Weather Radar Troubleshooting

BY DALE SMITH

Weather radars are pretty amazing. They send out a beam of pulsed high energy 100 or so miles off the nose, and that energy reflects off any liquid precipitation, usually raindrops, and returns back to the antenna. Then, those returns are processed and, depending on the precipitation's intensity, show up as one of three or four colors on a radar or MFD screen.

And it all happens in a literal "blink of an eye." Radars found on most general aviation aircraft process nearly 1,000 pulses per second.

Many factors will affect the performance of a radar system, including transmitter power, receiver sensitivity, signal-to-noise ratios, the shape of the beam itself, pulse repetition frequency and pulse width. Add to the fragile nature of the components the fact that, unlike other avionics systems, weather radars are made up of two and sometimes three or four different components, and it's no wonder many avionics technicians shudder at the thought of troubleshooting a radar system.

Older systems, such as the venerable Bendix RDR-1100, used four separate units: the receiver/transmitter (R/T), the waveguide, the antenna and the display unit. Newer two-piece systems, such as the Garmin GWX 68, combine the waveguide, R/T and the antenna into one unit with the weather displayed on either a dedicated unit or an MFD.

Safety First

Weather radars can be the most dangerous critters in the cockpit. They use very high microwave energy to do what they do and, without proper care, that energy can be hazardous to you and others around the airplane.

The best place to start any troubleshooting project is by reading FAA AC 20-68B, "Recommended Radiation Safety Precautions for Ground Operation of Airborne Weather Radar." Although it was written in 1980, it is loaded with valuable safety information about the dangers associated with microwave radiation and includes guidelines on how to calculate a recommended safe working distance from the antenna for a particular radar system. This advisory circular includes the same information found in the radar's manual, but with the age of some systems, those documents might be long gone.

Bill Knauf, manager of customer and product support for Honeywell, suggests taking an even more conservative route by following the guidelines for MPEL (maximum personal exposure limit) radius that can be obtained from IEEE C95.1-1991, which is followed by the FCC, OSHA, NIOSH and others.

Knauf said the safest thing is to always assume the radar is transmitting — even in the "test" mode. And it should never be pointed at buildings, vehicles or people.

Radar Troubleshooting 101

Weather radar systems offer avionics technicians their own unique set of challenges when it comes time to troubleshoot a problem.

"Radar systems have two or three pieces per system, where most other (avionics) equipment is single box," said Dan Magnus, team leader for technical services at Duncan Aviation. "The biggest thing is, there is no ramp test equipment to assist you in troubleshooting the unit. You don't have a way to go out and slap a box on it and determine what's bad and what's not."

While a technician might not be able to "slap a box on it," there is a way to get a head start on a system's ills: Talk with the pilot. When talking with the pilot, Knauf said to ask the right questions, such as: "Does adjusting the tilt have any effect on the problem?" or "Can the radar paint ground targets?"

He also said technicians should review a copy of Honeywell's "Radar Training Course" on CD because it will help them better understand pilot "squawks" and how to formulate better questions for pilots.

"The most common reason for squawks like 'The radar couldn't see the rain that we could see visually,' is tilt management," he said.

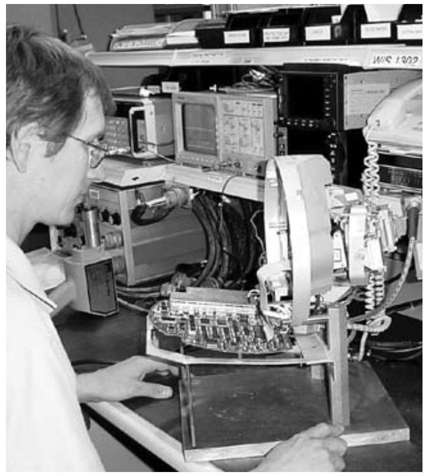
Operator error aside, radar troubleshooting is a challenge and an opportunity for a technician to use his finely tuned set of skills.

"You really need to use good troubleshooting skills and the troubleshooting logic tree to work your way through the different components," said Rick Ochs, owner of Spirit Avionics. "A logical analysis of what it is doing and not doing is the best way to start."

When ascending the troubleshooting tree, consider the age of the system.

"Older systems have a tendency to have more than one problem when they come in for repairs," Magnus said. "You may have a transmitter and a receiver problem, and you may have some corrosion in there, too. As a rule, with the older systems, you have to fix a couple of things before you get to the bottom of it."

The first place most technicians



generally start is at the receiver/transmitter.

"They have the greater failure rate because they have the power supplies in them," Magnus said. "They have modulators that fail, magnetrons that fail, and then receivers — that's probably the chronological order of where you will find problems with them."

Ochs said indicators are a major source for failures as well.

"A lot of older radars have a CRT tube in them with a high-voltage power supply like an old TV. The power supply, or the horizontal or vertical driver, or the tube itself can go," Ochs said. "You just can't point at one possible problem."

What the Radar Said

What symptoms the radar displayed before it "died" can help a technician shorten the troubleshooting path. Sometimes, however, those clues can be a proverbial "red herring." Take the problem of "spoking," for example.

"Spoking is a common symptom of radar failures. And, more often than not, kind of the default troubleshooting analysis is that the problem is the magnetron," Ochs said. "I've been guilty of that myself. But it's not always the case."

Ochs said in older radar systems in particular, there are times when the waveguide could be the culprit. In many installations, the waveguide has to remain pressurized to work correctly so it will have a line going from the unit to the cabin that allows pressurized air to be injected into the waveguide. If it goes unpressurized in a high-altitude aircraft, problems in the waveguide that can cause spoking might occur.

