Rod Machado's Instrument Flight Training Syllabus

A complete "minimalist" syllabus to help instructors prepare students for the instrument rating.

Photo: Pitor Mitelski

Copyright 2024: rodmachado.com

Rod Machado's Instrument Pilot Flight Training Syllabus

Copyright – 2024
By Rod Machado
(www.rodmachado.com)
All rights reserved

A Note to the CFII

I am presenting this instrument training syllabus with the hope of facilitating your training of instrument students. Drawing on over five decades of experience in pilot training, I have experimented with various teaching methods to refine my approach. This syllabus represents one of my successful endeavors, striking a balance between the incremental building-block approach and effective learning strategies. It begins with the fundamentals of instrument flight, progressively enhances these skills, and emphasizes mastery of each stage before advancing.

The most common mistake made by instrument instructors is allowing students to progress to instrument approaches before mastering essential skills such as instrument scanning, VOR/GPS navigation, and holding patterns. This premature advancement often leads to challenges in completing IFR training. I urge you not to let this happen to your students.

Understanding the learning plateau is crucial for both instructors and students in instrument training. Instrument training involves prolonged plateaus, exacerbated by the absence of visual references and the need to unlearn seat-of-the-pants flying instincts. Students may experience frustration around the 30-hour mark, questioning their ability to execute unassisted approaches. From my experience, I can assure you that breakthroughs will occur, typically between 30 to 35 hours of training. It is during this period that students begin to grasp the intricacies of instruments, moving maps, and navigation systems, transitioning towards becoming competent instrument pilots. Awareness of these extended learning plateaus is essential to prevent self-doubt in your instructional abilities. With experience, you will learn to anticipate and effectively manage these plateaus with your students.

Lastly, emphasize the importance of theoretical knowledge alongside practical flying. A thorough understanding of the aircraft, its avionics, and the IFR system is indispensable for developing confident instrument pilots. Encourage your students to read extensively and ask a lot of questions—it's the path to deeper understanding. I recommend resources such as *Rod Machado's Instrument Pilot's Handbook* or my *50-hour Instrument Pilot's eGround School*, which provide comprehensive insights into instrument flying while making learning enjoyable.

Sincerely,

Rod Machado

IFR LESSON SCHEDULE

Lesson 0: VFR Review of Attitude Flying (1.5 Hrs.)

Lesson 1: Introduction to Attitude Instrument Flying (Airplane): The Attitude Indicator (1.5 Hrs.) 1.5 Hrs.^{T}

Lesson 2: Introduction to Attitude Instrument Flying (Airplane): Pitch Control and Trim (1.5 Hrs.) 3.0 Hrs.^{T}

Lesson 3: Pitch Control, Bank Control, and Trim (1.5 Hrs.) 4.5 Hrs.^{T}

Lesson 4: Pitch Control, Bank Control, Power Control, and Trim (1.5 Hrs.) 6.0 Hrs.^{T}

Lesson 5: Slow Flight, Stalls, Constant Airspeed & Rate Climbs & Descents (1.5 Hrs.) 7.5 Hrs.^{T}

Lesson 6: Compass Turns, Unusual Attitudes, and Steep Turns (1.5 Hrs.) 9.0 Hrs.^{T}

Lesson 7: Electronic Navigation Using VOR (1.5 Hrs.) 10.5 Hrs.^{T}

Lesson 8: Electronic Navigation Using GPS (1.5 Hrs.) 12.0 Hrs.^{T}

Lesson 9: Holding Patterns: Part-1 (1.5 Hrs.) 13.5 Hrs.^{T}

Lesson 10: Holding Patterns: Part-2 (1.5 Hrs.) 15.0 Hrs.^{T}

Lesson 11: VOR Approaches: Part-1 (1.5 Hrs.) 16.5 Hrs.^{T}

Lesson 12: VOR Approaches: Part-2 (1.5 Hrs.) 18.0 Hrs.^{T}

Lesson 13: VOR and VOR-A Approaches: Part-3 (1.5 Hrs.) 19.5 Hrs.^{T}

Lesson 14: VOR & VOR/DME Approaches: Part-4 (1.5 Hrs.) 21.0 Hrs.^{T}

Lesson 15: Localizer Approaches (1.5 Hrs.) 22.5 Hrs.^{T}

Lesson 16: ILS Approaches: Part-1 (1.5 Hrs.) 24.0 Hrs.^{T}

Lesson 17: ILS Approaches: Part-2 (1.5 Hrs.) 25.5 Hrs.^{T}

Lesson 18: GPS Approaches: Part-1 (1.5 Hrs.) 27.0 Hrs.^{T}

Lesson 19: GPS Approaches: Part-2 (1.5 Hrs.) 28.5 Hrs.^{T}

Lesson 20: GPS Approaches: Part-3 (1.5 Hrs.) 30.0 Hrs.^{T}

Lesson 21: IFR Cross Country (4.5 Hrs.) 34.5 Hrs.^{T}

Lesson 22: IFR Checkride Prep: Part-1 (1.5 Hrs.) 36.0 Hrs.^{T}

Lesson 23: IFR Checkride Prep: Part-2 (1.5 Hrs.) 37.5 Hrs.^{T}

Hrs.^{T} = Total Hours

FAR Requirement for the Instrument Pilot Certificate

61.65 Instrument rating requirements

(a) ***General.*** A person who applies for an instrument rating must:

(1) Hold at least a current private pilot certificate, or be concurrently applying for a private pilot certificate, with an airplane, helicopter, or powered-lift rating appropriate to the instrument rating sought;

(2) Be able to read, speak, write, and understand the English language. If the applicant is unable to meet any of these requirements due to a medical condition, the Administrator may place such operating limitations on the applicant's pilot certificate as are necessary for the safe operation of the aircraft;

(3) Receive and log ground training from an authorized instructor or accomplish a home-study course of training on the aeronautical knowledge areas of paragraph (b) of this section that apply to the instrument rating sought;

(4) Receive a logbook or training record endorsement from an authorized instructor certifying that the person is prepared to take the required knowledge test;

(5) Receive and log training on the areas of operation of paragraph (c) of this section from an authorized instructor in an aircraft, full flight simulator, or flight training device that represents an airplane, helicopter, or powered-lift appropriate to the instrument rating sought;

(6) Receive a logbook or training record endorsement from an authorized instructor certifying that the person is prepared to take the required practical test;

(7) Pass the required knowledge test on the aeronautical knowledge areas of paragraph (b) of this section; however, an applicant is not required to take another knowledge test when that person already holds an instrument rating; and

(8) Pass the required practical test on the areas of operation in paragraph (c) of this section in—

(i) An airplane, helicopter, or powered-lift appropriate to the rating sought; or

(ii) A full flight simulator or a flight training device appropriate to the rating sought and for the specific maneuver or instrument approach procedure performed. If an approved flight training device is used for the practical test, the instrument approach procedures conducted in that flight training device are limited to one precision and one nonprecision approach, provided the flight training device is approved for the procedure performed.

(b) ***Aeronautical knowledge.*** A person who applies for an instrument rating must have received and logged ground training from an authorized instructor or accomplished a home-study course on the following aeronautical knowledge areas that apply to the instrument rating sought:

(1) Federal Aviation Regulations of this chapter that apply to flight operations under IFR;

(2) Appropriate information that applies to flight operations under IFR in the "Aeronautical Information Manual;"

(3) Air traffic control system and procedures for instrument flight operations;

(4) IFR navigation and approaches by use of navigation systems;

(5) Use of IFR en route and instrument approach procedure charts;

(6) Procurement and use of aviation weather reports and forecasts and the elements of forecasting weather trends based on that information and personal observation of weather conditions;

(7) Safe and efficient operation of aircraft under instrument flight rules and conditions;

(8) Recognition of critical weather situations and windshear avoidance;

(9) Aeronautical decision making and judgment; and

(10) Crew resource management, including crew communication and coordination.

(c) ***Flight proficiency.*** A person who applies for an instrument rating must receive and log training from an authorized instructor in an aircraft, or in a full flight simulator or flight training device, in accordance with paragraph (g) of this section, that includes the following areas of operation:

(1) Preflight preparation;

(2) Preflight procedures;

(3) Air traffic control clearances and procedures;

(4) Flight by reference to instruments;

(5) Navigation systems;

(6) Instrument approach procedures;

(7) Emergency operations; and

(8) Postflight procedures.

(d) ***Aeronautical experience for the instrument-airplane rating.*** A person who applies for an instrument-airplane rating must have logged:

(1) Except as provided in paragraph (g) of this section, 50 hours of cross-country flight time as pilot in command, of which 10 hours must have been in an airplane; and

(2) Forty hours of actual or simulated instrument time in the areas of operation listed in paragraph (c) of this section, of which 15 hours must have been received from an authorized instructor who holds an instrument-airplane rating, and the instrument time includes:

(i) Three hours of instrument flight training from an authorized instructor in an airplane that is appropriate to the instrument-airplane rating within 2 calendar months before the date of the practical test; and

(ii) Instrument flight training on cross country flight procedures, including one cross country flight in an airplane with an authorized instructor, that is performed under instrument flight rules, when a flight plan has been filed with an air traffic control facility, and that involves—

(A) A flight of 250 nautical miles along airways or by directed routing from an air traffic control facility;

(B) An instrument approach at each airport; and

(C) Three different kinds of approaches with the use of navigation systems.

(g) An applicant for a combined private pilot certificate with an instrument rating may satisfy the cross-country flight time requirements of this section by crediting:

(1) For an instrument-airplane rating or an instrument-powered-lift rating, up to 45 hours of cross-country flight time performing the duties of pilot in command with an authorized instructor; or

(2) For an instrument-helicopter rating, up to 47 hours of cross-country flight time performing the duties of pilot in command with an authorized instructor.

(h) ***Use of full flight simulators or flight training devices.*** If the instrument time was provided by an authorized instructor in a full flight simulator or flight training device—

(1) A maximum of 30 hours may be performed in that full flight simulator or flight training device if the instrument time was completed in accordance with part 142 of this chapter; or

(2) A maximum of 20 hours may be performed in that full flight simulator or flight training device if the instrument time was not completed in accordance with part 142 of this chapter.

(i) ***Use of an aviation training device.*** A maximum of 10 hours of instrument time received in a basic aviation training device or a maximum of 20 hours of instrument time received in an advanced aviation training device may be credited for the instrument time requirements of this section if—

(1) The device is approved and authorized by the FAA;

(2) An authorized instructor provides the instrument time in the device; and

(3) The FAA approved the instrument training and instrument tasks performed in the device.

(j) Except as provided in paragraph (h)(1) of this section, a person may not credit more than 20 total hours of instrument time in a full flight simulator, flight training device, aviation training device, or a combination towards the instrument time requirements of this section.

Introduction to the Instrument Student and Flight Instructor

Minimalist Syllabus

This IFR flight training syllabus aims to provide the most straightforward yet comprehensive guide for both flight instructors and students. While many instrument flight training syllabi exist, they often fall into two categories: overly simplistic and unstructured, leaving one to wonder how anyone could earn an instrument rating, or excessively complex, requiring a prescription for migraine medication to navigate. These intricate syllabi are filled with every conceivable training element an instrument pilot might need (or not need), spread across numerous pages. Though created with good intentions, such intentions don't always result in effective training tools.

This syllabus, however, is designed as a *minimalist* IFR training guide. Minimalism here doesn't mean lacking essential content; rather, it means being devoid of unnecessary fluff. What I offer is a clear, concise path for instrument training. Each lesson is condensed to a single page for easy consumption and review. These lessons include training objectives, elements, completion standards, homework assignments, and commentary on the training philosophy—all on one page.

Is This a Glass-Panel or Analog-Instrument-Panel Syllabus?

Ultimately, flight instruments provide the same flight information (with some exceptions). This syllabus introduces a three-step instrument scan applicable to both glass and analog flight instruments. The scanning technique for analog and glass instruments is essentially the same, with the exception of using the glass panel's turn-trend-rate line to establish a specific rate of turn. While the altimeter and airspeed indicator on glass panels use tape lines, students will need to adapt to how this information is presented. This is part of the challenge of learning to fly with glass instruments. Therefore, instructors should not tell students that primary and secondary instruments differ on glass panels; that notion is simply not accurate.

What's Expected of Instrument Students

This syllabus does not cover the skills required to be a competent private pilot. It is reasonable to expect that properly trained private pilots know how to scan for traffic, land an airplane in a crosswind, and understand the concept of "attitude plus power equals performance," among other skills. However, not every student beginning instrument training is a competent private pilot. That's why the very first lesson in this syllabus (Lesson 0) involves a review of basic attitude flying skills (stick and rudder skills). If a students have difficulty with basic pitch/power/trim control, it is best for them to develop these VFR skills before continuing with instrument training.

What the First 25% of This Syllabus Covers

As soon as instructors and students begin using this syllabus, they will notice the emphasis placed on basic attitude flying skills. Understanding these basics is crucial before progressing to more advanced aspects of instrument training, such as flying instrument approaches. It is not uncommon to find instrument students with only three hours of instrument-scan training attempting instrument approaches. These students struggle for hours, making little progress. This struggle can be avoided if instructors follow this syllabus and ensure their students master the basics of pitch control, bank control, power control, and trim (PBP&T) training as outlined here. Mastery of the basics is paramount to success in learning to fly instruments. Period!

Instrument instructors must strive to keep their students motivated to learn PBP&T early in their training. They can achieve this by sharing examples from their own life experiences, demonstrating how skills acquired through hours of practice can lead to mastery. Examples such as playing a musical instrument, welding, or painting illustrate the need for practice to achieve proficiency. Instructors should relate their personal experiences that required extensive basic training to master. A good, relevant success story can be very motivating for students.

Flight Training and Ground Training

Each lesson allocates 1.5 hours for flight training. While ground instruction isn't explicitly listed in this syllabus, it's reasonable to assume that ground training time should at least equal flight training time. This does not include the homework that each student should complete before each lesson. Ground training for the lesson of the day is essential. This involves sitting down with the student, reviewing the previous homework assignment, and applying it to the upcoming lesson. Instructors will find that the recommended homework assignments for each lesson are designed to cover that lesson, but there are always additional topics that need to be addressed, such as specifics related to the airplane, the local instrument training environment, current weather conditions, and so on.

Homework Assignments

Each lesson specifies the homework for the upcoming lesson, and students are expected to complete these assignments beforehand. If a student fails to complete the homework, instructors should consider canceling the flight portion of the lesson to focus on the homework instead. Students should be prepared to pay for the instructor's time if assignments aren't completed in advance, which is why I rarely have issues with students neglecting their homework.

The homework assignments consist of specific chapters or module excerpts from either *Rod Machado's Instrument Pilot's Handbook* or *Rod Machado's 50-Hour Instrument Pilot's Ground School*. These resources go way beyond the ground knowledge to prepare the student for instrument training and the instrument pilot's knowledge exam. If the book is used exclusively to prepare for the knowledge exam, it's recommended to acquire one of the excellent test question guides available on the market today.

Choosing the Right Airplane for Instrument Training

Here is where things get interesting. Instrument students should focus on learning how to fly under instrument flight rules (IFR) in the national airspace system, not solely on mastering advanced avionics equipment. Yes, it's possible to do both simultaneously with sufficient time and money. The question is: Should IFR students opt for a simple (inexpensive to rent) airplane with analog flight instruments, VOR, and an IFR-certified GPS? Or should they dig deep into their wallets and rent an airplane with a glass cockpit featuring a primary flight display and a multifunction display?

Several factors should be considered. First, training in a technically advanced airplane may cost between $350 and $400 per lesson, including the cost of the instructor. If budget is a limiting factor, training in an older Cessna 172 or Piper Warrior with standard analog instruments and a simple IFR-certified, panel-mounted GPS is recommended. Once the instrument rating is obtained, investing in avionics training software and transitioning to a Technically Advanced Aircraft (TAA) becomes a relatively straightforward and less expensive process.

However, it's acknowledged that some instrument students may have learned to fly in a TAA. Therefore, earning an instrument rating in such an airplane should not present significant difficulty.

Simulators for Training (ATDs: AATD & BATD)

Most general aviation training today uses either Aviation Training Devices (ATDs) or Basic Aviation Training Devices (BATDs) in their IFR curriculums. Regulations permit up to 10 hours (or 20 hours for an Advanced Aviation Training Device, AATD) of the required 40-hour minimum instrument time for the instrument rating to be obtained using these devices. Examples of an AATD include the Redbird FMX or the Elite PI-1000.

Any AATD or BATD used must be approved by the FAA. Therefore, any off-the-shelf computer simulator hardware/software combination is likely not an AATD or BATD unless it is accompanied by an FAA letter of approval from the manufacturer. Generally, the manufacturer obtains this approval and includes it in the sales literature. If you are unsure whether an ATD is approved, contacting the manufacturer for clarification is advisable.

It’s also important to note that for any of these "simulated" hours (regardless of whether obtained in an FTD or ATD) to be counted, they must be conducted under the supervision of an authorized instructor. The instructor must log the time as "dual given" in either a BATD or AATD in the student’s logbook. This means that solo 2 a.m. PC flight sim sessions at home in bed while wearing bunny slippers and clip-on aviator wings are not possible. To avoid confusion regarding total times at a later date, it is recommended to create a separate column in the logbook labeled "ATD" time.

Why Are There No AATD/BATD Lessons in This Syllabus?

Except for the long IFR cross-country flight and the first three lessons (Lessons 0, 1, and 2), any lesson can be conducted in an AATD or BATD. Additionally, any lesson can be repeated in an AATD or BATD. Therefore, the choice of using an ATD or an airplane is at the discretion of the instrument instructor. Instructors may choose to utilize these devices when airplanes are unavailable for training or for other reasons. Holidays often result in rental airplanes being unavailable for several days, disrupting a student’s training schedule. It is also possible that the flight school’s simulator is quite old, requiring instructors to frequently tap on its vacuum tubes to keep it running. What fun is that?

There is strong advocacy for using simulators in IFR training. Therefore, students and instructors are encouraged to make use of them. As a general rule, most students benefit from at least five hours of ATD time in addition to the training times outlined in this syllabus.

Can Students Benefit From Having a Desktop Simulator Such as X-Plane or FS2024 at Home?

Absolutely! It’s hard for this author to express enough enthusiasm for using a desktop simulator at home for practice and review of each lesson. This is especially true at the beginning of these lessons, where the student is learning the basic technique of scanning. This technique involves placing small word-stickers (see Appendix-4, Page 4-10) under each instrument to help students identify the primary instruments associated with the desired flight condition. There’s no sense in learning this in the actual airplane when it can be easily learned in an office or at home.

Do students need rudder pedals with this desktop simulator? While it's nice if they are available, they aren’t necessary for this type of training. A simple joystick will suffice. Remember, the goal is not to learn how to fly but to learn how to scan instruments.

Either *Microsoft Flight Simulator* or *X-Plane* works well for home training. X-Plane 11 or 12 is easy to use and realistic enough to be beneficial.

What About the IFR Knowledge Exam?

If students can pass the IFR knowledge exam before they begin training, then all the better for them. Unlike the private pilot knowledge exam, students don’t benefit from having several hours in the airplane to make ground school material more relevant. This is why IFR students can easily pass the IFR knowledge exam without even having flown an instrument approach. This exam should at least be passed by the time the student flies the long IFR cross-country (Lesson 21).

How Much Instrument Dual Is Actually Needed for the IFR Rating?

While regulations state that 40 hours of instrument training time is necessary for the instrument rating, this is rarely the case in real life. Practically speaking, expect to spend between 45 and 55 hours of instrument training (airplane and AATD/BATD) before being ready for the checkride. If a student uses a desktop simulator to practice the relevant principles in each lesson, they will likely be ready for the IFR checkride closer to the 40-hour mark.

How Often Should Lessons Be Taken?

It is recommended that students train at least three times a week, with each lesson spaced by at least two days. This allows enough time to complete the homework between lessons. Two lessons per week are also acceptable, but this will extend the training time by a few hours.

Why No "Do-Demonstrate" Items Like Those Shown in the Private Pilot Syllabus?

The instrument student already knows how to fly, and instrument training is primarily accomplished by the instructor's verbal commands rather than by demonstrating maneuvers. Therefore, there's no need to instruct the instructor on how to demonstrate maneuvers for the student.

How Should the Instrument Airplane ACS Be Integrated With This Syllabus?

It is absolutely essential that both the instrument instructor and student understand and use the *Airman Certification Standards* (ACS) alongside this syllabus. While specific ACS items are not referenced for each lesson, relevant areas of operation are noted. Each area of operation is introduced at the appropriate point in the syllabus. Instructors should ensure students have their own personal copy of the Instrument Airplane ACS, which can be downloaded from the FAA website, from the moment they start training

Hey, Where Are the Phase Checks?

Many training syllabi use *phase checks* to provide instructors with valuable feedback and keep students informed of their progress. However, many instructors elect not to offer phase checks for any number of reasons. Therefore, if you wish to add phase checks at any point in this syllabus, please do. It's your syllabus to use as you see fit.

Recommended Study Materials

Rod Machado's Instrument Pilot's Handbook (book or ebook—or optional *Audiobook*), or

Rod Machado's 50-hour Instrument Pilots eGround School

Rod Machado's How to Fly an Airplane Handbook (book or ebook)—or optional *Audiobook*

IFR enroute and approach charts for your area or a flight planning program for your iThingy (tablet)

Airmen Certification Standards (the newer version of the *Practical Test Standards*)

AIM – Aeronautical Information Manual (get combo FAR and AIM if possible)

FS X/2022/2024 or X-Plane 11/12 with a joystick (rudder pedals optional)

Rod Machado's Web Site: www.rodmachado.com
Contact Rod via the contact page on his website.

For those who are interested in using any of the eLearning courses shown above to prepare for their instrument rating, please examine the eLearning Course Demos shown below:

1. Rod Machado's 40-hour Private Pilot eCourse Demo
2. Rod Machado's 50-hour Instrument eCourse Demo
3. Rod Machado's How to Fly an Airplane eCourse

Lesson 0: VFR Review of Attitude Flying (1.5 Hrs.)

Lesson Objective: To introduce the beginning instrument student to the basics of attitude flying and ensure that the student has the basic VFR flying skills necessary to succeed at instrument flying.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

Introduce concept: Attitude + Power = Performance (A+P=P)

Introduce how major attitude changes are made: Select attitude, then power, then trim (A, P, T)

Emphasize how the airplane's "attitude" is primary for all major attitude changes and relate this to the airplane's AI

Climb demonstration and practice:

- Demonstrate sequence: *attitude, power, trim* for entering and establishing a climb
- Demonstrate proper trim technique when established in a climb
- Student practices entering, establishing, and trimming in a climb

Descending demonstration and practice:

- Demonstrate sequence: *attitude, power, trim* for entering and establishing a descent
- Demonstrate proper trim technique when established in a descent
- Student practices (visually) entering, establishing, and trimming in a descent

Transitioning to level flight from either a climb, descent or turning flight

- Demonstrate sequence: *attitude, power, trim* for entering and establishing level flight
- Demonstrate proper trim technique when establishing level flight
- Student practices (visually) entering, establishing, and trimming level flight

> **HOMEWORK FOR NEXT LESSON**
> Pre-lesson Homework Assignment
> *Rod Machado's Instrument Pilot's Handbook*, Read:
> **Chapter-2** Your Flight Instruments (Pages 2-1 through 2-34)
> **Chapter-3** A Plan for the Scan (Pages 3-1 through 3-12)
> *Or study:*
> *Rod Machado's Instrument Pilot's eGround School*
> **Your Flight Instruments,** Parts 1
> **A Plan for the Scan,** Part-1, Sections 1 through 3

Turning demonstration and practice:

- Demonstrate sequence: *attitude, power, trim* for entering and establishing a 15° banked turn
- Demonstrate proper trim technique when established in a 15° banked turn
- Student practices (visually) entering, establishing, and trimming in a 15° banked turn

Climbing turn demonstration and practice:

- Demonstrate sequence: *attitude, power, trim* for entering and establishing a 15° banked climbing turn
- Demonstrate proper trim technique when established in a 15° banked climbing turn
- Student practices (visually) entering, establishing, and trimming in a 15° banked climbing turn

Descending turn demonstration and practice:

- Demonstrate sequence: *attitude, power, trim* for entering and establishing a 15° banked descending turn
- Demonstrate proper trim technique when established in a 15° banked descending turn
- Student practices (visually) entering, establishing, and trimming in a 15° banked descending turn

Completion Standards: The student should understand the steps necessary for making any major attitude change. Students should understand how assessing the airplane's attitude (viewed through the windscreen and other windows) is fundamental for airplane control. Skill at manually trimming the airplane to maintain any desired attitude after an attitude or power change is expected here. Correct any deficiencies in *stick and rudder* skills before proceeding to the next lesson.

> **LESSON PHILOSOPHY**
> - It's imperative that you ensure all new instrument students have a good understanding of basic stick and rudder skills. This includes the concept of *attitude flying*. Do not assume that holding a private pilot certificate implies even a basic understanding of these principles. That's why this first lesson (Lesson 0) involves a review of basic flying skills.
> - The single most important focus for this lesson is to instill the cadence "Attitude, power, trim" when making any MAJOR ATTITUDE CHANGE. This just happens to be the first step of the three-step instrument scan technique I'll teach later.
> - All trimming should be done manually, not with the electric trim! The latter takes too long and diminishes the feel of the airplane. Period!
> - If you or your instrument student need a good foundation for basic flying skills, then I recommend obtaining a copy of my "*Rod Machado's How to Fly an Airplane Handbook*." There's a wealth of essential information in this book that's valuable for all beginning IFR students.

Lesson 1: Introduction to Attitude Instrument Flying: The Attitude Indicator (1.5 Hrs.) T^T-1.5

Lesson Objective: To introduce the beginning instrument student to six basic flight instruments and establish the primacy of the attitude indicator (AI) for instrument flying. All major attitude changes begin with the AI, followed by scanning the primary instruments for the desired flight condition. From now on, a view-limiting device will be used in all lessons.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Review *ACS* Operation I, *Preflight Preparation*, Task A/ Review *ACS* Operation I, *Instrument Flight Deck Check*, Task C

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

Demonstrate AC control solely by reference to AI (cover all other pitch/bank instruments)

- Emphasize this sequence for a major attitude change (Step-1 of the 3-Step scan): attitude, power, & trim
- Climb, turn, level off, and descend, on AI all by pitch/power changes only
- Apply rough manual trim change to maintain desired attitude
- Use three general power settings (climb power, cruise power, approach descent power) as appropriate
- Use 15° of bank for turns, climbing turns, & descending turns.
- Practice until the student can precisely select and maintain the desired attitude on the AI

HOMEWORK FOR NEXT LESSON

<u>*Rod Machado's Instrument Pilot's Handbook*, Read:</u>

Chapter-2 Your Flight Instruments (Pages 2-34 through 2-58)

Chapter-3 A Plan for the Scan (Pages 3-13 through 3-21)

Chapter-4 The Human Brain (Pages 4-1 through 4-18)

Or study:

<u>*Rod Machado's Instrument Pilot's eGround School*</u>

Your Flight Instruments, Part 2

A Plan for the Scan, Part-1, Sections 4 through 7

The Human Brain, Part-1, Sections 1 through 3

Introduction to radial scanning primary instruments in this order (emphasis on pitch control)

Airspeed indicator (AI uncovered/uncover ASI)

- Introduction to the *Radial-Spoke* method to scan ASI
- Student climbs, levels off, descends, and turns using AI to radial scan ASI (other four primary instruments covered)

Altimeter (AI uncovered/cover ASI and uncover Altimeter) Use altitude bug as altitude reference if using PFD.

- Student radial scans the altimeter to maintain level flight
- Student turns right and left (15° of bank on AI) holding altitude

Vertical speed indicator (AI uncovered/cover ASI/ALT and uncover VSI)

- Student radial scans the VSI to maintain level flight
- Student turns right and left (15° of bank) while maintaining zero rate of climb/descent

Heading indicator (AI uncovered/cover VSI and uncover heading indicator)

- Student radial scans heading indicator to maintain straight flight
- Student turns to different headings, rolls out, then maintains those headings

Turn coordinator (AI uncovered/cover DG and uncover turn coordinator)

- Student radial scans turn coordinator indicator to maintain standard rate turn
- Student turns to different headings, rolls out, then maintains those headings

Attitude indicator errors (all instruments uncovered)

- Demonstrate 180°/360° turning error (gyro instrument only)
- Demonstrate acceleration/deceleration error (gyro instrument only)
- Demonstrate skidding error (gyro instrument only)

Simulate radar vectors for return to airport traffic pattern with Foggles/hood on (vectors to VFR final approach if possible)

LESSON PHILOSOPHY

- Your sole objective in this lesson is to establish the value of the AI when making any major attitude change. If your students don't grasp this idea, then repeat this lesson until they do. This is absolutely essential.
- Ensure that the AI's miniature airplane rests directly over the horizon bar when the airplane's established in unaccelerated, level flight before beginning this lesson. Adjust if necessary.
- It's important that the student learns to move from the AI to the primary instrument, decide what correction is needed to make this instrument read as desired, then return to the AI and make the appropriate correction.
- Use *Post Its* to cover tape instruments on a PFD and always place the altimeter bug to identify the target altitude (makes it easier to identify this altitude).
- You must constantly reinforce the cadence, "attitude, power, trim" when making attitude changes.
- Introduce half-bar corrections on AI to correct for small variations in primary instrument indications.
- You (the instructor) must read pages 4-1 through 4-28 titled, *How to Scan Your Instruments* In Appendix-4 of this syllabus. It tells you all about the 3-Step scan.

Completion Standards: By the end of this lesson, the student should understand the importance of the attitude indicator as the starting point (the hub of the hub-spoke scan process) for making any major attitude change as well as recognizing and using the primary instruments as the end-points on the hub-spoke method of instrument scanning.

Lesson 2: Introduction to Attitude Instrument Flying: Pitch Control and Trim (1.5 Hrs.) T^T-3.0

Lesson Objective: To introduce the 3-step instrument scan and the proper sequence for making any major attitude change. Emphasis is placed on pitch control and trim usage. Pitch and power settings are established (and recorded) for climbs, cruise, and descents for the training airplane. All flight instruments are available to the student during this lesson.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Review *ACS* Operation II, *Preflight Procedures*, Tasks A and C

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

Full panel introduction to the 3-step scan for major attitude changes:

- Step-1 (select: attitude, power, & trim)
- Step-2 (radial scan the primary instruments)
- Step-3 (final trim, then circular scan the 6-main flight-control instruments)

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-3 A Plan for the Scan (Pages 3-21 through 3-28)

Chapter-4 The Human Brain (Pages 4-8 through 4-40)

Or study:

Rod Machado's Instrument Pilot's eGround School

A Plan for the Scan, Part-2 Sections 1, 2, 3

The Human Brain, Part-1, Section 4

The Human Brain, Part-2

Straight and level flight (transition to S&L then do the following)

- Trim usage introduction (teach *manual* not *electric* trim)
- Demonstrate how to trim (sequence: elevator, rudder, aileron)
- Demonstrate hands-off trim usage and use of rudder pressure to control the airplane when hands are busy

Airspeed changes in level flight (attitude, power, trim)

- Change from normal cruise speed to below Vlo (or Vfe for non-retractable aircraft) then to fast cruise (repeat)

Standard rate turns (attitude, power, but no trim necessary during normal turns). Lead rollouts by half the AI bank angle

Constant airspeed climbs (attitude, power, trim)

Leveling off from a climb (attitude, power, trim). Lead level-off by 50' for most general aviation aircraft

Establish pitch/power settings for the following:

- Cruise climb (Airspeed_____, Pitch____°, Power (RPM_____ MP_____)
- Best rate of climb (Airspeed_____, Pitch____°, Power (RPM_____ MP_____)
- Best angle of climb (Airspeed_____, Pitch____°, Power (RPM_____ MP_____)
- Slow cruise (Airspeed_____, Pitch____°, Power (RPM_____ MP_____)
- Fast cruise (Airspeed_____, Pitch____°, Power (RPM_____ MP_____)

Constant airspeed descents (attitude, power, trim)

Establish pitch/power settings for the following:

- Descent at cruise speed (gear up) (Airspeed_____, Pitch____°, Power (RPM_____ MP_____)
- Descent in terminal environment (gear up) (Airspeed_____, Pitch____°, Power (RPM_____ MP_____)
- Descent at approach speed (gear down) (Airspeed_____, Pitch____°, Power (RPM_____ MP_____)

Leveling off from descents (attitude, power, trim). Lead level-off by 50' for GA aircraft

Simulate radar vectors for return to the airport traffic pattern with students wearing their view-limiting device

Completion Standards: Students should clearly understand step-1 (attitude, power, and trim) of the 3-step instrument scan and be able to apply that to any desired attitude change. Familiarity with step-2 and step-3 of the scan should be achieved by the end of this lesson along with documenting the airspeed, pitch, and power settings for the most common flight conditions.

LESSON PHILOSOPHY

- Step-1 of the scan has a cadence of three items (attitude, power & trim). Don't confuse this with the three-step scan. Two different things.
- To help identify primary instruments, mark them as I show in Appendix 4 at the end of this syllabus.
- Students should use their flight simulator to practice all maneuvers covered in each lesson. Any desktop simulator using Microsoft FS or X-Plane 11/12 works just fine. A joystick with a small throttle will also work well here.
- When entering a climb, it's best to begin with the attitude change, followed by the addition of power (this prevents prop overspeed).
- When entering a descent, the best approach is to slow the airplane in level flight until reaching the desired descent speed, then further reduce power for the desired descent rate. I'm not a fanatic about this. It's OK to reduce throttle, select the descent attitude, then trim.
- The instructor should decide on the appropriate airspeed needed for cruise speed, terminal speed, and approach speed.
- Unless otherwise noted, the moving map display should not be available to the student here. Cover it or disable it if possible.

Lesson 3: Pitch Control, Bank Control, and Trim (1.5 Hrs.) T^T-4.5

Lesson Objective: To further develop the student's ability to control the airplane on instruments with the added tasks of turning, climbing turns, and descending turns, emphasizing the use of the AI during all major attitude changes. Emphasis is placed on pitch control and bank control while entering climbs, descents, turns, and level flight. Step 1 of the three-step scan (attitude, power, then trim) is emphasized in this lesson; steps 2 & 3 are re-introduced. The concept of the pitch and bank triangles of agreement and the inverted "V" scan to evaluate the correct operation of the AI are also introduced.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)/Review *ACS* Operation II, *Preflight Procedures*, Task B

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

Emphasis on radial (hub-spoke) method of airplane control on instruments

Emphasis on use of the primary instruments as previously marked on the instrument panel with tape (see Appendix-4)

Reinforce Step-1 of the instrument scan for all flight maneuvers (select: attitude, select power, then trim)

Practice: Straight and level flight

- Emphasize primary instruments for straight and level (ALT-Pitch, DG-Bank, ASI/RPM-power)
- Half-bar and full-bar AI corrections for slight altitude adjustments turning flight
- Entering, sustaining, and exiting turns
- Standard rate turns
- Airspeed change while turning
- Timed turns to a heading using TC (lead by half AI bank rate)

Introduce the inverted "V" pyramid AI accuracy check (See "*" below.)

Steep turns (45° of bank) are introduced here

- Trim control while turning for steep turns only (only if necessary)

Introduce and practice the following maneuvers:

- Constant airspeed climbs & climbing turns (Step-1, 2 and 3 of the 3-step scan are used here)
- Leveling off from a climb & climbing turns (Step-1, 2 and 3 of the 3-step scan are used here)
- Constant airspeed descents & descending turns (Step-1, 2 and 3 of the 3-step scan are used here)
- Leveling off from descents & descending turns (Step-1, 2 and 3 of the 3-step scan are used here)
- Airspeed change in level flight, in climbs, and in descents (Step-1, 2 and 3 of the 3-step scan are used here)

Fly Pattern-A (See Appendix-2)

Basic instrument approach (i.e., VOR approach) return to airport if possible

HOMEWORK FOR NEXT LESSON

<u>*Rod Machado's Instrument Pilot's Handbook*, Read:</u>

Chapter-3 A Plan for the Scan (Pages 3-28 through 3-34)

Chapter-8 FAR Part-61 (Pages 8-1 through 8-8)

Or study:

Rod Machado's Instrument Pilot's Handbook, Read:

A Plan for the Scan, Part-2, Sections 4 through 9

FARs Part-61 (Part-1)

Completion Standards: Students should understand the purpose of the primary instruments and be able to apply the 3-step instrument scan sequence when making any major flight attitude change. Additionally, students should deepen their understanding of A+P=P (Step-1 of the 3-step scan) and know how to confirm the correct operation of the attitude indicator using the inverted "V" instruments.

LESSON PHILOSOPHY

- One of the most common problems with instrument flight training occurs when instructors attempt to rush students through the initial stages of training. If students do not understand attitude flying basics well, they'll have great difficulty flying approaches later in their training. The first few lessons here are fundamental but very important. It's your job to motivate your students to learn this material well. These basic skills must become reflexive if they're going to be useful later on.
- When rolling out from any turn, don't focus on the heading indicator during the rollout. Instead, when reaching the desired heading lead on the DG, focus on the AI, returning the airplane to level flight attitude. If the lead you're using doesn't work for you, then change the lead.
- *Since the AI is emphasized here, it's important to know how to check and ensure it is giving you accurate information. The inverted "V" *analog* instruments offer both pitch (VSI) and bank (turn coordinator) information and operate on separate power systems (i.e., gyro [AI], atmospheric [VSI] and electric [TC]). A quick check of all three instruments should show no conflict between all three instruments. Anytime the AI is suspect of being in error, check the inverted "V" instruments.
- When the primary pitch/bank instruments are off by less than 100 feet or 5 degrees of heading, use half-bar or 5-degree bank corrections (respectively) to return to the primary instruments to the desired reading. Major attitude changes are not necessary in these instances.
- Pattern-A is introduced here. This is a very basic pattern that helps students divide their attention between the instrument panel and the directions that they'll eventually have to follow on an approach chart. Introduce Pattern-A at the end of the lesson and have the student fly it one time as an introduction. Some instructor assistance might be necessary in helping the student fly this practice pattern.

Lesson 4: Pitch Control, Bank Control, Power Control, and Trim (1.5 Hrs.) T^{T}-6.0

Lesson Objective: To further develop skill at the 3-step (hub-spoke) method of instrument scanning. The intent is to refine the student's ability to reflexively identify and use the primary instruments to maintain any desired flight condition, then use Step-2 and Step-3 of the scan to establish and maintain the desired flight condition. At the end of this lesson the instructor introduces two different practice patterns to help develop the student's skill at instrument scanning and planning while experiencing the distraction of following printed commands of the practice pattern.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Review *ACS* Operation IV, *Flight by reference to Instruments*, Task A

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

Emphasis on radial (hub)-Spoke method of airplane control on instruments

Emphasis on the use of primary instruments as previously marked on the airplane's instrument panel with tape

Introduce the philosophy of *Attitude + Power = Performance* for all flight maneuvers

Practice 3-Step scan on the following maneuvers:

- Straight and level flight
- Turns (standard rate turns and steep turns)
- Constant airspeed climbs
- Constant airspeed climbing turns
- Leveling off from a straight climb
- Leveling off from a climbing turn into a level turn
- Constant airspeed descents
- Constant airspeed descending turns
- Leveling off from a straight descent
- Leveling off from descending turns
- Airspeed change in level flight (change airspeed by +/- 10 & 20 knots)
- Airspeed change in a climb (change airspeed by +/- 10 & 20 knots)
- Airspeed change in a descent (change airspeed by +/- 10 & 20 knots)

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-8 FAR Part-91 (Pages 8-8 through 8-14)

Chapter-7 How the IFR System Works (Pages 7-1 through 7-15)

Or study:

Rod Machado's Instrument Pilot's eGround School

FARs Part 91 (Part-2), Sections 1 through 5

Understanding the IFR System (Sections 1.1 through 1.15)

Practice exercises:

- Practice Pattern B (Appendix-2)
- Vertical-S Pattern C (Appendix-2)

Basic instrument approach (i.e., VOR approach) return to airport if possible

Completion Standards: Students should be proficient at identifying and using the AI, primary instruments, and trim to make and sustain climbs, descents, turns, or any combination thereof. This skill is further refined when using the basic practice patterns introduced at the end of this lesson.

