



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
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Attachment 11 – Delta Air Lines Flight Crew Training Manual

[Excerpt]

OPERATIONAL FACTORS

DCA19CA208



DAL Flight Operations

FCTM MD88-90

Document Reference: DAL/MD89/FCTM

Revision 2.0.0

25-Nov-2019

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1.14 TURBULENT AIR PENETRATION

Severe turbulence should be avoided if at all possible. However, if severe turbulence is encountered, use the Severe Turbulence procedure listed in the Vol. 1, SP.16, Turbulence. Turbulent air penetration speeds provide high/low speed margins in severe turbulent air.

During manual flight, maintain wings level and smoothly control attitude. Use the attitude indicator as the primary instrument. In extreme updrafts or downdrafts, large altitude changes may occur. Do not use sudden or large control inputs. After establishing the trim setting for penetration speed, do not change pitch trim. Allow altitude and airspeed to vary and maintain attitude. However, do not allow the airspeed to decrease and remain below the turbulent air penetration speed because stall/buffet margin is reduced. Maneuver at bank angles below those normally used. Set thrust for penetration speed and avoid large thrust changes. Flap extension in an area of known turbulence should be delayed as long as possible because the aircraft can withstand higher gust loads with the flaps up.

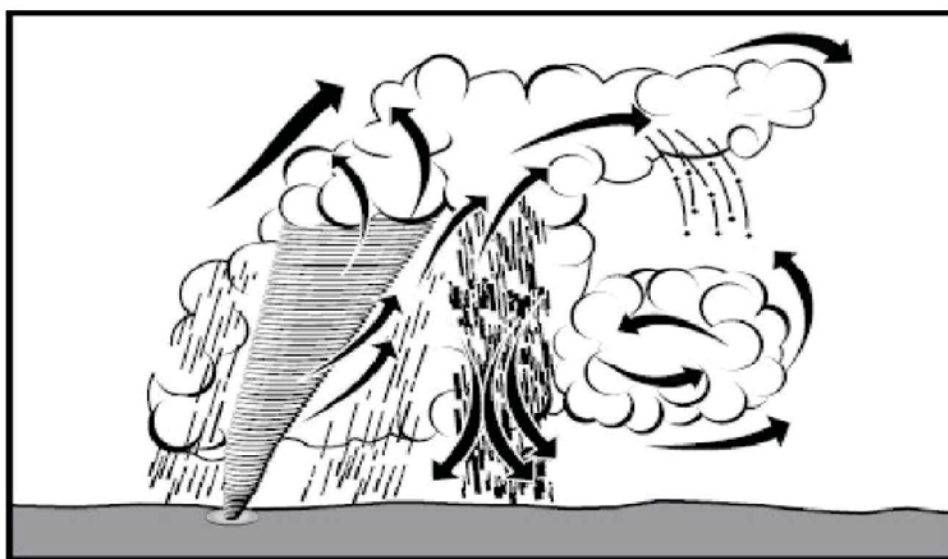
Normally, no changes to cruise altitude or airspeed are required when encountering moderate turbulence. If operating at cruise thrust limits, it may be difficult to maintain cruise speed. If this occurs, select a higher thrust limit (if available) or descend to a lower altitude.

10.4 WEATHER RADAR

10.4.1 Turbulence Avoidance

Research has shown that when any part of a storm reaches Level 3 strength, moderate to severe turbulence occurs with equal probability throughout all areas of the storm, including the Level 1 and 2 areas. For turbulence avoidance, all areas of a storm should be avoided when any part reaches Level 3.

The color green is often associated with safe to go or normal operation. Green does not imply go or safe in conjunction with weather radar or turbulence avoidance. In weather depiction, green simply denotes the area of Level 1 precipitation. When associated with convective weather, green areas of rain may contain violent vertical activity. The graphic below illustrates how tornadoes are most often located at the outer edge of thunderstorms in the Level 1 areas of precipitation.



