NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

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Attachment 3 – Flight Operations Manual [Excerpts]

OPERATIONAL FACTORS

DCA19CA206

Flight Operations Manual
Volume I
A320 Series

For a summary of changes, **Click Here**

FLIGHT OPERATIONS

Ensuring Frontier Airlines' success through the safe, professional and efficient operation of our aircraft

FRONTIER AIRLINES

Severe Turbulence and/or Mountain Wave Activity Induced Altitude Deviations of Approximately 200 feet

When an aircraft experiences weather induced altitude deviations of approximately 200 feet, the pilot will contact ATC and state "Unable RVSM due to (state reason)" (e.g., turbulence, mountain wave). Until the pilot reports clear of the weather phenomenon, the controller will (traffic permitting) apply merging target vectors to one or both passing aircraft to prevent their targets from merging.

NOTE: If not issued by the controller, pilots should request vectors to remain clear of traffic at adjacent FLs.

Example: **Pilot:** "Denver Center, Frontier Flight 434, FL 340, unable RVSM due to severe turbulence."
ATC: "Frontier Flight 434, fly heading 290, traffic twelve o'clock, 10 miles, opposite direction; eastbound 727 at FL 330" (or the controller may issue a vector to the 727 traffic to avoid Frontier Flight 434).

Pilots should also report the location and magnitude of turbulence or MWA to ATC. If desired, a FL change or re-route may be requested as noted below.

Mountain Wave Activity MWA encounters do not necessarily result in altitude deviations on the order of 200 feet. When pilots encounter MWA of less significant magnitude, they should contact ATC and report the magnitude and location of the wave activity. When a controller makes a merging targets traffic call, the pilot may request a vector to avoid flying directly over or under the traffic.

Example: **ATC:** "Frontier Flight 434, traffic twelve o'clock, 10 miles, opposite direction, eastbound 727 at FL 310."
Pilot: "Frontier Flight 434 request vector to avoid traffic."
ATC: "Frontier Flight 434, fly heading 290."

FL Change or Re-route To leave airspace where MWA or severe turbulence is being encountered, the pilot may request a FL change and/or reroute, if necessary.

THUNDERSTORMS

Pilots should attempt to avoid any thunderstorm activity within the takeoff, departure, approach and landing paths.

Enroute operations will be conducted in such a manner as to avoid, whenever possible, all thunderstorm cells and associated turbulence. If extensive deviations are required, Dispatch should be notified.

TURBULENCE

When anticipating or encountering turbulence:

- Reference Table 25.50.1 for crewmember actions based on type and timing of turbulence encounters.
- If severe turbulence, reduce to the appropriate severe turbulent air penetration speed.

NOTE: An aircraft logbook entry is required upon arrival at the destination in cases of severe or greater turbulence (see Section 25.20 Aircraft Discrepancies/Irregularities).

- Report turbulence encounters to ATC and to Dispatch using the criteria described in Table 25.50.1. Pilots should report location(s), time (UTC), intensity, whether in or near clouds, altitude, type of aircraft and duration of turbulence to ATC and to Dispatch. Duration may be based on time between two locations or over a single location. All locations should be readily identifiable.

Example: Over Omaha, 1232Z, moderate turbulence in clouds at flight level three one zero, A320.
From five zero miles south of Albuquerque to three zero miles north of Phoenix, 1250Z, occasional moderate chop at flight level three three zero, A319.

