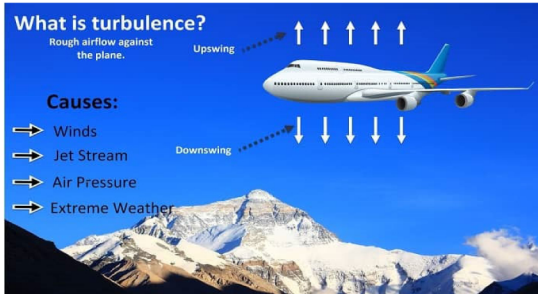




Turbulence

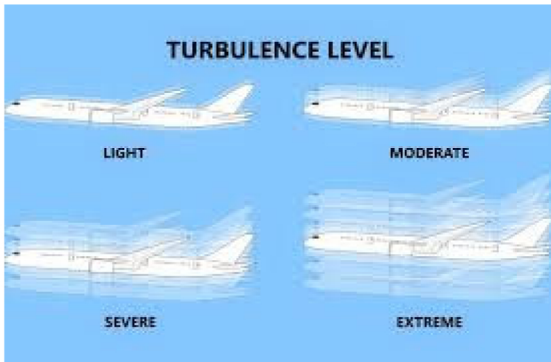


Turbulence is one of the most unpredictable of all the weather phenomena that are of significance to pilots. Turbulence is an irregular motion of the air resulting from eddies and vertical currents. It may be as insignificant as a few annoying bumps or severe enough to momentarily throw an airplane out of control or to cause structural damage. Turbulence is associated with fronts, wind shear, thunderstorms, etc.

There are five causes of turbulence:

1. **Mechanical Turbulence.** Friction between the air and the ground, especially irregular terrain and man-made obstacles, causes eddies and therefore turbulence in the lower levels. The intensity of this eddy motion depends on the strength of the surface wind, the nature of the surface and the stability of the air. The stronger the wind speed (generally, a surface wind of 20 knots or higher is required for significant turbulence), the rougher the terrain and the more unstable the air, the greater will be the turbulence. In strong winds, even hangars and large buildings cause eddies that can be carried some distance downwind. Strong winds are usually quite gusty; that is, they fluctuate rapidly in speed. Sudden increases in speed that last several minutes are known as squalls and they are responsible for quite severe turbulence.
2. **Mountain waves** are turbulent eddies that are found downwind from mountain ridges. They are caused by and are therefore stationary with respect to the mountain ridges. Mountain waves produce some of the most severe turbulence associated with mechanical agencies.
3. **Thermal (Convective) Turbulence.** Turbulence can also be expected on warm days when the sun heats the earth's surface unevenly. Certain surfaces, such as barren ground, rocky and sandy areas, are heated more rapidly than are grass covered fields and much more rapidly than is water. Isolated convective currents are therefore set in motion with warm air rising and cooler air descending, which are responsible for bumpy conditions as an airplane flies in and out of them. Turbulence extends from the base to the top of the convection layer, with smooth conditions found above. If cumulus, towering cumulus or cumulonimbus clouds are present, the turbulent layer extends from the surface to cloud tops. Turbulence intensity increases as convective updraft intensity increases. In weather conditions when thermal activity can be expected, many pilots prefer to fly in the early morning or in the evening when the thermal activity is not as severe.
4. **Frontal Turbulence.** The lifting of the warm air by the sloping frontal surface and friction between the two opposing air masses produce turbulence in the frontal zone. This turbulence is most marked when the warm air is moist and unstable and will be extremely severe if thunderstorms develop. Turbulence is more commonly associated with cold fronts but can be present, to a lesser degree, in a warm front as well.
5. **Wind Shear.** Wind shear is the change in wind direction and/or wind speed over a specific horizontal or vertical distance. Atmospheric conditions where wind shear exists include areas of temperature inversions, along troughs and lows, and around jet stream. When the change in wind speed and direction is pronounced, quite severe turbulence can be expected. **CLEAR AIR TURBULENCE (CAT)** is sudden severe turbulence occurring in cloudless areas that causes violent buffeting of aircraft associated at high altitudes.

