How pilots avoid runway overruns

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A few weeks ago, a Pegasus Airlines Boeing 737-800 attempted to land in wet and stormy weather in Istanbul. After touching down, it didn't slow down as planned and ran off the end of the runway where it broke into three pieces.

In the resulting carnage, 180 people were injured and three people were killed.

Whilst the official investigation is still under way, runway overruns, or runway excursions as they are known in the aviation industry, are a well-understood event.

The history of aviation accidents has identified the main causes of a runway excursion and as a result, procedures have been put in place to minimise the chances of them occurring.

Safe stopping plan

As the saying goes, safety doesn't happen by accident. The safe delivery of passengers from gate to gate starts right at the top of an airline with the culture a CEO promotes to their staff. This mindset will filter all the way down the company, directly to the front line where the pilots are the final arbitrators of safety.

Within the industry, this is known as the "Swiss cheese" model. An accident never happens for one single reason. It's only when all the holes of a Swiss cheese line up that the errors in the system will result in an accident. Even with 99% of the holes lining up, there's one last chance to stop an accident from happening and this lies with the pilots.

Safety doesn't happen by accident. (Photo courtesy of Air Tahiti Nui)

Most airlines worth their salt will have a set of rules which minimise the chances of a runway excursion.

By having these rules in place and by ensuring that pilots are well trained in their application, the risk of a runway excursion can be greatly reduced.

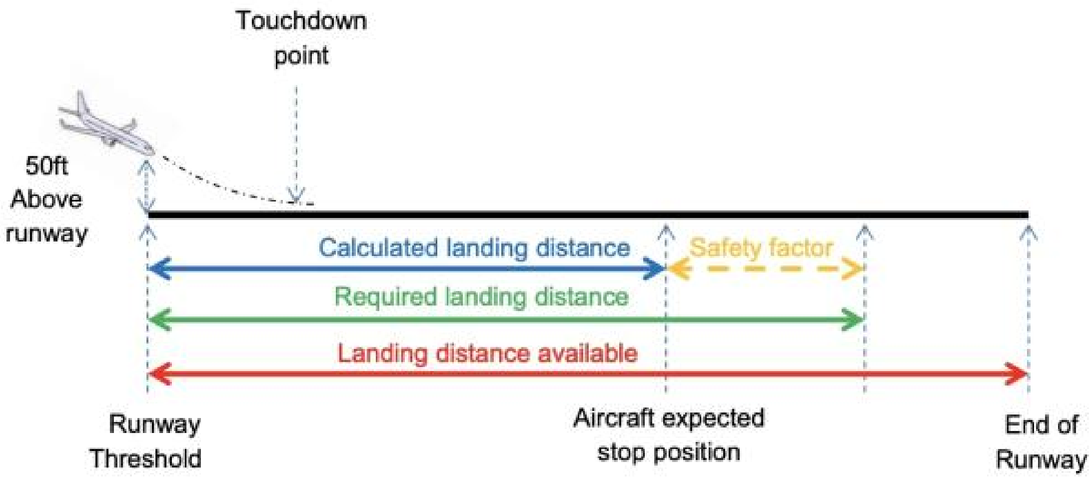
Landing distance calculation

The process of stopping safely on the runway begins hours earlier in the calm of the cruise. Here, the first step is to decide if the runway we plan to land on is long enough for the aircraft weight and the given weather conditions.

Landing distance required

Landing distance is defined as the horizontal distance traversed by the aeroplane from a point on the approach path at a selected height above the landing surface to the point on the landing surface at which the aeroplane comes to a complete stop.

In plain English, this means the distance required from passing over the start of the runway at 50 feet to becoming stationary. This is also known as the calculated landing distance. However, as this is the minimum distance calculated for a textbook landing, most airlines use a safety factor of 5% to 15% on top of this.



(Image by Charlie Page/The Points Guy)

This ensures that should the landing not be perfect — for example, if the aircraft touches down a little deeper than planned, there is still sufficient runway remaining. This is known as the required landing distance.

Therefore, in all cases, the landing distance available must be greater than the required landing distance.

Wind

For the same airspeed on touchdown, the speed over the ground will vary with the wind. Say the aircraft is flying at 100 knots — this is the speed of air over the wings in order to generate lift. If there is a 20-knot headwind, the speed of the aircraft over the ground is just 80 knots — the ideal situation as it results in a shorter required landing distance. This is why pilots prefer to land their aircraft into the wind. However, the reverse is therefore the case with a tailwind.

