How pilots keep you safe while flying through strong winds

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We know summer is officially over when the leaves start to change colour, Starbucks start selling Pumpkin Spice Lattes and strong winds batter the country.

Autumn brings not only some of the most challenging conditions for pilots, but also some of the most satisfying. It's the time when our flying skills really come to the fore, each take off and landing needing our utmost focus and skill.

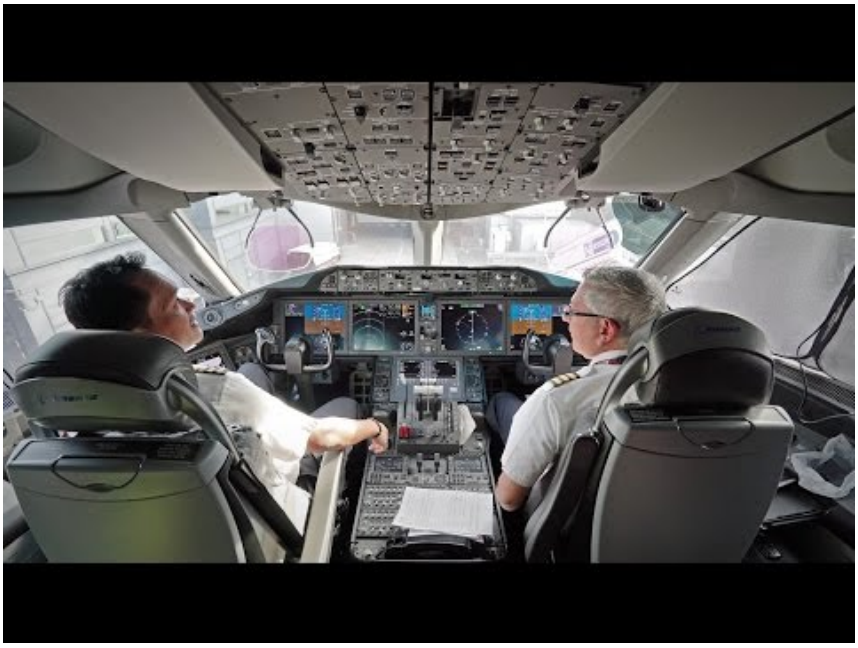
So why do strong winds cause turbulence? What are crosswinds and what problem do they pose for pilots? Also, should you be worried if your aircraft performs a 'go-around'? For all the answers, read on.

Turbulence

When you think of windy flying conditions, I'm sure you think of turbulence. Whilst this is not always the case, flights do tend to be more bumpy when it's windy. To explain this, we need to go back to flying basics and look at how aircraft create the lift needed to fly.

Contrary to popular belief, lift is not generated by the engines. It's created by air flow over the wings. The engines merely provide the forward thrust to get the air flowing over the wings. In order to maximise this, we prefer to take off and land into wind. The more airflow generated by the wind means that we don't have to be going as fast over the ground.

As the airflow increases, the lift increases. A great example of this is in the video below during the take-off run. As the aircraft accelerates down the runway, the airflow over the wings increases and you can see the tip of the wing start to lift. When enough lift is created, the aircraft rotates into the sky. (Start at the 4:00 mark.)



Watch Video At: https://youtu.be/qAmCpIBGd1w

However, once up in the air, the airflow over the wing isn't always constant. Variations in the wind speed and direction mean that at one moment there is more lift, the next moment there is less lift. Multiply this hundreds of times per second and this is what gives you turbulence. The greater the difference in the variations of lift, the great the bumps experienced.

To help smooth this out, the wings act very much like the suspension on your car. When driving down a country road, the suspension rises and falls to dampen the effects each bump has on the passengers. On an aircraft, the wings are designed to flex and bend to have the same dampening effect, as can be seen in the video below. Whist it may look alarming to see the wings flexing like this, they are not only doing what they are meant to do, but they are even designed to bend far more than any turbulence could make them.

Watch Video At: https://youtu.be/B53w5Recxqo

From the pilots perspective, turbulence like this is merely an inconvenience. We know that the aircraft is designed to endure forces far greater than any weather system we can expect to encounter. The biggest threat comes from loose items, or people, inside the aircraft. In the cruise, it's a matter of switching the

seatbelt signs on and making sure that all passengers are safely secured in their seats.

We'll normally slow down a little to enable the aircraft to ride the bumps a bit better and keep a close eye on the airspeed. Sometimes we are able to change our cruising altitude where ATC have had reports that it is smoother. However, quite often, if it's bumpy at one altitude, it will be bumpy at all altitudes. In these situations, it's just a case of riding it out until the conditions start to smooth.

