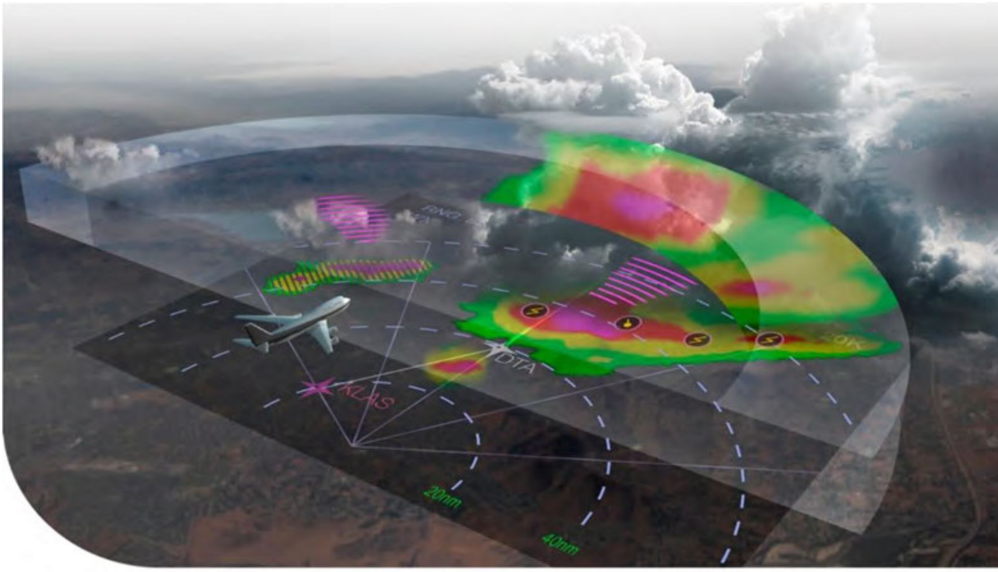
Honeywell

IntuVue™ RDR-7000



IntuVue 3-D Automatic Weather Radar System

For Fixed Wing Aircraft

Pilot's Guide

NOTE

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SECTION 1: INTRODUCTION

Welcome to Honeywell'sIntuVue 3-D Automatic Weather RadarSystem, the RDR-7000. The RDR-7000 introduces several innovative technologies not found in previous generation Radar Systems. Some of the major operational differences arehighlighted here. Note that the availability of some features will depend on the installation configuration.

RDR-7000 OPERATIONAL ENHANCEMENTS

- Automatic control of antenna tilt for reduced pilot workload
  - No traditional tilt control.
- 3D (Three-Dimensional) Volumetric Memory
  - The entire area 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.
- Predictive Hail and Lightning Icons (if installed)
  - Areas ahead of the aircraft that have a high probability of producing hail or lightning are indicated by the display of appropriate icons.
- REACT (Rain Echo Attenuation Compensation Technique)
  - Indicates areas where attenuation of the radar signal is severe enough to degrade the ability to display weather behind significant intervening weather.
- Vertical Display (if supported by display system)
  - Indicates reflectivity along the flight plan or a selected azimuth
- Weather/Turbulence Ahead Indication (if installed)
  - Annunciates situations where significant weather or turbulence is detected ahead of the aircraft, but is not selected for display.
- GMAP mode for identification of terrain features
  - Use GMAP mode for identifying prominent terrain features, such as coastlines, lakes, and large built-up urban areas.
- Internal TopographicalInformation
  - Used to remove ground clutter from weather displays and to remove weather returns from the GMAP display.
- More sensitive weather detection for more accurate weather depiction
  - Improved long-range performance.
  - 3D scanning detects more weather close to the aircraft as compared to other weather radar systems.

- Differentiation of weather in and out of path of the aircraft
  - In WX ALLmode, weather that is far above or below the aircraft’s flight path (Off Path) is displayed in a different pattern than On Path weather.
  - In WX PATH mode (if installed), the display of weather that is Off Path is suppressed. Only the weather that is relevant to the flight path is shown.
  - In WX MAN (manual altitude)mode, view horizontal slices through the weather in 1,000-foot increments, from ground level to 60,000 feet.
  - In MANUAL AZIMUTH mode, view the weather along a selected azimuth on the vertical display.

OPERATIONAL LIMITATIONS AND CONSIDERATIONS

The RDR-7000 is a technologically advanced system. As with any such system, the limitations of the technology and the constraints of the operating environment come into play. The limitations of the radar system have been consolidated here because of their importance. This section should be read thoroughly and frequently as a reminder of weather radar limitations.

- Aviation weather hazard detection, analysis, and avoidance are the primary functions of the radar system. Airborne weather systems are not intended as a terrain or traffic collision avoidance system.
- Your radar is a weather avoidance tool. It should never be used for weather penetration. It will help you see and plan avoidance maneuvers around significant weather encountered during flight.
- Radar detects raindrops, hail, and ice particles. It does not detect clouds or fog.
- Radars detect the presence of precipitation. Storm-associated turbulence without precipitation can extend several thousand feet above a storm and outward more than 20 nm.
- Turbulence detection requires the presence of precipitation. Clear-air turbulence is not detected or displayed.
- The weather display corresponds to the selected range, while the turbulence display is overlaid for the first 40 or 60 nm in the WX ALL and WX PATH modes (regardless of range selected).Turbulence isshown in the WX ALL, WX PATH, and WX MAN modes.
- Hail and lightning icons indicate that conditions are conducive to the development of hail or lightning. Since this technology is

predictive, icons often display prior to the actual formation of the hail or lightning. Hence, the presence of icons does not guarantee that hail or lightning will be present. Similarly, the absence of an icon does not guarantee that the condition will not be present.

- Below 1,800 feet,windshear and weather scans are interleaved (if PWS is installed).The windshear detection operation is transparent to the crew unless an alert is issued.
- While on the ground, the radar will automatically be in FORCED STANDBY mode unless the WX/PWS qualifiers are satisfied. There is no radiation hazard to nearby personnel while in this mode.
- The antenna beam is very narrow at close ranges and widens significantly with range. Therefore, the resolution and accuracy of weather reflectivity is better at ranges closer to the aircraft.
- As with previous radars, low-lying stratus weather may be difficult to discriminate from ground returns. The radar may not show this sort of weather on the display.
- The use of the internal topographical information results in a significant reduction in ground returns. However, the radar is not aware of man-made reflectors such as buildings at airports and cities. Therefore, it is possible that not all ground clutter will be eliminated.
- There are several potential sources of false weather indications, including RF interference sources external to the aircraft, anomalous signal propagation due to atmospheric conditions, strong returns from urban areas and mountainous regions, and others. Before making operational decisions based on small isolated indications on the weather display, the validity of these indications should be verified via PIREPS, ground-based weather sources and/or ATC communications.
- Reference the following Federal Aviation Administration (FAA) Advisory Circulars:
  AC 00-24B Thunderstorms
  AC 00-6A Aviation Weather
  AC 00-50A Low Level Wind Shear
  AC 20-68B Recommended Radiation Safety Precautions.

SECTION 2: SIMPLIFIED OPERATING PROCEDURES

CONFIGURATIONS

Your system may have one of many controllerand display interfaces. Specific modes and mode names will vary. Refer to your display system user's manual for details of available modes and control options. The information in this section provides examples only.

Modes	OFF, STBY, FORCED STBY, ALL WEATHER (WX ALL, WX-A), ON-PATH WEATHER (WX PATH, WX-P, ON PATH), MANUAL WEATHER (WX MAN, WX-M), MANUAL AZIMUTH, GMAP
Turbulence Detection	First 40 or 60 nm (configured at installation) WX ALL, WX PATH, and WX MAN modes
Hazard Detection (if installed)	First 160 nm WX ALL, WX PATH, and WX MAN modes
REACT	Provided in WX ALL, WX PATH, and WX MAN modes
WX/Turb Ahead Indication (if installed)	Annunciation provided when turbulence or hazardous weather exists ahead of the aircraft. WX-AHEAD or TGT
Predictive Windshear Detection (if installed)	Automatic below 1,800 feet. Detects windshear conditions up to 5 nm ahead of the aircraft.

Depending on the controller in use, control of Hazard Detection, REACT, and TURB features may be combined onto one selection (button or knob setting), usually labeled HZD. On other controllers, these may be available as individual selections. Turbulence detection is always provided. The availability of the Hazard Detection and Predictive Windshear features depends on choices made at installation.

ON/OFF

The Radar is **OFF** (**Not Transmitting)** when:

- The aircraft is on the ground and the WX/PWS Qualifiers are not satisfied. (See *AUTOMATIC RADAR ACTIVATION* on page15.)
- **Or**both sides have selected OFF on the radar controller.

The Radar is **ON (Transmitting)** when:

- The WX/PWS Qualifiers are satisfied while the aircraft is on the ground. (See *AUTOMATIC RADAR ACTIVATION* on page15)
- **Or** Ground Override has been selected.(See *GROUND OVERRIDE* on page16.)
- **Or** the aircraft is in the air.

Radar data is shown on the display when:

- The radar is on and selected for display
- **Or**(on some systems) the radar is on and not selected for display, and a PWS Alertoccurs.(See *AUTOMATIC RADAR ACTIVATION* on page15.)

TURN ON AND TEST

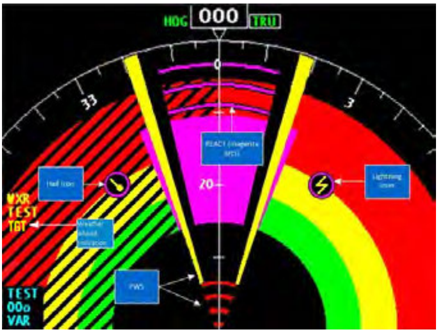
Select TEST mode to perform a system test.

- It is good practice to run the test sequence after system power-up or after a system fault has occurred.This may be performed by the flight crew or by maintenance personnel.
- The test sequence may be run at any time as desired. If in the air, no actual tests are performed, but the test pattern is displayed, followed by any current faults.
- If PWS is installed, observe the PWS Test Sequence shown below (when on ground only).
- Note the test pattern on the display. The test pattern shown depends on the installation. See examples below.
- Following the test pattern, one or more configuration pages will be shown, followed by any current faults, or a page showing "Radar OK" if there are no faults. These information pages will continue to cycle while TEST mode is selected.
- If a fault message displays, follow standard operating/maintenance procedures.
- During test mode, there is no radiation hazard to personnel in the vicinity of the aircraft.

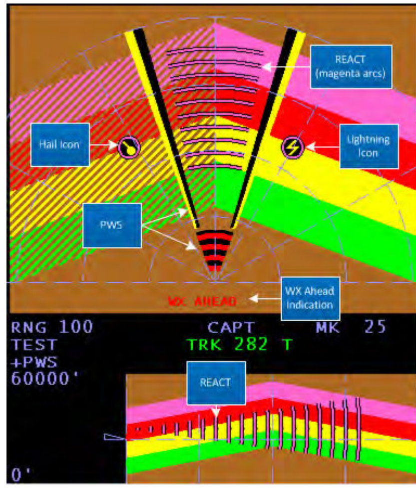
PWS Test Sequence (if installed)

Time TEST Selected	Approx. 2 Sec.	Approx. 4 Sec.	Approx. 6 Sec.
PWS FAIL/INOP	On	OFF (ON if failure is detected)	
PWS VISUAL ALERTS	Off	Amber (WINDSHEAR)	Red (WINDSHEAR)
PWS AURAL ALERTS	None	Tone "Whoop, Whoop" or "Monitor Radar Display"	"Go Around, Windshear Ahead, ... Windshear Ahead, Windshear Ahead"
DISPLAY	Normal Test Pattern, followed by configuration and fault info.		
"Whoop, Whoop," or "Monitor Radar Display" is selected at installation.			

WEATHER RADAR TEST PATTERN EXAMPLES



The artifacts shown on the test pattern reflect the installation status of each feature. For example, if Hail and Lightning indications are not installed, the sample icons will not display on the test pattern.



CONFIGURATION AND STATUS INFORMATION EXAMPLES

FAULT DISPLAY EXAMPLES

TAKEOFF AND DEPARTURE

- Mode: WX ALL or WX PATH
- Turbulence: On
- Hazard (if provided): On
- REACT: On
- PWS(if provided): On
- Gain: AUTO or as required to assess threats. (Refer to *GAIN CONTROL*on page 31 for more details.)
- Range: Pilot Flying – 10 to 40 nm, other side at least one range higher.
- Avoid any magenta turbulence cells and monitor the display for weather intensity to avoid any weather threats.
- Avoid any cells associated with Hail or Lightning Icons (see page 21).
- In areas where the REACT field is shown, expect the possibility of weather that may have to be avoided.
- If there is weather in the area, ensure that the radar has been turned on in time to allow pilot(s) to evaluate any threats prior to takeoff.
- See *PLANNING A PATH* on page48 for more information.

