Garmin's New GWX 68 Radar

They began with a solid foundation and designed up.

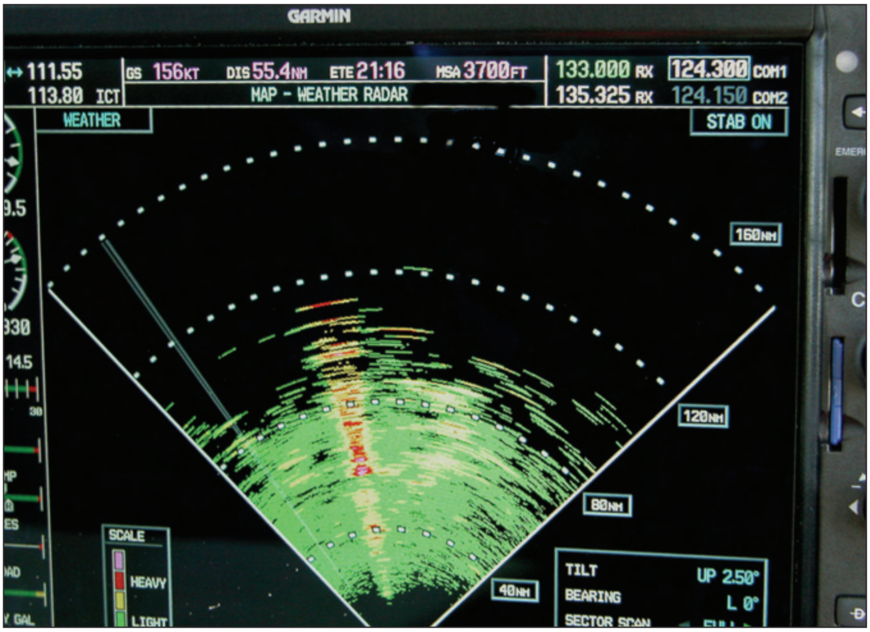
By Archie Trammell

Wise engineers know you never begin a new radar design on a clean sheet of paper. You start with a proven radar, tweak it with state-of-the-art circuits and components, add some up-to-date features — and hope you didn't mess anything up.

That's essentially what Garmin radar engineer Troy Simonton and his staff have done in creating the GWX 68. It started life as a King KWX-56/58, which has a long history as a good radar. When King became part of AlliedSignal and then Honeywell, the KWX-56/58 was sold off to Narco. Garmin acquired it from Narco as the basis for its entry into the world of airborne weather radar.

As clever engineers do, Simonton first conducted an exhaustive search of 56/58 maintenance history and identified the 10 most frequent failures. He and his staff corrected all of them with more robust components and improved circuitry. To make certain they hadn't overlooked anything, they switched to a more modern flatplate antenna design and a magnetron with a much higher MTBF. Next, they reviewed which features have kept the 56/58 near the top in the popularity sweepstakes for 20 years. They retained them and added several more.

The first thing that will grab you when you are introduced to the GWX 68 with the G1000 MFD is the display size, 10 whole inches. Those who have flown glass cockpits for a while will not think it's unusual, but if you have spent many hours squinting at radar displays squeezed into the center stack of a light twin, you will think you have died and gone to Valhalla or some such place. It is huge by comparison. And when displaying radar data it's uncluttered with other stuff, such as a compass rose, waypoints, ETA, TAWS, CAS and whatnot. Just radar data. Some non-radar information is discreetly arranged around the periphery, out of the way of what's really important. Wonderful!



The GWX 68 is an over-the-horizon radar. This is at 9,500 feet agl. Line-of-sight distance is 97 miles, but strong echoes are detected at 110 nm. One hit is at 120 nm. Why the line of echoes out toward 11 o'clock? The great plains effect. In the Midwest United States, section lines run north-south/east-west. Houses, barns and towns are all gathered along those section lines. Radar picks them up clearly.