Crosswinds

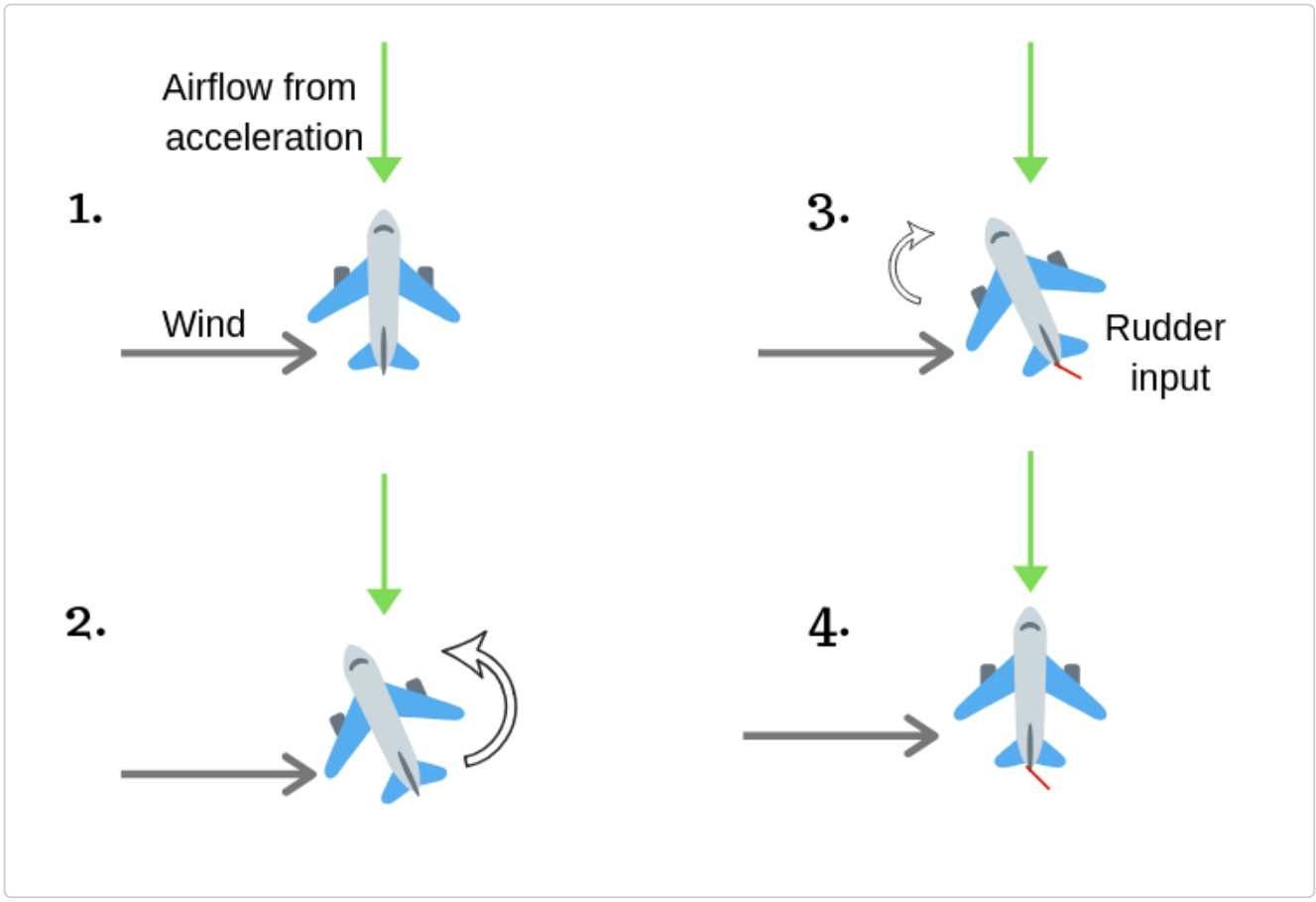
Take Off

As we discussed above, aircraft like to take off and land into the wind. However, what happens when the wind is from neither direction the runway is facing but is instead mostly across it? This is what we call a crosswind and it takes different techniques both when taking off and landing.

During a cross-wind take off, as the speed down the runway increases, a couple of effects are felt by the aircraft. Firstly, the weathercocking effect.

Have you seen a weathercock on top of a building which shows which direction the wind is coming from? The tail on the aircraft has a similar effect. As the aircraft accelerates down the runway, the wind pushes against the tail, (1. in the image below). This force, in turn, turns the aircraft nose into the wind (2).

In order to counteract this, we use the pedals under our feet to operate the rudder on the tail. Working very much like a rudder on a boat, this forces the airflow to push the tail back in the direction of the wind (3). By modulating the amount of rudder input, we keep the aircraft tracking straight down the runway (4).

