# A320 Line Training

***Last Updated:* *14th Jan, 2020***

TheAirlinePilots.com

# COMMON ITEMS ALREADY EXPLAINED

Refer to ATR Line training Syllabus:
http://www.theairlinepilots.com/forumarchive/atr/atr-line-training.pdf

# CHAPTERS TO BE REVIEWED FROM FCOM

- FCOM - 04 DEC 18 - PIA - A318/A319/A320/A321
  - Aircraft Systems
    - 22_20 Auto Flight - Flight Management
    - 22_30 Auto Flight - Flight Guidance

# CHAPTERS TO BE REVIEWED FROM OM

| PAKISTAN International Airlines Great People to Fly With | Operations Manual<br>Part – A<br>Edition – III | **Chapter 0**<br>Page 11 |
|---|---|---|
| | **INTRODUCTION** | Rev : 04<br>**24th Dec, 2018** |

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| 8 | Flight Preparation & Planning | 1-22 |

# MISC REFERENCES

1) Overhead Panel (Technical):
https://www.theairlinepilots.com/forumarchive/a320/a320-lights-switches.pdf

2) Normal Procedures:
https://www.theairlinepilots.com/forumarchive/a320/a320-normal-procedures.pdf

3) Abnormal Procedures:
https://www.theairlinepilots.com/forumarchive/a320/a320-abnormal-procedures.pdf

5) Limitations:
https://www.theairlinepilots.com/forumarchive/a320/a320-limitations.pdf

6) Memory Items:
https://www.theairlinepilots.com/forumarchive/a320/a320-memory-items.pdf

7) SAFA Ramp Inspection:
http://www.theairlinepilots.com/forumarchive/aviation-regulations/safa-ramp-inspection.pdf

8) Miscellaneous:
https://www.theairlinepilots.com/forumarchive/a320/a320-misc-references.pdf

# A320 SPECIFIC ITEMS IN CFP

-A320/M-SDFGHIRWXY/S

/M – Medium 7000-13600 kg wake turbulence category.

S – VHF RTF + VOR + ILS (Standard Com/Nav/Approach Aid Equipment).

D – DME.

F – ADF.

G – GNSS. If the letter G is used, the types of external GNSS augmentation, if any, may be specified in Item 18 following the indicator NAV/ and separated by a space.

H – HF RTF.

I – Inertial Navigation.

R – PBN Approved. Performance Base Navigation (PBN) levels that can be met shall be specified in Item 18 following the indicator PBN/.

W – RVSM.

X – MNPS approved.

Y – VHF with 8.33 kHz channel spacing capability.

/S – Transponder Mode S.

-PBN/A1B2B3B4D1L1O1S2

A1 – RNAV10 (RNP10)

B2 – RNAV5 GNSS

B3 – RNAV5 DME/DME

B4 – RNAV5 VOR/DME

D1 – RNAV1 All Permitted Sensors

L1 – RNP4

O1 – Basic RNP1 All Permitted Sensors

S2 – RNP APCH with BARO VNAV

| **A320** | |
|---|---|
| RNAV 10 (RNP 10) | GPS (MMR), ADIRU |
| RNAV 5 | GPS(MMR), DME/DME, VOR/DME, ADIRU |
| RNAV 2 | ALL PERMITTED SENSORS (GPS(MMR), DME/DME, DME/DME/ADIRU) |
| RNAV 1 | ALL PERMITTED SENSORS (GPS(MMR), DME/DME, DME/DME/ADIRU) |
| RNP 4 | GPS (MMR), ADIRU |
| RNP 1 | ALL PERMITTED SENSORS (GPS(MMR), DME/DME, DME/DME/ADIRU) |
| RNP APCH | WITHOUT BARO-VNAV, WITH BARO-VNAV |

*C1 is also valid but not added because of space limitation.*

RNAV Designators are A, B, C, D.

A = RNAV 10

B = RNAV 5

C = RNAV 2

D = RNAV 1

RNP Designators are L, O, S, T.

L = RNP 4

O = RNP 1

S = RNP Approach

T = RNP Approach with or without authorization required.

Note: If you have all sensors then you just file the first option. E.g. D is for RNAV 1. It has 4 categories i.e. D1, D2, D3, and D4. D2 is if you have GNSS sensor, D3 if DME/DME, D4 if DME/DME/IRU. If you have all of them then just file D1 that stands for all permitted sensors.

For more details on these fields and items refer to: **https://contentzone.eurocontrol.int/fpl/**

```
-E/0326 P/TBN R/VE S/M J/LF D/06 180 C YELLOW
```

Endurance 3:26

Persons on board: To be Notified.

Emergency radio: VHF and ELT.

Survival equipment: Maritime.

Jacket: Light and fluorescent.

Dinghies: 6 with a total capacity of 180 (30 in each), color yellow.

**LOAD AND TRIM SHEET**

```
PAKISTAN INTERNATIONAL AIRLINES
L O A D S H E E T              CHECKED               APPROVED        EDNO
ALL WEIGHTS IN KILOGRAM          65254                                  1

FROM/TO FLIGHT          A/C REG    VERSION         CREW     DATE       TIME
PEW AUH PK 217/16        APBLZ     P8/Y160         2/5    16/APR/19   1823
                          WEIGHT              DISTRIBUTION
LOAD IN COMPARTMENTS      T1597          1/0 3/1597 4/0 5/0 0/0
PASSENGER / CABIN BAG       11978   159/1/1 TTL 160+1  CAB 0 POB 168
                                    6/154      SOC 0/0

TOTAL TRAFFIC LOAD          13575
DRY OPERATING WEIGHT        43963
ZERO FUEL WEIGHT ACTUAL     57538 MAX   62500     ADJ
TAKE OFF FUEL               12300
TAKE OFF WEIGHT   ACTUAL    69838 MAX   75500     ADJ
TRIP FUEL                    8500
LANDING WEIGHT    ACTUAL    61338 MAX   66000   L ADJ

BALANCE AND SEATING CONDITIONS          LAST MINUTE CHANGES
BI       52.1  DOI      52.4     DEST  SPEC  CL/CPT  + -  WEIGHT
LIZFW      64.9  MACZFW     31.2
LITOW      63.2  MACTOW     29.4
LILAW      65.6  MACLAW     31.1
FUEL DENSITY   0.770

A33.B46.C48.D33.JMP0
TAXI WGT   70038 MAX  75900
PAX WEIGHTS USED: A75.0 C38.0 I15.0        PANTRY  INTL/1570/6.3
UNDERLOAD BEFORE LMC       4662        LMC TOTAL
A/C TYPE: A320-200_8P/160Y
LOADMESSAGE AND CAPTAINS INFORMATION BEFORE LMC
CG LIMIT   ZFW FWD   41.67   AFT   84.67
           TOW FWD   36.36   AFT   91.66

LDM
PK217/16.APBLZ.P8/Y160.2/5
-AUH.159/1/1.T1597.1/0.3/1597.4/0.5/0.0/0
.PAX/6/154.DHC/0.PAD/0
SI FUEL DENSITY                       785
TEMP                                     23
LOAD SHEET PREPARED BY CLC PEW.
WEIGHT REPORT 48
AUH   C 0        M 0       B 0/1597      O 0        T 0

LANDING LIMITED TOGW 74500
```

# MEL REPAIR INTERVALS

| PAKISTAN International Airlines<br>**A320**<br>**MINIMUM EQUIPMENT LIST** | **MEL ITEMS**<br>**PREAMBLE**<br>REPAIR INTERVAL |
|---|---|

**REPAIR INTERVAL**

Applicable to: ALL

Inoperative items, deferred in accordance with the MEL, must be rectified at or before the expiration of the repair interval that is established by the following letter designators given in the "Repair Interval" column.

Repair Interval A : No standard interval is specified, however, items in this category shall be rectified in accordance with the dispatch conditions stated in the MEL.
Where a time period is specified in calendar days, it shall start at 00:01 on the calendar day following the day of discovery.
Where a time period is specified in number of flights or flight hours, it shall start at the beginning of the first flight following the discovery of the failure.

Repair Interval B : Items in this category shall be rectified within three (3) consecutive calendar days, excluding the day of discovery.
For example, if it were recorded at 13:00 on January 26th, the 3-day interval begins at 00:01 on January 27th and ends at 23:59 on January 29th.

Repair Interval C : Items in this category shall be rectified within ten (10) consecutive calendar days, excluding the day of discovery.
For example, if it were recorded at 13:00 on January 26th, the 10-day interval begins at 00:01 on January 27th and ends at 23:59 on February 5th.

Repair Interval D : Items in this category shall be rectified within one hundred and twenty (120) consecutive calendar days, excluding the day of discovery.

| PAKISTAN International Airlines<br>**A320**<br>**MINIMUM EQUIPMENT LIST** | **MEL ITEMS**<br>**AUTO FLIGHT**<br>FLIGHT CONTROL UNIT (FCU) - FCU CHANNEL |
|---|---|

| 22-81-03-01 | FCU Channel |
|---|---|

Applicable to: ALL

**22-81-03-01A Non ETOPS flight**

| Repair interval | Nbr installed | Nbr required | Placard |
|---|---|---|---|
| **C** | **2** | **1** | **No** |

One channel may be inoperative provided that:

**1)** ETOPS is not conducted, and

**2)** Two RMPs, all DUs, both RAs, both LGCIUs, both FACs, both Automatic Cabin Pressure Control Systems, all ADIRUs and the ISIS altitude indication are operative.

