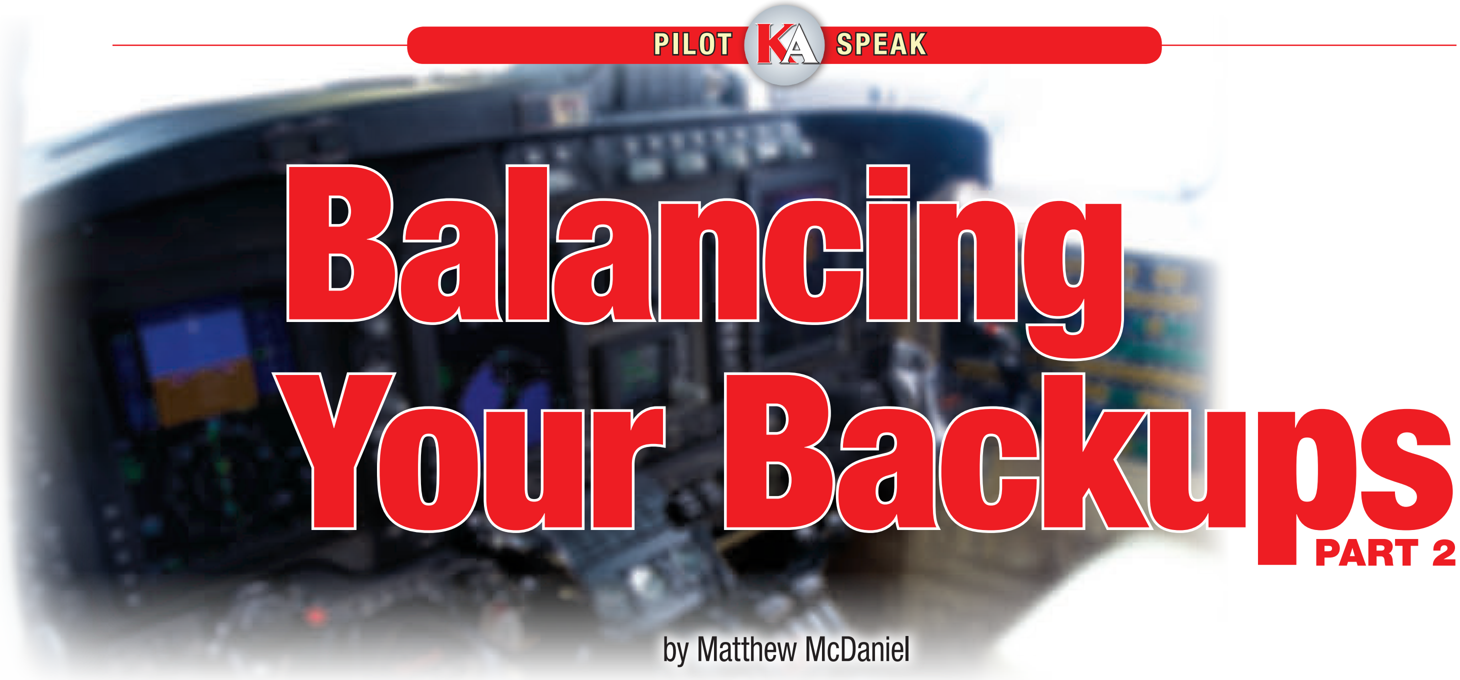

Balancing Your Backups
PART 2

by Matthew McDaniel

In Part 1, the article left off with GPS failures that would affect both primary and secondary GPS units (such as failures related to shared antennas, identical software bugs, satellite outages, or the loss of shared power sources or cooling equipment). In such cases, being able to revert to "old school" forms of navigation can sometimes be the only options left. We pick up the discussion there...

Very High Frequency Omnidirectional Range (VOR)

VOR's stations are cumbersome and expensive to maintain. Many have been shut down in recent years and an accelerated decommissioning schedule looms in the near future. However, while the number of VOR facilities may be on the decline, VOR navigation is a long way from disappearing, as Victor Airways (below FL180 in the United States) and Jet Airways (FL180 and above in the United States) are still in common use. Yet, the explosion of advanced avionics over the past decade-plus, has made it far more common to track such routes via GPS or FMS overlays of the actual airway. Regardless, pilots should still practice their airway and VOR radial intercepting and tracking skills, should the need arise to do so using an actual VOR signal as the sole source of navigation. Sadly, it has become all too common during training events to see pilots fumbling with their avionics to complete the simple (but unpracticed) tasks of tuning and identifying a VOR and selecting an assigned radial or airway. What was once IFR-101 has become an "advanced skill" in the age of glass panels and GPS. When was the last time you practiced these tasks?