CLIMB UP TO FL200

- Mode: WX ALL or WX PATH
- Turbulence: On
- Hazard (if provided): On
- REACT: On
- Gain: AUTO or as required to assess threats. (Refer to *GAIN CONTROL*on page 31for more details.)
- Range: Pilot Flying – 10 to 40 nm, other side at least one range higher.
- Avoid any magenta turbulence cells and monitor the display for weather intensity to avoid any weather threats.
- Avoid any cells associated with Hail or Lightning Icons (see page 21).
- In areas where the REACT field is shown, expect the possibility of weather that may have to be avoided.
- See *PLANNING A PATH* on page 48 for more information.

CRUISE ABOVE FL200

- Mode: WX ALL or WX PATH
- Turbulence: On
- Hazard (if provided): On
- REACT: On
- Gain: AUTO or as required to assess threats. (Refer to *GAIN CONTROL*on page 31for more details.)
- Range: Pilot Flying – 20 to 80 nm, other side at least one range higher.
- Within 60 nm, sufficient resolution exists for evaluating cells. At this point, On Path and Off Path weather will become more prominent and WX MAN mode can be used for vertical analysis.
- Avoid any magenta turbulence cells and monitor the display for weather intensity to avoid any weather threats.
- Avoid any cells associated with Hail or Lightning Icons (see page 21).
- In areas where the REACT field is shown, expect the possibility of weather that may have to be avoided.
- See *PLANNING A PATH* on page 48 for more information.

DESCENT AND APPROACH

- Mode: WX ALL or WX PATH
- Turbulence: On
- Hazard (if provided): On
- REACT: On
- PWS: On
- Gain: AUTO or as required to assess threats. (Refer to *GAIN CONTROL* on page 31for more details.)
- Range: Pilot Flying – 10 to 40 nm, other side at least one range higher.
- Avoid any magenta turbulence cells and monitor the display for weather intensity to avoid any weather threats.
- Avoid any cells associated with Hail or Lightning Icons (see page 21).
- In areas where the REACT field is shown, expect the possibility of weather that may have to be avoided.
- Start evaluating cells by 40 nm and finish by 20 nm.
- Make your weather decision by the 20-nm point.
- See *PLANNING A PATH* on page 48 for more information.

AVOIDANCE MANEUVERS

When considering avoidance maneuvers, keep the following in mind:

- Never deviate under a storm cell or the associated anvil.
- Plan deviations on the upwind side of storm cells to avoid turbulence generated downwind of convection, which may not be detectable by the radar.
- When flying between storm cells, allow at least 40 nm separation.
- Damaging hail can be thrown at least 20 nm from the storm cell by upper level winds.
- Avoid all yellow, red, or magenta areas, particularly if they can be associated with convective activity.
- Avoid any cells associated with Hail or Lightning Icons by a minimum of 20 nm (see page 21).
- In areas where the REACT field is shown, expect the possibility of weather that may have to be avoided.
- Establish an avoidance plan before getting within 40 nm of the cells to allow time to negotiate a deviation with ATC. (See *PLANNING A PATH* on page 48 for more information.)
- Consider the height of a storm cell when planning avoidance.
  - Avoid all green, yellow, red, and magenta areas of cells taller than 28,000 feet by at least 20 nm.
  - Cells exceeding 35,000 feet should be considered extremely hazardous and additional separation (in addition to the 20 nm) should be used.
  - WX MAN mode can be used to evaluate the heights of storm cells.
- As with previous radars, low-lying stratus weather may be difficult to discriminate from ground returns. The radar may not show this sort of weather on the display.
- The use of the internal topographical information results in a significant reduction in ground returns. However, the radar is not aware of man-made reflectors such as buildings at airports and in cities. Therefore, it is possible that not all ground clutter will be eliminated.
- There are several potential sources of false weather indications, including RF interference sources external to the aircraft, anomalous signal propagation due to atmospheric conditions, strong returns from urban areas and mountainous regions, and others. Before making operational decisions based on small isolated indications on the weather display, the validity of these indications should be verified via PIREPS, ground-based weather sources and/or ATC communications.

SECTION 3:EXPANDED OPERATING INSTRUCTIONS

TURN ON &SYSTEM SELECTION

Radar data is displayed wheneverWXR is selected in any mode other than STBY or OFF. When on the ground, the radar will not transmit until the autoactivation conditions are met (see *AUTOMATIC RADAR ACTIVATION* on page15). This behavior can be temporarily overridden by activation of the Ground Override feature. When in the air, the radar scans continuously, always updating the memory so that current weather is immediately available.(See also *ON/OFF* on page 8.)

On initial activation of the radar, the radar first looks at the part of the sky that is near the aircraft's altitude.This data is displayed as soon as it is available.As data is gathered from the remainder of the sky in front of the aircraft, the display quickly fills in with any additional information.It takes no more than 30 seconds for the complete picture to become available.

AUTOMATIC RADAR ACTIVATION (WX/PWS QUALIFIERS)

When on the ground, the radar is in Forced Standby Mode (not transmitting) unless Ground Override is activated by the crew.

The radar will turn on automatically under the following aircraft conditions (called "WX/PWS Qualifiers"):

In Air, or

On Ground: Depends on installation. Typical trigger conditions include, but are not limited to, one or more of the following:

- RAAS indicates On Runway (if installed)
- Groundspeed is greater than 30 knots (speed is configurable at installation)
- Longitudinal acceleration is greater than 0.15 (acceleration is configurable at installation).

GROUND OVERRIDE

Selecting ground override allows the radar to operate on the ground when the WX/PWS qualifiers are not satisfied. Some flight decks provide a dedicated control selection for Ground Override. If no control selection option is provided, select ground override by pushing the HZD button four times within 3 seconds. If either side selects ground override, normal radar operation will commence. To return to Forced Standby, deselect ground override on the control panel if such a control is available, or select the Standby radar mode.

NOTE: On some systems, ground override must be deselected on the side (or sides) that selected it. In any case, observe the radar mode annunciations to confirm that the radar has returned to FSBY.

WEATHER DETECTION

AUTOMATIC WEATHER MODES (WX ALL&WX PATH)

GENERAL DESCRIPTION

The WX ALL and WX PATH modes provide weather, turbulence, REACT, and (depending on installation choices) predictive windshear detection, and/or Hail and Lightning prediction indications. The system processes the data to fill the 3D memory and extracts the selected data for display. When aPWS event is detected, an icon is shown on the display. Returns determined to be ground clutter are not shown.

Weather targets are color-coded by the intensity of the return. The display correlation to approximate rainfall (with Gain set to AUTO) is as follows:

Reflectivity Color Codes (Gain at AUTO)

Color	Returns	Reflectivity	Rainfall Rate
Black	Very light or none	Less than 20 dBZ	Less than 0.7 mm/hr (0.028 in/hr)
Green	Light	20 – 30 dBZ	0.7 – 4 mm/hr (0.028 – 0.16 in/hr)
Yellow	Medium	30 – 40 dBZ	4 – 12 mm/hr (0.16 – 0.47 in/hr)
Red	Strong	40 dBZ or greater	Greater than 12 mm/hr (0.47 in/hr)

The RDR-7000 fills the 3D memory with all the detected weather in front of the aircraft out to 320 nm, and from ground level up to 60,000 feet mean sea level (MSL). The RDR-7000displays weather within the flight path envelope using solid colors. This is ON PATH weather. All other weather is considered to beOFF PATH weather.

Select the WX ALL mode to display both On Path and Off Path weather. The Off Path weather is displayed with black stripes through it. (See diagram on page 40.)

When in the WX PATH mode, only the On Path weather is displayed.

Note that while the use of the internal topographical information results in a significant reduction in ground returns, the radar is not aware of man-made reflectors such as buildings at airports and in cities. Therefore, it is possible that not all ground clutter will be eliminated from the weather display.

There are several potential sources of false weather indications, including RF interference sources external to the aircraft, anomalous signal propagation due to atmospheric conditions, strong returns from urban areas and mountainous regions, and others. Before making operational decisions based on small isolated indications on the weather display, the validity of these indications should be verified via PIREPS, ground-based weather sources and/or ATC communications.

UNDERSTANDING THE DISPLAY IN WX ALL AND WX PATH MODES

In WX ALL or WX PATH modes, the RDR-7000 projects a three-dimensional memory space onto a two-dimensional display. This means the weather displayed for any one memory cell is the color of the strongest return in that column of memory cells. Specifically, if there is any weather data in a given column that is inside the envelope for OnPath weather; the color of the strongest of these returns is displayed. If there is no weather data inside the envelope, then the color of the strongest return from outside the envelope is displayed as Off Path weather.

Stronger returns outside the envelope (Off Path weather) never override the returns displayed as OnPath weather.

The nominal flight path weather envelope is ±4,000 feet with respect to the expected flight path. These boundaries are expanded in areas where convective activity is detected.

The upper boundary for the relevant weather envelope is never less than:

- 10,000 feet OR
- 25,000 feet, if potentially hazardous convection is detected.

and never greater than 60,761 feet.

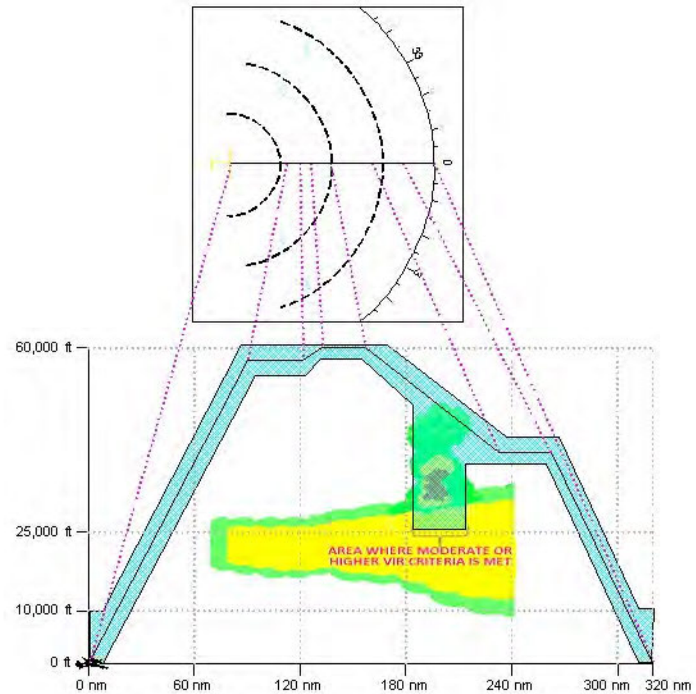
The lower boundary of the relevant weather envelope is:

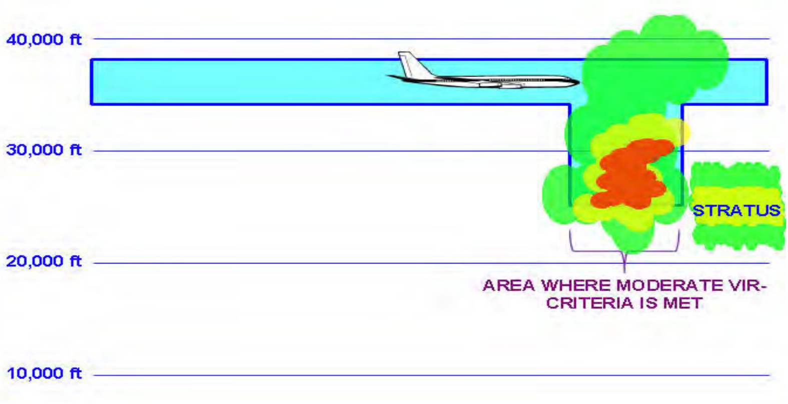
- 4,000feet below the altitude of the intended flight path of the aircraft OR
- At most 25,000feet, if potentially hazardous convection is detected.

and never less than 0 feet.

The following figure shows the aircraft flight plan and the associated flight path weather envelope. The black line graphs the aircraft elevation at the waypoint distances from current position. The shaded region is the relevant area generated from the elevation graph. This area is rotated 360 degrees around the aircraft position to produce the relevant weather envelope. Reflectivity outside the scan area of the radar will eventually age to black if not refreshed.

The expanded envelope is associated with areas of potentially hazardous convection (moderate or higher Vertical Integration of Reflectivity).


