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Catering to Your BLACK BOXES

■■ Radios that perform reliably and well are important to any pilot. If he flies VFR, radio problems can take the fun out of any trip; if he flies IFR, reliable radio performance is vital to the safety of the flight.

The best radio in the world won't perform well if the installation is done poorly. Three factors in the installation have a vital effect on good performance. The first is provision for adequate cooling, the second is proper wiring, and the third is proper antenna installation.

Heat

Heat is an insidious enemy of radio performance and often results in radio breakdown and failure. When a radio part fails, there's no way of knowing for sure whether heat was a factor or whether some other problem, such as a defective component, was the cause. But all too often we blame the radio manufacturer for radio-reliability problems that are really caused by heat. How hot can it get inside a parked aircraft on a sunny day? On a day when the temperature is 85° F, the plane's interior can be hotter than 160°. The high interior temperature is caused by "greenhouse" effect: great for growing plants but extremely detrimental to radio reliability.

These high temperatures are working against us whether or not the equipment is operating. Suppose we open the door of the aircraft and let it cool down enough so we can sit in it before we take off. That radio stack is not going to cool down anywhere near as fast as the seats. Turning the radios on is going to add internally generated heat to an already bad situation.

Maybe your radios seem to take this kind of heat. What you don't realize is that the failure you experience in January was caused by a component that was weakened by heat last July.

The only answer to the heat-protection problem for the aircraft parked in the sun is a cockpit canopy. The price is cheap when compared with radio repair bills.

Heat buildup in a radio stack is a very frequent cause of radio failure. I have watched a nav receiver grow more and more erratic after two or three

Some pointers on installation that can mean the difference between poor and reliable operation — and can save you money in the long run

hours of operation. The signal started out fine, but as time and heat increased it became more unreliable. The next day, when the radio was cold again, it would work fine. The radio in question was on the top of the stack, with the com side always working well no matter how hot the set got.

Heat under these circumstances is an identifiable culprit. More often than not, a buildup of heat causes slow deterioration of the components until some of them reach the failure point. For each 10°C (18°F) rise in temperature, the life of the electrical insulation and components is cut in half. It's no wonder air-conditioned planes have greater avionics reliability.

How do you know your radios are getting too much heat? Any buildup of heat above the cockpit temperature will start taking life out of your radios. If you can feel any warmth on the front face plate of the radios after the first two or three hours of flight, they are too warm.

There are two ways to deal with this problem. The first one is suggested by King Radio Corp., which recommends that you space your radios one-quarter inch apart on the radio stack. This arrangement doesn't take much space, but allows air to move between each set so that heat from the whole stack doesn't end up accumulating in the top set.

The second means to combat heat buildup is installation of cooling kits, which should be added even if you get the recommended one-quarter-inch spacing. Installation of cooling kits at the time you put in your radios adds less than $50 to the cost, but adds at least a 100% increase in radio reliability.

The kits scoop cool air and blow it over the sides of the radio stack. They should be added to both sides of the stack, not just one. If you have a full stack, the plenum chamber of the cooling kit probably won't cover all the radios. Set one high and one low, so that each radio has at least one source of cool air blowing across it.

The air from the cooling kit has to escape some place out the top of the panel. Most aircraft have a screen opening above the radio stack. Cessna, for some unknown reason, puts plastic louvers on the bottom side of its ventilation panels. If a radio is installed right up against those plastic louvers, almost no air flow can escape. It's a simple job to remove the plastic, but many radio shops don't.

The most desirable situation, of course, would be for radio manufacturers to design cooling right into the set. Narco's DME 190 does this by having a cooling air inlet as part of the chassis. King's new 65C DME has a blower built into the set.

Does a TSO assure you of protection against heat? Only in a very limited way. The TSO means the equipment is intended for continuous operation at a maximum of 55°C (131°F); for short periods of operation, at 70°C (160°F) maximum. But if reliability is our goal, these temperatures are too hot. The heat is shortening the life of components and inviting failure.