It seems the procedures for intercepting and tracking radials should be the same, regardless of whether that radial is created by a VOR signal or is being mimicked by a GPS signal. At the most basic level, that is essentially true. However, it is more complicated than that. Because VOR radials emit in all directions from a VOR station, the width of a given radial is never constant. Instead it is ever-widening, from zero at the station to eight miles wide (or more) at triple digit distances from the station (taking into account, of course, the service volume of the VOR station in question [Figure 1]). Thus, VOR radials become less precise with increased distance from the station. This is not the case with GPS courses programmed to overlay VOR radials. Such GPS courses are constant in width and that width is subject to the Course Deviation Indicator (CDI) scale the GPS unit is set to (a setting that can be changed automatically as a function of software and aircraft position, or manually by the pilot). Additionally, VOR

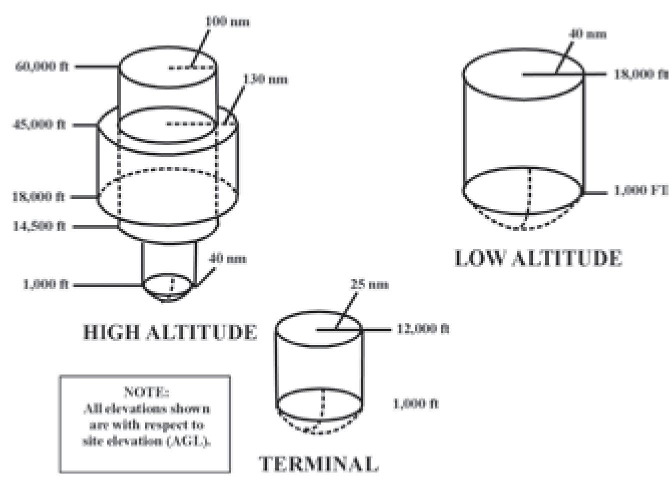

Figure 1: Aeronautical Information Manual (AIM), Figure 6-3-20, Frequency Protected Service Volume for VOR. This diagram details the service volumes (effective ranges) of the various VOR types in Above Ground Level (AGL) altitudes and straight-line distances. These numbers should be considered maximum numbers, as signals received beyond these parameters should be considered unusable. Other factors can further reduce the effective range of VOR signals, including (but not limited to) line of sight limitations, antenna capabilities and receiver condition.

radials reflect magnetic courses to/from the station and, thus, are always straight lines. In contrast, GPS routes that are not pre-programmed to follow true or magnetic courses are, by default, great-circle courses between fixes (curved lines that are actually shorter than a straight line between the same points because they follow the curvature of the earth). The point being – GPS courses are generally far more stable and easier to intercept and track because they are not subject to constantly changing signal sensitivity. Most of us already know that, intellectually. But, recalling the nuances of intercepting and tracking VOR radials at various distances from the station, when GPS has unexpectedly failed you, is a skill that can only be retained through routine training and practice.

During your next training event in a simulator or the actual airplane, ask the instructor to create a scenario requiring you to tune and identify a VOR. Then choose a specific radial to intercept and track. Do this for courses both TO and FROM the station. Overfly the station to refresh your memory and skills related to the ever-increasing signal sensitivity leading to the "cone of silence" (the area overhead the station where VOR signal reception is briefly lost). Then leave an assigned radial to intercept and track a different radial and, again, practice this for both TO and FROM courses. You might be surprised how much you fumble with these very basic IFR skills which, if you are like most pilots, you've allowed to atrophy through disuse.

Distance Measuring Equipment (DME)

In U.S. airspace, an IFR enroute certified GPS unit can be used in lieu of enroute DME. Similarly, an IFR approach certified GPS may be used in lieu of DME required for terminal procedures. Thus, the use of true DME has fallen dramatically with the widespread usage of GPS. Yet, most turbine aircraft still have DME unit(s) installed or incorporated into integrated avionics packages.

When enroute or terminal VOR navigation becomes necessary, one must still be able to track position along the route as well. This requires the ability to utilize DME and/or triangulation via crossing radials/bearings from other navigation aids. Traditional airway intersections and fixes are all still identified and charted via one or both of those methods. Yet, pilots struggle mightily to read IFR enroute charts to determine alternate means of identifying fixes when GPS/Moving Maps fail. Such struggles often increase sharply while attempting to setup and interpret the backup avionics appropriately.

DME and GPS distances do differ slightly in that GPS is, again, the great-circle distance to the active waypoint. DME, on the other hand, is straight-line, magnetic-course, slant-range distance to the station. While DME slant-range error is greatest near and/or at high altitudes above the station, great-circle versus magnetic course error is greatest at the midpoint between given GPS waypoints. When using GPS in lieu of DME, we've become accustomed to measuring our distance TO the active waypoint. DME might identify the same fix via a specific distance TO or FROM the DME station. Arrival at a GPS waypoint will always happen at an indicated 0.0 distance, while arrival at a fix using DME measurements will almost never occur at 0.0 (unless that fix is the VOR which is co-located with the DME station, while at altitudes below 600 feet AGL [0.1NM]).