60,000 ft
25,000 ft
10,000 ft
0 ft
0 nm
60 nm
120 nm
180 nm
240 nm
300 nm
320 nm
AREA WHERE MODERATE OR
HIGHER VIR CRITERIA IS MET

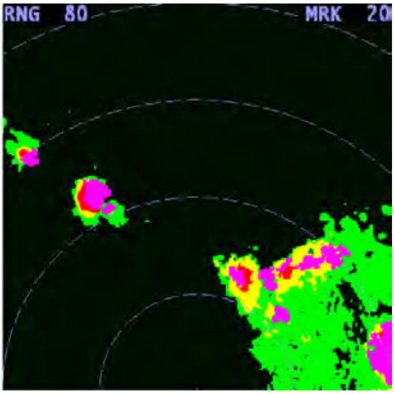

40,000 ft
30,000 ft
20,000 ft
10,000 ft
STRATUS
AREA WHERE MODERATE VIR-
CRITERIA IS MET

TURBULENCE DETECTION

Turbulence detection is an automatic function of this weather radar system.

For turbulence detection and evaluation use the following procedure:

1. Mode: WX ALL, WX PATH, or WX MAN(optionally GMAP)
2. Turbulence: On (may be included on HZD selection)
3. Range: As desired.



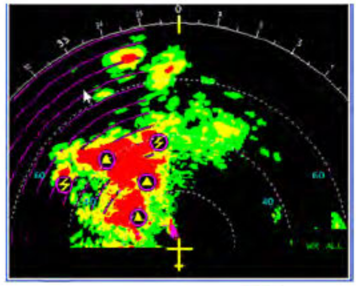
Turbulence information is limited to the first 40 or 60 nm (configured at installation). Turbulence within this range and inside the flight path weather envelopewill be displayed in magenta.

The turbulence data is represented in a blocky shape, helping to visually differentiate it from reflectivity data.

The turbulence detection feature of the RDR-7000 is quite sensitive as compared to previous radar functionality. The threshold for displaying indications of turbulence is based on the potential aircraft response to that turbulence. Therefore, magenta blocks may be displayed on top of any color, including black.

PREDICTIVE HAIL AND LIGHTNING

If the Hazard Display Configuration of the radar system is installed, icons will be displayed on top of the reflectivity to identify areas that have the signature characteristics of hail, lightning, or both. If this feature has been installed, hail and lighting icons will be included on the test pattern.



LIGHTNING ICON HAIL ICON

For hazard display, use the following procedure:

1. Mode: WX ALL, WX PATH, or WX MAN
2. Hazard: On (may be included on HZD selection)
3. Range: As desired.

The radar does not directly detect hail or lightning; it analyzes the data in the 3D memory to identify areas that have a high probability of containing these hazards.

Hail and lightning icons indicate that conditions in the associated weather cell are conducive to the development of hail or lightning. They do not guarantee that hail or lightning will be present, nor does the absence of an icon guarantee that the condition will not be present. Note that an icon cannot indicate the exact location of any expected hail or lightning. Treat the entire weather cell or area as a threat.

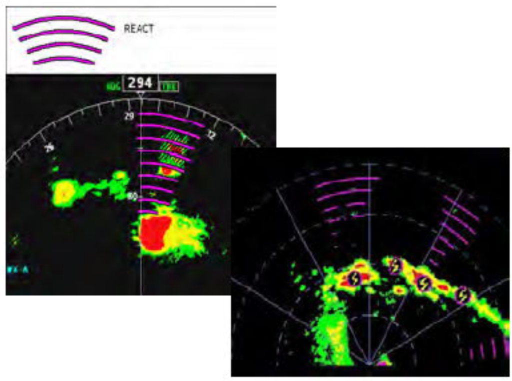
See *PLANNING A PATH* on page 48 for details on how to utilize the information provided by the Hail and Lightning Icons.

REACT

REACT stands for *Rain Echo Attenuation Compensation Technique.* As the transmitted radar signal travels through heavy rain or over a long distance, it loses power, or becomes attenuated. If this attenuation is severe enough, weather behind a storm cell may not be detectable, or it may be displayed as being less severe than it actually is (e.g., green instead of yellow).

For REACT, use the following selections:

1. WXR: Selected
2. Mode: WX ALL, WX PATH, or WX MAN(optionally GMAP)
3. REACT: On (may be included on HZD selection)
4. Range: As desired.



The RDR-7000 can automatically indicate areas where the radar signal has been attenuated. These areas are shown as magenta arcs superimposed over the reflectivity in the areas where the signal attenuation is significant. These arcs indicate that there could be severe weather in that area, even though only mild or no reflectivity is shown.

In areas where the REACT field is shown, expect the possibility of weather that may have to be avoided. The geometry between the aircraft and the attenuating weather may change as the flight progresses. This may allow weather that was in the REACT area to later be outside of the REACT field, and the radar will then more clearly display weather in that area.

WEATHER-AHEAD INDICATION

Weather/Turbulence Ahead indication lets the pilot know when significant weather or turbulence is detected ahead of the aircraft or along the flight plan when the weather display is not active. This is similar to the “Target Alert” function on other radars, except that if this feature is installed, it is always available whenever the radar is scanning.

- The area within +/- 20 nmof the current flight plan (if active) or aircraft track, and from 0 to 100 nm ahead of the aircraft is constantly monitored to detect the presence of red weather or turbulence.
- If red weather or turbulence is detected within this area, but is beyond the selected display range, or when the WXR is not selected for display, either an annunciation on the display (usually TGT), or a text message (e.g., “WX AHEAD” or “TGT”) is provided.

PREDICTIVE WINDSHEAR (PWS) DETECTION

The predictive windshear feature detects the presence of windshearup to 5nmahead of the aircraft, giving 10 to 60 seconds of warning before the encounter. Windshear detection mode operates automatically below 1,800 feetabove ground level (AGL), with alerts available at 1,500 feet AGL and below. If a windshear event is detected, the system provides the crew with Advisory, Caution and/or Warning annunciations, and a windshear icon shows on the weather display. This system is meant to supplement other means of detecting and avoiding hazardous windshear conditions. It will not detect all possible hazardous windshear conditions such as extremely dry events or events masked by unusual radar clutter.

AUTOMATIC WINDSHEAR ACTIVATION

The Windshear mode will automatically be turned on under the following specific aircraft conditions:

In Air: Below 1,800 feet. AGL

On Ground: Depends on installation. Typical trigger conditions include one or more of the following:

- RAAS indicates On Runway
- Groundspeed is greater than 30 knots
- Longitudinal acceleration is greater than 0.15.

If the display is showing radar data other than weather (such as gmap or standby) when a windshear event takes place, the display automatically switches into the WX ALL mode, and the windshear icon is overlaid on the weather data. Unless the pilot changes the display settings, the display will return to its previous state once the windshear event is no longer detected.

If the display is showing data other than weather (such as ground proximity terrain data) when a windshear event takes place, the radar will provide the aural and lamp or text annunciations, depending on the installation. Change to any weather mode to see the windshear icons that identify the location of the threat.

WINDSHEAR ALERT REGIONS

- The PWS mode can generate three types of alerts; **Advisory**, **Caution**, and **Warning**. Thesedepend on the location of the windshear event, not the strength. When a windshear event is encountered below 1,500 feet AGL, the appropriate alert is issued, and the icon automatically shows on the display. As an installation choice, all advisory alerts may be suppressed.

ADVISORY ALERTS (if enabled)

- The Advisory Alert region is ±40° from the aircraft track and from 0.5 nm to 5.0 nm in front of the aircraft.
- Between 50 feet and 1,500 feet AGL the system indicatesADVISORY Alerts by overlaying the windshear icon(s) on the radar display. New Advisory Alerts are inhibited below 50 feet AGL if airspeed is greater than 100 knots on takeoff, or greater than 60 knots on approach. These speeds and altitudes may vary, depending on installation choices. Advisory alerts may be suppressed altogether during installation.

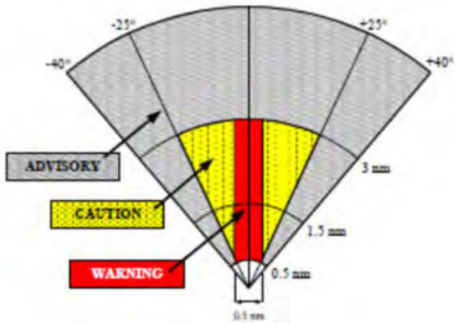
CAUTION ALERTS

- The Caution Alert region is ±25° from the aircraft track and from 0.5 nm to 3.0 nm in front of the aircraft.
- Between 50 feet and 1,200feet AGL the system indicates CAUTION Alerts with visual and aural annunciations in addition todisplaying the windshear icon(s). New Caution Alerts are inhibited below 50 feet AGL if airspeed is greater than 100 knots on takeoff, or greater than 60 knots on approach. These inhibit speeds and altitudes may vary, depending on installation choices. On approach, new Caution Alerts may be inhibited from as high as 400 feet AGL if specified during installation.

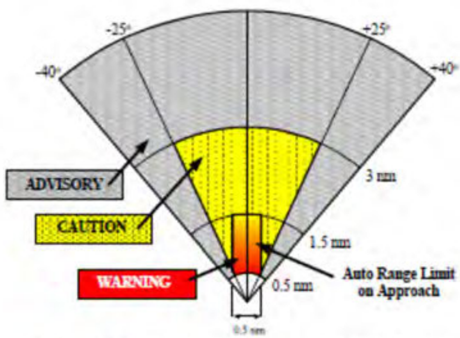
WARNING ALERTS

- The WARNING Alert region is ±0.25 nm either side of the aircraft track and from 0.5 nm to 1.5 nm (3.0 nm on the ground) in front of the aircraft. On approach below 370 feet, the alert range is gradually decreased to avoid alerting on events that are past the far end of the runway.
- Between 50 feet and 1,200feetAGL the system indicatesWARNING Alerts with visual and aural annunciations in addition to displaying the windshear icon(s). New Warning Alerts are inhibited below 50 feet AGL if airspeed is greater than 100 knots on takeoff, or greater than 60 knots on approach. The takeoff-inhibit speeds and altitudes may vary, depending on installation choices.

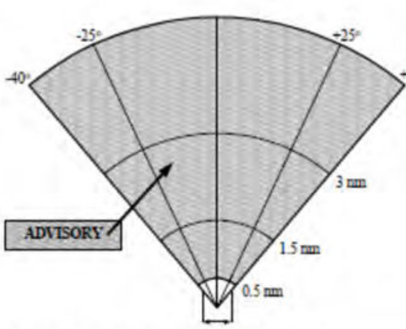
WINDSHEAR ALERT REGIONS (HORIZONTAL)



Takeoff Roll Ground Mode

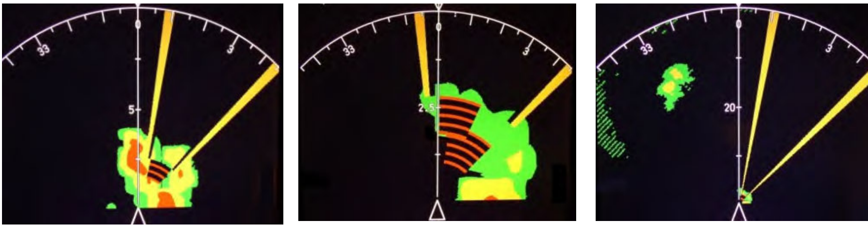


Takeoff Climb, Approach, and Go-Around
In Air below 1200 ft AGL



Takeoff Climb, Approach, and Go-Around
In Air above 1200 ft AGL

ICON DISPLAY



WINDSHEAR ICONS WITH SEARCH LINES

The windshear icon shown on the display represents the location of the event in both range and azimuth. In the left example, the windshear event begins about 2 nm ahead and 25° to the right of the aircraft. The center example shows two icons, indicating two windshear events. The yellow and black search lines help locate the icon in case a long range is selected.

Visual/textual and audio PWS alert annunciations may vary by display system. The following information is typical, but your system may differ. Consult the display system user guide for details.

VISUAL/TEXTUALPWS ALERT ANNUNCIATIONS

Visual/textual Caution and Warning Alerts are annunciated on the Electronic Displays.

- **Caution Visual Alert:** Amber “W/S AHEAD” or similar
- **Warning Visual Alert:** Red “W/S AHEAD” or similar.