Severity of Turbulence and Reporting



The perception of turbulence severity experienced by an aircraft depends not only on the strength of the air disturbance but also on the size of the aircraft - moderate turbulence in a large aircraft may appear severe in a small aircraft. Hence, pilot reports of turbulence should mention the aircraft type to aid assessment of the relevance to other pilots in, or approaching, the same area. Reporting and forecasting of air turbulence by pilots is graded on a relative scale, according to its perceived or potential effect on a 'typical' aircraft, as Light, Moderate, Severe and Extreme:

1. **Light turbulence** is the least severe, with slight, erratic changes in attitude and/or altitude.
2. **Moderate turbulence** is similar to light turbulence, but of greater intensity - variations in speed as well as altitude and attitude may occur, but the aircraft remains in control all the time.
3. **Severe turbulence** is characterised by large, abrupt changes in attitude and altitude with large variations in airspeed. There may be brief periods where effective control of the aircraft is impossible. Loose objects may move around the cabin and damage to aircraft structures may occur.
4. **Extreme turbulence** is capable of causing structural damage and resulting directly in prolonged, possibly terminal, loss of control of the aircraft.

Air Traffic Control and Pilot Interaction during Turbulence



Air traffic controllers must stay alert and monitor weather reports for the possibility of turbulence particularly with encounters of wake turbulence or mountain turbulence resulting in aircraft loss of control or ground contact.

When pilots report to Air Traffic Control of encounters with turbulence, a controller can expect request(s) for:

- Change of flight levels (either climb or descent) where the ride is smoother.
- Emergency descent depending on the severity and/or structural damage to the aircraft or injuries to flight crew or passengers or imminent crash.
- Diversion due to structural damage to the aircraft or injuries to flight crew or passengers.

Air traffic controllers can also assist by:

- Facilitating climb or descent request from flights encountering turbulence.
- Request from flights PIREPS on the ride at higher or lower flight levels and communicate this information to flights encountering turbulence.
- In emergency situations assist the flight in whatever way possible.
- In severe or extreme turbulence, increase the required vertical, lateral, or longitudinal separation.
- Inform other flights of the phenomenon and the ride reports and suggest possible alternate flight levels/routes.

The Effect of Turbulence in the aircraft Cabin



In 2022, for the 5th consecutive year, the most common category of accidents in the Americas was Turbulence. Hence, it is critical that Air Operators develop policies and procedures for the prevention of Turbulence-Related Injuries.

When an aircraft experiences turbulence, the plane can drop or change altitude suddenly. The sudden movement can be risky to passengers' safety. In general, passenger airlines will use safety procedures which involve having the Flight Crew caution passengers by illuminating the 'fasten seat belt sign' in order that passengers will follow the instruction

and stay seated whilst experiencing flight turbulence. Appropriate Public Address Announcements will be made of the need to be seated and remain seated with the seat belt fastened; the Cabin Crew will also verify that the passenger cabin is secured. The captain of the flight, at his/her judgement will instruct the Cabin Crew of the need to abort the cabin service based on the severity of the turbulence. The duration of the turbulence depends on the condition of the irregular airflow and the path of the flight.

Aircraft are designed to withstand all types of turbulence. Turbulence may cause alarming panic. However, pilots are specially trained accordingly. During turbulence, passengers need to fasten your seat belt and remain calm until the turbulence ends.

Passengers can prevent injuries from unexpected turbulence by keeping their seat belt fastened at all times. The following guidelines also help passengers to be remain safe during flight:

1. **Listen** to the pilots and flight attendants — Civil Aviation regulations require passengers to be seated with their seat belts fastened whenever the seat belt sign is illuminated during flight.
2. **Pay attention** to the safety briefing at the beginning of your flight and read the safety briefing card.
3. **Approved child safety seats or devices** must be used for infants.
4. **Airlines' carry-on restrictions** must be adhered to for the prevention of inflight injuries.