Instrument Flying Update

Preface and First Page From Each Chapter

Preface

If you completed your instrument training in the era of VOR, ILS, and basic GPS, it is time you make a commitment to getting yourself up to speed for new world IFR.

Instrument flying is evolving at an incredible pace. New technologies (like WAAS and TAWS) are being applied, new rules (like those on transitioning onto RNAV approaches) are being written, and new procedures (like LPV approaches) are being developed. The big payoff is in unprecedented 3-D position accuracy and enhanced situational awareness as the aircraft position is displayed in relation to complex waypoint strings together with surrounding terrain and obstacles.

Hopefully, all of this technological and procedural evolution will result in lower accident rates, especially CFIT (Controlled Flight Into Terrain) accidents. Indeed, there are signs that this is already happening with the airlines. But while exotic avionics make it possible to precisely fly complex 3-D routes with only a few pilot inputs, the same avionics can also overwhelm a pilot who lacks a full understanding of the on-board equipment and/or the newly developed rules and procedures governing its use.

To navigate the new world of IFR safely and efficiently, pilots and controllers need to do their homework. We need to keep up with the nuances of the new equipment as well as the rules and procedures that evolve with the equipment. To cite the most important example, many thousands of pilots are about to upgrade from GPS to GPS/WAAS. With this upgrade comes the promise of vastly improved instrument approaches, but we also move into an environment which we have not yet been trained to enter–where, for example, we get strange messages from our avionics saying that LPV is unavailable because VPL exceeds VAL, or where LNAV/VNAV is available, but a knowledgeable pilot will know that, given the current weather, LNAV might be better. The relatively simple days when we tuned an NDB or VOR, identified it, and flew the chosen course are ending.

Safe and efficient operation in this new environment is going to take a commitment to continuing education. I hope this book will help.

Introduction

Instrument flying has changed in many important ways in the short time since I published *IFR: A Structured Approach*. My purpose with the present book is to bring you up to date.

The big news is that the Wide Area Augmentation System (WAAS) has been commissioned, and along with that has come a family of vertically guided almost-precision approaches–LPV, LNAV/VNAV, and approaches with what is called "advisory vertical guidance." These approaches allow us to fly final descents with cockpit displays showing ILS-like glidepath deviation indications even though our runway is not served by ILS facilities. Given that CFIT (Controlled Flight Into Terrain) accidents on approach are about five times as likely when the approach lacks vertical guidance, WAAS will certainly be a significant benefit to a substantial subset of the aviation community. (See "Killers in Aviation: FSF Task Force Presents Facts about Approach-and-Landing and Controlled Flight into Terrain," *Flight Safety Digest*, November-December, 1998.)

What do you need to know before you start flying confidently with WAAS? I suggest the list goes something like this: How does WAAS work? What do all those new acronyms–HAL, VAL, HPL, VPL, LPV–really mean? What new rules apply to WAAS users? How are WAAS-based approaches constructed? What are the similarities and differences between WAAS-based approaches and ILS, VOR, or non-augmented GPS? Why is the LNAV

1. Understanding WAAS

This is the first of several chapters on WAAS, the Wide Area Argumentation System. WAAS is a huge infrastructure devoted to correcting the errors inherent in GPS position solutions, and it is the biggest news in instrument navigation since GPS itself. In the present chapter we will look at the sources of GPS errors and at how WAAS succeeds in creating a more accurate position solution.

This is a fairly technical chapter, filled with investigations of issues like how solar activity effects the ionosphere, which then confuses GPS by slowing the satellite signal to your receiver–not exactly the stick and rudder material most pilots love. But WAAS is the future. And some day in the future you may be counting on an LPV approach to bring you home when you get a message from your GPS/WAAS receiver saying that VPL exceeds VAL and the approach is unavailable. Wouldn't you like to know what that is all about? You can't know too much.

In the following chapters we will examine some of the nuances of how WAAS-aided approaches (e.g., LPV and LNAV/VNAV approaches) are constructed and what new rules and constraints we must understand in order to fly these procedures safely.