For an aircraft approaching at 100 knots with a 20-knot tailwind, the ground speed is 120 knots. This will massively increase the required landing distance, much more than you'd think. As a result, pilots are acutely aware of the wind shifting during their approach.

Runway condition

Once the wheels are on the ground, it's time for the wheel brakes to start to slow the aircraft. However, like in your car, the condition of the runway surface can have a huge effect on the effectiveness of the brakes.

If the airfield weather states that it is raining, or it may rain during the time of landing, pilots will treat the runway as wet and calculate the performance accordingly. Rain is fairly common, so a wet runway is nothing abnormal. However, what happens when the rainfall is so heavy that the runway becomes slippery? In order to work out how effective the braking will be, we use the table below.

Read more: 8 of the most challenging airport approaches for pilots

Assessment Criteria		Control/Braking Assessment Criteria	
Runway Condition Description	RwyCC	Deceleration or Directional Control Observation	Pilot Reported Braking Action
• Dry	6	---	---
• Frost • Wet (Includes damp and 1/8 inch depth or less of water) ***1/8 inch (3mm) depth or less of:*** • Slush • Dry Snow • Wet Snow	5	Braking deceleration is normal for the wheel braking effort applied AND directional control is normal.	Good
-15°C and Colder outside air temperature: • Compacted Snow	4	Braking deceleration OR directional control is between Good and Medium.	Good to Medium
• Slippery When Wet (wet runway) • Dry Snow or Wet Snow (any depth) over Compacted Snow ***Greater than 1/8 inch (3 mm) depth of:*** • Dry Snow • Wet Snow ***Warmer than -15°C outside air temperature:*** • Compacted Snow	3	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced.	Medium
Greater than 1/8 inch(3 mm) depth of: • Water • Slush	2	Braking deceleration OR directional control is between Medium and Poor.	Medium to Poor
• Ice	1	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced.	Poor
• Wet Ice • Slush over Ice • Water over Compacted Snow • Dry Snow or Wet Snow over Ice	0	Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain.	Nil

(Image courtesy of Charlie Page/The points Guy)

Calculating the distance

Many older aircraft require the pilots to use complicated tables with multiple rows and columns to collate all the above factors and work out the required landing distance. At times of high workload and reduced personal performance from tiredness, just the smallest mistake can result in an erroneous calculation. To help combat this threat, the 787 Dreamliner has the Onboard Performance Tool.

Using this computer, pilots enter all the relevant information as seen in the image below. The OPT then calculates the distance required. Not only does it reduce potential errors but it also allows pilots to quickly carry out a new calculation if the reported wind or runway in use changes. With some very short runways around the world, a shift in the wind could make all the difference between landing safely and going off the end of the runway.

Stable approach

Once we know that we have enough runway to stop, we can start the approach. That said, the required landing distance is based on the aircraft touching down in the correct place on the runway at the correct speed and correct configuration. If we do not meet these parameters, the calculated required distance is meaningless.

The aim of an approach is to fly the aircraft to a point above the runway from where a safe landing can be made. If this has not been achieved, a go-around **must** be flown.

In the history of aviation, a major contributing factor to runway excursions is when the pilots have arrived at this point above the runway too fast and too high. The chances of recovering the situation are close to zero. However, as the pilots are likely so overloaded, their capacity to call for a go-around at this moment is greatly reduced.

To prevent pilots getting into this position, most airlines have a stable approach rule.

Read more: What are the strange noises and sensations you experience on a flight?

A stable approach rule reduces the risk of a runway excursion. (Photo by Nicolas Economou/NurPhoto/Getty Images)

At 1,000 feet above the ground, all the pilots in the flight deck must confirm that the aircraft has met certain parameters for landing. The aircraft must be at or close to its final approach speed, on the correct vertical profile and in the landing configuration.

If these criteria have been satisfied, the aircraft is declared as “stable”.

If any of these have not been met, the aircraft is “unstable”’ and a go-around **must** be flown.

Not only must these parameters be met at the 1,000 feet point, they must also be maintained all the way to touch down. If not, a go-around **must** be flown.

Correct speed

The speed of the aircraft is directly linked to its energy. Too much energy could result in a runway excursion. If the speed is too great at the 1,000 feet point, there is a good chance that it won’t be back at the approach speed as the aircraft crosses the runway threshold.

That said, ATC quite often require pilots to fly a certain speed, normally until around four to five miles from touch down. This is to ensure the separation between aircraft is maintained. However, four to five miles normally equates to around 1,400 to 1,700 feet above the ground. This still gives us plenty of time to slow the aircraft to the final approach speed.

If the aircraft is not close to the correct speed at the 1,000 feet point, a go-around **must** be flown.

