Brace for impact! How the landing gear on the 787 Dreamliner works

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News

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“I didn’t even realise we’d landed!” Of all the comments pilots like to receive from passengers, this has to be right up there. Everyone loves a smooth landing, it makes us pilots feel proud and passengers feel safe.

However, no matter how smoothly we fly, bringing a 190-ton aircraft down onto the runway at 170 mph requires some serious technology to keep all those onboard safe.

The landing gear of a modern airliner is not only built to absorb the forces of a gentle touch down, but it is also designed to take some serious punishment in the most extreme conditions.

Built for a pounding

The landing gear on a commercial airliner is built to take a beating. The forces put through the assembly, particularly in windy conditions, can often be extreme. As a result, manufacturers need to know that the gear is up to the challenge.

In order to do this, before an aircraft is certified for flight, the gear must undergo a test known as the drop test. Here, manufacturers drop the gear to simulate forces experienced in not only normal and testing conditions, but also those well beyond what the aircraft might ever expect to encounter.

To absorb the shock of the landing impact, the landing gear has an oleo strut, which acts as a type of suspension. This uses a mix of compressed air and hydraulic fluid to dissipate the forces experienced on landing across the airframe and also to dampen any recoil to reduce the chances of the aircraft bouncing back up into the air.

In the video below (starting at 1:29) you can see how the aircraft “sits down” onto the oleos as it settles onto the runway.

Wheels and doors

The landing gear system on the 787 Dreamliner consists of two main landing gear assemblies and one nose gear assembly. Each main gear set up has four wheels, each of which has an electronic brake. The nose gear has two wheels, neither of which have a brake.

Even though the aircraft has a maximum landing weight (201.8 tons for the 787-10), the landing gear is strong enough to absorb the impact of a landing up to the 250.8-ton maximum takeoff weight.

When airborne, to reduce drag, the gear is retracted and folded away into the belly of the aircraft, waiting to be used for landing. However, leaving the retracted gear exposed to the elements would still create a large amount of drag, drastically increasing both fuel usage and noise. To stop this from happening, the gear bays have doors.

With the aircraft on the ground, or in fact in the air, it's difficult to notice the gear doors. It's only when the pilots move the gear lever in the flight deck that it's possible to see them in action.

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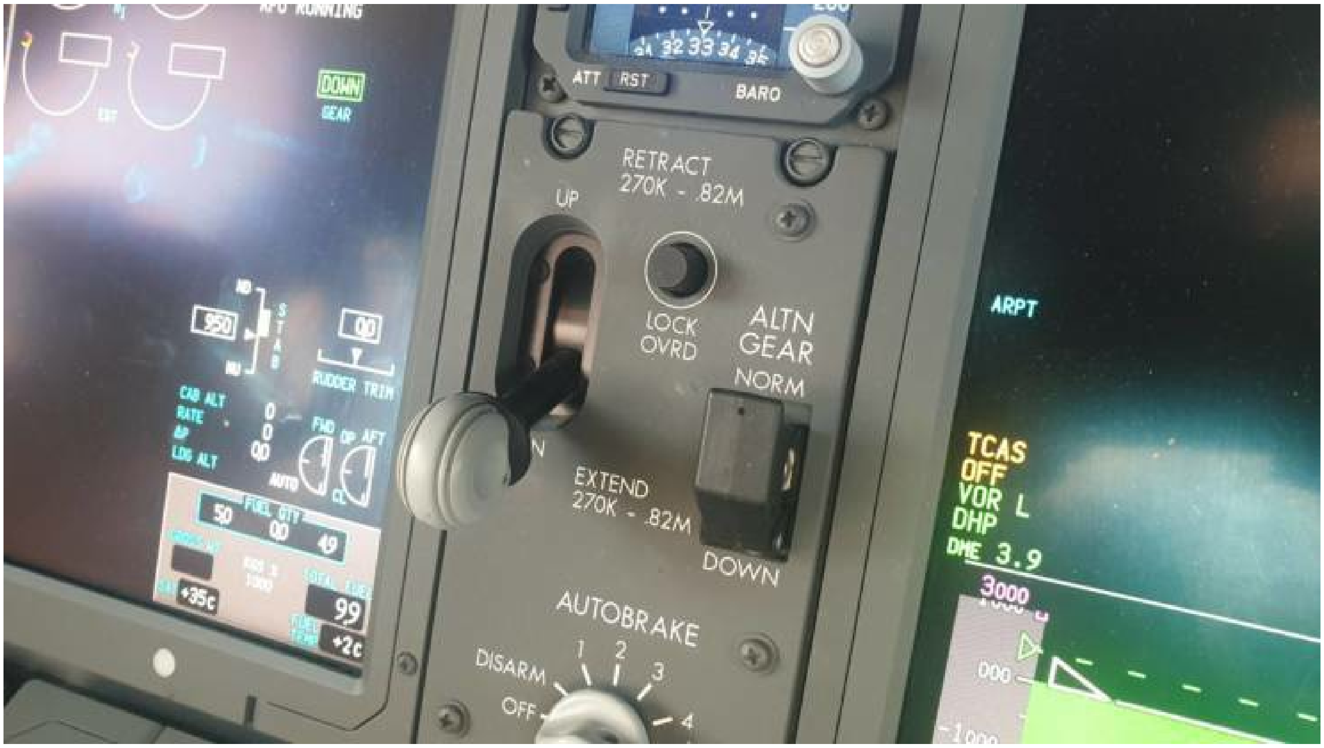
Operating the landing gear