Another great feature is transmitted power — it's 6,500 watts nominal. The nearest competitor is only 4,000 watts. To equal GWX 68 power, you will have to pay roughly $10,000 more.

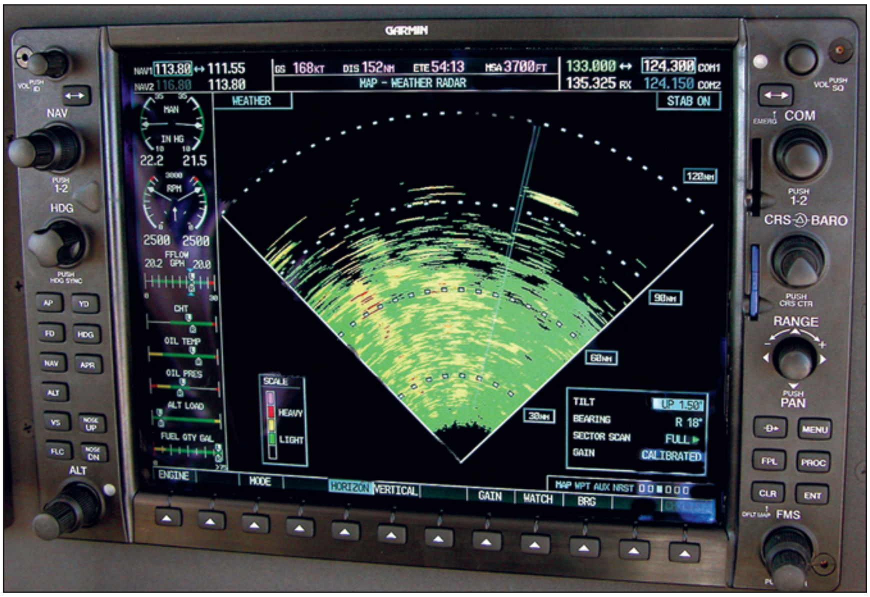
What does high power do for the pilot? It allows the use of a fixed-transmission time per pulse, which results in consistent performance at all normal displayed range selections — consistent performance in terms of weather penetration capability, detection of smaller rain droplets, and range resolution. It also reduces the amount of circuit hocus-pocus that can do bad things to your bank account.

But note we said "the normal displayed range selections." Garmin engineers have added a displayed range of only 2.5 nm, coupled with a reduced transmission time of only one microsecond. You may question the value of a 2.5-nm look-ahead, since most light twins and turboprops cover 2.5 nm in under a minute when en route and just over a minute in terminal areas. That gives pilots little time to begin an avoidance maneuver. The advantage of a 2.5-nm displayed range is in the scaling effect. You will appreciate it first time you are in a rainy terminal area picking your way around little rain shafts. Thunderstorms as small as 1,800 feet in diameter have caused major accidents. When minimum displayed range is five nm, a 1,800-foot rain or hail shaft is so small on the display you may overlook it. But on a 2.5-nm display it's twice as big. Plus, that one microsecond pulse results in a 400-percent improvement in range detail, compared to the normal pulse of four microseconds.

Features and Benefits

Beyond those pluses, the GWX 68 has many other features, some of which will benefit pilots, some of which will benefit radar salesmen more than pilots. In the former category, the wisest thing (after that 2.5-nm range) Garmin's engineers have done is add Vertical Scan. This feature first appeared on old

Photography courtesy of Garmin



The G1000 displays radar data as it ought to be displayed: big and uncluttered with other stuff. It's on a 10-inch MFD. Engine data are stacked on the left. Com frequencies, nav data and nav frequencies are arranged across the top. The remainder of the space is for radar — unless you'd prefer TAWS, CAS, maps and other stuff rather than radar. At this time you can't have radar and other stuff simultaneously. On the right side is a slot for loading updated data. Ground paint is being displayed here to a distance of 100 nm, notice.