AURAL PWS ALERT ANNUNCIATIONS

Caution Aural Alerts may be one of the following (selected at installation):

- Option 1: “Whoop, Whoop”
- Option 2: “Monitor Radar Display”

Warning Aural Alerts are as follows:

- Take-Off: “Windshear Ahead, Windshear Ahead”
- Approach: “Go Around, Windshear Ahead”

PWS SYSTEM FAILURE ANNUNCIATION

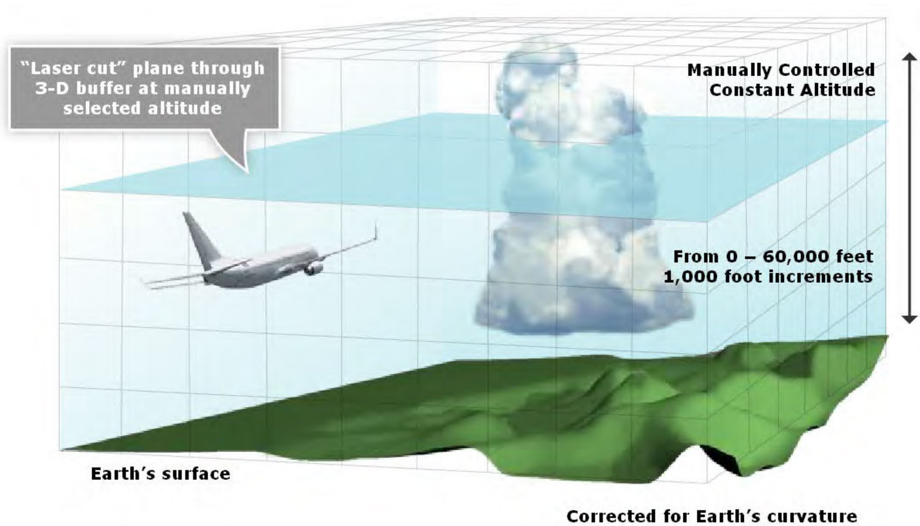
System failuresare annunciated on the Electronic Displays. Examples: PRED W/S, PWS INOP, or NO PWS.

WEATHER ANALYSIS

MANUAL ALTITUDE WEATHER MODE

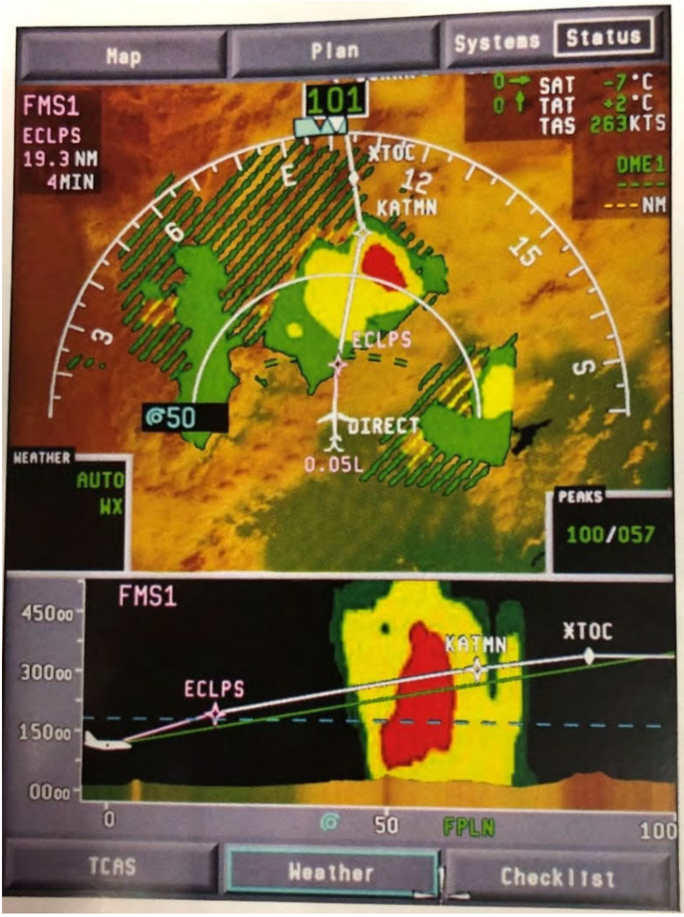
WX MAN Weather Modeprovides a means to assess storm cell height and development by providing selectable altitude slices. These slices from the 3D memory are corrected for the curvature of the earth, providing a view at a constant altitude level.

The altitude control is used to select the desired altitude slice from 0 to 60,000 feet, in increments of 1,000 feet.



MANUAL AZIMUTH WEATHER MODE

The vertical profile view (when available) shows a vertical slice of weather from the 3D memory. By default, the weather along the unwrapped current flight plan is shown, or along the aircraft track if flight plan information is not available. The azimuth control is used to select weather along a specific azimuth line instead.



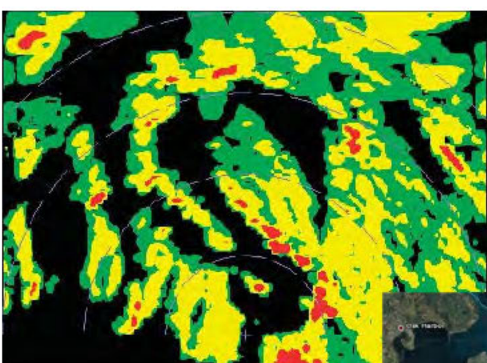
FULL COVERAGE GROUND MAP MODE

The RDR-7000 Weather Radar System can be used in Ground Map mode to identify terrain features. For ground mapping use the following procedure:

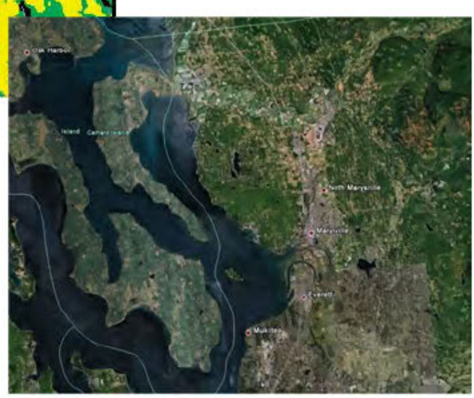
1. Mode: GMAP
2. Range: As desired
3. Gain: If necessary, adjust for optimum observation of terrain features.

The purpose of the GMAP mode is to aid in identifying prominent terrain features, such as coastlines, lakes, and large built-up urban areas. GMAP mode provides an extended ground map picture by piecing together individual scans and combining them in the memory for display. Reflectivity data that is considered ground clutter (and removed from the weather views) is the basis for the Ground Map display. Data from the terrain database is not used, providing an independent verification of position. The Ground Map is generated automatically and simultaneously with weather.

See the following pictures for a comparison of a GMAP display and a satellite photo of the same area.



RDR-7000SEATTLE AREA GMAP DISPLAY



SEATTLE AREA SATELLITE IMAGE (Picture from earth.google.com)

GAIN CONTROL (GAIN)

GAIN control is active in all modes. The calibrated (AUTO GAIN) position is the only position where the colors represent the FAA-defined reflectivity and rainfall rates as shown in the table below. Immediately after adjusting the GAIN setting in either direction out of the AUTO GAIN position, an annunciation appears on the display indicating that the system is no longer in the calibrated mode. Some displays may show the amount of gain adjustment in dB or in percent. Other displays may annunciate "VAR" to indicate variable gain. The gain setting has no effect on turbulence detection or display. After using gain to assess the weather,the GAIN setting should be returned to the AUTOGAIN position.

Reflectivity Color Codes (Gain at AUTO)

Color	Returns	Reflectivity	Rainfall Rate
Black	Very light or none	Less than 20 dBZ	Less than 0.7 mm/hr (0.028 in/hr)
Green	Light	20 – 30 dBZ	0.7 – 4 mm/hr (0.028 – 0.16 in/hr)
Yellow	Medium	30 – 40 dBZ	4 – 12 mm/hr (0.16 – 0.47 in/hr)
Red	Strong	40 dBZ or greater	Greater than 12 mm/hr (0.47 in/hr)

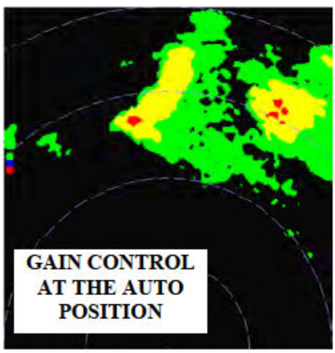
Setting the GAIN control to the minimum position reduces gain by approximately 16 dBZ. Setting the GAIN control to the maximum (MAX) position increases gain by approximately 10 dBZ.

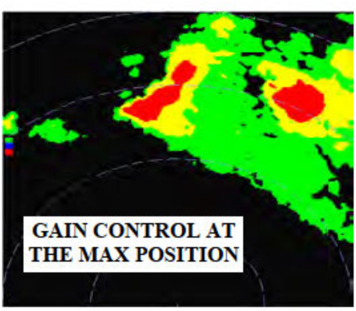
Proper use of the gain control can aid in the detection and assessment of storm cells. Gain reduction can be useful in several ways. Reducing the gain to MIN provides a quick assessment of the relative intensity between displayed cells. Since gain does not affect turbulence detection, reducing gain in the WX ALLor WX PATH mode to MIN will show turbulence information along with the strongest cells. This is important since the presence of turbulence along with high levels of reflectivity often indicates convective weather. In areas of heavy stratus rain, the display can show large areas of strong returns, but with little associated turbulence.

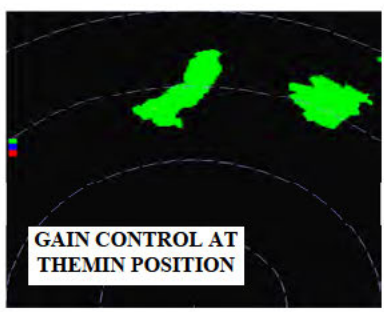
Reducing the gain can also help identify embedded storm cells within the stratus rain. It can help identify areas of significant attenuation by making radar shadows more prominent. Areas of missing terrain returns in GMAP mode that correspond with strong weather echoes may indicate a larger area of precipitation than is apparent on the weather display. (See SHADOWED AREAS on page 52.)

Use MAX gain only when at cruise altitudes. In WX MAN mode, MAX gain is useful when looking at altitude slices above the freezing level where particles are less reflective. High levels of moisture above the freezing level are key ingredients in hail formation.

Increase the gain briefly at any altitude to discover the relative reflectivity of a weather formation that is visible out the window but does not initially show on the display. This occurs when the reflectivity of the cloud is below the standard threshold for green weather.







SECTION 4: EQUIPMENT DESCRIPTION

UNIT DESCRIPTIONS

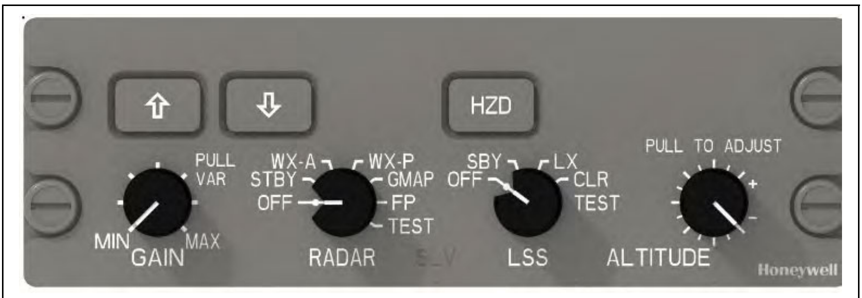
ART-7000ANTENNA RECEIVER TRANSMITTER WITH FLAT PLATE ANTENNA

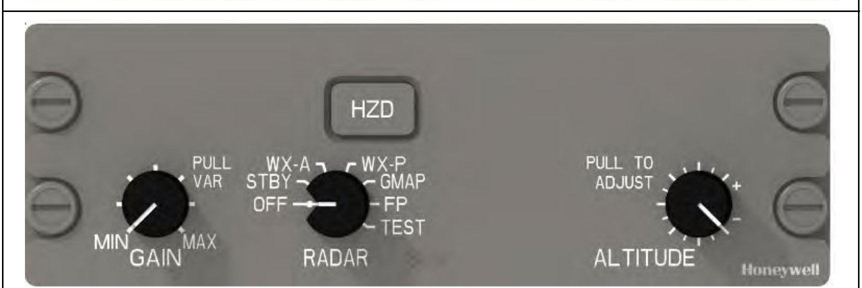
The Antenna Receiver Transmitter (ART)is the main unit. It contains the electronics thattransmit, receive, and process the radar pulses used to detect turbulence, windshear, weather, and terrain targets. It also contains system integrity monitoring and self-test electronics.It controls the modes of the radar, and formats the radar data for display. The ART-7000 is located within the radome. The integrated antenna drive scans a 120-degree sector in azimuth and ±15 degrees in elevation (tilt).

CONTROL PANELSand DISPLAYS

The RDR-7000 can be used with many varieties of controllers, control panels, and displays. The controllers and displays used will vary with the aircraft and the installation. Although the location and appearance of the controls may vary, the functionality is the same, and is described below. Refer to yourplatform-specific user's guide for detailed information. Some examples of typical control panels are shownbelow.

The RDR-7000has the ability to show two different radar display views simultaneously. The flight crew can operate each side independently without impacting radar performance, thus achieving maximum weather information display.