"It's something you see with older Citations and other jets with a remote R/T," Ochs said. "If that hose develops a leak, or if a seal goes bad, or you get corrosion around an "O" ring in the back of the waveguide itself, you will lose pressure and get spoking at altitude.

"The real problem for troubleshooting is, the system will work fine when it is down at lower altitudes," he said. "It could be looked at as one of the most overlooked parts of system troubleshooting."

Instances such as these are why Ochs and Magnus said technicians need to look at the radar system as a whole, not just as parts. It is critical to understand how the parts interact with each other and with other parts of the aircraft. The problem may not be where you are "sure" it is.

One example Ochs shared about the particularities of individual aircraft types is a problem with the forward bulkheads of older Citations.

"It has been known to actually expand — just a tiny bit, but enough to cause intermittent connections on a lot of bulkhead connectors," he said. "That will drive you batty because when the airplane is on the ground everything works perfectly."

Get Connected

When there's a problem, we all have the same reaction, "Something is broken." However, with radars, and older units in particular, that's not always the case. Sometimes it's just "mostly" broken.

"Corrosion in connectors is a big

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problem," Magnus said. "That can cause a whole variety of intermittent problems."

Magnus suggests before taking a system apart, examine it closely for telltale signs of corrosion or worn wires at or around the connectors.

Ochs experienced a situation in which he fixed a problem without actually finding it.

"We had a light jet in here with an intermittent on/off problem. The pilot would turn the radar on and it wouldn't come on for about 10 minutes. After that, it would work fine," Ochs said. "We rang out the system. We went through the electrical connectors, bulkhead connectors — unseated them and reconnected all of them. Then, the problem went away. That's all it took to knock off any tarnish or corrosion on a pin or something. We did a great job of 'fixing' the radar, we just didn't know it."

Don't Forget the 'Other' Component

Perhaps, the most overlooked part of any radar troubleshooting process often is staring a technician right in the face — the radome. While radomes normally are passive parts of the radar system, damage, erosion and water ingression can make them "active" participants in many reoccurring problems.

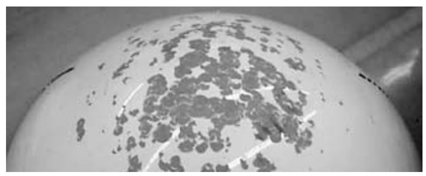
How do potential radome problems show up on the radar display?

"The kinds of things our customers report that may be radome-related are false echoes on a clear day, altitude rings — things like that," said Dan Orwig, sales manger for Saint-Gobain Flight Structures. "Odd ground returns where energy is being deflected down to the ground and coming back up — that's a bad radome."

But what can lead a good radome to behave badly?

Photos courtesy of Saint-Gobain Flight Structures.

Checking for trapped moisture.



Radome with hail damage.

"Usually, a combination of paint damage or static damage — anything that leaves holes in the paint will lead to moisture ingression," Orwig said. "That moisture will literally drill through the composite structure of a radome. When enough moisture gets in there, the radar can go 'blinky.'

"If you get enough moisture trapped in there, it will show up as a spot on the display. Trapped moisture will also lead to a 'freeze-thaw' cycle. That will not only cause considerable damage to the radome's structure, the ice trapped in there at 25,000 feet also causes problems for the radar."

Orwig said the good news is it's relatively easy to spot potential moisture problems in a radome. He said a technician should begin with a good, thorough examination of the outer skin and paint, remembering that nicks, scratches, dings or any damage can let moisture inside.

"You often have a situation where the radome has been improperly repaired," he said. "A good-looking radome doesn't mean that it's free of faults…You can imagine all the scuffing, sanding and painting over the years that have 30 layers of fillers and paint on them. No way they can function correctly with all that built-up on them."

Any Water in There?

If you see any damage or suspect the radome has been repaired incorrectly to allow water ingression, Orwig suggests performing the trusted "tap test."

"Just tap the area locally with a coin to make sure it has a sound ring to it," he said. "Anything that has a dull thud instead of a ping — that's a sign that there's too much paint or the layers have been delaminated under the skin."

While the tap test works in many situations, it really can't indicate if there is water present. Orwig said an effective way to test for moisture inside the radome's honeycomb is with a moisture meter, which is a simple RF instrument that detects moisture in a composite structure.

"It works really well, but you have to use it from the inside of the radome because of the anti-static paint on the outside," he said. "Done correctly, it's the best way to validate a radome for moisture content."

While you're in there, Orwig suggests looking for signs of incorrect repairs.

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Photos courtesy of Saint-Gobain Flight Structures.

Radome with lightning damage.

"That's another big problem with older radomes — they've gone through a lot of field repairs and you find a lot of patches on them," he said. "You see lots of laps, and anytime you see one, you see added layers of material that may knock the radome down in terms of performance."

Toolbox Troubleshooting Tips

Here are some tips from the experts:

• Talk to the pilot to get as specific a complaint as possible. Many technicians chase the wrong problem because of an incorrect or incomplete "squawk sheet."

• Before replacing the magnetron, check the filament voltage to make sure it is there — that could cause the magnetron not to fire properly.

• Check the power supplies and connectors for corrosion and burned components.

• Always use a "dummy load" for safety's sake.

• The R/Ts and antennas can cause spoking problems. If the spokes are wide and pie-shaped, this normally is caused by an R/T problem. If the spokes are thin and extend out on all ranges, it is likely an antenna problem.

• Check the connectors, bonding straps and other components to ensure the equipment is properly bonded to the airframe.

• If the system has multiple displays, always check what the radar is doing on all of them before blaming the radar.

• Make sure you have the latest service literature available for that particular system. ❑

** Tips compliments of Dan Magnus, Duncan Aviation; Bill Knauf and Bill Snell, Honeywell Aerospace; and Ric Ochs, Spirit Avionics.*