Balancing Your Backups

PART 1

by Matthew McDaniel

[Author's Note: This two-part series will discuss a variety of navigation system failures and abnormalities, with ideas for training and handling them. While this installment will deal primarily with management of GPS abnormalities, the next installment will focus on the utilization of other navigation systems in GPS failure situations.]

It was a blustery spring afternoon in Wisconsin. I was scheduled to fly from Milwaukee's Mitchell International Airport (MKE) to Central Wisconsin Regional (CWA) in a Beech 1900D Airliner. Most King Air pilots will recognize the 1900 as the "big brother" of the King Air 350 and the Beech 99. That day, I flew as a line check airman with a brand-new first officer who was conducting his first leg of Initial Operating Experience (IOE). The weather was gloomy with overcast skies, rain and stiff winds from the south-southwest. At the time, CWA had ILS approaches to runways 35 and 8, but no precision approaches to runways 17 or 26. So, while ceilings were low, a non-precision approach would be the order of the day and we expected we'd be doing the LOC BC 26 upon arrival, in spite of the stiff crosswind that would present.

Upon checking in with Minneapolis Center, we were asked which approach we preferred at CWA. We responded that we were planning on the LOC BC 26, but that we'd need to get a little closer to pick up the ATIS and hear which approach was being advertised. When that happened, we were surprised to learn that the localizer utilized for both the ILS 8 and the BC 26 had become inoperative and that the airport was now using the VOR/DME-A approach instead (via the DME Arc and Circle to Land 17). Swell!

Of course, we had the proper equipment onboard to execute the DME Arc entry, the VOR/DME approach itself, and to fly the circling maneuver for landing on Runway 17. We were also technically "proficient" in such procedures as proclaimed by our airline's documentation stating we'd passed our most recent Proficiency Checks (PCs), which always included non-precision approach and circling procedures. But in normal operations, even back then (in the 1990s), we flew a real VOR approach very rarely, a circling approach even less frequently, and a DME Arc procedure almost never (including during simulator training events). After a thorough approach briefing, I flew the procedure and landed without incident or fanfare. Suffice it to say, the new first officer got more lessons than he'd probably bargained for that day. Not the least of those lessons was understanding the importance of having navigational backups and the skills to utilize them. The 1900s we flew were not equipped with autopilots, but they did have digital flight directors that proved invaluable in such operational circumstances. We made good use of them and other resources when our anticipated navaids for approach to landing became unavailable.

In today's IFR environment, GPS has become our primary source for enroute navigation, and even terminal navigation for operators lucky enough to have approach certified GPS equipment. WAAS-enabled GPS equipment has added an additional level of GPS capabilities, as well. These awesome navigational tools have made the lives of pilots exponentially easier, but they have not eliminated the need for backup equipment and procedures. Plus, they have complicated matters by introducing multiple GPS failure/downgrade situations that pilots often do not fully comprehend. Plenty of scenarios still exist that would force pilots to disregard their primary navigation systems and, instead, utilize their backup systems for enroute navigation, terminal navigation or both. After all, GPS signals can be degraded or fail for a variety of reasons.

RAIM

Receiver Autonomous Integrity Monitoring (RAIM) is the best predictor of adequate GPS signal strength for

Figure 1: A typical FMS/GPS unit's predictive GPS (or RAIM) page. Note that it displays the flight's destination (top left), ETA (top right), and the predicted availability of terminal/approach level GPS coverage at the ETA and plus/minus 5, 10, and 15 minutes of the ETA (the green "Y" indicating "yes"). A RAIM check of a specific waypoint (other than the destination) could be manually selected, as well.

terminal operations at the ETA. RAIM predictions can be acquired a variety of ways, including from Flight Service, the FAA website, or via the RAIM Prediction feature built into many IFR-certified GPS and FMS units. While WAAS GPS receivers perform RAIM checks continuously, non-WAAS units only perform an automatic RAIM check prior to commencing an approach. For non-WAAS users, the FAA recommends pilots perform manual RAIM checks before departure and as often as feasible before flying a GPS approach procedure (Figure 1). Additionally, non-WAAS GPS users must perform RAIM prediction checks prior to flying T and Q-Routes (GPS-based airways), or RNAV Arrival and Departure procedures (SIDs, STARs and ODPs). WAAS users are exempt from those requirements, assuming they are operating in WAAS coverage areas. Not only do WAAS-certified GPSs check RAIM automatically (within WAAS coverage areas), but they will also annunciate any RAIM-related problems. In the event a RAIM check fails, GPS approach procedures are not approved and the pilot must resort to visual or other means of approach navigation (VOR, LOC, etc.). Assuming the flight was planned legally, there should always be a non-GPS approach available at the destination and/or alternate airport (or VFR conditions forecast) to ensure the flight can be completed in the absence of available GPS navigation. For more specific details on GPS navigation and RAIM, refer to the Aeronautical Information Manual (AIM), 1-1-19.