**22-81-03-01B ETOPS flight**

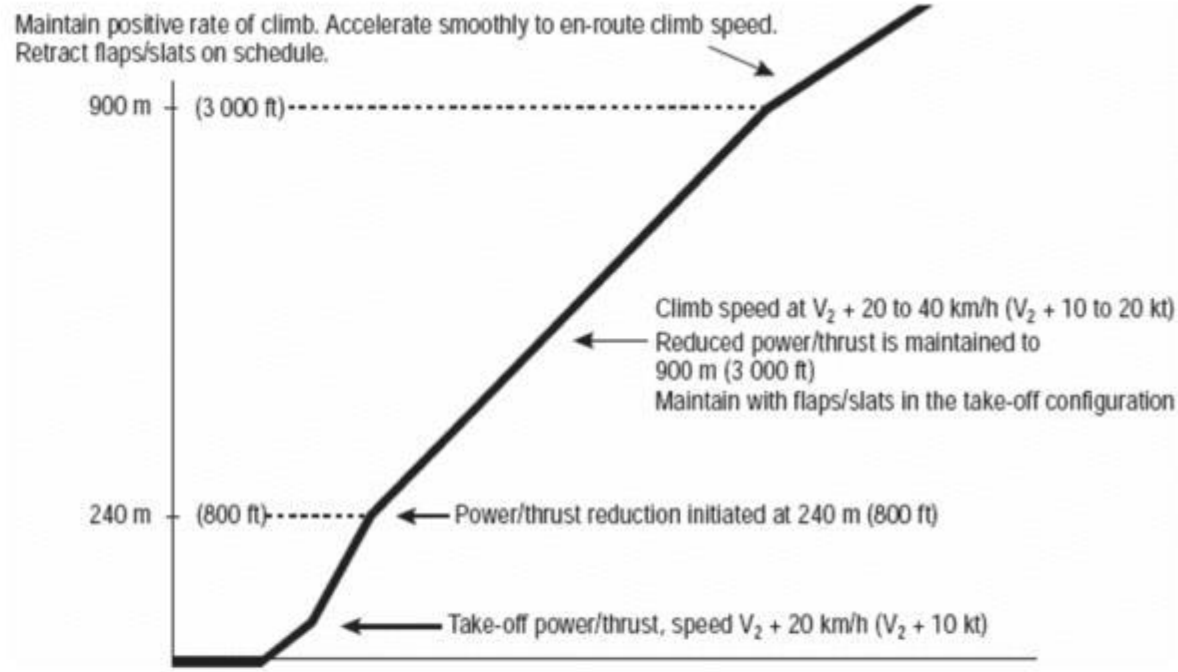
| Repair interval | Nbr installed | Nbr required | Placard |
|---|---|---|---|
| **A** | **2** | **1** | **No** |

For ETOPS, one channel may be inoperative for one flight provided that two RMPs, all DUs, both RAs, both LGCIUs, both FACs, both Automatic Cabin Pressure Control Systems, all ADIRUs and the ISIS altitude indication are operative.

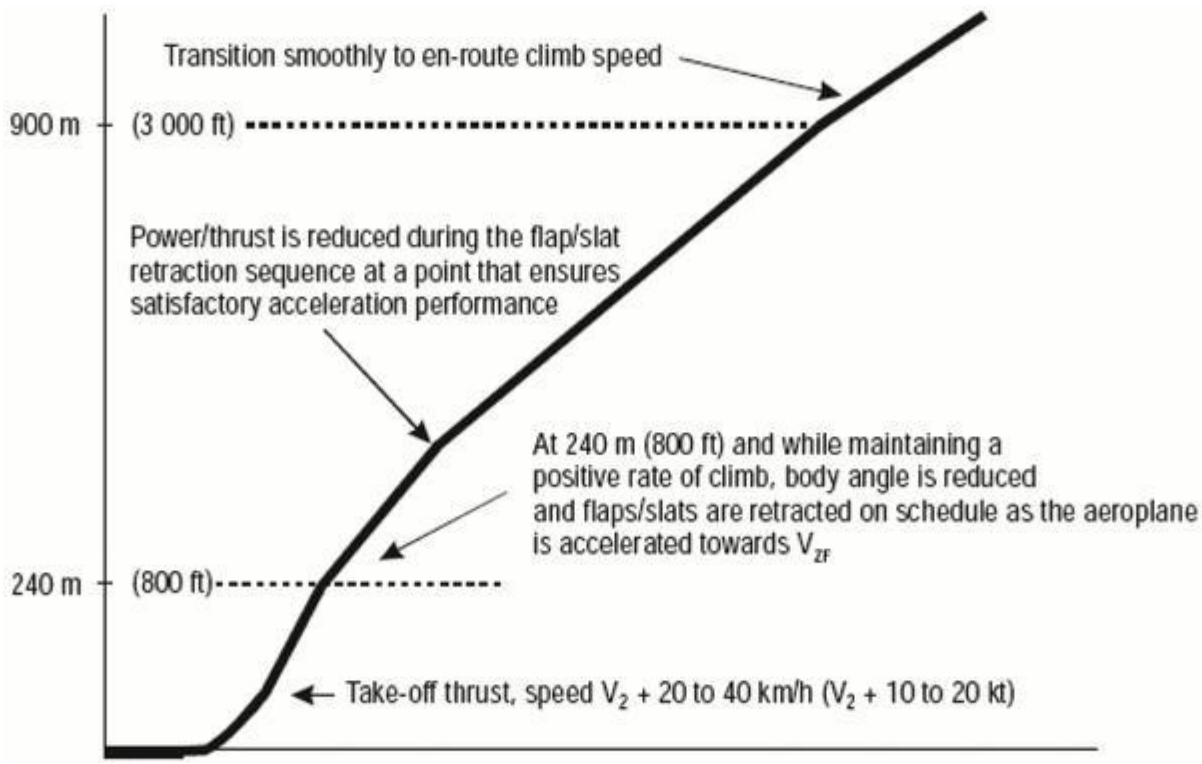
***Note: CDL (Configuration Deviation List) is given in AFM***

# NOSIE ABATEMENT

<u>NADP 1</u> – Alleviating noise close to the aerodrome




<u>NADP 2</u> - Alleviating noise distant from the aerodrome




***Note: Older NADP A and B are no longer part of the ICAO PANS-OPS Doc. 8168.***

For more details refer to: **http://www.theairlinepilots.com/forum/viewtopic.php?t=192**

# FMS RELATED STUFF

**FMS Pages:** For a quick review see: **https://www.theairlinepilots.com/forumarchive/a320/a320-fms-pages.pdf**

**Inflight Random Diversion:**

- Check the direct distance and fuel on FMS page: DATA > CLOSEST AIRPORT
- Secondary > Copy Active
- Lateral Revision from point of diversion > Change Destination
- Lateral Revision from point of diversion > Build the flight plan

**Changing a transition without changing the runway:**

Departure / Arrival have 2 pages. Transitions are on the second page. If you just want to change a transition without changing the runway, just go to next page and do it, instead of removing and adding the runway again.

**Maximum Altitude:**

- It is based on current engine and wing performance and does not take into account the cost aspect.
- Performance factors involved are current gross weight, temperature and assuming anti-ice off.
- It is the lower of the following two altitude:
  - Maximum altitude at maximum climb thrust with 300 ft/min vertical speed.
  - Maximum altitude at maximum cruise thrust in level flight.
- It provides the aircraft with a 0.3 g buffet margin.
- If the crew inserts a FL higher than REC MAX into the MCDU, it will be accepted only if it provides a buffet margin greater than 0.2 g. Otherwise, it will be rejected and the message "CRZ ABOVE MAX FL" will appear on the MCDU scratchpad. This message may also be triggered in case of temperature increase leading the aircraft to fly above the REC MAX FL.
- Unless there are overriding operational considerations, e.g. either to accept a cruise FL higher than REC MAX or to be held significantly lower for a long period, REC MAX should be considered as the upper cruise limit.
- If one engine is out, this field (REC MAX) in FMS displays the recommended maximum engine-out altitude, that is computed based on the long-range cruise speed and assuming that anti-ice is off.

**Optimum Altitude**

- It is based on best specific range i.e. maximum distance per kilogram of fuel and takes into account the cost aspect.
- Factors involved in its computation are based on:
  - Current gross weight.
  - Temperature and deviation from ISA.
  - Wind.
  - Cost index.
- This field (OPT ALT) in FMS displays dashes if an engine-out is detected.

**Changing the APD Factor**

The default code to change the APD factor in FMS is "ARM".

### Wind Entry for Step Altitude Computation

If there is a STEP in the F-PLN, ensure that wind is properly set at first waypoint beyond the step at both initial (the one cruising at) and step FL (the one you will be climbing to at step). If you don't have wind for the step level, insert the same for the level you were cruising on.