LESSON PHILOSOPHY

- Don't for one second think that this syllabus spends too much time on the basics of instrument flight. Frankly, the first six lessons should be entirely spent on making and sustaining straight and level flight, climbs, turns, and descents (or any combination of these). Attitude flying deficiencies are almost always the reasons students struggle with instrument approaches later in their training. Don't lest this happen.
- Here's a good place to remind your student that, "Slow is smooth and smooth is fast." You don't have to rush any major attitude change but you shouldn't dally when making these changes either.
- Introduce Pattern B and Vertical-S Pattern C near the end of this lesson. Pattern B first, then Pattern C. I can't quite express how important these patterns are in helping students translate written/symbolic commands into pilot/airplane actions. After all, this is exactly what an instrument approach chart does, right? Students that can easily fly these patterns have much, much less difficulty learning to fly instrument approaches. Some instructor assistance might be necessary in helping the student fly both practice patterns.
- Airspeed changes in level flight are accomplished by power changes. Remember, the ASI is the primary power instrument in level flight when a specific airspeed is desired. Airspeed changes in a climb or a descent (where a constant rate isn't required) assumes power is fixed. Therefore, these airspeed changes are accomplished with a change in pitch attitude.
- How should a student handle working a tablet device, charts, or avionics equipment at one time with only two hands? Here's how. Teach them to control the airplane's heading with the rudder while the hands are busy. Properly trimmed airplanes won't deviate quickly from the attitude selected. If the airplane begins to climb, push a bit of rudder to start a small turn and the nose will descend. If the nose begins to descend, nudge the yoke aft just a bit. Work those rudders when hands are occupied.

Lesson 5: Slow flight/Stalls/Constant Airspeed & Rate Climbs & Descents (1.5 Hrs.) T^T-7.5

Lesson Objective: To introduce the student to constant-rate descents and climbs, slow flight, and basic stall recovery under instrument conditions. During this lesson and following lessons, students are introduced to filing an IFR flight plan with the AFSS for VFR-ONTOP conditions (file to a local intersection and use the letters "OTP" in flight plan Block 15). Two additional and more challenging practice patterns are introduced to prepare the student for eventually flying instrument approaches.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Review *ACS* Operation III, *Compliance With Air Traffic Control Clearances*, Task A

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

IFR Departure checklist

File for and fly an IFR to VFR on top departure (do so even if VFR conditions are present at the airport)

Emphasis on all three steps of the three-step instrument scan for all major attitude changes

Constant airspeed/rate maneuvers

- Constant rate descents at a constant airspeed (use 500 fpm here)
- Constant rate climbs at whatever airspeed is needed to establish the desired rate (constant climb power assumed)
- Throttle-elevator-trim coordination during constant rate descents

Slow flight

- Entering slow flight
- Throttle-elevator-trim coordination*
- Exiting slow flight to normal cruise
- Climbing in slow flight
- Climbing slow flight turns
- Descending in slow flight
- Descending slow flight turns to a heading

Power-off stalls

- Power-off imminent/full stalls while holding a heading
- Power-off imminent/full stalls while turning

Power-on stalls (65% power max)

- Power-on imminent/full stalls while holding a heading
- Power-on imminent/full stalls while turning

Practice Pattern D (Appendix-2)

Vertical-S Pattern E (Appendix-2)

Basic instrument approach (i.e., VOR approach) return to airport if possible

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-8 FAR Part-91 (Pages 8-14 through 8-22)

Chapter-7 How the IFR System Works (Pages 7-15 through 7-20)

Or study:

Rod Machado's Instrument Pilot's eGround School

FARs Part-91 (Part-2), Sections 6 through 12

Understanding the IFR System (Sections 1.15 through 1.21)

Completion Standards: The students should be able to select and maintain a desired descent rate at a specified airspeed. With each introduction, the student should perform better on any practice patterns, ultimately flying these patterns without the assistance or intervention of the instructor. Slow flight and basic stalls shouldn't be entirely unfamiliar to instrument students given their private pilot certification and assumption of skill at basic VFR flight maneuvering. If this awareness is missing, IFR students should be reintroduced to these maneuvers in VFR conditions on a separate, independent non-IFR lesson.

LESSON PHILOSOPHY

- *Constant rate descents at a specific airspeed are essential for flying approaches having glideslopes or glidepaths. The coordination of throttle and elevator are essential in maintaining the desired airspeed and rate during the descent. You can use any technique for throttle/elevator control when flying VFR. However, it's recommended that you use the elevator to control the rate of descent and the throttle to control the airspeed here. Why? Because the VSI is the primary pitch instrument and the airspeed is the primary power instrument when making constant rate descents. Constant rate climbs are done at fixed (climb) power settings.
- Practice Patterns D and E have an added layer of complexity to help develop the student's scanning ability.
- Slow flight should be accomplished at the speed recommended in the instrument pilot ACS.

Lesson 6: Compass Turns, Unusual Attitudes, and Steep Turns (1.5 Hrs.) T^T-9.0

Lesson Objective: To control the airplane on instruments under partial panel conditions (needle, ball, and airspeed). To develop skills in using the compass for heading information, understanding compass errors, and understanding how the compass makes up part of the turn triangle of agreement. Unusual attitude recoveries are introduced. By this point the student should demonstrate the ability to fly any practice patterns unassisted by the instructor.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Review *ACS* Operation IV*, Flight by Reference to Instruments/Recovery from Unusual Attitudes*, Task B

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

IFR Departure checklist

Instrument takeoff

IFR/VFR on top departure

Compass turns (cover heading indicator)

- Acceleration/deceleration errors
- North/south turning errors

Introduce the *bank triangle of agreement*

Introduce the *pitch triangle of agreement*

Timed turns to headings

- Use a stopwatch or sweep second hand (clock)

Partial Panel (needle, ball, and airspeed)

- Straight & level
- Climbs
- Turns

Review constant airspeed descents (full panel)

Review constant rate descents (full panel)

Review airspeed changes (full panel)

Unusual attitude entries and recoveries

- Induce spatial disorientation (see Appendix-3 to learn how to induce vertigo)
- Descending unusual attitude recovery (with/without the use of AI)
- Climbing unusual attitude recovery (with/without the use of AI)

Recognizing and recovering from descending (graveyard) spirals

Practice Pattern D (Appendix-2)

Vertical-S Pattern E (Appendix-2)

Basic instrument approach (i.e., VOR approach) return to airport if possible

Completion Standards: Students should demonstrate basic competency at compass turns, partial panel flying, and unusual attitude recoveries. They should also clearly understand the relationship between standard rate turns and timed turns to a heading. At the end of this lesson, errors in pitch/bank instruments should be easily resolvable.

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-5 Electronic Navigation (Pages 5-1 through 5-28)

Or study:

Rod Machado's Instrument Pilot's eGround School

Electronic Navigation (Part-1), Sections 1 through 7

Electronic Navigation (Part-2), Sections 1.1 through 1.6

LESSON PHILOSOPHY

- Make it a point to have your students inform you if and when they are experiencing spatial disorientation (vertigo). You want to know this so you can verbally guide your students to "trust their instruments." Don't ever let an opportunity to do this slip by. The latter part of this lesson introduces unusual attitudes. Here, you'll purposely attempt to give your students vertigo and, if necessary, talk them through the recovery, all the while cueing them to "trust their instruments." (See Appendix-3 to learn how to induce vertigo.)
- The "graveyard spiral" can occur in approach configuration where the airplane is trimmed for approach speed and the airplane accidentally enters a turn. Unanticipated turning allows the nose to initially drop, steepening the bank which increases the airspeed, and tightening the turn (wash, rinse and repeat). Recovery begins with reducing power and leveling the wings.

Lesson 7: Electronic Navigation Using VOR (1.5 Hrs.) T^{T}-10.5

Lesson Objective: This lesson reviews (or reintroduces) the basics of VOR navigation including course interception, tracking, bracketing, etc. A basic understanding of DME arcs (interception and tracking) is expected during this lesson. Localizer interception, tracking, and bracketing are also introduced here, although the emphasis of this lesson is on VOR navigation. VOR navigation is accomplished using the full panel and partial panel so as to bolster skill at the latter. A basic understanding of the autopilot is expected here (if the airplane is autopilot-equipped). The moving map, if available, is disabled/covered.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Review *ACS* Operation V, *Navigation Systems*, Task A

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

IFR/VFR on top departure

Instrument takeoff

IFR Departure checklist

Navaid selection for VOR, LOC, DME (or NBD, if ADF used)

Identify the frequency of any Nav station being used

- Verbal frequency checklist (see it, say it, check it)
- Identify station (Morse code, if applicable)

VOR orientation (moving map—disabled or covered)

- Course/radial interception
- Course/radial tracking
- Bracketing

Localizer orientation/tracking

- Course interception
- Course tracking

DME arc orientation

- Interception
- Tracking

NDB orientation (Use G1000 PFD/RMI if not ADF equipped)

- Bearing interception
- Bearing tracking

Partial panel (or PFD backup instruments) VOR course intercept and track

Introduction and basic use of the autopilot (if equipped)

- Heading hold
- Altitude hold

Practice Pattern F-1 (Appendix-2)

Basic instrument approach (i.e., VOR approach) return to airport if possible

Completion Standards: Students should demonstrate a reasonable level of skill at VOR navigation, including course interception, tracking, and bracketing. Students should be able to orient themselves to a VOR station/course, immediately knowing the airplane's relation to selected courses and the heading needed for course interception (all without the use of any moving map display). Basic skill at using the autopilot is also assumed at the end of this lesson.

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-5 Electronic Navigation (Pages 8-28 through 8-50)

Or study:

Rod Machado's Instrument Pilot's eGround School

Electronic Navigation (Part-2) Sections 1.7 through 6.1

LESSON PHILOSOPHY

- It's assumed that instrument students understand the basics of using VOR for navigation. However, VOR navigation while on instruments is more challenging. Mental orientation (i.e., the ability to visualize this) to the VOR and the selected course is absolutely essential if a student is going to have any success at flying instrument approaches. The use of the moving map at this stage in the student's training hinders rather than helps his or her development. So, no moving map on this lesson.
- While NDB approaches are not very common, they still exist in the airspace system. Intercepting and tracking an NDB bearing is an essential IFR skill. If students haven't acquired this skill, read Appendix-6, which covers the essentials of ADF navigation.
- This lesson is a great place to introduce verbal checklists. Appendix-5 identifies several verbal checklists that all IFR students should memorize and use. In particular, one checklist has the instructor tapping the student on the shoulder and asking, "What are the next two things?" This should cue students to consider the next two things they must do for the operation being performed.
- The most effective method of bracketing any course doesn't involve the heading indicator (once the course has been intercepted). Instead, upon interception, you watch the needle's movement. If the VOR or LOC needle moves, you quickly roll into and out of a 10-degree bank (that's it). If the needle then moves a little in the opposite direction, you roll into and out of a 5-degree bank in the opposite direction. Trying to change headings a few degrees on the DG is very challenging. Try it this way and see what happens. Also, watch my Bracketing Video on YouTube for more details.
- At this point, all students should have some effective means of organizing their EFB (electronic flight bag). This can be something as basic as a lapboard with current charts, writing paper, clips, and a timing device (OK, it's not electronic). Or, students might have a tablet device that attaches to a local cockpit structure or the upper thigh.
- It's very important that students know the Nav source generating DME readings. Some airplanes have DME built into the VOR unit. Some airplanes have separate DME units that must be tuned separately from the VOR. Know your equipment.

Lesson 8: Electronic Navigation Using GPS (1.5 Hrs.) T^T-12.0

Lesson Objective: To understand and use the GPS for course selection, interception, and tracking. Course selection, interception, and tracking also apply to GPS-generated DME arcs. Familiarity with the autopilot's nav functions is expected here, and basic skills are developed for intercepting and tracking desired courses. Understanding the moving map display's use and limitations as it pertains to situational awareness is expected.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)/ Review *ACS* Operation V, *Navigation Systems*, Task A

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

IFR/VFR on top departure

IFR Departure checklist

Introduction to moving map display (if available)

GPS Waypoint selection/creation input

- Identify GPS input (see it, say it, check it)

Waypoint input/creation confirmation (see it, say it, check it)

GPS CDI/moving map orientation

GPS course selection

GPS course interception

GPS course tracking

GPS DME arc interception and tracking

Further introduction and basic use of the autopilot (if available)

- Nav interception
- Nav track
- Flight director use
- VNAV (introduction, show and tell)

Practice Pattern G (Appendix-2)

Demonstrate GPS approach on return to home airport

Review *ACS* Operation VIII, *Checking Instruments and Equipment*, Task A

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-6 Holding Patterns, Pages 6-1 through 6-16

Chapter-8 FAR Part-91/830 Pages 8-37 through 8-48

Or study:

Rod Machado's Instrument Pilot's eGround School

Holding Patterns (All)

FARs Part-91/830 (Part-4), All

Completion Standards: Students should be able to use the basic functions of the panel-mounted GPS unit. This includes selecting, intercepting, and tracking any GPS-defined course. The use of the autopilot in accomplishing the former is also expected.

LESSON PHILOSOPHY

- There are several popular panel-mounted GPS units installed in airplanes today. Should students select an airplane having an IFR-certified GPS-panel-mounted unit. The particular model of GPS unit should be one that they stick with for the remainder of their training. It doesn't make sense to switch from a Garmin GTN750 on one lesson to a G1000 the next. This only complicates flight training.
- Why are we now using the moving map display (if available)? Previously, it was necessary for students to develop and learn to rely on abstract thinking to help them remain oriented when using VORs for navigation. Given the ability to use a moving map display to help develop and maintain situational awareness it's only reasonable to ensure the student learns to use this technology. This is a good point to introduce and use it. However, a few of the following lessons will restrict the use of the moving map for educational purposes.

Lesson 9: Holding Patterns: Part-1 (1.5 Hrs.) T^T-13.5

Lesson Objective: The student will acquire basic skills at plotting, executing, and managing VOR and VOR/DME generated holding patterns without using the moving map display. The student will demonstrate the ability to identify, draw (plot), navigate to, and enter holding patterns using recommended entry methods. This includes basic skills and an understanding of holding pattern wind correction and the use of the 6Ts for holding pattern timing.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Review *ACS* Operation III, *Air Traffic Control (ATC) Clearances and Procedures*, Tasks A and B

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

IFR/VFR on top departure

IFR Departure checklist

Holding pattern (use dual VORs or VOR/DME)

Simulate ATC holding instructions

Identifying the hold (standard/non-standard patterns)

Drawing or visualizing the holding pattern

Navigating to the holding fix (dual VORs or VOR/DME)

Entering the holding pattern

- Direct entry
- Parallel entry
- Teardrop entry
- Use of holding pattern orienter (see Pages 6-12 of *Rod Machado's Instrument Pilot's Handbook*)

Outbound leg timing

Introduction to 6Ts when holding

Wind correction for holding patterns

Holding at VOR stations

Return instrument approach to home airport (instructor's choice)

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-11 Understanding Approach Charts, Pages 11-1 through 11-17

Or study:

Rod Machado's Instrument Pilot's eGround School

How Approach Charts Are Built, Sections 1.1 through 1.13

Completion Standards: Students will accurately interpret and execute ATC instructions (or those given by an instructor simulating ATC), identify, draw, or visualize the holding pattern, and navigate to the holding fix. They will demonstrate basic skills and understanding of direct, parallel, and teardrop entry procedures, precise outbound leg timing, wind correction, and effective use of the 6Ts when holding.

LESSON PHILOSOPHY

- The moving map display is not used for this lesson. Students need to rely on their cranial lobes to visualize the holding pattern and devise strategies for visualizing, navigating to, entering, and establishing the hold.
- Holding patterns are challenging for students since holding keeps an airplane in one location (which is antithetical to what airplanes like to do). This requires the ability to visualize the airplane's position in space in relation to navigation signals. I've never had a student master holding patterns in less than two lessons on the subject. Three lessons on the subject are not unusual. It's reasonable to say that if IFR students don't master holding, they'll never master instrument approaches. This is why you want to ensure the student learns this lesson well. The skills acquired here lead directly to flying instrument approaches.
- ATC offers many services, but there's one that too few instructors use. I'm speaking of asking ATC to give your students an actual holding pattern when they aren't busy with other traffic. Believe it or not, controllers get about as much practice issuing holding instructions as general aviation pilots get in receiving them, and that's not much. I can almost hear the excitement of the challenge in the controller's voice when you ask if he/she would provide holding instructions to your student at a local VOR or intersection.
- Over the decades, I've learned that it doesn't make any difference if students use a holding pattern orienter, a circular-manual holding pattern computer (yes, they exist) to determine holding pattern entries. The reason is that a manual-mechanical means of assessing entries supports the development of the abstract thinking necessary to determine entries without such devices.

Lesson 10: Holding: Part-2 Single-Radio Holding/DME & GPS Holding (1.5 Hrs.) T^T-15.0

Lesson Objectives: To develop a higher level of skill at holding, including planning, entering, and wind correction for ATC-assigned enroute holding, approach holding, or missed approach holding. Basic skill at single-VOR nav unit holding and holding at specified DME legs and GPS-identified waypoints is expected.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Review *ACS* Operation III, *Air Traffic Control (ATC) Clearances and Procedures*, Tasks A and B

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

IFR/VFR on top departure

IFR Departure checklist

Holding pattern (use both single and dual VOR nav units for holding)

ATC holding instructions

Identifying/drawing the holding pattern

Standard/non-standard holding/published/non-published patterns

Wind correction

Using a single VOR nav unit for holding

DME leg holding

Using GPS for holding

Use of moving map display for GPS holding

Holding at a waypoint

DME leg holding at a waypoint

Use of autopilot to reduce workload when holding

Return instrument approach to home airport

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-11 Understanding Approach Charts, Pages 11-17 through 11-32

Or study:

Rod Machado's Instrument Pilot's eGround School

How Approach Charts Are Built, Sections 1.13 through 2.1

Artful IFR Approaches, Sections 1.1 through 2.1

Completion Standards: Students will accurately interpret and execute ATC instructions, identify, draw, or visualize the holding pattern, and navigate to the holding fix using a single VOR nav unit. They will demonstrate correct entry procedures, precise outbound leg timing, wind correct, and effective use of the 6Ts during holding patterns. The student will execute holding patterns at VOR stations, DME fixes, and GPS waypoints, and use the autopilot as necessary to reduce cockpit workload.

LESSON PHILOSOPHY

- At this point in the student's training, it's reasonable to begin using the autopilot (if available) to reduce cockpit workload and enhance situational awareness.
- Use of the moving map display is permitted but only after the student demonstrates the ability to hold at a VOR-defined intersection (no DME use here) using a single VOR nav unit. Any student capable of doing this has sufficient situational awareness skills and shouldn't experience a diminishment of this skill in future lessons where the moving map display is used in their training.
- By the end of Lesson 10, students should have approximately 15 hours of instrument training time (and/or a few hours of training in an ATD). They should have the elementary skills necessary to fly basic VOR approaches during the next few lessons. The choke-point here will be the student's understanding of the common steps needed to fly these approaches. Verbal and/or written checklists should be used as necessary to help students learn these steps. This is why I emphasized the steps necessary to successfully fly a holding pattern. It's a good model to help students see the value of a "steps" verbal or written checklist for instrument flying.

Lesson 11: VOR Approaches: Part-1 (1.5 Hrs.) T^T-16.5

Lesson Objective: To gain familiarity with the hands-on process of flying a basic instrument approach procedure with all instruments operational. By this time the student has experienced (but not necessarily flown) several instrument approaches but has not been introduced to or practiced the steps necessary to fly an instrument approach and its missed approach. This lesson introduces those steps.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Review *ACS* Operation VI*, Instrument Approaches*/*Non-precision Approaches*, Task A

Emphasize the use of single-pilot resource management (SRM)

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

File IFR flight plan with the AFSS to a nearby airport having a simple VOR approach with straight-in minimums

IFR Departure checklist

Execute departure, enroute, and arrival for this approach

ATC permitting, request self-navigation for entire approach

Preparation for the approach:

- Continuous verbal checklist: What are the next two things?
- Listen to ATIS
- Select chart(s) for the approach in use
- Select primary navaid, tune (as required), and identify station (see it, say it, check it)
- Select course on primary navaid for the approach
- Slow to approach cruise when in approach environment
- Slow to approach airspeed before intercepting final approach

Approach briefing

- Briefing the approach plate (notes, MDA/DA, timing, MAP, etc.)

Verbal checklist for approach/missed-approach environments

- Where am I going? How do I get there? What do I do next?
- How low? How long? Which way?
- How high? How long? Which way?

Radar vectoring (if self-navigation not available). No moving map here.

Execute course reversal if self-navigation or vectors require PT

Intercepting the intermediate/final approach course

- When to descend during/after course interception
- Use of flaps and gear (if applicable)
- Use of 6Ts at FAF
- Selection of MDA based on approach category
- Descending to and leveling off at MDA
- Descending to and leveling off at circling MDA
- Use of VDP/step-down-fixes when available

Transitioning from minimums to the visual environment

Identifying the MAP and executing the missed approach

Request additional VOR approaches to nearby airports as time permits

Return instrument approach to home airport

HOMEWORK FOR NEXT LESSON

<u>*Rod Machado's Instrument Pilot's Handbook*, Read:</u>

Chapter-12 Approach Chart Analysis, Pages 12-1 through 12-22

<u>*Rod Machado's Instrument Pilot's eGround School*</u>

Inside the Briefing Strip (All)

Having What It Takes (All)

LESSON PHILOSOPHY

- Use of a bloated pre-approach "paper" checklist is not a wise idea here. I recommend using a series of three Post-Its on which the student has previously written the steps for the preparation for the approach to be flown, the steps for the approach briefing, and the steps for flying the final approach segment. These can initially be placed on the panel at the appropriate time by the instructor as a reminder for the student. This is how you train students to "think" about using these mental checklists. In a few lessons, these written checklists should become mental checklists (memorized) for students. However, I still use Post-Its on my panel as reminders of essential approach items when I fly instrument approaches. For instance, I'll write down the course direction, MDA/DA, time to MAP (if applicable), MAP location, and a symbol or two showing the initial steps needed to fly the missed approach.
- Sometimes ATC will allow you to fly the full route shown in your IFR clearance. In other words, you won't be immediately vectored to the approach at the destination airport, assuming it's not close by (in which case you'll probably receive vectors onto the final approach course). By asking to fly the entire route or saying "Request full route clearance," you can often fly the entire route, procedure turn and all, on your own. This is very educational the first few times you fly approaches.

Completion Standards: The student should become familiar with the sequential steps necessary to fly an instrument approach and the missed approach. This includes selecting an approach, self-briefing for the approach, and verbal checklists used during the approach (especially the 6Ts). Proficiency at flying the approach is not intended here. The student should understand that safe, successful approaches result from a sequence of steps.

Lesson 12: VOR Approaches: Part-2 (1.5 Hrs.) T^T-18.0

Lesson Objective: To gain additional familiarity with the hands-on process of flying a basic instrument approach procedure both with and without the use of the attitude indicator. This lesson adds to the student's general experience with following ATC instructions, reading back approach clearances, and maintaining situational awareness during the approach.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Review *ACS* Operation VI*, IAPs/Missed Approaches*, Task C/*Approach With Loss of Primary Flight Indicators*, Task-D

Emphasize the use of single-pilot resource management (SRM)

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

File IFR flight plan to a nearby airport with a VOR approach having straight-in minimums

IFR Departure checklist

Execute departure, enroute, and arrival for this approach

ATC permitting, request self-navigation for entire approach

Emphasis on developing situational awareness during this lesson (no moving map allowed here)

Preparation for the approach:

- Continuous verbal checklist: What are the next two things?
- Listen to ATIS
- Select chart(s) for approach in use
- Select primary navaid, tune (as required), and identify station (see it, say it, check it)
- Select course on primary navaid for the approach
- Slow to approach cruise when in approach environment
- Slow to approach airspeed before intercepting final approach

Approach briefing

- Briefing the approach plate (notes, MDA/DA, timing, MAP, etc.)

Verbal checklist for approach/missed-approach environments

- Where am I going? How do I get there? What do I do next?
- How low? How long? Which way?
- How high? How long? Which way?

Use radar vectoring or self-navigation (if required)

Intercepting the final approach course

- When to descend during/after course interception
- Use of flaps and gear (if applicable)
- Use of 6Ts at FAF
- Selection of MDA based on approach category
- Descending to and leveling off at MDA
- Descending to and leveling off at circling MDA (if required)
- Use of VDP/step-down-fixes when available

Transitioning from minimums to the visual environment at and beyond the missed approach point

Identifying the MAP and executing the missed approach

Request additional VOR approaches to nearby airports as time permits

Complete one VOR approach without use of the primary flight instruments (or, with PFD, use backup instrumentation)

Return instrument approach to home airport

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-14 Instrument Departures, Pages 14-1 through 14-10

Or study:

Rod Machado's Instrument Pilot's eGround School

Instrument Departures, Sections 1.1 through 1.11

LESSON PHILOSOPHY

- Request the full route clearance you received from ATC before departure. Often, ATC won't allow you to do this if the airspace environment is busy. Instead, ATC will vector you onto the approach course. The way I like to request this is to say the following: "Coast approach, this is 2132B, workload permitting, request to fly the full route clearance for this approach." This is a good strategy because it uses the empathetic phrase "workload permitting," which lets controllers know that you can't always allow this when they are too busy.

Completion Standards: The student should gain additional familiarity with the steps necessary to fly an instrument approach and the missed approach with and without the use of the AI. This includes selecting an approach, self-briefing for the approach, and verbal checklists used during the approach (especially the 6Ts). Maintaining situational awareness (without the use of the moving map) is an essential element that should show signs of development by the end of this lesson.

Lesson 13: VOR and VOR-Circling Approaches: Part-3 (1.5 Hrs.) T^T-19.5

Lesson Objective: To further develop the student's skill at flying a basic VOR approach. A basic understanding of instrument departure procedures is expected here, along with skill development in the necessary steps to fly a VOR approach to circling minimums. An understanding of how to transition from IMC to VMC from circling approach minimums at or beyond the missed approach point is also expected here.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.) Emphasize single-pilot resource management (SRM)

Review *ACS* Operation VI*, Instrument Approaches/Circling Approach*, Task D/*Landing from an Instrument Approach*, Task E

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

File IFR flight plan with AFSS to a nearby non-tower airport for a VOR approach having circling minimums

At the same time, file an IFR flight plan from the 1st destination to a 2nd non-tower airport having a VOR approach

IFR Departure checklist

Execute departure, enroute, and arrival to 1st destination airport (use circling minimums and circle to land, if possible)

Preparation for the approach:

- Continuous verbal checklist: What are the next two things?
- Listen to ATIS
- Select chart(s) for VOR approach in use
- Select primary navaid, tune, and ID the station (as required)
- Select course on primary navaid for the approach (if required)
- Slow to approach cruise when in approach environment
- Slow to approach airspeed before intercepting final approach

Execute course reversal if PT required

- Intercepting the final approach course
- When to descend during/after course interception

Approach briefing

- Briefing the approach plate (notes, MDA/DA, timing, MAP, etc.)

Verbal checklist for approach/missed-approach environments

- Where am I going? How do I get there? What do I do next?
- How low? How long? Which way?
- How high? How long? Which way?

Review the use of flaps and gear (if applicable) during the approach

Use of 6Ts at FAF/Selection of circling MDA based on approach category/Descending to and leveling off at circling MDA

Circling technique and hazards to avoid/Use of VDP when available/Transitioning the visual environment/Full stop landing

Request pre-filed ATC clearance from ATC/AFSS at 1st destination airport

Upon departure from both non-tower airports, use the recommended IFR *departure procedure*

- Obtaining the pre-filed clearance from ATC/AFSS/Review clearance void time, if issued
- Use an appropriate departure procedure, or VCOA (vertical climb over the airport)

Execute departure, enroute, and arrival to 2nd destination. Execute missed approach and hold at MAHP (if permitted)

Request additional VOR approaches to nearby non-tower airports and use circling minimums and circle-to-land techniques.

Complete one VOR approach without use of the primary flight instruments (or, with PFD, use backup instrumentation)

Return instrument approach to home airport

Completion Standards: Students should understand how to file for an IFR clearance with the AFSS, as well as how to obtain their IFR clearance from the AFSS at a non-tower airport and safely depart IFR from a non-tower airport. An understanding of flying a circling approach at circling minimums and executing a missed approach while circling are expected here.

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-12 Approach Chart Analysis, Pages 12-34 through 12-46

Chapter-9 IFR Weather Theory Pages 9-1 through 9-9

Or study:

Rod Machado's Instrument Pilot's eGround School

Profiles and Plan Views (All)

Course Reversals (All)

LESSON PHILOSOPHY

- This is where your students learn how to depart a non-tower airport in IMC. It's essential that students learn how to obtain their IFR clearance at a non-tower airport, how to handle "clearance void times," and how to depart safely when their IFR clearance doesn't tell them how to depart that airport.
- During a circling approach at circling minimums, it's extremely important that the student never loses sight of the landing runway threshold. This is especially critical at night when it's not visually clear how close you might be to the obstacles below you.
- You must ensure your student knows how to execute a missed approach while circling to land. This requires that you make a climbing turn toward the landing runway to remain within the obstacle-protected area, then follow the missed approach procedure on the approach chart.

Lesson 14: VOR and VOR-DME Approaches: Part-4 (1.5 Hrs.) T^T-21.0

Lesson Objective: To further the student's understanding of flying VOR approaches, VOR/DME approaches, and transitioning to landing from a circling approach. A thorough understanding of executing a missed approach while maneuvering at circling minimums is also expected here.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Emphasize the use of single-pilot resource management (SRM)

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

File IFR flight plan with the AFSS to a nearby non-tower airport with a VOR/DME approach

IFR Departure checklist

Execute a missed approach and request clearance for a VOR/DME approach to a nearby non-tower airport

Preparation for all approaches:

- Continuous verbal checklist: What are the next two things?
- Listen to ATIS
- Select chart(s) for approach in use
- Select primary navaid and identify station (see it, say it, check it)
- Slow to approach cruise when in approach environment
- Slow to approach airspeed before intercepting final approach

Approach briefing

- Briefing the approach plate (notes, MDA/DA, timing, MAP, etc.)

Verbal checklist for approach/missed-approach environments

- Where am I going? How do I get there? What do I do next?
- How low? How long? Which way?
- How high? How long? Which way?

Radar vectoring (if self-navigation is not available)

Execute course reversal if PT required

Intercepting the intermediate/final approach course

- When to descend during/after course interception
- Use of flaps and gear (if applicable)
- Use of 6Ts at FAF
- Selection of MDA based on approach category
- Descending to and leveling off at MDA/circling MDA
- Use of VDP/step-down-fixes when available

Estimating in-flight visibility from the cockpit

Transitioning from minimums to the visual environment

Identifying the MAP/execute the circling missed approach/hold at MAHP (if permitted)

Request additional VOR or VOR/DME approaches to nearby airports as time permits

Return instrument approach to home airport

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-17 Pilot Potpourri Pages 17-1 through 17-22

Chapter-9 IFR Weather Theory Pages 9-9 through 9-17

Or study:

Rod Machado's Instrument Pilot's eGround School

DAs, MDAs, & the Approach Light System (All)

Pilot Potpourri, Part-1 (All)

Understanding Weather Part-2 (All)

LESSON PHILOSOPHY

- If you want to train your students in circling-to-land procedures, you don't need to fly a VOR-A (B,C,D, etc.) approach. You simply use the circling minimums shown on the chart assuming you can actually circle to any runway without causing a traffic conflict. Sometimes this is easier done at a non-tower airport when traffic is light or non-existent.

Completion Standards: At this point, students should be able to fly a basic VOR approach with very little instructor assistance either in the non-radar environment or with radar vectors. Students should show a degree of self-reliance in obtaining an approach clearance, navigating to and flying a VOR approach, identifying the MAP, transitioning to VMC for landing and/or executing the missed approach, and holding at the appropriate fix (if required). Students should have acquired higher-level skills in situational awareness in the approach environment without dependence on the moving map display.

Lesson 15: Localizer Approaches (1.5 Hrs.) T^T-22.5

Lesson Objective: To understand localizer usage, localizer portrayal on the omni display, localizer tracking, bracketing and reverse sensing. Students should be able to fly a basic localizer approach. Back course approaches might require instructor input to ensure the student maintains the desired localizer track.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Emphasize the use of single-pilot resource management (SRM)

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

File IFR flight plan with the AFSS to an airport with a localizer approach

IFR Departure checklist

Execute departure, enroute, and arrival for this approach

Preparation for the approach:

- Continuous verbal checklist: What are the next two things?
- Listen to ATIS
- Select chart(s) for approach in use
- Select primary navaid and identify station (see it, say it, check it)
- Slow to approach cruise when in approach environment
- Slow to approach airspeed before intercepting final approach

Execute course reversal if self-navigation requires PT

- Intercepting the final approach course
- When to descend during/after course interception
- Review use of flaps and gear (if applicable) during the approach

Approach briefing

- Briefing the approach plate (notes, MDA/DA, timing, MAP, etc.)

Verbal checklist for approach/missed-approach environments

- Where am I going? How do I get there? What do I do next?
- How low? How long? Which way?
- How high? How long? Which way?

Execute course reversal if PT required

Intercepting the intermediate/final approach course

- When to descend during/after course interception
- Use of flaps and gear (if applicable)
- Use of 6Ts at FAF
- Selection of MDA based on approach category
- Descending to and leveling off at MDA/circling MDA
- Use of VDP/step-down-fixes when available

Emphasis on how to bracket the localizer

Estimating in-flight visibility from the cockpit

Identifying the MAP/execute the missed approach/hold at MAHP if permitted

Request LOC and LOC-BAK (back course) approaches to nearby airports as time permits

Return instrument approach to home airport

Completion Standards: By the end of this lesson, students should be able to demonstrate basic skill at localizer tracking and flying basic localizer approaches and understand how to fly a localizer back course approach.

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-17 Pilot Potpourri Pages 17-22 through 17-32

Chapter-9 IFR Weather Theory Pages 9-17 through 9-23

Or study:

Rod Machado's Instrument Pilot's eGround School

DAs, MDAs, & the Approach Light System (All)

Pilot Potpourri, Part-2 (All)

Understanding Weather Part-3 (All)

LESSON PHILOSOPHY

- Bracketing on the localizer is accomplished just as it is when tracking any VOR or GPS course or bearing. There is nothing new here except that you might use smaller AI bank corrections to stop and then return the localizer needle to its centered position.
- Tracking the localizer back course can be confusing for students. So, try this technique. Have students imagine that they are pulling the needle back toward its centered position with the sides of the localizer display (the omni case). If the needle moves to the left on the back course, then the left side of the omni case should be used to pull the left-deflected needle back to the centered position. That means making a right turn. The opposite applies with a right-deflected needle. Make a left turn to pull the right-deflected localizer needle back to the centered position.
- The moving map display is permitted here and in all further lessons.

Lesson 16: ILS Approaches: Part-1 (1.5 Hrs.) T^T-24.0

Lesson Objective: To introduce techniques for flying the ILS approach. Application of constant airspeed/rate descents to the ILS approach is expected along with applying bracketing skills for the localizer and glideslope. Use of the approach lights as a transition aid to visual conditions is introduced along with techniques for estimating inflight visibility at DA.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Review *ACS* Operation VI*, Instrument Approaches*/*Precision Approach*, Task B

Emphasize the use of single-pilot resource management (SRM)

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

File IFR flight plan to a nearby airport with an ILS approach

IFR Departure checklist

Execute departure, enroute, and arrival for this approach

Preparation for the approach:

- Continuous verbal checklist: What are the next two things?
- Listen to ATIS
- Select chart(s) for approach in use
- Select primary navaid and identify station (see it, say it, check it)
- Slow to approach cruise when in approach environment
- Slow to approach airspeed before intercepting final approach

Execute course reversal if PT required

- Intercepting the final approach course
- When to descend during/after course interception

Approach briefing

- Briefing the approach plate (notes, MDA/DA, timing, MAP, etc.)

Verbal checklist for approach/missed-approach environments

- Where am I going? How do I get there? What do I do next?
- How low? How long? Which way?
- How high? How long? Which way?

Intercepting the glideslope from below

Establishing a stabilized approach after intercept

Initially use rate suggested by GS angle and AC ground speed

Reduce power slightly when descending into denser air

Review the use of flaps and gear (if applicable) during the approach

Use of 6Ts at FAF (if FAF exists independently of ILS)

Selection of DA based on approach category

Descending to and making a decision at DA

Identifying the MAP/execute the missed approach/hold at MAHP if permitted

Request additional ILS approaches to nearby airports as time permits

Return instrument approach to home airport

Completion Standards: Students should be able to correlate previous instrument training to flying and maintaining the correct track on the localizer and glideslope. Students should be able to apply the required verbal checklists to help sustain situational awareness throughout the approach.

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-15 IFR Enroute Charts (All)

Chapter-9 IFR Weather Theory Pages 9-23 through 9-40

Or study:

Rod Machado's Instrument Pilot's eGround School

IFR Enroute Charts, (All)

Understanding Weather Part-4 (All)

LESSON PHILOSOPHY

- Bracketing the localizer and the glideslope is done almost exclusively on the attitude indicator. Small bank angles (2.5°/5°) changes and ½ bar width changes on the AI's miniature airplane are what you need to bracket for the ILS.
- Here's a video on how to bracket the glideslope
- The ILS has a FAP or *Final Approach Point* which is the point of glideslope interception. It might have a FAF if the ILS approach is collocated with a localizer approach. Therefore, it's wise to start timing at the FAF since most localizers with FAFs have a missed approach point based on time. This provides you with a backup should the glideslope fail.
- The approach light system is a fundamental part of the ILS. That means understanding the significance of the approach lights and a component of the approach light system known as the decision bar.
- As discussed earlier, the most effective technique to use when flying an ILS is to use throttle to control airspeed and elevator to control the descent rate.
- I'm all for making the very first ILS approach without the use of any view-limiting device. This allows the student to see just how close to the ground decision altitude takes the airplane. And that teaches the student respect for keeping the glideslope and localizer needle centered. Watch this video to learn just how little horizontal tolerance there is for localizer deviation on an ILS approach.

Lesson 17: ILS Approaches: Part-2 (1.5 Hrs.) T^T-25.5

Lesson Objective: To reinforce ILS approach skills. Higher level application of constant airspeed/rate descents to the ILS is expected along with bracketing skills for the localizer and glideslope are expected here. The use of the approach lights as a transition aid to visual conditions is introduced, along with techniques for estimating inflight visibility.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (EFB, iPad, charts, pencil, lap/kneeboard, etc.)

Emphasize the use of single-pilot resource management (SRM)

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

File IFR flight plan to a nearby airport with an ILS approach

IFR Departure checklist

Execute departure, enroute, and arrival for this approach

Preparation for the approach:

- Continuous verbal checklist: What are the next two things?
- Listen to ATIS
- Select chart(s) for approach in use
- Select primary navaid and identify station (see it, say it, check it)
- Slow to approach cruise when in approach environment
- Slow to approach airspeed before intercepting final approach

Execute course reversal if PT required

- Intercepting the final approach course
- When to descend during/after course interception

Approach briefing

- Briefing the approach plate (notes, MDA/DA, timing, MAP, etc.)

Verbal checklist for approach/missed-approach environments

- Where am I going? How do I get there? What do I do next?
- How low? How long? Which way?
- How high? How long? Which way?
- Ensure GPS integrity/how to handle the loss of GPS integrity

Intercept the glideslope from below

Establishing a stabilized approach after intercept

Initially use rate suggested by GS angle and AC ground speed.

Reduce power slightly when descending into denser air

Review the use of flaps and gear (if applicable) during the approach

Use of 6Ts at FAF (if FAF exists independently)

Selection of DA based on approach category

Descending to and deciding at DA

Identifying the MAP/execute the missed approach/hold at MAHP (missed approach holding point) if permitted

Request additional ILS approaches to nearby airports as time permits

Return instrument approach to home airport

Completion Standards: Students should be able to correlate previous instrument training to flying and maintaining the correct track on the localizer and glideslope. A higher level of tracking/bracketing skill with the localizer and glideslope is expected here. Students should be able to fluidly apply the required verbal checklists to help sustain situational awareness throughout the approach. Executing the ILS missed approach and holding should not present difficulty for the student at this level in the syllabus.

