What’s happening in the flight deck during a rejected takeoff?

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“The pilot’s quick thinking saved the day.”

A fairly standard newspaper headline when an airliner has rejected its takeoff and come to a rapid halt on the runway. However, calling this “quick thinking” is a real disservice to the thousands of people who, over the history of commercial aviation, have worked to improve safety.

The decision to abort a takeoff is not made in a split-second by the pilot, it’s a binary decision based on science and maths. It’s calculated before the engines are even started and discussed in depth between all the pilots on the flight deck before they enter the runway. If that rare moment does occur, it puts into action hours spent practising in a flight simulator for this exact moment.

(Photo by ADEK BERRY/AFP/Getty Images)

To stop or continue?

No two takeoffs are ever the same. As a result, before each and every departure, pilots carry out a performance calculation to determine what is the most efficient and safe way to get airborne.

De-rated takeoff

Contrary to popular belief, aircraft very rarely use full power during takeoff. Runways at most international airports such as London Heathrow and Los Angeles are nearly 2.5 miles long, which is more than enough for even the heaviest of aircraft to get airborne.

So why increase the strain on the engines when you can utilise the runway length by accelerating more slowly and still getting safely airborne by the end?

Manufacturers design the aircraft and engines to be able to get airborne using as little engine power as possible. This is known as a de-rated takeoff. Not only does save on engine wear, but it also reduces the noise experienced by those who live and work near the airport.

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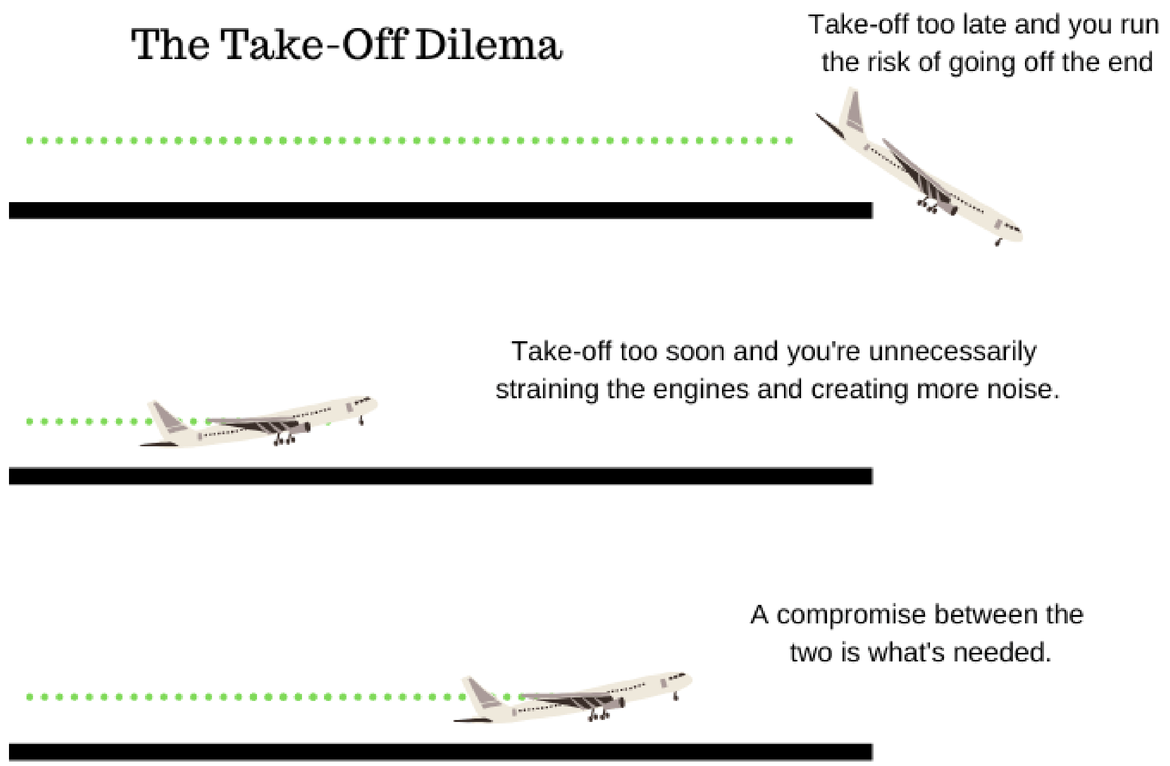


(Image by Charlie Page/The Points Guy)

However, this creates a trade-off. Takeoff too far down the runway and you run the risk of going off the end should something unexpected happen. Takeoff too soon and you're using more engine power than you need to be, increasing engine wear and fuel burn.