During the same practice suggested in the VOR section, incorporate DME usage into the training exercises. Observe the slant-range error by flying directly over the VOR/DME station. Track radials to specific DME distances, while flying towards and away from the station. Choose radial intercept angles that will allow interception to occur at specified DME distances.

DME Arc Procedures

DME Arcs are still an aircraft separation tool used by Air Traffic Control (ATC) in both published and non-published versions. Published DME Arcs are generally limited to the initial legs of Instrument Approach Procedures (IAPs), where they are used in lieu of traditional procedure turns. Modern IFR approached certified GPSs have such arcs built into their databases as curved flightpaths between GPS waypoints. As such, they are flown simply by keeping the CDI centered while tracking around the arc and distance is measured TO the active waypoint (usually the arc's exit point or a step-down fix along the arc where an altitude change may be initiated). Yet, such published arcs are usually associated with VOR/LOC/ILS type approaches and, thus, can be flown without the aid of GPS, if necessary. Without GPS, traditional navigation of the arc would be required via your backup navigation equipment (VOR and DME) [Figure 2].

Non-published DME Arcs are assigned randomly by ATC, usually for the purpose of aircraft separation in times of heavy traffic load, radar outages (or non-radar environments), and/or when airspace or terrain require it. Non-published arc courses cannot be overlayed with GPS courses and must be flown using VOR crossing-radial navigation methods to determine position along the arc's course. Those savvy in the art of modern GPS navigation might say they can fly a non-published DME Arc using GPS information alone … and they would be correct. However, the process for properly programming and setting up such a procedure is both beyond the scope of this article and is, in fact, every bit (if not more) complicated than that required to set up and fly the arc using more traditional methods.

Flying a DME Arc requires good situational awareness and the ability to visualize your position, even with a functional GPS, and certainly so without one. These are skills that are becoming more and more scarce as the population of IFR pilots shifts from those that learned on conventional gauges to those that learned on (and have

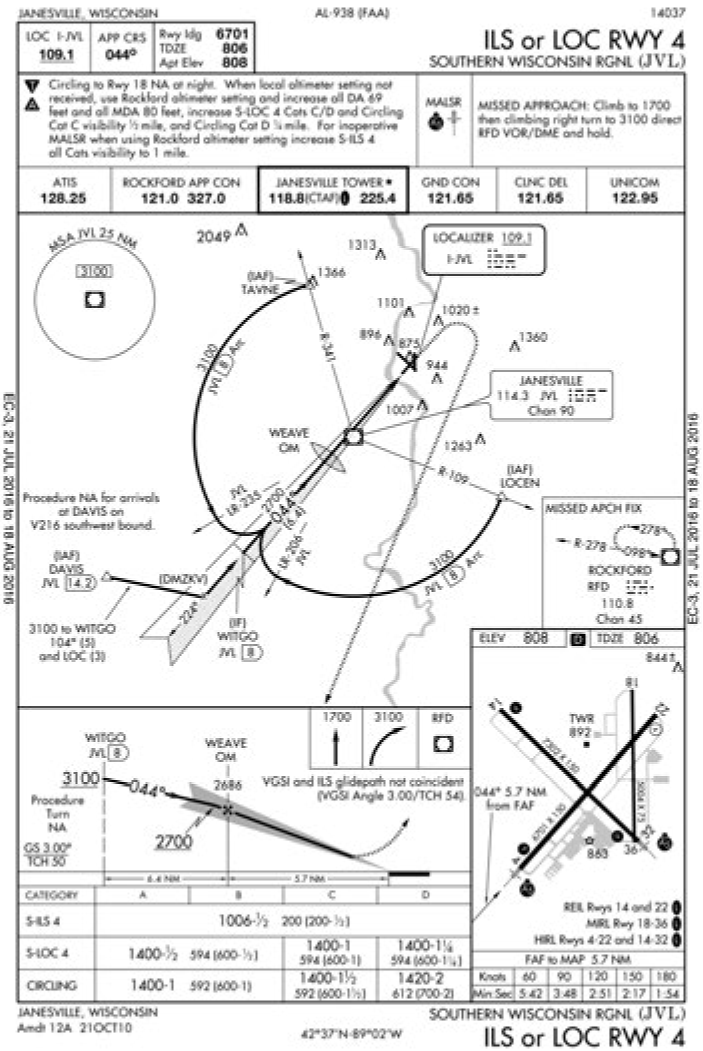

Figure 2: Terminal Procedure Chart (Approach Plate) for ILS or LOC Runway 4 at Southern Wisconsin Regional Airport (KJVL) in Janesville, Wisconsin. A good example of a non-GPS approach that uses DME arcs, in lieu of standard procedure turn options, for course reversal and to become established on the inbound approach course (in this case, a localizer). While the DME arc portion could be legally flown using an approach certified GPS, the entire procedure can be flown without the aid of GPS (or in the event of GPS failure) for aircraft equipped with DME and LOC/GS receivers.