### Changing Origin / Destination in Secondary

A new flight plan can be created in the SEC flight plan inflight through its INIT & PERF pages. If a SEC flight plan already exists then origin / destination pair cannot be changed without first deleting the existing SEC F-PLN. Four-letter origin & destination is a must to create a new flight plan in secondary's INIT page. The new route created in secondary (or primary during preflight) can be stored by going to the stored routes page and then selecting "Store Secondary" (or primary).

### Creating a New Runway

To create a new runway first get the coordinates for the location where runway is to be made. This can be done on the FIX page by the Place/Bearing/Distance method to create a point and then noting its coordinates. Using these coordinates, you can then create a runway. NAVAIDS like ILS / VOR can then be added to this runway.

### IDENT for a Newly Created Runway

While creating a new runway, the runway IDENT comprises of the airport identification and the runway direction. You can use six or seven digits e.g. CYYZ24L and LFRJ08. A new runway is identified by the first 4 letters (ICAO airport identifier) of the runway ident although all 6 or 7 letters/digits have to be entered while creating the runway. First four letters can be any alphabets like even ABCD. So, if you created a runway ABCD36R and you want to use this as the origin airport for creating a new route to OPLA then in the origin/destination pair you will enter ABCD/OPLA.

### Diversion from an ETP

- First locate the ETP (DATA > EQUITIME POINT).
- It's given in the "Waypoint Name/ -Distance" format e.g. MOLTA/ -25 meaning that ETP is 25 nm short of MOLTA.
- Next create and insert a waypoint in the flight plan that corresponds to the ETP location. According to the above example it will be MOLTA/-25.
- From this created point (which corresponds to ETP location), carry out a lateral revision and change the destination.
- Then lateral revision from the same point to build the routing.

### Understanding the BIAS

Each FMGC computes a vector from its MIX IRS position to the radio position or GPIRS position. This vector is called the "BIAS". Each FMGC updates its bias continuously as long as a radio position or a GPIRS position is available. If an FMGC loses its radio/GPIRS position, it memorizes the bias and uses it to compute the FM position, which equals the MIX IRS position plus the bias. Until the radio or the GPIRS position is restored, the bias does not change. The flight crew can update the FM position manually. This also updates the BIAS.

### Position Update Prompt

If this feature is installed it is used for manual position update. It appears on the PROG page when you deselect the GPS from DATA > POS MONITOR > SEL NAVAID > DESELECT GPS.

### Indication of a Failed FMGC

Among other indications, it can be simply identified with FD status on PFD e.g. if no 2 FMGC fails then instead of 1FD2 the FD status on PFD will indicate 1FD1.

***Note: In managed guidance, FCU window is dashed. 45 secs for HDG/TRK and V/S & 10 secs for SPD/MACH.***

# PERFORMANCE

### Takeoff Performance

Refer to: **https://www.theairlinepilots.com/forumarchive/a320/a320-takeoff-performance.pdf**

### Landing Performance

Refer to: **https://www.theairlinepilots.com/forumarchive/a320/a320-landing-performance.pdf**

### Dry Check:

On wet and contaminated runways, the screen height is reduced to 15 feet (instead of 35 feet that is used for dry runways). Using the 15 feet screen height and/or reverse thrust for performance can sometimes (in some conditions) end up in max TOW (or flex temperature) to be higher than that obtained for a dry runway. Regulations do not permit max TOW to increase beyond dry takeoff weight. Therefore, it is mandatory to compare both dry and wet charts and retain the lower of the two weights (or flex temperature) and the associated speeds determined for a wet runway. This is known as dry check. There is no need to do a dry check if the top of the wet chart specifies "DRY CHECK" as comparison has already been inserted in the wet runway calculation.

### Contamination Greater than 3mm

Takeoff performance data for contamination greater than 3mm is not in FCOM. For dry/wet snow, water, slush less than 3mm consider it as wet (as per FCOM takeoff performance). For greater than 3mm contamination, use the performance software.

**QRH Performance** consists of:

- Landing.
- 1 engine out.
- Both engine performance.
- Flight without pressurization (cruise table LRC at FL100).
- MISC Conversions

# WEATHER RADAR

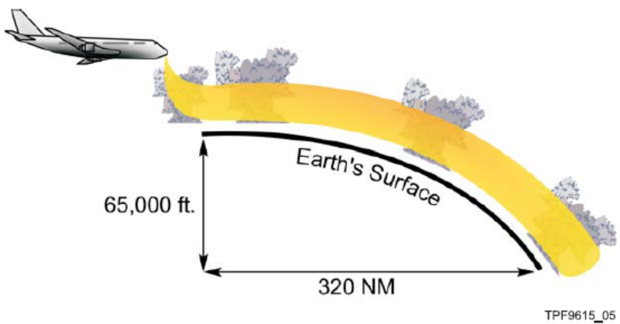
Collins WXR-2100, Multi Scan, Fully Automatic.



## THE IDEAL RADAR BEAM

Understanding thunderstorm reflectivity and the effect that radar tilt angle has on it allows us to envision a hypothetical ideal radar beam for weather threat detection. The ideal radar beam would look directly below the aircraft to detect building thunderstorms and then follow the curvature of the earth out to the radar's maximum range (figure 3-4). Thus, the ideal beam would keep the reflective part of all significant weather in view at all times, from right at the aircraft out to 320 NM.

*Figure 3-4 Ideal Radar Beam*




**NOTE**

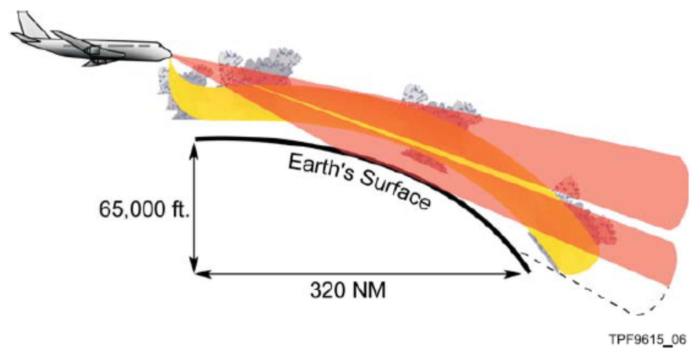
Note that the earth's curvature causes a drop of approximately 65,000 feet over a distance of 320 nautical miles.



## MULTISCAN EMULATION OF THE IDEAL RADAR BEAM

MultiScan emulates an ideal radar beam by taking information from different radar scans and merging the information into a total weather picture. Rockwell Collins' patented ground clutter suppression algorithms are then used to eliminate ground clutter. The result is the ability for flight crews to view all significant weather from 0 to 320 NM on a single display that is essentially clutter free (figure 3-5).

*Figure 3-5 MultiScan Emulation of Ideal Beam*




## THE MULTISCAN PROCESS

Figure 3-6 illustrates the MultiScan process. Two scans are taken, each optimized for a particular region in front of the aircraft. In general, the upper beam detects intermediate range weather while the lower beam detects short and long range weather by automatically adjusting the beams' tilt and gain settings (figure 3-7). The information is then stored in a temporary database. When the captain or first officer selects a range, the computer extracts the appropriate portions of the desired information, merges the data, then eliminates the ground clutter. The result is an optimized weather display for whichever range scale the flight crew selects.