Table 25.50.1 – Turbulence Reporting Criteria and Recommended Crewmember Actions

Turbulence Reporting Criteria and Recommended Crewmember Actions				
Intensity	**Aircraft Reaction**	**Reaction Inside Aircraft**	**Flight Deck**	**Cabin**
Light	Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw). Report as **Light Turbulence**; or Turbulence that cause slight, rapid and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude. Report as **Light Chop**.	Occupants may feel a slight strain against seat belts or shoulder straps. Unsecured objects may be displaced slightly. Food service may be conducted and little or no difficulty is encountered in walking.	**If expecting turbulence:** Advise FAs of turbulence and expected time of entry (via interphone). **At least five minutes prior, or if unexpected turbulence is encountered:** At captain's discretion: • Turn the seat belt sign "ON." • Make PA advising passengers to be seated and fasten all seat belts.	Continue inflight service with caution; avoid serving hot liquids. **If the seat belt sign comes on:** • Make PA reinforcing need for passengers to be seated with seat belts fastened. • Monitor seatbelt compliance by visually checking that passengers are seated with seat belts securely fastened.
Moderate	Turbulence that is similar to Light Turbulence but of greater intensity. Changes in altitude and/or attitude occur but the aircraft remains in positive control at all times. It usually causes variations in indicated airspeed. Report as **Moderate Turbulence**. or Turbulence that is similar to Light Chop but of greater intensity. It causes rapid bumps or jolts without appreciable changes in aircraft altitude or attitude. Report as **Moderate Chop**.	Occupants feel definite strains against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.	**If expecting turbulence:** Advise FAs of turbulence and expected time of entry (via interphone). **At least five minutes prior:** • Ensure seat belt sign is "ON." • Make PA advising FAs and passengers to be seated and fasten all seat belts. **If unexpected turbulence is encountered:** • Ensure seat belt sign is "ON." • Workload permitting, make PA advising FAs and passengers to be seated **immediately**, fasten all seat belts, and discontinue cabin service (or as appropriate for the situation). **During/After turbulent conditions:** • Continue communication with FAs as required. • Ensure reports to ATC and Dispatch are made when time/workload permits. • Inform FAs when turbulence conditions have suspended.	**If expecting turbulence:** Have all carts and galley equipment stowed at least five minutes prior to expected entry into turbulence. **If advance notice is given, once the seat belt sign comes on:** • Make PA reinforcing need for passengers to be seated with seat belts fastened. • Time permitting, monitor seatbelt compliance by visually checking that passengers are seated with seat belts securely fastened. • Be seated with seat belt and shoulder harness secured. **If unexpected turbulence is encountered:** • Immediately stop all inflight service. • Be seated with seat belts and shoulder harness secured, or take nearest seat in the cabin or sit on floor, if necessary. • Make PA reinforcing need for passengers to be seated with seat belts fastened. **During turbulent conditions:** • FA "A" continues communications with flight deck on conditions in cabin as needed. • Remain seated until notified by the flight deck it is safe to resume duties. Upon notification it is safe, check passengers and cabin.
Severe	Turbulence that causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control. Report as **Severe Turbulence**.	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food service and walking are impossible.		
Extreme	Turbulence in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage. Report as **Extreme Turbulence**.			

REPORTING TERMS AND DEFINITIONS

Occasional – Less than 1/3 of the time.

Intermittent – 1/3 to 2/3 of the time.

Continuous – More than 2/3 of the time.

CAT (Clear Air Turbulence) – High level turbulence (normally above 15,000 feet ASL) not associated with cumuliform cloudiness, including thunderstorms, should be reported as CAT preceded by the appropriate intensity, or light or moderate chop.

HOLDING PROCEDURES

(Aeronautical Information Manual)

Start speed reduction when three minutes or less from the holding fix. Cross the holding fix, initially, at or below the maximum holding airspeed.

Maximum Holding Airspeeds for Turbojet Aircraft (Altitudes MSL):

In U.S. Airspace:
- MHA to 6000 feet: . . . . . 200 KIAS
- 6,001 feet to 14,000 feet: . . . . . 230 KIAS
- Above 14,000 feet: . . . . . 265 KIAS

In Mexico Airspace:
- MHA to 6000 feet: . . . . . 200 KIAS
- 6,001 feet to 14,000 feet: . . . . . 210 KIAS
- Above 14,000 feet: . . . . . 230 KIAS

In Dominican Republic Airspace:
- MHA to FL140. . . . . 230 KIAS
- FL140 to FL200 . . . . . 240 KIAS
- FL200 to FL340 . . . . . 265 KIAS
- Turbulent air up to FL340 . . . . . 280 KIAS or Mach 0.8
- Above FL340. . . . . Mach 0.83

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Volume II
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FLIGHT OPERATIONS

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FRONTIER AIRLINES

PASSENGER & CARGO DOOR LIMITATIONS

MAXIMUM WIND FOR PASSENGER DOOR OPERATION	***65kts***
MAXIMUM WIND FOR CARGO DOOR OPERATIONS	***40kts/50kts(1)***

(1) *If the aircraft nose is oriented into the wind, or if the cargo door is on the leeward side of the aircraft, operation of the cargo door is permitted in winds up to 50 knots. If wind speed begins to exceed these limitations, the cargo door must be closed before the wind speed exceeds 65 kts.*

SPEED LIMITATIONS

AIRSPEED

VMO/MMO	350 kt/0.82 Mach

RECOMMENDED TURBULENT AIR PENETRATION SPEED

Operating Altitude	***A319/A320***	***A321***
FL190 and below	***250 kt***	***270 kt***
FL200 to FL310	***275 kt***	***300 kt***
Above FL310	***0.76 Mach***	***0.76 Mach***

NOTE: If severe turbulence is anticipated or encountered, reference FOM Vol. II Section 5.45 Severe Turbulence for Thrust Setting for Recommended Speed in Severe Turbulence charts.