Bendix/AlliedSignal RDS series radars years ago as Vertical Profile. For unknown reasons, the innovators never adequately explained what it's good for. Actually, it is such a great addition to any radar it's amazing other manufacturers haven't picked up on it. (You can get something similar if you have a spare $200,000 lying around.)

Why so great? First, Vertical Scan reveals the altitude structure of storm cells. It is well known to scientists that cells exhibiting a very high reflectivity up around 25,000 feet (in the United States) are the ones most likely to contain extreme rain, hail, microbursts and perhaps a tornado or two. VS (as Garmin prefers to call it), which commands the antenna to sweep vertically through a 60-degree arc, will show where the high reflectivity is with the touch of a couple of buttons. A second plus is the extended look-up capability VS gives you. With normal tilt you can look up only 15 degrees. That is inadequate in several parts of the world (the U.S. West, for instance) where the base of storms may be at 5,000 feet to 10,000 feet. VS scans upward 30 degrees.

Sector Scan is another feature they have added that's been around a long time, but only on radars costing three to four times the price. Garmin practiced a hefty bit of one-upmanship on this feature. In most cases, high-priced competition simply reduces the scanned sector from 120 degrees to 60 degrees. GWX 68 scanned sectors can be 20 degrees, 40 degrees or 60 degrees, plus the normal 90 degrees. The scanned sector can also be displaced left or right of straight ahead. This, of course, can be helpful when maneuvering in terminal areas. It allows you to search into turns. Since the scanned sector is reduced, the update, or refresh rate, is much faster, as fast as 54 looks per minute, compared to a normal 12.

A WATCH feature has been incorporated. Those who have flown RCA/Sperry/Honeywell radars will know it as REACT. Collins has PAC. What it does in the instance of the GWX 68 is turn on a grayish background where the display

Garmin GWX 68 Specs

Frequency	X-Band (9375 MHz)
Power Output	Nominal . . . . 6.5 kW
Pulse Length	5 – 320 nm . . . . 4 ms 2.5 nm . . . . 1 ms
Power Required	2A/28 VDC
Antenna Size	10-inch or 12-inch phased array
Antenna Beam Widths	12 inch . . . . 7.8° 10 inch . . . . 9.0°
R/T/A Size	10-inch antenna, 9 pounds 12-inch antenna, 9.1 pounds
Scan Angle	90°
Scan Rate	Full sweep . . . . . . 2 looks/minute 60° sweep . . . . . 18 looks/minute 40° sweep . . . . . 27 looks/minute 20° sweep . . . . . 54 looks/minute
Tilt Range	± 15°
VS Sweep	± 30°
Selectable Modes	SBY, WX, MAP, VS, SECTOR

GAIN Control Range	G1000 MFD . . . . . . -28 to +12dB G200 . . . . -28 to +3.5dB
Performance Index	12-inch antenna . . . . 217dB 10-inch antenna 214dB
STC Range	Extended . . . . .80 nm
Display Size	6- or 10-inch diagonal
Displayable Ranges	G1000 . . . . . . 2.5, 5, 10, 20, 40, 60, 80, 100, 120, 160, 240, 320 MX200 . . . . 2.5, 5, 10, 20, 40, 80, 160, 320
Stabilization	±30°
Indicator Weight	G1000 . . . . 6.5 pounds MX200 . . . . .3.1 pounds
MPEL	12-inch antenna . . . . . 10.83 feet 10-inch antenna . . . . 9.2 feet
Pressurization	None required
TSO	C63C
Interface Outputs	ARINC 429/453

may not be properly calibrated in terms of colors. Calibration shifts may occur due to intervening rain or simply long range. This is one of those features for the sales department. Pilots must be alerted to the truth that it doesn't always work. The feature assumes radomes are always properly manufactured and repaired, are never blinded by excessive paint and are never contaminated by heavy rain or ice. Actually WATCH/REACT/PAC try to do something all radars do naturally without any help from fancy electronics. Run TILT down to where the radar should be painting ground. Where no ground is painted, don't plan to go there. A black area behind an echo is a "radar shadow," caused by an object so dense radar energy can't penetrate it. Neither can airplanes.