A happy medium needs to be found between the two — a takeoff point which optimises engine power whilst leaving enough runway to stop if the need arises.

The critical speed: V1

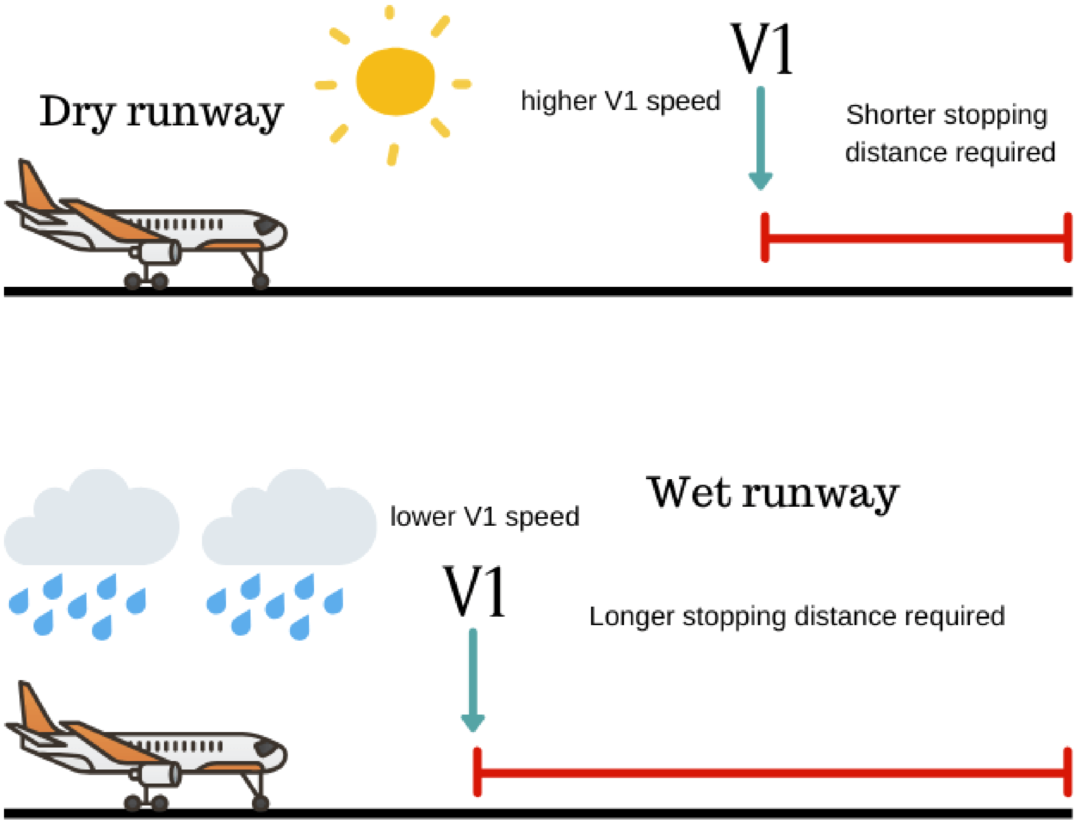
V1 is the speed at which the aircraft can both reject the takeoff, stoping safely on the runway and also at which it can continue to takeoff safely. To put this into more practical terms, the European Aviation Safety Agency (EASA) and the Federal Aviation Administration (FAA) defines V1 as "the maximum speed during takeoff at which the pilot must take the first action to stop the aircraft".

It is often referred to as the "takeoff decision speed" but this isn't totally accurate. The actual decision to reject the takeoff must be made before V1 has been reached. This gives the pilot enough time to react and make the first action to reject the takeoff before the aircraft reaches the V1 speed.