GPS Downgrades or Component Failures

Degraded GPS signals can and do cause RAIM warnings. However, RAIM is generally black or white, in that it is (or is predicted to be) within acceptable levels or not. If the prediction is outside acceptable RAIM level, that would immediately eliminate the option of conducting any GPS terminal or approach procedures. But, when operating with WAAS, multiple leveled problems can occur. Most common with WAAS units is not a GPS navigation failure, but a downgrade in capabilities. WAAS operations require an increasingly precise level of GPS guidance for the various types of WAAS approaches. When a WAAS receiver determines it cannot meet the tolerances of, say, a Localizer Precision with Approved Vertical Guidance (LPV) procedure, it will then determine if it can meet the tolerances of a lesser type of GPS approach. If it can, it will "downgrade" and advise the pilot of the highest tolerances it is capable of. Most common would be a downgrade from LP or LPV capabilities to LNAV-only capabilities. In many such cases, the same approach can still be flown, but the higher LNAV minimums must be respected (due to the less precise lateral guidance and the lack of approved vertical guidance). That assumes, of course, the approach in question publishes both LP(V) and LNAV minima. If not, it is likely that a separate approach exists with LNAV minimums. Plus, while many WAAS avionics incorporate for-reference-only vertical guidance into LNAV procedures (LNAV+V), both approved and reference-only vertical guidance is removed whenever the system determines a downgrade is required. It is imperative that WAAS GPS users brief each approach with the possibility of a signal downgrade in mind (Figure 2). Such downgrades will often not be detected until the Final Approach Fix (FAF) becomes the active waypoint and the GPS unit alerts the pilot of the downgrade

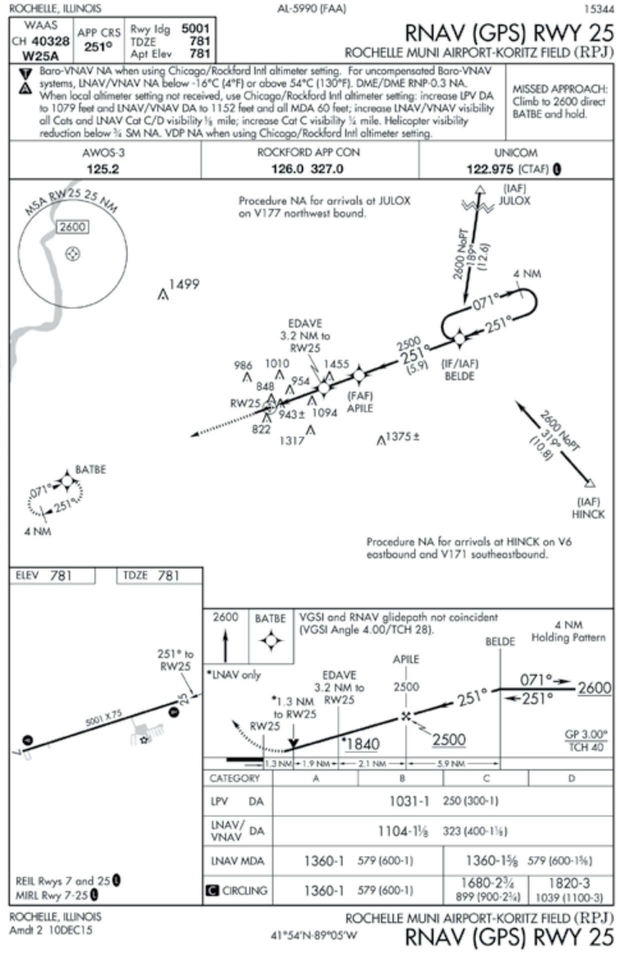

Figure 2: The RNAV (GPS) RWY 25 approach into Rochelle, IL (KRPJ) is a typical WAAS-type approach with multiple sets of minimums. While LPV minimums are published, if the WAAS service level is downgraded for any reason, the most common result would be a "Downgrade to LNAV" message. The approach could still be flown, using the published LNAV minimums, but no vertical guidance should be expected.

(and/or the Course Deviation Indicator (CDI) sensitivity is annunciated as "LNAV" versus the expected "LP" or "LPV"). This is not the time to re-brief the approach and fly it as a downgraded procedure. Better to abandon the approach and start fresh, briefing the downgraded or alternate approach procedure to be used subsequently. In the rare event that a downgrade or RAIM-induced failure occurs inside the FAF, the IFR-certified GPS will continue to function to the best of its ability for five minutes thereafter to give the pilot an opportunity to safely initiate a missed approach procedure.