*Figure 3-6 The MultiScan Process*

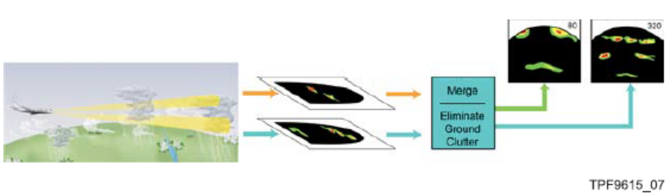



*Figure 3-7 MultiScan Upper and Lower Scan*

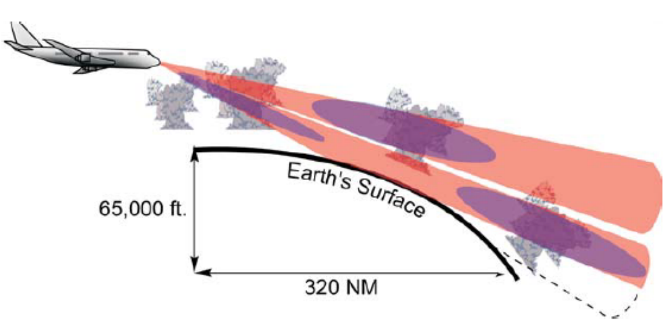



*Figure 3-10 MultiScan Display With GCS Off*

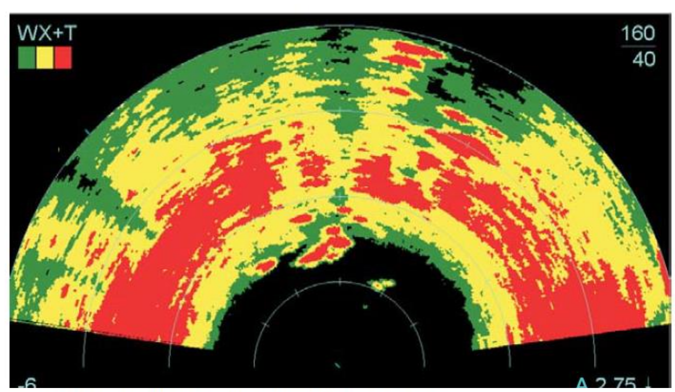



*Figure 3-11 MultiScan Display With GCS On*

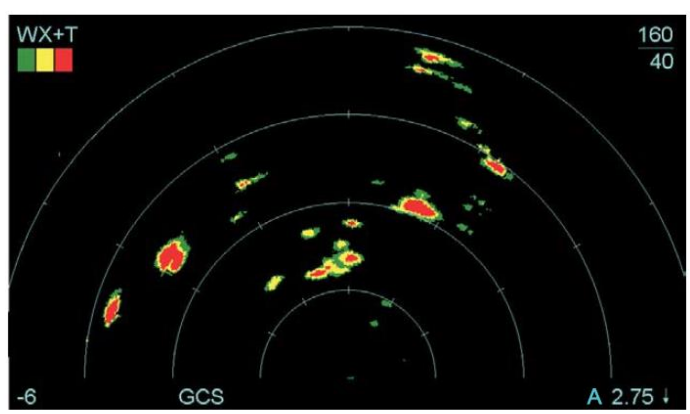


*Figure 4-1 Airbus Dual-System, Single-Function Control Panel, #622-5130-820*

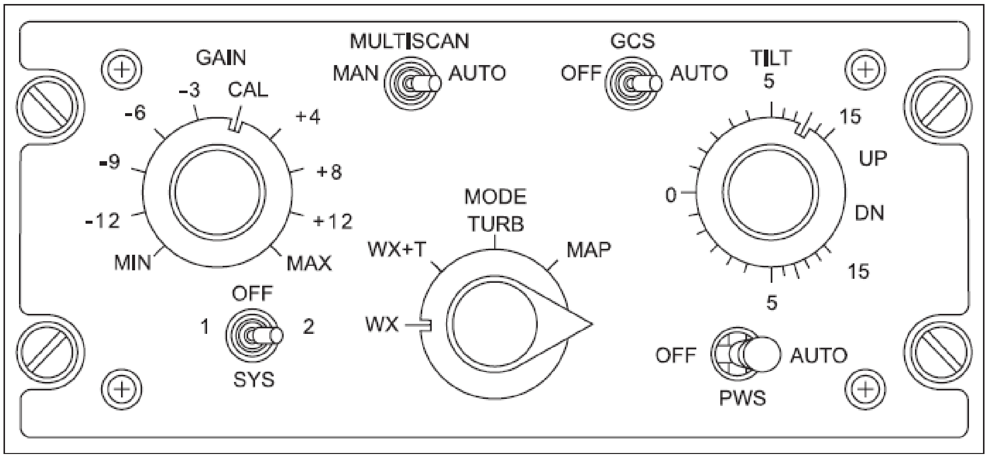
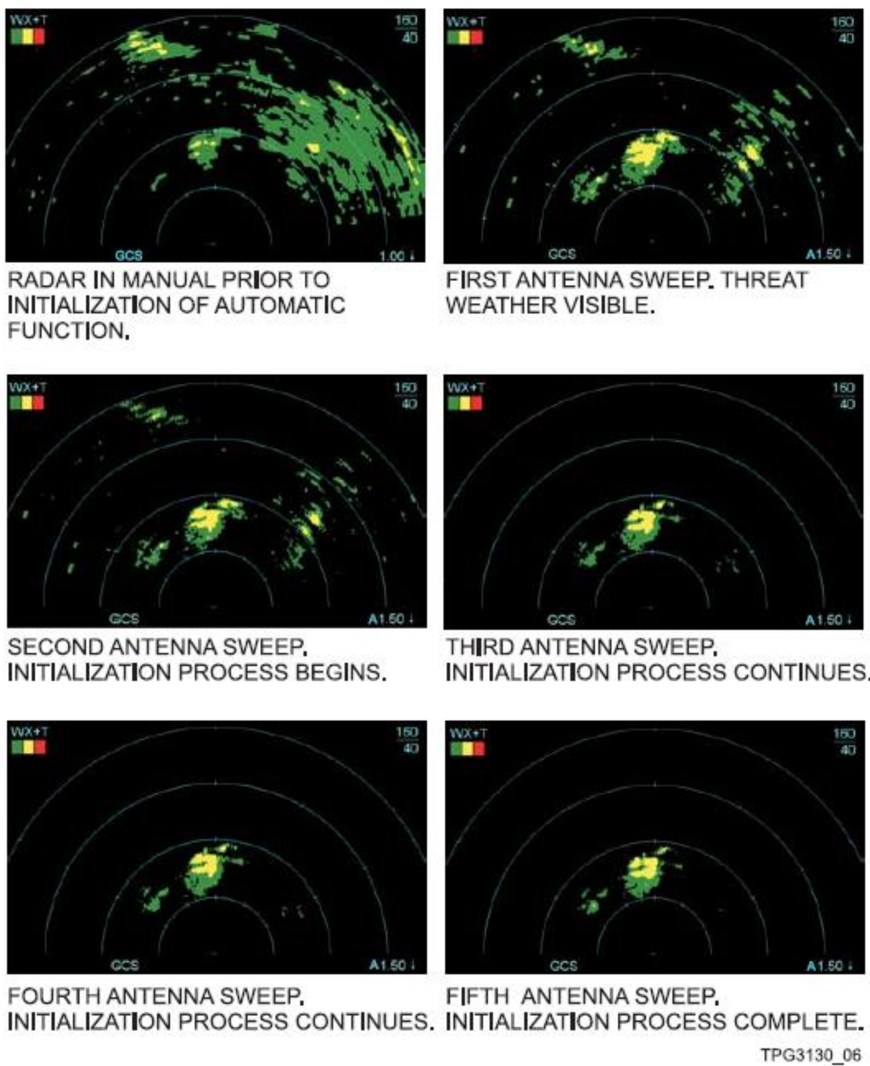



*Figure 4-13 MultiScan Initialization Process*




**NOTE**

MultiScan has a “coast” feature that allows the pilot to momentarily switch to manual, then back to automatic. If the pilot switches from auto to manual, then returns to auto within 38 seconds, the radar will remember the automatic settings and will not need to re-initialize.

### *PATH ATTENUATION COMPENSATION (PAC) ALERT*

If intervening rain fall creates an attenuated area, sometimes known as a radar shadow (♦page 6-27), PAC Alert places a yellow arc on the outer most range scale to warn the pilot of the attenuated condition (figure 4-41). PAC Alert is operative whenever the radar is being operated in **CAL** gain and the aircraft is within 80 NM of a thunderstorm.

**WARNING**

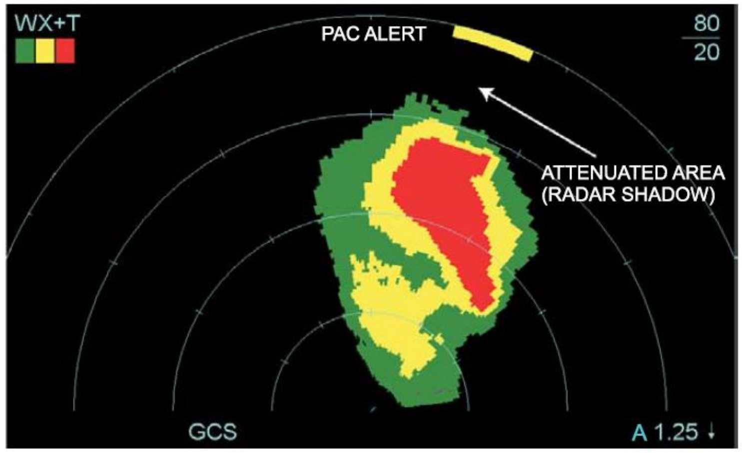
NEVER FLY INTO A RADAR SHADOW!

**CAUTION**

PAC Alert is disabled for all non-**CAL** settings.

**NOTE**

PAC Alert is activated during both automatic and manual radar operation.

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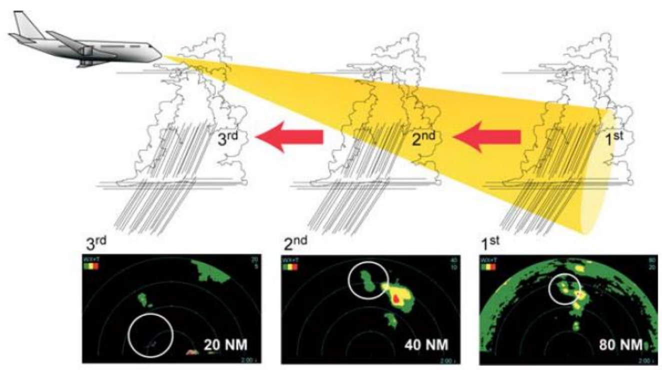
## *OVERFLIGHT PROTECTION*

Current generation radars tend to over-scan the reflective portion of thunderstorms (♦page 5-5) at cruise altitudes. When this occurs, the actual thunderstorm top may still be in the aircraft flight path and inadvertent penetration of a storm top is possible. Figure 4-42 shows traditional manual operation of the radar and illustrates this phenomena. In the first picture the air crew has selected an 80 NM range scale and adjusted tilt to place ground clutter in the outer most range scale (♦page 4-69). Two cells are clearly visible (circled) at 60 NM. In the second picture, the 40 NM range scale has been selected and the thunderstorm cells are now at 30 NM. Note that as the aircraft nears the thunderstorms the radar beam narrows and begins to move higher into less reflective areas of the cells. As a result, the intensity of the storms is decreased and the returns appear as green cells only. In the third picture the wet top (radar top) of the storms have fallen below the radar beam and the cells have disappeared entirely from the radar display although the actual (visual) top remains in the aircraft flight path.