I grew up listening to stories from my father and his friends about flying B-24s and Boeing Stratocruisers over the Pacific, finding their way with celestial navigation, pilotage, dead reckoning, and an occasional NDB. In his day, a good navigator could fix his position accurately enough to bring a tiny atoll into sight

2. LPV, LNAV/VNAV, and LNAV Approach Design Concepts

In this chapter I am going to outline the approach design criteria used when the FAA builds an LNAV, LNAV/VNAV, or LPV approach. This is a complex topic, and we are not going to bog down in all of the byzantine details from the TERPS (U. S. Standard for Terminal Instrument Procedures). But some knowledge of approach design methodology is useful for instrument pilots. For example, if you are about to do an approach that is more or less lined up with the intended runway, but only circling minima are listed (e.g., Aspen, Colorado), that ought to raise a red flag. Ideally the approach would not be that way, but TERPS forced it. Why? Or if you contemplate an approach where the missed approach point is five miles from the runway threshold (e.g., Hailey, Idaho), again you know the TERPS forced it. Why? And per our topic for this chapter, why would a "dive and drive" LNAV approach have lower minima than a vertically guided, WAAS-enabled LNAV/VNAV? Is there something lurking on the final approach segment that we ought to think about? It turns out that there is, so let's get to work.

When a specific approach is designed by the FAA, the end product is the result of a great many factors: (1) There is the runway itself. Does it meet the requirements for a precision approach, for example? (2) There is the local terrain/obstacle topography. Does the approach need to bend around an AM radio tower? (3) There are neighboring airports with their own airspace requirements. (4) And there are hundreds of pages of complex rules called TERPS regarding such issues as the required obstacle clearance for each segment

3. Flying with WAAS

In previous chapters we have explored how WAAS can improve GPS accuracy, especially altitude accuracy, and we have looked at how TERPS criteria are used to construct approaches for WAAS-enabled aircraft. In the present chapter most of our time will be spent looking at issues related to flying with WAAS. We will open with a few generalities (primarily preflight actions and alternate requirements) and then focus on approaches.

Preflight and Alternate Requirements with WAAS

There are some preflight issues that are unique to WAAS. As part of your preflight, you should check WAAS NOTAMS. The NOTAMS may contain an advisory indicating that WAAS is predicted to be “unreliable” or “unavailable” over certain areas or at certain locations. Airport-specific “unreliable” NOTAMS (such as “LPV and LNAV/VNAV unreliable”) are passed on by Flight Services *when requested by the pilot*, but ATC is not required to provide such information. WAAS asset outages will result in NOTAMS indicating that WAAS is unavailable over a wide area. ATC is required to include this information when issuing an RNAV clearance, unless the same information is provided on ATIS. In either case, LNAV operations may be supported, and pilots can utilize LPV or LNAV/VNAV minima if their onboard equipment indicates that the required accuracy is available. For LPV you need HAL and VAL of at least 40m and 50m, respectively. And for LNAV/VNAV you need HAL and VAL of at least

4. The New RNAV Departures, Q-routes and T-routes

This chapter begins with a quick general review of IFR departure procedures and then focuses more closely on the new RNAV SIDs. We will look at questions like the following: Can you fly these new procedures with any IFR certified GPS? The answer is, No. Then how do you find out if your GPS receiver qualifies? What else is required besides an approved GPS receiver? And what about the notes on the procedure regarding Type A and Type B? These and other questions will be explored, and when this is completed, we will look briefly at the new Q- and T-routes.

IFR Departures

Following publication of my book, *IFR: A Structured Approach*, I received some readers' comments that convinced me that even very experienced instrument pilots often do not understand the instrument departure process. Pilot confusion was particularly acute with respect to the use of textual obstacle departure procedures. The reasons for the confusion within the pilot community are easy to find: First, there have been several changes in official terminology within the past few years. Second, when ATC issues a clearance, the textual departure procedure is not stated, even though ATC might expect the pilot to fly it. Third, both the FAA and the instructor community have done a poor job of bringing pilots up to speed on this issue. Let's deal with the terminology first.