BRT
HZD
PATH
PULL VAR
MIN
GAIN
MAX
TEST
STBY
OFF
WX-A
GMAP
MODE
50
25
10
100
200
300
FPLN
RANGE
PULL TO ADJUST
ALTITUDE
Honeywell
Rdr Mode
Off
Hazard
OFF
Gain
Cal
Range
25 nm
Off
Stby
All
Path
Man
GMap
FP
Test
Rdr Mode
All
Hazard
OFF
Gain
Cal
Range
25 nm
5
10
25
50
100
200
300
Rdr Mode
All
Hazard
OFF
Gain
-9 dB
Range
25 nm
-16
Cal
10

OPERATING CONTROLS

While the radar can be turned off completely by setting both sidesto OFF, this is not recommended. The radar operates by continuously scanning the whole sky in front of the aircraft, saving the results in 3-D memory. On initial activation, the radar first looks at the part of the sky that is near the aircraft's altitude. This data is displayed as soon as it is available. As data is gathered from the remainder of the sky in front of the aircraft, the display quickly fills in with any additional information. It takes no more than 30 seconds for the complete picture to become available.

The radar will not operate while on the ground until the WX/PWS qualifiers are satisfied, or Ground Override is selected. This is to protect personnel on the ground in front of the aircraft. (See *AUTOMATIC RADAR ACTIVATION*and *GROUND OVERRIDE*on page 15.)

SYSTEM CONTROL

OFF: If selected on only one side, control is slaved to the other side. In this case, the radar is controlled from one side, and same information is shown on both displays. If OFF is selected on both sides, or if there is only one controller, it turns the RDR-7000 radar and all associated functions off. The radar will not transmit. Predictive windshear detection will not be available.

STBY: The RDR-7000 works by continuously monitoring the entire sky, and automatically displaying the weather ahead of the aircraft. This works best if the radar is always on and scanning while in the air. The STBY setting on the control panel commands the Standby Display Mode. In this mode, the radar is still scanning and filling the 3D memory, but the display does not show any weather data. The Weather Ahead (TGT) function is active, if installed. If the predictive windshear feature is installed, windshear events up to 5 nm in front of the aircraft will be indicated.

Forced Standby (FSBY):FSBY is an automatic, non-selectable radar mode. When on the ground, the radar will not operate unless either the WX/PWS qualifiers are satisfied, or Ground Override has been selected. In this situation, the radar is in Forced Standby. (See *AUTOMATIC RADAR ACTIVATION*and *GROUND OVERRIDE*on page 15.)

Ground Override: Allows the radar to operate on the ground when the WX/PWS qualifiers are not satisfied. This mode can be selected on the control panel, if available. If no control selection option is provided, select ground override by pushing the HZD button four times within 3 seconds. If either side selects ground override, normal radar operation will commence. To return to Forced Standby, deselect ground override on the control panel, if such a control is available,orselect the standby radar mode. If both sides selected ground override, then it will have to be deselected on both sides to return to FSBY.

Test: When on the ground, runs the full system self-test. Displays a test pattern, followed by configuration information, and a report of any faults found. If in the air, only the test pattern, configuration, and current fault information is shown. (See *TURN ON AND TEST* on page 9.)

FP (Flight Plan): The FP position puts the radar systemin the flightplan mode, which clears the screen of radar data so ancillary datacan be displayed.Display ranges out to 1,000 nm are available. In this mode, the radar continues to scan to keep the 3D memory filled so that the most up to date weather information is always available. The Weather Ahead (TGT) function is active, if installed. If installed, predictive windshear detection is active. If a windshear event is detected and PWS annunciations are not inhibited, the radar will provide both aural and lamp or text annunciations, depending on the installation.Change to any weather mode to see the windshear icons that identify the location of the threat. The icons will remain on the weather display until the event has dissipated. (See *WINDSHEAR ALERT REGIONS* on page 24.)

DISPLAY SELECTION

WX ALL– Automatic Weather Mode. Both On Path and Off Path weather are shown. Off Path weather returns are shown with black stripes through them. This mode provides display of weather out to 320 nm. If the Turbulence, REACT, and/or Hazard Display features are selected, those will also be shown. The Weather Ahead (TGT) function is active, if installed. If the predictive windshear feature is installed, windshear events up to 5 nm in front of the aircraft will be indicated.

WX PATH – Automatic Weather Mode. Only On Path weather is shown (Off Path weather is suppressed). This mode provides display of weather out to 320 nm. If the Turbulence, REACT, and/or Hazard Display features are selected, those will also be shown. The Weather Ahead (TGT) function is active, if installed. If the predictive windshear feature is installed, windshear events up to 5 nm in front of the aircraft will be indicated.

WX MAN– Constant Elevation (Weather Analysis Mode). Only weather at the selected altitude is shown. The displayed altitude slice can be moved up or down in 1,000-foot increments using the Manual Altitude control. This mode provides display of weather out to 320 nm. If the Turbulence, REACT, and/or Hazard Display features are selected, those will also be shown. The Weather Ahead (TGT) function is active, if installed. If the predictive windshear feature is installed, windshear events up to 5 nm in front of the aircraft will be indicated.

VERTICAL DISPLAY – Shows an unwrapped view of the weather along the flight plan, or along a selected azimuth. This is only available on displays that support vertical display of weather.

GMAP– Displays Full Coverage Ground Map. If the predictive windshear feature is installed, windshear events up to 5 nm in front of the aircraft will be indicated.The Weather Ahead (TGT) function is active, if installed.If a windshear event is detected, the radar will overlay windshear icons on the weather display until the event has dissipated, then return to theselected display mode.

MANUAL GAIN–GAIN control is active in all weather and map modes. Immediately after adjusting the GAIN setting in either direction out of the AUTO GAIN position, an annunciation shows on the display indicating that the system is no longer in the calibrated mode. Some displays may show the amount of gain adjustment in dB or in percent. Other displays may annunciate “VAR” to indicate variable gain. The gain setting has no effect on turbulence or REACT detection or display. After using gain to assess the weather, the GAIN setting should be returned to the AUTO GAIN position.

FEATURE CONTROL

The following controls may be available, depending on the installation and the controller in use. Consult the display system documentation for details of your system. It is strongly recommended that these features be selected for display if they are installed in your system.

HZD ON/OFF: The HZD button controls the display of Turbulence, Hail & Lightning icons (if installed), and REACT. While some controllers have individual selections for these features, most will allow one-touch control for decluttering the display when necessary. It is recommended that these features be turned on at all times, as they indicate the weather conditions that are most important to avoid. When selected on, these features will be overlaid on the weather display in WX ALL, WX PATH, and WX MAN modes.

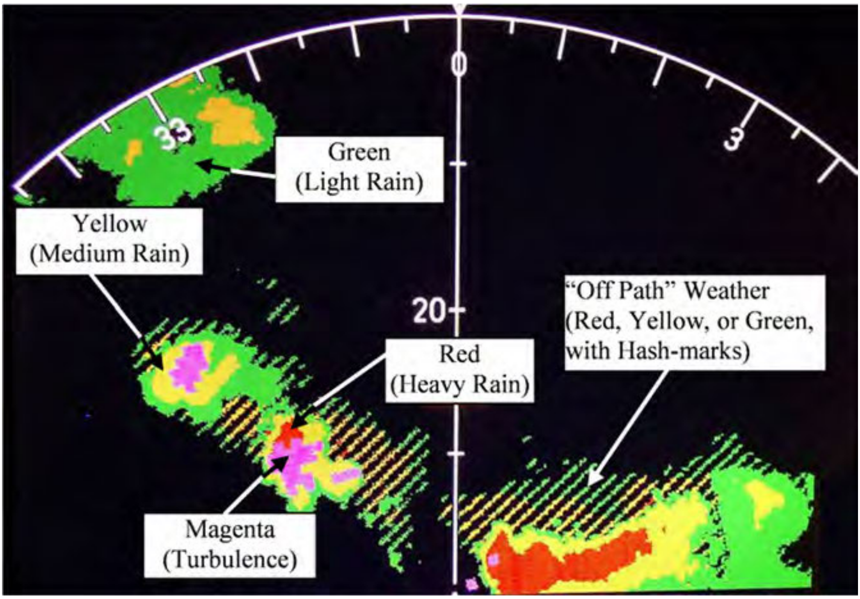
> **Turbulence**: Magenta Turbulence indications are overlaid on the weather display.
>
> **Hazard Display:** Hail and/or Lightning icons indicate areas that are likely to contain those hazards.
>
> **REACT:** Magenta arcs indicate areas where the radar signal has been attenuated. There could be severe weather in that area, even though only mild or no reflectivity is shown.

PWS: Icons will indicate areas where windshear threats exist during takeoff or approach. Aural and visual/textual annunciations are provided for caution or warning alerts.

DISPLAY ANNUNCIATIONS

Actual annunciations are display dependent. The following images are provided as examples only.

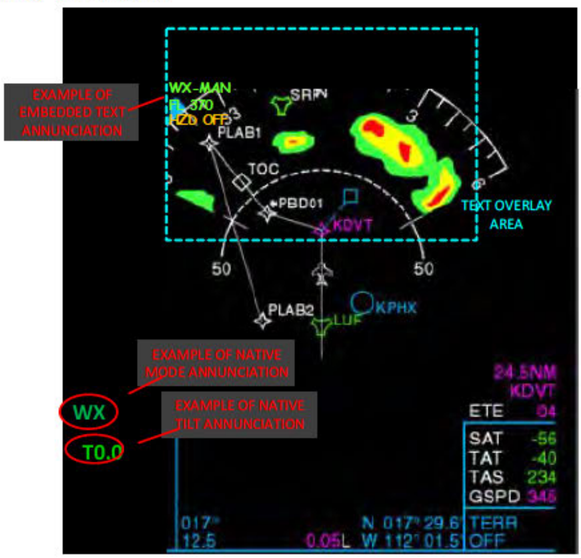
DISPLAY COLORS



WEATHER RADAR DISPLAY COLORS

RADAR MODE ANNUNCIATIONS

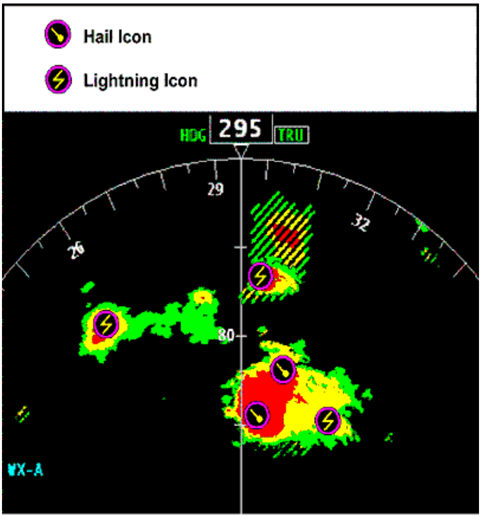
The RDR-7000 is designed to interface with a variety of legacy display systems.Whenever possible, all mode annunciations are performed by the display itself. However, some displays are unable to provide appropriate mode annunciations. In this case,the selected modemay be annunciated in the weather display area, as shown below. Elevation information when in WX MAN mode is also shown in this way, as is the status of the HZD selection. When manual gain is selected, some installations will annunciate “VAR” below the HZD annunciation. If these annunciations are used, the colors and location are chosen at installation. The TEST and GMAP annunciations are always available on the displays themselves, so are not redrawn by the radar.



<u>Possible embedded text annunciations:</u>

WX-FSBY
TX OFF
WX-STBY
WX-ALL
WX-PATH
WX-MAN
FL XXX
HZD OFF or HZD (chosen at installation)
TGT (when not otherwise available)
VAR (installation specific)

HAIL AND LIGHTNING ICONS



REACT INDICATIONS

WEATHER AHEAD INDICATION

Most displays will indicate Weather Ahead by using the TGT annunciation (usually **TGT**). Some may instead provide a text message (e.g., “WX AHEAD” or “TGT”) below the radar mode annunciation. Colors and locations may vary.

If this feature is installed, it is always on, sothere is no separate “TGT armed” annunciation.

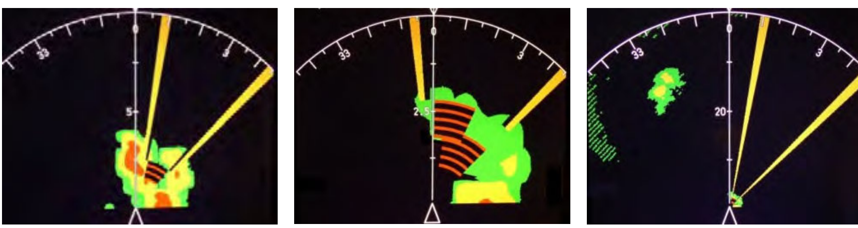
PREDICTIVE WINDSHEAR ANNUNCIATIONS

VISUAL/TEXTUAL PWS ALERT ANNUNCIATIONS

Visual/textual Caution and Warning Alerts are annunciated on the Electronic Displays or via lamps.