Why don't manufacturers design sets to take heat? They would if they could. Some very interesting studies of component reliability have been made. Take a device like a transistor, operated at 77°F (25°C). At this particular temperature, it will have a certain failure rate. Let's arbitrarily assign that failure rate a value of one. Now, raise the temperature to 149°F (65°C) and the device's failure rate is 50 times greater. Raise the temperature to 185°F (85°C) and the failure rate becomes 500 times greater.

Couldn't a manufacturer use better and more costly components to stand up under the heat? Take a popular radio like the King KX 170B, priced at $1,500. This set operates reliably at 77°F (25°C). Now, put in more costly components, so that the set will give reliable operation at 149°F (65°C). The set will now cost $7,000, or more than 4½ times as much.

These figures show why manufacturers just can't design sets to meet the heat problem. If you want reliable operation, you are going to have to use good installation and operating practices to control the problem.

Wiring

Clean, neat cabling is of vital importance.

Take a look in back of your instrument panel sometime. It's a tightly congested area with a maze of wires, cables, vacuum hoses, etc.

From time to time, instruments, omni indicators, gyros, and other things have to be removed for maintenance and overhaul. A mechanic is going to have a hard time just wiggling things out. If all the wiring is bundled neatly and protected, chances are that none of these wires will work loose. If the wires are not tied down and bundled together, it is extremely easy for them to break loose.

If you have all your radios installed at once, it is a whole lot easier for the radio shop to neatly bundle the whole harness together. If you are adding radios through the years or changing other things around, make sure your radio-shop men understand that you are willing to pay for the time to keep that wiring harness bundled neatly. In the long run, a neat wiring bundle is going to save you maintenance dollars.

Antennas

Antennas are a vital part of good radio performance; yet most pilots don't give them the slightest thought, and many radio shops don't either. Chances are that, in shopping around for the radio at your local shop, you haven't even asked what kind of antenna you might be getting. The radio shop is under the gun to give you a competitive quote for your installed radio package, so they'll include an inexpensive antenna to keep the price down. Also, they have to keep the antenna installation labor down because of that inexpensive price, so the antenna may not be located in the best spot, since it might take more labor to put it there.

Perhaps the antenna is the one originally supplied in the aircraft by the manufacturer. Chances are, then, that it will be located in the right place, but it may not be the antenna that would give the best performance. The manufacturer knows that you aren't going to select or reject his aircraft because of the type of antenna he supplies, and the manufacturer too is under the gun to keep costs down.

There are three basic elements to be considered in antenna performance: mechanical durability, electrical performance, and proper placement.

Mechanical durability is not much of a problem in light aircraft that fly at low speeds, VFR only. When you move up to a retractable-gear aircraft or one instrument-equipped for flying in icing conditions, mechanical durability is of prime importance. No one likes to lose an antenna when he's carrying a load of ice under IFR conditions; yet vibration, wind resistance, and the drag and weight of the ice itself can put a very heavy load on the antenna. Just washing the belly of the airplane is enough to break off many of the little ball-type transponder antennas, and V-type wire nav antennas can easily get severe enough vibration to break off when coated with ice. So do many standard ADF sense antennas.

continued

How do you tell if an antenna is strong enough to stand up to ice? First, take a good look at the construction. Better manufacturers rate antennas for top speeds. If the antenna can take 100 or 200 knots above your cruise speed, then it will have a large safety factor in mechanical performance. Make sure that the antenna is strongly attached to the aircraft. A good, strong installation frequently requires a doubler under the skin.

Reducing drag is important, and the smaller the antenna the less drag it will create. It is also important that antennas be installed so they create the least amount of drag in level flight. (Level flight is not the same as level on the ground.) If the antennas are cocked, particularly if they are the blade type, they can add considerably to drag.

The electrical performance of most com, marker beacon, glideslope, DME, and transponder antennas is very similar; but VOR navigation antennas can have significant performance differences. There are two basic types of nav antennas: the "V" and the balanced loop.