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-13 GPS Approach Charts Pages 13-1 through 13-12

Chapter-18 The GPS Machine Pages 18-1 through 18-19

Chapter-9 IFR Weather Theory Pages 9-40 through 9-52

Or study:

Rod Machado's Instrument Pilot's eGround School

RNAV(GPS) Approach Charts, Sections 1.1 through 1.16

GPS Tips & Techniques, Sections 1.1 through 1.7

Understanding Weather Part-5 (All)

LESSON PHILOSOPHY

- How long does it take the average instrument student to develop some fidelity flying ILS approaches? If students can bracket a VOR or localizer needle, transferring those skills to bracketing a glideslope is relatively easy. This is made especially easy since bracketing a glide slope only requires making small adjustments on the AI, not the VSI (see my glideslope bracketing video). Perhaps two or three lessons are enough for students to feel comfortable flying ILS/LPV (glideslope/glidepath) approaches.

Lesson 18: GPS Approaches: Part-1 (1.5 Hrs.) T^T-27.0

Lesson Objective: To introduce the basic procedures for flying RNAV(GPS) approaches. Before beginning this lesson, the use and limitations of GPS approaches should be thoroughly understood. During this lesson, basic skills and understanding should be achieved in selecting and activating the desired GPS approach from the GPS equipment selection menu. Students should become familiar with changing and/or activating the previously selected approach when in the approach environment, along with identifying the missed approach points, then tracking to and holding at the MAHP if required.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (iPad, charts, pencil, lap/kneeboard, database currency, etc.)

Emphasize the use of single-pilot resource management (SRM)

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

Review *ACS* Operation VII*, Emergency Operations*, Task D/RAIM check (if required)

File IFR flight plan to a nearby airport for an RNAV(GPS) approach. Store/add flight plan to GPS unit

Select RNAV(GPS) approaches (4 if possible) with LNAV, LNAV/VNAV, LP, or LPV minimums

IFR Departure checklist

Execute departure, enroute, and arrival for this approach

Use of moving map display and GPS (always "track up")

Use of autopilot to assist GPS approach operations

Preparation for the approach:

- Continuous verbal checklist: What are the next two things?
- Listen to ATIS
- Select chart(s) for approach in use
- Select GPS approach, activate approach, activate vectors-to-final (as appropriate)
- Check previous selections (see it, say it, check it)
- Slow to approach cruise when in approach environment
- Slow to approach airspeed before intercepting final approach

Execute course reversal if PT required

- Intercepting the final approach course
- Evaluate minimums allowed based on GPS integrity
- Understanding and using ATD (along-track distance)

Approach briefing

- Briefing the approach plate (notes, MDA/DA, timing, MAP, etc.)

Verbal checklist for approach/missed-approach environments

- Where am I going? How do I get there? What do I do next?
- How low? How long? Which way?
- How high? How long? Which way?
- Ensure GPS integrity/how to handle the loss of GPS integrity

When to descend during/after course interception

Use of 6Ts at FAF (a good habit even if not necessary here)

Selection of MDA/DA based on approach category

Descending to and leveling off at DA/MDA

Identifying the MAP/execute the missed approach/hold at MAHP if permitted

Return instrument approach to home airport

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-13 GPS Approach Charts Pages 13-12 through 13-24

Chapter-18 The GPS Machine Pages 18-19 through 18-24

Chapter-9 IFR Weather Theory Pages 9-53 through 9-70

Or study:

Rod Machado's Instrument Pilot's eGround School

RNAV(GPS) Approach Charts, Sections 1.17 through 2.1

GPS Tips & Techniques, Sections 1.8 through 1.14

Understanding Weather Part-6 (All)

LESSON PHILOSOPHY

- Flying GPS approaches with advanced avionics equipment is nothing like flying simple VOR approaches with a 720-channel NAV/COMM radio. That's why the use of the autopilot and moving map display are very useful at this stage of training. If your student is not highly proficient with these, please make sure they become proficient.
- One issue with flying GPS approaches in a radar environment is not knowing how ATC will transition you onto the approach structure. Will you be cleared to the Intermediate fix, vectored onto final, or cleared to an IAF many miles from the airport? You don't know. That's why it's wise to become proactive and ask ATC for the transition onto the final approach course that you desire. In other words, say something like the following, "Coast approach, this is 2132B, request direct Ollie intersection if available." You might not always get what you want but there's no harm in asking.

Completion Standards: Students should have a basic understanding and skill level in using their GPS for GPS approaches. They are expected to understand menu selection, integrity evaluation, and missed approach navigation. They are also expected to use the autopilot to help minimize cockpit workload and increase situational awareness.

Lesson 19: GPS Approaches: Part-2 (1.5 Hrs.) T^T-28.5

Lesson Objective: To apply basic and advanced instrument skills to flying GPS approaches while flying these approaches to LNAV, LP, LNAV/VNAV, and LPV minimums.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (iPad, charts, pencil, lap/kneeboard, database currency, etc.)

Review *ACS* Operation V, *Departure, En Route and Arrival Operations*, Task B

Emphasize the use of single-pilot resource management (SRM)

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

RAIM check (if required)

File IFR flight plan to a nearby airport for an RNAV(GPS) approach. Store/add flight plan to GPS unit

Select RNAV(GPS) approaches (4 if possible) with these minimums: LNAV, LNAV/VNAV, LP, LPV, LNAV+V

IFR Departure checklist

Use of RNAV(GPS) departure procedure (DP/ODP) when available

Execute departure, enroute, and arrival for this approach

Use of moving map display for navigation (always "track up")

Use of autopilot to assist GPS approach operations

Preparation for the approach:

- Continuous verbal checklist: What are the next two things?
- Listen to ATIS
- Select chart(s) for approach in use
- Select GPS approach, activate approach, activate vectors-to-final (as appropriate)
- Check previous selections (see it, say it, check it)
- Slow to approach cruise when in approach environment
- Slow to approach airspeed before intercepting final approach

Execute course reversal if PT required

- Intercepting the final approach course
- Evaluate minimums allowed based on GPS integrity
- When to descend during/after course interception

Approach briefing

- Briefing the approach plate (notes, MDA/DA, timing, MAP, etc.)

Verbal checklist for approach/missed-approach environments

- Where am I going? How do I get there? What do I do next?
- How low? How long? Which way?
- How high? How long? Which way?
- Ensure GPS integrity/how to handle the loss of GPS integrity

Review the use of flaps and gear (if applicable) during the approach

Use of 6Ts at FAF (a good habit even if not necessary here)

Selection of MDA/DA based on approach category

Descending to and leveling off at DA/MDA

Identifying the MAP/execute the missed approach/hold at MAHP if permitted

Request additional GPS approaches to nearby airports as time permits

Return instrument approach to home airport

HOMEWORK FOR NEXT LESSON

Rod Machado's Instrument Pilot's Handbook, Read:

Chapter-16 IFR Flight Planning (All)

Chapter-8 FAR Part-91 (Instrument Regulations) Pages 8-22 through 8-37

Chapter-9 IFR Weather Theory Pages 9-70 through 9-78

Or study:

Rod Machado's Instrument Pilot's eGround School

IFR Flight Planning, Parts 1, 2 (All)

Understanding Weather Part-7 (All)

LESSON PHILOSOPHY

- The ACS requires that instrument applicants accomplish one non-precision approach procedure without the use of an autopilot and without the assistance of radar vectors. A GPS approach is a good place to test the student's skills at hand-flying GPS approaches. It's way too easy to become dependent on the autopilot when flying more complex approaches. Students should have no difficulty flying these approaches manually.
- Given that students have already flown (or should have) approaches without the use of radar vectors, they should be well prepared to do this on their checkride already.

Completion Standards: Students should be able to transition onto the GPS approach structure, evaluate GPS integrity, select an approach, navigate to it, activate the approach, then fly the approach. Integrating the skills of autopilot and the moving map for GPS approaches is now assumed here.

Lesson 20: GPS Approaches: Part-3 (1.5 Hrs.) T^T-30.0

Lesson Objective: To apply basic and advanced instrument skills to flying GPS approaches while flying these approaches to LNAV, LP, LNAV/VNAV, and LPV minimums.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

Cockpit organization (iPad, charts, pencil, lap/kneeboard, database currency, etc.)

Emphasize the use of single-pilot resource management (SRM)

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

RAIM check (if required)

File IFR flight plan to a nearby airport for an RNAV(GPS) approach. Store/add flight plan to GPS unit

Select RNAV(GPS) approaches (4 if possible) with these minimums: LNAV, LNAV/VNAV, LP, LPV, LNAV+V

IFR Departure checklist

Use of RNAV(GPS) departure procedure (DP/ODP) when available

Execute departure, enroute, and arrival for this approach

Use of moving map display for navigation (always "track up")

Use of autopilot to assist GPS approach operations

Preparation for the approach:

- Continuous verbal checklist: What are the next two things?
- Listen to ATIS
- Select chart(s) for approach in use
- Select GPS approach, activate approach, activate vectors-to-final (as appropriate)
- Check previous selections (see it, say it, check it)
- Slow to approach cruise when in approach environment
- Slow to approach airspeed before intercepting final approach

Execute course reversal if PT required

- Intercepting the final approach course
- Evaluate minimums allowed based on GPS integrity
- When to descend during/after course interception

Approach briefing

- Briefing the approach plate (notes, MDA/DA, timing, MAP, etc.)

Verbal checklist for approach/missed-approach environments

- Where am I going? How do I get there? What do I do next?
- How low? How long? Which way?
- How high? How long? Which way?
- Ensure GPS integrity/how to handle loss of GPS integrity

Review the use of flaps and gear (if applicable) during the approach

Use of 6Ts at FAF (a good habit even if not necessary here)

Selection of MDA/DA based on approach category

Descending to and leveling off at DA/MDA

Identifying the MAP/execute the missed approach/hold at MAHP if permitted

Request additional GPS approaches to nearby airports as time permits

Return instrument approach to home airport

Completion Standards: Students should be able to transition onto the GPS approach structure in a radar or non-radar environment while understanding the essentials of flying a complete GPS approach to any available minimums.

HOMEWORK FOR NEXT LESSONS

- Prepare IFR flight plan(s) for the long IFR cross country flight to be flown on the next lesson. File these IFR flight plans with the AFSS one to two hours before the scheduled departure time from the home airport. Review the *Flight Planning* Chapter in Rod Machado's Instrument Pilot's Handbook or in Rod Machado's 50-hour Instrument Pilot eCourse.
- Complete any homework assignment not already completed.

LESSON PHILOSOPHY

- Enough can't be said about your students knowing how to use their GPS equipment, autopilot and the moving map display. Both the student and the instructor should read Page 18-24 of *Rod Machado's Instrument Pilot's Handbook* and study the FIVE BIG GPS TRAPS TO AVOID:
- 1. *Mode confusion*
- 2. *Switch confusion*
- 3. *Catastrophic keystroke error*
- 4. *No or invalid RAIM prediction*
- 5. *Inappropriate alternate selected*

Lesson 21: IFR Cross-Country (4.5 Hrs.) T^T-34.5

Lesson Objective: To introduce students to the skills necessary to fly a long instrument cross-country flight. This includes IFR flight planning, weather/NOTAM interpretation, departure/enroute/approach procedures, emergency procedures, lost comm procedures, and so on.

Elements:

Ensure aircraft meets FAR requirements for IFR flight (inspections, VOR accuracy/sensitivity, databases, etc.)

IFR preflight weather briefing/NOTAMs/TFRs/alternate airports, if required/etc.

Review *ACS* Operation VII, *Loss of Communications*, Task A/Area of Operations I *Preflight Prep*aration, Tasks B and C

Prefile three separate IFR flight plans to meet FAR 61-65's requirement for the 250 NM instrument XC flight

1. Depart the home airport to the first destination
2. From the first destination to the second destination (request VFR-on-top operations from ATC after departure for this leg of XC). Maintain VFR-on-top operations until nearing the approach environment, then request a hard IFR altitude.
3. Second destination to home airport

Select three different approaches to be flown: RNAV(GPS), ILS, VOR, VOR/DME, LOC or other types.

Use of electronic tablet software for cross-country flight planning. CFII should review the following:

- Route selection, altitude selection, wind effects, fuel reserve requirements, personal minimums, alternate selection (if required), preferred routes, NOTAMs, chart supplement, considerations, activating and closing flight plans

Cockpit organization (iPad, charts, pencil, lap/knee board, database currency, etc.)

Emphasize the use of single-pilot resource management (SRM)

Flight instrument checks before and during taxi (AI [5° +/-], DG [moves], Compass [swings], VSI [+/- 100'], Altimeter [+/-75']

RAIM check (if required)

IFR Departure checklist

Use of departure procedures (DPs) at all three departure airports when available

Enroute ATC communication

Radar/non-radar environment operations

Use of moving map and autopilot to assist any flight operations

Use of onboard weather equipment and weather avoidance strategies

In-flight emergencies to review

- Lost comm
- Rerouting
- Fuel emergencies
- Weather emergencies, see Appendix-6 (icing, fog, thunderstorms, etc.)
- Equipment malfunction emergencies, etc.

Preparation for the approach/Approach briefing

HOMEWORK FOR NEXT LESSONS

- Review missed questions on IFR knowledge exam.
- Review all areas where the instructor feels there's a weakness in the student's knowledge.

Completion Objectives: To ensure the student understands how to flight plan for and fly an instrument cross-country flight.

LESSON PHILOSOPHY

- By this point there should be no doubt that the student can perform within the knowledge and skill limits of the ACS.
- It would be ideal to fly this XC in actual conditions. Of course, that's not always possible, especially in places like Arizona in the summer (e.g., thunderstorms). Nevertheless, providing the student with actual instrument conditions should be an important objective for the instructor throughout all these lessons when appropriate.
- Before beginning this XC, the students should have a commanding grasp of their flight planning software. For instance, most students enjoy using *Foreflight* for flight planning and navigation. This isn't a simple software to use. It requires many hours for students to understand all its nuances. Please encourage students to spend time learning to use this software.
- Does the student actually have to fill out a flight log sheet showing the time and distances on legs estimated to be flown in the filed flight plan? Maybe that was reasonable 40 years ago, but today is different. ATC reroutes traffic to accommodate other traffic, depending on who is the big Kahuna in the lineup. With one reroute your flight planning often goes out the door. Instead, it's more reasonable to let the software calculate time, distance, and fuel consumption for you as long as you understand the details. In some ways software can easily calculate a potential diversion enroute, letting you know if it's even possible to fly it based on fuel reserves and weather. But you never want students to become dependent on anything that doesn't make them think. So, use technology as long as you don't let it weaken your student's mind.

Lesson 22: IFR Checkride Prep: Part-1 (1.5 Hrs.) T^T-36.0

Lesson Objective: To conduct a complete review of the ACS requirements for the instrument airplane rating.

Elements:

Full panel maneuvering

Partial panel (or PFD backup instruments) maneuvering

Slow flight

Stalls, power-off, power-on, full and imminent stalls

Steep turns

Compass turns

Unusual attitude recoveries

Navigation (intercept, tracking)

- VOR, GPS, DME
- Use of moving map
- Use of autopilot/FMS

Holding

- Standard, non-standard patterns
- Holding at VOR, intersections, DME holding,
- Hold pattern entries
- Holding wind correction

Approaches

- VOR
- VOR/DME
- Localizer
- ILS
- (RNAV)GPS

Circling approaches

Emergencies

Completion Standards: The student should comply with, meet, and operate within all ACS instrument-airplane standards.

HOMEWORK FOR NEXT LESSONS

- Review missed questions on IFR knowledge exam.
- Review all areas where the instructor feels there's a weakness in the student's knowledge.

LESSON PHILOSOPHY

- Your student should already be intimately familiar with the ACS (*Airman Certification Standards*) for the instrument rating. You should have students make a comprehensive review on their own and identify any areas where they feel they need more training. Then, offer them that training.

Lesson 23: IFR Checkride Prep: Part-2 (1.5 Hrs.) T^T-37.5

Lesson Objective: To correct any deficiency in skill or understanding in preparation for the instrument-airplane rating.

Elements:

Full panel maneuvering

Partial panel (or PFD backup instruments) maneuvering

Slow flight

Stalls, power-off, power-on, full and imminent stalls

Steep turns

Compass turns

Unusual attitude recoveries

Navigation (intercept, tracking)

- VOR, GPS, DME
- Use of moving map
- Use of autopilot/FMS

Holding

- Standard, non-standard patterns
- Holding at VOR, intersections, DME holding,
- Hold pattern entries
- Holding wind correction

Approaches

- VOR
- VOR/DME
- Localizer
- ILS
- (RNAV)GPS

Circling approaches

Emergencies

Completion Standards: The student should comply with, meet, and operate within all ACS instrument-airplane standards.

HOMEWORK FOR NEXT LESSONS

- Review missed questions on IFR knowledge exam.
- Review all areas where the instructor feels there's a weakness in the student's knowledge.

LESSON PHILOSOPHY

- Your student should already be intimately familiar with the ACS (*Airman Certification Standards*) for the instrument rating. You should have students make a comprehensive review on their own and identify any areas where they feel they need more training. Then, offer them that training.

Appendix-1
A Convective Question

Copyright 2024 By Rod Machado

Most of my students and friends know how much I love Chinese eateries. These emporiums of Eastern eating have all the things I look for in good restaurants—low lights, paper lanterns and waiters talking about me in a language I don't understand.

I always have the greatest conversations in these places, which was why I was fortunate to be sitting with three fellow CFIs at the *I'm Wokin' Here* broccoli palace. Over a meal of chopper suey (I've given many of the entrées aviation names) I couldn't help but ask the question, What criteria distinguishes a convectively harmless cumulus cloud from one that can damage an airplane?

This is a question I've been asking pilots in all my IFR seminars for years. On one hand, the answer is pretty simple. A pilot must avoid any cloud having a significant chance of severe turbulence or even the slightest chance of destructive turbulence. On the other hand, the sister question to the first is not so easy to answer: How can a pilot tell if this level of turbulence exists in a convective cloud?

The fact is that these are important questions to instrument rated pilots, questions in need of answers. So let me offer you the response I offered to my fellow CFIs as we discussed both of these questions while eating chewy suey. Before I begin, I need to thank my good friend, radar expert and source for my musings, Captain Dave Gwinn. He has taught me more about radar and convective weather than I've learned from any book ever written on the subject.

Our story begins with how airplanes are built. Airplanes certificated under Part 23 prior to September 14, 1969 were required to withstand vertical sharp edge gusts of 30 feet per second (FPS) at Vc, which is the *velocity of cruise* or the beginning of the airspeed indicator's yellow arc. Beech Bonanza aircraft are typical of airplanes in this category. Those certificated on or after this date were required to withstand vertical sharp edge gusts of 50 FPS at Vc. The newer Rockwell Commander is an airplane falling into this category. This doesn't mean, however, that airplanes in the pre- '69 category can't withstand vertical gusts of greater intensity. This was just the minimum vertical gust requirement necessary according to the regulations at the time.

Ready for more? Fine, let's talk about water.

To keep large volumes of water suspended it in the atmosphere it takes a lifting force, otherwise known as *updrafts*. The more water suspended within a cloud the greater the lifting force or updraft that's required to keep it there. When the amount of water suspended exceeds the lifting force that suspends it, the water falls. We call this *rain* and measure the amount in inches per hour.

It doesn't have to rain, however, for us to measure the amount of water suspended inside the cloud. We can merely identify the amount of water in a cloud using radar and say that if it did rain, then the rainfall rate would be a specific amount, calibrated in inches per hour.

Given this observation, it's logical to say that a cloud with a rainfall rate (or potential rainfall rate) of .5 inches per hour has less updraft action than a cloud with a rainfall rate of 2 inches per hour. We can conclude that the larger the rainfall rate (or potential rainfall rate), the stronger the updrafts found inside a cloud.

As you undoubtedly know, radar energy is reflected by solid objects. The water suspended in a cloud is a solid object, but the cloud itself isn't. The more water suspended within the cloud, the greater the ratio of radar energy returned for a given amount sent out by the radar unit. The amount of this reflected radar energy, referred to as *reflectivity* or *Z*, is calibrated in the form of a quantity known as *dBZ* or *decibels of Z*.

If you've stayed with me so far, then things about to get really interesting.

Years ago Project Rough Rider (and subsequent studies) established a correlation between the amount of water suspended in a cloud and the vertical gusts found within that cloud (measured in feet per second). If we can equate rainfall rates with radar reflectivity or dBZ's, we can make some interesting assumptions using the results of the Rough Rider study.

It turns out that rainfall rates producing radar reflectivity ranging from 16 to 29 dBZ's (known as a *Level 1* radar return) generate a 100% probability of light turbulence and a 10% chance of moderate turbulence. Light turbulence is defined as vertical gusts from 0-19 FPS and moderate turbulence is defined as vertical gusts from 20 to 34 FPS.

Rainfall rates producing radar reflectivity ranging from 30 to 39 dBZ's (known as a *Level 2* radar return) generate a 100% probability of light turbulence, a 40% chance of moderate turbulence and a 2% chance of severe turbulence. Severe turbulence is defined as vertical gusts from 35 to 49 FPS.

Rainfall rates producing radar reflectivity ranging from 40 to 49 dBZ's (known as a *Level 3* and *4* radar return) generate a 100% probability of light turbulence, a 90% chance of moderate turbulence, a 10% chance of severe turbulence and a 3% chance of destructive turbulence. Destructive turbulence is defined as vertical gusts of 50 FPS and higher.

Now you know the answer to the question, What criterion distinguishes a convectively harmless cumulus cloud from one that can damage an airplane? The answer is, *Any convective cloud with a radar reflectivity of 40 dBZ's (a Level 3 radar return or higher) needs to be avoided and treated as an immediate threat to your safety aloft.* The 3% chance of destructive turbulence is simply too significant to ignore. While the chances are small, the outcome is eternal.

Sharp pilot that you are, I'm sure you're wondering why I would not suggest the mandatory avoidance of a Level 2 radar return when flying a pre 1969-certificated airplane. After all, a Level 2 return has a 40% chance of 20 to 34 FPS gusts, which can exceed the certificated stress limit of this airplane when it is flown at Vc. Consider the following idea.

Airplanes typically cruise at high altitudes which means that the higher they fly, the less their IAS. In my A36 Bonanza, at lower altitudes I can cruise at more than 170 knots indicated (about 5 knots over Vc). At 10,000 feet, I'm indicating about 145 knots in cruise (which is about 5 knots above the "gross weight" maneuvering speed). When cruising at higher altitudes, the A36 should be able to withstand sharp edge gusts a little greater than 30 FPS without experiencing any problems (not that I look forward to or even desire to experience this, of course). What about the 2% chance of severe turbulence? Well, this also implies that there is a 98% chance of not experiencing severe turbulence. We have to choose our risks and this one doesn't disturb me that much given the following preference.

Whenever possible, I always try to avoid flying in or near Level 2 radar returns, regardless of when the airplane was certificated. If you're flying IFR and you want to obtain full utility from your airplane, you may often fly in or near areas containing Level 2 returns. I wouldn't, however, enter a Level 2 return if I thought there was any chance of it evolving into a Level 3 or greater return. How would I make this assessment? There are many clues. One of the best is the presence of any Level 3 or greater returns within the same airmass. If these exist, it's reasonable to assume that the airmass is unstable enough to hatch Level 3 and greater convective weather.

At this point I know you're wondering it's possible for you to identify the strength of radar returns when you don't have radar. There are several ways to do this, all of which require that you use OPR's (*Other People's Radar*).

For instance, some airplanes now have uplinked, real time NEXRAD radar available in the cockpit. Though it's called *real time*, this is a misnomer. NEXRAD radar updates can be five to six minutes old when received in the cockpit. As Captain Gwinn says, this is ancient history when it comes to thunderstorm development. Given this limitation, we can still derive some very valuable information from cockpit based NEXRAD radar when we use dBZ values to assess the information.

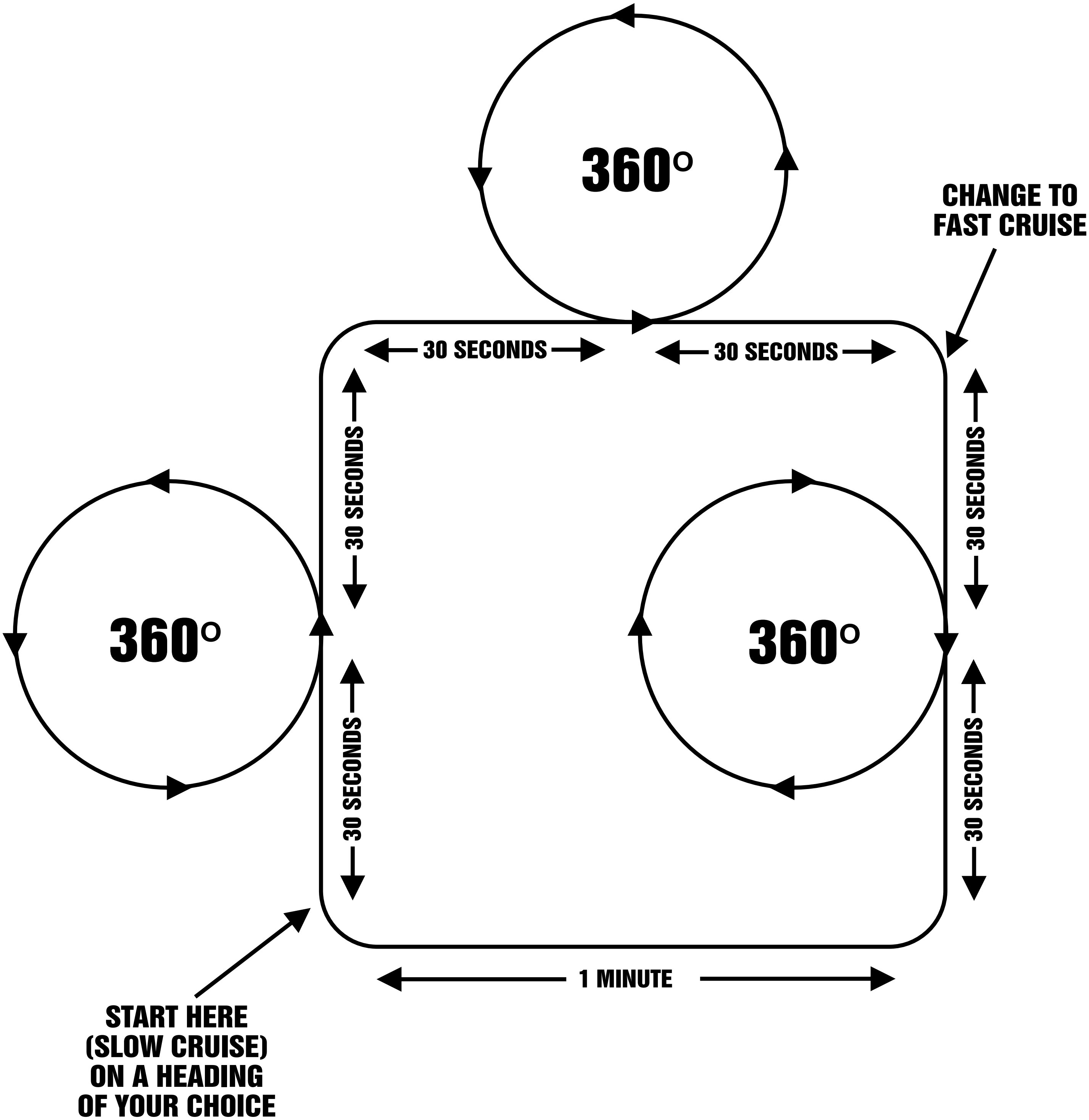
If you're using NEXRAD, you want to identify the color representing 40 dBZ's. These are the areas representing Level 3 radar returns. You want to avoid them and all the sub-levels associated with that radar return. The Rough Rider study indicated that the highest level of anticipated turbulence within the storm applies to all the sub-levels within the storm (i.e., the Level 1 and 2 portions, too). So if an area of Level 3 radar returns are present, the entire area should be avoided.

The real issue here is that pilots shouldn't use uplinked NEXRAD in IMC to pick their way through convective weather in the way someone with airborne really real-time weather radar might attempt the feat. Instead, they should be using this information to decide whether they to remain in VMC and visually avoid the storms, when and where to make major route changes or tap into additional sources of information such as that provided by Stormscope/StrikeFinder devices, pilot reports, Center radar, Approach radar, FSS radar and so on.

At this point I hope your mind isn't stir fried like the Chinese dinner my fellow CFIs and I were eating when I began this discussion. If you understand the relationship between dBZ's and the probability of turbulence associated with radar returns, you're now in a position to make better, safer weather decisions when flying IFR. Wok on.

Appendix-2

Pattern-A



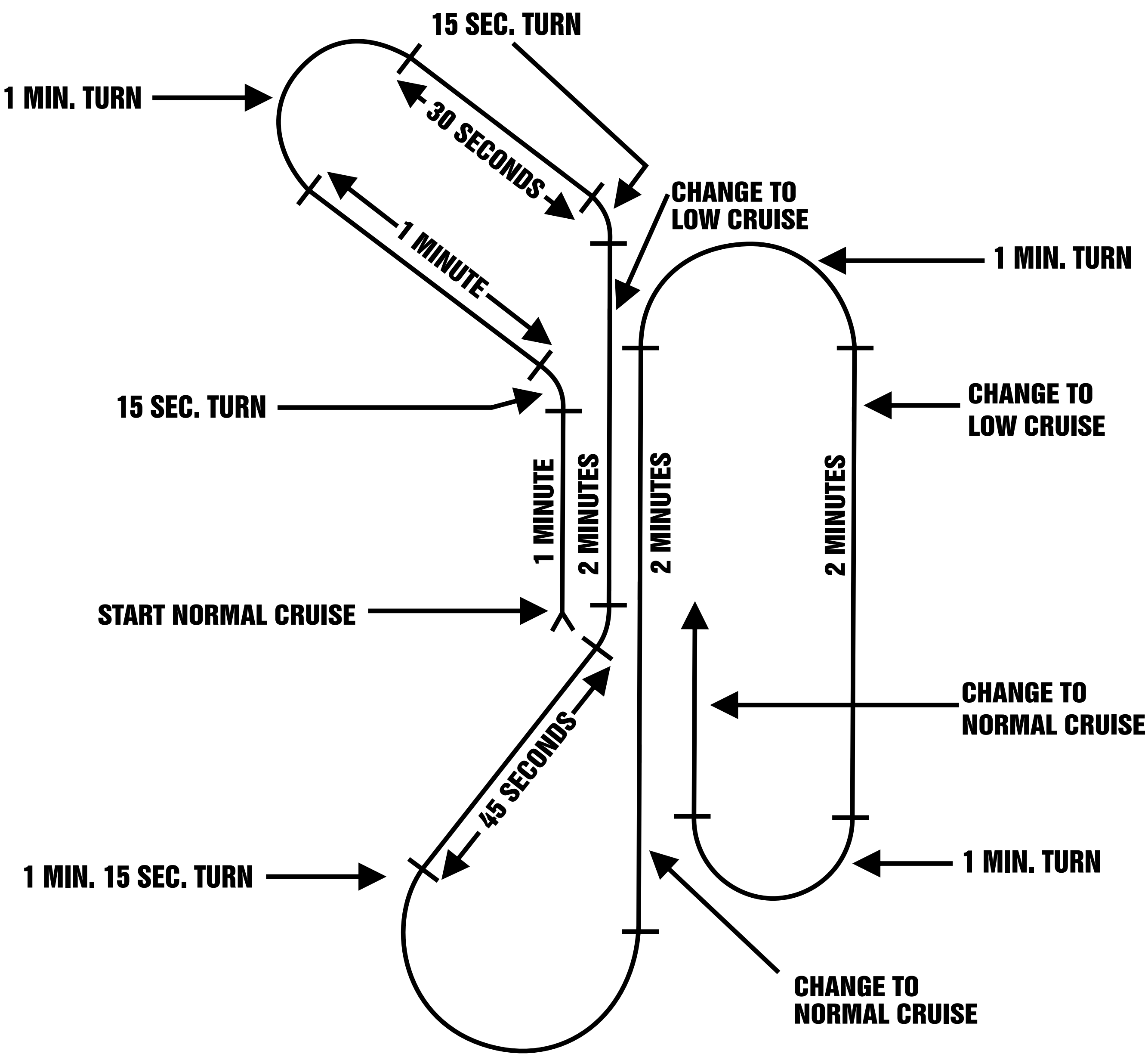
Note: Starting this pattern on other than a cardinal heading makes this exercise more challenging for the first-time student. I recommend starting on a heading of 360º the first time this pattern is introduced. On the next introduction, start on some non-cardinal heading such as 140º. This requires the student to keep track of the heading change throughout the exercise.

Copyright Rod Machado 2024

Pattern B

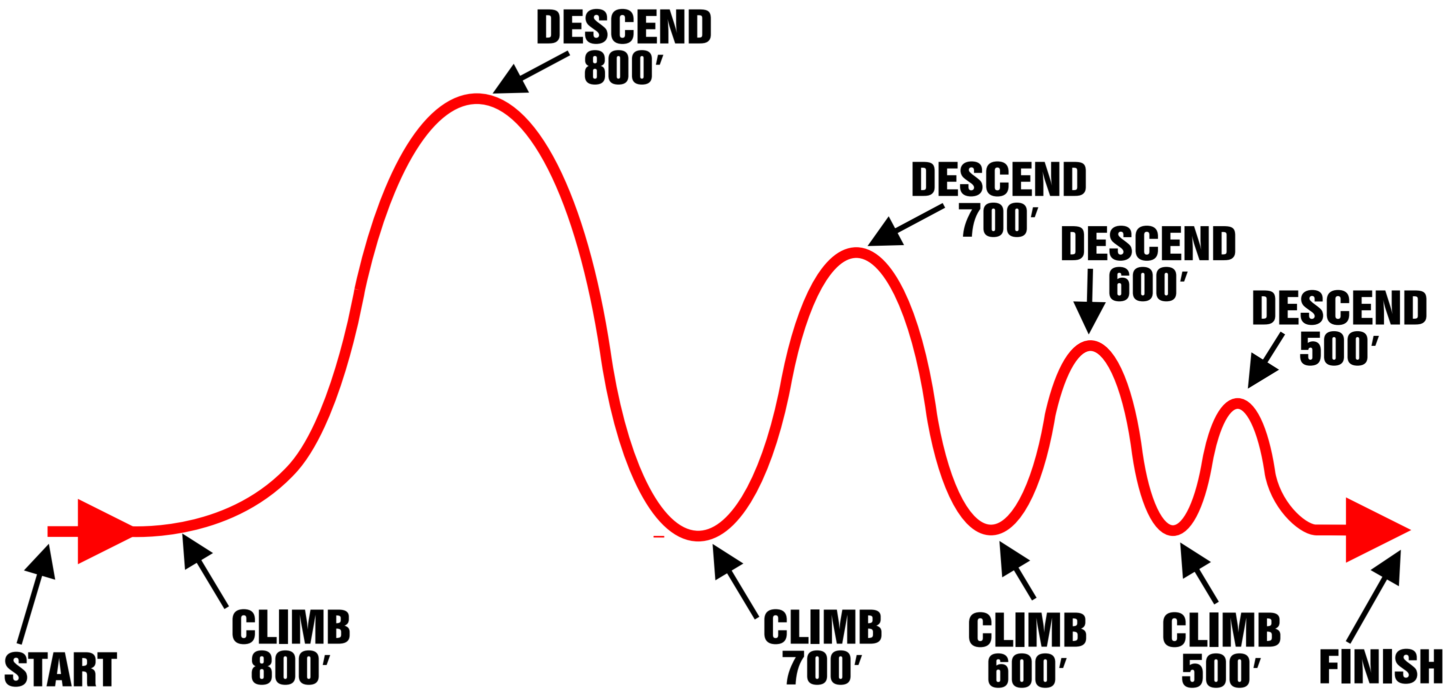
The purpose of both Pattern "A" and Pattern "B" is to further develop the pilot's ability to control the aircraft without deliberate thought. These patterns help prepare the student for the holding patterns and procedure turns he will fly during radio navigation. Initial practice should be on cardinal headings for simplification; however, as proficiency increases the student should be able to accomplish the patterns on any heading. The instructor may make various changes in the patterns, or, the patterns may be flown over a navigational facility, correcting for drift on each leg.

1. *Brief Student Thoroughly Prior to the Flight*
2. *Performance of Maneuver in the Aircraft*
   a. This maneuver should be performed first with all available instruments, then on partial panel,
   b. Start Pattern "A" and demonstrate through the first three turns, then have the student continue.
   c. All turns are done at standard rate.
   c. Timing should start when the clock second hand is on a cardinal point, preferably the



Copyright Rod Machado 2024

Pattern C
(VERTICAL-S in Straight Flight)

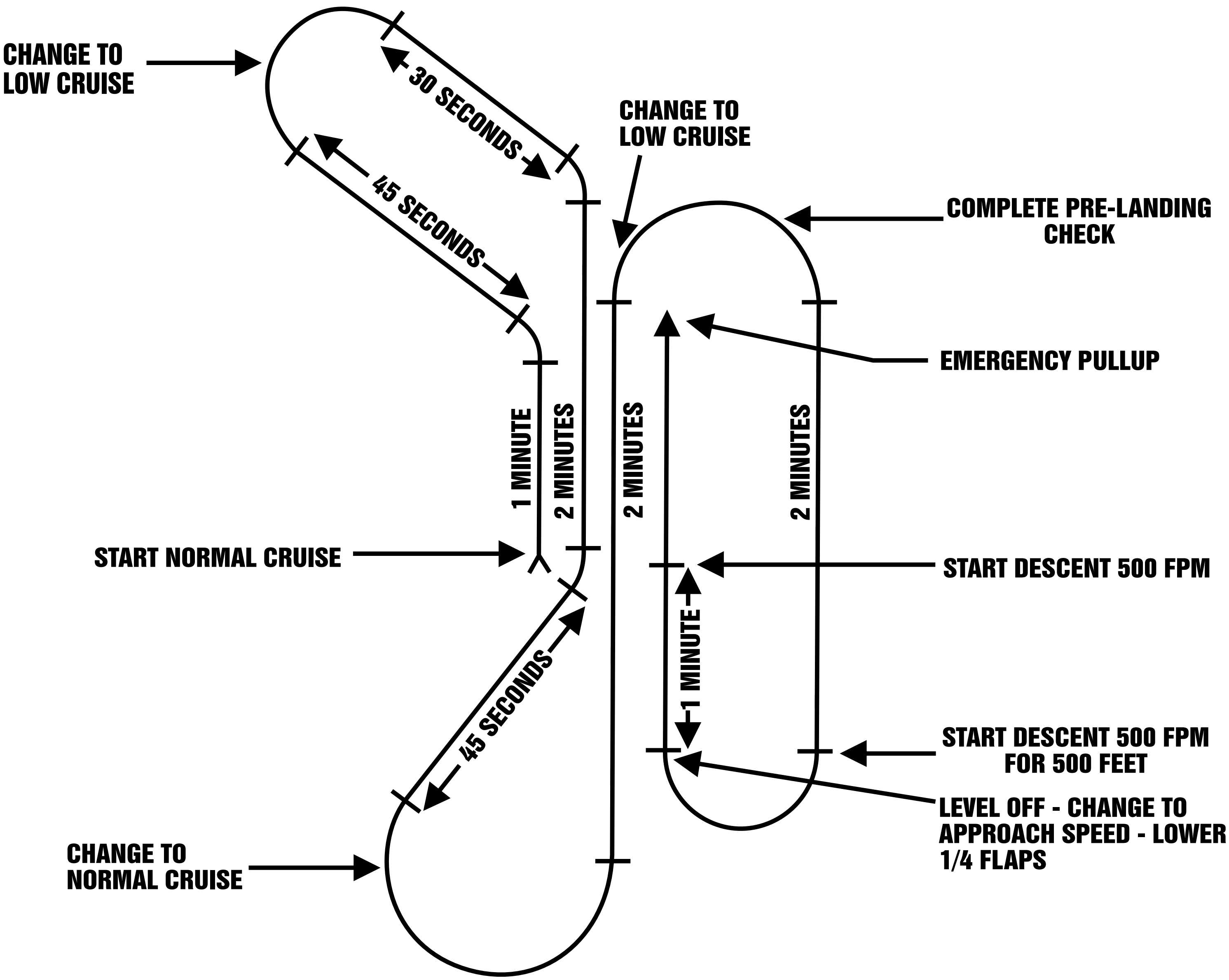


NOTE: In airplanes with smaller (non-big-bore) engines, The vertical-S should be practiced with full power for climbing and idle power for descending. In airplanes where shock cooling is an issue, the instructor should decide on an acceptable level of power reduction for the descent. This pattern is flown on a constant heading.