The landing gear lever in the flight deck is situated on the centre panel within easy reach of both pilots. If you look closely, you'll notice that it's actually in the shape of a wheel. This is not by accident.

During WW2, hundreds of accidents were attributed to pilots inexplicably raising the landing gear just before landing. On closer study, it was found that instead of lowering the flaps for landing, pilots were instead raising the landing gear. Why?

It was found that, combined with severe fatigue, the identically shaped levers for the landing gear and flaps were being confused and the wrong ones being used.

Aircraft designers decided to change the shape of the levers so the landing gear lever felt like a wheel and the flap lever felt like a flap. As soon as these changes were made, these kinds of accidents stopped virtually overnight.



The gear lever is shaped like a wheel. (Photo by Charlie Page/The Points Guy)

To raise the gear, we simply move the gear lever to the up position and this starts the gear retraction sequence. Firstly, the gear bay doors start to open, creating space for the wheels to be retracted into the belly and nose of the aircraft. However, before this occurs, one other important thing must happen first.

On liftoff, the tyres will be spinning at around 180 mph. Bringing them up inside the aircraft at this speed could cause some serious vibration to be felt in the passenger cabin. As a result, before the wheels are folded away, the brakes on the main wheels are applied to stop them from spinning.

To lower the gear, pilots simply do the opposite. When the gear lever is moved to the down position, the gear bay doors open and the wheels free-fall out of their stowage without the use of the hydraulics system. When in the down position, it locks into position to stop them from folding on touchdown.

When all the gear is down and locked, the gear position indicator in the flight deck shows “down” in green, as seen in the photo above.

Early gear door opening

To improve aircraft performance on the 787-9 and 787-10, one second after the aircraft detects that it is airborne, the main landing gear doors automatically open. This happens even before the pilots select the landing gear lever to the up position. This action may seem random but it is done quite deliberately.

All takeoff performance is done presuming that an engine will fail at the critical moment of takeoff. If this happens, how the pilots rotate the nose into the air is absolutely crucial. Rotate too slowly and the aircraft may not get airborne before the end of the runway. Rotate too quickly and the aircraft may be flying too slowly to climb safely away from the ground.

To hit the sweet spot in between these two extremes, pilots must rotate the nose up to a line projected in the head-up display called the "TOGA reference line". Once there, and the aircraft is stable, we can then transfer back to normal guidance.

On the 787-8, at the moment, we've just found the right nose-up angle, it's time to bring the gear up. As the gear doors open, the change in aerodynamics causes the TOGA reference line to dip, requiring us to lower the nose slightly. With this adjustment made and the landing gear retracting, we then have to raise the nose again.