Correct vertical profile

Most approaches to international airports are flown using some kind of signal to guide pilots to the runway. This can either be sent up from the ground such as an ILS (Instrument Landing System) or using the GPS position of the aircraft to fly a guided approach to the ground.

Whichever type of approach is used, it will normally have some kind of vertical guidance element to indicate our height relative to the horizontal distance to go. For most approaches, this is based on a 3-degree path called the glideslope or glidepath.

Pilots must maintain the correct vertical profile all the way to touchdown. (Photo by Raj k Raj/Hindustan Times/Getty Images)

When the aircraft reaches 1,000 feet, the aircraft must be in the correct position vertically, based on the guidance available to us. Too low and there's a chance that we could end up hitting the ground short of the runway. Too high and there's a chance that we will touch down too far along the runway.

If the aircraft is not on the correct vertical profile at the 1,000 feet point, a go-around **must** be flown.

Landing configuration

In order to land safely, we must make a number of configuration changes to the aircraft. The most obvious one is that the landing gear must be down. This may sound obvious but depending on the aircraft type, it can take several seconds from moving the landing gear lever to the gear actually being down and locked in position. The gear in transit is not acceptable. It must be down and locked.

Secondly is the flap position. The flaps are used to increased the surface area of the wing, thus creating more lift when flying at slower speeds. The greater the flap setting, the slower the aircraft can fly.

The calculated landing distance required will be based on a certain approach speed and thus a certain flap setting. On the 787 Dreamliner this is normally either Flap 25 or Flap 30.

When reaching the 1,000 feet point, the flap setting chosen for landing must be in position. It can take a few seconds for the flaps to change position, especially from the F20 to the F30 position. Like with the gear, the flaps in transit is not acceptable. They must be locked in the desired setting.

If the aircraft is not in the correct configuration at the 1,000 feet point, a go-around **must** be flown.

Safe touchdown

With the aircraft stable at 1,000 feet, our workload in the last few minutes of the approach should be relatively low. This gives us the capacity to focus on the next stage of flight, the landing.

Crossing the runway threshold at 50 feet and at the final approach speed, the Pilot Flying (PF) will be looking towards the end of the runway. At this stage of flight their mind is working in overdrive. Visually judging the rate of descent whilst simultaneously monitoring the airspeed, digital rate of descent and aircraft trajectory. The Head Up Display (HUD) in the Dreamliner is a great help in these tasks.

The PF is looking to ease the control column back at around 30 feet, raising the nose and slowing the rate of descent. This should result in the aircraft's wheels meeting the runway within the prescribed touchdown zone — part of the requirements to satisfy the calculated landing distance required.

The touchdown zone is indicated by the six sets of white dashes on the runway. (Image courtesy of go Google)

However, this doesn't always happen and we must be prepared to take action if not.

On breezy days, gusts of wind can often change the trajectory of the aircraft. A sudden increase to the headwind can lift the aircraft, potentially resulting in it landing beyond the touchdown zone.

In the most dangerous case, an increased tailwind has two negative effects on an aircraft. Not only does the wind push the aircraft further down the runway before touchdown, it also increases the ground speed. Now, the aircraft is landing further down the runway at a much higher speed than planned.

In all these cases, if we are not satisfied that the aircraft will touch down in the correct position at the correct speed, a go-around must be flown. If the aircraft has started the flare or has even touched down, it is not too late to change the plan. In this situation, a rejected landing is flown.

Landing run

Once the main wheels have touched down on the runway in the correct position and at the correct speed, we must then bring the aircraft to a safe stop.

As the weight of the aircraft settles on the wheels, the speedbrake automatically deploys. This raises the large panels on top of the wing, dumping any residual lift and allowing the brakes to have maximum effect.

When the PF is satisfied that they will be able to stop safely on the runway, they remove their hand from the thrust levers and engage the reverse thrust. This deploys deflector panels in the engines, directing the engine power forwards, helping to slow the aircraft. Once the reverse thrust has been activated, we have committed to stopping and can no longer reject the landing.

As the aircraft slows to a taxi speed, at around 30 knots the PF cancels the reverse thrust and gently steers the aircraft off the runway.

Bottom line

Aviation has a good record of learning from previous mistakes and accidents. As a result, the conditions leading to a runway excursion are well understood. Being stable at the 1,000 feet point is key to a safe landing. If at any point the aircraft becomes unstable, it is far safer to go-around and try again than to continue to try and land.

Featured photo by Fabrizio Gandolfo/SOPA Images/LightRocket/Getty Images