To practice dealing with such procedures, find a knowledgeable CFI and/or simulator instructor who's well versed in creating such scenarios with the equipment in your aircraft. Most WAAS-enabled GPS units (whether independent, part of an FMS unit or incorporated into an integrated avionics system) allow WAAS features to be manually de-selected. An instructor knowledgeable in your navigation system should be familiar with a variety of ways to force degraded capabilities and ways in which you can best utilize the capabilities which remain.

One requirement of stand-alone IFR GPS installations is an external/separate CDI for each GPS unit. These external CDIs are usually incorporated into a Horizontal Situation Indicator (HSI), Electronic HSI (EHSI), or traditional Nav-Heads (combo OBS/CDI instruments). They must be installed within the scope of a "normal instrument scan." However, in the event of an external CDI failure, most stand-alone GPS units incorporate an internal digital CDI. While this CDI is not approved for primary navigation purposes, it can be used in lieu of the external CDI in emergency situations. For emergency and abnormal situations that might call for it, GPS users should know how to make their system display its backup CDI, how to determine its lateral limits (needle sensitivity), and how that CDI may or may not be coupled to installed Flight Director (F/D) and/or Autopilot (A/P) systems. Modern integrated flight deck systems need not have external CDIs, as those systems have built-in redundancies that traditional panel-mounted GPS installations do not. Such systems generally have multiple GPS units, with each unit capable of displaying its navigation signal on multiple pilot-selectable CDIs and bearing pointers. While this lessens the chance of single-point failures in such advanced systems, pilot proficiency in system programming is vital when dealing with abnormalities that require using secondary navigation sources and/or non-standard arrangements of navigation instruments/indicators.

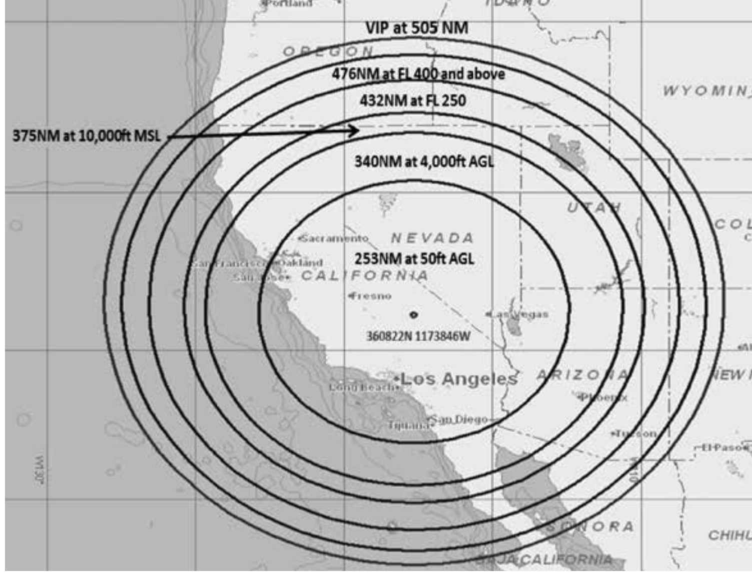

Figure 3: A portion of FAA Flight Advisory CHLK 16-08 advising of GPS testing causing unreliable or unavailable GPS signals over a huge area and altitude spectrum across the southwestern United States.

Complete GPS Loss

GPS is also subject to inference, rendering signals unreliable or unavailable. Such was the case throughout most of June 2016 in a multi-state area in the southwestern United States, due to GPS testing periods. In those instances, the FAA issued a Flight Advisory (Figure 3), as well as multiple NOTAMs related to the times, areas, and altitudes of the GPS outages.

Complete GPS failures are rare, to be sure, but no electronics are failure proof. Individual GPS units can lose power, become overheated, or simply stop functioning. Often, modern GPS units are components of an integrated avionics unit. Thus, the failure of such an integrated unit induces the failure of the GPS it contains. GPS receivers that are not experiencing power or heat problems, can still be rendered inoperative by losing communications with their antenna via loose or broken connections or through software glitches. Obviously, any such failures would require the pilot to consult backup navaids. While such backups often include secondary GPS units, that would not help in situations of shared antennas, identical software bugs, satellite outages, external avionics cooling fan failures, GPS interference or testing, or the loss of shared power sources. Thus, reverting to "old school" forms of navigation will sometimes be the only options left.

In Part Two, we will discuss several forms of non-GPS backup navigation and how to incorporate them into your typical missions in order to maintain proficiency in their use. KA

Matthew McDaniel is a Master & Gold Seal CFII, ATP, MEI, AGI & IGI. In 25-plus 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. His company, Progressive Aviation Services, LLC, (*www.progaviation.com*), 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*.