If not done carefully, it can result in the aircraft "porpoising" as we attempt to fly the ideal flight path.

On the -9 and -10, the early gear door opening eradicates this problem as the initial pitch angle we must fly does not change. This makes for a much more straightforward and easier manoeuvre to fly.

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Air-ground sensing system

Certain systems only work on the ground, and others in the air. As you'd hope, the landing gear lever will not allow the gear to move to the up position when the aircraft is on the ground. So how does the aircraft know where it is?

On each of the main landing gear beams, there are micro-switch sensors. When there is "weight on wheels", these switches are compressed telling the aircraft that the aircraft is on the ground.

When the aircraft gets airborne, there is no longer weight on the wheels. This results in pressure coming off the switches, letting the aircraft systems know that the aircraft is now in the air.

Preventing tail strikes

Longer aircraft are great. Manufacturers can stretch an original aircraft design and create a load more space for passengers and cargo and this can often be done without a complete redesign. A great example of this is when Boeing took the original 787-8 and stretched it by 20 feet to create the 787-9.

However, there is only so much stretching you can do without needing to completely redesign the aircraft. You only need to look at the problems Boeing have had with the 737 models to realise this.

So, when Boeing created the even longer 787-10, (40 feet longer than the 787-8), it ran into a problem. When pilots reach a certain speed during the takeoff run, we gently pull back on the control column. This causes the tail of the aircraft to sink lower, using the landing gear as a pivot to raise the nose into the air.

The reason for this manoeuvre is to increase the angle which the oncoming airflow hits the wings, known as the angle of attack. In those few seconds, the speed of the air over the wings, combined with the change of angle of attack, enables the aircraft to lift off the runway.

However, there comes a critical moment before lift-off where the tail of the aircraft comes into fairly close proximity to the runway. The longer the fuselage, the greater the risk of it striking the ground.

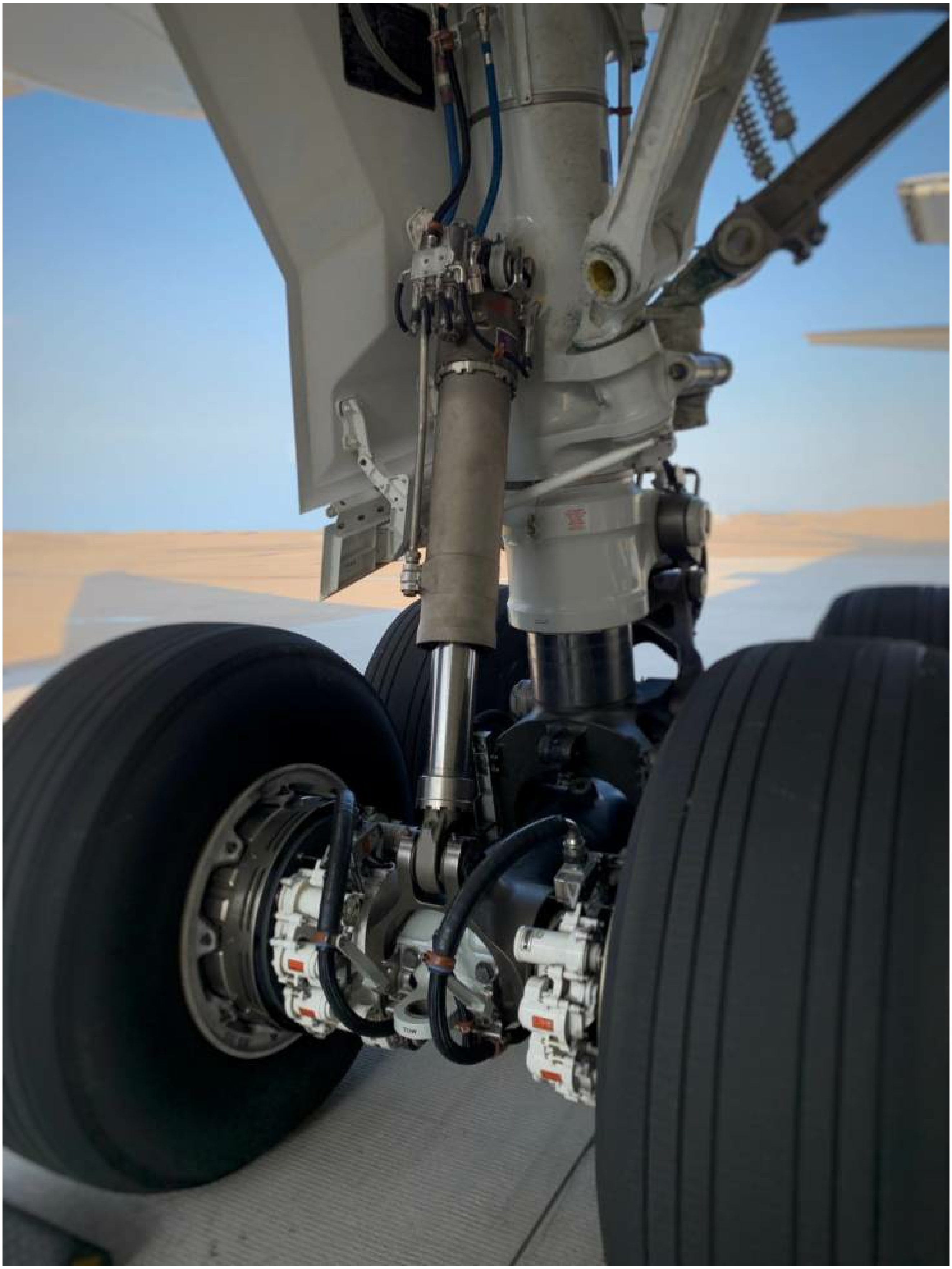
The original landing gear design was fine for the 787-8 and 787-9, however, the increased length of the 787-10 meant that a tailstrike on takeoff was more likely.

