway Condition Code or RWYCC from which we can base our performance calculations for wet or contaminated runways. Your operator will provide you with a copy of the RCAM, most likely in the QRH.

Conditions will be closely monitored, and downgrades or upgrades will be made if reported conditions are no longer accurate. Downgrades can be made at any time, but upgrades may only be made when the initial RCC was 0 or 1 with a maximum upgrade to RCC 3. Flight crews are no longer allowed to upgrade Runway Condition Codes. RWYCC is mainly used to establish landing performance with take-off performance calculations still required to use contaminant type, depth and OATs with some exceptions for solid contaminants. The industry is looking into harmonising this perhaps with the double input of contaminant depth and Runway CC. Please look at your company procedures for proper guidance on how you will be using the performance software to interact with GRF.

OLD changes to LDTA which is Landing distance at Time of Arrival with an extra requirement to establish the lowest acceptable RWYCC for landing performance when the runway is contaminated. Don't forget that associated lower crosswind limits may also exist. There is also a requirement for flight crew to report if braking action encountered is not as reported, both better or worse. Standard phraseology should be used and a crew report of "Less than Poor" will cause a runway closure until the airport operator can improve the condition. Just to define that "less than poor" for you it would be when braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain.

There is a slight change to runway condition definitions. Damp is no longer used, and a new Slippery Wet condition is introduced for EASA countries. Non EASA countries will use Wet with a RWYCC of 3 for this condition. WET is now a runway whose surface is covered by any visible dampness or water up to and including 3mm deep within the area intended for use. We also get a "specially prepared winter runway" condition which is a runway with a dry frozen surface of compacted snow or ice which has been treated with sand or grit or has been mechanically treated to improve runway friction.

Having mentioned a number there I should also point out that the RWYCC ranges from 0-6 with 0 being less than poor where take-off is prohibited and 6 being dry. We'll let you take a look at the rest wherever your company put the RCAM. The RCAM will only cover contaminants with a deterministic performance effect with other conditions addressed by the downgrade/upgrade mechanism coming under the additional assessments, or situational awareness section, of the report. Other things included in this situational awareness section could be reduced runway lengths, chemical treatments on the runway, snowbanks, taxiway and apron conditions and plain language remarks.

A runway is now considered contaminated when any 3rd of the runway is covered with more than 25% contaminant. When giving the Runway condition report each third is assessed and if any number between 10 and 25% of that third is seen to be covered with contaminant the report will say 25% sometimes giving us a margin of safety, not that we'd know it.

Finally, we've got off the ground so let's see what sort of performance we need to consider enroute.

On the ground we input Cost Index in the FMC. This is based on a complicated equation far above my paygrade that figures out the ratio between time related costs of 737 operation and the cost of fuel. Our climb, cruise and descent Econ speeds are based on the CI input with wind input having its effect highlighting the importance of programming those winds into the box. For example, a tailwind will result in lower climb and cruise speeds as well as TOD moving further away from the destination as descent Econ speeds remain constant whatever the wind input.

CI inputs can be between 0 and 500 and you can't use VNAV with entering a figure. 0 will cause the ECON speed to be maximum range where the speed for descent will be close to L/D max. This is the strategy used to conserve fuel where fuel costs are the most limiting factor.

CI 500 however, will ignore fuel costs giving you the minimum flight time with speeds being VMO/MMO.

When on the Cruise page we have the option of LRC. This gives us the speed above Max range cruise that results in a 1% decrease in fuel milage. For this 1% decrease you get a 3-5% higher cruise speed. LRC is not adjusted for wind in the cruise so is only really valid in zero wind conditions. Your company will have procedures on its use but in this day and age of high fuel costs I'm sure the cost index you'll be using would be well below what LRC would give you!

CI has an effect on our optimum altitude. CI 0 through 40 will increase the OPT altitude and numbers above 100 will decrease it. Optimum altitude gives us the minimum trip cost based on the CI unless there are more favourable winds at different levels as Optimum altitude is based on still air and gross weight with temperature having almost no effect. As a ballpark figure, to operate 5000ft below optimum altitude will require tailwinds in excess of 20kts to break even.

As Mark mentioned, optimum altitude is also based around gross weight, so as we burn off fuel our optimum altitude increases. A rough estimation is that for every 3T burned our optimum will increase by 1,000ft. This leads us into the step climb technique where we periodically climb to a higher cruise altitude to keep us within the optimum envelope. In the 737 a 2000ft step climb would be required at about every 2.5 hours, so we don't expect it to happen very often on a typical 737 flight.