We must mention that other radars with this feature have been prone to "Terminal Area Redout." It occurs when flying at lower altitudes in moderate to heavy stratiform rain. The entire indicator turns red, making it impossible to see the most intense areas of rain. It can be defeated by selecting MAP, but on the GWX 68 that causes display colors to switch and color calibrations to shift. Now you don't know the true intensity of the rain ahead. Not good. It will be interesting to fly this radar in heavy rain to observe if Terminal Redout occurs. If you experience it, do notify Garmin.

While on features of questionable benefit to pilots, the GWX 68, along with just about everyone else's radar these days, has "TARGET ALERT. When you are on a short displayed range selection, or not displaying radar data on the MFD, the system will alert you to strong echoes in the far distance. Problem is, those echoes may be from weather or they may be reflections from cities and towns. To determine which, you must go to a longer displayed range and employ a bit of smarts derived from long use of the radar and many observations of echoes in the distance on it.

Let's Fly

Features and benefits are interesting, but the real question is, how well does it perform the basic radar function of revealing things in front of you? Thanks to those wonderful folks at Raytheon in Wichita, a new Baron, ready for delivery to a customer, was made available to us so we could have a look. Lou Johansen, a Baron guru at Raytheon, flew it over to Olathe, Kan., the home of Garmin, for our flight. Although a beauty otherwise, when we saw the aircraft we noted a blemish for radar testing purposes. Wrapped around the lower portion of its nose was a black stripe and below it a brown finish. Lovely, but not ideal for radar performance. When radar goes in, paint stripes and other nose art should come off. Our recommendation: Make certain your aircraft's nose is a class "A" radome. That's after the final coat of paint is applied. Otherwise, radar performance will be compromised. (We made note to apply mental allowances on this flight.)

It was a great day for flying, almost CAVU. You don't want thunderstorms around for the initial look at a new radar. Thunderstorms get in the way, because what you must do before punching into weather is determine how well the system detects and paints ground returns. If it'll do well on ground objects, and with good detail, it'll do well in keeping you out of a bad scene.

As we taxied out, the fact that wonderfully large display is an MFD made itself apparent. At power-up we saw no radar, just the airport runway layout.

To see radar data, buttons must first be pushed. Only a piano player will be comfortable at first encounter with a row of 12 buttons across the bottom of this MFD, which must be played in tune or the radar remains silent. Johansen had to help.

Before takeoff one has to make certain the radar is working properly. That's done by turning it on, in a weather mode, TILT full up, then bringing TILT down until echoes appear. But first you must push more buttons to get the radar out of STANDBY, which the GWX 68 automatically goes into on the ground via an airspeed switch. When it is first turned from off to on, the radar takes about a minute to warm up. It then passed our see-echoes-before-takeoff test very well, so off we went.

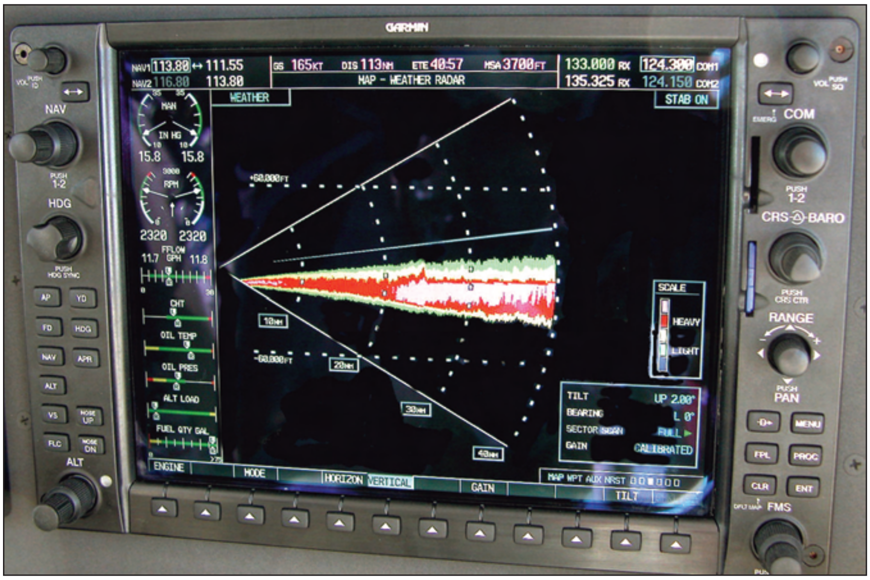
To conduct the evaluation, we asked Johansen to climb to 10,500 feet and fly southwest toward Tulsa. The wheels were not in the wells before we realized that big, uncluttered display is a spoiler; one trip behind it and you will never think of radar the same way again. Radar performs all sorts of non-weather functions when the display is large and uncluttered, such as navigation backup, attitude awareness, altitude confirmation and even terrain avoidance. Engine gages are stacked on the