If the decision to stop is made at V1, by the time the first action is taken to stop, the aircraft will be travelling in excess of the V1 speed, putting it at risk of going off the end of the runway. Seeing as some runways finish in the sea or with steep embankments, this is undesirable, to say the least.

The V1 for any departure will depend on a range of variables such as aircraft weight, runway length, air pressure, air temperature and wind speed and direction. It also varies with the runway condition. If a runway is dry, the stopping efficiency is much better than if the runway is wet or slippery. As a result, the V1 will be slower on a wet runway. This means there will be more runway remaining on which to stop when the V1 speed is reached. If a problem occurs after V1, we must continue to get airborne. Even in the event of an engine failure, we can still climb away safely. The performance which we calculate before departure is based on this very event.

Read more: How pilots avoid runway overruns



The effect of a dry vs wet runway on the V1 speed. (Image by Charlie Page/The Points Guy)

How it's done in a 787 Dreamliner

For all flights, the pilot responsible for flying the aircraft is nominated as the pilot flying (PF). This could be either the captain or the first officer. The other pilot is then nominated as the pilot monitoring (PM).

The actions of a rejected takeoff (RTO) are clearly defined for both PF and PM and they start when we are sat on the gate waiting to depart. As part of the cockpit set up, we turn the auto brake selector to RTO which arms the auto brake system.

The automatic system will then command maximum braking pressure if the following three criteria are fulfilled — the aircraft is on the ground, the groundspeed is above 85 knots and both thrust levers have been moved to idle.

Emergency briefing

With all the flight preparation complete and nearing departure time, we will conduct an emergency briefing. Part of this includes not only what we will do in the event of a rejected takeoff, but also how we will do this.

As mentioned above, the decision to reject a takeoff must be made before the V1 speed is reached. To make this decision easier in the heat of the moment, we discuss the events for which we will reject the takeoff during the emergency briefing.

If the decision to reject the takeoff is made, a clear call of "STOP!" will be made.

The total energy that must be dissipated during an RTO is proportional to the square of the aircraft velocity. This means that during the latter stage of the takeoff, for a small speed increase, the total energy increases significantly.

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For this reason, the takeoff is spilt into two-speed regimes. The low-speed regime up to 80 knots and the high-speed regime above 80 knots.

Pilots always conduct an emergency briefing before every departure. (Photo by Christophe Archambault/AFPGetty Images)

Below 80 knots, the captain may reject the takeoff for a number of items. The most serious being a fire or fire warning, an engine failure or a predictive windshear warning. They should also reject the takeoff for an activation of the master caution system, an unusual noise or vibration, a tyre failure, an abnormally slow acceleration, a takeoff configuration warning or if they deem that the aircraft is unable to fly.

Above 80 knots, an RTO becomes more serious due to the increased energy. As a result, the events for which the captain can reject the takeoff are limited to just the most serious – a fire or fire warning, an engine failure, a predictive windshear warning or if the aircraft is unsafe or unable to fly.

In addition, if the first officer is PF, they are authorised to call stop anytime up to V1 for a fire or fire warning, an engine failure, a predictive windshear warning, a significant handling difficulty or a blocked runway.

Initial actions

On the call "STOP!" by either pilot, the first action of the PF is to immediately close the thrust levers.

If the call is due to an engine failure or fire, there may also be a sudden loss of power in one of the engines. With more power being produced on one side than the other, there could be a marked swing of the aircraft towards the failed engine. If this happens, the PF must use their feet to control the rudder and keep the aircraft pointing straight down the runway.

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At the same time as closing the thrust levers, the PF must also press the autothrottle disconnect button located under their thumb.

At low speeds up to 80 knots, the autothrottle tries to ensure that the correct power for takeoff is set. If there is a change to the position of the thrust levers at this stage, the autothrottle assumes this is an error and tries to reset the takeoff power. Not what you want if you're trying to stop the aircraft. Above 80 knots, this feature is no longer active.