A technique often used is to climb above the optimum to begin with to "claim the level" in busy airspace. In doing this care needs to be taken to maintain manoeuvre margin and thrust limits. Cruise thrust limit altitudes will be temperature dependant so just be a little careful if in a warmer than ISA atmosphere or flying toward warmer air where you may erode margins and find yourself unable to maintain cruise speed which will necessitate a decent.

The FMC will not compute an optimum step point it will only compute an ETA and distance based upon gross weight and max altitude constraints so beware of the FMC telling you to climb right up to max altitude. A 4,000ft enroute climb costs us 135-225kg or 3-500lbs of fuel. The penalty is highest when we are at high gross weights and low initial altitudes. This extra burn is offset by fuel savings in the descent and the climb is usually beneficial when recommended by the FMC or flightplan provided wind information is reliable.

Ian just mentioned Max altitudes. We all know our max certified is 41,00ft but we also have manoeuvre margin limited altitude and thrust limited altitude. Manoeuvre margin limited altitude is based on 1.3g although this can be changed by maintenance so check your airline policy. It is not affected by temperature. Thrust limit altitude is the altitude where the 737 has sufficient thrust available to provide a specific minimum rate of climb. This rate is again selectable by maintenance but is defaulted at 300fpm. The Performance Inflight Chapter of the FCOM shows maximum altitude based on 100ft/min rate of climb.

Our FMC max altitude is calculated real-time and is based on gross weight, centre of gravity and ISA deviation.

On leaving our optimum altitude and heading toward destination we can use our Econ descent speed, or we can select a, normally higher, speed. The effect of selecting this higher speed means a steeper gradient, reduced descent segment and therefore less time and fuel for the descent. Sounds great, so why aren't we all doing 350kts down the slope? Well, unfortunately that increased descent gradient means more time in the cruise and its associated fuel with the net effect being an increased fuel consumption, so sorry all back to those Econ/TMA directed speeds we go to keep those bean counters at head office happy and releasing the pay cheque each month.

We wouldn't leave descent performance without a quick recap on the drift down and the techniques we have available. A quick mention of the fact that we have very high TAS at high altitudes and a very powerful rudder moment so we're not talking large rudder inputs for controllability, and you'll find only a small amount of trim may be needed. When we're unable to maintain altitude single engine we will set continuous thrust on the operating engine and then on the FMC cruise page select the ENG OUT prompt and then which engine. We will now be shown target speeds and max altitudes as per current gross weight.

A little tip that we use here is that when you're at top of climb press these prompts to have a look at the current speed and altitude requirements single engine. I then personally set speed in the captains MCP course window and sensible altitude in the FOs course window. This gives me a quick reference which I update periodically. Also take a glance at how close your speed is to current speed giving you an idea of the time you have to react and get continuous set and the descent going should you have to.

Strategies you may use in a drift down include Obstacle clearance where you initiate descent at best engine out speed giving least possible rate of descent, or, fixed speed where descent is initiated at a higher speed and is maintained that way which can be used to meet ETOPS criteria. Something else to think about is if your diversion airfield is close in perhaps you could consider an idle descent and maintain symmetry.

As an idea level off altitude on the 737-800 we fly at max take-off weight would be around FL200. Performance regulations wise in the descent the net flight path must clear all terrain and obstacles by at least 2000ft within 5nm either side of the intended track. Should this not be possible in those areas of extremely high terrain you will have company specific procedures often referred to as escape routes you should be well versed in.

That's the take-off and cruise reviewed so now for a quick look at landing performance before we talk to Thiago and he puts us right on a few things no doubt.

Back to before take-off to start with. We can't actually go anywhere until we know we can land at the other end, both destination and alternate wise. Sensible enough. We can check whether we meet approach or landing climb gradients as well as field length requirements by picking up that trusty approved performance tool and inputting the relevant numbers. Max planned landing weight may be restricted by Max certified weight, the landing field length limited weight, landing or approach climb limited weights or any company specific weights within your company manuals. Not so much of an issue where Mark and I operate in Europe, but PCN may also be another thing to be wary of in other places around the world. Something that Thiago has flagged for his neck of the woods.

The lowest weight from the Performance Dispatch data is our performance dispatch limit. Under EASA rules you can't dispatch beyond this limit weight unless you have special dispatch relief under the exemption rules.

On a dry runway our landing dispatch performance assumes we will land on the most favourable runway no wind, AND, the most likely assigned runway with wind so both distances shall be calculated. Under EASA, if you are unable to comply with the most favourable runway when landing conditions assessed were either wet or dry then you may not dispatch. However, if that condition was a contaminated runway, then you could dispatch if two compliant alternate aerodromes are used. If you can't comply with the "most likely assigned runway" criteria only then dispatch will be allowed if you have one compliant alternate elected.