MAXIMUM FLAPS/SLATS SPEEDS

Lever Position	**Indication on ECAM**	**A319/A320 Placarded Speeds(1)**	**A321 Placarded Speeds(1)**	**Flight Phase**
1	1	230 kt	235 kt	Holding
	1 + F	215 kt	225 kt	Takeoff
2	2	200 kt	215 kt	Takeoff / Approach
3	3	185 kt	195 kt	Takeoff/ Approach/ Landing
FULL	FULL	177 kt	190 kt	Landing

(1) *If placarded speeds are exceeded, a maintenance write up is required.*

Unless an abnormal or emergency procedure dictates otherwise, slats/flaps will be extended at a maximum of VFE - 10 knots, except for Flaps Full, which should be extended at a maximum of VFE - 15 knots, to avoid inadvertently exceeding placarded speeds.

LANDING GEAR SPEED – MAXIMUM

Retraction (VLO)	220kts/0.54 Mach
Extension (VLO)	250kts/0.60 Mach
Extended (VLE)	280kts/0.67 Mach

GROUND OPERATIONS IN HEAVY RAIN OR HIGH HUMIDITY

When the aircraft is parked on the ground during heavy rain and/or high humidity conditions, it can take moisture into the avionics ventilation system via the open skin air inlet valve. To prevent this, the following procedure should be applied:

- **On approach prior to or immediately after landing:**
  - EXTRACT . . . . . OVRD
    This closes the avionics ventilation system, preventing rainwater/moisture laden air from entering.
  - PACKS 1 and 2 . . . . . CHECK ON
    This adds air from the air conditioning system to ventilation air. If bleed air is not available, the configuration can function for a limited time as follows:
    - OAT ≤ 39° C: no limit
    - 39°C ≤ OAT ≤ 45° C: 3 hours
    - OAT ≥ 45° C: 30 minutes
- **Takeoff**

  A PACKS ON / APU BLEED ON takeoff should be planned using PACKS OFF performance data.
- **After climb check (on takeoff):**
  - EXTRACT . . . . . AUTO

RAIN REPELLENT

If the rain repellent is operative, the flight crew should only use the rain repellent in moderate to heavy rain.

SEVERE TURBULENCE

GENERAL

If turbulence is unavoidable, aim to keep the speed in the region of the target speed given in this section, so as to provide the best protection against the effect of gust on the structural limits, while maintaining an adequate margin above VLS. Consider requesting a lower flight level to increase margin to buffet onset. Sufficient buffet margin exists at optimum altitude.

Severe turbulence is defined as turbulence that causes large, abrupt changes in altitude or attitude. It usually causes large variations in airspeed. Occupants are forced violently against their seat belts and loose objects will move around the aircraft. If severe turbulence occurs during a flight, the flight crew must make a logbook entry in order to initiate maintenance action.

NOTE: Recommendations for severe turbulence are also applicable to extreme turbulence.

AUTOPILOT/AUTOTHRUST

Keep the autopilot ON. When thrust changes become excessive: Disconnect Autothrust. For approach: Use A/THR for managed speed.

THRUST AND AIRSPEED

Set the thrust to give the recommended speed (see appropriate table below). This thrust setting attempts to obtain, in stabilized conditions, the speed for turbulence penetration given in the graph below. Only change thrust in case of an extreme variation in airspeed, and do not chase your Mach or airspeed. A transient increase is preferable to a loss of speed that decreases buffet margins and is difficult to recover.