In the old, old days prior to 1998, there were two types of pre-planned instrument departures. There were SIDs (Standard Instrument Departures),

5. Ground Proximity Warning Systems and TAWS

Another new wrinkle for instrument pilots is the proliferation of terrain alerting and warning systems. The popularity of these systems is due both to technological advances that have made these systems feasible on relatively low-end panel-mounted (and even hand-held) avionics and to regulatory changes instituted in 2005. We will begin with some background.

J. Cooper, writing in the February 1995 issue of *Aerospace*, estimated that 30,000 people had died in CFIT (Controlled Flight into Terrain) accidents between 1931 and 1995. Since then there have been several major CFIT accidents, including American 965 in Cali, Columbia in 1995 and Korean Air 801 in Guam in 1997. Fortunately, the number of CFIT accidents is presently declining, thanks largely to improvements in avionics and crew training. Here is a little history on the topic.

By the late 1960's airlines, regulators, and avionics manufacturers were moving toward procedures, regulations, and hardware that might lessen the incidence of CFIT accidents. In 1969, Scandinavian Airlines began using a radar-altimeter based GPWS (Ground Proximity Warning System) pioneered by United Control, later to become part of Honeywell. The GPWS was adopted voluntarily by a handful of airlines in the early 1970's and offered as an option by Boeing in 1973.

The catalyst for regulatory change was the tragic loss of TWA 514 on a premature descent during initial approach to Dulles in December of 1974. Within two weeks of the accident, the FAA put in place a requirement for ground proximity warning systems (GPWS) on all Part 121 large jet and turboprop

6. ATC's Minimum Safe Altitude Warning System

In the previous chapter we examined both the old GPWS and the new TAWS systems for on-board terrain alerting. ATC also has a terrain warning system built into its automated radar programs. The radar system is called MSAW, Minimum Safe Altitude Warning system. The function of MSAW is to alert controllers when aircraft are dangerously low, and controllers then pass on the alert to pilots. We begin with a little history.

Background on MSAW

On December 29, 1972 Eastern Airlines 401 diverted from its approach to landing at Miami International after its nose gear position indicator failed to illuminate. The Lockheed L-1011 climbed to 2000 feet and maneuvered over the everglades on a moonless night as the crew attempted to sort out the anomaly. At some point the autopilot altitude hold function was disconnected, and the airplane began a slow descent that ended in the destruction of the airplane and the loss of 101 lives. As a result of its investigation, the NTSB issued a safety recommendation to the FAA asking it to "Review the ARTS III program for the possible development of procedures to aid flight crews when marked deviations in altitude are noticed by an Air Traffic Controller." (Recommendation A-73-46.) A year after the NTSB safety recommendation, the FAA commissioned Univac to design such a system.

The resulting program was called "MSAW," Minimum Safe Altitude Warning system. MSAW is incorporated into the software generating ATC radar

7. Radar Vectors and Minimum Vectoring Altitudes

This chapter may seem to take us off the track of "what's new with IFR," but as I said in the introduction, if we are going to put the new gadgets, procedures, and rules into their most important context–namely, safety of flight–we need to venture beyond simply what's new. I think you will see that there is value in this when we finish the present chapter and then put all this study to work when we explore a recent accident on a night departure from San Diego in the following chapter.

Minimum Vectoring Altitude (MVA)

The FAA has drawn up minimum vectoring altitude charts for use by ATC personnel. Like most other minimum altitudes, the MVA is predicated upon the height of nearby terrain/obstacles. The MVA chart divides the area of radar coverage into numerous irregularly shaped sectors, and the minimum vectoring altitude in each sector affords at least 1000 feet of obstacle clearance in non-mountainous areas. In designated mountainous areas there is 2000 feet of obstacle protection, unless an exception is granted. An exception might be given to facilitate transitions onto approaches when the area is served by ASR, Airport Surveillance Radar. MVA sector boundaries can appear to be quite random, but they are drawn to afford at least 3 miles of lateral separation from the terrain/obstacle defining the MVA in an adjacent sector.