- **Caution Visual Alert:** Amber “W/S AHEAD” or similar
- **Warning Visual Alert:** Red “W/S AHEAD” or similar.

PWS ICONS



WINDSHEAR ICONS WITH SEARCH LINES

The windshear icon shown on the display represents the location of the event in both range and azimuth. In the left example, the windshear event begins about 2 nm ahead and 25° to the right of the aircraft. The center example shows two icons, indicating two windshear events. The yellow and black search lines help locate the icon in case a long range is selected.

FAULT ANNUNCIATIONS

Fault annunciations alert the pilot that the radar system is not performing to established standards. Built-in test equipment (BITE) automatically and constantly tests the radar system.

Failures will generally be indicated by the native mode annunciation on the display changing to amber.Some faults will result inalldisplayed radar data to go away entirely, or the radar may change to Standby mode. Actual fault annunciations depend on the display in use and the type of fault. When in TEST mode, any fault information is displayed on pages that are shown after the test pattern. A PWS failure is annunciated either via text on the electronic display or a lamp in the cockpit.

If the fault does not resolve itself shortly, cycle power to the system. If that action does not correct the problem, turn off power to the system.

<table>
<tr><th colspan="2">FAULT DISPLAY EXAMPLES</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

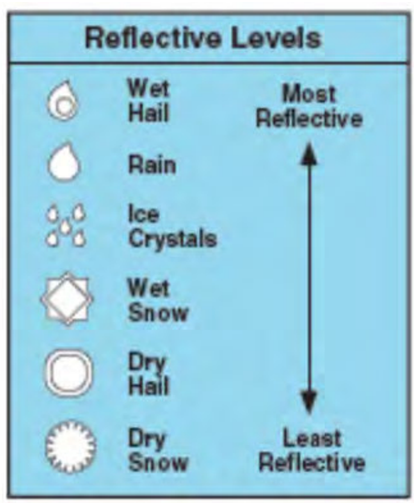
SECTION 5: PRINCIPLES OF WEATHER RADAR USE

WEATHER RADAR PRINCIPLES

Airborne weather avoidance radar, as its name implies, is for avoiding severe weather - not for penetrating it. Whether to fly into an area of radar echoes depends on echo intensity, spacing between the echoes, and the capabilities of both pilot and aircraft. Remember that weather radar detects only precipitation; it does not detect minute cloud droplets. Therefore, the radar display provides no assurance of avoiding inclement weather in clouds and fog. Your display may be clear between intense echoes; this clear area does not necessarily mean you can fly between the storms and maintain visual separation from them.

Weather radar detects droplets of precipitation size. The strength of the radar return (echo) depends on drop size, composition, and amount of water. Water particles return almost five times as much signal as ice particles of the same size. This means that rain is more easily detected than snow, although at times large, wet snowflakes may give a strong return.

Hail usually has a film of water on the surface; consequently, a hailstone is often reflected as a very large water particle. Because of this film and because hailstones usually are larger than raindrops, thunderstorms with large amounts of wet hail return stronger signals than those with rain. Although wet hail is an excellent reflector of radar energy, some hail shafts are extremely small (100 yards or less) and make poor radar targets. If hailstones are cold and dry, they give poor returns and might not show on the display.



STORM CELL CHARACTERISTICS

Airborne weather radar allows pilots to identify and avoid potential weather hazards. The radar performs signal processing to estimate the radar reflectivity of the weather ahead. Reflectivity correlates to precipitation rate, and is displayed as green (light), yellow (moderate), or red (heavy) precipitation.

Reflectivity helps to identify the presence of potentially hazardous weather. However, reflectivity alone cannot determine the degree of hazard. It is important that pilots be able to recognize hazards based on the form of the weather (convective versus stratiform), not by observing the reflectivity level alone.

CONVECTIVE WEATHER

Convective weather is associated with hazards due to turbulence, hail, and lightning strike. Recognizing convective weather is instrumental in avoiding these hazards.

Convection results in towering storm structures that can contain high wind gradients that lead to turbulent motion. Very vigorous convection can generate severe turbulence near the high reflectivity core, downwind of the core, and at the top of the storm. The strength of the convection can be judged by the vertical size of the convective cell and the extent of high reflectivity portions of the storm.

The RDR-7000 uses these characteristics to automatically determine the presence of turbulence. At ranges less than 40 or 60 nm (depending on installation configuration), magenta blocks indicate areas of particularly turbulent activity. The radar is capable of measuring turbulent areas of the storm cell at or below the green threshold, thus it is possible to see magenta turbulence indications over green or black reflectivity. Manual mode can be used to reveal the vertical extent of the storm. Note that moisture must be present to detect turbulence. The radar will not detect clear air turbulence (CAT).

If the Hazard Display features are installed, hail or lightning icons will automatically identify areas where those hazards are likely to occur.

STRATIFORM WEATHER

In addition to reflectivity associated with convective weather, the radar will typically display reflectivity associated with stratus, or stratiform, weather. Whereas convection is characterized by localized towers with updraft and downdraft features, stratiform precipitation results from much more widespread and much less vigorous uplift. As a result, stratus precipitation is more layered in form with much lower gradients in radar reflectivity. However, the reflectivity of stratiform weather can be sufficient to cause yellow and red on the radar display. These high reflectivities result from relatively high rain rates, as well as from enhancement of reflectivity due to melting of snow particles just below the freezing level. High reflectivity of stratus weather does not indicate any significant hazard (with the exception of any potential for icing, or takeoff and landing performance issues associated with high rainfall rates).

ICING

Updrafts in thunderstorms support abundant water; when carried above the freezing level, this water becomes supercooled. As the temperature in the upward current cools to about -15°C, much of the remaining water vapor sublimates as ice crystals. Above this level, the amount of supercooled water decreases.

Supercooled water freezes on impact with an aircraft. Clear icing can occur at any altitude above the freezing level; but at high levels, icing may be rime or mixed rime and clear. The abundance of supercooled water makes clear icing occur very rapidly between 0°C and -15°C, and encounters can be frequent in a cluster of cells.

PLANNING A PATH

Remember to plan a deviation path early. Simply skirting the red or magenta portion of a cell is not enough. Wherever possible, plan an avoidance path for all weather echoes which display beyond 100 nm since this indicates they are quite dense. If a REACT field is shown, plan to avoid that area since there may be weather there that the radar cannot detect. Refer to the FAA Approved Airplane Flight Manual and to the FAA Advisory Circulars referenced on page 5 for detailed information on flying in the vicinity of and avoiding thunderstorms and turbulence.

The most intense echoes indicate severe thunderstorms. Remember that hail may fall several nm from the cloud, and hazardous turbulence may extend as much as 20 nm from the cloud. Avoid the most intense echoes by at least 20 nm, if possible. If the Hazard Display features are installed, avoid areas with hail or lightning icons by a similar distance. As echoes diminish in intensity, you can reduce the distance by which you avoid them.

The lightning and hail icons provide additional clues as to whether reflectivity indications are associated with convective developments and provide an indication that the convection may be generating hail and/or lightning. As with any weather radar system, the crew must integrate all possible information including information from sources other than weather radar such as forecast conditions, PIREPs, ground-based weather systems and Air Traffic Control when making deviation and penetration decisions.

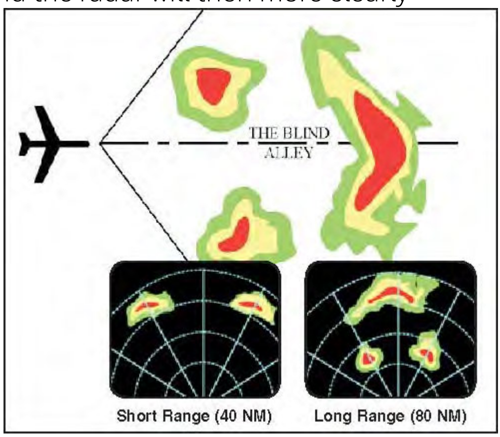
Also, note that by definition Clear Air Turbulence is always possible in areas of no displayed reflectivity.

PATH PLANNING CONSIDERATIONS

- Where possible, any indicated reflectivity should be avoided.
- Reflectivity may generally be penetrated if the crew is sure that the reflectivity is associated with stratus (non-convective) rainfall.
    - Stratus rainfall is characterized by widespread, relatively uniform reflectivity, with tops often below 25,000 feet, and with little or no indication of turbulence.
- Weather with tall vertical development (as can be determined using the manual mode), indications of turbulence, lightning, and/or hail should be considered convective and should be avoided.

- Hail and lightning icons identify which cells are likely producers of the associated hazard, but do not explicitly detect the present location of the hail or the lightning. Since lightning and hail can extend a significant distance from the core of the cell, the entire cell should be considered as containing the hazard.
  - Icons are placed on the display at or near the center of the area where the hazard-producing convection is located. It is possible that a single icon could indicate the presence of a number of separate hazardous convective cells in order to avoid display clutter. To better resolve the individual convective cells with hazards associated, select a lower display range. It is possible for an icon to showand have no reflectivity displayed in association with it. However, in this case it should be assumed that the associated convective cell is covered by the icon, and the presence of the hazard in the vicinity of the icon must be assumed.
- Cells with hail icon indications should be assumed to also be producers of lightning.
- Convective cells should be avoided by 20 nm. Characteristics of convective cells include one or more of the following:
  - Cells with large vertical structure (as can be determined using the manual mode)
  - Hail icons
  - Lighting icons
  - Turbulence indications.
- For a build-up of scattered cells where it may not be practical to observe the 20 nm avoidance guideline, plan a path upwind of the cells with the lesser hazard while avoiding other cells by 20 nm. In areas where the REACT field is shown, expect the possibility of additional weather that may have to be avoided.
  - Generally, consider cells with any magenta turbulence and hail icons as the most hazardous cells, then in order of decreasing severity:
    - Cells with turbulence and lightning indications (no hail indications).
    - Cells with no hazard icon, but with turbulence indicated.
    - Cells with reflectivity only, with maximum reflectivity of red.
    - Cells with reflectivity only, with maximum reflectivity of yellow.
    - Cells with reflectivity only, with maximum reflectivity of green.

- If a squall line or system of cells must be penetrated, plan a path through the weather in a region of the least indicated hazard with the lowest reflectivity, generally staying upwind of the most severe hazards. In areas where the REACT field is shown, expect the possibility of additional weather that may have to be avoided.
- When REACT fields are shown, the geometry between the aircraft and the attenuating weather may change as the flight progresses. This may allow weather that was in the REACT area to later be outside of the REACT field, and the radar will then more clearly display weather in that area.
- A Blind Alley or Box Canyon situation can be very dangerous. When viewing the short ranges, periodically switch to longer-range displays to observe distant conditions. In the example shown to the right, the short-range returns show an obvious corridor between two areas of heavy rainfall but the long-range setting shows a larger area of heavy rainfall.

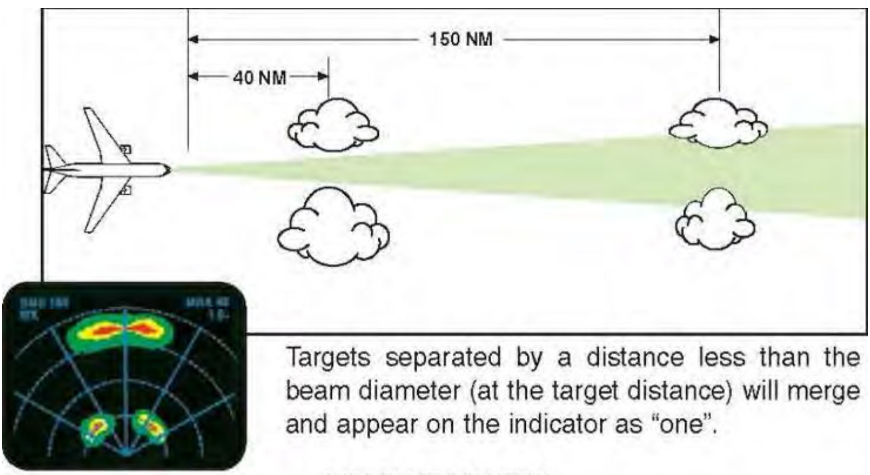


- Thunderstorms build and dissipate rapidly. Therefore, you SHOULD NOT attempt to pre-plan a flight plan course between closely spaced echoes, or under or over convective cells. Avoid individual storms in flight either by visual sighting or by use of airborne radar.
- As with previous radars, low-lying stratus weather may be difficult to discriminate from ground returns. The radar may not show this sort of weather on the display.
- The use of the internal topographical information results in a significant reduction in ground returns. However, the radar is not aware of man-made reflectors such as buildings at airports and in cities. Therefore, it is possible that not all ground clutter will be eliminated.
- There are several potential sources of false weather indications, including RF interference sources external to the aircraft, anomalous signal propagation due to atmospheric conditions,

strong returns from urban areas and mountainous regions, and others. Before making operational decisions based on small isolated indications on the weather display, the validity of these indications should be verified via PIREPS, ground-based weather sources and/or ATC communications.