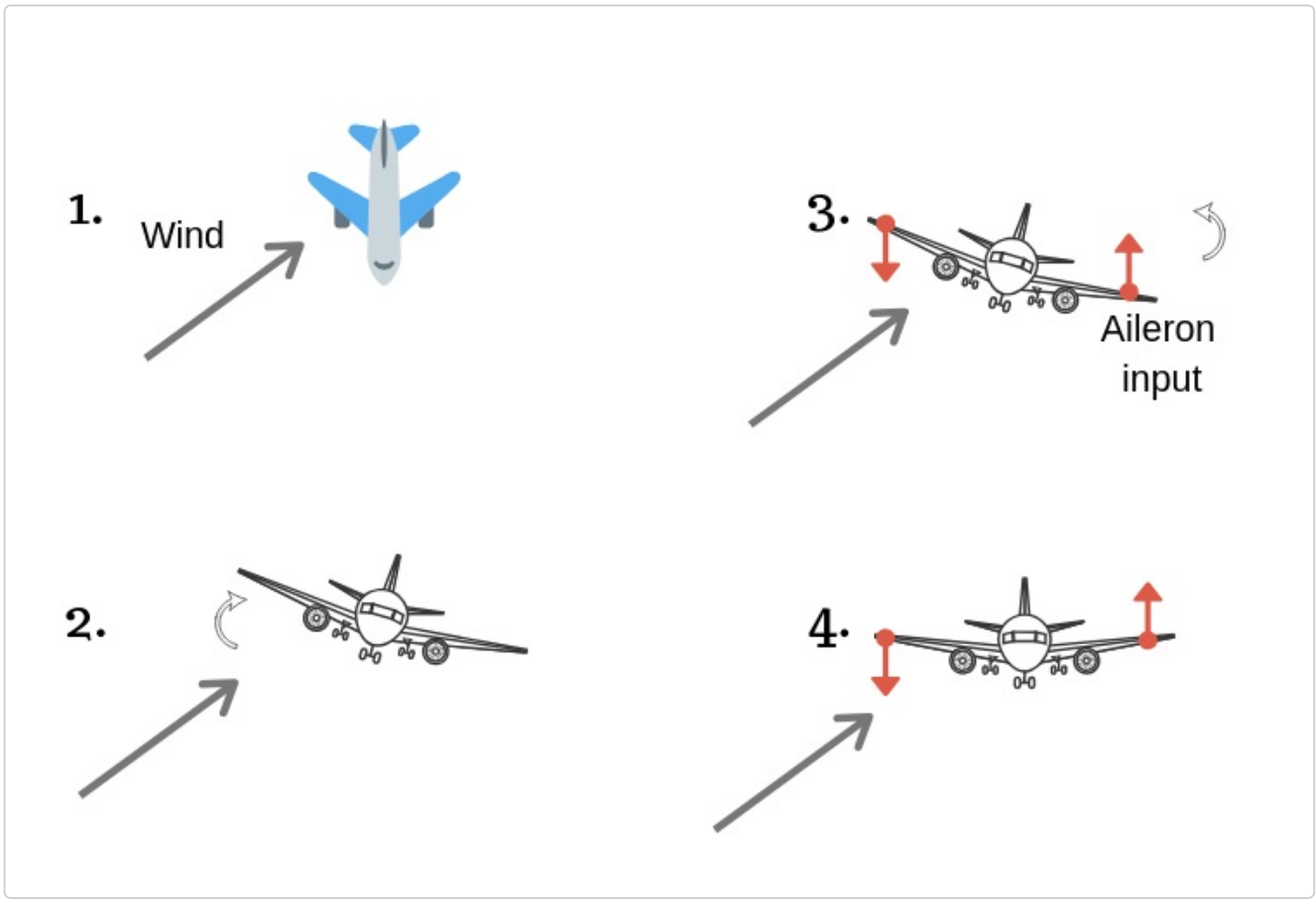


The effects of crosswinds during take off (image by author)

Whilst this technique is great for keeping the nose pointing straight, it doesn't negate the other force acting on the aircraft.

In crosswind conditions, air is passing over the upwind wing quicker than it is over the downwind wing (1. in the image below). As we saw above, it's this airflow which gives the wing lift. More lift from one wing than the other will cause one wing to raise higher than the other (2).

To counter this, we turn the control column to activate the ailerons on the wings which keep the upwind wing from raising too quickly (3). By keeping the control wheel into wind during the take-off run, we ensure that the wings remain level throughout the take-off run.



The effects of crosswinds on take-off (image by author)

By combining these two techniques at the same time, pilots are able to keep the aircraft tracking straight down the runway with the wings level. As the aircraft rotates away from the runway and up into the air, the pressure on the rudder is gently relaxed and the aircraft is allowed to weathercock into the wind.

