

EDITOR'S NOTE: This is the fourth and final part of a white paper, authored by TexasGYRO. This white paper presentation is for training purposes only. Its sole intent is to improve the maintenance technician's knowledge and understanding of airborne weather radar systems. Refer to manufacturer's most current technical data, maintenance and/or installation manuals or pilot's guides whenever performing maintenance on aircraft or aircraft components.

Airborne Weather Radar

PART IV: Theory & Operation for More Effective Troubleshooting

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FLIGHT-LINE TROUBLESHOOTING AND REPAIR

► Major Players in Airborne Weather Radar

An understanding of the major players and the history of the companies involved is important to the servicing of any radar system. There have been mergers, consolidations and many systems have changed brand names over the past 40 years. Many of the radar systems are 25-years-old and have been out of production for 15 or more years, yet they are still reliable and in service.

Collins

Collins has not sold its radar systems or merged with anyone of any consequence for the servicing of general aviation radar systems. Today, it is called Rockwell Collins after its avionics merger with Rockwell.

Honeywell

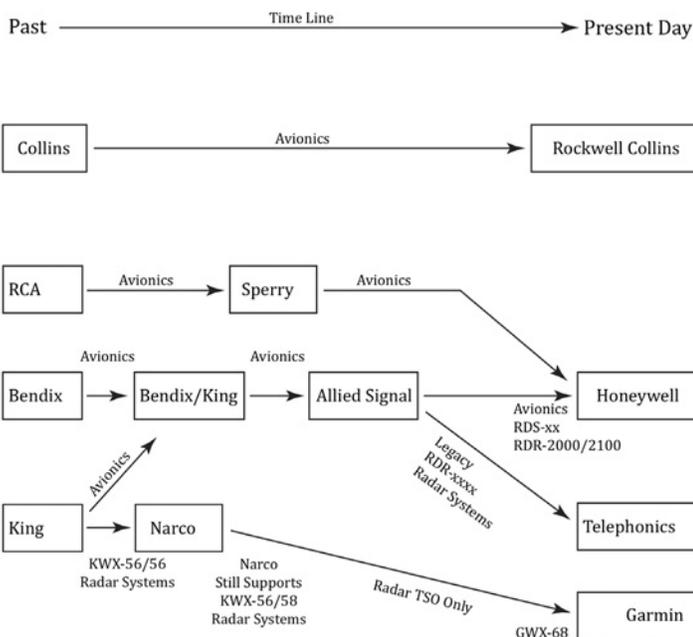
RCA produced a good line of weather radars under the RCA name. These are the PRIMUS series of radars. RCA then sold its avionics division to Sperry, which continued to produce many of these same radar systems under the Sperry name. Sperry also designed some new systems. Sperry then sold its avionics division to Honeywell, who continued to manufacture and support these same radar systems. There are many popular radar systems on the market that bear the RCA, Sperry or Honeywell name, yet have the same part number and model number.

Bendix produced a great line of radars using the RDR-xxxx model schema. Bendix merged with King and became Bendix/King and then later changed its name to Allied Signal.

King produced the KWX-40/50 and KWX-56/58 series of radars. At the time of its merger with Bendix, the KWX-40/50 had been discontinued. Bendix/King was formed by the merger of Bendix and King. The name was later changed to Allied Signal. Allied Signal manufactured the RDR-xxxx, RDS-xx and RDR-2000/2100 series of weather radars.

Narco purchased the KWX-56/58 line of weather radars from King when King merged with Bendix. This sale occurred because the SEC required either King or Bendix to sell one of its lines of radar systems in order to approve the merger between King and Bendix.

Many years later, Narco sold the TSO rights for this radar to Garmin; however, Narco continues to support all existing KWX-56/58 systems still in operation. Garmin has greatly improved upon this radar, which is now currently being sold as the GWX-68.



-- Figure 5-1: Manufacturers' Time Line --

Allied Signal then merged with Honeywell. When this happened they sold the RDR-xxxx series to Telephonics. Honeywell kept the RDS-81/82/84/86 series and the RDR-2000/2100 product line. Honeywell has kept the Bendix/King name for these systems, as well as the general aviation line of avionics.