To reduce the threat of this happening, designers took an idea used on the 777-300ER and transferred it onto the 787-10. It's known as semi-levered gear.

Semi-levered landing gear

On the 787-8 and -9, at the moment of liftoff, all four main wheels on each gear assembly are in contact with the runway. This limits the nose-up angle to 8.1 degrees before the tail hits the runway. To enable a greater nose-up angle, a hydraulic strut was added to the front of the gear on the -10.

This strut improves takeoff performance by limiting the tilting movement of the main gear truck. This causes the front two wheels to leave the runway first as the rotation occurs over the rear wheel axel, in effect “tip-toeing” the main gear off the ground.



The hydraulic strut on the semi-levered gear of the 787-10. (Photo courtesy of 787 Guide)

This increases the tail clearance and allows a higher nose-up angle (9 degrees) for the same takeoff speed. Not only does this increased tail clearance reduce the risk of a tail strike, the higher nose angle means that the aircraft doesn't have to accelerate to a faster speed in order to takeoff.

If this were to happen, the aircraft would either require a longer runway or have to offload passengers or cargo — something airlines would be reluctant to do.

What if the wheels don't come down?

One of the worst fears some passengers have is the landing gear not coming down for landing. Whilst problematic, like all systems onboard the aircraft, there is a back up to the main system should it not work properly.

As the gear uses gravity to deploy in normal operation, the only thing hindering them is the gear doors, which are powered hydraulically. Should there be a problem with the normal system, we can use the alternate extension system.

Read more: Perfect landing: How pilots avoid colliding with the ground in tricky situations

This consists of a dedicated DC-powered electric pump and fluid from the centre hydraulic system to extend the gear. Selecting the alternate gear switch to the down position releases the gear doors and locks which lock the gear in the up position.

This enables the gear to fall out of the gear bay naturally and lock into the down position.

The moment of impact

We all love a "greaser" — a landing where you can barely feel the touchdown, but sometimes planting the wheels firmly on the runway is the safer option.

As the wheels meet the runway, they spin up to around 160 mph in an instant, hence the smoke which is often seen on touchdown. However, the whole point of landing is to bring the aircraft to a safe stop and this can't be done until all the weight of the aircraft is firmly on the wheels.