Multifunction Displays

So, the GWX 68 has a wonderful big display, excellent performance and many useful features. Are there no howevers? Yes. First, the radar display is an MFD, meaning it has many knobs and buttons, which are unnecessary for staying away from thunderstorms. For radar operation you need only four controls — MODE, RANGE, TILT and CALIBRATION, plus a couple of on/off switches. But on a multifunction display you also get multifunction buttons and knobs. On the G1000 MFD we counted 32 buttons and eight dual, some triple, function knobs. That's the price you must pay for a do-it-all machine. Which would be OK if controls for radar were more or less conventional. They aren't. To change CALIBRATION you must punch, push and turn. (Or is it turn, push and punch?) To finesse on TILT and CALIBRATION simultaneously, which is vitally necessary for properly analyzing a storm and for ground mapping, you must conduct a finger fandango on buttons and knobs.

This MFD is no worse than others we've flown and better than some. And certainly the argument can be made that with practice it all becomes second nature. But an encounter with any MFD is a reminder that when radar is one of its many functions, MFD human factors need serious study. Dealing with thunderstorms is a stressful situation at best. When they're all around is no time to accidentally push a wrong button or twist a knob in the wrong direction and find yourself looking at the runway layout for Keokuk, Iowa, rather than the magenta monster up ahead. That's a risk because it is an MFD.

Another consideration (and this is true for all all-glass-cockpit aircraft): What about display failure modes? As currently configured, assuming the G1000 system, if the right display fails, you've lost radar. Which is no different, of course, than with a stand-alone radar display. In this instance, however, if the left display fails you also lose radar, because vital data on the left must now play on the right. Only someone well versed in theoretical statistics can calculate how relevant that is. Radar use for actual thunderstorm avoidance is critical only about 10 percent of total flight time. But, no matter how small the risk may be, it's twice as high with this setup. Garmin engineers are at work to resolve that issue.



VS (formally known as VP) is a major benefit to pilots. Users will be surprised how often VS shows no weather from their altitude down, but strong weather above them. Vertical scan is ±30 degrees. Here no weather, just ground is being depicted, illustrating that VS can also be used to maintain a level deck attitude – in case all else fails.

left side, where they don't speak unless spoken to, with frequencies, speeds and distances strung across the top.

Radar modes are annunciated alpha across the bottom. A vertical color bar in the lower left corner displays five storm "levels" — black, green, yellow, red and magenta. What do they mean? Black indicates areas where there is no detectable precip (but there may be very light rain, or even dry hail). In green echoes expect light rain and light turbulence. In a yellow echo, moderate rain and a bumpy ride. In a red echo be prepared for heavy to very heavy rain with severe, possibly extreme turbulence and much lightning. In a magenta one you will find intense to extreme rain, extreme turbulence, large hail, tornadoes, microbursts and sometimes all of the foregoing. It must be noted that the hazards possible in an echo are not related to the color you are in, but by the highest color level indicated. That is, flying in the green part of a cell with magenta showing in it elsewhere, you are subject to all the magenta hazards. Magenta is not just where magenta is, nor is red just where red is.