AZIMUTH RESOLUTION

Azimuth resolution is a function of the beam width. When two targets are closely adjacent in azimuth andat the same range, the radar may display them as a single target. However, as the targets are approached, they seem to separate. The ability of the radar system to resolve these targets is a function of the antenna’s beam width and the range of the target. The limited azimuth resolution also results in storm cells that will tend to show being wider in azimuth than the actual width. The increase in apparent azimuth width increases with increasing range.



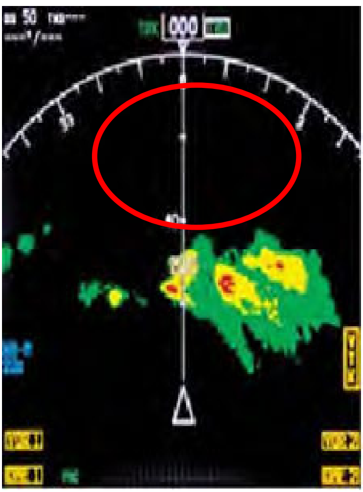
AZIMUTH RESOLUTION

ANGULAR RESOLUTION EFFECT ON VERTICAL RESOLUTION

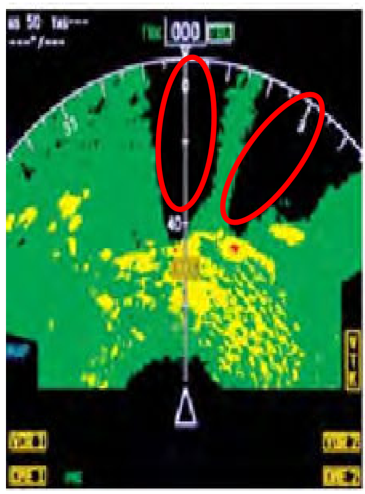
Beam width also has a range-dependent effect on the vertical resolution of weather. The typical effect is the apparent echo tops of the weather to be increasingly higher in altitude than the true echo top as range increases. Although the tops of distant storms may actually be lower than displayed, any decision regarding ability to overfly distant cells should consider the potential for the tops of growing convective cells to be higher than expected when the aircraft reaches the cell location.

SHADOWED AREAS

Extremely heavy rainfall or high terrain can reduce the ability of the radar to penetrate and present a full picture of the weather area. This is called radar attenuation. Use GMAP mode along with the weather modes to identify areas of shadowing. Observe the ground returnsin the area behind the strong weather echo. With very heavy intervening rain, the ground returns behind the echo will not be present but rather will display as a shadow. This may indicate a larger area of precipitation than shows on the weather display.



Weather display. Note the area of apparent clear weather behind the storm cells. If the GMAP display shows a shadow in this area, there may be weather here that the radar cannot see.



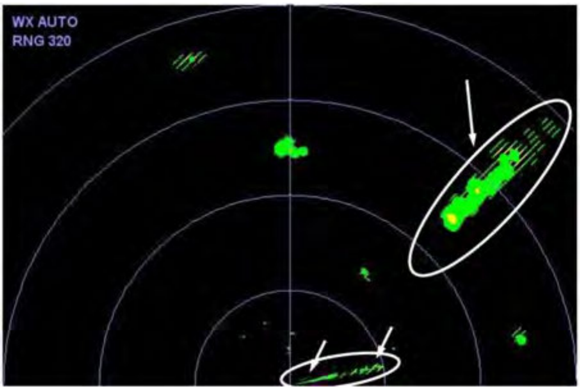
Corresponding GMAP display. The lack of radar returns in the circled areas indicates that terrain or very heavy rain in front of those areas prevents the radar signal from penetrating any farther.

EFFECTS OF INTERFERING RF SOURCES

An interfering radio frequency (RF) source operating at a frequency close to the radar's operating frequency can create unusual returns on the display. The interference may display as occasional isolated dots, or as radial spikes of any color (including magenta) on the display.

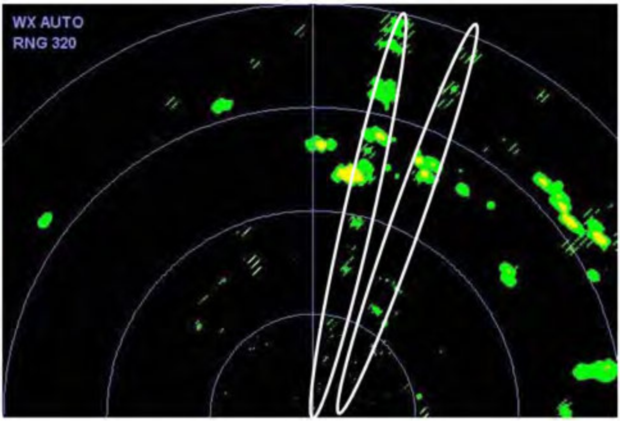
Algorithms in the software suppress most of these returns, but they cannot always be completely suppressed. Once the source of interference is no longer active, the spots will typically be removed after the antenna re-scans the area and updates the memory (approximately 30 seconds).

Adjusting the manual gain may help alleviate the effect of the interfering source but the effect will not completely go away until the interfering source is no longer in the radar's field of view and that area of the memory has been refreshed.



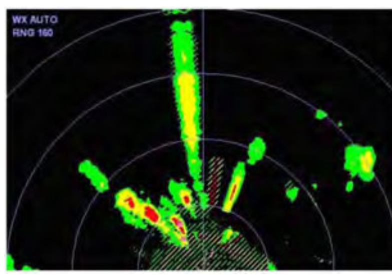
In the above picture, there are at least three sources of interference, at different frequencies.

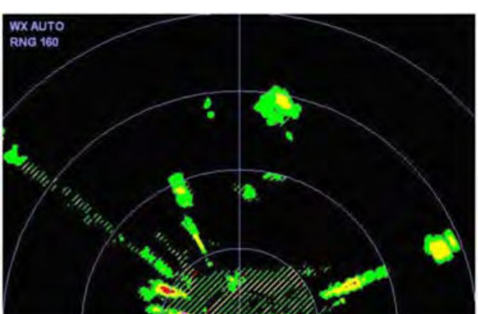
This figure shows a zoomed-in view of the near-range interference from the previous figure.



In this figure, the interference is a bit more subtle, as it is mixed in with real weather. However, a close look reveals several radialspokes. The two most obvious ones have been circled.

These figures show more examples of RF interference.





RADAR WINDSHEAR DETECTION

During both takeoff and landing, microbursts have been the cause of numerous aircraft accidents.

WINDSHEAR/MICROBURST DESCRIPTION

A microburst is a cool shaft of air, like a cylinder, between ½ and 1½ nm across that is moving downward. When it encounters the ground, the air mass mushrooms in a horizontal direction curling inward at the edges. The downward air velocities associated with these narrow air shafts range from 20 to 40 knots.

Two types of microbursts exist; wet and dry. In a wet microburst, rain droplets within the airshaft fall largely intact all the way to the earth’s surface. This type of event is typical of humid areas like the southeast United States. A dry microburst may contain virga, or rain that exits from the cloud base, but mostly evaporates before reaching the ground. Virga occurs in high-based rainstorms found in places like the high plains and western United States. Regardless of whether the microburst is wet or dry, the airshaft’s wind characteristics are identical.

When the downward moving airflow becomes a horizontal flow at the base of the airshaft, the outflow winds have front-to-back velocities ranging from 20 to 80 knots.

WINDSHEAR/MICROBURST DETECTION PROCESS

When the airshaft of a microburst encounters the ground, it mushrooms outward. By measuring the horizontal velocity of the associated water droplets, the RDR-7000 is able to infer the horizontal and vertical velocity of the winds carrying the raindrops.

The radar processor detects the Doppler frequency shift imparted onto the reflected microwave pulses by a microburst. As the radar scans across the windshear event, it will detect raindrops moving toward it at one range and away from it at a slightly greater range.

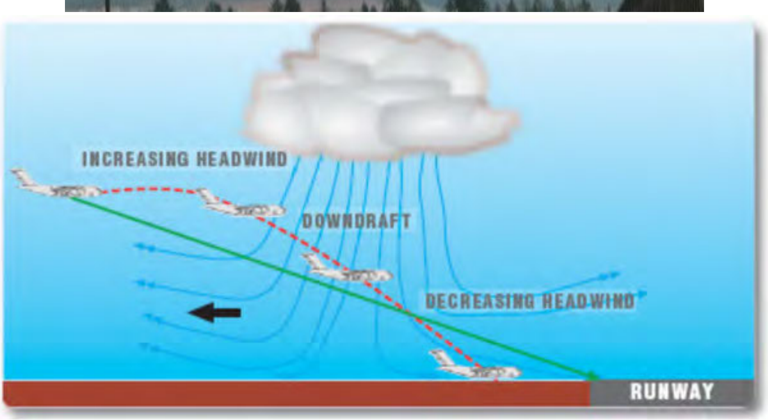
The difference in range between the raindrops moving toward and away is the width of the base of the microburst. After the radar detects this condition, it then assesses the severity of the event by measuring how fast the droplets are moving. If the assessment of the severity of the micro-burst exceeds a preset threshold value, a windshear alert is issued on the radar display and through the flight deck audio system.

The RDR-7000 has the ability to detect the presence of microbursts up to 5 nm ahead of the aircraft when below 1,800 feet AGL.

WINDSHEAR AVOIDANCE FLYING

The air shaft of a microburst creates problems for aircraft for two reasons. The first problem is due to the downward air movement. Since the aircraft is flying within the air mass, as the air mass plummets earthward, so does the aircraft. Second, the lift that is generated by the wing is related to the relative velocity of air traveling over the wing. If the air velocity suddenly changes, so does the lift. When the lift is reduced, the aircraft descends. As an aircraft enters a microburst, depending on the point of entry, it will experience at least one of these conditions and most probably both.

The key to surviving a microburst is to enter it at a high enough aircraft energy state (high altitude and fast airspeed). The RDR-7000 system provides a warning prior to encountering the windshear, significantly improving the chances of surviving the encounter.

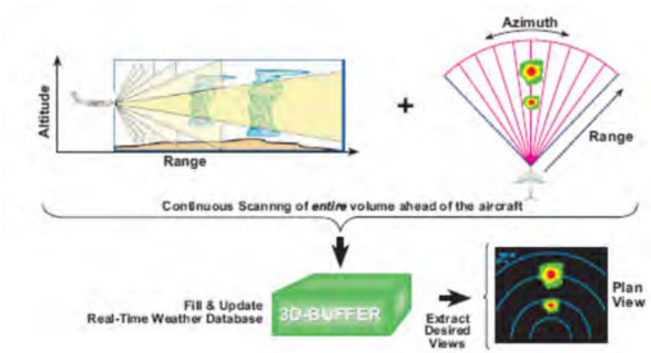


MICROBURST ENCOUNTER EXAMPLE

SECTION 6: RDR-7000TECHNICAL OPERATION

3D VOLUMETRIC MEMORY SCANNING/PROCESSING

The RDR-7000 collects a complete 3D volumetric scan of all the weather and terrain ahead of the aircraft. The RDR-7000 contains internal worldwide topographical information, enabling it to extract ground clutter without the significant losses associated with signal-based ground clutter suppression techniques. The data in the memory is continuously updated and compensated for aircraft movement.

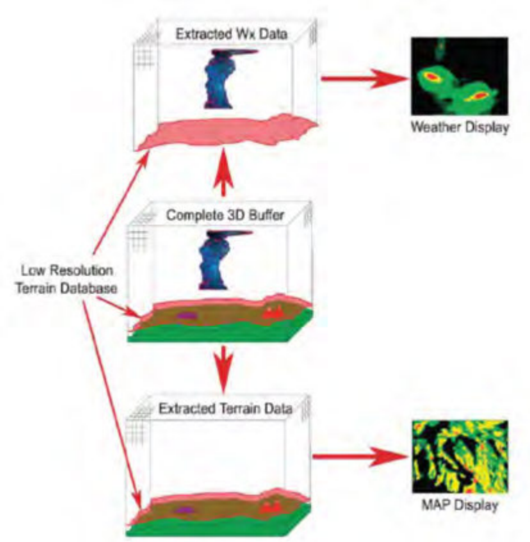


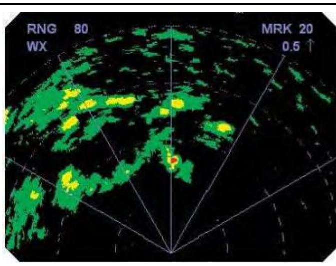
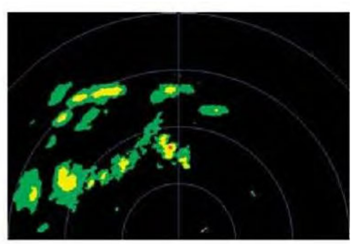
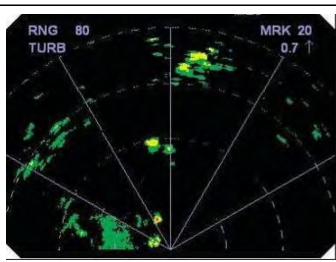
In conventional radar systems, there is a one-to-one real-time correspondence between the approximately 4-second side-to-side movement of the antenna, and the radar image update on the displays. In such systems, the display update is synchronized to the antenna tilt angle and sweep. Only the data required for immediate display is collected and processed. In contrast, the RDR-7000 system has eliminated this limitation. The mechanical scanning pattern of the antenna is de-coupled from the weather images shown on the displays. The radar system continuously scans the entire 3D space in front of the aircraft and stores all reflectivity data in 3D memory. This memory is continuously updated with reflectivity data from new scans and the data is compensated for aircraft movement. This reflectivity data is extracted from memory to generate the selected views without having to make (and wait for) view-specific antenna scans.