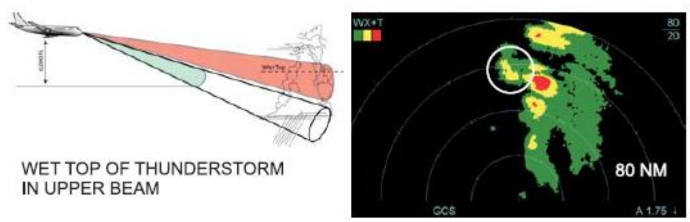
*Figure 4-42 Pitfalls of Over-Scanning Thunderstorms*




OverFlight protection is designed to prevent thunderstorms that are in the aircraft flight path from falling below the radar beam and off the radar display during high altitude cruise. At extended ranges the upper radar beam scans the wet, reflective portion of a thunderstorm in the same manner that conventional radars scan weather today. As the aircraft approaches the storm and the cell begins to fall below the upper radar beam, MultiScan utilizes 6,000 feet of bottom beam information to keep the reflective part of the storm in view. Within approximately 15 NM of the aircraft MultiScan compares the stored digital image of the thunderstorm with the latest sweep information and displays whichever return is greater. If a cell that is a threat to the aircraft begins to fall below the radar beam MultiScan displays the stored digital image (figure 3-6) of the storm, thus ensuring that any threat thunderstorm will remain on the display until it moves behind the aircraft. OverFlight protection is operational above 22,000 feet MSL.

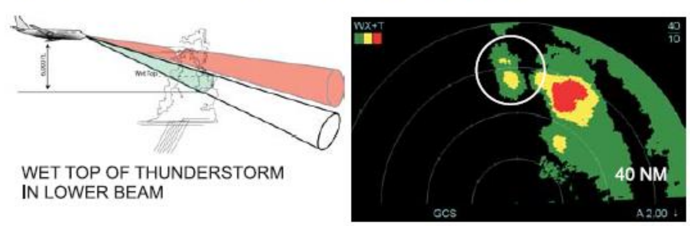
Figures 4-43 through 4-46 illustrate OverFlight functionality. Compare the MultiScan weather returns with the manual returns in figure 4-42 for a clearer understanding of OverFlight benefits.

*Figure 4-43 Wet Top of Thunderstorm in Upper Beam*




TPG3130_11

*Figure 4-44 Wet Top of Thunderstorm in Lower Beam*




TPG3130_12

*Figure 4-45 Wet Top of Thunderstorm in Memory*

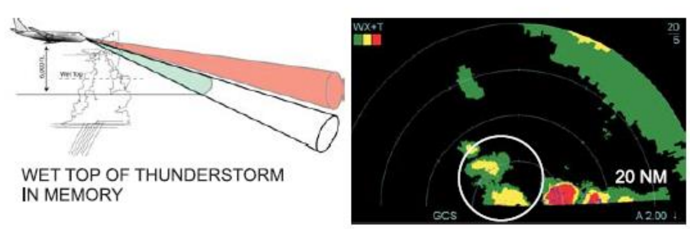
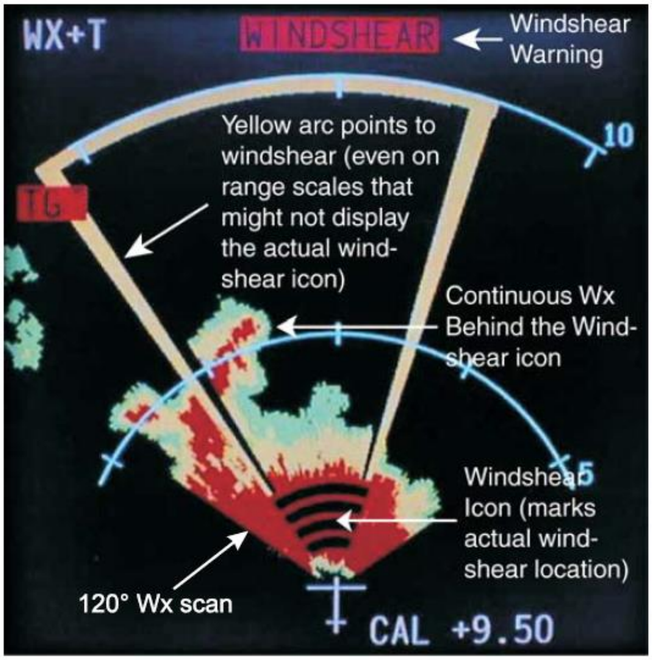


*Figure 4-49 Windshear Alert and Displays*




*Windshear Alert Table*

| Alert Type | Aural Alert | EFIS Visual Alert | EFIS Icon Alert |
|---|---|---|---|
| Warning | "Windshear Ahead" or "Go Around, Windshear Ahead" | WINDSHEAR or W/S AHEAD or WINDSHEAR AHEAD | Windshear Icon* and Weather |
| Caution | "Monitor Radar Display" | WINDSHEAR or W/S AHEAD or WINDSHEAR AHEAD | Windshear Icon* and Weather |
| Advisory | None | None | Windshear Icon* and Weather |

*** Windshear Icon – Alternating red and black horizontal arches indicating the actual location of the Windshear Event (figure 4-49).**

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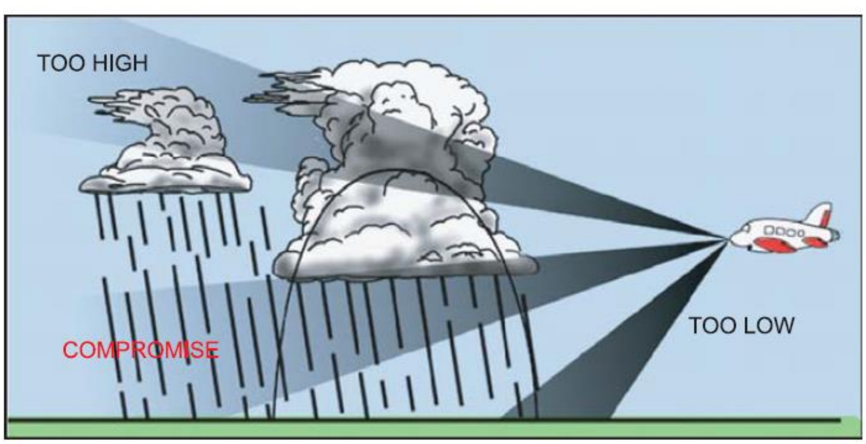
## *TILT CONTROL*

The **TILT** control is active only during MANUAL operation and allows the flight crew to adjust the antenna tilt for the best display. During MultiScan AUTOMATIC operation, the **TILT** control is not active since the antenna tilt settings are managed automatically by the MultiScan function.

Tilt control is **the most important factor** for proper manual operation of the radar. In most instances, the flight crew is looking for a compromise tilt angle between too much ground return and too little weather return (figure 4-61 and ♦page 5-6). The best tilt setting will vary depending on the aircraft phase of flight (i.e., low altitude, mid altitude and high altitude). Recommended tilt settings for the various phases of flight are discussed in the scenarios that follow.

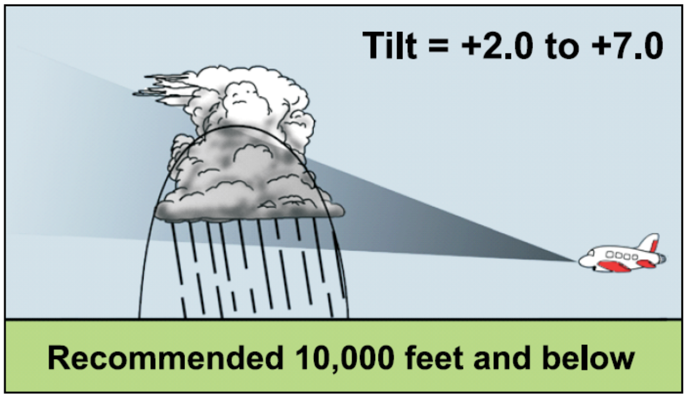
*Figure 4-61 Tilt Setting Compromise*



***LOW ALTITUDE TILT SETTINGS (10,000 FT AND BELOW)***

Below 10,000 feet, a tilt setting of between +2° and +7° is recommended with +5° being a good compromise setting. Below 10,000 feet, the flight crew is busy with a variety of tasks from completing checklists to talking with approach/departure control. Setting a +5° tilt and leaving it set through 10,000 feet reduces cockpit work load. The +5° setting will eliminate most ground clutter and detect the majority of the weather in the immediate vicinity of the aircraft (figure 4-62). The two topics that follow (Climb and Descent) explain the logic behind these guidelines, and when a +2° tilt setting and a +7° tilt setting might be appropriate.