Landing

If take off sounded like fun, landing is where the workload really goes up. In essence, as the same forces apply to the aircraft, the same techniques are used, just in reverse.

If you've ever seen an aircraft coming into land in a crosswind, you'll have noticed that it doesn't point at the runway, it's angled off to one side. This is called 'crabbing'. In order to keep the aircraft flying in a straight track over the ground, pilots deliberately angle the nose into the wind.

This is fine when in the air, but what happens when the aircraft touches down? Depending on the aircraft, there can be a few options when it comes to the landing. The approved techniques are detailed in the aircraft training manual written by the manufacturer.

On the 787 (and 777), the most commonly used technique is know as the 'de-crab during flare'. The objective of this technique is to keep the wings level throughout the approach whilst maintaining a crab into the wind. As the aircraft approaches the runway, the pilot flares (pulls back on the stick) as normal. This raises the nose and reduces the rate of descent. Just before the main wheels touch down, the pilot squeezes in some rudder to straighten the nose and align it with the runway centreline.

If this sounds complicated enough, remember back to our second force in the take-off case: the uneven lift. As the nose straightens, the upwind wing travels through the air faster than the other wing, creating more lift. To counter this, the pilot must also apply some into-wind aileron by turning the control wheel.

This means that the pilot is simultaneously pulling back on the control stick, turning it into the wind and squeezing the rudder pedals with their feet – all whilst travelling at 160mph. Multitasking at its finest. The video below shows two 777s demonstrating this technique perfectly. (Start at the 9:50 mark.)

Watch Video At: https://youtu.be/j7_oA1Ooe98

Windshear

When the wind gets really strong, windshear becomes a factor. Windshear is defined as sudden change of wind velocity and/or direction. Now, this may sound the same as what was discussed in the turbulence section and you'd be right to think so. However, windshear is commonly referred to in the stages of flight close to the ground.

We already know that lift is generated by airflow passing over the wings. If that airflow changes rapidly, the lift can suddenly increase, or worse, decrease. If this happens close to the ground, the results can be somewhat undesirable.

So what do we pilots do in windshear conditions? We divide our thought process into three stages: Avoidance, Precautions and Recovery.

Avoidance

Firstly, our theoretical knowledge of weather systems will alert us to the potential of windshear

conditions from the moment we study the weather in the briefing room. Thunderstorms, frontal systems, jet streams and mountain waves all have the potential to create windshear.

If windshear conditions have been reported or there is a thunderstorm sitting over the airfield, we may well make the decision to delay the take off or enter a holding pattern until the winds have calmed down. It's conditions like this which make up part of our decision on how much fuel to carry.

Precautions

On take off, a windshear encounter just after lift off could cause some serious problems. On most take offs, to save engine wear, aircraft rarely use the full power the engines can generate. However, in windshear conditions, we want to be able to climb away from the ground as quickly as possible. To do this, most aircraft will use the maximum power available with a higher flap setting. This can make for quite a 'sporty' take off experience but it's done to maximise safety.

When approaching the destination airport, weather updates from ATC keep us informed of the very latest conditions. The weather radar on board the aircraft also indicates areas of thunderstorms. If we deem the conditions safe enough to start an approach, we will make maximum use of the automatics (autopilot and auto-throttle) to enable us to closely monitor the key flight parameters such as airspeed and altitude. If at any point we enter windshear conditions, it's time for the...

Recovery

Entry into windshear conditions can be confirmed by the windshear warning, a two-tone siren followed by "WINDSHEAR, WINDSHEAR, WINDSHEAR", or unacceptable flight path deviations. These deviations can be recognised by changes to the flight conditions greater than 15kts airspeed, 5 degrees pitch attitude, 500 feet per minute descent or climb rate and significant deviation from the vertical approach slope. The reaction of the pilots to entering windshear conditions is to perform the Windshear Escape Manoeuvre. In essence, this means applying full engine power and breaking off the approach and back up to a safe altitude, like in the video below. (Start at 1:56.)

Watch Video At: https://youtu.be/_AW--9_F6OU

Bottom Line

Strong winds are responsible for most turbulence which you'll experience during a flight, but commercial aircraft are built strong enough to withstand conditions far worse than they could ever expect to encounter.

Whilst flying in windy conditions brings its challenges, it also brings out the best in your pilots. We are all trained to deal with the worst the weather can throw at us and it's on days like these when we really earn our bread.

At the same time, as much as pilots prefer to take off and land into wind, it's not always possible. When the wind is across the runway, special techniques are required to keep the aircraft safely on the runway. These are some of the most challenging, but also most satisfying, days in the office for pilots.

These conditions are well forecast so pilots will normally take extra fuel to allow for holding and then a potential a go-around and diversion to another airport. Even during windshear conditions, pilots will always have a plan up their sleeve.

Photo by Darren Murph / The Points Guy