Views are not limited to the single diagonal slice that is inherent to conventional radars. The standard horizontal view provided by the RDR-7000 represents a weather envelope based on flight path slope, and corrected for the curvature of the earth. Horizontal views are generated independently for each side of the cockpit.

GROUND CLUTTER EXTRACTION

The radar processor contains an internal terrain database with elevation data. The radar compares the collected reflectivity data with the terrain database. Reflectivity data that correlates to terrain data is considered ground-clutter, and is suppressed from the weather images. However, the data that is suppressed from the weather images is retained for display when the radar's GMAP Mode is selected.



CONVENTIONAL RADAR	RDR-7000
	
	
IMPROVED CLUTTER REJECTION/ENHANCED WEATHER PRESENTATION (ALBUQUERQUE ~70 NM, RIGHT OF TRACK)	

ON PATH WEATHER VS. OFF PATH WEATHER

The WXALLorWX PATH modesare used for the strategic detection of weather. This fully automatic weather detection is enabled by the 3D volumetric memory. In these modes, OnPath weather, or weather near the altitude of the intended flight path, is displayed as distinct from Off Pathweather, which is further removed in altitude from the flight path. The result is a presentation of weather information that is intuitive, improves awareness of the entire weather situation, and reduces the potential for misinterpretations, thus reducing crew workload.

The separation of On Path from Off Path weather is based on several parameters:

- Aircraft altitude
- Flight phase (climb, level flight or descent)
- Flight path (if available, or slope of aircraft climb or descent if not)
- Presence of convective weather.

The separation is done by applying an envelope around the intended flight path: weather within the envelope is considered On Path weather, weather outside the envelope is Off Path weather. On the display, Off Pathweather is distinguished from On Pathweather by black stripes(see illustration on page40). If a flight plan is available, it is used in the envelope calculation. Otherwise, the flight path angle is computed based on the ratio of calculated vertical speed to ground speed. In this case, the expected flight path altitude is extrapolated to 60 nm. Beyond 60 nm, level flight at the calculated altitude is assumed.

ENVELOPE BOUNDARY DEFINITION

The upper and lower boundaries of the separation envelope are based on the parameters listed above. The envelope is not bounded in the horizontal plane. During level flight the envelope extends from 4,000 feet above to 4,000 feet below the aircraft's altitude. At cruise altitudes above 29,000feet MSL, the lower boundary is extended down to 25,000 feet MSLin areas where convective weather is detected, to ensure that the most reflective parts of any convective cells are displayed. The upper boundary cannot go lower than 10,000 feet MSL. Additionally, absolute envelope boundaries of 60,000 feet and ground level apply. The resulting rules are shown in the following table.

Envelope Boundary Limits

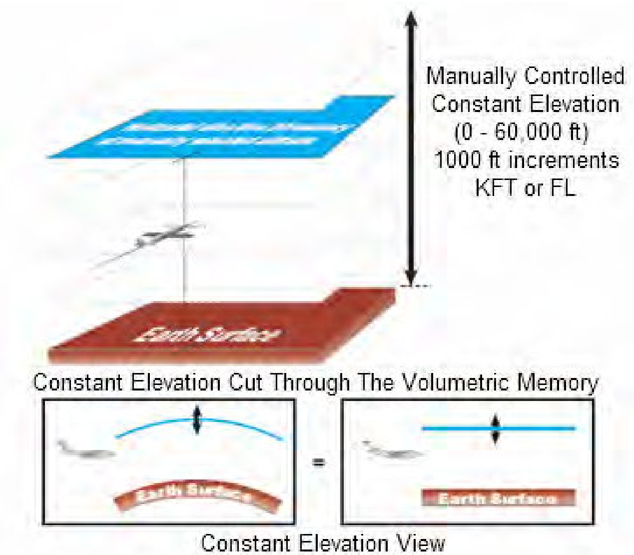
<table>
<tr><th>Aircraft Altitude (feet MSL)</th><th>Lower Envelope Boundary</th><th>Upper Envelope Boundary</th></tr>
<tr><td>> 29,000</td><td>25,000 feet MSL or Flight Altitude minus 4,000 feet</td><td rowspan="2">Flight Altitude plus 4,000 feet (max. 60,000)</td></tr>
<tr><td>29,000 to 6,000</td><td rowspan="2">Flight Altitude minus 4,000 feet (min. ground elevation)</td></tr>
<tr><td>< 6,000</td><td>10,000feet MSL</td></tr>
</table>

In the WX ALL and WX PATH modes, the RDR-7000projects a three-dimensional memory space onto a two-dimensional display. This means the weather displayed for any one memory cell is the color of the strongest return in that column of memory cells. Specifically, if there is any weather data in a given column that is inside the envelope for OnPath weather;the color of the strongest of these returns is displayed. If there is no weather data inside the envelope, then the color of the strongest return from outside the envelope is displayed as Off Path weather if in the WX ALL mode. In the WX PATH mode, no Off Path weather is displayed.

Stronger returns outside the envelope (Off Path weather) never override the strongest returns displayed as OnPath weather.

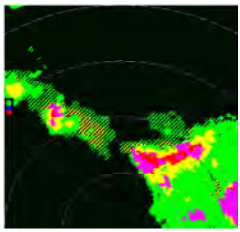
WEATHER ANALYSIS MODE: MANUAL ALTITUDE

Manual Altitude mode is an analysis mode providing a constant elevation slice throughout the entire 180-degree plan view. It is called constant elevation because the elevation slice extracted from the memory is corrected for the earth’s curvature. With traditional tilt angle settings the earth curves away from the beam farfrom the aircraft making it difficult to exactly measure the height of a cell. The constant elevation 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 or constant Flight Level).

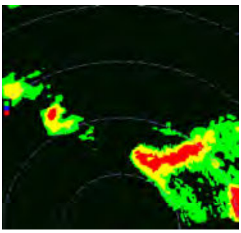


The elevation slice is selected by the WX MAN control. The elevation is selectable between zero and 60,000 feet in 1,000feet increments. On activation of the WX MANmode, the slice at the current aircraft altitude (rounded to the nearest 1,000feet) is chosen. The view does not move up or down when the aircraft altitude changes. The pilot can quickly measure the tops of cells without any calculations. By varying the selected altitude until a cell just goes away, the cell height can be directly read from the display.

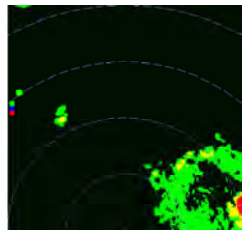
The example below demonstrates the WX MAN mode. In the top center picture, the system is in the WX ALL mode at an aircraft altitude of 20,000 feet MSL. In the second center picture, WX MANmode has been selected.This is an elevation slice at the current aircraft altitude (20,000 feet MSL). The remaining pictures show the returns at different elevations. Observe that the cell tops exceed 25,000 feet.



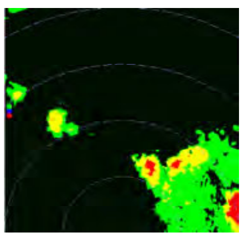
WX ALL MODE



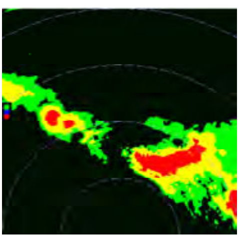
MANUAL MODE:
SLICE AT 15,000 FT



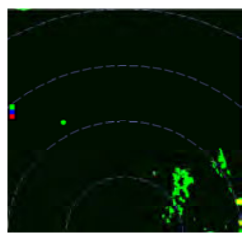
MANUALMODE:
SLICE AT 25,000 FT



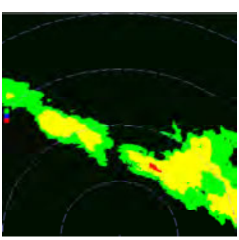
MANUALMODE:
SLICE AT 20,000FT
(e.g. AT A/C ALTITUDE)



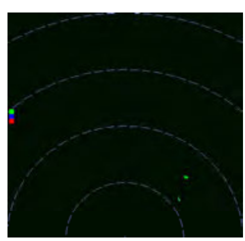
MANUAL MODE:
SLICE AT 10,000 FT



MANUALMODE:SLICE
AT 30,000 FT



MANUALMODE:
SLICE AT 5,000 FT



MANUALMODE:SLICE
AT 45,000 FT

MANUAL ALTITUDE MODE EXAMPLE
USING VARYING ELEVATIONS

APPENDIX

SAFETY INFORMATION

CAUTION

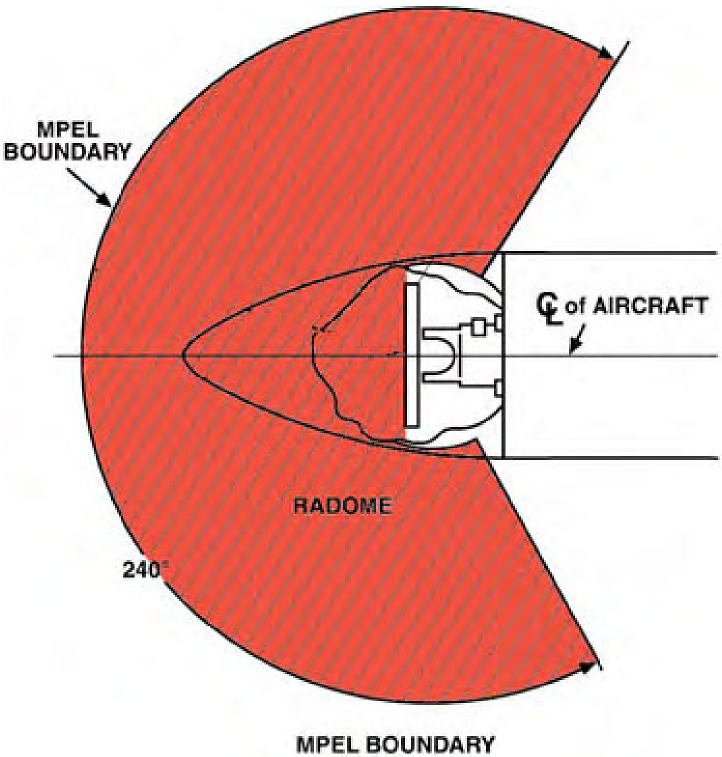
MAINTAIN PRESCRIBED SAFE DISTANCE WHEN STANDING IN FRONT OF A RADIATING ANTENNA.*

*Reference FAA Advisory Circular #20-68B

MAXIMUM PERMISSIBLE EXPOSURE LEVEL (MPEL)

FAA advisory circular AC 20-68B defines the method for determining the MPEL boundary. All personnel should remain beyond the distance indicated in the illustration below. Manufacturers are required to calculate two distances; the MPEL boundary is determined by the greater of these two distances. The first distance is the near field/far field boundary which is the distance from the antenna that it takes for the beam to form. The second is the distance where the radiation level exceeds the U.S. Government standard of 10 milliwatts per square centimeter. In TEST mode, the system transmits two 550 microsecond pulses at the beginning of the test sequence. For the RDR-7000, these distances depend on the size of the antenna in use. The table below summarizes the various safe distances for each antenna size.

Safe distance (for 10 milliwatts /centimeter^2)	**RDR-7000 with 18” Antenna**	**RDR-7000 with 12” Antenna**
Maximum Permissible Exposure Level (MPEL) distance	10.1 feet (3.1 meters)	7.0 feet (2.1 meters)
Safe fuel distance	1.9 feet (0.6meters)	1.3 feet (0.4 meters)
Test Mode distance	0.67 inch (1.7 cm)	0.46 in (1.2 cm)


MPEL
BOUNDARY
℄ of AIRCRAFT
RADOME
240°
MPEL BOUNDARY

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