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Look Up, Look Down ...

A basic guide to the most valuable navigation device you probably rarely use.

by **Joe Ratterman**

If you are experienced using your airplane's on-board radar, and you turn it on during most of your flights, then congratulations! You are a rare breed!

However, if you are like most pilots, you probably don't use your radar often and feel much more comfortable using NEXRAD when it comes to navigating through the springtime thunderstorm season each year.

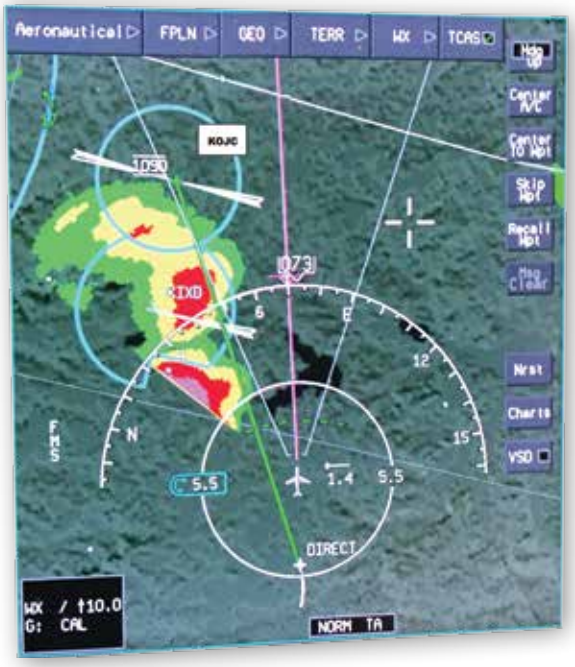
My goal in writing this article on basic radar usage is to get your attention, arm you with enough information to *start* effectively using your radar, and encourage you to keep learning how to use your radar. It's possibly one of the most valuable tools in your aviation arsenal, and my hope is that you come to trust and rely on it as much as I do.

Look Out!

NEXRAD versus Radar

The first question we need to ask is, why do we need on-board radar at all if we have a NEXRAD weather product available in the cockpit? Sure, NEXRAD is easy to read and packaged up nicely so anyone can interpret where the weather dangers are, right? Well yes, and mostly NO! Yes, it's easy to read, but it doesn't tell you where the storms are, it only tells you where they used to be. You need to understand that, based on the way these images are created on the ground beforehand, the data on your screen is actually older than what it says, by as much as 15 to 20 minutes!

Have a look at these two images I took this spring, one of my NEXRAD (top), and the other of my radar (bottom), both taken within a few seconds of each other as I was planning to land at KOJC.



Quite a different perspective, wouldn't you say? If I had decided to fly a heading directly toward KOJC (my airport destination), the NEXRAD image indicated, "Come on over, the coast is clear." But the radar image was screaming, "Steer clear, a thunderstorm just popped up in front of you!" Because I was using the radar, I flew around the dangerous weather and approach my airport from the south. As you can see, a lot can happen in 15 to 20 minutes, and the real-time nature of your on-board radar is vital to making tactical navigation decisions when the weather is changing around you.

Why Don't We Use Our Radars?

So if NEXRAD is delayed, and radar is truly real-time, why don't more pilots use their radar? Maybe because NEXRAD is easy to read and our radar systems are simply mysterious to us. The manual for your radar reads like college physics and geometry textbooks, and you get all kinds of different results as you turn the different dials.

Why so many controls: STBY, BRG, TILT, GAIN, GND, Stabilizer, Vertical Profile, and others? It seems like an engineering degree is required to use these things!

A lot of papers and instructional manuals have been written on how to "operate" radar systems, but not enough information is available on how to "use" the radar. It is easy to turn on NEXRAD and watch the screen fill up with safe greens, cautious yellows, and dangerous reds and purples.

The primary reason that NEXRAD is so easy to read, even if it is dangerously delayed, is that the images are created using a ground-based radar network. The NEXRAD Doppler radar beams are sent from the ground up into the sky, so there is no chance for confusing "ground returns" to show up in the final images. Your on-board radar system, however, generally must deal with ground returns because, most of the time, at least part of your radar beam is hitting the earth as you operate it *from the sky*.

If on-board radar systems could somehow ignore ground returns, and only return weather related depictions in our path, then your radar display would look much more like a NEXRAD display, and it would be in real-time. Wouldn't that be awesome?

Using your radar will never be as easy as using NEXRAD. But with knowledge and a little practice, you can learn to be an ace pilot when it comes to your on-board radar.

The 7,000-foot Convective Hotspot

The key to using your radar is simply knowing "what" to look for and "where" to look for it. Your radar beam is like a flashlight beam, spreading out from the front of your airplane in a cone shape, sweeping left and right. What you are looking for are storms that are brewing. Where you need to look is where storms begin and end, and more precisely, you need to know where in the *vertical dimension* to look.