*Figure 4-62 Recommended Tilt For Low Altitude*



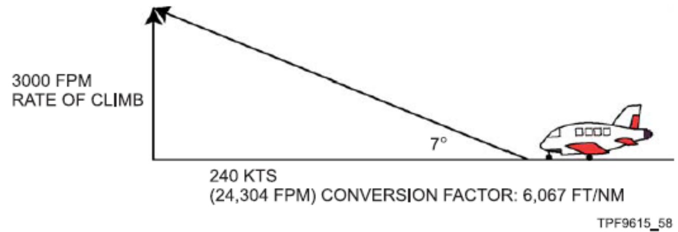

**CAUTION**

Caution: If the tilt setting is too high, the radar beam may scan above the radar tops (♦page 5-5) of thunderstorms that are a threat to the aircraft. If the tilt is too low, the radar may not detect vaulted thunderstorm energy (♦page 5-15).

***CLIMB***

It is typical for a two engine air transport category aircraft to climb out after takeoff at approximately 240 knots with a 3000 fpm rate of climb. This equates to a 7° climb angle from the horizontal (figure 4-63). Therefore, a +7° tilt setting keeps the radar aligned along the aircraft flight path, alerts the crew to potential penetration of vaulted thunderstorm areas (♦page 5-15) and eliminates ground clutter.

*Figure 4-63 Climb Out Flight Path*




The drawback to a +7° tilt is that weather detection is limited to the general vicinity of the aircraft. This can be shown using the general formula that says 1° of tilt gives you 100 feet per NM of beam position change. For instance, with a +7° tilt the center of the beam is at 24,500 feet at 35 NM.

**TECH DETAIL**

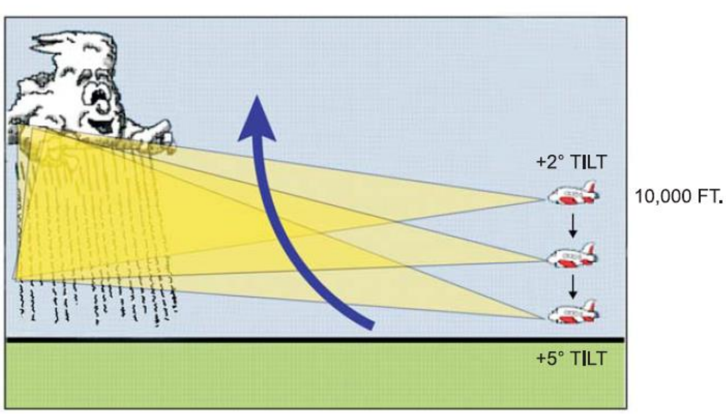
1° of tilt at 35 NM yields 3,500 feet of beam position change. Multiply 3,500 by 7 (due to the 7° of tilt). The result is the 24,500 feet used in the above paragraph.

This means that if the radar top of the thunderstorm is less than 24,500 feet, it may not be displayed on the radar. At 50 NM, the center of the beam is at 35,000 feet, and the majority of the weather at this range will not be visible due to the fact that the radar is looking at the top (♦page 5-5) of storms at this range. Since the radar beam is approximately 3.5° wide (♦page 6-20), a +5° radar tilt angle provides a good compromise because it keeps the outer edge of the radar beam pointed close to the aircraft flight path and provides marginally better weather detection ranges.

***DESCENT***

Below 10,000 feet, a +5° tilt angle remains the best compromise for descent if cockpit work load is heavy. This tilt angle will detect most weather while at the same time eliminating the majority of ground clutter. The benefit to this method is that the tilt setting can be set and forgotten during the critical approach and landing phase of flight. However, it is possible to descend into thunderstorms that are developing below the aircraft flight path and are under the radar beam. Therefore, an alternate tilt procedure for descent below 10,000 feet is to initially set a +2° tilt setting, then gradually raise it to +5° as the aircraft descends to lower altitudes (figure 4-64).

*Figure 4-64 Recommended Tilt Settings For Descent*




*The **bounded weak echo region**, also known as a **BWER** or a **VAULT**, is a radar signature within a thunderstorm characterized by a local minimum in radar reflectivity at low levels which extends upward into, and is surrounded by, higher reflectivity aloft. This feature is associated with a strong updarft and is almost always found in the inflow region of a thunderstorm. It cannot be seen visually.*

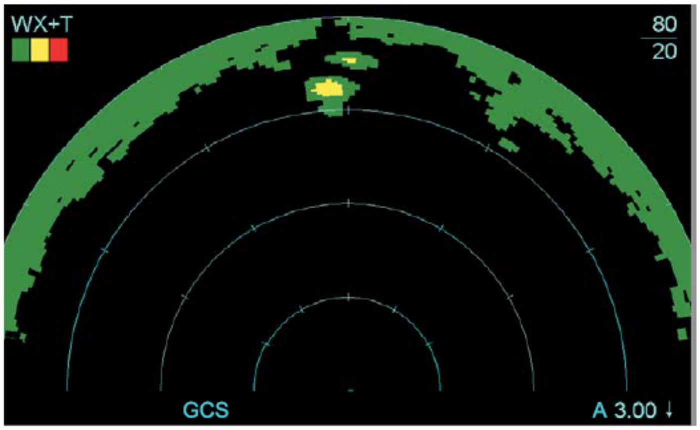
*The BWER is a nearly vertical channel of weak radar echo, surrounded on the sides and top by significantly stronger echoes. The BWER, sometimes called a vault, is related to the strong updraft in a severe convective storm that carries newly formed atmospheric particulates, called hydrometeors, to high levels before they can grow to radar-detectable sizes.*

### *MID ALTITUDE TILT CONTROL (10,000 – 25,000 FT)*

For overland operation at mid altitudes, the best general guideline is to tilt the antenna until a small amount of ground return appears at the outer edge of the display. When operating over water ground clutter may more closely resemble the clutter in figure 4-68, regardless of which range scale is selected. Should ground clutter be insufficient for determining the appropriate tilt angle during over water flight, the table on page 4-72 provides suggested tilt angles for different altitudes.

Figure 4-68 shows the radar set to the 80 NM range scale. Antenna tilt is adjusted so that ground return is displayed in the outer most range scale. Note that this picture will look the same when the 40 NM range scale is selected and clutter is displayed in the outer most range scale.

*Figure 4-68 Radar at 80 NM, Mid Altitude*




### *HIGH ALTITUDE TILT CONTROL (25,000 FT AND ABOVE)*

At higher altitudes thunderstorm tops can be all but invisible to radar. When outside air temperature falls below -40 °C, thunderstorm tops are formed entirely of ice crystals and reflect very little radar energy (♦page 5-5). Significant down tilt is required to ensure that the radar beam is picking up the more reflective part of the storm that is at lower altitudes.

Over land ground clutter can be used to determine proper tilt within 160 NM of the aircraft. For longer range targets, special procedures must be used (♦page 4-79). Within 160 NM, tilting the radar so that some ground clutter appears in the outer most range scale keeps the antenna pointed towards the reflective portion of the thunderstorms that are towards the outer edge of the selected range scale (see figures 4-68 and 4-69).

Note that while over-scanning (♦page 4-40) of thunderstorms may be a problem at low and mid altitudes, the problem becomes a significant threat at high cruise altitudes. Many pilots use tilt settings based on the 80 NM range scale during high altitude cruise. However, at high altitudes this setting only optimizes weather returns between approximately 50-80 NM. Significant weather may be present in the 0-50 NM area. Over-scanning and subsequent inadvertent thunderstorm top penetration is a significant concern. Targets inside 50 NM may be over-scanned and disappear from the display but still cause significant turbulence. To view targets inside the 50 NM range, large down tilt settings are necessary. The large down tilt may prevent more distant storms from being detected, and in overland operations, will cause excessive ground clutter to appear.

**NOTE**

Several pilot techniques that can be used to avoid over-scanning threat weather can be found in the Over-Scan Prevention Techniques section on ♦page 4-72.

**WARNING**

Over-scanning and the resulting inadvertent thunderstorm top penetration is a significant threat during high altitude operations.

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*Recommended Over Water Tilt Settings*

| Altitude (feet) | 40 NM | 80 NM | 160 NM |
|---|---|---|---|
| 40,000 | -7° | -3° | -2° |
| 35.000 | -6° | -2° | -1° |
| 30,000 | -4° | -1° | 0° |
| 25,000 | -3° | -1° | 0° |
| 20,000 | -2° | 0° | +1° |

**NOTE**

Lower tilt settings may be required due to the non-reflective nature of oceanic weather (♦page 5-16).

## *OVER-SCAN PREVENTION – PILOT TECHNIQUES*

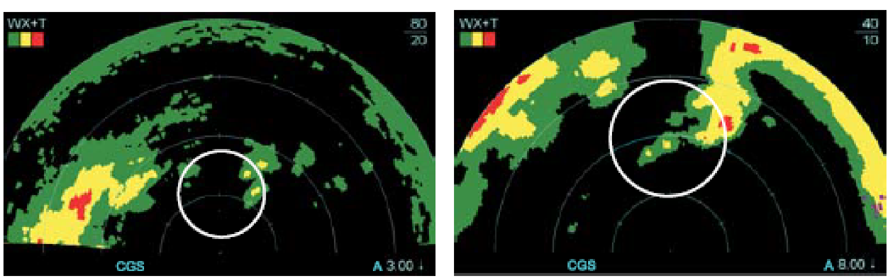
**Method 1**: One pilot technique that is used to judge which storms are a threat and which are not when using the 80 NM range scale is to use the 40 NM range (the mid point on the display) for a decision point criteria. If the storm stays in the radar beam (i.e., is painted on the display) through 40 NM, then it should be considered a potential threat and avoided. Thus, a storm cell that disappeared from the display at 40 NM is still a potential threat. The position should be tracked mentally and avoided.