When MAP is selected, by the way, those colors change to black, cyan, yellow, magenta and blue and the calibration levels for each color change.

In the lower right corner of the display are four readouts for TILT, BEARING, SECTOR SCAN and GAIN. Antenna TILT is displayed as a digital value. BEARING is used to select the centerline position of either VERTICAL or SECTOR SCAN. Widths of SECTOR SCANS are given as FULL or a lesser numerical value, per the selection.

A clever feature is the distances shown on range arcs at various displayed range selections. They are keyed to the displayed range selected, of course, but switch from multiples of five to multiples of 10 as appropriate. The number of displayed ranges possible, 12, is much greater than normal for other radars. Jet pilots will be pleased to discover 100 nm is possible, as well as 80 nm or 120 nm.

Pertinent buttons and knobs used for radar control adjustments are on the right, which is where they should be. In that location, the captain's hand and arm don't cover up anything vital as he or she reaches across to make RANGE, TILT and GAIN changes. Radar modes, however, are selected with that array of "soft" buttons across the bottom mentioned earlier. ("Soft" meaning they are electronic buttons, not real ones.)

Speaking of adjustments, it's interesting that the word GAIN is still used. In truth, a GAIN control on airborne radars disappeared 20 or so years ago.

Prior to that, GAIN actually varied receiver sensitivity. No more. Since "digital radar" came into being, receiver gain is left at full sensitivity, or just less than full, while GAIN effect is achieved by varying thresholds for the colors. Thus, what was once a GAIN control is now, in fact, a CALIBRATION control, but still called GAIN on everyone's radar.

We like the unique GAIN readout that Garmin uses. It is a blue horizontal bar. When the control is at the calibrated value, the readout properly says CALIBRATED. Makes sense. Take it out of CAL and the word goes away, to be replaced by a tick mark across the blue bar, with a small triangular indicator. Turn a knob in the lower right corner of the MFD clockwise and the blue bar grows to the right, indicating a higher value. The tick mark remains at CALIBRATED, so you know how much you're increasing CAL. Turn counterclockwise and the blue bar moves left of the tick mark, indicating lower values. What does that do? Higher values cause echoes to appear stronger than fact; lower values cause echoes to appear weaker than fact. How can that help? Suppose you see a red echo. Red means it's either a strong or very strong storm, a huge difference in how close you should get. So which is it? Tweak CALIBRATION higher — to the right. If you begin to see magenta in the echo after just a small tweak, it's a very strong storm. You are much too close. It will have very heavy rain in it, may even contain hail. If it takes a lot of increase before you see magenta, it's only strong. Don't get any closer.

But always return the system to CAL before doing anything else. Otherwise you may make a fatal mistake.

As stated earlier, several things are displayed full time around the edges of the display, where they don't get in the way. But in addition to radar, the major area of the right display will display maps, CAS, TAWS, NEXRAD, StormScope, nav data and on and on. Currently, when any of that stuff is being displayed, you can't have radar; when you have radar you can't have any of that stuff. That's not all bad, but stay tuned.

The 'What If" Factor

The most important question in aviation is "What If?" If you have thought about what can happen and how to cope before it happens, it won't be an emergency. So, "what if" this radar fails? The possibility of that happening should be low, because the basic system is a mature design growing out of the KWX-56/58. If a failure does occur, it should be a brief problem. Garmin is aware that breaking into the airborne weather radar market is high risk. Since Rockwell Collins and Honeywell are so well dug in, only giant killers have a chance. Therefore, Garmin plans to keep customers happy. Field repairs are not authorized. Instead, spares will be placed in strategic locations. Suffer a failure and a loaner will go in your aircraft within hours.

