Introduction

This book is written for serious pilots who wish to learn more about flying than the minimum required to pass an FAA exam. It is written for pilots who have moved beyond the simple airplanes and easy flights they were trained for, and who now find themselves in command of elaborately equipped high performance airplanes that they were not specifically trained to fly.

There is a serious gap in the education of general aviation pilots. We train on equipment that is small, simple, slow, and stable, and then as soon as our economic circumstances allow, we move right on, with little or no new training, to airplanes that are relatively big, complex, fast, and less stable. Consider the book work we are required to do. The beginning pilot must study an intimidating array of subjects—airspace, aerodynamics, powerplants, instruments, aircraft systems, maneuvers, weather, communications, flight planning, FARs, and so on and on. With such a broad range of subjects, not much depth of understanding is expected by the typical flight instructor, examiner, or the FAA itself. Study materials are geared to the simple airplanes being flown for training, as are the written and oral test questions for the private license. The object of the whole process seems to be to create a pilot who is competent to fly a Cessna 150 or Piper Cherokee on a short cross country flight.

The next step up the ladder is generally the instrument rating. Again the pilot is faced with a constellation of challenging subjects—procedures, rules, instrument mechanics, communications, weather, and so on and on once more. Again, the breadth of subjects limits the depth of the study.

At the end of the private license and instrument rating, the student generally has shown himself or herself to be competent to fly instrument *procedures* in *simple airplanes*, like the ones used for training. Nothing is wrong with this, as long as the pilot limits himself or herself to flying nothing more demanding than "instrument procedures in simple airplanes." But what now stands between the pilot and a hard IFR trip in a Malibu or 58P Baron through known moderate ice with embedded thunderstorms and low ceilings? Not much.

To take the Malibu, you need flight instruction and an instructor's signature saying you are competent, per FAR 61.31(e), to fly "high performance airplanes." (High performance airplanes are defined as airplanes with more than 200 horsepower *or* retractable gear, flaps, and a controllable propeller.) Note the plural in the endorsement, "airplanes." You can get your instruction and signoff in a Skylane, and then be perfectly legal in a B36TC Bonanza, Malibu, T210, Caravan, or TBM700. No type-specific training is required. The checkout for complex airplanes is usually perfunctory. There is no minimum number of hours required, and no written test.

The situation is similar if you want to take the 58P Baron. This time you will need to obtain a multiengine class rating, but you still do not need type-specific training, nor do you need to pass a written exam. You can do five hours of training and then take your ride in a Seminole the day before you launch in the 58P.

What we have is a system where most flight training is undertaken in low-end airplanes and most study is of the performance, loading, engines, systems, and avionics management for these simple airplanes. A pilot may never have flown anything more complicated than a Seminole, and then when his or her financial circumstances allow, he or she can blast off into the Flight Levels in a 58P Baron. The new plane may have radar, known ice equipment, turbochargers, and a flight director. Is there any requirement that the pilot be trained or demonstrate competence in the use of these items? No. His or her private training was devoted to simple airplanes that lack these systems and capabilities. And the instrument training was devoted to procedures in simple airplanes—not real trips in high performance airplanes. (The new FAR 61.31(f) incorporated in April of 1991, is a small step in the right direction. It requires that pilots receive ground and flight training prior to acting as pilot-in-command in a "high altitude airplane"—defined as an airplane with a service ceiling or maximum operating altitude, whichever is lower, above 25,000 feet MSL. This is long overdue, but it does not go far enough for three reasons: (i) Airplanes with maximum operating altitudes of 25,000 feet and lower are exempt—that leaves out the Malibu, P210, the Piper Aerostar 601P, 58P Baron, and many more general aviation airplanes. (ii) The required training is not type specific. (iii) Pilots who served as pilot-in-command of or took proficiency checks or rating rides in "high altitude airplanes" prior to April 15, 1991 are exempt.)

What is the serious pilot of a complex airplane to do? First, get type-specific training from an instructor with lots of experience *in type*. In the past 10 years there has been a real boom in this business from owners' organizations and training corporations. Second, it is high time you upgrade your general aeronautical education. The book work you did for your private license left out an awful lot that is relevant to the safe operation of real high performance airplanes—airplanes with a wide range of operating speeds and altitudes, airplanes with turbochargers, two engines, radar, deice and anti-ice systems, pressurization, autopilots and flight directors. I wrote this book to help you with this second task, that is, the study of more advanced generic (as opposed to type-specific) topics.

As you page through the Table of Contents, you will see chapters on all the aforementioned subjects—turbochargers, two engines, radar, deice and anti-ice systems, pressurization, autopilots and flight directors—plus a lot more. We start with a study of the air, since it is fundamental to everything that follows. Air density affects airplane and engine performance. The dynamic pressure of the air determines lift and drag. And static pressure affects the instruments and the air density. We devote five chapters to a study of the engine and prop. We have chapters on normally aspirated engines, turbochargers, mixture, turbines, and propellers. Most pilots end their study of engines at what is really the beginning. They understand the four-stroke cycle, and they have been fed a few rules of thumb (don't lean below 5000 feet, or don't operate oversquare) that might politely be called oversimplifications, but are more accurately described as patently false. Most pilot training does not even equip pilots to read the engine performance graphs in the manual that came with their engine. Many pilots now operating turbocharged airplanes have only the sketchiest idea of what they are dealing with, so we devote a chapter to exploring the details. Leaning and the importance of the fuel/air mixture ratio have a chapter of their own. It is especially important to re-examine this subject in light of the new generation of engines that are approved for operation lean of peak EGT. The chapter on turbine engines is offered as an introduction for piston pilots who are curious or new turbine pilots in need of the basics prior to their formal transition class. And the propeller gets a chapter of its own. Most pilots do not realize that variations in RPM are nearly as effective in enhancing operating efficiency as variations in EGT. Again the role and importance of RPM is underplayed in training, because the only airplanes most pilots ever study have fixed pitch props.