A321 THRUST SETTING FOR RECOMMENDED SPEED IN SEVERE TURBULENCE

SEVERE TURBULENCE											
N1 SETTING FOR RECOMMENDED TURBULENCE SPEED (%)											
FL	Speed or Mach	WEIGHT (1000 lb)									
		120	130	140	150	160	170	180	190	200	210
390	0.76	83.4	84.3	-	-	–	–	–	–	-	-
370	0.76	82.4	83.1	83.9	-	-	–	–	–	-	-
350	0.76	81.8	82.5	83.2	83.9	84.7	-	-	–	-	-
330	0.76	81.7	82.3	83.0	83.6	84.3	84.9	-	-	-	-
310	300	84.9	85.2	85.6	86.0	86.4	87.0	87.8	88.6	-	-
290	300	82.7	83.1	83.5	84.0	84.5	84.9	85.4	85.9	86.4	87.0
270	300	81.5	81.8	82.2	82.6	83.0	83.5	84.0	84.6	85.2	85.8
250	300	80.1	80.5	81.0	81.4	81.9	82.3	82.8	83.4	84.0	84.7
200	300	76.3	76.8	77.3	77.7	78.2	78.8	79.4	80.0	80.7	81.5
150	270	68.1	68.7	69.2	69.9	70.6	71.3	72.1	73.0	74.0	75.3
100	270	64.1	64.7	65.3	66.0	66.7	67.5	68.4	69.3	70.1	71.4
50	270	60.8	61.3	61.8	62.3	62.9	63.6	64.3	65.1	65.9	67.2

A320 NEO THRUST SETTING FOR RECOMMENDED SPEED IN SEVERE TURBULENCE

SEVERE TURBULENCE									
N1 SETTING FOR RECOMMENDED TURBULENCE SPEED (%)									
FL	Speed or Mach	WEIGHT (1000 lb)							
		100	110	120	130	140	150	160	175
		N1%							
390	0.76	77.5	78.5	79.8	81.1	–	–	–	–
370	0.76	76.5	77.4	78.3	79.4	80.6	–	–	–
350	0.76	76.0	76.7	77.6	78.4	79.3	80.4	81.6	–
330	0.76	75.8	76.5	77.2	78.0	78.8	79.6	80.5	82.1
310	280	75.7	76.2	76.9	77.5	78.3	79.0	79.7	81.0
290	280	74.0	74.6	75.2	75.8	76.5	77.2	78.0	79.3
270	280	72.5	73.0	73.5	74.2	74.8	75.5	76.2	77.5
250	280	70.8	71.3	71.8	72.5	73.1	73.8	74.5	75.7
200	280	67.0	67.5	68.0	68.6	69.2	69.8	70.5	71.6
150	260	60.0	60.6	61.3	62.0	62.7	63.5	64.3	65.6
100	260	56.1	56.6	57.2	57.8	58.5	59.3	60.1	61.4
50	260	52.6	53.0	53.6	54.1	54.7	55.4	56.1	57.3

A320 CEO THRUST SETTING FOR RECOMMENDED SPEED IN SEVERE TURBULENCE

- **IF A/C 201-216, 221, 223**

FL	Speed or Mach	GROSS WEIGHT (1000 lb)							
		100	110	120	130	140	150	160	170
		N1%							
390	0.76	80.3	81.5	82.6	84.0	–	–	–	–
370	0.76	79.3	80.2	81.2	82.3	83.5	–	–	–
350	0.76	79.0	79.6	80.4	81.3	82.3	83.3	–	–
330	0.76	79.0	79.6	80.1	80.9	81.7	82.6	83.5	84.5
310	275	78.2	78.9	80.1	80.9	81.7	82.6	83.5	83.4
290	275	76.7	77.3	79.5	80.2	80.8	81.5	82.4	82.0
270	275	75.2	75.8	78.0	78.7	79.5	80.3	81.1	80.7
250	275	73.7	74.2	74.9	75.6	76.4	77.2	78.1	79.1
200	275	70.0	70.5	71.0	71.6	72.3	73.0	73.8	74.6
150	250	62.1	62.9	63.7	64.7	65.7	66.9	68.1	69.1
100	250	58.5	59.3	60.0	60.8	61.7	62.6	63.7	64.8
50	250	54.5	55.2	56.0	56.9	57.9	59.0	60.1	61.0

- **IF A/C 220, 227-238**

SEVERE TURBULENCE									
N1 SETTING FOR RECOMMENDED TURBULENCE SPEED (%)									
FL	Speed or Mach	WEIGHT (1000 lb)							
		100	110	120	130	140	150	160	170
		N1%							
390	0.76	80.1	81.0	82.1	83.1	–	–	–	–
370	0.76	79.2	79.9	80.8	81.8	82.7	–	–	–
350	0.76	78.9	79.4	80.1	80.9	81.7	82.7	-	–
330	0.76	78.9	79.5	80.0	80.6	81.3	82.0	82.9	83.7
310	275	78.2	78.7	79.3	80.0	80.5	81.2	81.9	82.7
290	275	76.6	77.2	77.7	78.4	79.1	79.9	80.6	81.4
270	275	75.1	75.7	76.2	76.8	77.5	78.3	79.2	80.1
250	275	73.6	74.1	74.7	75.3	76.1	76.8	77.6	78.5
200	275	69.9	70.4	70.9	71.4	72.1	72.7	73.4	74.2
150	250	62.0	62.7	63.5	64.3	65.3	66.4	67.6	68.6
100	250	58.4	59.1	59.8	60.5	61.4	62.5	63.6	64.8
50	250	54.4	55.0	55.8	56.6	57.6	58.8	60.1	61.1