I fly a Cessna 210 on instruments and occasionally pick up some ice. The original navigation antenna was a standard wire "V" supplied by Cessna and installed high up on the tail. With ice on it, this type of antenna has been known to vibrate and then break off. I therefore decided to replace it with an antenna more resistant to icing, the Dorne & Margolin DMN 42-1, a distinctive-looking, "towel-bar" antenna.

Because this antenna is solid and tied down on both ends, it will operate with more than one inch of ice and stay on the aircraft. This was the main reason I purchased the antenna. I did not realize, however, that the balanced loop would give me an amazing improvement in navigational range. In flat country I've gotten good nav signals without flags at 20–23 miles from the VOR—while the aircraft was sitting on the ground. Flying directly from Portland to Seattle at 9,000 feet, I have gotten strong signals from the Seattle VOR while I was more than 100 miles from Seattle. Over flat country, I have gotten reception ranges of 50 miles when I have been only 1,500 feet above the ground.

In addition to this greatly increased range, I get much more stable signals, without the needle's jumping around.

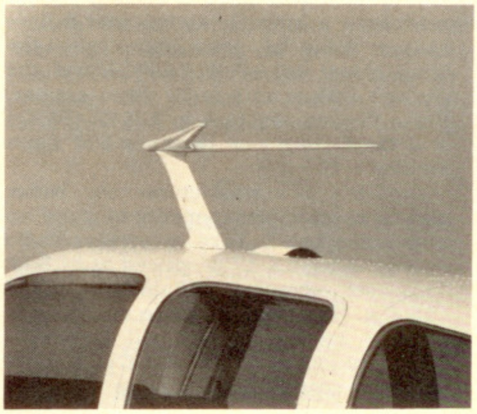
This antenna is a $124 item. But if you fly on instruments, you probably have at least $5,000 worth of radio equipment in your aircraft. It seems almost criminal not to spend $75 more and get a nav antenna that will give you at least 25% greater reception distance and a much more stable signal.

The balanced loop is a superior type of nav antenna. This type can be a set of blades, and you see this a lot on heavy twins and jets. But a set of blades costs $300 or more. Fortunately, the same electrical performance is available from the towel-bar antenna, which costs a lot less and is simpler to install.

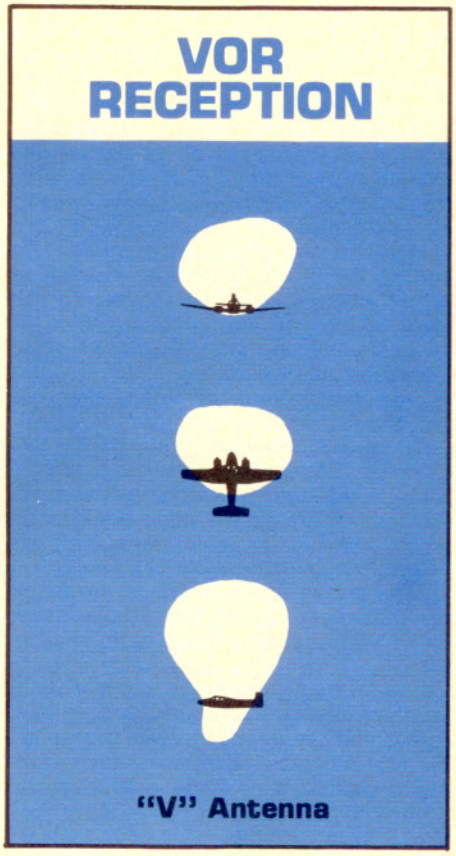
A horizontal balanced loop in free space provides a reception pattern that is ideal for VOR/LOC service. It receives signals from all azimuths in the horizontal plane. Also, it is totally insensitive to signals approaching from directly above or directly below the antenna.