Telephonics purchased the RDR-xxxx series from Allied Signal when Allied Signal and Honeywell merged. Telephonics continues to support the legacy systems and currently manufactures the RDR-1400, 1500, 1600, 1700 series of weather radars.

► **Pilot's Operation/Complaint**

When troubleshooting a radar failure, it is important to know the complaint from the pilot. It is very important to know the point of the flight when failure occurred.

Was it on the ground prior to departure, three hours into the flight or on descent into Houston on a hot humid summer afternoon? An aircraft making a descent after several hours cold soaking during high altitude cruise into a hot humid environment will experience heavy condensation in the avionics bay and under the radome.

Whether the malfunction occurred at low or high altitude is important to identifying the failure. RF arcing, either in the RT or the waveguide, can occur in the low atmospheric pressure of high altitudes.

Did any other aircraft anomalies occur during the flight? Were there power fluctuations, inverter failures, vacuum or gyro failures?

"Weak returns" or "fails to paint" are common complaints. Verify that gain is in detent (AGC). This is often inadvertently left out of detent (AGC) causing weak or no returns. Verify that the antenna scans and tilts correctly, and turn stabilization off. An antenna stuck in full tilt up will scan over any weather and have no returns. Inspect the radome and waveguide. Failure in the RT is the most common cause of weak or no returns.

"Spoking" is a common failure and pilot squawk. Automatic frequency control is used in the RT to keep the receiver locked to the magnetrons exact transmitter frequency. When AFC is unlocked due to a malfunction or temporary glitch, the local oscillator in the RT will sweep at approximately one sweep every five seconds. As the LO sweeps across the transmitter frequency, the AGC will saturate and display a solid red bar from the center to the outer edge of the display.

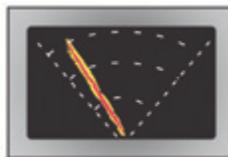
"Spoking" is defined as periodic flashes radiating from the apex to the outer edge of the display. It is often, but not always, a solid red bar. Any abnormalities that radiate from the apex to the outer edge of the display can be referred to as "spoking."

In the rarefied thin atmosphere of high altitude flight, many things can arc causing either a temporary or permanent AFC unlock. High voltage in the RT can arc. High power RF can arc in the waveguide if it has lost pressurization. A RT failure is the most often cause of spoking.

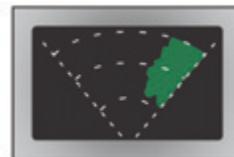
A "noisy (many green dots) display" is most often caused by a failure in the RT.

"Paints ground on one side" is indicative of stabilization errors.

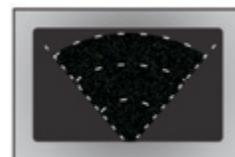
This will require a stabilization alignment. Any malfunctions in the gyro, inverter or radar system related to stabilization can easily be diagnosed during the stabilization alignment.



-- Figure 5-2:
Spoking --



-- Figure 5-3:
Stabilization Errors --



-- Figure 5-4:
Noisy Display --

► **Physical/Mechanical**

The radome acts as a window to the RF. Improper repairs or lead-based paint can hinder the passage of RF through this window. Inspect for delimitation or prior repairs, water or condensation, cracks or dents. Lightly tap with a small screwdriver handle listening for dead spots or trapped moisture.

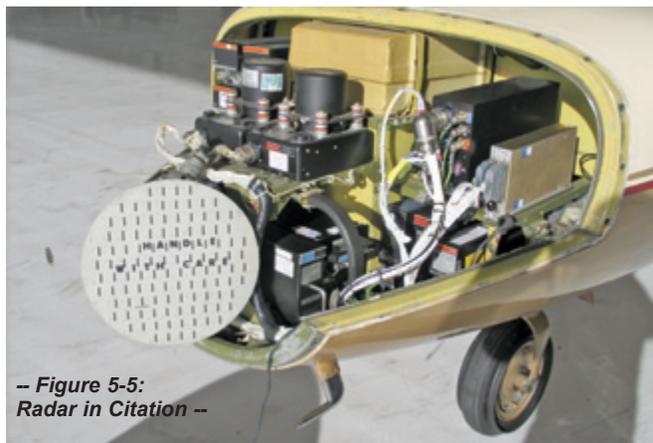
Delamination, trapped moisture or poor condition can reduce the amount of radiation passing through. It can also deflect the beam, often pointing towards Earth and painting constant weather. Radome degradation can affect the radar's performance.