10.4.1.1 Turbulent Activity

Turbulent activity occurs away from the heavy rain core. Enroute deviations should be made upwind of the storm whenever possible, especially if winds aloft are strong. Deviating downwind greatly increases the chance of encountering hail and turbulence. Turbulence can be expected to exist downwind of the storm 1 NM for every knot of windspeed at flight altitude. The storm acts as an obstruction to the wind, creating turbulent eddies downwind of the storm.

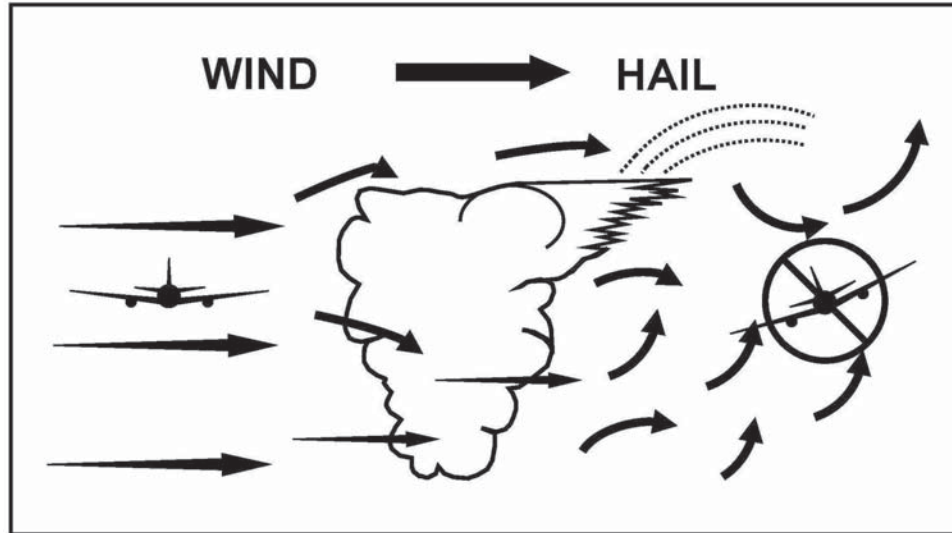
To detect turbulence select the TURB mode to identify areas of horizontal movement of precipitation, which can be a good indication of turbulence.

- Turbulence will be displayed in magenta, overlaying the weather display.
- TURB mode will not detect clear air turbulence.
- Turbulence detection is limited to 40 NM.

Turbulence detection can be useful in identifying areas of turbulence, particularly in light rain areas. Some storm targets may display little or no turbulence, but that does not mean it is safe to penetrate. An absence of indicated turbulence does not justify penetrating a weather area that by other indications is hazardous.

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The graphic below illustrates how enroute deviations should be made upwind of the storm and the turbulence that can be encountered downwind of the storm.



10.4.2 Windshear Avoidance

Airborne radar cannot detect microbursts. However, microbursts are a product of convective cells, so airborne radar should be one of several factors considered.

10.4.2.1 Wet Microburst Environment

Wet microbursts are associated with extremely high rain rates.

- Be alert for signs of attenuation, such as crescent shaped returns or radar shadows.
- Strong returns at mid to upper levels of weather are signs of hazardous convective activity.
- Microburst producing storm cells can be small in diameter, so use short ranges when evaluating nearby cells.

10.4.2.2 Dry Microburst Environment

Dry microbursts can be produced by very light rain cells.

- Level 1 returns can produce severe microbursts.
- Dry microbursts are produced by high based virga activity.
 - Use UP TILT to direct the beam will above the flight path.
 - When evaluating the departure path before takeoff, full UP TILT may be inadequate to detect high based showers within 10 NM.
- TURB mode may be useful. Turbulence indicated in light returns is evidence of strong activity.
- Cells may be small. Use short ranges when evaluating nearby targets.

Radar has inherent limitations when evaluating nearby and or intense weather areas. Consider all factors, including visual cues, in making windshear avoidance decisions.