Copyright Rod Machado 2024

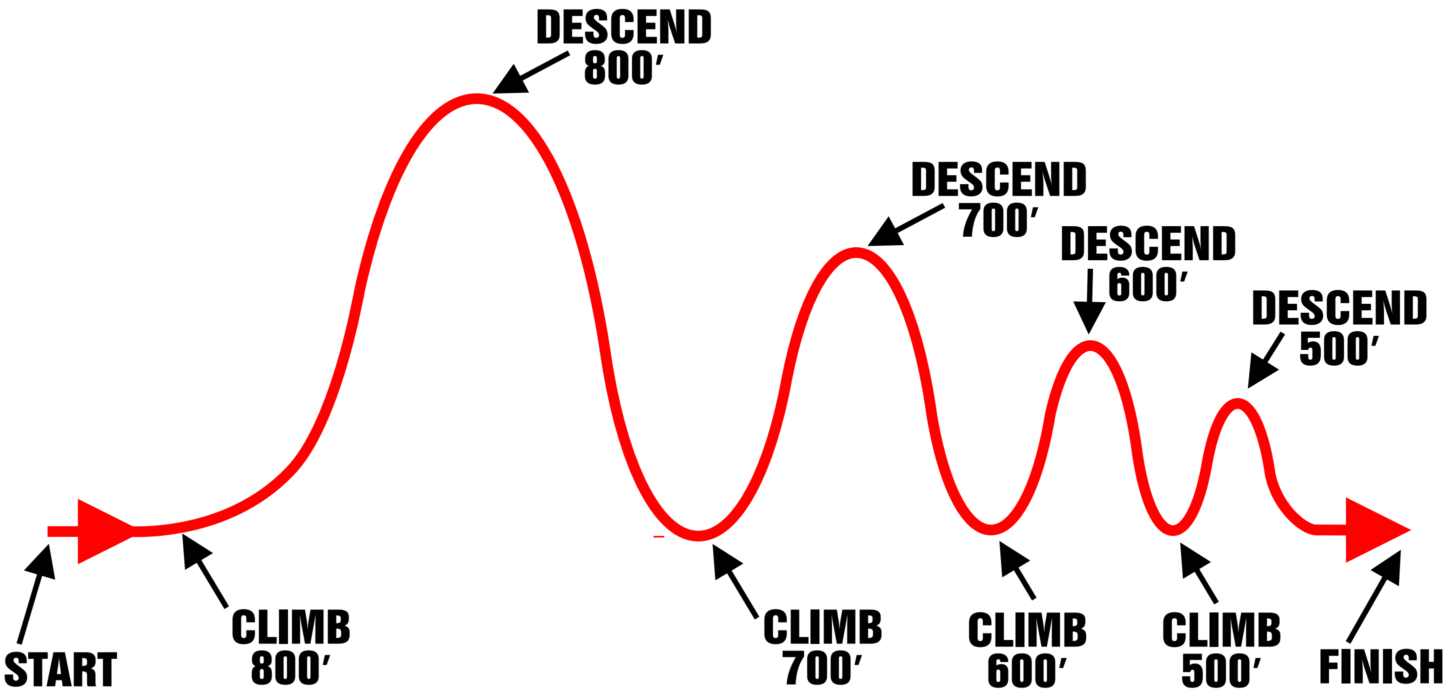
Pattern D

I. *Brief Student Thoroughly Prior to. the Flight*
2. *Performance of Maneuver in the Aircraft*
   a. Do not demonstrate unless absolutely necessary.
   b. All available instruments are used.
   c. Roll out on headings regardless of time.
   d. When changing airspeed in turns; simultaneously change bank and power, also pitch if applicable.
   e. The descending final turn is made at an absolute rate.
   f. The final descent is made to a minimum altitude set by the instructor, or until the time expires, whichever comes first.
   g. The emergency pull-up is made as a normal go-around procedure, climbing to the original altitude.

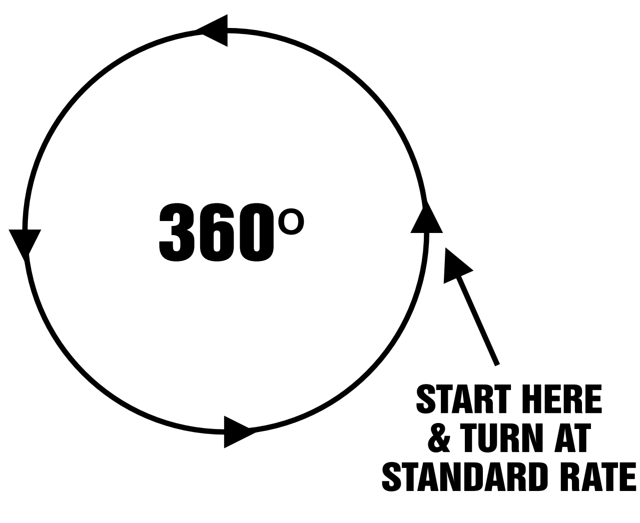


Copyright Rod Machado 2024

Pattern E
(VERTICAL-S in a Turn)



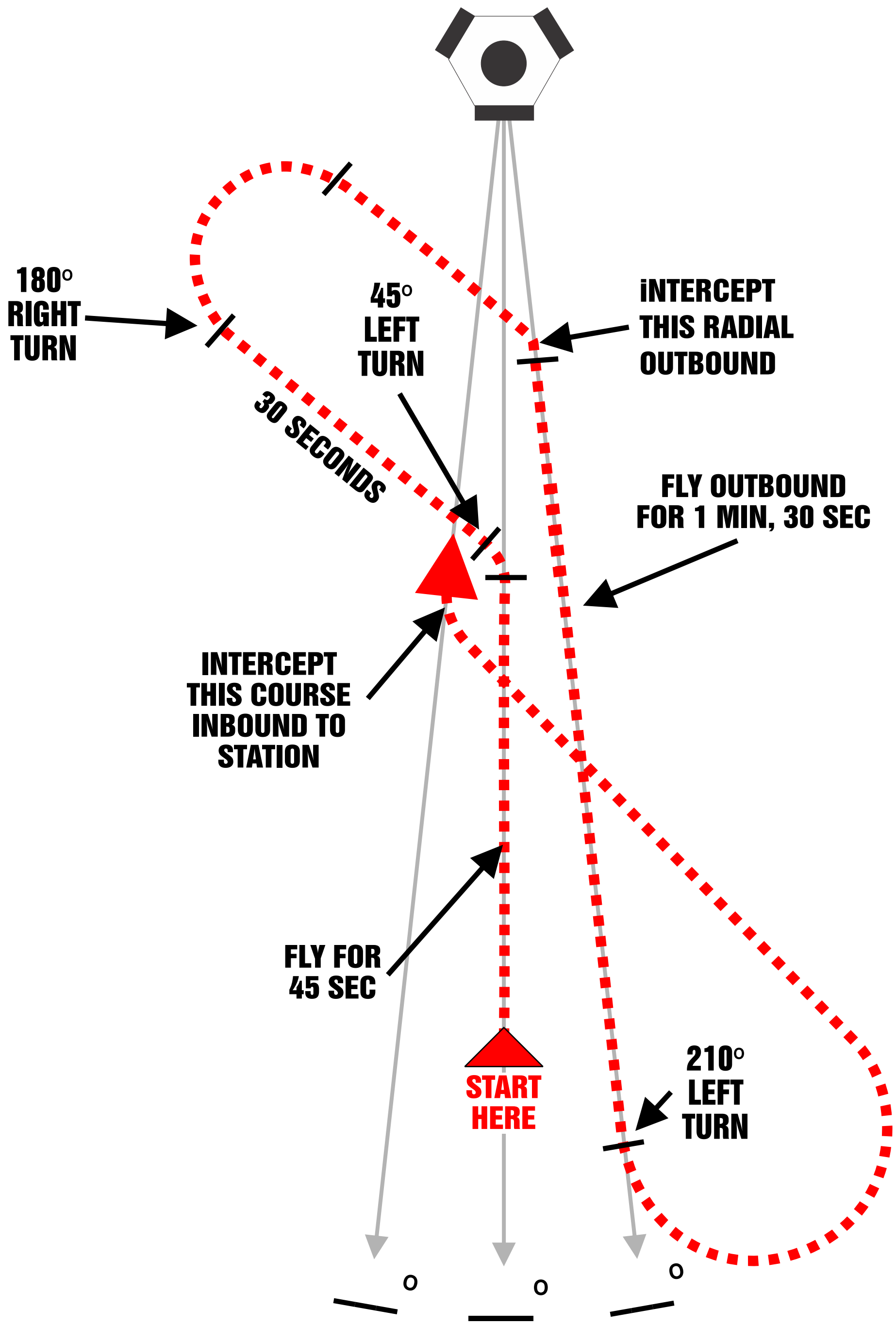
NOTE: This Vertical-S pattern is accomplished in a standard rate turn.



Copyright Rod Machado 2024

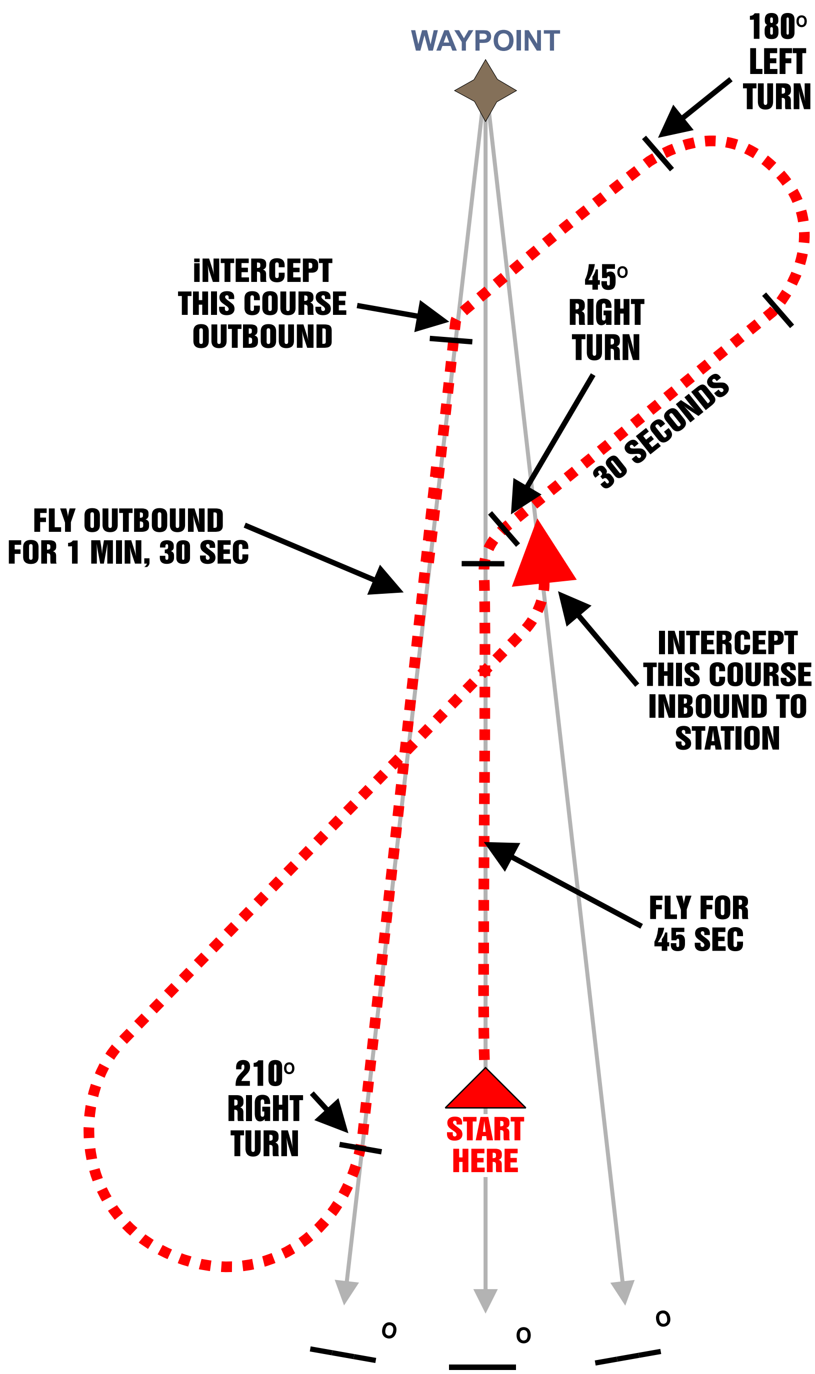
Pattern F-1

This pattern helps instrument students orient themselves to VOR courses and radials. Of course, it might be difficult (geographically) to place the airplane within a few miles of a VOR station so as to track a specific radial inbound. However, this pattern F-1 allows the instructor to write-in any three “10 degree” separated radials allowing the airplane to start this maneuver anywhere around the VOR station.



Pattern G

Pattern G is designed for use with the airplane's panel-mounted GPS unit. This pattern allows the instructor to write-in any three "10 degree" separated courses. Begin by creating any waypoint or selecting any intersection with the GPS. We'll cal this point "WAYPOINT." The "Start Here" position should be located at least three miles from the waypoint. Select an inbound course and proceed with the pattern.



Copyright Rod Machado 2024

Appendix-3

Demonstration of Spatial Disorientation

There are a number of controlled aircraft maneuvers a pilot can perform to experiment with spatial disorientation. While each maneuver normally creates a specific illusion, any false sensation is an effective demonstration of disorientation. Thus, even if there is no sensation during any of these maneuvers, the absence of sensation is still an effective demonstration in that it shows the inability to detect bank or roll. There are several objectives in demonstrating these various maneuvers.

1. They teach pilots to understand the susceptibility of the human system to spatial disorientation.
2. They demonstrate that judgments of aircraft attitude based on bodily sensations are frequently false.
3. They help lessen the occurrence and degree of disorientation through a better understanding of the relationship between aircraft motion, head movements, and resulting disorientation.
4. They help instill a greater confidence in relying on flight instruments for assessing true aircraft attitude.

A pilot should not attempt any of these maneuvers at low altitudes or in the absence of an instructor pilot or an appropriate safety pilot.

Climbing While Accelerating

With the pilot's eyes closed, the instructor pilot maintains approach airspeed in a straight-and-level attitude for several seconds, and then accelerates while maintaining straight-and-level attitude. The usual illusion during this maneuver, without visual references, is that the aircraft is climbing.

Climbing While Turning

With the pilot's eyes still closed and the aircraft in a straight-and-level attitude, the instructor pilot now executes, with a relatively slow entry, a well-coordinated turn of about 1.5 positive G (approximately 50° bank) for 90°. While in the turn, without outside visual references and under the effect of the slight positive G, the usual illusion produced is that of a climb. Upon sensing the climb, the pilot should immediately open the eyes and see that a slowly established, coordinated turn produces the same feeling as a climb.

Diving While Turning

Repeating the previous procedure, with the exception that the pilot's eyes should be kept closed until recovery from the turn is approximately one-half completed can create this sensation. With the eyes closed, the usual illusion is that the aircraft is diving.

Tilting to Right or Left

While in a straight-and-level attitude, with the pilot's eyes closed, the instructor pilot executes a moderate or slight skid to the left with wings level. This creates the illusion of the body being tilted to the right. The same illusion can be sensed with a skid to the right with wings level, except the body feels it is being tilted to the left.

Reversal of Motion

This illusion can be demonstrated in any of the three planes of motion. While straight and level, with the pilot's eyes closed, the instructor pilot smoothly and positively rolls the aircraft to approximately a 45° bank attitude. This creates the illusion of a strong sense of rotation in the opposite direction. After this illusion is noted, the pilot should open his or her eyes and observe that the aircraft is in a banked attitude.

Diving or Rolling Beyond the Vertical Plane

This maneuver may produce extreme disorientation. While in straight-and-level flight, the pilot should sit normally, either with eyes closed or gaze lowered to the floor. The instructor pilot starts a positive, coordinated roll toward a 30° or 40° angle of bank. As this is in progress, the pilot tilts his or her head forward, looks to the right or left, then immediately returns his or her head to an upright position. The instructor pilot should time the maneuver so the roll is stopped as the pilot returns his or her head upright. An intense disorientation is usually produced by this maneuver, and the pilot experiences the sensation of falling downward into the direction of the roll.

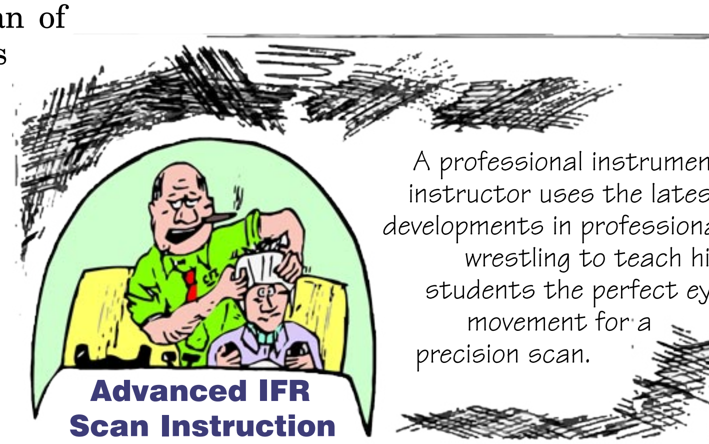
In the descriptions of these maneuvers, the instructor pilot is doing the flying, but having the pilot do the flying can also be a very effective demonstration. The pilot should close his or her eyes and tilt their head to one side. The instructor pilot tells the pilot what control inputs to perform. The pilot then attempts to establish the correct attitude or control input with eyes closed and head tilted. While it is clear the pilot has no idea of the actual attitude, he or she will react to what the senses are saying. After a short time, the pilot will become disoriented, and the instructor pilot then tells the pilot to look up and recover. The benefit of this exercise is the pilot experiences the disorientation while flying the aircraft.

Appendix-4

How to Scan Your Airplane's Flight Instruments

Copyright Rod Machado 2024

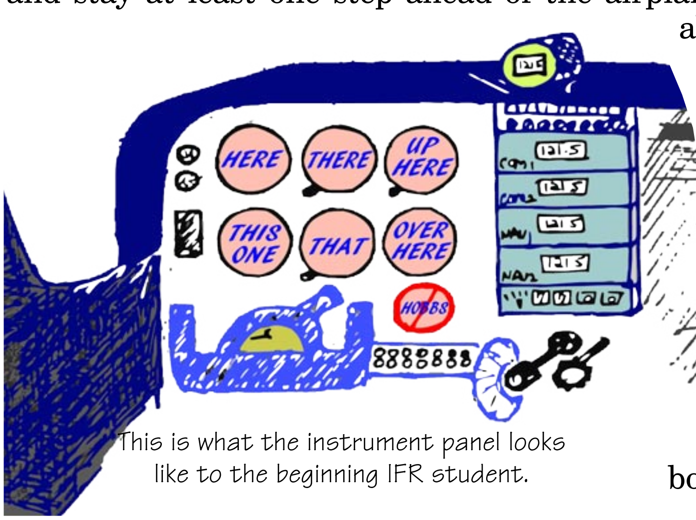
Flying instruments is one of the most challenging and rewarding achievements you'll attain in aviation. It satisfies and gratifies a pilot's inherent need to be a master of the machine, environment, and universe while offering its own form of entertainment along the way. In fact, instrument flying is analogous to a video game in three dimensions, except you don't get to shoot down any Klingons with your joystick. Your next flight is the free game you receive for a satisfactory score or performance. Developing a good instrument scan is the foundation for meeting the challenge instrument flying offers. We are, in the end, measured by the span of our scan. Yet it's in this area that we as instrument pilots are most often deficient.



A professional instrument instructor uses the latest developments in professional wrestling to teach his students the perfect eye movement for a precision scan.

My initial instrument instructor would insist on tapping the instruments with his metal pointer, his baton leading my eyes in scan while looking like the conductor of a runaway orchestra. This was about as educational as being at an Amish science fair. He would say, "OK, look here (airspeed); look there (attitude indicator), don't look at that (heading indicator), look at this one (turn coordinator)..." For a long while, I thought that's what the instruments were called: HERE, THERE, THAT and THIS ONE. He had fun and I got a headache.

Many pilots end up having survived, rather than mastered, every IFR flight. For them, it's a victory, but it's rarely a comfort. Too bad, because there *is* a realisitc method to the madness of scanning instruments (one that doesn't involve a pointer). Mastering the art of instrument flying means acquiring the scanning skills that allow you to become a good in-flight manager. The proper scan gives you time to think, plan, anticipate, plot, scheme, and stay at least one step ahead of the airplane. This is what instrument flying is all about, mastering the mechanics of flying, and freeing up your imaginative capacity to be aware of your position and anticipate what's next.



This is what the instrument panel looks like to the beginning IFR student.

In this chapter I'll show you a very simple method for scanning your instruments. At first, we'll discuss scanning the typical *six pack* of analog instruments, then we'll apply this scan to the electronic instruments of a PFD or primary flight display. It's absolutely imperative that you read and understand both methods if you're flying technically advanced airplanes equipped with PFDs. Why? Because the loss of your PFD, or one of its essential instruments, often leaves you with only your backup analog instruments on which to fly (most technically advanced airplanes have backup analog instruments). Additionally, flight instruments are flight instruments, so what you learn on a traditional panel directly applies to a PFD.

There are two fundamental conditions in instrument flying—steady state, and change. Either the airplane is straight and level with everything set, or you are in some kind of transition. In the steady state condition, you are primarily monitoring to make certain everything *stays* steady. Transitions, on the other hand, involve a very active role. Once something is disturbed, as it must be to climb, descend, or turn, everything changes and you then have the job of putting it right again after making that climb, descent, or turn. Executing these transitions well is the defining skill for a competent instrument pilot. All it takes is three specific steps, performed consistently.

The Three Steps

There are three essential steps in the effective instrument scanning process. These steps are to be executed *every time a major attitude change is made*. In other words, when you make any *major attitude change*, you'll go through three steps, one right after the other, until the airplane is established in its new attitude. It should take approximately 10 to 15 seconds to accomplish all three steps. Here are the three steps of the scan, in the order they should be done:

Step 1: Select attitude and power. Trim and confirm.
Step 2: Radial scan the primary instruments.
Step 3: Trim using the VSI and monitor scan the 6-Pack

Essentially, the airplane is put in the desired attitude, power is adjusted, and an initial twist of trim is applied to hold the airplane in this attitude. The correct operation of the most critical instruments is checked by a confirmation process. The primary instruments are then scanned in an organized fashion, and small corrections are made to fine tune the airplane to the proper attitude. The final trim adjustment is made, and the airplane's new attitude is monitored on the six main flight instruments. This is the big picture of how the instruments are scanned in this three-step process. Let's take a more detailed look at how it works.

Step One of the Scan

The first step in the three-step scan is to select the attitude, power and trim conditions for the new flight attitude. This first step is executed by focusing on the attitude indicator and selecting, from experience, the attitude that educated approximation says will provide the desired flight conditions. If you're ever going to have an attitude, now is the time to do it. The implication here is that you have or are acquiring knowledge of the predetermined attitudes necessary to make the airplane climb, turn, and descend as commanded.

After the first few hours of instrument flying, you should decide on an array of specific power settings and flight attitudes that will cause the airplane to do exactly what you wish. These power settings and flight attitudes are values or reference points on the tachometer or manifold pressure gauge and attitude indicator. In a light general aviation trainer, climbs are typically done with full power (or nearly so) and a 5 to 10 degree nose-up pitch attitude. This will consistently result in a good climb rate and speed. Most turns are accomplished with a 15 to 20 degree bank. This is close to the bank necessary for a standard rate turn at normal cruising conditions.

Remember, a standard rate turn simply means that the nose of the airplane changes direction at three degrees per second. The easiest way to figure out what bank is required for a standard rate turn is to drop the last number off the airspeed and add the number 5. If the airspeed is 125 knots, then the bank required for standard rate is 12 + 5 or 17 degrees. If the airspeed is 90, then the standard rate bank is 9 + 5 or 14 degrees. If the airspeed is 600 knots, then the bank required is 65 degrees. This could be real interesting for the passengers! There is a good chance some of the older passengers will experience a dislodging of their uppers. The general rule is never to exceed 30 degrees of bank under IFR conditions even if something steeper is required for a standard rate turn.

After thousands of hours of exposure to g-forces caused by steep turns and turbulence, a pilot's body is subtly altered. One of the unique benefits of this condition is the tendency of the pilot to always remain upright if he topples off the seat in a fit of vertigo.

Someone once suggested that most airline pilots avoid steep turns because of the debilitating effects of G-forces on posture. After spending many years in a flight crew seat, professional pilots have been known to take on the shape of a Lazy-boy recliner. I suppose the critical stage is reached when pilots start to look like they have just graduated from the Quasimodo posture school.

No VFR pilot worth his or her weight in slow Hobbs meters would deny that looking outside at the horizon is a good thing. The earth's horizon is what allows you to keep your airplane in the correct attitude for flight. In fact, most pilots flying VFR spend well over 90% of their time referencing the visible horizon. Why should this be any different during instrument flight? When the earth's horizon is no longer visible, the airplane's attitude indicator (artificial horizon) is a most welcome substitute.

Step one of the instrument scan suggests that the attitude indicator be exclusively observed during major attitude changes. This is certainly contradictory to what you may have been told about instrument flying. It's always been considered a punishable offense to stare at any one instrument. For the most part, this is a good rule—except when it comes to step one of the scan.

The *Air Force Instrument Flying Manual* (AFM 51-37) states:

"The attitude indicator is the only instrument which you should observe continuously for any appreciable length of time. Several seconds may be needed to accomplish an attitude change required for a normal turn. During this period you may need to devote your attention almost exclusively to the attitude indicator to ensure good attitude control."

Since the USAF pretty much knows which side of an airplane is up, it's a sure bet that they have given this statement a great deal of thought. Problems with instrument scan often occur when you spend too little rather than too much time observing the attitude indicator.

Appendix-4

Many years ago, a military study of professional pilots discovered something educationally interesting. When cameras were targeted on the eyes of these professional pilots during their instrument scan, it was discovered they spent 85% of their time looking at the attitude indicator. The only reasonable conclusion that can be drawn is that this behavior has evolved because it is imminently useful and efficient. The pros know, and the rest of us will do well to follow.

The attitude indicator is a complete instrument. Unlike other instruments, it contains both pitch and bank information, so it's reasonable to focus on this instrument when changing attitude. If attitude indicators never failed, there would be no concern with them being the center of your attention. As an entry instrument, it is the core of the scan. But you cannot be obsessed with its presence nor crippled by its absence. These instruments do fail, often with disastrous consequences for anyone who is addicted to the attitude indicator but who rejects all other injections of information. Knowing how to detect instrument failure and correct for it is the defensive countermeasure that balances the emphasis on the attitude indicator.

Mind Twister

I was cleared for an immediate departure. I went through the final checklist: time, instruments, transponder and strobe. When checking the directional gyro with the compass and runway heading, I noticed it was 20 degrees off and made a mental note to keep track of precession.

After passing through about 500 feet, I was told to contact Departure. I acknowledged and hit the flip-flop button on the #1 com and called. I got no response, so I tuned the #2 com to Departure to try again. In my airplane, the radios are located beneath the yokes, with #2 on the bottom. This requires a large movement of the head in two axes. When I raised my head, I noted the attitude indicator was way off to the right, and I started to follow it. It became clear, almost immediately, that something was wrong, as the airspeed was building and the rate-of-climb was descending. I caught a glimpse of the approaching ground before I got back under control with the turn-and-bank and started to resume a climb. I simultaneously called Departure and declared a no-gyro emergency...The controllers acted with aplomb and reassurance, and a successful no-gyro ILS was accomplished.

What happened? The A.I. had a leak in the case (discovered by the instrument shop the next week) causing it to slow down and tilt and the D.G. to precess. The rapid head movement of returning the radio caused vertigo, and I started to follow the tumbling A.I. My instrument crosscheck located the defective gyros in time to prevent disaster. Partial panel ability with excellent assistance from ATC assured a successful landing.

How to prevent similar occurrences? I have raised my personal minimums for instrument takeoff in controlled airspace...

ASRS Report

In the first step of this scan, you will compare and validate the result of control input to the response of the attitude indicator. This is the confirmation process, which ensures that the attitude indicator is working properly. In other words, the attitude indicator should respond in a manner consistent with how the controls are moved. It's kind of like using an unseen instrument—the nonsense detector.

If control pressure is applied to make a right turn, the attitude indicator should show (brace yourself) a right turn deflection in proportion to the amount and rate of control input. Who said instrument flying is difficult? A slight amount of back pressure on the controls should show a gradually increasing pitch on the attitude indicator. Any discrepancy between control input and attitude response should be checked by consulting the turn or pitch "triangle of agreement. Keep in mind that you only need to check the turn or pitch triangle of agreement if you suspect the attitude indicator or any other flight instrument of error. In other words, it's not necessary to check the triangle of agreement every time a major attitude change is made. Of course, if you're going to *check* the triangle of agreement, we'd better take a look and see what it is.

Making Three Agree

A *triangle of agreement* is an attempt to solve a vexing instrument aviation problem. Sometimes instruments fail. When they do, how do you know for sure what's right and what's wrong? If you compare any two instruments showing the same kind of information, the best you can get is an unresolved disagreement. Instrument pilots inherently dislike ambiguity. So, we add the word from a third, with point, game, and match going to the two instruments that agree.

To take part in a triangle, the three participating instruments must show the same type of information (turn, climb, etc.) but be independent in terms of their power source. If the vacuum system fails, obviously *everything* that's vacuum powered will fail, so having two vacuum powered instruments in a triangle would create problems rather than solving them.

When you look at the instruments in a triangle of agreement, at least two of the three should agree, and should be consistent with the quality and quantity of control input.

The Turn Triangle of Agreement

For example, the *turn triangle of agreement* (Figure 1) consists of the attitude indicator, turn coordinator and magnetic compass. All three of these instruments respond to a turn. When turning, these instruments should reflect similar rates and similar directions of turn.

If the three don't agree, you have a problem *somewhere*. In the context of this discussion, *problem* is a nice way of saying something has gone belly up, and you now have an urgent need to know what's talking trash and what's giving you good information. If the lead suspect is the attitude indicator, the other two instruments of the triangle should be consulted, starting with the turn coordinator. If the turn coordinator does not reflect the attitude indicator's expected direction and rate of turn, the magnetic compass should be checked for movement. The instrument in disagreement with the other two is the one most likely to have failed.

For instance, if the attitude indicator reflects a turn and the compass shows a heading change, but the turn coordinator indicates a constant heading, this says that the turn coordinator is in error. The majority wins. It's just like professional wrestling,

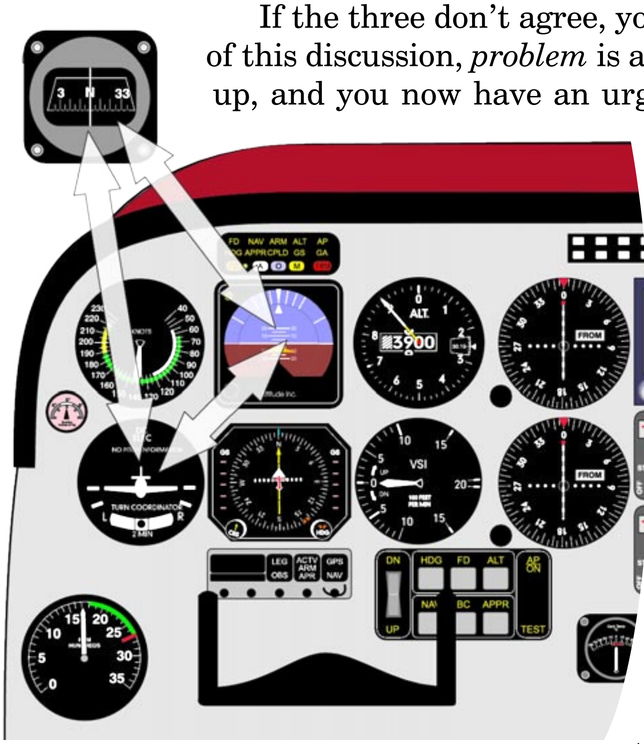


Figure 1. The turn triangle of agreement.

which, by the way, isn't real. If it's Wally, the Flying Cadaver Creator or Herbert, the Organ Donor Provider, the wrestler who has the loudest fans usually wins.

On most modern general aviation airplanes, the turn coordinator is electrically operated, the attitude indicator is vacuum powered and the magnetic compass is blessed and powered by Mother Nature. This means that each of these three turn indicators is operated by an independent power source, thus meeting our requirements for forming a triangle of agreement. Generally, these independent power sources won't all fail at once. Why isn't the heading indicator part of this triangle? The heading indicator on many (not all) airplanes is vacuum powered. Since it operates on the same power system as the attitude indicator, a failure of the vacuum system would render both these instruments inoperative.

Several years ago, a high performance, single engine, general aviation airplane entered a repair shop to have work done on the vacuum system. Apparently the mechanic forgot to put the air filter on the intake line that allows air to be drawn over the vacuum instruments by the vacuum pump (the air intake for this airplane was located on the engine side of the firewall). The aircraft departed IFR and entered a solid wall of precipitation. Water was drawn through the air intake of the vacuum line and into the vacuum system. The pilot stated that he looked up at his instruments and saw water filling up the attitude indicator and the heading indicator. Wow! Now that's something his instructor probably never told him about. What would most pilots think if this happened to them? Maybe they'd suddenly remember the full lyrics for The Beatles' *Yellow Submarine*. Or they might think the mechanic installed an auto-timed, self-lubricating, gyro system. Your job, as an instrument rated pilot, is to always be a Boy Scout (even if you're not a boy). Be prepared, mentally and operationally. Instruments can and do fail.

Though they're not officially part of the triangle, there are a few other instruments that can help you identify when the airplane is turning and which direction it's headed. If you're operating your panel mount GPS, it's possible that the instrument is sensitive enough to identify when the airplane changes heading. For instance, many portable GPS units show a ground track azimuth. When the airplane changes headings, the azimuth shows this change. Keep a heading constant on this azimuth and the airplane flies straight. Neat, eh?

Garmin's portable GPS units (and other manufacturers, too) provide pitch and turn information in the cockpit.

A good handheld GPS unit can do the same thing for you. For instance, the HSI mode on the Garmin 195 can be used as a supplemental bank instrument. In fact, the Garmin 196 handheld unit has a wide screen display that simulates airspeed, bank, altitude and vertical speed instruments through the use of GPS information.

If you have an ADF aboard your airplane, you can also use it to detect a turn. This is why many pilots keep their ADF tuned to a strong signal when flying instruments. If they have to consult the turn triangle of agreement, they need only look at the ADF needle to determine if the airplane is turning, as well as the direction in which it's turning.

A steady needle means the airplane is probably not turning. Keeping the ADF needle steady will keep the airplane on a constant heading.

The Pitch Triangle of Agreement

Creating a pitch triangle is a bit more challenging, because there are only two independently-powered instruments reporting pitch information. The pitch triangle of agreement (Figure 2) consists of the attitude indicator, vertical speed indicator and alternate static system. The attitude indicator and the VSI operate on separate power sources—vacuum and static pressure, respectively. Neither the airspeed indicator nor the altimeter can be used as the third instrument in the triangle, because both these instruments operate on the same static source as the VSI. If a pitch discrepancy exists between the attitude indicator and the VSI, it is possible the static source is blocked, in which case the altimeter and airspeed indicator may also read in error. The appropriate action is to eliminate the VSI as source of error. Simply activate the alternate static source and note any change in VSI indication. If the VSI's indication doesn't change with the selection of the alternate static source (other than an immediate needle wiggle when the static source is opened), the attitude indicator is most likely in error. If the VSI's indicator does change, then leave the alternate static source open.

What's required if you have a pitch discrepancy and don't have an alternate static source? Break the instrument, right? Which one? Break em' all and use Braille? When any instrument is to be broken, pilots often think first of the Hobbs meter. No matter how tempting this may be, it's not appropriate. Making a small break in the glass in the VSI would be the correct choice for creating an alternate static source. Of course, you should only do this if you are in actual IFR conditions. Imagine the heart attack the owner of the FBO will have if a student pilot returns from the traffic pattern with the VSI smashed.

Note that I said a "small break." A controlled impact keeps from smashing the VSI through the firewall into the engine compartment. Be aware that the VSI will work *backwards* if static pressure is sensed from the front of the instrument through the newly created opening. If it worked the same way with Hobbs meters, many pilots would invest heavily in precision glass smashing equipment.

With several means of checking for instrument failure, you should now feel much more confident about focusing on the attitude indicator during major attitude changes.

Setting Power in the First Step

After the initial attitude is selected, the power is adjusted for the desired flight condition. If selecting a climb, add power as you raise the nose. This reflects the principle, *pitch plus power equals performance*. There is no need to look at the

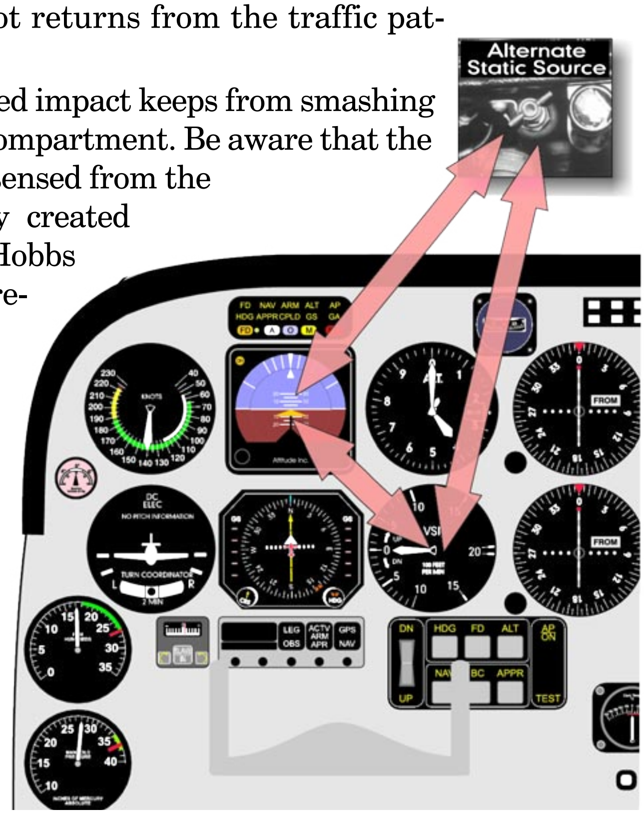


Figure 2. The pitch triangle of agreement.

tachometer when entering a climb in fixed pitch propeller airplanes, since the climb is accomplished at full power. In high performance airplanes, first the propeller (if necessary) and then the throttle control should be moved while the aircraft is entering the climb attitude. The propeller RPM and manifold setting can be set by making a quick glance at the engine instruments. Initially, this setting need only be approximate. A more precise setting can be made when the new attitude is finally established. When you gain experience, it's possible to make initial power settings by sound alone!

To enter a descent, the power is reduced first, then the attitude is adjusted. The more these two actions become simultaneous, the less indicated airspeed variance will be noticed by you and your passengers. It's not necessary to even look at the power gauges when the initial power reduction is made, since the setting can be approximated by experienced feel. You'll want to keep a keen eye on the attitude indicator during the attitude change, to maintain complete control of the aircraft in the transition.

Once an attitude is selected and power is adjusted, trim should be added to keep the selected attitude constant. This initial *gross* application of trim should be just enough to keep the airplane's attitude from wandering. All *Wheel of Fortune* fans should avoid the temptation to yell, "Come on, one thousand" when twisting the trim wheel. The final and more accurate application of trim should be completed in step three. Give the trim wheel a couple of good turns as experience indicates, then go on to step two.