FAA Advisory Circular AC-43-14 (Maintenance of Weather Radar Radome) for guidance on radome maintenance.

Waveguides must be pressurized for any operation above 25,000 feet. Missing o-rings, cracked or bent waveguides, missing pressure windows can all cause loss of waveguide pressurization. This can cause RF arcing and spoking at altitude, yet everything will check out fine on the ground.

Inspect the array or parabolic dish. Radar arrays must be flat; any warps, dents or distortion will affect the radar beam and are unacceptable. A parabolic dish must not be dented or distorted.

Inspect the antenna pedestal or ANT/RT for level installation. Missing shims can cause an unlevel scan and painting of the ground on one side.



-- Figure 5-5:
Radar in Citation --

Continued on following page

AIRBORNE WEATHER RADAR

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► **Operational Check-out**

Safety is paramount. RF radiation from the radar system is harmful to the human body. Follow the manufacturer's maintenance manual.

The following discussion is to present the concept of a typical ground check. The manufacturer's maintenance manual must be followed any time you are working on an aircraft or an aircraft component.

It is important to have a known target that you paint. For example, a water tower at nine miles makes an excellent target. This will give a point of reference for future ground radar functional checks.

Typically, on the ground, you will paint targets in the 5 to 25 mile range. Start with the tilt at zero degrees. Slowly adjust the tilt between negative five degrees and five degrees tilt up. This is optimum to paint a known target on the ground.

Use a power cart, and do not ground test the radar system on aircraft batteries. It is common for many radar systems to exhibit errors when the source voltage is below 26VDC. Insure that both 28VDC and 400Hz AC are good. Many systems require 400Hz AC for cooling fans and proper antenna operation. Most gyros require 400Hz; a very few require vacuum.

Some systems in certain installations have a weight on wheels sensor to prevent radar transmissions on the ground. This must be disabled for ground check out.

A typical radar system ground check is as follows:

1. Position aircraft as appropriate location, take into account scan angle. Ensure safe transmit lanes.
2. Remove radome.
3. Ensure both good DC and AC power.
4. Turn system to standby, and allow appropriate time in. This is important to allow the filaments in the magnetron to warm up.
5. Place system in test. Observe indicator display for correct display, colors and absence of blooming. View test pattern, and verify correct test pattern with manufacturer's manual.
6. Observe antenna for proper tilt and scan throughout the entire range. This must be done from the side of the aircraft away from the RF radiation beam.
7. Verify radar paints a known target. Allow system to paint for several minutes, monitoring for any breaking up of signal.

8. It might be necessary to repeat the operational test with the radome attached to rule out the possibility of radome related failures.

9. Power system down; several systems have a time out period.

This completes a typical ground check. Note any abnormalities. Consult manufacturer's maintenance manual for troubleshooting. Block diagrams in these manuals are helpful for knowing LRU functions.

► **Stabilization Alignment**

The purpose of radar stabilization is to maintain a constant radar scan of desired tilt angle level with the Earth's horizon during normal aircraft operations and maneuvers. Radar stabilization will tilt the antenna array as appropriate to maintain a level scan with the horizon at all times. A radar stabilization alignment will calibrate the radar, gyro, inverter and aircraft together as one.

The radar will receive pitch and roll data in one of many methods, ARINC 429 digital, 10,000Hz sine wave or 400Hz sine wave that varies in amplitude depending on pitch or roll angle. This sine wave will be 50 millivolt per degree for fixed wing aircraft or 200 millivolt per degree for helicopters. Roll right/left and pitch up/down is determined by the phase relationship of the pitch/roll signals versus the reference signal (400Hz or 10,000Hz). Refer to the manufacturer's maintenance manual for system specific details.