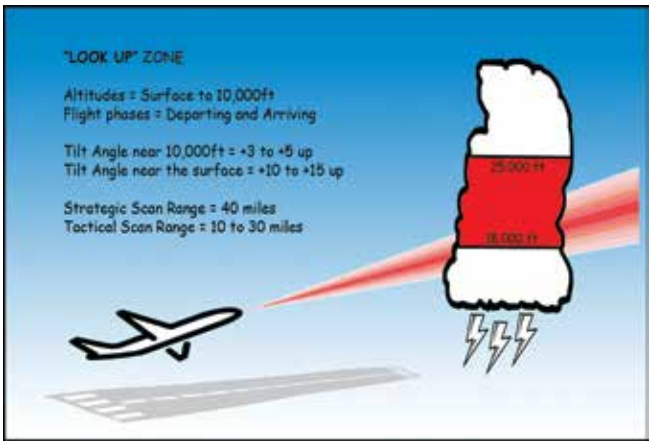
Convective storms, regardless of what stage they are in, will nearly always show up between 18,000 feet and 25,000 feet. This is where a thunderstorm's wind and water are either going up or down, and where the moisture (i.e. large rain drops) is the most reflective from your radar beam's energy.

If your radar beam can be confidently pointed at the vertical slice of sky in front of you that captures this 7,000-foot hotspot, then you are going to see all you need to see. It really is that easy. If we are flying anywhere below 18,000 feet, then we need to be looking UP for the convective area above us. If we are flying at or above that level, we need to be looking OUT or DOWN at that same 7,000-foot window. Point your radar beam at this hotspot for convective storms, and you'll see what you need to see on your radar screen.

Three Zones, Same Plan

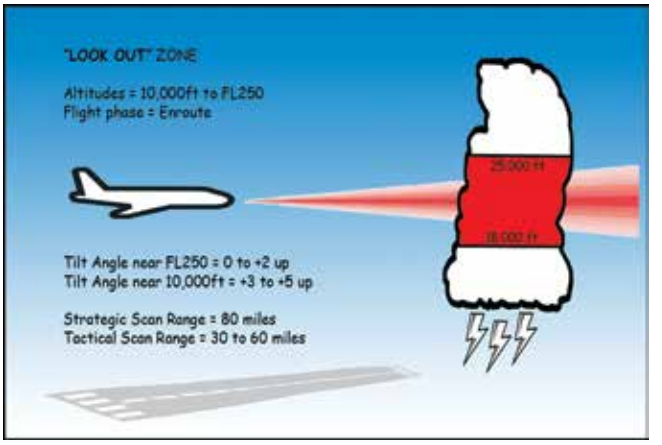
I like to think about three unique "radar usage zones:" The LOOK UP zone, the LOOK OUT zone, and the LOOK DOWN zone. Let's briefly cover each of these in turn. As we do, you can feel free to ignore most of your radar controls except for TILT. The TILT knob should be the only control you need to worry about until you have more experience and confidence in using your radar.

In the LOOK UP zone, we might be taxiing, departing for our destination, or arriving at the end of our trip. In all cases, we are within a few thousand feet of the ground, and any convective weather dangers are above us. You need to TILT your radar beam up to see the dangers above, the dangers that are waiting to come crashing down on your head. Right after takeoff, start by TILTING your radar as high as it will go, typically +15 degrees, and then slowly adjust the TILT to between +3 or +5 degrees as you approach 10,000 feet.This should give you a good idea of the stuff above you, looking out for the next 10 to 40 miles. Any returns that show up as red or magenta should be avoided at all cost. From this low-altitude vantage point, your radar returns will look a lot like your NEXRAD display because you won't have any ground returns on the display. Stuff you see on the screen that looks like a storm IS A STORM and should be given the respect it deserves Avoid it by a healthy margin. Don't try to look out any further than 40 miles in front of you in this zone, and plan to make tactical heading changes to circumnavigate storm cells in the 10 to 30 miles immediately in front of you.

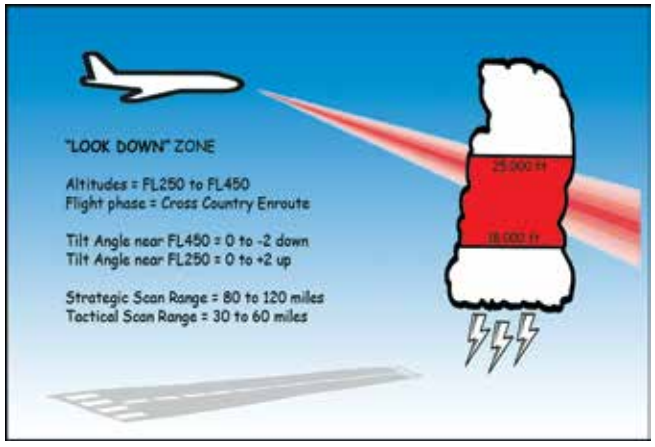


Once you have climbed up above 10,000 feet, you are now in the LOOK OUT zone and in the same altitude range as the core of any thunderstorms in front of you. In this zone, you will now have to start dealing with "ground returns," which can obscure any weather depictions in the same area over the ground. This is where science leads to art, and where you need to learn to TILT your radar until you can distinguish between the ground and dangerous weather.