Step Two of the Scan

Step two of the three-step scan procedure is to radial scan the primary instruments. Primary instruments are those that display the needed information to accomplish the intended maneuver. These instruments are primary in the sense they reaffirm that the selected attitude is correct. The primary instruments allow you to *fine tune* the attitude selected on the attitude indicator. The primary instruments also provide you with additional confirmation that the attitude indicator is reading correctly (please see "IFR Purist" sidebar on the exception to this observation.)

To radial scan means to begin the scan at the attitude indicator. I've made this easier to remember by placing the word *start* under the attitude indicator in Figure 3. You should then move to the appropriate primary instrument, extract information from it, return to the attitude indicator and make a correction in attitude, if necessary. This is called the *radial* scan because the visual scanning track is from the attitude indicator out to

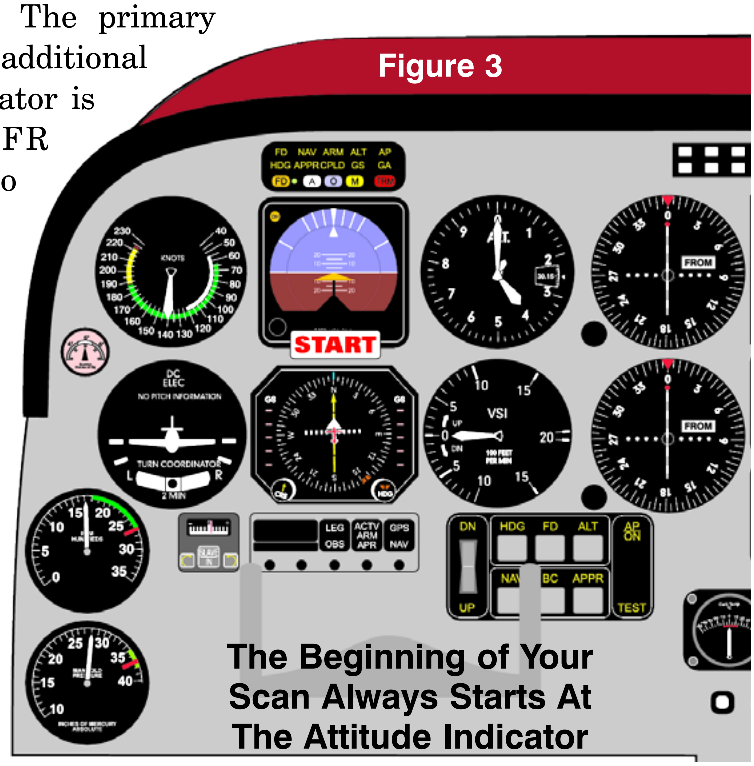


Figure 3

The Beginning of Your Scan Always Starts At The Attitude Indicator

The IFR Purist

I present the following case for the IFR purist. The primary instruments, with the occasional exception of the heading indicator, operate on power systems that are separate and independent from the attitude indicator. This means that a failure of one power system should be noticed as a discrepancy between the primary instrument and the attitude indicator. In many aircraft the heading indicator operates on the same vacuum system as the attitude indicator. Since the heading indicator is primary for bank when performing any "straight" maneuver (i.e., straight and level, straight climb or descent), there may be concern about how the attitude indicator's accuracy can be determined in this condition. In addition to checking control application against attitude indicator response, there are several other ways that erroneous bank information on the attitude indicator would be noticed:

1.The turn coordinator is easily within your peripheral vision when the heading indicator is being scanned. Any failure of the attitude indicator would probably be observed on the turn coordinator when the heading indicator is radial scanned. In other words, if the heading indicator isn't moving and the turn coordinator is, the vacuum system may have failed; therefore, the turn triangle of agreement should be consulted.

2. It's likely that a failed attitude indicator would first be noticed by a discrepancy in pitch information from the primary pitch instrument. This is particularly likely since our scan procedure teaches that the primary pitch instruments be radial scanned before the primary bank instruments.

3. The heading indicator and the attitude indicator, in a failing mode, are likely to indicate conflicting attitude information. This occurs as the gyros spin down and behave in a peculiar manner. Despite the attitude indicator and the heading indicator operating on the same power system, these additional means of detecting vacuum failure should be comforting to you.

the primary instrument, then back to the attitude indicator, making what appear to be spokes radiating from the attitude indicator to all the primary instruments, as shown in Figure 4.

The attitude indicator is marked *start* because this is where all attitude changes begin. It's very important that you understand how the radial scan is accomplished. Your eyes should move from the attitude indicator to a primary instrument, observe its reading or detect its movement, then return to the attitude indicator and make an attitude adjustment necessary to stabilize the primary instrument (Figure 4).

Unfortunately, readily identifying, in flight, which instruments are primary for a given flight condition is difficult for many new instrument pilots. Experienced professionals know exactly what instrument they need to look at to make the airplane fly precisely. In fact, skill at instrument flying lies not so much in scanning all the instruments, but in learning which instruments deserve the greatest investment of time at any given moment. When time is spent efficiently, the airplane is easily controlled. This is where instant recognition of the primary instruments becomes very important if you want to fly instruments with success.

Figure 4

Radial Scanning Always Starts At The Attitude Indicator

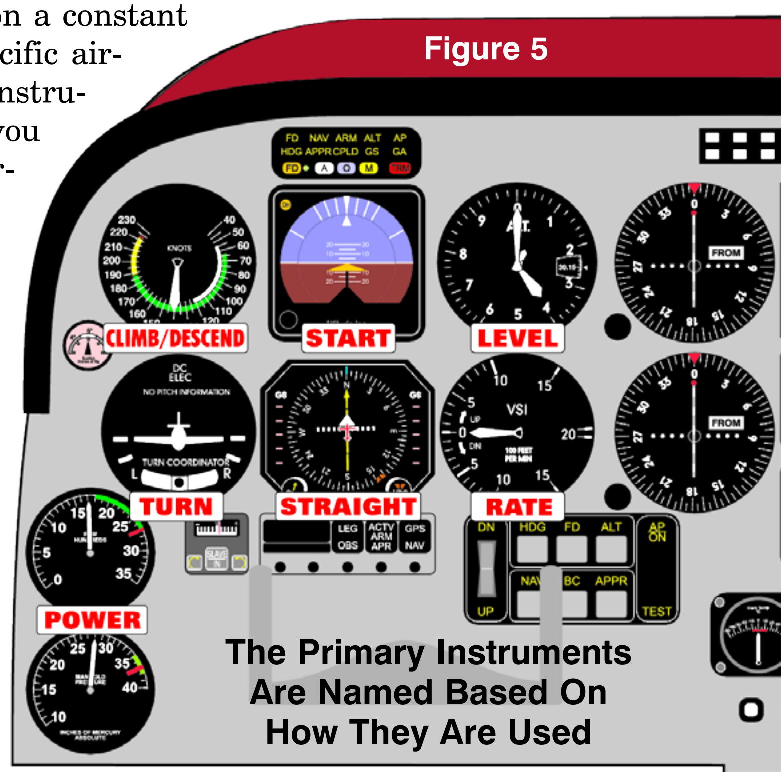
Appendix-4

There are always going to be *three* primary instruments for any condition of flight: one for *pitch*, one for *bank* and one for *power*.

If you know which instruments are primary, you can avoid the ocular waste resulting from scanning instruments that provide only redundant information. The best way to recognize these primary instruments is to tape the words shown in Figure 5 under each instrument on the panel. The FAA considers the word *bank* to be associated with either *holding a heading* or *a heading change*. This makes sense, considering that controlling the bank is directly related to the control of the heading.

Figure 5 shows which instruments are primary for specific conditions of flight. For instance, in straight and level flight you should look at the panel and find those instruments listed as *straight* and *level*. The directional gyro is primary for bank, or, going straight, the altimeter is primary for pitch (remaining *level* in this instance) and the tachometer is primary for power (Note: If you are trying to maintain a specific airspeed in straight and level flight, then your airspeed indicator will be primary for power. Under typical IFR conditions, however, we usually use our RPM or manifold pressure gauge to set our power and don't worry too much about trying to maintain a specific airspeed). In constant airspeed climbs or descents, airspeed is always the primary pitch instrument. In a turn, the turn coordinator is always primary for bank. The primary instruments for a climbing turn would be airspeed for pitch, turn coordinator for bank and tachometer for power. The primary instruments for a level turn would be: altimeter for pitch, turn coordinator for bank and tachometer for power.

In a *straight climb* or *descent*, at a specific *rate*, the VSI is primary for pitch and the heading indicator is primary for bank. If a specific airspeed is necessary for the constant rate descent (and it most often is on ILS approaches), then the airspeed indicator will be primary for power. This is one of the few situations where the tachometer is not primary for power as listed. Think of it this way, "What is the job to be accomplished and what is primary to do the job?" The job, on a constant rate descent, is to maintain a specific airspeed, heading and rate. The only instrument that can do the job of telling you if the airspeed is correct is the airspeed indicator. Power is modified to maintain this specific airspeed.



So, to determine which instruments are primary, you should seek the words under each instrument making up the intended flight condition. This visual prompt precludes the awkward mechanics of having to rigidly memorize the primary instruments. This can be a difficult task for the neophyte, when instrument relationships may yet be a bit murky. After you have flown IFR for awhile with the primary instruments labeled, these will become familiar and the words can be removed from the panel.

Of course, removing these taped-on words assumes they have not been welded on with *super tape*. I think this super tape is made by the same people who make the instructor's *No-Peekies*. These are the round attachable items that are placed over individual instruments to simulate partial panel operations. These suction cups are sometimes so powerful they can pull the entire instrument right out of its socket. I've seen a student pull so hard on one of these that he yanked the glass covering completely off the airspeed indicator. As punishment, I think I placed a No-Peekie over the left lens of his eyeglasses and the critical instruments at the same time. I believe this is called *partial-partial panel*.

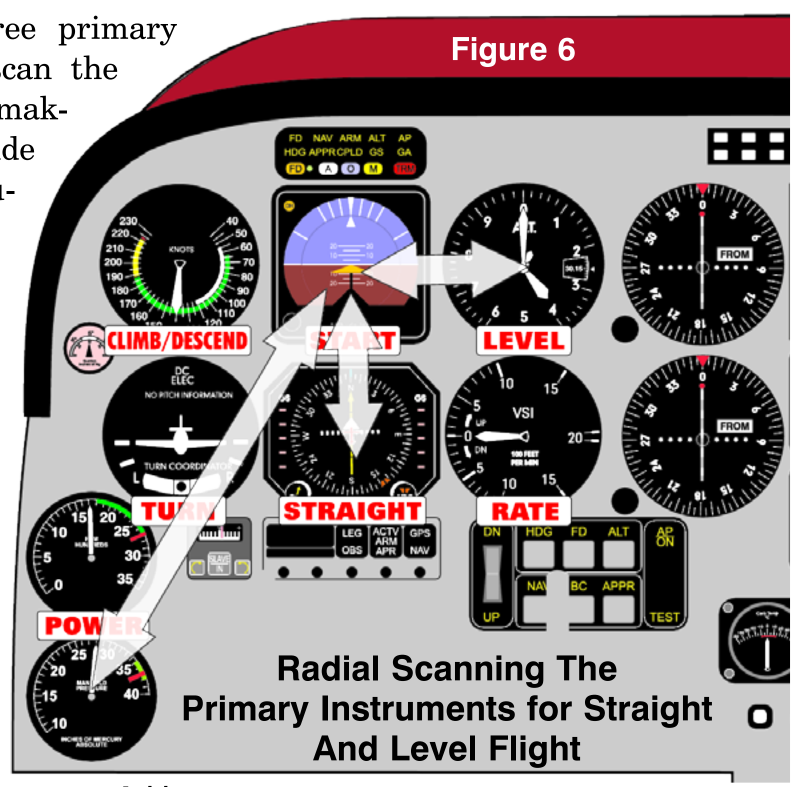
Let's examine the scan for straight and level flight more closely (Figure 6). You would immediately radial scan the altimeter by observing it, then return to the attitude indicator. If the altimeter needle was moving, a small pitch change would be made on the attitude indicator to neutralize and then correct this movement. The heading indicator should be radial scanned next, by observing it and returning to the attitude indicator. If the heading indicator was turning, or was not on the desired heading, a small correction in bank would be applied to the attitude indicator. Use a five degree bank correction on the attitude indicator to return to a heading that's not off by more than 20 degrees. It's important to stop a straying parameter, then correct it.

The tachometer or manifold pressure gauge should be radial scanned last. Look at these instruments and make any final adjustment in the setting, then immediately return to the attitude indicator. There is usually no need to initially radial scan either of these power instruments more than once during a major attitude change. If carburetor or induction system ice is suspected or detected, then the power instruments should be scanned more often.

After radial scanning all three primary instruments, alternately radial scan the altimeter and heading indicator, making small corrections on the attitude indicator to stabilize these instruments.

Notice how the pitch instruments were radial scanned first, the bank instruments second and the tachometer last. In other words, the primary instruments were radial scanned from the top of the panel in a downward direction. This is effective because pitch changes are more critical and require more time to correct than bank changes. Remember, an ATC violation can occur if you are off your assigned altitude by

Figure 6



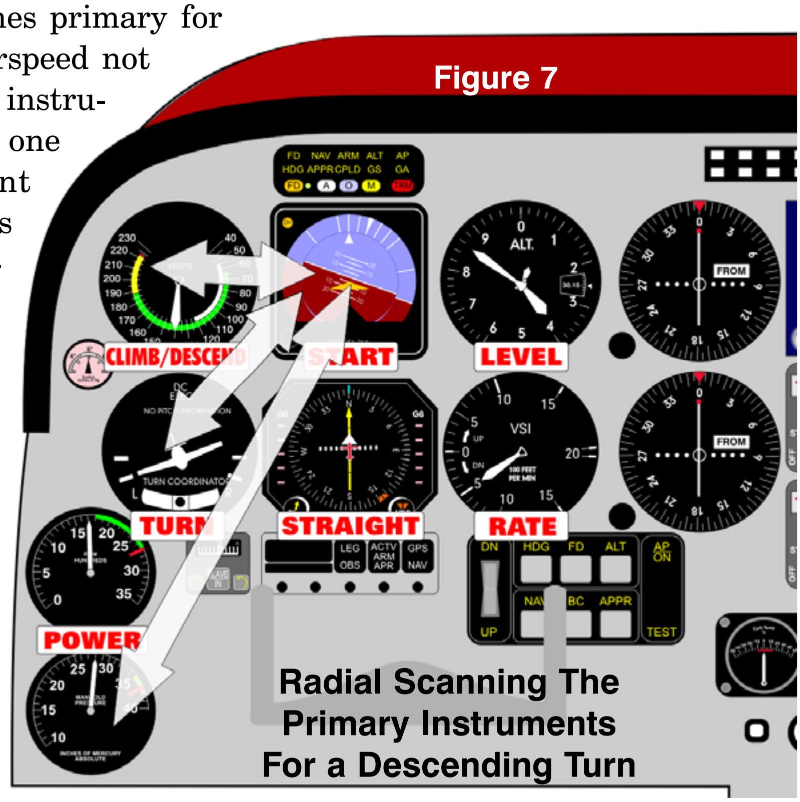
Radial Scanning The Primary Instruments for Straight And Level Flight

300 feet. Being 30 degrees off an assigned heading for a very short period of time, however, does not normally ring bells and whistles. RPM or manifold pressure changes are the least critical and take the least time of all to correct.

In no way am I suggesting that it's proper for you to be off your assigned heading. I'm merely pointing out how the ATC system prioritizes flight deviations. I fully realize that some folks may have difficulty holding headings. In fact, as an instrument student, I was often tempted to reach up and twist the heading indicator back to the assigned heading when my instructor wasn't watching. Of course I would have corrected it later. I suggested to my instructor that some pilots might pay handsomely for electric heading adjustment knobs in their aircraft. I thought these little devices could come in handy, especially on IFR checkrides. These observations pretty much explain why my instrument instructor bid for early retirement to the place where all crazed flight instructors go: *La Casa de Burnout*. It's been several decades, but I think he's still there.

Figure 7 shows the proper instrument scan for a *descending turn*. The primary instruments for this condition are airspeed for pitch, turn coordinator for bank, and the tachometer for power. The power is reduced as a 15 degree (or the bank necessary for a standard rate turn) left banked turn of approximately three degrees nose down pitch is selected. An initial application of trim is applied to stabilize the airplane, thereby completing step one of the scan. The airspeed indicator, turn coordinator and tachometer are initially radial scanned and small adjustments to the attitude indicator are made to make the primary instruments indicate as desired.

Figure 8 shows the proper instrument scan for an ILS approach. The ILS approach requires that a constant rate descent be maintained, as well as a specific airspeed. The VSI becomes primary for pitch control, the heading indicator becomes primary for bank and the airspeed indicator becomes primary for power. Remember, despite the airspeed not being labeled a primary power instrument in Figure 5, this is the one exception to primary instrument identity. The throttle position is predicated on maintaining a specific airspeed, and the airspeed indicator thus becomes primary for power.



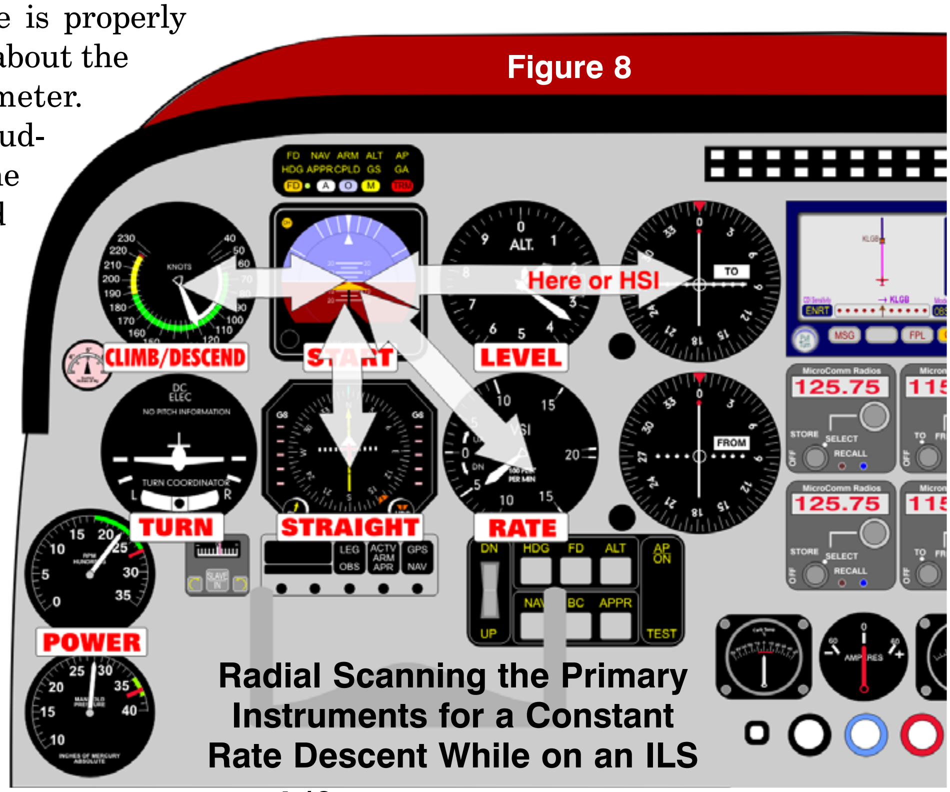
Step Three of the Scan

Step three, the last step, is to make the final trim adjustments using the VSI, and monitor scan the new aircraft attitude on the 6-Pack instruments, which I'll describe shortly. Step three is accomplished once all the primary instruments have been radial scanned and are indicating the proper values. If rudder trim is available, it should be used first, followed by aileron trim, then elevator trim.

For most small general aviation airplanes, the elevator trim will usually be the only one available. To properly trim the airplane for pitch, the VSI should be used. This instrument is very sensitive for *small* pitch changes and will indicate almost immediately the direction of movement. The VSI also has a large, noticeable needle swing that is visually easy to identify. When leveling off, or when established in a climb or descent, trim for a constant VSI indication.

A gradual easing of control pressure will make it evident if the airplane is properly trimmed. There is never any reason to suddenly let go of the controls when trimming, as though scalded by a hot pot, just to see what the airplane will do. This causes pilots more heartaches than it's worth (and scares the passengers, too). By letting completely go of the controls, an untrimmed airplane could rapidly deviate from the planned flight attitude, depending on just how out of trim it was. You would then face the task of returning the airplane to its previous flight condition before it could be retrimmed. Your unfortunate passengers, meanwhile, might think you're trying to qualify for a merit badge in the Evil Knievel fan club. It's so much easier to ease up ever so slightly on control pressure, study VSI movement, and make a corresponding change in the trim. Very small adjustments in trim can now be made without having to recapture a runaway airplane (or passengers!). Another valid reason to hold on while trimming is turbulence. In turbulent air, you can still apply aileron control while trimming for pitch.

Of course, once the airplane is properly trimmed, there's no reason to keep your hands on the controls all the time. Feel free to release them as you see fit. Under these circumstances, it's perfectly acceptable to use the rudder to control the direction of the aircraft as long as the airplane is properly trimmed. Don't worry about the ball in the inclinometer. Simply apply enough rudder pressure to keep the airplane on its desired heading. Your hands are now free to sort charts, tune radios and complete other cockpit chores requiring the use of more than one hand. The airplane may wander up and down a bit, but it shouldn't stray a great deal from the desired flight condition. This is consistent with what you



Radial Scanning the Primary Instruments for a Constant Rate Descent While on an ILS already know. You *walked* the airplane down a runway for takeoff and you *walked* a heading with your feet to land. Minor heading changes are easily *walked* enroute also.

After the final trim adjustments are made, the *6-Pack* or six main panel instruments, are monitored. This may be done in a sideways fashion, going from the top row to the bottom row of instruments, or in a clockwise, circular fashion as shown in Figure 9. Select any scanning pattern with which you feel comfortable. The objective is to monitor deviations from the established attitude. When deviations are noted, make small adjustments using the attitude indicator to maintain the desired flight conditions. This is the steady state condition, the one in which you will spend most of your time. It is the condition between major attitude changes.

The first two steps of the three-step scan process should take about 10 seconds, with each step taking about 5 seconds. There are instances where you must return to step two of the scan. In turbulence, or when on an instrument approach, you may find yourself obliged to rapidly radial scan the primary instruments to maintain precise control of the airplane.

Hail of an Idea!

This story is that when all the lights went out and all those circuit breakers started tripping, the First Officer and I were well equipped with size D cell flashlights—you know, those heavy duty jobbers made of aluminum that the fuel truck could run over and not squash. His was a two-cell and mine a three-cell. Lots of long lasting light to supplement the lousy two light bulbs that are supposed to illuminate the instrument panel—or what is left of the instrument panel when one is operating on emergency power.

We had our hands full. The stabilizer was stuck at 1/2 degree so the bloomin' airplane was trying to dive into the ground; the auto pressurization had failed along with auto temp control and, of course, the autopilot. The captain's heading and attitude indicator circuit breakers had tripped so heading information was available only from the standby compass which is not illuminated and has to be viewed through two mirrors... but that is another story. What I needed here was one of those little flashlights that you can hold in your teeth. To give you one more hand to fight the airplane with. Like fighter pilots use. Like I now carry in my flight bag as a backup. Along with the spare batteries and bulbs that zing the x-ray machines. We made it down OK...and my big ol' three-cell was still running when the last of the passengers walked off, just as the ship's batteries ran down.

So there you have it folks: The 'D' cell flashlight (or its equivalent) is required by FARs for some aircraft. But no matter what bird you fly, some of you may decide that it makes good sense to pack a mini-flashlight as your backup.

ASRS Report

Remember, radial scanning is a lot of work visually, intellectually, and emotionally. It is possible to radial scan all the instruments on the panel, but this is usually unnecessary and can become very tiresome. Radial scan only the minimum instruments necessary to control the airplane.

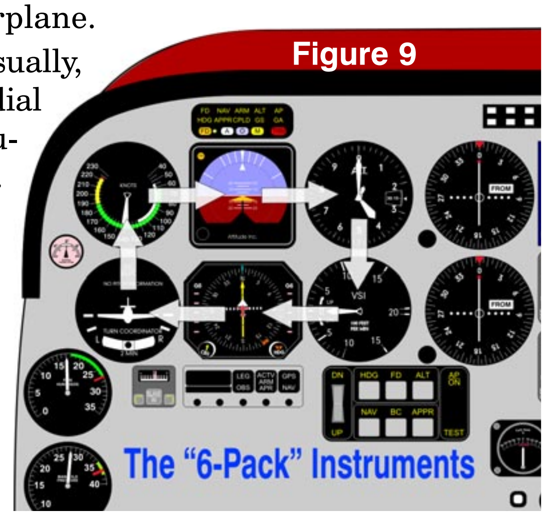
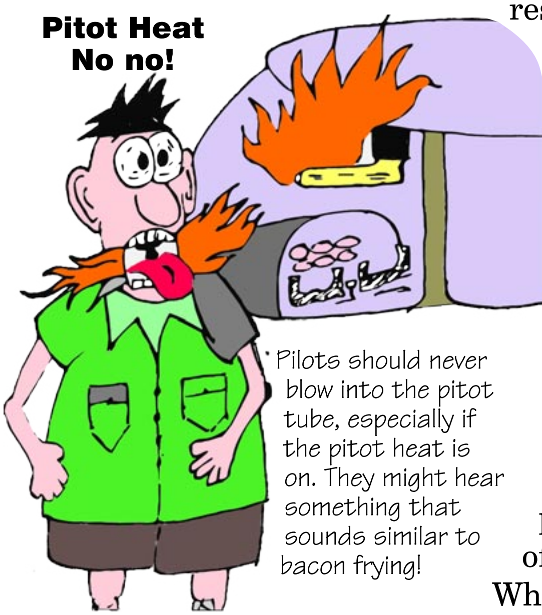


Figure 9

Tips From the Professionals

Some professionals have a rather unusual method of detecting instrument deviation once the airplane is established in its new attitude and trimmed. They focus their vision in the center of the panel, just underneath the attitude indicator and rely on their peripheral vision to watch for instrument movement. In much the same way a speed reader is taught to take in three to four words at a glance, you can absorb information from clusters of instruments at a single glance. Developing this ability takes practice, but it does seem to represent a more evolved level of instrument flying. Until then, when step three of the scan is completed, you should keep your eyes moving around the panel, looking for attitude deviations.



Pilots should never blow into the pitot tube, especially if the pitot heat is on. They might hear something that sounds similar to bacon frying!

The radial scan is also useful for scanning non-control items in the aircraft. Everyone has probably had the perilous experience of driving an automobile with a bumblebee inside the car when the little critter goes on the attack. From the outside, the hand movements look like a hyperexcited person in convulsions, trying to land a B-29. Most folks don't crash their cars in these instances because of the way they allocate their time and attention to the problem. They look at the road, go hunting for the offending critter, then look back at the road again. While the little varmint is yelling, "Tora, Tora, Tora," the insect is being radial scanned, with the road being the start point of the scan. This is similar to the role of the attitude indicator in the radial scanning process.

The radial scan should be used when scanning approach plates, radios, engine instruments or copying in-flight clearances. The secret to airplane control when looking away from the panel is to return to the attitude indicator every few seconds and make small adjustments to keep the airplane on the planned flight path.

Subtle Secrets

After a certain amount of exposure to instrument flying, many pilots start to notice subtle secrets that make instrument flying easier. Professionals understand that these little bits of information are what add polish to the art of flying instruments. In many cases, these subtle clues directly contradict what you may have heard about instrument procedures.

For instance, does the airspeed indicator have a lag in its response? Many instrument pilots say it does. Experienced professionals know this just isn't accurate. If a pilot walked out to an airplane and blew into the pitot tube, two things would happen. One, all the valves on every mechanic's heart would seize with shock at such a sight. *Never* blow into a pitot tube, under any circumstance. The delicate pressure sensing mechanism inside the instrument would be immediately damaged. Second, the instant a pilot blew into the pitot tube, the airspeed needle would immediately indicate Mach 3. There would be no appreciable lag in this instrument.

The apparent lag in the airspeed indicator is caused by the airplane's inertia, or resistance to changing speed. When the nose is raised, the airplane begins losing speed. It may take a few seconds for the airplane to settle down to a new velocity. This implies that you should select a specific attitude, then wait for the airspeed to settle down to its final value. If the airspeed is still off its assignment, then change the attitude and wait for the new indication. That's why the deviation is stopped first, then a correction is applied. Chasing the airspeed indicator is a common error among new instrument pilots. You won't see the pros do it. When you get a few instrument flying hours under your belt, you'll learn that time can be saved by memorizing an array of power settings for specific conditions of flight. Setting 1,900 RPM into the tachometer yields a constant rate descent of approximately 500 feet per minute at 100 knots in small airplanes such as a Cessna 172 or Piper Warrior. The difficulty arises when the RPM is set while the airplane is above the intended approach speed. Professionals are aware that when power is reduced from the cruise setting to 1,900 RPM, the higher airspeed will have a pinwheel effect on the tachometer reading. Essentially, the higher airspeed will cause the RPM to act like a pinwheel and vary with a change in airspeed. When the airplane is slowed to the new approach speed, the decrease in wind flowing over the propeller causes the RPM to settle to a lower setting.

Serious Cirrus Thoughts

Approach called with instructions to use the DME arc to Runway 13 ILS. The weather was ideal. I had never executed a DME arc before. Neither Approach nor the tower caused the problem which occurred. This airport does not have radar. All of my instrument training had been in a radar environment. I flew the arc well, but in retrospect I realize that I flew it too well. I flew right through the localizer without realizing it, and continued around the arc for a while before I realized my error. There was no danger this time, but I have not been able to stop thinking about just how bad this could have been in real IFR weather. My training and checkride was in a single without DME; now I fly a twin with DME. I made sure when I bought the twin that I knew how to fly it. I should have had instruction on the DME as well. Now I know better!

ASRS Report

You can handle this problem by setting the tachometer about 50 to 75 RPM *higher* than the desired setting when slowing the airplane. When increasing speed, set the tachometer 50 to 75 RPM *lower* than the desired setting, since the RPM indication will increase with an increase in airspeed.

You'll also discover that the attitude indicator offers its own brand of instrument error. At the completion of a 180 degree turn, the attitude indicator will experience its greatest error due to precession, indicating a slight climb and a slight turn in the opposite direction. This precessional error tends to cancel itself out if an additional 180 degrees of turn is made in the same direction. When making a turn of approximately 180 degrees, be prepared for the attitude indicator to precess, and anticipate its reading to be slightly in error. This precessional error varies between instruments and will generally take from 5 to 15 seconds to completely disappear. This emphasizes the value of the primary instruments during this short period.

The vertical speed indicator is an instrument that has not received the credit it deserves. While the VSI does have a very slight lag, you can quickly learn to anticipate this and become fairly good at flying specific rates. This is what allows someone who is considered to be a *good stick* to fly the VSI on an ILS and keep the indication within 20 to 30 feet per minute of a specific indication in smooth air. When the airplane's attitude is *abruptly* changed, the VSI will initially show a very slight climb or descent in the opposite direction. This is because of the inertia of the needle and inner mechanisms, which varies with changes in G-force. This is why the VSI is a superb trend indicator.

The VSI, once mastered, provides useful information for precise control of an aircraft. Taking time to learn to fly the VSI with a great deal of precision pays off handsomely. You'll find the VSI very useful in level flight. Instead of radial scanning only the altimeter during any level flight condition, you'll scan the VSI as well. The large swing arc of the needle and its greater sensitivity make it easy to detect a deviation from level flight.

Meet Inspector Pinkslip

He's a checkride machine. If he doesn't scare you then you're already dead.

You should practice until you can keep the VSI needle within 50 feet per minute of a specific value during a constant rate descent in smooth air. If you can do this, you can probably pass the toughest ATP checkride, even if it's with an inspector named Mr. Pinkslip. I've seen pilots who can keep the needle paralyzed at a specific rate. It often looks like the VSI is broken! These pilots realize that precision control of the VSI is the key to shooting enviable ILS approaches and maintaining altitudes within the 10- to 20-foot mark. This is certainly a skill worth developing.

Flying Glass

If you've stepped into some of today's modern production airplanes, you'll notice that they're not anything like your daddy's airplane. Many are now equipped with what's become known as *glass cockpits*. At first, this sounds like an immediate restriction on anyone who enjoys flying in his underwear. And I don't mean to throw stones at those with such proclivities (which you should never do in a glass cockpit…throw stones, that is), but that's not what "glass" means. I'm referring to technically advanced airplanes having electronic flight displays, specifically a primary flight display (PFD) and possibly a multifunction flight display (MFD), as shown in Figure 10.

Earlier in this chapter we covered the instrument scan on airplanes with traditional analog gauges. The question that you may be asking now is, "How do I scan the instruments on a PFD?"

The answer is deceptively simple. *You scan them the same way you do any other six pack of analog flight instruments*. The instruments on a PFD provide you with the same information as analog instruments, and a bit more, too. Sure, the instruments may have shifted position and mor-

Figure 10. Today's glass cockpits with PFDs and MFDs are nothing like your daddy's airplane.

phed in shape, just like airline pilots do over a long career, but they're still flight instruments. The three fundamentals of instrument flying—cross check, interpretation and control—remain exactly the same, with the minor difference being in how you interpret a tape-type digital airspeed indicator and altimeter as well as the instrument's trend lines (found on several PFDs).

Let's explore a generic PFD and see how our three-step scan plays out using this equipment. The one I'll use is similar to the popular Garmin G1000 (they call it a G1000 because 1,000 is the number of times you'll say "Gee!" when you hear how much it costs). Keep in mind that this chapter is about scanning the PFD, not understanding the engineering behind it. The inner workings of your PFD is best left to books like my *Instrument Flying Handbook*, your avionics operations manual or any of the great books on the market that discuss the mechanics of how these devices work.

The PFD

Figure 11 shows the instruments found on a common PFD. The very first thing you should notice is that the flight instruments are clustered into four main areas. There's the airspeed tape on the left, the altimeter tape and the vertical speed indicator on the right, the heading indicator as a slaved gyro in combination with an HSI at bottom center and, behind the entire cadre of instruments, is the attitude indicator making up the entire background of the PFD.

The striking thing about the PFD is that the attitude indicator is enormous. In a sense, what is often called the *artificial horizon* is so large that it almost doesn't seem artificial anymore. It's as if someone cut out a large square of the instrument panel the size of the PFD just so you could see the real horizon through it. Many pilots enjoy the

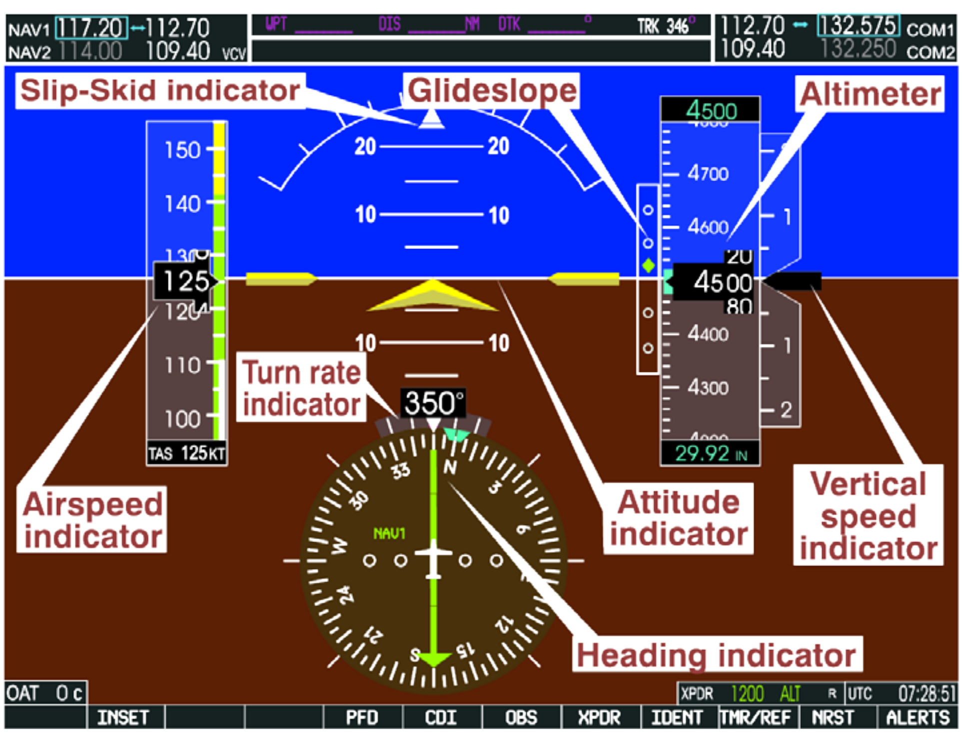


Figure 11. The typical PFD (primary flight display) shows all the standard flight instruments in a center cluster with the attitude indicator set in the background of the display.

size of the attitude indicator since it makes for easier interpretation and greater precision in attitude control. Because of its size, it's often more believable for some pilots than the tiny (by comparison) size of the traditional analog version of the instrument. This is why it's often easier for pilots to move from an analog attitude indicator to a PFD than the other way around.

The tape type airspeed indicator and altimeter are newcomers to the general aviation instrument world. At first it may seem unnatural to place the values of airspeed and altitude on a vertical scale. Yet, when you think about, a vertical scale actually better models the numerical values of each instrument than needle-type instruments. Why? Because a vertical change in attitude (up or down pitch) typically results in an airspeed and altitude change. Change your attitude on the attitude indicator's scale (also a vertically calibrated instrument) and you typically change a value on the vertically calibrated airspeed and altimeter tape. The models match. The universe is in harmony and birds and cats are finally friends. Well, not quite.

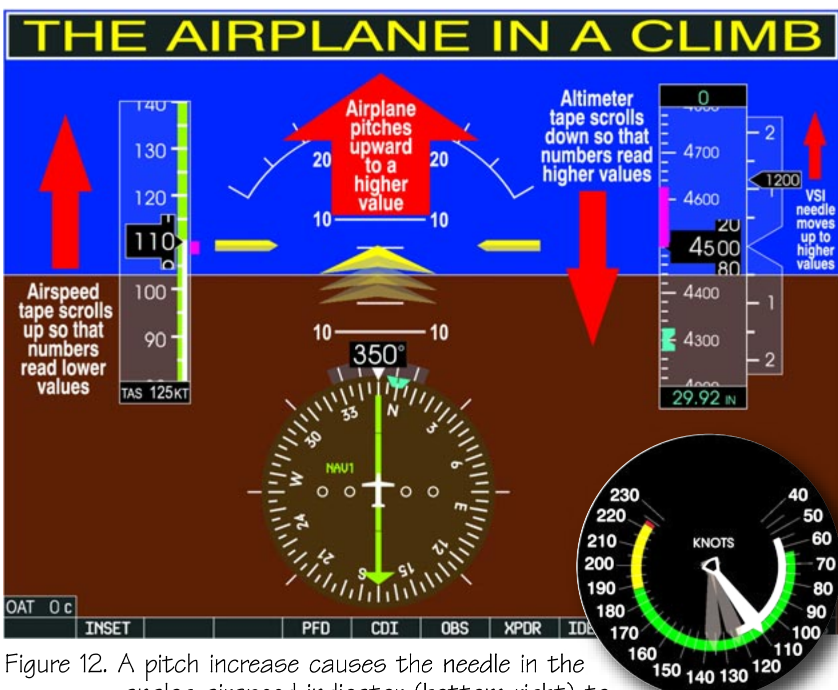


Figure 12. A pitch increase causes the needle in the analog airspeed indicator (bottom right) to swing upward toward lower airspeed numbers. The PFD's airspeed tape also scrolls upward (showing smaller airspeed numbers) but the airplane appears to pitch toward the higher airspeed values, which is counterintuitive to some pilots.

While the altimeter tape is intuitive and easy to interpret, the airspeed tape is initially a bit more challenging. The problem is that these tapes move in opposite directions as shown in Figure 12. Increase the pitch and the altimeter tape scrolls downward, thereby showing larger numbers in the altimeter tape window. This type of movement seems intuitive since the airplane pitches up toward the higher altitude numbers. The same pitch increase produces an upward movement (scroll) of the airspeed tape, which produces smaller numbers in the airspeed tape window. This is counterintuitive to most pilots, since the airplane seems to be pitching up toward larger airspeed numbers located at a higher position on the airspeed tape. This certainly isn't the way it works on an analog airspeed indicator, where pitching up swings the airspeed needle upward toward smaller numbers and pitching down swings the airspeed needle toward larger numbers.