Safety is paramount. RF radiation from the radar system is harmful to the human body. Follow the manufacturer's maintenance manual.

The following discussion is to present the concept of a typical stabilization alignment. The manufacturer's maintenance manual must be followed any time you are working on an aircraft or an aircraft component.

Use a power cart, and do not perform a stabilization alignment on aircraft batteries. It is common for many radar systems to exhibit errors when the source voltage is below 26VDC. Ensure that both 28VDC and 400Hz AC are good. Many systems require 400Hz AC for cooling fans and proper antenna operation. Most gyros require 400Hz or vacuum.

A typical radar stabilization alignment is as follows:

1. Position aircraft as appropriate location, take into account scan angle. Ensure safe transmit lanes.
2. Remove radome.
3. Ensure both good DC and AC power.
4. A protractor must be used for all angle measurements.
5. Verify that the antenna pedestal (or ANT/RT) is mounted perfectly level with the aircraft. The seat rails are gener-

ally a good level reference. Measure seat rails with a protractor, and use this measurement to offset all stab calculations. Take into account the aircraft may not be sitting level.

6. Remove the vertical gyro and place it on a tilt table; use an extender harness.
7. Place in correct mode per manufacturer's maintenance manual. Some systems need to be in test, others standby.
8. Each system will have different adjustment locations for pitch/roll stabilization compensation. These can be analog in the antenna, receiver transmitter or indicator. Some systems utilize a digital adjustment from the indicator. Refer to the system's maintenance manual.
9. It is often confusing as to where to tilt (up or down in relation to scan azimuth) when the aircraft is on the ground, especially in roll. Imagine the aircraft is in a left bank, and then think where the array needs to point to maintain level with the horizon when the array is fully deflected to either side.
10. Pitch the gyro up 20 degrees and zero degrees roll, and watch the movement of the radar array. At dead ahead, the array should tilt 20 degrees down to compensate for the aircraft's 20 degrees pitch up. Adjust pitch compensation for 20 degrees tilt up. Repeat the procedure for aircraft nose down and array tilting up. This will often need to be repeated several times.
11. Roll the gyro left 20 degrees and zero degrees pitch, and watch the movement of the radar array. On a 120 degree sector scan system, at full left deflection the array will pitch 17.5 degrees up when the aircraft is in a left bank. Adjust roll compensation for 17.5 degrees tilt up. Repeat the procedure for aircraft right roll and array tilting down. This will often need to be repeated several times.
12. Pitch and roll can interact. After performing adjustments, go back and verify accuracy of pitch and roll.
13. Power system down; several systems have a time out period.

This completes a typical radar stabilization alignment. Note any abnormalities. Consult manufacturer's maintenance manual for troubleshooting. Block diagrams in these manuals are helpful for knowing LRU functions.

► **Benefits of Bench Checking All Components Together**

When a radar failure occurs, even if only one component is suspect, it is recommended that all system components be bench tested together. The benefits are as follows:

1. Condition and performance of one LRU can be masked by a failure in a different LRU.
2. In many systems, the RT, IND and ANT share a low voltage power supply from one LRU source, such as the RT. System bench tests eliminate possibility of diagnosing the incorrect LRU as failed.
3. The system may present a failure in one LRU, but the other LRUs may suffer from degraded performance. System bench checks and alignment as one will keep the radar system operating at peak performance.
4. Anything under the radome takes an environmental beating. A hard RT or IND failure in a system may be defined. But, if the system is tested together, any corrosion can be detected before it causes a serious and expensive failure.
5. An all-together bench test gets the entire system on the same maintenance schedule. An annual system test is good practice.



— *Figure 5-6: Shop Radar Bench Test* —

► **More About TexasGYRO**

An AEA member since 2003, TexasGYRO is an FAA and EASA Part 145 certified repair station in Burleson, Texas. The avionics shop specializes in the repair and overhaul of airborne weather radar systems. TexasGYRO has facilitated a weather radar training course at previous AEA conventions and regional meetings. For more information, contact TexasGYRO at 817-282-7500 or visit www.txgyro.com. □