The calculated landing mass must allow us to do a full stop from 50ft above the threshold at Vref within 60% of the LDA at the ETA. The calculations will be done for destination and any alternate and assume no reverse credit. OPT will take into account aerodrome altitude, 50% headwind/150% tailwind and the runway slope if greater than 2%.

When forecasts indicate the runway may be contaminated, the dispatch check is done on wet or contaminated figures with the most restrictive applying. Environmental factors including Autoland conditions will also have an effect. Landing configuration and any MEL items shall also be accounted for.

Having mentioned those wet and contaminated figures let's have a look a little closer. For wet runways the LDA shall be at least 115% of the dry dispatch requirement again with no reverse credit.

For contaminated runways the LDA will be the greater of that wet figure, or, 115% of the actual calculated contaminated landing distance.

As previously mentioned, approach or landing climb limited weights may be what restricts us so let's just define what these are.

Certification requirements demand that we attain certain gradients which will allow us to safely execute a missed approach or balked landing. For approach climb this is 2.1% and is based on engine inoperative at the missed approach flap setting with the gear up and of the two this is normally the more limiting mass.

Landing climb certification is based on a 3.2% gradient with all engines running allowing for GA thrust 8 seconds after advancing the levers from idle, a landing flap setting and gear down.

These two are certification requirements but on the day, we must also meet the published missed approach gradient. This gradient, unless otherwise stated, is based on 2.5% for PANS-OPS operations. I'm sure most of us have come across the multiple minima based on missed approach gradients. On our routes one such example is the ILS 01 into Dalaman where your DH if able to achieve a 5.0% climb gradient would be 200ft but with the standard 2.5%

gradient it is upped to 840ft. As a very rough approximation for you based on a normal 737-800 approach speed a 5% gradient equates to about 750fpm.

For instrument approaches with a missed approach climb gradient greater than 2.5 %, the operator should verify that the expected landing mass of the aeroplane allows for a missed approach with a climb gradient equal to or greater than the applicable missed approach gradient in the engine inoperative missed approach configuration and at the associated speed. Another reason for the importance of getting that gear up in the GA.

We've complied with all that and now we're airborne. Just to mention first that when we've complied with our contaminated dispatch requirements you may find that due to factoring involved the inflight landing performance becomes more restrictive than the dispatch.

Back to the GRF now and that new Landing Distance at Time of Arrival or LDTA. This is defined as a landing distance that is achievable in normal operations based on landing performance data and associated procedures determined for the prevailing conditions at the time of landing.

For our wet and contaminated performance, we should now base this on the reported RWY CC using the worst of the 3 sections reported. We would normally carry out this calculation as part of our descent preparation but if we have a particularly short flight time, we may wish to do this on the ground before departure.

Something to think about here is that the RCR is based on the physical extent of the runway, or as stated in the Gens "the full length of paved surface between the start of TORA or LDA from one direction to the start of TORA or LDA from the opposite direction, whichever in longer. This means it doesn't consider a displaced threshold. ICAO state "Runway thirds are based on the total runway and not from the threshold or take-off run available (TORA). Therefore, there may be instances where the threshold is not in the first runway third and operators have to take this into account accordingly." That's one you'll have to check into with your operator. We'll include a link on the B737talk.com website to the ICAO webpage covering the GRF implementation, another thing which has been delayed by Covid.

Having calculated our LDTA based on the latest weather we should now figure out the lowest acceptable RWY CC we could accept, when operating into changeable conditions giving us a greater situational awareness. Don't forget about the associated crosswind limits. We can then monitor the weather during the approach and only accept conditions we have justified. Finally, if the braking conditions on that landing roll don't tally with those being reported, both better or worse, you are required to report them using standard phraseology.

Before wrapping up our part with a look at brake cooling, we'll quickly jump back into V speeds with a look at VREF and how we set our command speeds.

VREF is our landing reference speed, based on aircraft weight, at which to cross the threshold in the landing configuration. VREF is used for aircraft categorisation based solely on max landing weight with the 737 being either CAT C or D. We also use VREF for landing performance calculations and as a basis for flap manoeuvring speeds with that familiar VREF

40 + 70 etc. VREF, along with flap manoeuvre speeds give us that 40° or 25 + 15° bank angle manoeuvre capability.

VREF must be at least 1.23VSR in the landing configuration and equal to or greater than VMCL or our minimum control speed in the landing configuration.

If we use the autothrottle for landing, we set our command speed to VREF + 5kts whereas if we disconnect the autothrottle prior to landing we use a wind additive. This wind additive is half the steady headwind component plus the full gust increment with the outcome being a minimum 5kts to a maximum of 15kts or placard speed -5.

During the flare the 5kt and part of the extra steady wind additives are bled off with the gust increment maintained until touchdown.