Because of this counterintuitive design, pilots initially trained on analog instruments who transition to a PFD often have to convert digital airspeed changes (say, 105 knots to 85 knots) into movement of an imaginary airspeed needle before they can interpret what they see. Anyone used to watches with moveable hands knows that it's not uncommon to convert the digital watch readout into tiny hand positions before assessing the time. Some pilots overcome this confusion by imagining that an upward pitch on an airspeed tape actually pulls the lower numbers upward toward the center of the airspeed tape display and a downward pitch pushes the higher numbers downward toward the center of the airspeed tape display. Other than the issue with the airspeed tape, most pilots find learning on or transitioning to glass instruments relatively easy, with one additional exception.

The initial challenge for these pilots is maintaining the selected value of airspeed or altitude while resisting the urge to chase that number from one end of the kingdom to the other when that value varies slightly. Most pilots, after all, don't panic when they see an altimeter needle move 20 feet, a value that matches the width of the altimeter needle on the altimeter's scale (Figure 13). On a PFD, however, a 20 foot variation means that the digital value of the assigned altitude is no longer present in the display window. Now the chase begins. This is one more reason why pilots flying glass need to place more emphasis on attitude control to produce the desired airspeed, altitude and turn values instead of keeping a specific number precisely centered in a display window. Don't get me wrong here. You should be able to hold your altitude, but you shouldn't be a fanatic about it. You shouldn't treat the altitude, airspeed and rate variations any differently than you would when flying airplanes having analog instruments. Then again, you can hold altitude a lot easier on a PFD if you set the altitude bug on the desired altitude. Now you hold the bug, not the number, assuming you don't mind holding bugs!

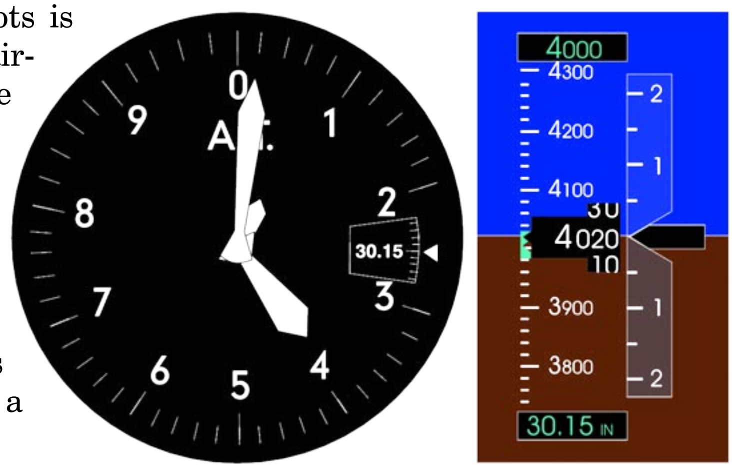


Figure 13. A 20 foot variation in the analog altimeter isn't as noticeable or attention grabbing as it is in the altimeter tape display on a PFD.

The fact is that pilots love needles because they're a better fit for the pilot brain. You can see a needle's swing and, as a result, predict where it will be a few seconds from now. Needles display their own trends, which is why the loss of needles adds to the loss of trend indication. That's why manufacturers of PFDs have added magenta trend lines to all those instruments that once had needles or used needle-like behavior (airspeed indicator, altimeter and turn trend lines), as shown in Figure 14, positions A, B and C.

Figure 14. The magenta trend (vector) lines on a PFD (climbing) extend to where the airplane will be six seconds in the future.

The end of these magenta trend lines grows or shrinks to show where the airplane will be six seconds into the future.

Figure 14 represents an airplane in a climbing left turn. Notice that the airspeed trend line (position A) moves opposite the altitude trend line (position B). Despite the counterintuitive airspeed tape, this should make sense since the trend is toward a lower airspeed. In a sense, the airspeed's trend line helps (at least a little) compensate for the counterintuitive (reversed) calibration of the airspeed tape. Figure 15 shows the airplane in a right descending turn.

Figure 15, position F shows the turn trend line, which takes the place of the analog turn coordinator. There are two indices that are located 18 degrees to the immediate left and right of the airplane's present heading at the top of the heading indicator. When the airplane is turning at 3 degrees per second (a standard rate turn), the turn trend line is on the second (18 degree) index. Hopefully this also makes sense, since the trend line projects where the airplane will be six seconds into the future, and three degrees times six seconds equals 18 degrees. A half-standard rate turn is accomplished by banking the airplane until the trend line is on the first index to the right or left of the airplane's present heading.

Figure 15. The magenta trend (vector) lines on a PFD (descending) extend to where the airplane will be six seconds in the future.

The one instrument that we haven't mentioned is the vertical speed indicator. This instrument is often a vertically calibrated instrument, although some PFD manufacturers have left this instrument in needle-based form as shown in Figure 16.

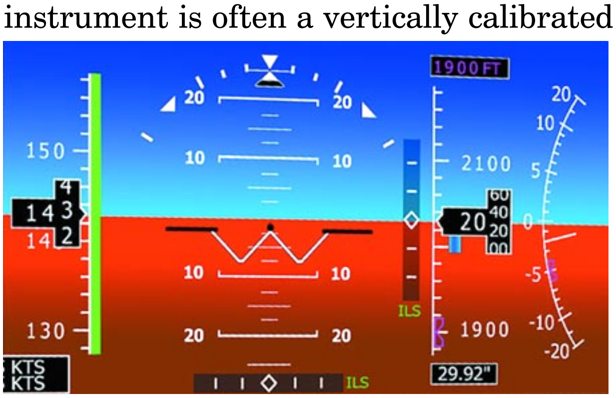


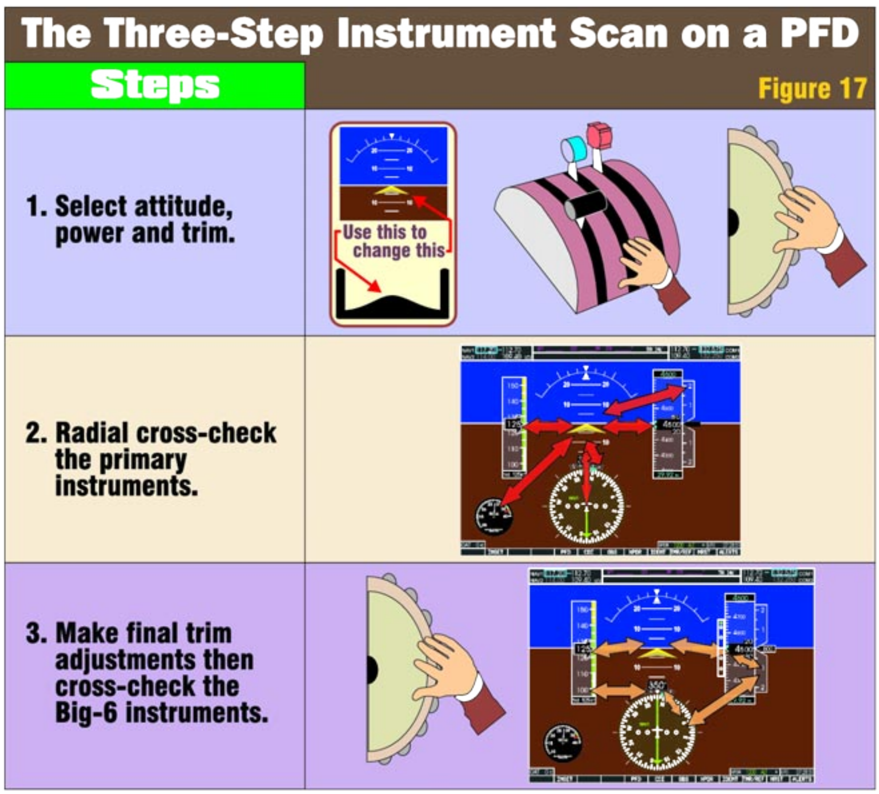
Figure 16. Some manufacturers keep the VSI needle on their PFDs in needle (analog) form.

Now that you've got the gist of glass, let's use our three-step scan procedure on a PFD. This information will be nearly the same as what you've read about scanning analog instruments. The main difference here is that you don't really need to concern yourself with the *pitch* and *bank* triangles of agreement in the event of an instrument failure. That's because if and when an instrument fails on a PFD it's usually revealed by an instrument warning that you simply can't help but see unless you've spent your life arc welding without the helmet. So we won't chat about these agreement triangles here, despite our having respect for our welders.

Appendix-4

The Three Steps

There are three essential steps in the instrument scanning process. As with our analog instruments, these steps are to be executed *every time a major attitude change is made*. Completing all three steps should take no more than 10-15 seconds. Make any *major attitude change* and you must go through three steps, one right after the other, until the airplane is established in its new attitude. Failure to comprehend this important point means you've missed the essence of this entire chapter. Major attitude changes require all three steps to be performed.



The big picture of these three steps goes something like this. The airplane is put in the desired attitude, power is adjusted, and an initial twist of trim wheel or push of the trim button is applied to hold the airplane in this attitude. The primary instruments are then scanned in an organized fashion, and small corrections are made to fine tune the airplane to the proper attitude. The final trim adjustment is made, and the airplane's new attitude is monitored on the six main flight instruments (Figure 17). Now, let's take a more detailed look at how this works on a PFD.

Step One of the Scan

The first step in the three-step scan is to select the attitude, power and trim conditions for the new flight attitude. This step is executed by focusing solely on the attitude indicator and selecting the attitude that experience says will provide the desired flight conditions. The attitude indicator's size means the ability to be very precise in the selection of a pitch or bank attitude. The implication here is that you have or are acquiring knowledge of the predetermined attitudes necessary to make the airplane climb, turn, and descend as commanded.

Setting Power in the First Step

After you select the initial attitude, adjust the power for the selected flight condition. If selecting a climb, add power as you raise the nose. This reflects the principle, *pitch plus power equals performance*. There is no need to look at the manifold pressure when entering a climb in fixed pitch propeller airplanes, since the climb is accomplished at full power. In many of the technically advanced airplanes on the market today, the use of FADEC (full authority digital engine control) means you only need to move the throttle and leave the prop control untouched. Initially, this setting need only be approximate. A more precise setting can be made when the new attitude is finally established. When you gain experience, it's possible to make initial power settings by sound alone!

To enter a descent, the power is reduced first, then the attitude is adjusted. The more these two actions become simultaneous, the less indicated airspeed variance will be noticed by you and your passengers. Often, you won't even have to look at the power gauges when the initial power reduction is made, since the setting can be approximated by experienced feel. You'll want to keep a keen eye on the attitude indicator during the attitude change, to maintain complete control of the aircraft in the transition. It's also possible that on some high performance airplanes you'll make descents with the application of speed brakes before making power adjustments. There are many ways to bring an airplane down to earth, so use what works best for you.

Once an attitude is selected and power is adjusted, trim should be added to keep the selected attitude constant. This initial *gross* application of trim should be just enough to keep the airplane's attitude from wandering. The final and more accurate application of trim should be completed in step three. Hold the trim button for a bit or give the trim wheel a couple of good turns as experience indicates, then go on to step two. Don't mistake the trim button for the push to talk switch because the control pressure won't change but the tower will be able to tune in on your secret cockpit conversations.

Step Two of the Scan

Step two of the three-step scan procedure is to *radial scan* the primary instruments. As with our previous discussion on primary instruments, these display the information needed to accomplish the intended maneuver by *fine tuning* the attitude selected on the attitude indicator.

Radial scanning begins with the attitude indicator where I've once again placed the word *start* right onto the PFD and under the attitude indicator's reference airplane (Figure 18). From here you move to the appropriate primary instrument,

Figure 18. The instrument scan always begins with the attitude indicator.

extract information from it, return to the attitude indicator and make a correction in attitude, if necessary. This is called the *radial* scan because the visual scanning track is from the attitude indicator out to the primary instrument, then back to the attitude indicator. Radial scanning was originally based on a set of analog instruments that circled around the attitude indicator, making what appeared to be spokes radiating from the attitude indicator to all the primary instruments, as shown in Figure 19.

The attitude indicator is marked *start* because this is where all attitude changes begin. It's very important that you understand how the radial scan is accomplished. Your eyes should move from the attitude indicator to a primary instrument, observe its reading or detect its movement, then return to the attitude indicator and make an attitude adjustment necessary to stabilize the primary instrument (Figure 19).

Figure 19. The instrument scan begins with the attitude indicator then moves to the primary instruments.

As we've previously learned, readily identifying the primary instruments for a given flight condition is challenging for many new instrument pilots. On a PFD there are always going to be *three* primary instruments for any condition of flight: one for *pitch*, one for *bank* and one for *power*. As we did with our analog instruments, we'll stick the words shown in Figure 20 under each instrument on the panel (use the sticky strip portion of a PostIt since this is easy to remove and won't gum up the PFD's screen).

Figure 20. The primary instruments can be more easily identified by placing the names of the maneuver that they perform near that instrument on the PFD.

Figure 20 shows which instruments may be primary for specific conditions of flight. For instance, in straight and level flight you should look at the PFD and find those instruments listed as *straight* and *level*. The HSI's heading indicator is primary for bank, or, going straight, the altimeter tape is primary for pitch (remaining *level* in this instance) and the manifold pressure gauge (or tachometer) is primary for power.

In constant airspeed climbs or descents, the airspeed tape is always the primary pitch instrument. In a turn, the turn trend line is always primary for bank. The primary instruments for a climbing turn would be airspeed for pitch, the turn trend line for bank and manifold pressure for power. The primary instruments for a level turn would be the altimeter for pitch, turn trend line for bank and manifold pressure for power.

In a *straight climb* or *descent*, at a specific *rate*, the VSI is primary for pitch and the heading indicator is primary for bank. If a specific airspeed is necessary for the constant rate descent (and it most often is on ILS approaches), then the airspeed tape will be primary for power.

Figure 21. The scan above shows the primary instruments for straight and level flight.

Let's examine the scan for straight and level flight more closely (Figure 21). You would immediately radial scan the altimeter tape by observing it, then return to the attitude indicator. If the altimeter tape was moving, a small pitch change would be made on the attitude indicator to neutralize and then correct this movement. The heading indicator should be radial scanned next, by observing it and returning to the attitude indicator. If the heading indicator was turning, or was not on the desired heading, a small correction in bank would be applied to the attitude indicator. Use a five degree bank correction on the attitude indicator to return to a heading that's not off by more than 20 degrees. It's important to stop a straying parameter, then correct it.

The manifold pressure gauge should be radial scanned last. Look at the instruments and make any final adjustment in the setting, then immediately return to the attitude indicator.

After radial scanning all three primary instruments, alternately radial scan the altimeter tape and heading indicator, making small corrections on the attitude indicator to stabilize these instruments.

Figure 22 shows the proper instrument scan for a *descending left hand standard rate turn* at a constant airspeed of 125 knots. The primary instruments for this condition are airspeed for pitch, turn trend line for bank, and manifold pressure for power. The power is reduced as an 18 degree (or the bank necessary for a standard rate turn)

Figure 22. The scan above shows the primary instruments for a descending left turn at 125 knots.

left banked turn of approximately six degrees nose down pitch is selected. An initial application of trim is applied to stabilize the airplane, completing step one of the scan. The airspeed tape, turn trend line and manifold pressure are initially radial scanned and small adjustments to the attitude indicator are made to make the primary instruments indicate as desired.

Figure 23 shows the instrument indications for a *climbing right hand, standard rate turn*. The primary instruments for this condition are airspeed for pitch, turn trend line for bank, and manifold pressure for power. The power is increased as an 18 degree right banked turn (or the bank necessary for a standard rate turn) of approximately six degrees nose-up pitch is selected. An initial application of trim is applied to stabilize the airplane, thereby completing step one of the scan. The airspeed tape, turn trend line and manifold pressure are initially radial scanned and small adjustments to the attitude indicator are made to make the primary instruments indicate as desired.

Figure 23. The scan above shows the primary instruments for a climbing right turn at 125 knots.

There's one additional advantage that trend lines offer. Since the trend line extends six seconds into the future, you can use it to estimate when to begin leveling off from a climb or descent or when to begin rolling out of a turn. Here's how this works. When the magenta trend line is opposite the altitude or heading targeted for level off or rollout, begin returning the airplane to a straight and level attitude by keeping the end of the trend line matched with the intended level off or rollout value as shown by the sequence in Figure 24. For instance, if you're in a climbing turn and want to level off 4,500 feet or rollout on a heading of 360 degrees, begin the level off or rollout when the trend line in on 4,500 feet (our bugged altitude) and the trend line is on 360 degrees. The objective is to lower/raise the nose or rollout slowly enough to keep the magenta line on the altitude or roll out value, respectively. This is only a very rough approximation but it works well enough in practice to keep the technique in mind.

Figure 24. The magenta trend lines can be used to help you determine when to begin level off or roll out.

Rod Machado's 3-Step Instrument Scan

Figure 25 shows the proper instrument scan for an ILS approach. The ILS approach requires that a constant rate descent be maintained, as well as a specific airspeed. The VSI becomes primary for pitch control, the heading indicator becomes primary for bank and the airspeed tape becomes primary for power. Remember, despite the airspeed not being labeled a primary power instrument in Figure 25, the ILS approach is the one exception to primary instrument identity. The throttle position is predicated on maintaining a specific airspeed, meaning that the airspeed indicator becomes primary for power. In addition to these primary instruments, you need to include the glideslope in your scan, too.

Figure 25. The scan above shows the primary instruments for an ILS approach (constant airspeed/rate descent).

Step Three of the Scan

Step three, the last step, is to make the final trim adjustments using the VSI, and *monitor scan* the new aircraft attitude on the 6-Pack cluster of instruments, which I'll describe shortly. Step three is accomplished once all the primary instruments have been radial scanned and are indicating the proper values. If rudder trim is available, it should be used first, followed by aileron trim, then elevator trim.

For most small general aviation airplanes, the elevator trim will usually be the only one available. To properly trim the airplane for pitch, the VSI should be used. This instrument's calibration is precise enough to detect the small changes in vertical speed necessary to determine where trim is needed. When leveling off, or when established in a climb or descent, trim for a constant VSI indication.

After the final trim adjustments are made, the *6-Pack* cluster of panel instruments are monitored. This may be done in a sideways fashion, going from the top row to the bottom row of instruments, or in a clockwise, circular fashion as shown in Figure 26. Select any scanning pattern with which you feel comfortable. The objective is to monitor deviations from the established attitude. When deviations are noted,


Figure 26. Scanning the 6-Pack cluster of instruments can be done to the right or to the left in a circular pattern.

make small adjustments using the attitude indicator to maintain the target flight conditions. This is the steady state condition, the one in which you will spend most of your time. It is the condition between major attitude changes.

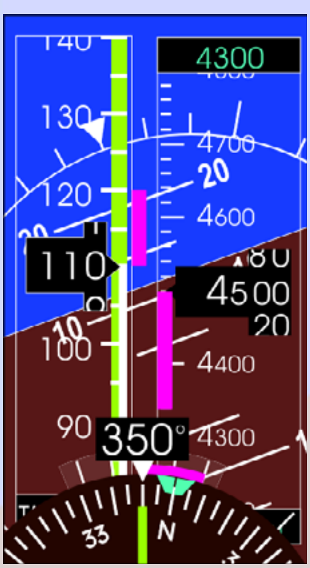
The first two steps of the three-step scan process should take about 10 seconds, with each step taking about 5 seconds. There are instances where you must return to step two of the scan. In turbulence, or when on an instrument approach, you may find yourself obliged to rapidly radial scan the primary instruments to maintain precise control of the airplane.

Remember, radial scanning is a lot of work visually, intellectually, and emotionally. It is possible to radial scan all the instruments on the panel, but this is usually unnecessary and can become very tiresome. Radial scan only the minimum instruments necessary to control the airplane.

There are many boring things to do in life, but instrument flying isn't one of them. The art of flying instruments is a challenging test of your mettle (and sometimes of the airplane's metal!). Instrument flying offers you the opportunity to master your airplane and yourself. A rather sophisticated form of satisfaction results from this combination. Perhaps this is why many instrument pilots appear to be so happy. They realize the scope of their accomplishment. They should be warned, however, not to look too happy at the airport or they'll be inviting someone from the FAA to make them take a drug test.

My good friend Captain Dave Gwinn was flying his 727 when the controller came on the radio and asked, "Flight 1313, what are you vacating?" Dave replied, "The last two weeks of September, how about you?" Communication problems are a real problem in IFR flight, especially when pilots have problems communicating with themselves. The next phase of instrument flight pilots are required to master is learning to communicate through the use of self-talk dialogues.

Those Trendy Trend Lines



Learning the instrument scan on six round-dial instruments requires many hours of practice. So how much easier is it to learn when two additional instruments are added to the panel? The answer is pretty clear. Eight instruments can be more challenging to scan than six instruments. And that's exactly what you have with a PFD—eight instruments—compared to six round-dial instruments.

On a PFD, trend lines accompany the airspeed and altimeter tapes. Ever wondered why? Round-dial instruments such as the airspeed and altimeter have needles that provide quantitative (numerical) information as well as qualitative information (trend indications). The airspeed and altimeter tapes of a PFD only provide quantitative information (it is, after all, difficult to sense trends when reading these instruments). That's why trend lines accompanied these two instruments.

Ultimately, the additions of trend lines accompanying the PFD's airspeed and altimeter tapes were necessary for these instruments to give you the same information that their round-dial counterparts provide (quantitative and qualitative information). Said another way, two PFD instruments were required to match the information provided by one round-dial instrument.

Does that mean the PFD is harder to scan than round-dial instruments? Not necessarily. For some pilots, it may be more challenging to learn the instrument scan on a PFD, mainly because of the large number of items that move on the screen. Fortunately, the trend line's location next to its companion instrument ultimately makes both of them easier to scan as a single entity. This is certainly the case with the turn trend line located directly above the heading indicator. Looking there for turn rate information is much easier than looking at the round-dial turn coordinator on the bottom left of the panel.

Cockpit Conversations:
Self-Talk for Survival

Copyright Rod Machado 2024

After mastering the three-step instrument scan procedure, you must now learn to master yourself. Psychologists say we spend up to 70% of our time talking to ourselves. In one ear, out the other, but at least you know who you're talking to.

There is certainly nothing peculiar about this behavior, as long as it's not done out loud, with witnesses. Performed at Denny's restaurant around 3 o'clock in the morning, this particular behavior is considered quite normal. Self-talk dialogues are a very important part of the process governing behavior, and these dialogues have a considerable effect on learning to fly instruments professionally.

Silently talking to one's self is as much a part of daily experience as eating, drinking and sleeping; it's just a bit quieter. Usually. If people were to stop this silent, internal dialogue, they would have to respond to the world through mental pictures and visceral emotions. Sort of like feeling your inner tiger. While this would have some interesting psychological results, it wouldn't be immediately useful, since most of a person's more sophisticated behaviors are learned through the coding of the English language. It's reasonable to assume that behaviors are shaped by the language used to instill them.

One linguistics professor reaffirmed the power of language to change people's behavior. The professor said that it's man's ability to use language that makes him the dominant species on the planet. A crusty, high time flight instructor at the airport disagreed with this bit of wisdom. This fellow believed that what sets us apart from all the other animals on the planet is that humans are not afraid of vacuum cleaners. It's a thought that has long dogged me, and not a line of reasoning with which I particularly agree. Perhaps having 25,000 hours teaching and observing humanity from the right seat of a small trainer alters an old-timer's thinking process (and lots of other things) in peculiar ways.

Good Attitude Indicator

Self-talk activity serves to guide flying behavior by reminding you to accomplish tasks such as lowering the landing gear prior to touchdown, or closing your flight plan at the destination airport. Used correctly, this self-talk behavior can be a valuable asset in accelerating the process of learning to fly instruments.

After many years of observing people struggle to become instrument rated, it became apparent to me that those whose behavior improved most efficiently in the early stages of instrument training were responding in a more active, self directed manner. For these people, behavior was being self guided via an internal dialogue consisting of a specific set of questions or statements. These questions or statements offer something akin to an audio checklist, reminding the user of the order and frequency of behaviors to be performed. The objective of the self-talk dialogue is to make a particular behavior so reflexive that the internal dialogue is no longer necessary.

The Panic Attack and Dissociation

When you are overcome by panic, self-talk becomes very helpful, if not life saving. This form of communication has been known, for many years, to help people maintain the inertia of proper response while in the throes of anxiety. It's as if the verbal portion of the psyche can command the behavioral part of the mind. Words are symbols having a tremendous power of influence over our behavior, regardless of whether we say them or someone else says them.

Psychologists have been saying for years, when overcome by erratic behavioral inertia, we should immediately start telling ourselves what to do, either silently or aloud. Panic, the inability to function effectively, can often best be dealt with by saying, "OK, remain calm, breath slowly" or "Slow down, relax, look at the problem" or "Wait, let's think before acting." These statements have been known to save the lives of people gripped by incapacitating fear, anger or panic.

The proper self-talk dialogue can help you purposefully change your behavior in an airplane. I have always been impressed with those individuals who, in the face of overwhelming odds, continue performing emergency piloting duties. Consider the pilot who's lost his engine in IFR conditions and still carefully follows the required emergency procedures to the letter, though the airplane is being summoned to earth by gravity. The pilot feels dissociated, or outside himself, when in the midst of a life-threatening emergency. This emotional detachment allows him to be intensely involved in solving the emergency problem on an intellectual level and not be distracted by debilitating emotions like fear.

This dissociation effect probably results from two things: having sufficient training in emergency procedures to feel overwhelming confidence in your ability to extricate yourself and following a specific internal dialogue that implements these procedures.

Essentially, you know what to do as a result of your training, then proceed to direct yourself while performing the required behavior. If you were to respond to deep, visceral emotions in the face of an emergency, you would probably be prone to panic.

Mind Twister

Who hasn't had the experience of getting angry and telling themselves to "calm down" or "be relaxed"? I remember once, at a grocery store, a father was strolling with his young son who was throwing an awful tantrum. The father kept saying, "Calm down, Monte; don't lose control, Monte; just remain calm, Monte." I was so impressed with this man's patience that I went up to him and said, "Sir, the way you talk to your son is most impressive, and your patience is extraordinary." He replied, "You don't understand—I'm Monte." Author

For some of you, your first solo was responsible for producing such an anxious and primitive response. When told you were going to solo, you ran from the airplane, through the runup area, while being chased by the flight instructor. When finally caught, you wrapped your hands around the instructor's waist and refused to let go. It usually took four firemen and the Jaws of Life to effect a separation. Internal dialogues keep your mind away from the instinctual, more primitive responses and focused on rational, unemotional solutions to the problem at hand. You do not *go spontaneous* because it kills!

Big Picture Self-Talk

Directed self-talk dialogue can dramatically increase your positional awareness during instrument approaches. This offers great value since most instrument students starting the approach phase of their training find it difficult to maintain an awareness of their position. This big picture orientation is an absolute necessity for safe flight in the IFR system.

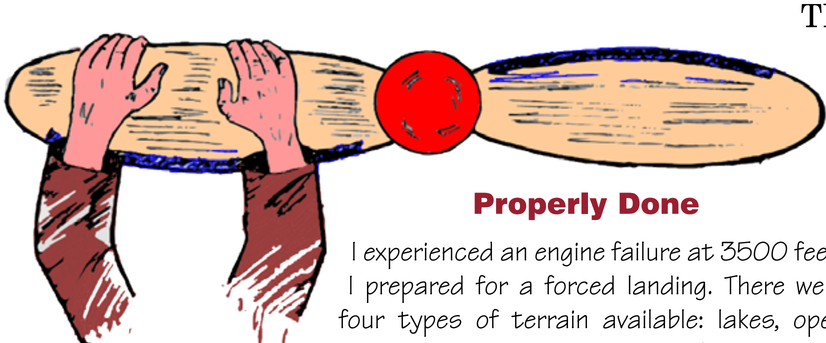
Instrument students often fly through approach courses, forget descents and have little or no idea of their position. Perhaps this explains why controllers have been heard to ask IFR students questions like, "32 Bravo, where are you going?" Students often reply, "Ahh, wherever this thing is pointed, sir." I have found that the self-talk dialogue of the following three questions develops the big picture comprehension necessary for safe instrument flying. The three questions are:

Where am I going?
How do I get there?
What do I do next?

These questions represent one of the most important internal dialogues you can have with yourself. You should be continuously asking yourself these three questions as you move about in the IFR system. Ask the questions silently or aloud, depending on preference, although CFI's prefer having instrument students ask them aloud. I find that professionals automatically seek the information gleaned from asking these questions. After so many years of training, a professional's behavior is reflexive and he or she doesn't have to be prodded to ask the questions to get the information. With a little practice, you too will find that this information-soliciting behavior soon becomes automatic.

The first question, "Where am I going?" helps you understand that you are headed toward some specific navigational goal and must accomplish a number of tasks in order to get there.

It's very easy to be so preoccupied when flying instruments that there is not a spare gray cell left. This is the minutiae swamp, also known as Camp Quick Sand, a place many pilots visit and get lost in all too often. While wrestling with the airplane,



Properly Done

I experienced an engine failure at 3500 feet. I prepared for a forced landing. There were four types of terrain available: lakes, open swamps, small timber up to 20 feet tall with butts up to five inches, and heavy large timber up to 50 feet tall with large butt size. I chose the small timber and entered it with airspeed in excess of 70 MPH. The aircraft clipped off the small trees for a distance of 85 paces before a wheel touched the ground and then stopped in another 20 paces. Because the small trees brought the aircraft to a stop gently, none of the occupants were injured. The point of this is that the safest forced landing terrain—other than a hard, smooth long surface like a road or runway—is in small timber, brush or new growth that is probably not over 20 feet tall.
ASRS Report

they forget where it is they're headed. For instance, you may be vectored to an airway and have a specific radial as the destination end point. You may be navigating on a radial to an intersection, at which point a procedure turn lies in wait. If you don't keep in mind the goal of the radar vector or navigational track, then you may not recognize when you have gone beyond that point. "Wherever I am, that's where I am" is fine New Age philosophy; it's very poor instrument navigation.

Please remember that you are *always* navigating toward a specific spot during IFR flight. When the controller asks you where you want to go, you don't say, "Oh, it doesn't matter, whatever is convenient for you." Who knows to what strange place you would be sent? During radar vectoring to an instrument approach, the *someplace* you are going is usually the thick black line in the center of the approach chart, as seen in Figure 1. This maximum thick line is known as the *approach procedure track*.

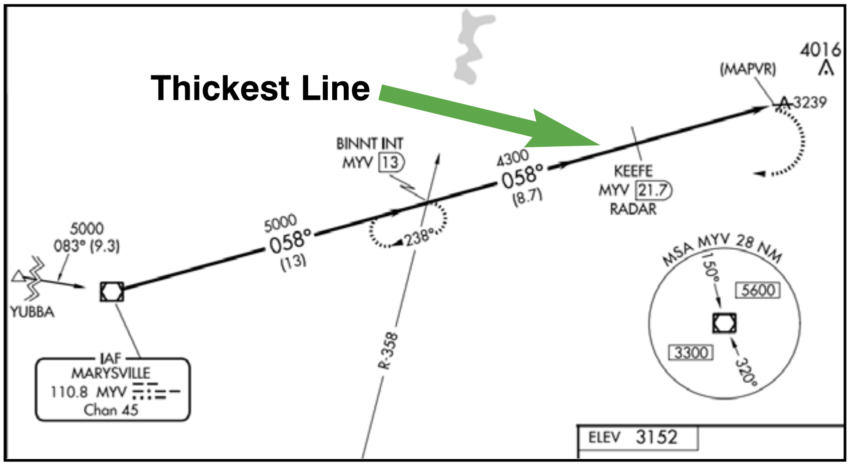


Figure 1. The approach procedure track (thickest black line) is where pilots can expect to be radar vectored.

Keep in mind that no matter what is happening during the radar vectoring process, you will eventually end up on that thick black line. Radar vectoring would perhaps be a more pleasant experience for the controller if he just said, "Hey, 32 Bravo, do you see that big black line? Well, go get it; sic 'em." With a goal like this in mind, you would easily get on course and the controller would probably be happier than a Russian radar man receiving a position report from a Stealth Bomber.

Humulonimbus

During one IFR day in Southern California, an apprentice controller was given the job of vectoring aircraft to the localizer at a local airport. Her trainer's attention was diverted from the screen and the scope suddenly got very busy. She accidentally vectored one aircraft through the localizer. When the pilot complained, she brought the aircraft around and accidentally vectored it through the localizer once again. This happened a third time. She finally got so frustrated that she picked up the mic and said, "2132 Bravo, these vectors aren't working, for gosh sakes, take over visually and save yourself.
Author

Asking "How do I get there?" allows you to develop a navigational strategy for getting to the location that surfaced from asking the first question. It also permits you to decide if the current navigational strategy is working. There is always a heading, or a route to fly, that will move you closer to the final objective. In the case of an instrument approach, that objective is the approach procedure track. This question develops the positional awareness necessary to identify any incongruities between where you are, where you want to go, and how you are attempting to get there.

When you are being vectored toward, say, the ILS Runway 30 instrument approach, you should always use your navigational equipment to keep yourself oriented to the approach course. Unfortunately, some students use their navigational equipment only to decide when they've arrived, rather than *if* they will arrive on the approach course.

For instance, when inbound on the approach to Runway 30, you'll fly a heading of approximately 300 degrees. Therefore, a left needle indication means a heading to the left of 300 degrees must be flown to intercept the localizer. A right needle deflection means you must fly some heading to the right of 300 degrees to intercept the localizer. Using your navigational equipment this way helps you determine if your present heading is taking you closer to the intended destination. If it isn't, you might be OK (radar vectors happen) or you might be headed for some portion of our granite planet (mistakes happen, too). You'd better know which one is the case.

Proper planning is the result of asking the third question, "What do I do next?" You should be constantly planning for the next course to be intercepted, the next radio to be set, or the next chart to be accessed. With an ATC system that frequently demands three hands and two heads, you cannot afford to delay planning for the next phase of flight. The subtle prodding offered by this question is indispensable for successful instrument flying.

There is always something for you to do while in flight, even if it is just checking circuit breakers or ammeter indications. That's what makes it more fun than driving. If there is nothing to do, there is a good chance something has already been forgotten. The third question keeps you thinking. When you stop thinking, the Grim Reaper is your copilot and you are a candidate for the Museum of the Permanently Still. In a busy terminal environment, there should be no time when you are not asking these questions at least once every minute or so. If you have the professional mentality, you will never find yourself in IFR flight without the consistent companionship of these three questions.

Humulonimbus

FORE!

While returning to the airport, flying about 1,500 feet above a golf course, my engine sputtered and stopped. Since I was at a comfortable altitude, I had plenty of time to choose an appropriate fairway—facing the wind, with an uphill slope and no people. I spiraled down and made a fine power off landing...no damage, no injuries. While refueling, several golfers told me about their flying days during WWII, and asked if I would please depart as I came in—without interrupting their game.

And please call out loudly "FORE" before commencing takeoff.

ASRS Report

See It, Say It, Check It

Another problem experienced by some instrument pilots is making small but devastating mistakes with numbers (and sometimes letters, too). Perhaps you can remember a time when you set your VOR course selector and heading bugs to a number that wasn't right. Anyone who has ever flown can remember setting the radios to an inappropriate frequency, or failing to set them to the new frequency, thus creating an opportunity to share their mistake with listeners for hundreds of miles around. There is a way of minimizing these mistakes by initiating another self-talk dialogue.

Repeating the words, *see it, say it, check it* provides the check and balance needed to minimize these mistakes. When you are involved in any activity using letters or numbers, you should make sure to *see* the specific character you are using. You should repeat the words *see it* to yourself as you're referencing the specific value on the chart, instrument or navigation equipment. This statement should compel you to specifically study the number or letter being used. For instance, when setting the OBS to a specific number, make sure you see the radial number on the chart, as well as seeing the number as you set it into the VOR equipment. Look at this number as set into the equipment and compare it to the airway direction on the chart. When programming your GPS, make sure you see the exact letter-number airport, navaid or intersection identifier that is set into the equipment.

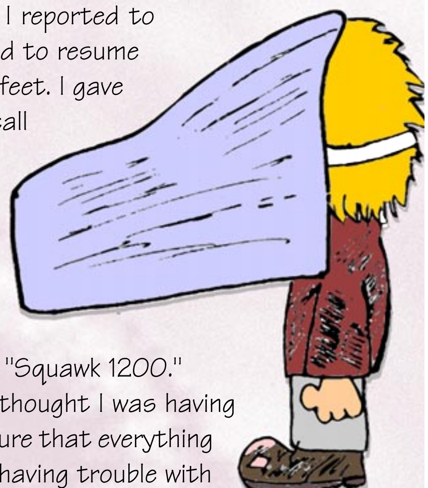
Next, *say* the letter or number aloud as you set your equipment. Psychologists tell us that a small percentage of the population, although quite functional, sometimes experiences dysnumeria. This is similar to dyslexia, but it affects numbers instead of letters. Now, that's not anorexia-dyslexia, which means that you can read thin books backwards. Dysnumeria is an impairment of the ability to sequence numbers. This can be more than just a nuisance in an airplane.

Under the stressful conditions of instrument flying, the likelihood of misinterpreting a letter or number increases. Saying the specific heading, altitude or frequency aloud lessens the chance of error. This visual and aural contrast should make apparent any discrepancy. This is why most airlines require their pilots to repeat all numbers back to the controller.

Short-term memory is capable of retaining seven to nine items for approximately 20 seconds. Then it begins abandoning the most antique of the group. This is why some

Hoodwinked

OL' PRO EATS CROW



Upon taking off from the high altitude field (VFR in Class B airspace), I reported to Departure and was instructed to climb to 7000 feet. I was then instructed to resume my own navigation, so I turned to about 220 degrees and leveled at 7000 feet. I gave a radio call, "Level at 7000," with no answer. I intended to give another call when the controller asked, "Are you climbing or what? I show you at 8000 feet." I responded that I was level at 7000 feet. He replied with a traffic report at 8000 in an area to my right. I spotted it about 3/4 mile to my right, at an altitude of, perhaps, 100 feet lower than I was. It passed ahead of me, and I resumed my heading (I had turned left when observing the traffic). When he passed he told the controller, "That guy sure is not at 7000." The controller informed me that I was leaving the Class B airspace, "Squawk 1200."

I said, "Thanks, I' ll get my altimeter checked." And I was very serious: I thought I was having trouble with my Mode C when he first reported the improper altitude. I was sure that everything was properly set and functioning during preflight and takeoff. We had been having trouble with the Mode C transponder and had had it in the shop...But that was not the problem—it was ME! After leaving Class B airspace, I tuned back in on the airport ATIS and heard 30.16. This shocked me, as I was certain it was 29.16 when I set it during preflight. In fact, that was the first thing I looked at when the controller said I was at 8000.

Well, I did a lot of thinking about making such a stupid mistake. You see, I have always prided myself about being a real pro when it came to my flying—former Chief Pilot, instructor, etc.... So how did Ol' Pro get himself into such a fix? The biggest single cause was, most likely, fatigue. I had been involved in a number of serious business issues of late, not sleeping well, got to the airport on a tight schedule, only to find that they had forgotten to ramp my plane...So, by the time I climbed into the plane, I had set myself up real good: not for flying, but for goofing up! And that' s what I did. During my preflight, I set the wrong value in the altimeter. In the long run, this will serve as a good lesson; I now realize that I am not invulnerable. I' d better start listening to some of the advice I have so freely given in the past about not flying when over-stressed, etc., etc. I may even take some vacation… .

ASRS Report

clearances can easily exceed your ability to retain information without committing it to paper. An additional value of repeating numbers or letters is that short-term memory is reinforced 25% to 100% with aural repetition. This increases the chance of the correct value being used. Seeing the correct letter or numerical value, then repeating it, offers the necessary check and balance to minimize errors.

Saying *check it* offers a final check by prodding you to validate the specific value a final time. Looking back at the specific letter or numerical value to be used helps prevent regrettable mistakes. You can count on it.