Figure 1 shows the MVA chart centered around the radar antenna site

8. The Midnight Departure

On the afternoon of October 23, 2004 a Lear 35A, N30DK, departed Albuquerque for El Paso on the first of four legs of a lifeguard flight. The flight subsequently went to Manzanillo, Mexico and San Diego before heading back toward Albuquerque. The captain, 56, was a 13,000 hour ATP, type rated in the Challenger, Westwind, and Learjet, with 525 hours in the Lear 35 and 639 hours in the Lear 25D. The first officer, 30, was a commercial pilot and CFI-I with 3000 hours and 100 in the Learjet.

The flight departed Albuquerque International Sunport (ABQ) about 1500 PDT with the crew plus two medical personnel. It then picked up an additional medical crewmember in El Paso. The flight subsequently flew on to Manzanillo, where it boarded a patient and passenger. As 30DK approached San Diego, SOCAL (Southern California Terminal Radar Approach Control) cleared it for a VOR-A approach to San Diego, Brown Field. The crew reported having visual contact with the airport and cancelled IFR prior to landing at about 2324 PDT. The patient and passenger were then dropped off just before midnight. At 2317 PDT, just prior to the landing, the Brown Field ASOS was reporting 2100 scattered and 8 miles. A few miles away, at San Diego International, the weather was 3000 broken and 10 miles. Winds were light in the area, and the moon was about 34° above the horizon with 85% illumination.

At 0002 PDT on the 24th, one of the pilots called FSS to file IFR from Brown Field back to Albuquerque via direct Palm Springs with an ETD of 0020 PDT. No weather information was requested from the FSS specialist. This was a Part 91 repositioning flight.

9. Getting Established on an Approach

Notice that when you bring up an approach from your GPS database, the GPS gives you a limited number of options with respect to how you might get established on the approach. You are offered all of the initial approach fixes (IAFs) that are charted for the requested procedure, a charted feeder route (if there is one), and vectors to final. This is in keeping with a long-established policy that is still found in the AIM (5-4-7 e.):

> Except when being radar vectored to the final approach course, when cleared for a specifically prescribed IAP..., pilots shall execute the entire procedure commencing at an IAF or an associated feeder route as described on the IAP chart.

The pre-2006 versions of the controller's Handbook (FAA Order 7110.65, 4-8-1) made much the same point, saying:

> Standard Instrument Approach Procedures shall commence at an Initial Approach Fix or an Intermediate Approach Fix if there is not an Initial Approach Fix. Where adequate radar coverage exists, radar facilities may vector aircraft to the final approach course in accordance with para 5-9-1, Vectors to Final Approach Course.

That all seemed very clear–either you got vectors to the final approach course or you flew the full charted procedure starting at a feeder route or an IAF (or IF if there is no IAF). See the RNAV (GPS) Rwy 3 approach to Driggs, Idaho. (Figure 1.) If you select this procedure on the Garmin 530, it will offer you the following options for transitioning onto the approach: vectors to the final approach course via interception of a half-line that runs from FIXOD through

10. “Proceed Direct OZNUM”

Let us first lay out the bare sequence of events for this accident and then analyze those events in light of the work we have done on approach construction, MSAW alerts, and recommended ATC handling per the ATC Handbook.

The Facts

At 1600 local time (0000Z) on January 23, 2002, a Cirrus SR20, N893MK, departed Napa, California (APC) on an IFR flightplan to Reid Hillview (RHV), just 57 nm to the southeast. The weather at Reid Hillview was 1200 broken, 8000 overcast, visibility 4, wind 280° at 12 knots, temperature 16° C with dewpoint 15° C, and altimeter 30.24” Hg. The only occupant of the airplane was the 50 year-old private pilot, who was instrument rated. The pilot had 461 hours total time, with 334 hours in make and model, including 50 hours make and model in the preceding 90 days. Earlier in the day, the pilot had flown from RHV to APC.

We pick up the flight a few minutes after takeoff. (“A/CR” is Northern California TRACON Richmond radar position. “A/CG” is the Grove radar position. “A/CT” is the Toga sector. “A/CL” is the Licke sector. “RHV” is Reid