**Method 2**: For aircraft equipped with a split function control panel (♦page 4-2), another technique can be used to reduce the threat of over-scanning significant weather. In this case one pilot should utilize the 80 NM range scale (or higher) with a tilt setting that places ground clutter in the outer most range scale while the second pilot utilizes a 40 NM range (or less) with an increased down tilt that places clutter in the outer range scale of the 40 NM display. Use suggested mid and high altitude tilt settings over water when ground return is not present.

The 80 NM range is then available to help plan any required course changes and the shorter range can be used to prevent over-scanning and inadvertent thunderstorm top penetration.

The left picture shows the radar display with the aircraft at 35,000 feet with 40 NM range selected. The picture on the right shows the radar display at the same altitude, but with 80 NM range selected. Note the cell directly in the aircraft path that has disappeared from the 80 NM range scale.

*Figure 4-70 Radar Displays Using Split Function*




TPG3130_20

**Method 3**: The threat of over-scanning can be reduced by periodically selecting the 40 NM range scale and adjusting the tilt so that some clutter appears in the outer most range scale. Observe potential target threats in this region. Then switch to the 80 NM range scale and adjust the tilt upwards until ground clutter is once again in the outer range scale only. Continue adjusting the range and tilt until the desired range scale is in use. Repeat the procedure periodically or when the location of thunderstorms within 40 NM of the aircraft needs to be determined.

**Method 4**: Another way to detect possible impending turbulence is through using a combination of **MAX** gain and tilt control. Setting the tilt to zero and the gain to **MAX** may allow the radar to see the ice crystals that compose the top of the thunderstorms (figure 4-71). If ANY weather is detected in front of the aircraft, then adjust the tilt downward to see if the weather return grows in intensity (figure 4-72). If it does, you can be fairly sure that you are approaching the glaciated (composed of ice crystals) top of a thunderstorm cell.

### *STORM HEIGHT ESTIMATION (RADAR TOP ONLY)*

**WARNING**

Although the following formula is valid for estimating the wet tops of storm cells within 100 miles, pilots should be aware that the weather radar will not “paint” frozen dry top precipitation such as snow or hail (due to low reflectivity). These low reflectivity targets are frequently accompanied by severe turbulence. This fact should be taken into account – for this reason it is not recommended that pilots attempt to overfly or underfly storm cells.

The height of the radar top or wet top (♦page 5-5) of a thunderstorm can be estimated by raising the tilt until the storm disappears from the radar display (figure 4-73). Height is then equal to the aircraft altitude + (antenna tilt x distance x 100).

**WARNING**

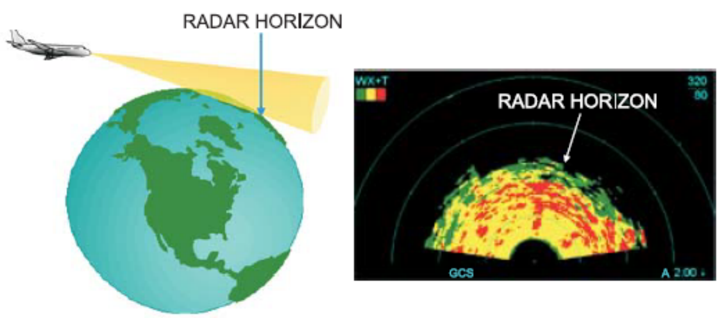
The top of the precipitation activity is not necessarily the top of the danger area. Dangerous turbulence frequently exists at altitudes significantly above the altitude at which detectable precipitation is formed.

## *LONG RANGE (OVER THE HORIZON) WEATHER DETECTION*

The ability to gather strategic weather information out to 320 NM is possible if proper tilt procedures are utilized. First one must realize that over a distance of 320 NM the curvature of the earth causes the earth’s surface to fall away by approximately 65,000 feet. Thus, if the aircraft is at 25,000 feet at its current position, the earth’s surface is actually 90,000 feet below the aircraft at 320 NM distance. If common practice is followed and the tilt is adjusted to eliminate the majority of ground clutter, the radar beam will scan over the top of long range weather and distant thunderstorms will remain undetected (see figure 4-75).

The radar horizon is the point where earth’s surface has dropped below the radar beam and ground return is no longer displayed.

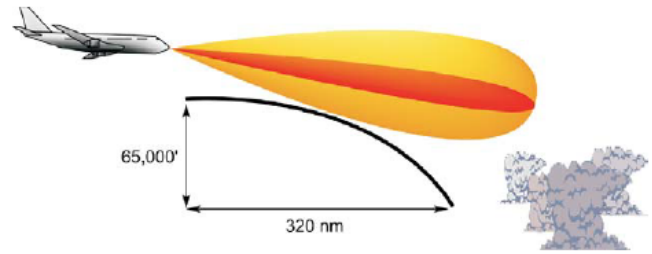
*Figure 4-75 TILT Set To Scan Radar Horizon*




TPF9615_65

If common practice is followed and the tilt is adjusted to eliminate the majority of ground clutter, the radar beam will scan over the top of long range weather (see figure 4-76). In most cases, eliminating ground clutter from the radar display limits weather detection to between 120 and 140 NM.

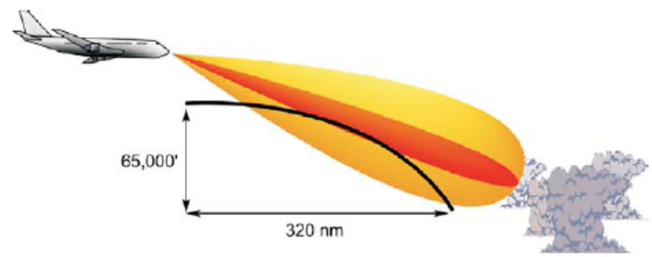
*Figure 4-76 Long Range Scan With Minimal Down Tilt*




TPF9615_63

To detect long range weather, the radar beam should be adjusted so that it “peeks” over the radar horizon. Adjusting the tilt so that the radar beam is centered on the horizon directs the center of the beam towards the threat weather and allows long range weather to be displayed (see figure 4-77).

*Figure 4-77 Long Range Scan With Increased Down Tilt*




TPF9615_64

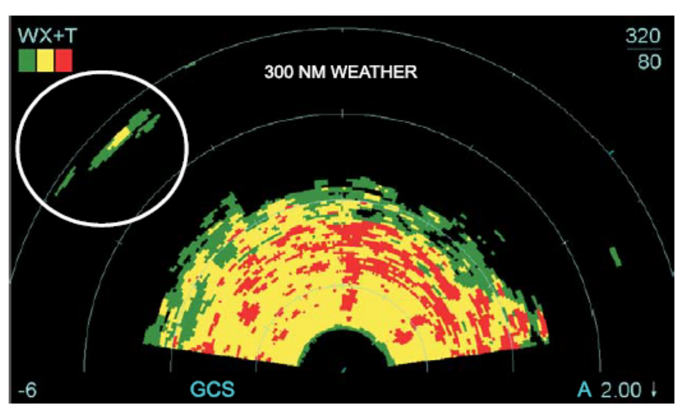
One technique that can be used for long range weather detection is to adjust the tilt downwards until ground clutter first begins to appear at the radar horizon. Then adjust the beam an additional 2° down. This will position the center of the beam near the radar horizon. If you are over water and ground clutter is not present, the approximate tilt angle to center the beam on the radar horizon can be calculated using the following formula: Angle to the horizon = – 0.0167 times the square root of the altitude.

*Tilt Angle to Horizon Settings*

| Altitude (feet) | Angle to Horizon |
|---|---|
| 44,000 | – 3.50° |
| 38,000 | – 3.25° |
| 32,000 | – 3.00° |
| 27,000 | – 2.75° |
| 22,000 | – 2.50° |
| 18,000 | – 2.25° |

Figure 4-78 shows the end result. The aircraft is at 23,000 feet. A down tilt of -2° has been selected by the pilot. Intermediate weather is masked by the ground, but long range strategic weather is now clearly visible at 300 NM. The radar horizon is at 186 mile (see formula above for calculations). Ground clutter is not displayed beyond this point.