A319 THRUST SETTING FOR RECOMMENDED SPEED IN SEVERE TURBULENCE

- **IF A/C 938, 939, 949**

FL	Speed or Mach	GROSS WEIGHT (1000 lb)								
		90	100	110	120	130	140	150	160	170
		N1%								
390	0.76	79.0	80.0	81.1	82.4	83.7	–	–	–	–
370	0.76	78.3	79.0	79.9	80.9	82.1	83.2	–	–	–
350	0.76	77.9	78.6	79.3	80.0	80.9	82.0	83.1	–	–
330	0.76	77.9	78.5	79.2	79.8	80.5	81.3	82.2	83.2	84.2
310	275	77.2	77.7	78.4	79.1	79.8	80.5	81.2	82.1	83.0
290	275	75.7	76.3	76.9	77.5	78.2	79.1	80.0	80.7	81.6
270	275	74.2	74.7	75.4	76.0	76.7	77.5	78.3	79.3	80.4
250	275	72.7	73.2	73.8	74.4	75.2	76.0	76.8	77.7	78.7
200	250	69.2	69.6	70.1	70.6	71.2	72.0	72.7	73.5	74.3
150	250	61.5	62.1	62.8	63.7	64.6	65.6	66.8	68.0	69.0
100	250	58.1	58.7	59.4	60.0	60.8	61.6	62.6	63.6	64.7
50	250	54.1	54.7	55.3	56.1	57.0	57.9	58.9	60.1	61.0

- **IF A/C 910, 941, 943**

SEVERE TURBULENCE										
SPEED AND THRUST SETTING FOR RECOMMENDED TURBULENCE SPEED										
FL	Speed or Mach	GROSS WEIGHT (1000 lb)								
		90	100	110	120	130	140	150	160	170
		N1%								
390	0.76	79.1	80.0	81.1	82.4	83.7	–	–	–	–
370	0.76	78.3	79.0	79.9	80.9	82.1	83.2	–	–	–
350	0.76	77.9	78.6	79.3	80.1	81.0	82.0	83.1	–	–
330	0.76	77.9	78.5	79.2	79.8	80.5	81.3	82.2	83.3	84.2
310	280	77.9	78.4	79.0	79.7	80.2	80.9	91.6	82.4	83.3
290	280	76.4	76.9	77.4	78.1	78.8	79.5	80.3	81.0	81.9
270	280	74.9	75.4	76.0	76.6	77.2	77.9	78.8	79.7	80.6
250	280	73.3	73.8	74.4	75.0	75.7	76.5	77.2	78.0	79.0
200	280	69.9	70.3	70.7	71.2	71.8	72.4	73.1	73.9	74.7
150	255	62.3	62.8	63.5	64.3	65.2	66.1	67.2	68.3	69.3
100	255	58.9	59.4	59.9	60.6	61.3	62.1	63.0	64.0	65.0
50	255	55.0	55.5	56.1	56.8	57.6	58.5	59.5	60.4	61.3

ALTITUDE

If the crew flies the aircraft manually:
- Expect large variations in altitude, but do not chase altitude.
- Maintain attitude and allow altitude to vary.

SPEEDBRAKES

Whenever speedbrakes are applied, keep a hand on the speedbrake handle, except while performing some other specific cockpit function (changing power, resetting altimeter, etc.).

LANDING

Configuration FULL or 3 can be used. However, configuration 3 provides more energy and less drag.