Awareness Self-Talk

Maintaining a high degree of awareness is essential during instrument flight. In the medical arena, physicians refer to this as having a *high index of suspicion* about the presence of a particular condition, and perhaps we should think of it that way as well. Be alert. Be suspicious. Be aware of what's there.

Professional instrument pilots train themselves to be highly aware and on the lookout for potential problems before they become serious problems. It's good to be suspicious when flying an airplane! Apathy is pathetic in these instances. Dangerous, too. For instance, imagine floating along in the system for a couple of hours only to discover that the ammeter needle has disappeared off the left side of the instrument. It's as if the alternator output is so low that the electrical equipment is sucking the needle into the wires. This is not the type of problem you want to first discover during solid IFR flight just as the battery gives up its last volt. There's no revolting in flight. At this point, some pilots start making transmissions that don't require a radio. The person they want to speak with is always listening: *Hello Allah; come in Buddha; speak to me Krishna*.

The following questions are very important for maintaining a high degree of cockpit awareness. Train yourself to ask them reflexively every few minutes. Most professional pilots routinely ask themselves some version of the following questions.

How am I feeling?
How is the aircraft?
How is the environment?

Asking "How am I feeling?" should cause enough introspection to allow you to assess your physical and emotional state. Sometimes you just don't attend to these states, and end up in the wrong state—highly fatigued, agitated or hungry, without even being aware of it. This is certainly not safe. Ask any pilot who hasn't eaten for quite a while. With the liability of low blood sugar, mental capabilities fade quickly. After a few hours without food, you can start to feel as though you have an IQ a grade lower than bean dip. You could even start hallucinating, misinterpreting the clock's sweep second hand for the weather radar and notice that every 30 degrees of sweep there is precipitation taking the shape of big numbers.

At the slightest indication of physical or emotional debility, consider getting your airplane down. It takes your full concentration to handle an airplane in solid IFR. Being out of shape doesn't help much either. I have a friend who is so out of shape that he gets winded putting on a seatbelt. In fact, the last time he ran was in 1993, and that was because he didn't hear the bells on the ice cream truck. It's always best to be in good physical shape if you're serious about flying instruments.

Expect more problems with fatigue at night than during the day. Perhaps this offers a partial explanation of why there are 10 times more single-pilot IFR accidents at night than during the day. These IFR pilots may be so fatigued that they're unable to maintain a high level of awareness, allowing them to get caught in dangerous traps.

Any sign of drowsiness is alien to a pilot's attentive nature. If you find yourself fatigued, do this little trick to help keep yourself fresh. Sit up straight and take a few deep hits off the oxygen system (assuming you have an oxygen system, of course). This is especially useful before making an instrument approach. Even this little bit of refreshing oxygen can keep you sharp, giving you an extra edge on safety.

Remember, the retina is highly sensitive to diminished oxygen levels. While you might not notice a loss of visual acuity during the day at 5,000 feet, you certainly might at night. The effects of hypoxia are experienced at lower altitudes at night.

The next time you're on a night flight and have oxygen onboard, try this little experiment. Take notice of the number of stars you can see. Then breathe a little oxygen. Now look at the stars again. You'll probably notice many more stars once that oxygen begins flowing from hose to nose and vein to brain. Do you really think all those stars just came out in the last 10 seconds? Think of one of those new-found stars as an approaching 747. This should provide all the motivation you need to use that oxygen if and when you even suspect that fatigue or reduced vision is lessening your performance.

On an IFR cross country flight, in a turbocharged, small airplane over-the-mountains, a pilot and his three passengers were all on oxygen. The pilot and the front passenger were on the built-in system and the two rear passengers were on a portable system. The pilot knew the portable tank of oxygen would likely run out before the descent was made below 13,000 feet. He planned to switch the rear passengers to the built-in system. He had instructed the rear passengers to let him know when the tank gauge was at 200 PSI, or if the flow indicator turned red. The pilot was transferred to Approach Control who wanted a fast descent. There were heavy cumulus clouds with moderate turbulence and the pilot was concentrating on the busy, turbulent approach. He did not check the rear oxygen tank pressure/flow, as he had been doing regularly during cruise. At about 11,000 feet, the rear passengers "awoke"—somewhat confused with no flow to their masks. Obviously, the rear passengers ran out of oxygen during the descent and, either because they forgot to check or because the effects of hypoxia, they did not realize they were running out. The pilot, who had been watching the rear tank, neglected to do the same because of a demanding instrument approach. No apparent damage was done to the passengers. Everyone was thankful for a good outcome, but frightened by what might have been.

ASRS Report

There are few things more frightening than falling asleep in an airplane at night during cruise flight with the autopilot activated, except perhaps to fall asleep during night cruise *without* an autopilot activated! This only has to happen once, and a pilot will never be the same again.

In 1976, just such an experience was mine to claim. On a flight from Santa Barbara to John Wayne airport in Southern California at 11:30 p.m., my sleek A-36 Bonanza had just leveled off at 7,500 feet. At the time, I chose this altitude to avoid some specific airspace as well as to stay above an inland overcast. Visibility was not great, averaging only about 5 miles. Without a moon, the sky was exceptionally dark. The autopilot was engaged. Mesmerized by the enchanting hum of the engine, I drifted off.

When I woke up, gasping for breath, the reality was shocking. There was absolutely nothing to be seen in front or to the sides of my airplane. It was pitch, pitch black! California is known for its high terrain, and my spastic, pounding heart reminded me of this. Immediately glancing at the clock, it became apparent that nearly 30 minutes were unaccounted for. I quickly turned 180 degrees, checked fuel and reestablished my position. This is *not* an experience I'm likely to repeat in any of my next several lifetimes, and I was fortunate not to have used one of them up in this instance.

Now, my flight bag provisions include sunflower seeds in the shell for those long night cross countries. I have a need for seed, to keep me awake. Few pilots can fall asleep while ferreting out these tiny nuts from their shells. I also make it a point to carry red pistachio nuts if I have a copilot onboard. I'm kept awake thinking how much fun I'll have watching him walk around the airport with big red lips. It also keeps him from eating my sunflower seeds.

When a passenger is in the green, a seasoned professional flight instructor will tape the barf bag to the chin of that suspect . This frees the passenger's hands to apply a Tibetan Death Grip to the seatback.

Asking "How is the aircraft?" should prompt you to monitor all engine, electrical and vacuum instruments. Start at the left side of the panel and work your way across, looking at every instrument, making sure it's indicating properly. Are the gauges in the green? Are the passengers in the green? Perhaps smoother air should be found. How's the ammeter doing? Does it show a needle deflection comparable to the electrical demand of the equipment being used? It should. What about the vacuum gauge? If the vacuum pump is lost, then you must fly partial panel. It's called partial panel because you realize just how partial you are to those instruments that aren't working.

Asking "How is the environment?" should cue you to assess any changes in the weather, examining them carefully to see if they make any difference to you. If anything even looks suspicious, start asking more questions.

This question is also quite valuable for many other in-flight situations. For example, when you are entering a busy terminal area in VFR conditions, you must concern yourself with traffic vigilance as well as flying the instrument approach. While landing, it's very important for you to pay attention to the runway environment. After all, there may be something on it that's not supposed to be there.

If you're a cautious pilot, you'll constantly check your environment. You'll carefully monitor the taxiway for obstructions and visually verify that no one is approaching to land before you taxi onto the runway. Cautious pilots know they only have to let their guard down once to get bitten.

Appendix-5

Emergency Self-Talk

Handling in-flight emergencies can be accomplished by using another self-talk dialogue that compels you to use a rational approach to solving the problem. The following four questions should be asked whenever any unusual situation presents itself in the airplane:

What is happening?
What actions must I take to correct the problem?
What limitations must I now observe?
When do I have to land?

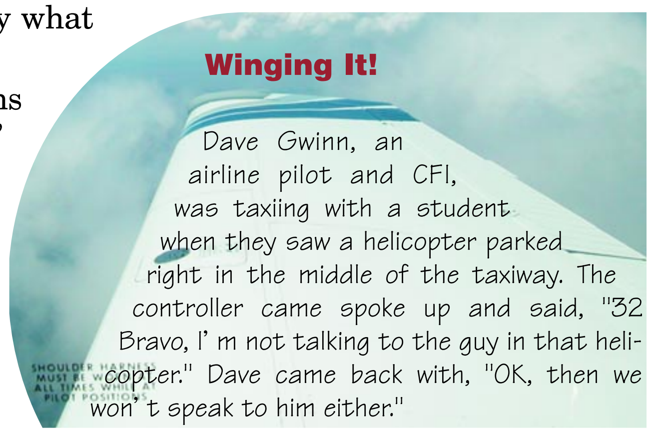
The first question, "What is happening?" directs you to specifically identify the problem and its effect on the airplane. There are times when you hesitate to identify the precise problem and these precious moments, once lost, cannot be recovered. Asking this question starts the process so crucial to solving aviation problems.

Sometimes in-flight problems are subtle and it is difficult to identify precisely what is happening. In-flight icing can be one of those insidious problems. It is possible that you have insufficient experience in icing conditions and might not realize you are an ice collector until it's too late. Anyone who has experienced icing at night knows it's difficult to see unless they are specifically looking for it. This is one reason why you carry flashlights at night (hopefully a flashlight isn't the container in which you carry your dead batteries, either). Illuminating the wing or the windshield with the flashlight will usually identify the icing problem. Icing can go unnoticed until you have a full-scale aerodynamic danger on your hands.

Sometimes in-flight problems are blatant, and easy to identify. If the problem is an engine failure, then rest assured, this is pretty easy to detect. In fact, passengers are most helpful in pointing out these problems for the pilot. On one charter flight, in a Cessna 421, caution told me to shut down an engine during cruise flight because of an over-temperature condition. The throttle was gently eased back, the propeller gently feathered and the plane was trimmed with a minimum of telltale vibration.

Suddenly, one of the passengers leans through the curtains and says, "Hey! What's happening, buddy?" as he's pointing to the engine. Trying to use a little humor, my retort was, "Oh, it's just a spare, and we don't use it much in cruise unless the other one stops." He went, "Oh...OK." Amazingly, that satisfied him for a few minutes, until the other three passengers discussed multi-engine airplanes and the number of engines they'd rented. They suspected something was up. Now your creative author was forced to explain exactly what was happening.

The second question to ask is "What actions must I perform to correct the problem?" Essentially, you should be trying to discover what must be done to return the situation to normal. With an icing problem, you should respond in one of two ways: either get out of the clouds or go to where the temperatures are warmer than freezing. The answer is very clear for this type of problem.



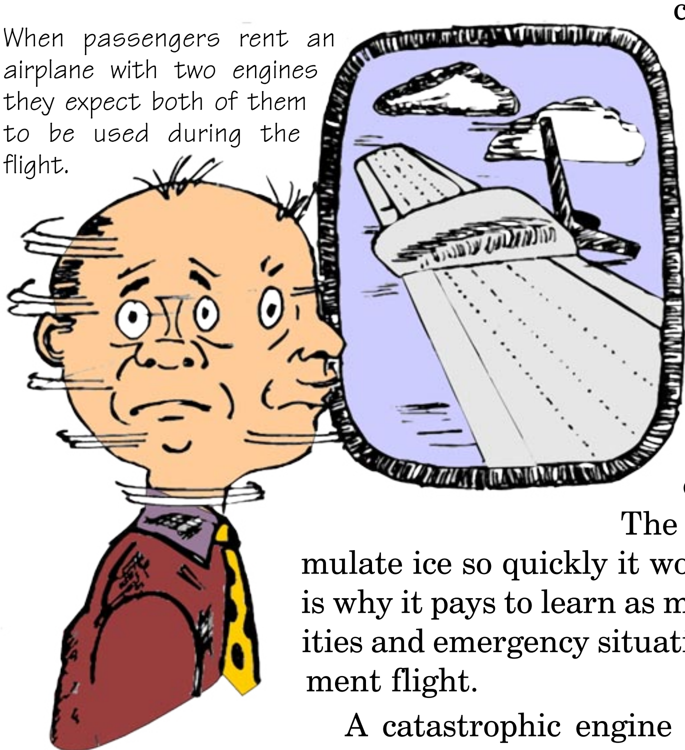
Winging It!

Dave Gwinn, an airline pilot and CFI, was taxiing with a student when they saw a helicopter parked right in the middle of the taxiway. The controller came spoke up and said, "32 Bravo, I' m not talking to the guy in that helicopter." Dave came back with, "OK, then we won' t speak to him either."

If the problem is an engine failure with assurance that there is no internal damage, the proper action might be to attempt a restart. Remember, most engine failures are caused by pilots running their airplanes out of fuel or not being able to find the fuel that's onboard. Restarting is the proper action in these instances. So, reroute the fuel, if this is an option. If no fuel remains, then you have an entirely different problem and should return to question number one, because you will soon be returning to earth.

Once the problem has been identified and action taken, ask "What limitations must I now observe?" With a load of ice, you must operate within specific limitations. In other words, this wouldn't be a good time to practice your commercial maneuvers, such as chandelles or lazy-eights. You now have specific bank, altitude and range limitations and a whole host of other limits.

When passengers rent an airplane with two engines they expect both of them to be used during the flight.

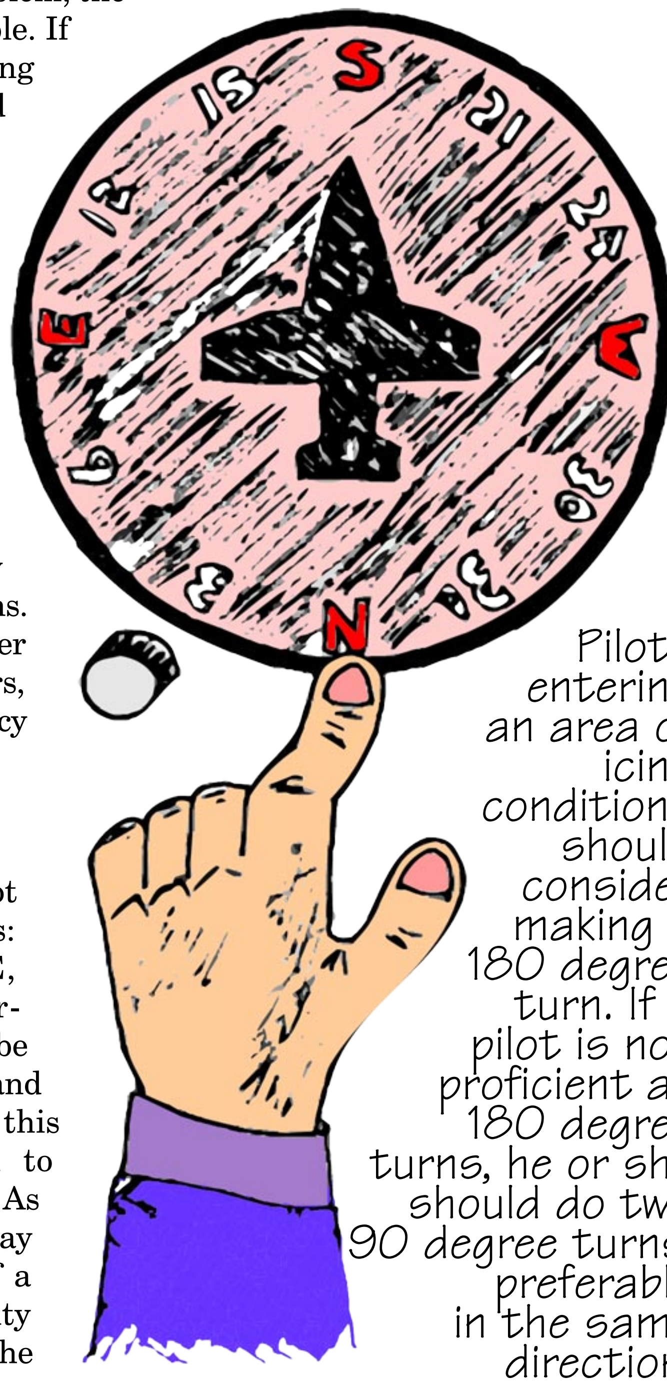


Having some practical experience with the problem certainly helps you identify these limits. For instance, instinct may tell you to make an immediate descent away from icing conditions and to put your gear down to expedite the descent. If you do this, you are probably going to turn your airplane into a gravity test probe. You could easily become one of God's *frozen* people. The gear, exposed to the airflow, could accumulate ice so quickly it would be difficult to maintain altitude. This is why it pays to learn as much as possible about potential abnormalities and emergency situations that can be experienced under instrument flight.

A catastrophic engine failure under IFR conditions is a pilot's worst nightmare. Given options, my preference would be to barbecue hotdogs in a gasoline suit rather than contemplate a dead stick landing from the discomfort of the clouds. The first action you must perform under these conditions is to *fly the airplane*. At this moment, nothing else matters more. With the probable loss of the vacuum system, let's hope that you are current on partial panel flying. Hopefully you'll know the location of airports that are within gliding distance. This is where a GPS and your ability to use it comes in real handy. By selecting the *nearest airport* feature, you can proceed to, descend over and land at some place hospitable to airplanes. Planning for such an eventuality seems almost unreasonable, considering the rarity of engine failure in today's powerplants. Maybe it is unreasonable, but there's little benefit in planning for what can go right and a lot of benefit to planning for what can go wrong. Remember, chance favors the prepared mind. So be prepared.

Fortunately, problems with icing can be dealt with on a more strategic level. You can often plot and scheme to manipulate your way out of this problem. There are very few instances when icing will immediately smite an airplane and pull it from the sky. Freezing rain is one of those rare occurrences. It demands immediate action. Freezing rain can whittle away lift fast enough that there won't be enough time to get an open channel to the pilot's savior of choice. A 180 degree turn is one of the immediate actions needed to correct the problem.

The last question for dealing with in-flight emergencies or abnormalities is "When do I have to land?" With an engine failure the answer is quite clear: land now. With partial power failure, or the loss of only one engine in a twin, the situation becomes a little more complex. When you have any serious problem, the objective is to get down as soon as possible. If you have the windshield implode during IFR conditions, you might want to land whether or not there is an airport underneath you. If need be, you could make your own airport by landing on a road or a field. If you lost one engine in your twin and could maintain altitude, you might consider other options. If you were to land at the nearest airport, without runway considerations, you might experience a long, long rollout on a short, short runway. With a gear malfunction, you might want to select an airport with emergency facilities to handle possible complications. Having enough practical experience, either your experience or the experience of others, is a must for successfully solving emergency problems.



Pilots entering an area of icing conditions should consider making a 180 degree turn. If a pilot is not proficient at 180 degree turns, he or she should do two 90 degree turns, preferably in the same direction.

The 6 T's

There is probably no instrument pilot alive who hasn't heard of the 6 T's: TURN, TIME, TUNE, THROTTLE, TALK and TRACK. The T's are performed in this order so the sequence can be used for approaches, holding patterns and other activities. Keep in mind that this sequence is an aural checklist used to remind you about the behaviors desired. As soon as the turn is *started*, the time may also be started. Punching the button of a timer is not a workload intensive activity so there should be no delay in starting the time at the appropriate place on an approach. This "T" pattern should be very versatile and work as an effective behavior reminder for approaches, holding patterns, turning at intersections, etc. There are, however, several variations of this "T" pattern. I once met an instrument student who had 12 T's! I suppose if this student didn't come up for air around the 9th T, he would surely get hypoxia. If caught in icing conditions, he could always have iced tea. One of my more nervous students added a 7th T—THROW UP. No matter how you count them, the 6 T's are another excellent example of a useful self-talk dialogue.

Normally, the 6 T's are used at the final approach fix (FAF) of an instrument approach to fly and configure the airplane for descent to the minimum descent altitude (MDA). There are additional uses for the 6 T's, and they make instrument flying easier. When flying holding patterns, you will find the 6 T's a useful reminder to begin a *turn* to the specific entry heading; start the *time* upon entering the holding pattern entry; *tune* the VOR omni bearing selector to track the inbound leg of the holding pattern; *throttle* to the specific holding airspeed; *talk* to the controller to report entering holding; and *track* the inbound course. In fact, the 6 T's should be used when reaching an intersection, regardless of whether or not a turn is required.

FAF Self-Talk

Another internal dialogue can be employed when inbound at the final approach fix. You should ask yourself these three questions:

How low?
How long?
Which way?

Every instrument approach in the United States has a minimum altitude for descent. It's possible that if you descend below this altitude at an inappropriate time, you may hear three little tire squeaks and notice a housing suburb where the runway should be. One fellow came back from an instrument flight with a television antenna actually impaled on the landing gear of his Cessna 172. Can you imagine trying to explain this to the FAA? Asking "How low?" and reaffirming the minimum altitude for descent while on the approach, is always a good practice.

Asking "How long?" and "Which way?" provide useful reaffirmations of critical missed approach and approach direction information. It's all too easy to leave the timer untouched when inbound at the final approach fix on nonprecision approaches. It's also a common error to forget to make any additional turns required at the final approach fix to track the approach course. These last two questions, while appearing rather obvious, can provide a useful defense against an inattentive mind.

Richard Buckminster Fuller, the engineer, mathematician, and planetary-change guru, once said, "The only way for people to think is by asking themselves questions." As an instrument pilot, you must think well. It's your job. It's your internal dialogues that structure your thinking and compel you to act in the most meaningful and disciplined way. Asking questions and stating directives mentioned in the internal dialogues covered in this chapter will have a profound effect on your ability to think properly in the instrument environment.

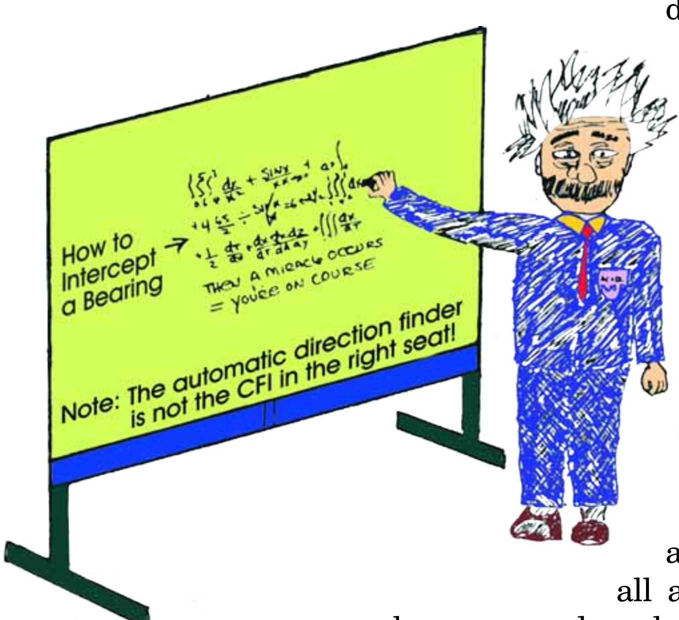
Intentionally Left Blank

Chapter 5
ADF—A Living Legacy

As an instrument student, I originally thought the ADF or *automatic direction finder* was the flight instructor sitting in the right seat. It seems that other instrument students have their own interpretation of what ADF means. One student, when asked what the letters *ADF* meant, stated, “It means I may not pass my IFR checkride.” While performing an ADF approach is no longer required for the instrument rating, I believe it’s very important to understand how this little instrument of torture can also be used for navigation.

Remarkably, we’re minting more and more instrument pilots who know less and less about how to really navigate. Some, suffering the illusion of a delusion, think that pressing the *direct to* button on a GPS is the highest form of navigational ability. Unfortunately, for many people it is.

In the past, tracking to a station using the ADF was considered a standard skill for any pilot, right up there with pilotage. If you couldn’t do it, no self-respecting instructor would send you out for a final IFR checkride. Now, by pushing the *direct to* button, we’re becoming a group of homers, perhaps reflecting the rise of Homer Simpson and the decline of pilots who meet the basic test of knowing where they’re going. Homing via a GPS requires neither skill nor thought. It’s the ultimate lack of commitment. Instead of choosing a line of flight, navigating to it, and staying on that line, we’re homing—continually re-defining the line of flight so that it extends from wherever we’ve let ourselves drift to wherever we’d like to wind up.



Yes, you eventually get there that way, at the cost of failing to sharpen your skills: identification, interception and tracking. These skills are what IFR is all about. Having them available might just save your bacon some day when the going gets challenging and the GPS won’t get going. These skills are so important that I’ve kept this chapter in this revised edition of my *Instrument Pilot’s Survival Manual* even knowing that ADFs are disappearing faster than pork rinds at a Superbowl party. There is a method to my madness. Please take the time to understand the fundamentals of ADF navigation, whether or not you have an ADF in your airplane. Not only will this help you with GPS navigation, it will also help you in all other aspects of instrument navigation.

ADF navigation can be easily understood and mastered when the similarity of NDB bearings to VOR radials is understood, and by applying two very important rules for navigation.

Appendix-6

Picture This

VOR navigation is done via radials, 360 of them, radiating away from the station, while ADF navigation is done on bearings oriented *to* and *from* a nondirectional beacon (NDB). These bearings can be thought of as similar to VOR radials. You know when you are on a specific VOR radial when the needle on the VOR display centers. At this point, you turn the airplane to the heading selected in the course selector and fly either to or from the station. Think of the VOR as a very fancy calculator. It does all the math, and presents you with a nice, neat number that tells you what radial (or course) you are on.

NDB bearings are a little more challenging. The navaid is called a *nondirectional* beacon because there is nothing intrinsic to the signal it produces that lets you resolve, using just the ADF, what bearing you are on. The ADF is *not* a calculator. For that, you have to use your brain, which becomes an ADF plug-and-play peripheral. You are on a specific NDB bearing when you can *turn to the direction of the bearing and have the ADF needle point to the nose or the tail of the airplane.*

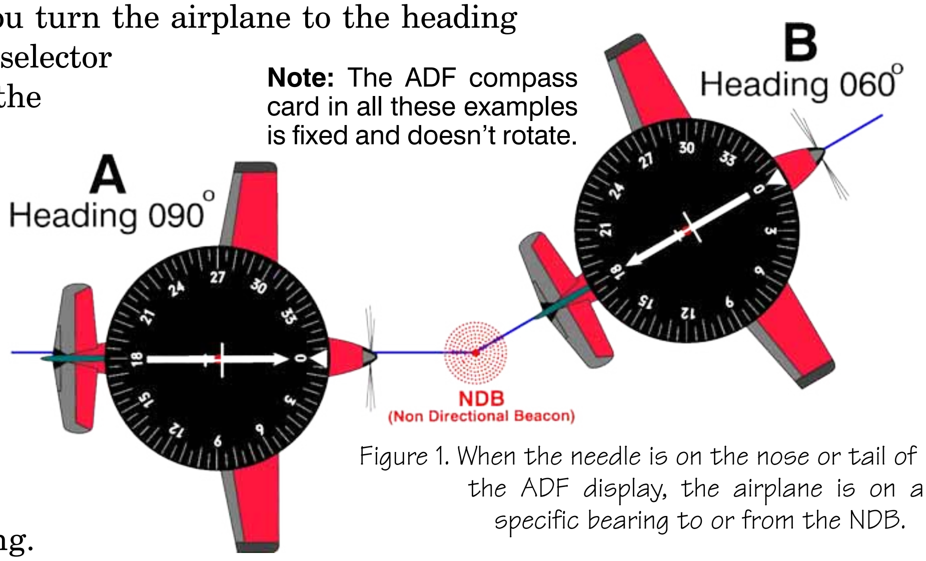


Figure 1. When the needle is on the nose or tail of the ADF display, the airplane is on a specific bearing to or from the NDB.

Nose or Tail

Figure 1 shows two airplanes flying to and from an NDB. Airplane A is on the 090 degree bearing to the station, since it is heading 090 degrees and the needle is pointed to the nose of the ADF display (from now on, when I say nose or tail of the ADF I mean the very top or bottom center of the ADF's azimuth display). Airplane B is on the 060 bearing from the station since it is heading 060 degrees and the needle is pointed to the tail of the ADF (assume the ADF compass card in all these figures is fixed and doesn't rotate).

Figure 2 shows that airplanes C and D are not on the 090 degree bearing to the station. Both airplanes are on a 090 heading, but their ADF needles are pointed to the right and left of center, respectively. From that bit of information, we know these airplanes are not going to or from the NDB on the desired bearing. For airplane C to be on the 090 degree bearing to the NDB it would have to move to the right; airplane D would have to move to the left.

Referring to Figure 3, is airplane E on the 300 degree bearing to the station? Is airplane F on the 300 degree bearing from the station? The answer to both question is *yes*. Both airplanes are on a specific NDB bearing when you can turn to the heading of that bearing and have the ADF needle point directly to the nose or the tail of the ADF display.

ADF—A Living Legacy

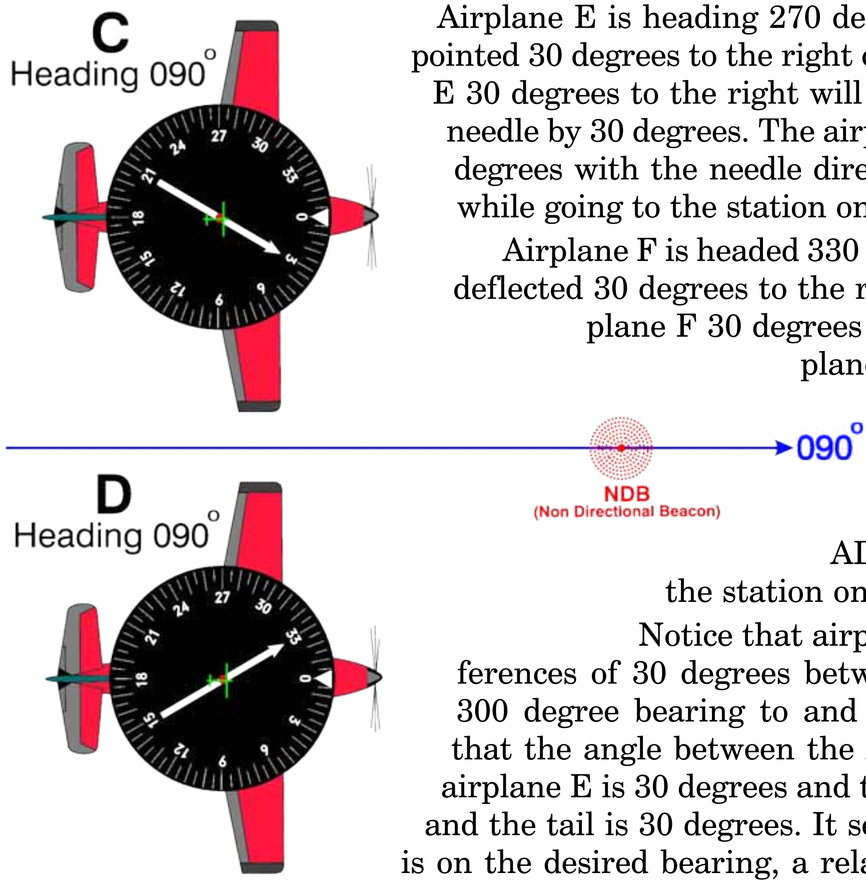


Figure 2. Airplane C is to the left of the 090 degree bearing to the NDB and airplane D is to the right of the 090 degree bearing to the NDB.

Airplane E is heading 270 degrees and the ADF needle is pointed 30 degrees to the right of the nose. Turning airplane E 30 degrees to the right will pivot the airplane about the needle by 30 degrees. The airplane will now be headed 300 degrees with the needle directly on the nose of the ADF, while going to the station on the 300-degree bearing.

Airplane F is headed 330 degrees with the ADF needle deflected 30 degrees to the right of the tail. Turning airplane F 30 degrees to the left will pivot the airplane about the needle by 30 degrees. The airplane will now be headed 300 degrees with the needle directly on the tail of the ADF, while going away from the station on the 300-degree bearing.

Notice that airplanes E and F both have differences of 30 degrees between their headings and the 300 degree bearing to and from the NDB. Notice also that the angle between the ADF needle and the nose of airplane E is 30 degrees and the angle between airplane F and the tail is 30 degrees. It seems that when the airplane is on the desired bearing, a relationship exists between the angle at which the bearing is being intercepted, and the angle the ADF needle makes with the nose or tail of the ADF instrument. This relationship is *very, very* important. To understand this relationship is to successfully comprehend ADF navigation.

Understanding the basic concepts is not only important in ADF navigation, it's also important for all higher knowledge. Einstein talked about relativity or time distortion. I never understood this until I realized that the length of one minute depends on which side of the bathroom door you happen to be on. It's interesting to consider that Einstein is remembered for $E=MC^2$. You would think that a guy who was smart enough to create this formula would understand that *Bad Haircut + No Conditioner = The Frizzies*.

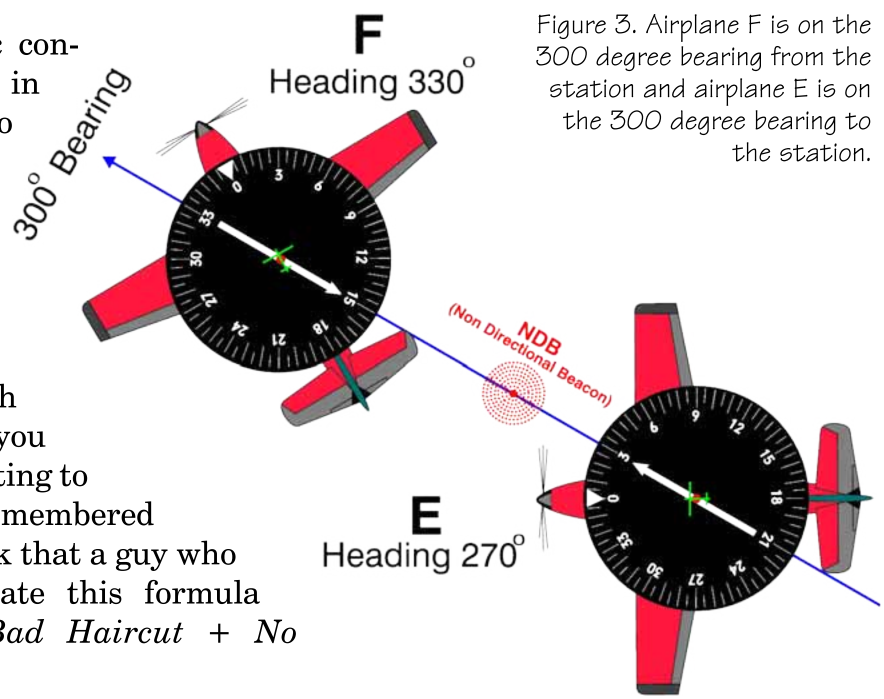


Figure 3. Airplane F is on the 300 degree bearing from the station and airplane E is on the 300 degree bearing to the station.

Appendix-6

Now that you can identify when you are on a specific bearing, you are ready for the two most important rules in ADF navigation:

Rule 1:

When holding a constant heading, the head of the ADF needle always falls to the bottom of the instrument.

Rule 2:

When a specific NDB bearing has been intercepted, the angle of intercept will be shown between the needle and the nose of the ADF or the needle and the tail of the ADF.

Rule number one becomes extremely important for identifying the airplane's position in relation to specific bearings. Try the following experiment on the ground. Pick a reference spot about 20 feet in front of you and assume this spot is the NDB station. Point to this spot with an arm stretched out while pretending your arm is an ADF needle. Keeping your arm pointed to this spot as you move and walk in any direction while maintaining a constant heading. You'll notice your arm moves towards the rear of your body regardless of which way you are walking as long as your heading is constant as shown in Figure 4. Of course, be real careful while walking. One time I sent a student home to do this. He showed up the next day with a bandage on his noggin. He apparently walked square into his refrigerator, narrowly missing a Fred Flintstone magnet. Imagine carrying around and advertising that impression for the rest of your life.

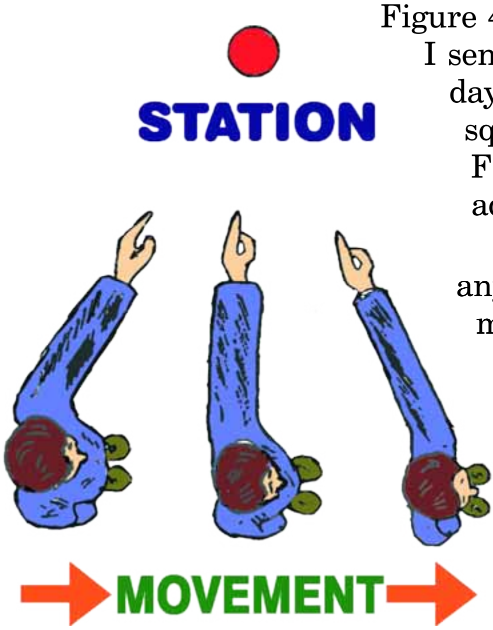


Figure 4. Maintain a constant heading and all stations ahead of you will eventually move to the rear.

While holding a constant heading in an airplane, any station in front of the airplane will eventually move toward its tail. And any station already behind the wing will move further toward the tail of the airplane. Thus, the ADF needle always *falls* toward the bottom of the ADF instrument while the airplane maintains a constant heading as shown in Figure 5 (the only exception to this rule is during very strong wind conditions when the airplane is very close to the station. For all practical purposes, this exception can be ignored). This action implies that while the airplane maintains a constant heading, the angle made between the needle and the nose of the ADF instrument will continue to increase. It also implies that the angle made between the needle and the tail of the ADF instrument will continue to decrease.

Rule number two states that you have intercepted a specific bearing when the angle of bearing interception is shown between the needle and the nose or the needle and the tail of the ADF, depending on whether it's a bearing to or from the station respectively as shown in Figure 6. If the airplane is intercepting a bearing to the station, the intercept angle will be shown between the needle and the nose of the ADF instrument. If the airplane is intercepting a bearing from the station, the intercept angle will be shown between the needle and the tail of the ADF instrument.

Basic Navigation

Keep in mind that the intercept angle I'm speaking of is the angle made between the needle and the nose or the needle and the tail of the ADF, *not the numbers to which the ADF needle points on the compass card*. The fact is that the compass card on some ADF units is rotatable. For all our purposes, we'll just leave the *zero* reference set to the top of the instrument on all our examples. As far as you are concerned, the printed numbers on the face of the ADF dial have no meaning during initial ADF practice. In fact, you shouldn't even think of the numbers on the ADF card as numbers, you should think of them as 5-, 10- and 30-degree reference marks around the face of the dial. These reference marks make it easy for you to tell how many degrees the needle is deflected away from the nose or tail of the ADF instrument. Unless you think of the ADF numbers as simple indices, you may have a very difficult time learning basic ADF navigation. You could become so frustrated that you fall to the cockpit floor and start flopping around like a dumb fish. Maybe *that's* what ADF really stands for?

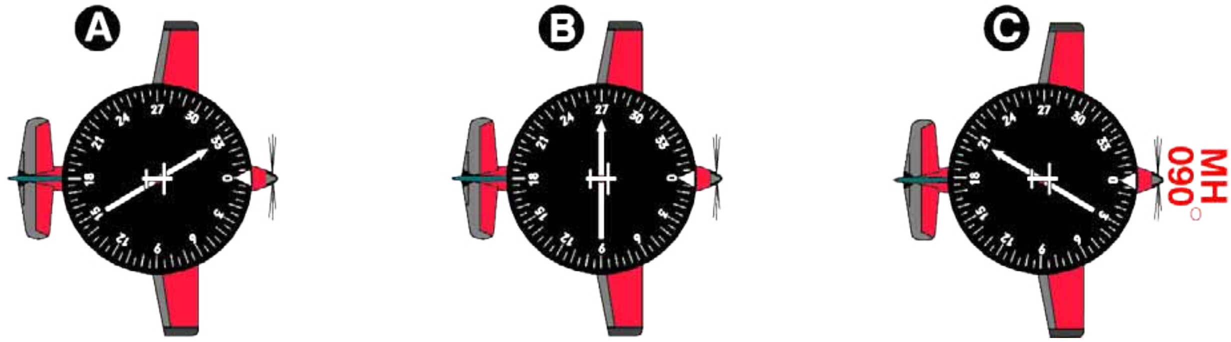


Figure 5. When a constant heading is maintained, the ADF needle will always fall (move downward) to the bottom of the instrument.