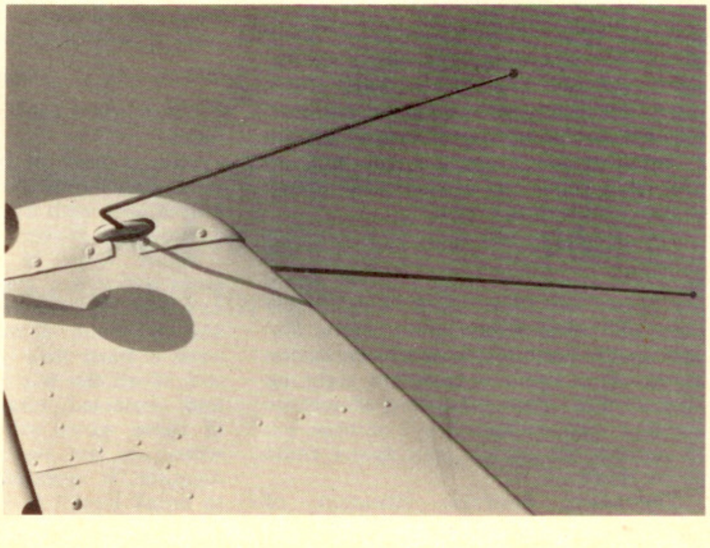
The drawing that accompanies this article sketches the respective reception patterns of "V" and balanced-loop antennas. These patterns show that sensitivity of the "V" at elevation angles near the horizon is quite low, and that this antenna is quite insensitive in a number of directions. The azimuth pattern of the loop, on the other hand, provides more than adequate sensitivity in all directions.

The balanced loop also affords another important advantage. It is electrically balanced and, because of this, provides a high degree of rejection of vertically polarized signals and noise—



The "deerhorn" type of "V" antenna—structurally stronger than the "Cat's whiskers," but electrically the same.

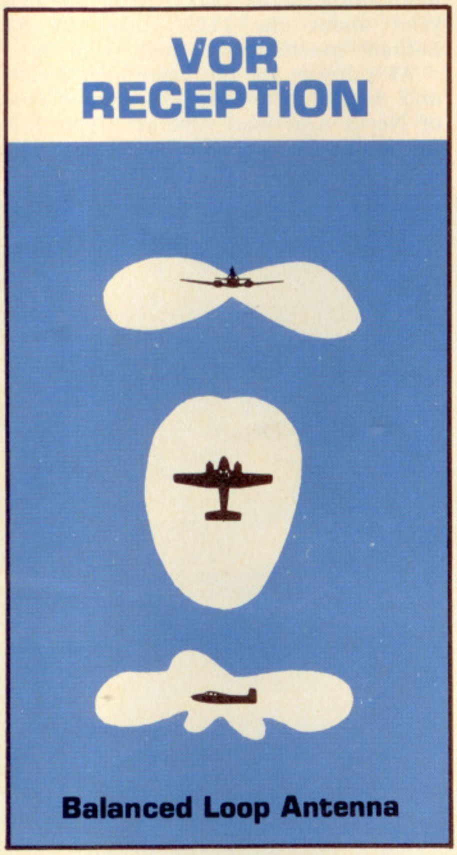


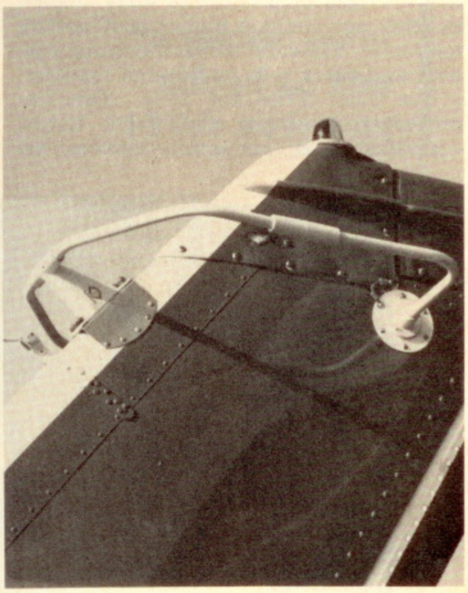


The most common type of "V" antenna, the "cat's whiskers."