WINDSHEAR OR DOWNBURST CONDITIONS

PRECAUTIONS FOR SUSPECTED WINDSHEAR

- **Before TAKEOFF**
  - Delay takeoff until conditions improve.
  - Evaluate takeoff conditions:
    - Using observations and experience.
    - Checking weather conditions.
  - Select the most favorable runway (considering location of the likely windshear).
  - Use the weather radar or the predictive windshear system before commencing takeoff to ensure that the flight path clears any potential problem areas.
  - Select TOGA thrust.
    - While TOGA thrust is required for suspected windshear, use of FLEX takeoff data (V speeds) is approved. Utilizing TOGA thrust with FLEX takeoff data (V speeds) will provide additional energy in the event windshear is encountered during the departure.
  - Monitor closely airspeed and airspeed trend during the takeoff run for early signs of windshear.
- **During APPROACH**
  - Delay landing or divert to another airport until conditions are more favorable.
  - Evaluate condition for a safe landing by:
    - Using observations and experience.
    - Checking weather conditions.
  - Use the weather radar.
  - Select the most favorable runway, considering also which has the most appropriate approach aid.
  - Select FLAPS 3 (provided runway length/condition is adequate).
  - Use managed speed in the approach phase.
  - Check both FDs engaged in ILS, FPA or V/S.
  - Engage autopilot for a more accurate approach and earlier recognition of deviation from the beam when ILS is available.

NOTES:
- *When it is using the GS mini function associated with managed speed, the system will carry extra speed in strong wind conditions.*
- *If downburst is expected, increase VAPP displayed on the MCDU up to a maximum of VLS + 15 knots.*

WINDSHEAR AND WINDSHEAR AHEAD PROCEDURES

See the aircraft specific QRH for these procedures.

REPORTING

Whenever operating in areas affected by volcanic activity, flight crews should be aware of volcanic reporting procedures and be familiar with the use of the ICAO Special Air Report of Volcanic Activity (Model VAR).

If the aircraft encounters a volcanic ash cloud, the flight crew should report the location, altitude, and direction of drift for the ash cloud to ATC, flight conditions and crew duties permitting.

WEATHER RADAR

OPERATIONAL USE

TILT AND RANGE

CAUTION

Before selecting WX, WX/T or MAP mode on the control unit, make certain that:
- No one is within a distance less than 17 feet from the antenna in movement, within an arc of plus or minus 135° of either side of the aircraft centerline.
- The aircraft is not directed towards any large metallic obstacle, such as a hangar, which is within 17 feet in a arc of plus or minus 90° on either side of the aircraft centerline.

DETECTION AND INTERPRETATION

General

1. The flight crew should monitor the weather at long range, as well as that at shorter ranges, in order to be able to plan efficient course changes and to avoid weather-defined blind alleys and box canyons.
2. Ground returns usually appear smaller, sharper, more packed, better defined, and more angular than weather targets, whereas the latter usually appear larger, have less definite shapes, and tend to remain relatively unchanged.
3. The line-of-sight distance to the horizon is:
   D(NM) = 1.23 √(aircraft altitude (feet)).

Red and magenta areas: thunderstorms, tornadoes, hail The steeper the gradient of rainfall rate, the stronger the turbulence (magenta color) and the possibility of hail.

- To use the radar effectively for avoiding thunderstorms, the flight crew should select the following ranges on the NDs (if possible):
  - 160 NM on the Pilot Non-Flying (PM) ND
  - 80 NM on the Pilot Flying (PF) ND
- To avoid a large storm, the flight crew must make decisions while still 40 NM from it. Therefore the flight crew should:
  - Avoid magenta (WX+T mode) and red areas and fringes by at least 20 NM above FL230 and by 5 to 10 NM below FL230.
  - Avoid single magenta areas of turbulence (not associated with heavy precipitation) by at least 5 NM.
- Flight crew should readjust the tilt frequently in order to monitor storm development and to get the best cell echo.
- Failure to tilt the antenna down periodically may cause a target to disappear.
- The following formula calculates the vertical distance between the top of the cell and the aircraft flight level:
  $\triangle h$ (feet) ≈ d (NM) × Tilt (degrees) × 100.

Example: Cell at 40 NM disappearing at less than 3 degrees downtilt
$\triangle h \sim 40 \times 3 \times 100 = 12\,000$ feet.

- The pilot should not attempt to penetrate a cell or clear its top by less than 5000 vertical feet, because otherwise the aircraft may encounter severe turbulence.
  If the top of cell is at or above 25000 feet, overflying should be avoided due to the possibility of encountering turbulence stronger than expected.
  In the same way, the pilot should avoid flying under a thunderstorm because of possible windshear, microbursts, severe turbulence, or hail.

Turbulence mode

- The turbulence detection mode is most effective when the ND is set on 40 NM and the antenna is tilted to avoid ground return.
- When examining areas of heavy rainfall in WX+T mode, the flight crew should adjust antenna tilt frequently, because turbulence areas vary with the altitude.
- Closely spaced (or thin lines between) color gradations are usually associated with severe turbulence.