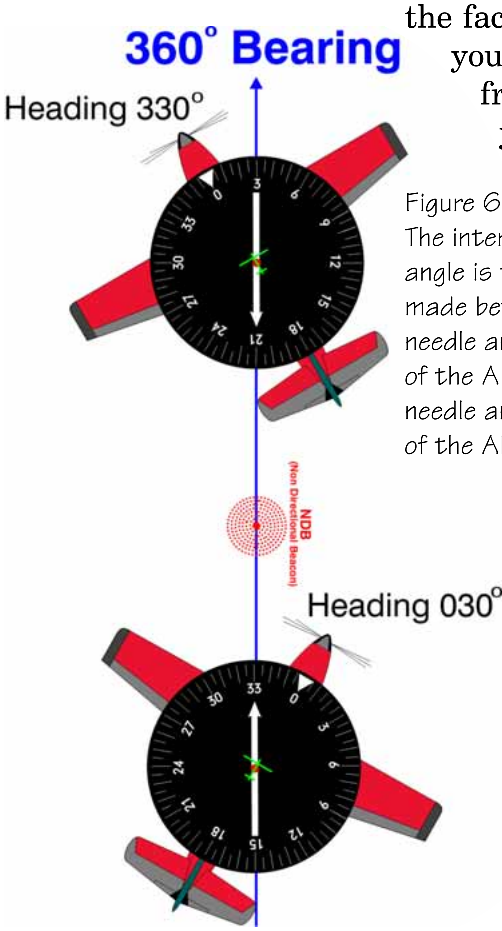


Figure 6. The intercept angle is the angle made between the needle and the nose of the ADF, or the needle and the tail of the ADF.

Intercept Angles

Figure 7A shows the progressive needle movement of airplane G as it heads toward the NDB approach course on an intercept vector. The intercept angle is the difference between the inbound bearing of 040 degrees and a heading of 070 degrees. An intercept angle of 30 degrees will be shown between the needle and the nose of the ADF when the airplane is on the 040 degree bearing. Since the NDB station is to the left of the airplane, the intercept angle will be shown to the left of the ADF's nose.

Appendix-6

You can immediately tell that airplane G1 is not on the approach course, since the angle between the needle and the nose is only 15 degrees. The intercept angle is 30 degrees, and this angle has not yet been reached. The important question to ask here is whether an angle of 30 degrees will ever be shown between the needle and the nose. The answer is *yes*. As long as an intercept heading of 070 is maintained, the needle will move from the top to the bottom of the ADF display, eventually reaching an angle of 30 degrees between itself and the nose of the ADF. At this point, you know you are on course (airplane G2) and should turn to a heading of 040 degrees to track inbound.

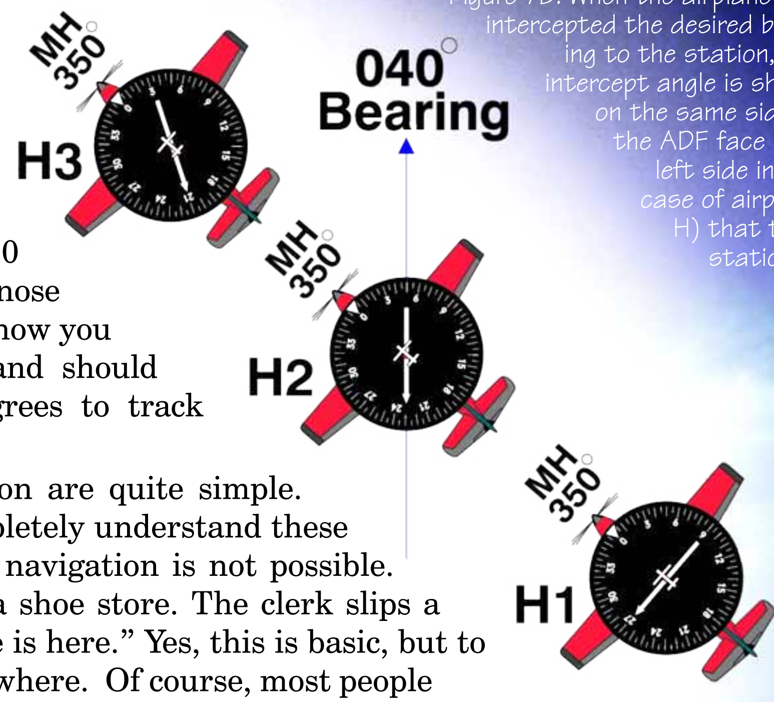


Figure 7B. When the airplane has intercepted the desired bearing to the station, the intercept angle is shown on the same side of the ADF face (the left side in the case of airplane H) that that station is on.

The basics of ADF navigation are quite simple. Unfortunately, unless you completely understand these basics, comprehension of ADF navigation is not possible. It's somewhat like going into a shoe store. The clerk slips a shoe on you and says, "Your toe is here." Yes, this is basic, but to get fitted he's got to start somewhere. Of course, most people look at the clerk straight-faced and say, "Oh, thank you, I've been looking for that." To learn ADF navigation, you've got to start with the basics, too.

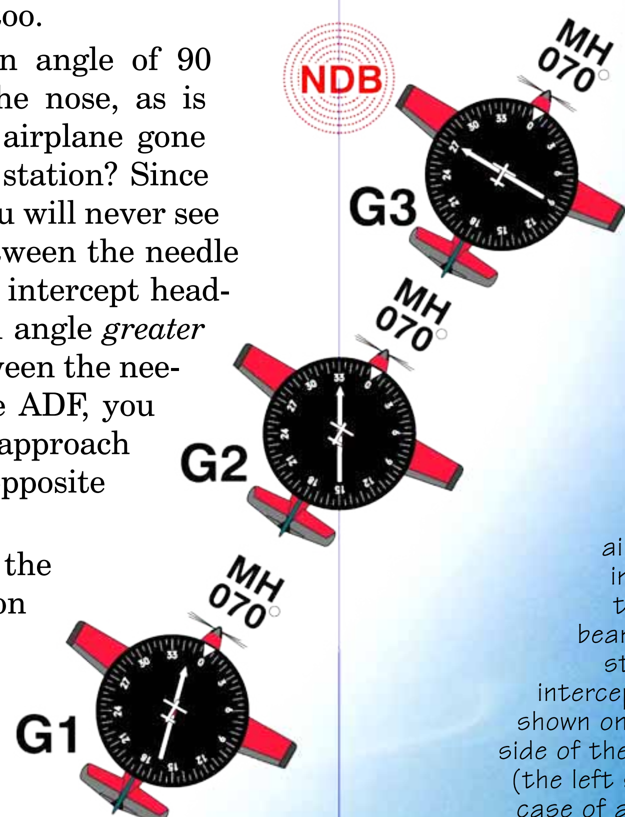


Figure 7A. When the airplane has intercepted the desired bearing to the station, the intercept angle is shown on the same side of the ADF face (the left side in the case of airplane G) that that station is on.

Suppose the ADF is showing an angle of 90 degrees between the needle and the nose, as is indicated by airplane G3. Has the airplane gone past the 040 degree bearing to the station? Since the needle always falls, you know you will never see an angle of less than 30 degrees between the needle and the nose as long as the present intercept heading is maintained. When you see an angle *greater* than the intercept angle shown between the needle and the nose on the face of the ADF, you know you have flown through the approach course and now must turn in the opposite direction to reintercept the course.

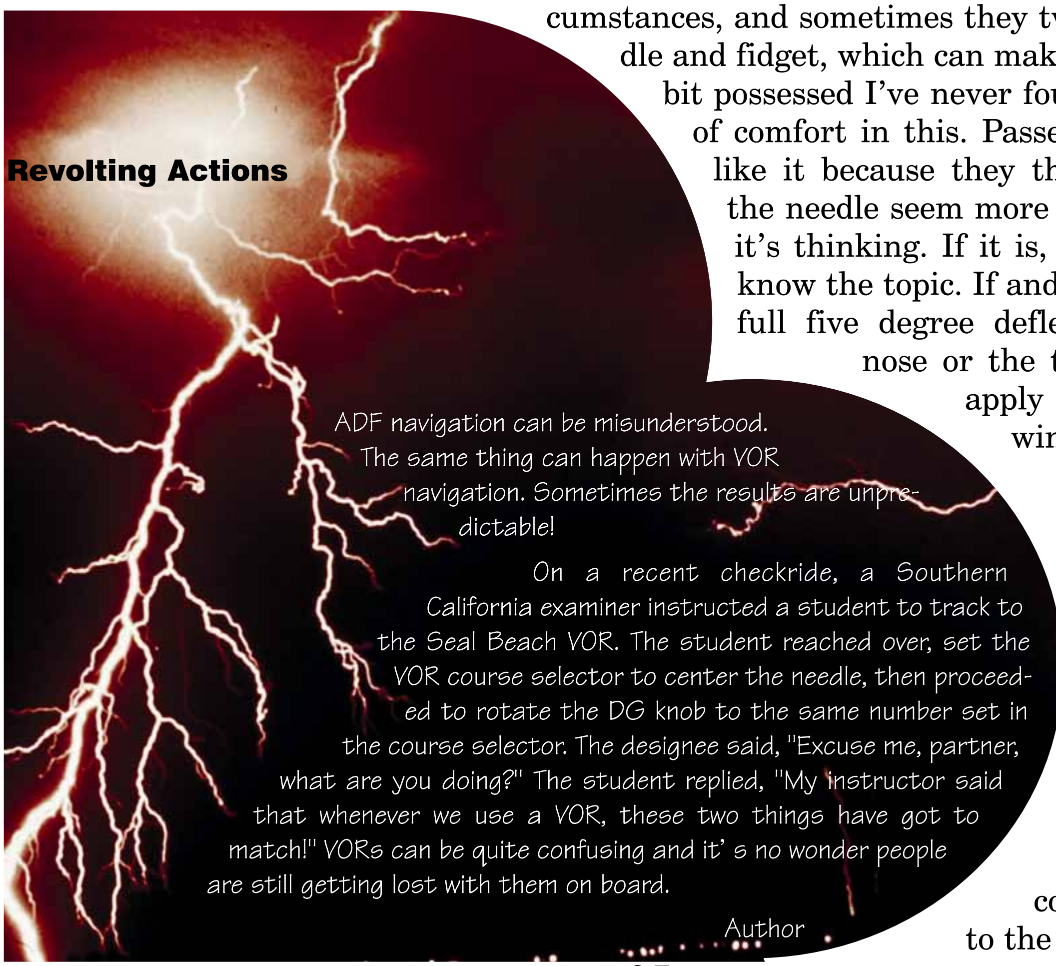
Assume you are being vectored to the 040 degree bearing from the station as shown in Figure 7B. Airplane H1 is on an intercept heading of 350 degrees. With a needle indication of 90 degrees to the left of the nose, you know that the ADF needle will continue to fall if a constant heading is maintained. The 040 degree bearing from the station will be intercepted when an intercept angle of 50 degrees (difference between 350 and 040) is shown between the needle and the tail. Since the NDB is to the left of the airplane, the intercept angle will be shown on the left side of the ADF. Airplane H2 shows this intercept angle. At this point, a right turn to an outbound heading of 040 should be made to track from the station.

Suppose you experience a major distraction by finding a stowaway in your Cessna 152. This causes you to fly beyond the 040 degree bearing. You would now have an indication similar to that shown by airplane H3. The needle is showing an angle of 30 degrees between the needle and the tail. It's very important that you recognize from this indication that you have flown beyond the 040 degree bearing. You should realize that the needle will continue to *fall* on this heading. There's no way the ADF will ever show an intercept angle of 50 degrees between the needle and the tail, as long as the current heading is maintained. You have flown beyond the 040 degree bearing and the only recourse is to turn back to the right and reintercept the course.

Wind Correction

If you are skilled at intercepting an NDB approach course, you can easily transfer these skills into making corrections for winds aloft. Once you're established on the desired bearing, simply maintain the inbound heading and watch for needle drift. Don't overreact. ADF needles have a tendency to wander a few degrees under the best of circumstances, and sometimes they twitch, pitch, fiddle and fidget, which can make them appear a bit possessed I've never found a great deal of comfort in this. Passengers, however, like it because they think this makes the needle seem more intelligent, as if it's thinking. If it is, I don't want to know the topic. If and when you see a full five degree deflection from the nose or the tail, it's time to apply a correction for wind.

Referring to Figure 8, it's evident that airplane J1 has drifted to the right of the 270 degree inbound bearing. At this point, you should reintercept the course by turning to the left, assuming a



Revolting Actions

ADF navigation can be misunderstood. The same thing can happen with VOR navigation. Sometimes the results are unpredictable!

On a recent checkride, a Southern California examiner instructed a student to track to the Seal Beach VOR. The student reached over, set the VOR course selector to center the needle, then proceeded to rotate the DG knob to the same number set in the course selector. The designee said, "Excuse me, partner, what are you doing?" The student replied, "My instructor said that whenever we use a VOR, these two things have got to match!" VORs can be quite confusing and it' s no wonder people are still getting lost with them on board.

Author

20 degree intercept angle, as shown by airplane J2. I recommend reintercepting at a minimum of 20 degrees because it gets you back on course quickly. Notice that airplane J2 now has a needle deflection of 15 degrees to the right of the nose. If an intercept heading of 250 is maintained, the intercept angle of 20 degrees will eventually be shown between the needle and the nose. Once this intercept angle is shown, you know you have reestablished yourself on the course, as shown by airplane J3. At this point, you should turn to a 5-degree wind correction heading of 265 degrees, as shown by airplane J4.

If this wind correction is sufficient, the ADF will continue showing the wind correction of five degrees between the needle and the nose while on a heading of 265 degrees. Remember, the test of whether you are on the bearing is if you can turn to the desired bearing and have the needle point directly to either the nose or the tail of the ADF. Turning five degrees to the right will have the needle of airplane J4 pointing to the nose, but not for long, since the wind will eventually blow the airplane off course.

Wind correction, while tracking outbound, is done in much the same manner as tracking inbound. You should wait for a needle deflection of five degrees off the tail, then turn 20 degrees in the appropriate direction to reintercept the course. Assume airplane J5 experiences a wind deflection while tracking outbound and turns to a heading of 290 degrees to reintercept. The angle between the needle and the tail of the ADF is now 25 degrees, as shown by airplane J6. When the airplane is back on course, the ADF will show the intercept angle of 20 degrees between the needle and the tail, as shown by airplane J7. At this point,

Figure 8. Wind Correction while tracking an NDB bearing.

a wind correction angle of five degrees is applied, as shown by airplane J8. If the wind correction is sufficient, the ADF will continue to show a five degree angle between the needle and the tail. If the wind correction angle is not sufficient, or the wind changes, then you should reintercept the course at a 20 degree angle and try a new wind correction angle. Always use a 20 degree angle to reintercept the course. This angle is small enough to let things happen gradually, but not so small that they happen too slowly.

Properly Done Tips

Here are a few more important items to consider when tracking an NDB bearing.

First, always make sure the heading indicator is set to the proper magnetic compass indication when doing ADF navigation. I have seen instrument pilots think they were doing a marvelous job of NDB navigation, only to discover they were 30 degrees off course. This is no fun for the pilot, but is sometimes entertaining for the controller.

Second, always leave the volume up slightly on the ADF receiver when doing an NDB approach. Since ADFs have no OFF flags, the only way to identify a failed station is if the Morse code identifier becomes inoperative.

Third, if you ever become confused about your position in relation to an NDB bearing, turn to the heading of that bearing and look at the needle indication. This will immediately confirm your position in relation to the desired bearing. If the needle is anywhere to the right of the nose, the bearing is to the right of the airplane. If the needle is to the left of the nose, the bearing is to the left of the airplane. You should turn in the appropriate direction to reintercept the course at a 20 degree intercept angle.

Fourth, if the ADF card is rotatable, set it so *zero* is on the nose. Then disregard the numbers on the face of the ADF card for basic ADF navigation. These numbers can be used with a rotary ADF card once the basics of ADF navigation are understood.

ADF navigation is certainly not the most accurate form of navigation available, but it may well be the most educational. ADF probably won't be your primary navaid, but you might be surprised to find someday that it's still there when everything else has given up the ghost. This is particularly true in mountainous areas, where VOR reception can be difficult or impossible. If you need a further argument for letting the ADF continue to live in your panel, consider this: it is the *only* FAA-approved navigational instrument that also receives AM radio broadcasts. If none of this floats your boat, then you can at least still pick up ball scores when aloft on the airways. So, be the first kid on your block to really understand how to use the ADF. It will make a better pilot of you, whether or not you ever spend one minute navigating by ADF under actual instrument conditions.

Rod Machado's Private/Commercial Handbook and Audiobook

Book - $84.95, eBook - $49.95

Rod Machado's Private/Commercial Pilot Handbook 704 pages 8-3/8 x 10-7/8, Softbound

---

Rod Machado's Private Pilot Audiobook - (30 Hours+)

Retention can increase by 70% with auditory learning!
Audiobook includes app for offline listening.

Price: $74.95

Welcome to your instructor in an audiobook. Rod's entire Handbook is presented in a warm, conversational manner. His tried-and-true method of instruction can be enjoyed during your commute, relaxing at home, or almost anywhere. It allows you to learn in a new, novel and often more efficient manner. Turn wasted freeway time into learning time. As one pilot said, "I felt like I had a flight instructor right there in the car with me." Perfect if you don't have the time or inclination to read, or for "tired" eyes at the end of the day. It's a pleasure to be read to, especially from a lively text spiced with humor. You can listen to the first eight chapters without referring to the book's graphics. For some chapters, you'll want to review pictures, picture text, graphs and charts in the Handbook.

This valuable one-stop audiobook will help you:

Fly as a knowledgeable and competent pilot
Prepare for the Private Pilot FAA Knowledge exam
Prepare for the Commercial Pilot FAA Knowledge exam
Prepare for the practical oral exam
Refresh for required currency training
Remain an up-to-date confident pilot

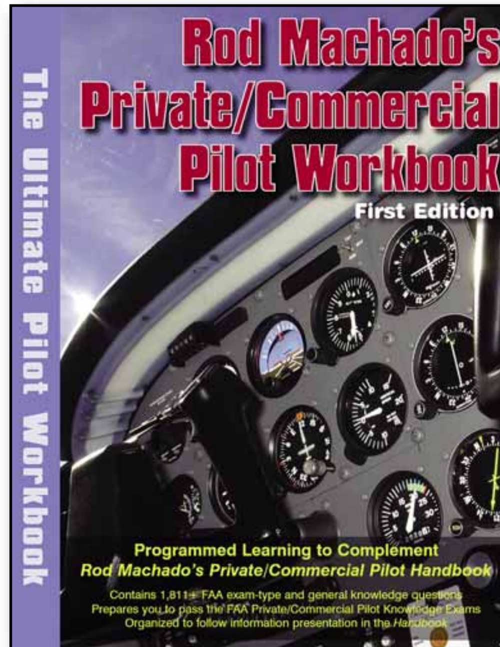
LISTEN and LEARN while:
- DRIVING
- RELAXING
- GARDENING
- EXERCISING
- EATING LUNCH
- BUILDING A KITPLANE

Narrator: Capt. Philip E. Hewitt Ph.D., CFII, ATP, Pilot Examiner, pro narrator
Guest Narrator: Alec Cody, CFII, comedic impressionist

Visit our web site at: *www.rodmachado.com*

Rod Machado's Pilot Workbook & Speaking of Flying

Rod Machado's Private/Commercial Pilot Workbook



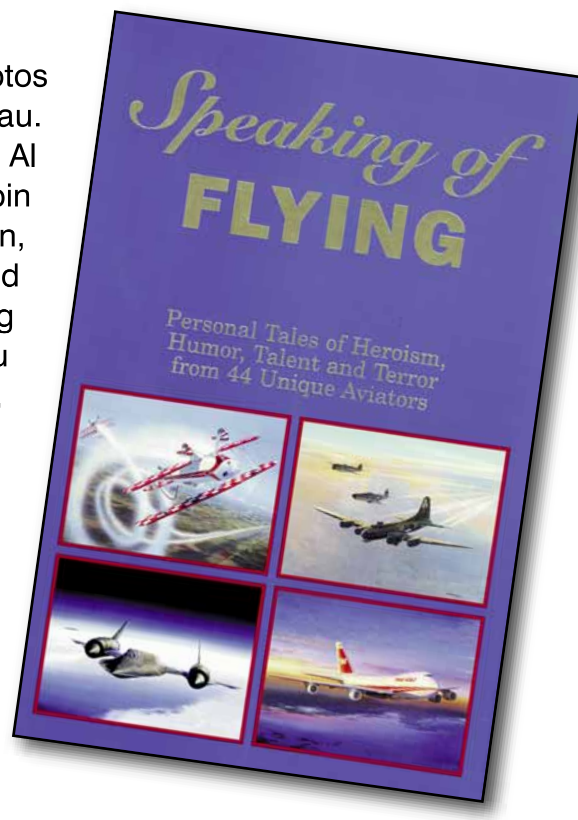
As a programmed learning guide, this book will help prepare you for the FAA Private/Commercial Pilot Knowledge Exams. The questions are organized to follow the presentation of material, section for section, as found in the *Handbook*. Not only will this book prepare you for the Knowledge Exams, it will help you understand and absorb the knowledge necessary for you to fly safely. You can test your knowledge and comprehension in each subject area with numerous weight and balance, performance, and flight planning problems.

This valuable one-stop workbook contains:

- An excellent, thorough and complete self-study system when used with *Rod Machado's Private/Commercial Pilot Handbook*.
- 1,811+ FAA Private/Commercial Pilot Knowledge Exams and general aviation knowledge questions.
- Questions organized to follow the layout of *Rod Machado's Private/Commercial Pilot Handbook* so you can test your knowledge and comprehension in each subject area.
- Color navigation charts & numerous weight-and-balance, performance, and flight planning problems.

eBook - $19.95

Speaking of Flying



A wonderful 438-page hardbound book with 230 photos written by 44 pilots with The Aviation Speakers Bureau. Includes Scott Crossfield, Julie Clark, Wally Funk, Capt. Al Haynes, Cliff Robertson, Rod Machado, Brig. Gen. Robin Olds, Bob Gilliland, Dick Rutan, Burt Rutan, Bill Lishman, John Nance, Barry Schiff, Brig. Gen. Steve Ritchie and Col. Bob Morgan. These funny, dramatic, and inspiring stories are gripping and unbelievable—but true. You would expect nothing less from aviation's celebrities, experts and specialists. Our flight plan sees us barnstorming in the U.S., flying aerial combat missions in World War II and Vietnam, test piloting new aircraft and performing air rescue. Go along as history is being made, meet true heroes, and learn what not-to-do from other's experiences. Be prepared to laugh, cry and feel the exhilaration.

Hardbound Book - $29.95 eBook - $19.95

Rod Machado's IFR Audiobooks & How to Fly an Airplane

Audiobook - Download Only - $74.95

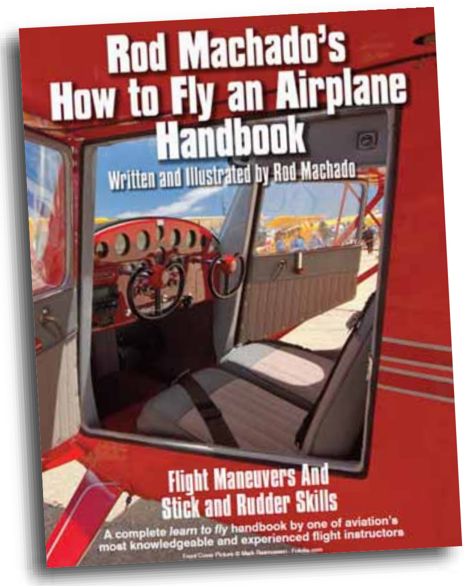
Rod Machado's Instrument Pilot Audiobook

Audiobook Includes App for Offline Listening - Third Edition

Now you can enjoy Rod's popular *Instrument Pilot's Handbook* during your daily commute or at home in the comfort of your own chair. This audiobook is a 30 hour narration of the *Instrument Pilot Handbook* by Rod Machado. While you can listen to the first ten chapters of the book without referring to the text, you'll still want to use the actual *Instrument Pilot's Handbook* as a reference for reviewing pictures, graphs and many of the incidental ASRS stories scattered throughout the text. This exciting audiobook is the key to learning quickly and efficiently while maximizing use of your scarce time.

Download Only

See www.rodmachado.com for download version!



Book-$59.95 eBook-$44.95

Rod Machado's How to Fly an Airplane Handbook & Audiobook

Rod Machado's *How to Fly an Airplane Handbook* (or audiobook recorded by Rod Machado) is a full color, 597 page softbound handbook. It contains all the information you need to learn the physical skills associated with flying an airplane. The book was written to help all pilots learn the basic maneuvers for flying an airplane as well as helping already rated pilots improve their stick and rudder skills.

This handbook contains the information necessary to:

- Learn the basic fundamentals of flying any airplane.
- Make flight training easier, less expensive and more enjoyable.
- Master all the private and commercial checkride maneuvers.
- Learn the "stick and rudder" philosophy of flying an airplane.
- Prevent an airplane from accidentally stalling and spinning.
- Allow you to learn to land an airplane quickly and enjoyably.
- Make you a better instructor by providing unique teaching strategies and explanations for student training.

These pages include:

- Practical flying skills that rely on sights, sounds and touch.
- The theory and practice of attitude flying for pilots of all levels.
- Multiple strategies for evaluating the roundout and flare.
- Multiple methods for controlling the airplane's glidepath.
- Strategies for evaluating the desired landing spot.
- Techniques for flying ground reference maneuvers.
- Handling bounces, floating, porpoising and ballooning.
- Wisdom and insights based on practical flying experience.
- Complex airplane operations, night flying, traffic pattern operations, slow flight, stall and spin recognition and recovery, and much more.

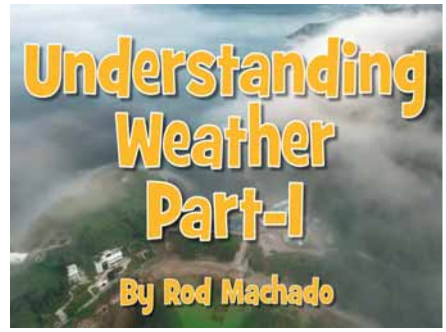
Audiobook Includes App for Offline Listening

See www.rodmachado.com for download version!

Audiobook - Download Only - $59.95

Rod Machado's eCourses

Rod Machado's eLearning Courses



Would you like to try a fun, new and exciting way to learn? Then purchase one of Rod Machado's *Interactive eLearning Courses*. Each course is narrated and accompanied by interesting graphics, animations, videos and educational interactions. In addition, each section within a course is accompanied by questions to help test your knowledge and reinforce important concepts. Of course, if questions aren't your thing, then simply skip them and continue with the course. While this course can be viewed on an iPhone or Android phone, the graphics would be difficult to see (unless you are an ant). These courses were designed to be used on an iPad, Android tablet device, laptop or desktop computer.

Visit: www.rodmachado.com

Rod Machado's IFR eGround School

Rod initially created the Instrument Pilot eGround School for Instrument Students. It covers the entire range of IFR topics that students must learn during their training for the rating. But, unlike a traditional ground school course just aimed at helping you pass a test, Rod explains WHY and HOW things work. In typical Machado fashion, he injects a healthy dose of fun into the explanations and makes dry topics interesting.

While great for students preparing for their IFR Knowledge Exams, the Instrument Pilot eGround School is equally helpful for Rusty Instrument Pilots looking to get proficient again, or prepare for an Instrument Proficiency Check (IPC). Rod will help you fill in any gaps in your knowledge and re-familiarize yourself with important concepts you may have forgotten.

The Instrument Pilot eGround School is also a tremendous resource for Instrument Instructors. You'll see how Rod teaches complex topics with ease, and keeps students engaged. Rod's interactive eLearning courses are a great way to learn complex topics in a simple and engaging way. They offer laughs and lightness that will help you learn and retain without the usual drudgery.

The Instrument Pilot eGround School includes narration, video, animation, graphics, and interactive elements. Each course includes optional quizzes that help test your knowledge and reinforce important concepts.

It runs on a laptop or desktop computer, or on an iPad or Android tablet. All you need is an internet connection–you'll have access to the entire library whenever and wherever you need it.

Visit: www.rodmachado.com

Rod Machado’s eCourses and Plane Talk Book

The Art of Takeoffs and Landings eCourse

Every flight starts with a takeoff and ends with a landing, yet many pilots lack the fundamentals to do them consistently because they weren’t properly taught, or they haven’t practiced enough to be proficient.

That’s where this course comes in. If you use it to pick up just one useful takeoff or landing technique, it will be worthwhile because you will use the technique over and over.

But (trust me) there are lots of useful techniques in this course. Some of the techniques Rod teaches are unique while others you may be familiar with, but Rod often puts a different spin on them or provides an example that suddenly makes things crystal clear. In some cases, Rod will validate a technique you are already using and that can be just as valuable.

Good takeoffs and landings start with a solid understanding and good technique — and that’s exactly what Rod delivers in this course.

These eLearning courses work on all iThingy devices, Android devices, laptops and PCs. Please use Chrome browser to access eCourse links.

Visit: www.rodmachado.com

Handling In-flight Emergencies eCourse

Welcome to Rod Machado's interactive eLearning course on handling in-flight emergencies. If you've ever wondered whether or not you could handle some of the more common and rare in-flight emergencies a pilot might experience, then this is the course that will train you to do so. Rod provides practical strategies for dealing with these emergencies and does so in a fun, interesting and highly educational way. Not only are these ideas presented with animation, you'll also see actual, in-flight demonstrations of certain emergency procedures.

This six-hour course also contains questions to test your knowledge. You can even download the course to your tablet device for off-line viewing. The following are some of the topics covered in this course.

These eLearning courses work on all iThingy devices, Android devices, laptops and PCs. Please use Chrome browser to access eCourse links.

Visit: www.rodmachado.com

Rod Machado’s Plane Talk

The Mental Art of Flying an Airplane

You’ll Learn, You’ll Laugh, You’ll Remember!

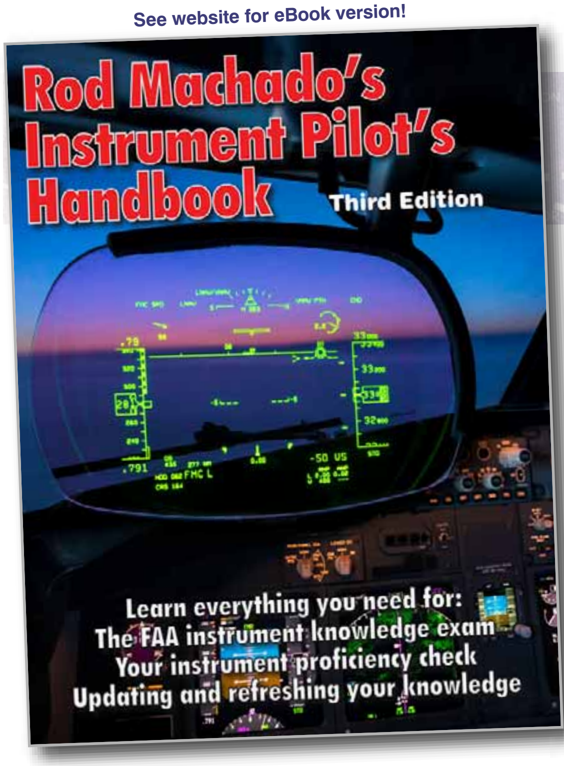
Welcome to a collection of Rod Machado’s most popular aviation articles and stories from the last 15 years. *Rod Machado’s Plane Talk* contains nearly 100 flights of fun and knowledge that will stimulate your aviation brain and tickle your funny bone.

In addition to the educational topics listed below, you’ll read about higher learning, the value of aviation history, aviation literature, aviation art and how an artist’s perspective can help you better understand weather. You’ll also find more than a few articles written just to make you laugh.

eBook - $24.95

Rod Machado's Instrument Pilot's Handbook

See website for eBook version!



ROD MACHADO'S
Instrument Pilot's Handbook - Third Edition

704 Full Color Pages - Softbound - $84.95, ebook $49.45 (2023)

Rod Machado's Instrument Pilot's Handbook is a teaching tour de force that takes pilots through the complex world of instrument flying.

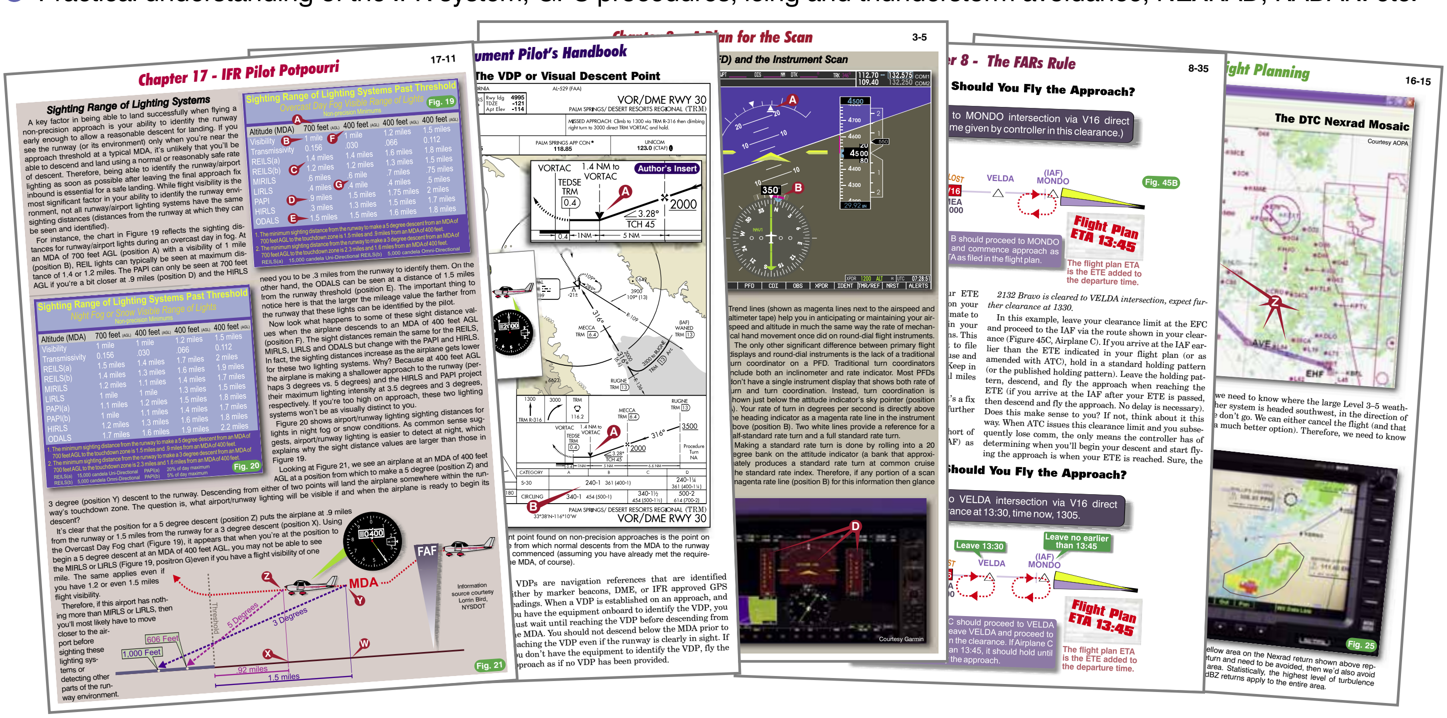
Long known for his unique ability to transform difficult concepts into simple-yet-complete explanations, Machado takes both new and experienced IFR pilots on a guided tour of instrument flying, from the basics through subtleties that even many professional pilots will find useful. He turns complexity into curiosity. Nearly 1,000 illustrations shine further light on the topic at hand.

From how the basic aircraft instruments really work through what's inside a thunderstorm and how a GPS approach works, Machado teaches IFR pilots not just the minimum needed to pass the instrument pilot written exam, but every aspect of IFR flying. This up-to-date text covers the latest information on GPS, glass cockpits, data uplinks, computer-based resources, and other new (and future) technologies and techniques. It is also a rich source of practical information about how real pilots really fly IFR. Readers learn how to gauge the thunderstorm potential of a cumulus cloud by estimating the rainfall rate, scan their instruments in a way that provides maximum performance with minimum effort, and keep the needle centered during an ILS or LPV approach by using the sky pointer on the attitude indicator.

There's flying by the book, and then there's flying by THIS book. *Rod Machado's Instrument Pilot's Handbook* is fun, thorough, and the next best thing to having Rod Machado sit by a pilot's side and talk him through each topic. Once again, Machado proves that you can have fun while learning what you need to know in order to fly safely.

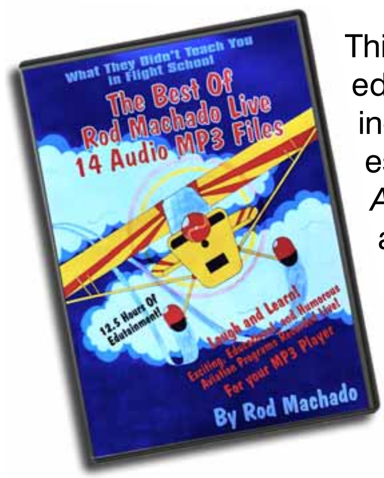
As a comprehensive information source book, these pages include:

- Simplification of the FAA's instrument scan concepts and an easy-to-use, cockpit-practical instrument scan technique
- Latest information on aviation decision making for instrument pilots
- Detailed understanding of analog and glass (PFD) flight instruments
- Detailed procedures for planning an IFR cross-country flight
- Easy to apply navigation methods for VOR, GPS, ADF and for flying approaches to LPV, LNAV, LNAV/VNAV minimums
- Clear, down-to-earth explanations of pertinent FARs, including instrument currency, lost comm, alternate requirements, etc.
- Step-by-step explanation of how instrument approach charts are constructed, including MDAs, DAs, procedure turns, etc.
- Practical understanding of the IFR system, GPS procedures, icing and thunderstorm avoidance, NEXRAD, RADAR. etc.



Rod Machado Live and Ordering

The Best of Rod Machado Live



This exciting 14-program set (12.5 hours of recorded material) was recorded live at Rod Machado's aviation training seminars. These programs include Rod's popular *Handling In-flight Emergencies* seminar and his latest programs on *Defensive Flying*, *The Nonpilot's Guide to Landing an Airplane*, *Samurai Airmanship*, *Cockpit Management*, and several additional live programs containing some of Rod's funniest standup aviation humor. You can laugh and learn while driving, gardening, or building your own plane.

MP3 Download-Only Version $24.95

Visit: www.rodmachado.com

CONTENTS

Audio-1 Laugh Your Empennage Off (95/5)*
Audio-2 Samurai Airmanship (30/70)*
Audio-3 Reducing Cockpit Stress Between the Sexes (60/40)*
Audio-4 Cockpit Management (40/60)*
Audio-5 An Aviation Sense of Humor (95/5)*
Audio-6 Creative Solutions to Common Problems (40/60)*
Audio-7 Handling In-flight Emergencies 1 (10/90)*
Audio-8 Handling In-flight Emergencies 2 (10/90)*
Audio-9 Handling In-flight Emergencies 3 (10/90)*
Audio-10 Handling In-flight Emergencies 4 (10/90)*
Audio-11 The Nonpilot's Guide to Landing an Airplane (30/70)*
Audio-12 Aviation Humor: The Light Stuff (95/5)*
Audio-13 Yoke and Pedal: The Art of Flying (10/90)*
Audio-14 Defensive Flying (10/90)*

*(% Humor content / % Information content)

"Rod has a wonderful sense of humor that will keep you in stitches and when you're done laughing, you'll be amazed at how much you've learned."
John & Martha King, King Video

"Mary Poppins once sang, 'A spoon full of sugar helps the medicine go down.' Rod Machado goes one step further by sugar coating invaluable aeronautical wisdom with entertaining wit and humor."
Barry Schiff, TWA Captain/Noted Author

How to Order for Bulk Book Purchases

Please visit:
www.rodmachado.com
to place an order.

For bulk quantities of paper books
our wholesale distributor is
Wing Aero Products:
5009 Martin Drive
Rowlett, TX 75088
www.wingaero.com
Direct 800-437-7080
Intl. 972-463-6080