In the event of a QRH VREF non normal instruction such as set VREF 40 + 40kts this speed now becomes the new VREF and normal wind corrections still apply unless otherwise instructed by the QRH.

And finally, we've landed and come to a successful stop but as with most 737 carriers we are now into thinking about those tight turnarounds. One factor that could affect how quickly we can execute the turn is how hot we've made our brakes. We would of course check the figures using PI section of the QRH in the cruise should we think this will be a factor just to give us an idea on how restrictive the cooling schedule may be.

We enter the tables starting by finding out the reference brake energy per brake using aircraft weight, OAT, pressure altitude and the wind corrected brakes on speed. As an example we'll use a 60T aircraft at 30° with a corrected speed of 140kts at sea level. That gives us 34.5 millions of foot pounds, which in all honesty doesn't mean a lot to me.

Next, we have tables for the adjusted brake energy using no reverse or two engine detent reverse. We'll say we used reverse idle and Autobrake 3. Interpolating, that gives us an adjusted reference of 26.3. Next, we need to move on to the cooling timetables and enter the one which matches the type of brakes we have. As a matter of interest, we'll look at both here. For Steel brakes we would be looking at just about 44mins whereas carbon would be just over 45mins so not a huge difference in that one. Steel brakes will allow for slightly more energy before entering the caution zone.

There are some important notes under these tables including additions to be made for taxi distances as well as advice for what to do if entering that caution, or fuse plug melt zone. When in the caution zone, plugs may melt and take-off should be delayed for an inspection after one hour, not somewhere you want to be if you were planning a 45minute turnaround. If the overheat occurred after take-off it is advised to keep the gear down for at least 7 minutes.

If in the fuse plug melt zone, you should clear the runway immediately and unless required to do so, do not set the parking brake. Something to bear in mind after an RTO, unless of course you are evacuating. Do not approach the gear or attempt to taxi for an hour and you may be required to replace the tire, wheel and brakes. After take-ff it is recommended to leave the gear down for at least 12 minutes.

The brake cooling time starts when we are parked.

As Ian just mentioned the RTO we'll quickly mention it here. We've mentioned the fuse plug melt zone, but what does that mean. Well, each main gear has four thermal fuse plugs made of metal alloy, which will deflate the tire once the temperature limit is exceeded. Depending on the fuse plug type this temperature will be between 177-199°C or 351-390°F. This prevents a potential tire explosion. This is a distinct possibility in the event of a highspeed RTO. You can however, at lower energy levels get a lag between the stop and the fuse plug melting, possibly even in excess of 40mins which could easily catch us out in the taxi after a short turnaround.

Ok, so now Ian and I are handing our work over to the professor of performance for marking in the hope we may scrape a pass.

Mark and I are very happy to announce our first guest on the Talk and a great one to start. Captain Thiago Brenner joins us from Brazil where he has operated the various 737 variants including the max for in excess 8,000hrs over a period of 15 years. Mark wasn't joking when he said Thiago was a professor of performance as he has been teaching the subject to grad students of Aeronautical sciences at a top university in Brazils southern region. Like me Thiago has two young children so knows the rigours of balancing airline life with the family. I'm personally amazed how he also manages to have the time and energy for writing books and teaching too but we're very grateful he has spared some for us and of course even offered this great little giveaway too. We'll get Thiago to set a not too tricky question for your chance to win instead of our normal tech ten this week. Then feel free to contact us through social media or the b737talk.com website over the next couple of weeks with your answer and we'll announce the winner of Thiago's book "Aircraft Performance Weight and balance" then.

So, without further ado, welcome to the Talk Thiago and it's great to have you here. Why don't you start by telling us how you got into flying?

Interview with Thiago Brenner

A big thanks again to Thiago for joining us today, it was a pleasure speaking to him and my brain is still trying to catch up with the performance knowledge level he has! He was kind enough to send us his question for the chance to win the digital copy of his fantastic book "Aircraft Performance Weight and Balance" which Mark and I both have copies of and is available from Amazon or the itunes store if you don't win. We'd highly recommend getting yourself a copy. So here it is "If we use Autobrake 3 on a dry runway would using reverse thrust make a difference to our performance landing distance?". You can answer us on Social media, the linkedin group b737training.org or via the contact us form on the website b737talk.com. Good luck to all who enter and we'll announce the winner on the not quite so long next episode!

That's it for this week's 737Talk and we hope you've enjoyed our first interview and found it useful in dusting off that performance knowledge ready for the line. Any questions on the subject please contact us via the b737talk.com website or our social media @b737talk and we’ll make sure we check our responses with Thiago first! Until next time though fly well and be safe.