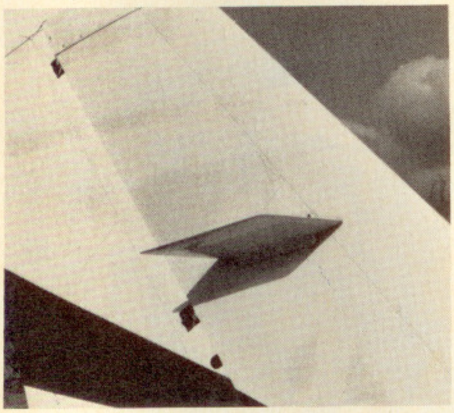
much higher rejection than is provided by "V" types.

VOR/LOC signals are horizontally polarized as sent from the ground station. Often these signals are reflected off terrain, ground objects, and parts of the airplane, and so are given a "polarization twist" before being picked up by the aircraft antenna. A bounced or reflected signal is very similar to the ghost image on a TV set. If the secondary signal is strong, the omni set can be receiving two conflicting signals. The result is a jittery or unstable omni reading. A balanced-loop antenna rejects those unwanted ghost signals, and because of this rejection it gives more stable and more accurate omni bearings. The balanced-loop antenna is a more expensive antenna, but its performance is worth the price.





A "towel-bar" type of balanced-loop antenna—only suitable for mounting on the vertical stabilizer.



A "blade" type of balanced-loop antenna. Expensive, but suitable for installation in a variety of aircraft locations.

Proper placement of your antenna is the final item to be considered. For example, you may have a dual nav/com to protect yourself against failure. You've got a major weak link in your dual systems, though, when you run both nav systems off of a common antenna. When you take the electrical signal coming from an antenna, divide it, and send it to two separate radios, each separate set will receive only a portion of the original signal. The dividing device is called a coupler. When you insert this coupler in your antenna line you have insertion loss, which reduces the signal strength getting to the radios by almost 30%. You have also added at least three connections between the antenna and the radio.

The obvious answer is to install two separate nav antennas. Doing this is easier said than done. The first problem is that the antennas should not be mounted closer to each other than three feet if they are still to give good performance. They also should be a minimum of three feet from the horizontal stabilizer.

Obviously, the best location for a nav antenna such as the towel bar is as high as possible on the tail. The farther you can keep this antenna from the horizontal stabilizer, the better it will perform. This takes care of one antenna, but where can you put the second?

The second antenna, if you want top quality and performance again, is going to be a blade-type antenna. Now we are talking about a fairly expensive antenna. It will have to be placed horizontally, and yet it has to be far from any other horizontal surfaces, such as the wings or the horizontal stabilizer—and far from another nav antenna. Finding a good location may be very tough, and you may not want to go to the extra trouble and expense. If you do, however, you'll gain additional reception range and reliability.

The antenna most likely to be poorly positioned is the communications antenna. Com antennas should be installed on the aircraft centerline.

Dual com requires dual antennas. Ideally, they should be 10 feet away from each other or any obstructions such as the tail. This is a full wavelength away. The maximum compromise should be five feet, or half a wavelength, away.

If two antennas are too close, when one is in use the other will reflect some of the signal and distort the transmission pattern. If close spacing with other antennas cannot be avoided, keep in mind that proximity to marker beacon or ADF antennas will probably be least objectionable. Proximity to the edges of metal mounting surfaces (e.g., at the top of the windshield) also degrades the radiation; keep the antenna at least two (preferably three) feet away from such edges.

Ideally, one antenna should be on top and the other on the bottom of the aircraft. There are two advantages: You will achieve maximum separation of the two, and the radiation patterns of each will be different. If one transmitter can't reach a station, the chances will be much better that the other one will.

Bottom antenna locations can have problems—among them adequate ground clearance. The shortest com antennas run about 11 inches. Add to this adequate clearance for grass or rough fields. In tricycle-gear aircraft the nose gear can throw rock or debris up at the antenna.

Adequate cooling, good wiring, and proper antenna installation are all little things. At most, they might add 5% to radio installation cost. Yet the return for the careful investor is far better and more reliable radio performance.

Black boxes have enough problems without inviting poor performance. Give them all the support you can. □