Generally, you will want to see a clear line of ground returns about halfway up your radar screen. Therefore, TILT your radar until the front (or bottom) half of your display is mostly black, and there is a ring of mostly green starting after that. Storm cells will still be yellow, red, and magenta farther past the black area, and will appear to blend in with the ground returns at times, but they will also continue to "march toward" your position and into the black zone if they are above the ground. As a rough guideline, your TILT angle will be around +3 to +5 degrees up near the 10,000 feet lower end of this zone. As you climb higher toward FL250, your TILT angle will be between 0 and +2 degrees up. Keep your radar range on 80 miles in this zone until you need to make tactical heading changes, and then focus on the next 30 to 60 miles in front of you for maneuvering.



The LOOK DOWN zone is similar to the LOOK OUT zone, but as you climb higher, your TILT angle will begin to have a more pronounced downward pitch, as much as -2 degrees down. In this zone, you can also look a little further out for exceptionally tall storms, often as far as 120 miles or more. As you continue to TILT your radar down, ground returns become even more pronounced, but you can adjust your TILT up and down until you can clearly see any weather dangers as distinct from ground returns. In this zone, cities will start to reflect back and look like big storms on your radar, but they won't "march towards you" into the black half of your screen, they will disappear long before that. Cities will also look more like wide rectangular returns and not so much like the typical oval returns of large thunderstorms. I can assure you that eventually you will become proficient at distinguishing between earth-based objects and actual storms.



Final Thoughts

Convective activity can be extremely dangerous to your safety in flight, so you need to be able to identify storms and avoid them. NEXRAD is a great tool that gives you a big picture view of area weather systems, but it should never be used to tactically maneuver around storm cells. That's where you radar system really shines.

While you are flying in and around weather, switch back and forth between your NEXRAD display and your radar display. Adjust your TILT up or down until your radar display maps visually to what your NEXRAD display is indicating. Once you have "mapped" these two views of the weather in front of you, rely mainly on your radar display for all short-range tactical heading changes. Use ATC as a third source of information to make sure what you see on your radar is an accurate depiction of the dangers in front of you.

Always avoid any red and magenta radar returns that look like storms, especially if you are in IMC conditions. Unless you can see a clear outline of a storm through the windshield, and know with absolute confidence that you can fly over it by at least 10,000 feet, trust your radar screen and fly around the red and magenta returns by at least 20 miles.

Practice on clear days finding and identifying your ground returns. Practice "painting storms" when you fly by them, even if they aren't in your path. Practice over water, finding islands and shorelines. Practice, practice, and then practice some more.

It should be noted that the TILT angle guidelines contained in this article are just that, guidelines. You should practice until you find the TILT positions that work best for your installation. Your dish size, radome condition, avionics and radar manufacturers, and specific airframe installation can all affect the radar returns you see at different TILT angles in your airplane. The general strategy, however, of looking UP, OUT, and DOWN for weather in the CONVECTIVE HOTSPOT vertical region will hold true in all cases.

If you made it this far in the article, then I hope you are excited to take your newfound knowledge with you on your next flight. We have only scratched the surface and there is so much more to learn. We didn't cover dish size (10-inch, 12-inch, or 24-inch) and the corresponding beam-angle size (10 degrees, 8 degrees, 4 degrees, etc.), and we didn't talk about GAIN, GRND MAP mode, Vertical Profile Mode, and the BRG selector. The learning has only just started, but you should now be armed with enough information to begin using your radar effectively.

I would like to give a shout-out to two individuals in particular, Archie Trammell and Erik Eliel, that have contributed a lot of information on radar usage to the pilot community, and I hope that you will follow up after reading this article by connecting with them and learning what they have to offer.

Archie and Erik are the "go-to" experts for airborne radar usage, and you can find their references and links at the end of this article. We didn't have enough time with this article to teach you the many important details that you can learn from them. If you understand the basic principles presented in this article, however, then take the next step and get Archie's advanced radar course and look for an opportunity to attend one of Erik's interactive radar seminars. Just like when you first got your private pilot license, you aren't really done now; the learning has just begun!

Additional resources for in-depth radar use:

Erik Eliel's website:
www.rtiradar.com/index.htm

Archie Trammell's websiteactual:
www.radar4pilots.com

To reach Archie:
mary@radar4pilots.com T&T

Joe Ratterman is an ATP pilot, type-rated in the Cessna Citation Mustang C510, with 2,500-plus hours in his logbook. Joe retired from a successful corporate executive career in 2015 and now flies as a professional charter pilot for Kansas City Aviation Company (KCAC) based in Overland Park, Kansas. He is also the current board chairman/president for Angel Flight Central.