When the aircraft detects that it is on the ground, the spoilers will deploy. These large surfaces on the top of the wing dump any remaining lift, dropping the weight of the aircraft onto the wheels.

At this point the brakes can begin to take effect, slowing the aircraft to a safe stop. When the runway is wet or slippery, pilots will try to make a firm touch down to get the brakes working as soon as possible.

Bottom line

Aircraft can experience severe loads on touchdown so they need landing gear strong enough to take this impact. Through rigorous design and testing, the gear on commercial aircraft can take far more force than any pilot could ever inflict on them during a normal landing.

Even if the gear fails to deploy properly, backup systems are in place to ensure that they can be lowered for a safe landing.

Featured photo by Marek Madl/Getty Images

Charlie Page Charlie Page is an airline pilot flying the Boeing 787 Dreamliner. Each Saturday he gives you a 'behind the cockpit door' insight to life in the flight deck.

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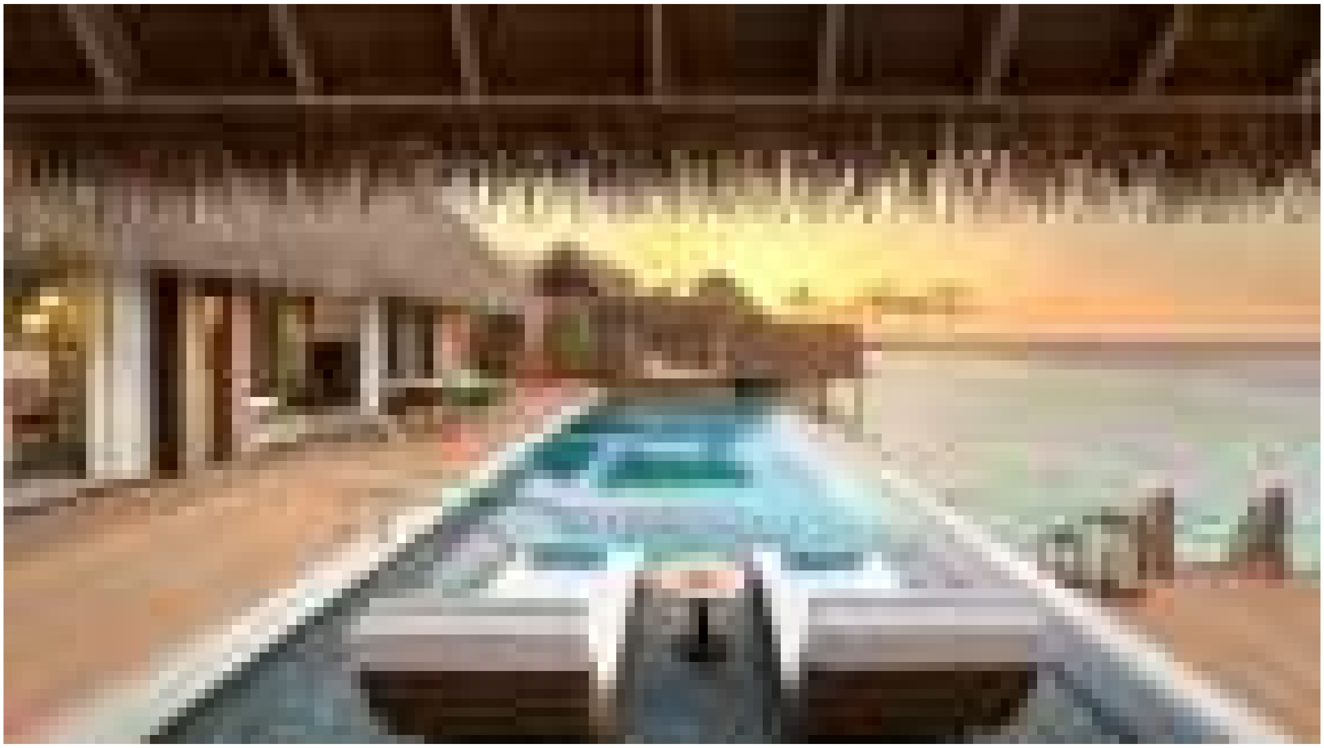

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