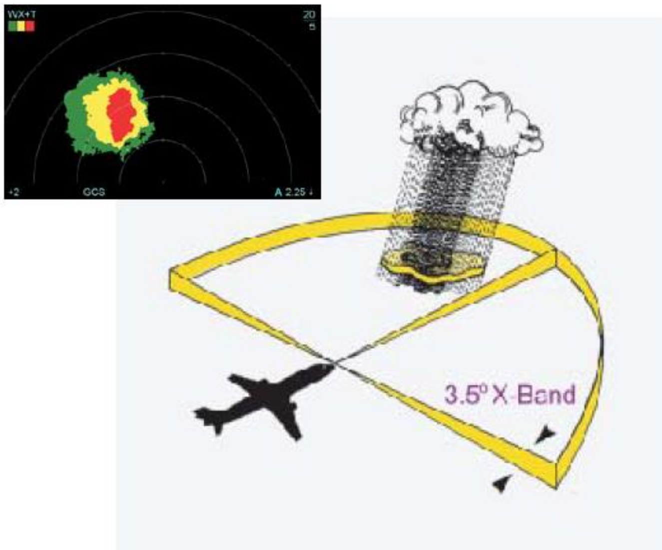
*Figure 4-78 Weather Return Visible At Edge of Radar Horizon*



## RADAR BEAM CHARACTERISTICS

The MultiScan radar uses a 28-inch antenna that produces a 3.5°-wide beam. As the beam sweeps through a thunderstorm at close range, it takes a “slice” out of the target and then displays that slice on the radar display (figure 6-20). The displayed weather presentation can change significantly based on the selected radar tilt and from where in the storm the slice is taken from (♦page 5-7).

*Figure 6-20 Weather Radar Beam “Slice” and Resulting Display*




## BEAM DIAMETER

A 28-inch flat-plate antenna produces a 3.5°-wide beam. At ranges less than 80 NM, this produces a fairly narrow and well-focused beam. Beyond 80 NM, the beam diameter increases until at 300 NM it is equal to 105,000 feet (figure 6-21). To put this into perspective, at this distance, it would take a storm cell over 22 NM tall and wide to fill the beam.

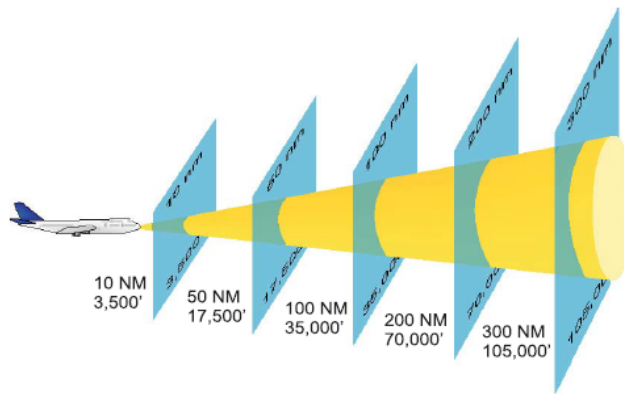
Because the beam remains fairly focused within 80 NM of the aircraft (and for reasons that will be mentioned in the next section), it is recommended that weather evaluation be done only when the weather is within 80 NM of the aircraft. Beyond 80 NM, the radar should be used primarily for strategic planning and weather avoidance.

The following formula can be used to calculate the approximate beam width at any range:

Beam width (in feet) = (Distance in NM + “00”) x 3.5

For example, to determine the width of the radar beam at 50 NM out from the aircraft, take the 50 NM distance and then add “00” to it for a result of 5,000. Multiply this figure by 3.5 to yield an approximate beam width of 17,500 feet at 50 NM.

*Figure 6-21 Weather Radar Beam Width Increases Over Distance*



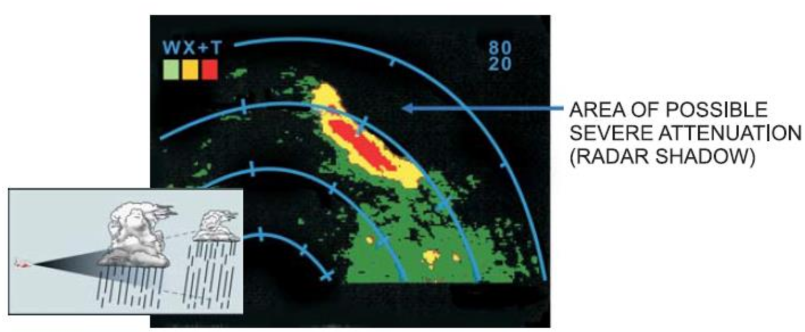

## PATH ATTENUATION (RADAR SHADOW)

When intervening rainfall becomes heavy the radar beam may be so severely attenuated that there is not enough energy to penetrate the weather, see what is behind, and then return to the aircraft (see figure 6-29). When this situation occurs, weather behind the intervening rainfall will be masked. This area of hidden weather is often referred to as an area of radar shadow.

Several characteristics of the displayed weather may give clues to attenuated areas. In figure 6-29, the display shows a normal green, yellow and red pattern on the front side of the thunderstorm. However, the backside of the storm shows red and yellow and no green. The concave shape on the back of the storm also points to a possible area of severe attenuation. Finally, the absence of ground clutter behind the cell is a third indication that the area behind this cell may be an area of radar shadow.

In order to evaluate the area behind the storm, lower the tilt until significant ground clutter appears on the display. If there is clutter to the right and left sides of the thunderstorm, but the area behind the cell remains black, then the radar beam has experienced severe attenuation in this region and a radar shadow exists.

*Figure 6-29 Weather Display with Radar Shadow*



## HONEYWELL RDR-4000

Some aircraft (e.g. AP-BMX) have got the RDR-4000 weather radar installed in them. The main differences to understand from operational point of view are:

- Automatic control of antenna tilt for reduced pilot workload
  - No traditional tilt control.
- 3D (Three-Dimensional) Volumetric Memory
  - The entire sky in front of aircraft is automatically scanned (out to 320 nautical miles (nm) and from ground to 60,000 feet (ft))
  - All weather information is stored and continuously updated.
  - Automatically corrects for curvature of the earth.
  - Pilots can choose among display options as desired.

Operating Procedures for:

1) Takeoff & Departure
2) Climb up to FL200
3) Descent & Approach

- System Control: L or R (dual system) or NORM (single system)
- Mode: AUTO
- Gain: CAL or as required to assess threats.
- Range: Pilot Flying – 10 to 40 nm, other side at least one range higher.

Operating Procedures for:

**CRUISE ABOVE FL200**

- System Control: L or R (dual system) or NORM (single system)
- Mode: AUTO
- Gain: CAL or as required to assess threats.
- Range: Pilot Flying – 20 to 80 nm, other side at least one range higher.
- Within 60 nm sufficient resolution exists for evaluating cells. At these ranges Flight Path and Secondary Weather will become more prominent and MAN mode can be used for vertical analysis.


The RDR-4000 has the ability to show two different radar display views simultaneously. The left side of the control panel controls the left side display (Captain) and the right side of the control panel controls the right side display (First Officer). The flight crew can operate each side independently without impacting radar performance, achieving maximum weather information display.

**MAN –** Manual Constant Altitude (Weather Analysis) mode. The altitude slice defaults to current altitude on MAN selection. It provides detection of windshear out to 5 nm and displays weather out to 320 nm. If Hazard Display is installed, turbulence is shown out to 60 nm, and lightning, hail, and REACT indications are shown.

**ALT –** Controls weather analysis altitude from 0 to 60,000 ft MSL in increments of 1,000 ft. Selected altitude is shown on the Electronic Flight Display.

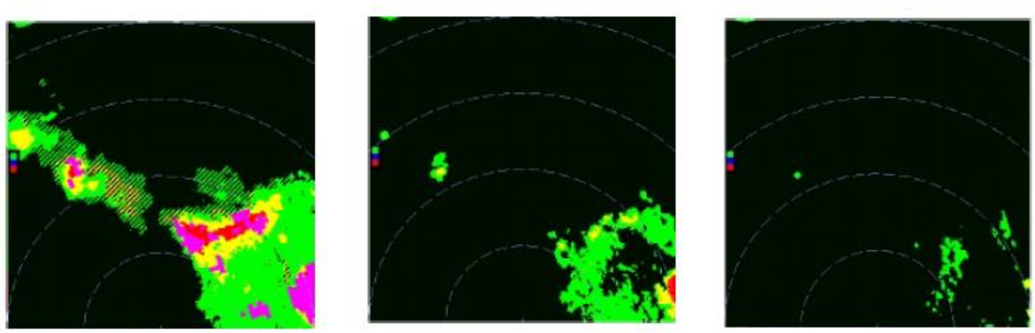
## *MANUAL WEATHER ANALYSIS MODE (MAN): CONSTANT ALTITUDE*

Constant altitude mode is an analysis mode that provides a constant altitude slice throughout the entire 180-degree plan view. It is called constant altitude because the altitude slice extracted from the memory is corrected for the earth's curvature. With traditional tilt angle settings the earth curves away from the beam far from the aircraft making it difficult to exactly measure the height of a cell. The Constant Altitude view provides a plan view that represents a thin slice through the volumetric memory of weather reflectivity data. This view is corrected for the curvature of the earth (i.e., it is a view at a constant MSL altitude level).

The altitude slice is selected by the ALT knob on the control panel. The altitude is selectable between zero and 60,000 ft in 1,000-ft increments.

On activation of the MAN mode, the slice at the current aircraft altitude (rounded to the nearest 1,000 ft) is chosen. The view does not move up or down when the aircraft altitude changes. The pilot can quickly measure the tops of cells without any calculations. By varying the selected altitude until a cell just disappears, the cell height can be directly read from the display.

**CONSTANT ALTITUDE MODE EXAMPLE USING VARYING ALTITUDES**



**AUTO MODE** | **MAN MODE: SLICE AT 25,000 FT** | **MAN MODE: SLICE AT 30,000 FT**

## EMERGENCY EQUIPMENT CHART

Available in aircraft document file.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