By pressing the autothrottle disconnect button, the pilot overrides this system and takes manual control of the thrust. This ensures that when the PF closes the thrust levers, the power stays at idle until commanded otherwise. For the sake of consistency, this is done for RTOs at all speeds.

Autobrake activation

At the same time, the PF must ensure that the RTO autobrake system is operating. During a high-speed RTO, this shouldn't be a problem. However, as the system won't be triggered if the speed is below 85 knots, the PF will have to apply manual braking themselves.

The final part of the immediate actions is to activate the reverse thrust. Normally used on landing, by lifting the two reverse thrust levers in front of the throttles, deflectors doors open in the engines and direct airflow forwards. This helps slow the aircraft and is most effective at high speed.

Keeping an eye on things

Whilst the PF is performing all the actions to bring the aircraft to a safe stop, it is the PM's job to confirm that the PF has completed them all. Once they have checked this, they must verbally confirm that the speedbrake has deployed.

When the PF closes the thrust levers during the takeoff run, the speedbrakes on the wing automatically deploy. These are the large panels on the top of the wing which dump any lift so that the brakes have their maximum effect. If they do no deploy automatically, the PM must manually extend them by pulling the speedbrake lever.

Autothrottle disconnect buttons on the side of the thrust lever and the reverse thrust levers on the right. Speedbrake lever at the back. (Photo by Charlie Page/The Points Guy)

The PM must also check the status of the reverse thrust. In the case of an engine failure or fire, the reverse thrust on that engine may not activate. If this is the case, they must announce this to the PF.

It may have taken you around a minute to read this section but in the flight deck, it only takes around five seconds for the crew to complete these tasks, as seen in the video below.

The braking force experienced during an RTO is nothing like you've ever felt before. Even the most extreme braking you've experienced on a landing is nothing compared to the force of an RTO. In my entire career, I've only ever had two RTOs. On both occasions, I was surprised at just how forceful the stopping action felt.

Read more: How do aircraft brakes work?

Watch Video At: https://youtu.be/8gIwZiEnULQ

Making a turn

As the aircraft slows to around 20 knots, the PF will cancel the autobrake by pressing the brake pedals with their feet. If the RTO was due to an engine problem, before bringing the aircraft to a complete stop, they will consider turning the aircraft slightly on the runway.

Investigations from historical RTOs due to engines fires have shown that wind blowing flames towards the fuselage can create problems in the case of an evacuation. As a result, the PF will endeavour to put the fire downwind of the aircraft.

In practice, this means making a turn towards the fire if there is a headwind on takeoff and turning away from the fire if there was a slight tailwind.

Once the aircraft has been brought to a safe stop, the parking brake is engaged. At this point, if the first officer was PF, the captain will take control of the aircraft and make a PA to the cabin instructing the flight attendants to wait at their doors.

The next things we do is nothing. We pause and we breathe.

Slow. methodical. deliberate.

The next few moments are critical as to how the rest of the event will unfold. We need to ensure that we make decisions based on correct facts and information. Rushing into an action in the heat of the moment could prove disastrous later on.

Together, we will confirm why the stop call was made and whether that factor still exists. What started off as an engine fire may now have been extinguished. Conversely, an engine failure may now have become a fire.

Ultimately, this diagnosis will result in one of two things happening. Either the situation is safe and we can taxi off the runway, or the situation is deteriorating and we deem it best to conduct an emergency evacuation.

This decision-making process can take some time so don't be surprised if you don't hear from us for what may seem an eternity.

Bottom line

A rejected takeoff is an extremely rare event. Most pilots will only experience a couple in their entire career. That said, every six months we practice several RTOs in the simulator to ensure that should it happen for real, we are up to speed with the procedure and actions.

The decision to stop isn't made in the heat of the moment. With careful briefing before departure, pilots know the events which will necessitate an RTO. Should any of those occur during the takeoff run, the decision has already been made.

Once stopped, the real thinking begins. It may take several minutes for you to hear from us in the cabin but don't be alarmed. Our priority is to ensure the aircraft is safe. As soon as we have a plan of action, we will let you know.

Featured photo by Photo by Darren Murph/The Points Guy