The next three chapters cover the theory and reality of airplane performance. We begin in Chapter 7 with a fairly careful study of drag. In the following two chapters, we get into specific performance areas like takeoff, climb, and landing, with special emphasis on the effects of high density altitude. We will find there is *much* your handbook does not tell you about your airplane's performance.

A chapter is devoted to the instrument flying technique known as "flying by the numbers." My personal experience in teaching this technique to high performance pilots is that it works wonders to improve a pilot's ability to get the airplane to do what he or she wants it to. If you do not fly this way already, I am sure you will find this to be the most helpful part of this book, at least insofar as "stick and rudder" basics are concerned.

Most pilots do not take their airspeed, g-load factor, and cg limits as seriously as they should. Again, this stems from the types of airplanes they study as new pilots, plus the fact that not much study happens after that. Training airplanes do not operate over a very wide range of airspeeds, so they typically cruise near their maneuvering speeds. For this reason they are generally less capable of inducing high g-loads. Center of gravity is usually less of an issue in training airplanes also, because they have few loading areas, and the areas are close together and gathered near the center of the allowable cg envelope. High performance airplanes are more likely to have nose and tail baggage areas that allow the cg to be located far outside the envelope. It takes a little study to understand the attending dangers. My object in these two chapters is to explain the rationale behind the airspeed, g-load, and cg limits, so you have reason to take them more seriously. In Chapter 13 I give some examples of weight and balance computer programs that you can modify to work problems for your airplane.

Chapters 14 and 15 study multiengine issues. The former chapter explores the aerodynamics of single engine operations. If you have not been studying this issue in detail recently, you should find a lot of thought-provoking information. Our focus is the critical nature of zero sideslip.

When and why do you want zero sideslip, and how do you attain it when you want it? The latter chapter offers suggestions for handling engine failures during all phases of flight.

Engine failures happen in single engine airplanes, too, of course, and we need to study ways of dealing with them. As with so much else, the primary student is given the simplest possible advice—land straight ahead. But is this always right? Is there an altitude high enough that we could turn around and make it back? How high is it? And what bank should be used? These and related questions are taken up in detail in Chapter 16.

The next two chapters explain systems found in many high performance airplanes, but never in trainers—flight directors and pressurization. Many pilots who operate these systems have never really studied them, no doubt because they did not have to and no sources were readily available even if they did.

The final two chapters deal partly with equipment (radar and deice and anti-ice gear) and partly with the type of weather that calls for their use. Many pilots fail to get as much information as they can from their radar, because they never have been properly instructed in its use. The icing chapter covers the effects of ice, the counter-effects of deice and anti-ice equipment, strategies for operating in and around ice, and various legal issues related to ice.

I think these are important subjects and that responsible pilots of high performance airplanes have an obligation to become informed. I commend you for making this effort, and I hope this book can help you.

It might be worthwhile discussing one of the more difficult didactic problems I had to wrestle with as I wrote this book, especially since it might affect the way you read it. If you want to understand why airplanes behave the way they do, you have to be willing to think analytically and, to some extent at least, mathematically. This is inescapable, and no amount of effort on my part to come up with arm-waving intuitive explanations or analogies can circumvent this fact. Pilots have vastly different educational backgrounds. Some could pick up an advanced aerodynamics text and read through it with ease, while others have not worked with an equation since high school, and unfortunately were not the beneficiaries of good training even then. Personally, when I am trying to understand something that is inherently technical/mathematical, I need to push on it until I can derive the equations. Only then do I feel that I understand it. This is my learning style, and I think it is the proper approach for certain subjects. But I also know that not everyone shares my feeling. Not only that, but some readers would get nothing at all from a mathematical treatment. I do not accomplish my objective of improving your understanding if I cloud the discussion in a blizzard of unhelpful mathematical symbols.

Some sort of balance needs to be struck. I need to make things as clear and simple as I can, but I can't make things too much simpler than they actually are. Also, this book is intended to offer a step beyond primary training, so it needs to explore some advanced subjects and to offer explanations for things you were told earlier, but were asked to accept on faith. The further you advance with a subject, the more you derive from first principles and the less you accept on faith.

There is no perfect solution, but here is what I have done. Things are said and points are made in the simplest way possible. Sometimes I use words, sometimes graphs, sometimes equations—whatever makes the point as clearly as possible. Simple equations like Lift = $b\alpha V^2$ (where b is a constant, α is angle of attack, and V is calibrated airspeed) are incorporated into the text. Nearly everyone should be comfortable with this level of math. If the math is more complicated than this, or if we use a lot of equations even though each one is simple, then the math is separated from the rest of the text either in an appendix or in a short section marked like this: [Math warning.....]. In either case a verbal explanation is offered to those who choose not to work through the math, so the least possible content is lost.

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