only ever flown) with GPS and glass cockpit technologies. IFR pilots wishing to maintain true proficiency should be seeking out both published and non-published DME Arcs for practice. During such practice sessions, incorporate primary and backup navigation methods to fly these procedures using all acceptable methods.

Bearing Pointers

As ADF units have become most useful as paperweights and NDBs have been decommissioned at airports far and wide, pilots have become used to tracking courses and determining position almost exclusively with the combination of CDIs and moving map information. Yet, most modern avionics packages still have bearing pointers incorporated into them; in fact, usually more than one. Unfortunately, through disuse or poor initial training, too many modern pilots have lost all proficiency in the use of bearing pointers, both as tools for determining position TO or FROM a fixed point and as a means of tracking TO or FROM that same point.

Even in totally normal situations where all avionics and navigation equipment are working properly, bearing pointers are a fantastic situational awareness tool that is all too often ignored. In most avionics packages, bearing pointers can be selected to reference a variety of source information (VORs, NDBs or GPS Waypoints). But, the principals of their operation are always the same, regardless. A bearing pointer always points directly at the selected station, fix, or waypoint. Thus, the head of a bearing pointer always indicates the bearing TO, while the tail always indicates the bearing FROM. That information alone is situational awareness gold [Figure 3]!

In true backup navigation situations, bearing pointers can really earn their keep. Their versatility is the reason they've been incorporated into modern integrated avionics packages, long after ADF equipment has been excluded from many such systems, at least in the U.S. While they require a bit more thought and visualization than a basic CDI for navigation, they are not subject to the many errors of ADF/NDB systems when used for VOR or GPS navigation. Many pilots actually prefer a bearing

Figure 3: An example of a typical Bearing Pointer presentation within a glass-cockpit integrated avionics system. In this case, two Bearing Pointers are available for display and both have been selected to VOR stations. VOR #1 is tuned to the YVV VOR and is represented by the single-line Bearing Pointer and the lower left data field. The aircraft is on a bearing of 214° TO or 034° FROM YVV, at a distance of 10.2 NM (DME distance). VOR #2 is tuned to the APN VOR and is represented by the double-line Bearing Pointer and the lower right data field. The aircraft is on a bearing of 283° TO or 103° FROM APN, at a distance of 109 NM (DME distance).

pointer for tracking DME arcs, as they always point to the station, or 90 degrees from the aircraft's heading, +/- wind correction. This not only makes position along the arc simple to monitor via the tail of the bearing pointer, it makes wind correction visualization simpler, as well. In short, bearing pointers are simple and versatile devices for navigation that are no less relevant today than they were in the pre-GPS era. Yet, I rarely see IFR pilots commonly utilizing or maintaining proficiency in bearing pointer usage. Those pilots that do, however, generally display some of the best situational awareness skills within the ranks of IFR pilots, professional or otherwise.

Conclusion

I don't believe for a minute that we should return to pre-GPS navigation. IFR pilots should absolutely embrace and take advantage of the latest and greatest advances in both navigation and flight control. Returning to old-school methods as a matter of routine holds no appeal to myself, nor makes practical sense. However, as technologies advance, it becomes ever more critical that we stay both abreast of them and of the longer established technologies that back them up. It is easy to become complacent when the wonders of GPS make advanced navigation chores seem so simple and routine. The use of back-up navigation systems becomes nearly forgotten, rarely practiced, and almost never studied. Of course, the problem with this reality is that when the primary navigation tools are compromised, the use of the secondary tools becomes a near emergency in and of itself, rather than the simple inconvenience that it should be. KA

Matthew McDaniel is a Master & Gold Seal CFII, ATP, MEI, AGI & IGI. In 26 years of flying, he has logged over 16,000 hours total, over 5,500 hours of instruction-given, and over 2,500 hours in the King Air and BE-1900. As owner of Progressive Aviation Services, LLC, (*www.progaviation.com*), he has specialized in Technically Advanced Aircraft and Glass Cockpit instruction since 2001. Currently, he also flies the Airbus A-320 series for an international airline and holds eight turbine aircraft type-ratings. Matt is one of less than 25 instructors in the world to have earned the "Master Certified Flight Instructor" designation for seven consecutive two-year terms. He can be contacted at (414) 339-4990 or *matt@progaviation.com*.