Your radar itself will go to Olathe where the people who built it will ensure it is repaired and tested thoroughly before return. We assume that procedure will also apply to the MFD. So, as is true for any new radar, even one based on an earlier design, failures there will be, but Garmin has a plan to ensure they are not overly vexing. Plus, we predict the up-to-24-hour downtime will be shortened to almost instantly. When the GWX 68 finds its way into air taxi and scheduled operations, as it surely will, that 24-hour AOG gap will become a no-no.

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Performance and More

Now back to the flight. It didn't take more than 5 minutes to discover this is a very capable radar. Climbing out we selected WEATHER, which is annunciated in the upper left corner of the display, and ran TILT down. At 4,000 feet agl the radar detected ground returns to 80 nm. At that altitude the horizon is only 63 nm away, so the radar was reaching out across the horizon to pick up buildings on the other side of the world. At 6,500 agl, red echoes were showing at 100 nm, which is 19 miles beyond the rim of the earth at that altitude. And there aren't many tall buildings in little towns between Kansas City and Tulsa. Note that performance was in spite of the black stripe and brown paint on the radome. Very, very good.

Echoes we saw at 100 nm and beyond, emphasized another advantage of high power. It enabled use of a short pulse, even at long displayed ranges, so echoes from buildings were displayed as thin slashes. That instantly identifies them as ground objects. A low-powered radar would have been displaying ground objects as fat blobs, due to range smearing, making them difficult to distinguish from weather.

On the return to Olathe we worked with that 2.5-nm range selection for several minutes. We couldn't quite count individual houses in the Olathe suburbs, but almost. When they get a look at this radar, helicopter pilots in particular are going to start a revolution in the front office. They will demand a 2.5-nm displayed range on all their radars. As noted above, fixed-wing pilots who are sometimes forced to fly in areas of rain, plus embedded thunderstorms, will also bow down to the engineers who created a 2.5-nm displayed range for them. You can have that feature with other radar systems, but it'll cost you several thousand dollars more.

Applications and Price

Application potential of the radar is just short of huge. Since the GWX 68 is built on the same frame as the KWX-56/58, it will go onto anything that radar went on. The list is almost endless. Included are all aircraft that have, or could have, a Bendix RDR-160, 230HP, RDS-81/82, RDR-2000/2100, Sperry WeatherScout II and on and on. In sum, all singles with a pod-mounted radar, almost any helicopter, light twin, turboprop or small jet. Garmin's current market and aftermarket prospects should have the sales department smiling for years.

Also, avionics shops now have another product to offer, but evidently not soon. As this is being written, to get the package we flew, with that wonderful big display, you'll have to buy an entire, new-from-the-factory aircraft. If you're not in line for one already, it'll be awhile before you can get one; the first are just coming off production lines. The G1000 MFD with radar isn't offered for field installs — yet.

If you'll settle for the GMX 200 MFD display, you'd best get in line for the radar sensor add-on pronto. We had to wait two months before Garmin could find an aircraft with a GWX 68 in it for us to fly. That may have changed by now. What about opting for a non-Garmin display? Garmin says no, but it'll happen.

Cost is open and shut. If your bank account is ready for a new aircraft, you can have the deluxe, big display version — eventually. Price for the package will be from $450,000 through $2 million or so. Otherwise the question of cost hinges on what you want to play radar data on. The transmitter/receiver/antenna section alone (most say R/T/A) is $20,995 with 10-inch antenna for pod mounts and $21,995 with 12-inch antenna for everything else. That's below all other airborne weather radars in the market. Garmin is pushing a new GMX 200 MFD for radar display in new or old airplanes. It'll also display data from several other systems; it just depends on how much you have got to spend. The basic GMX 200 is $14,995. They also still talk about having an MX 20 for $12,995, but we detected little enthusiasm for selling you one.

Bottom line? Troy Simonton and his engineers didn't mess anything up. And that's how success is measured in the radar engineering world.

Next we want to fly a GWX 68 in heavy weather. Garmin promised. **B&CA**