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Instrument Rating Quick-Review Sheets

Instrument Rating Requirements (§61.65(a))

1) Hold at least a current private pilot certificate (or concurrently apply for a private pilot certificate) with airplane rating
2) Be able to read, speak, write, and understand English
3) Receive and log ground training from an authorized instructor
4) Receive logbook endorsement for knowledge test
5) Receive and log flight training from an authorized instructor in an aircraft, full flight simulator, or flight training device
6) Receive logbook endorsement for practical test
7) Pass knowledge test
8) Pass practical test

Instrument Airplane Aeronautical Experience (§61.65(d))

- 50 Cross-Country Hours PIC
  - 10 Hours Must be in an Airplane
- 40 Simulated or Actual Instrument Time
  - 15 Hours Dual Received from authorized instructor who holds an instrument airplane rating
    - 3 Hours in Airplane appropriate to instrument airplane rating within 2 calendar months preceding practical test
    - IFR dual received cross country flight on a flight plan filed with an air traffic control facility that involves:
      - 250 nautical miles along airways or by directed routing from ATC
      - Instrument approach at each airport
      - 3 different kinds of approaches with use of navigation systems

Instrument Rating Privileges

1) Act as PIC under IFR (§61.3(e))
2) Act as PIC in weather conditions less than VFR (§61.3(e))
3) Conduct special VFR operations at night (sunset to sunrise) (§91.157(b)(4)(i))

Personal Documents Required to Exercise Privileges (§61.3)

P.P.M

- **P**ilot Certificate
- **P**hoto ID, valid government issued
- **M**edical Certificate

Personal Minimums & Risk Management

P.A.V.E.

- **P**ilot (I.M.S.A.F.E., currency, & proficiency
- **A**ircraft (D.I.E.)
- En**V**ironment (N.W.K.R.A.F.T.)
- **E**xternal Pressure

Pilot Self-Assessment

I.M.S.A.F.E.

- **I**llness
- **M**edications
- **S**tress
- **A**lcohol
- **F**atigue
- **E**xternal Factors

Airworthiness Documents

D.I.E.

- **D**ocuments (ARROW PEC)
- **I**nspections (AAV1ATE)
- **E**quipment (A TOMATO FLAME, FLAPS, GRABCARDD)

Documents

A.R.R.O.W. P.E.C

- **A**irworthiness Certificate (§91.203)
- **R**egistration (§91.203)
- **R**adio Operating License (international only FCC Form 605)
- **O**perating Limitations & AFM (§21.5)
- **W**eight & Balance (§91.103)
- **P**lacards (§91.9)
- **E**xternal Data Plate (§45.11)
- **C**ompass Deviation Card (§23.2610)

Inspections

A.A.V.1.A.T.E.

- **A**irworthiness Directives (§39)
- **A**nnual Inspection every 12 calendar months (§91.409)
- **V**OR Check within the preceding 30 days (§91.171)
- **1**00 Hour Inspection if for hire (§91.409)
- **A**ltimeter, Altitude Reporting Encoder, and Static System every 24 calendar months (§91.411)
- **T**ransponder every 24 calendar months (§91.413)
- **E**LT every 12 calendar months (§91.207)

Equipment (§91.205)

A. T.O.M.A.T.O F.L.A.M.E.S. (Day VFR)

- **A**irspeed Indicator
- **T**achometer for each engine
- **O**il Pressure Gauge for each engine using pressure system
- **M**anifold Pressure Gauge (altitude engines)
- **T**emperature Gauge (liquid-cooled engines)
- **O**il Temperature Gauge (air-cooled engines)
- **F**uel Gauge
- **L**anding Gear Position Lights
- **A**nti-collision Lights (after March 11, 1996)
- **M**agnetic Direction Indicator
- **E**LT
- **S**afety Belts

F.L.A.P.S. (Night VFR)

- **F**uses (spares or circuit breakers)
- **L**anding Light if for hire
- **A**nti-collision Lights (after August 11, 1971)
- **P**osition Lights
- **S**ource of adequate electrical energy

G.R.A.B.C.A.R.D.D. (IFR)

- **G**enerator/Alternator
- **R**adio – 2 Way + Navigation Equipment for route
- **A**ltimeter
- **B**all (Slip-Skid Indicator)
- **C**lock
- **A**ttitude Indicator
- **R**ate of Turn Indicator
- **D**irectional Gyro (Heading Indicator)

- **D**ME or RNAV (If above FL240 using VORs for navigation)

Preflight Planning Information (§91.103)

N.E.W.K.R.A.F.T.

- **N**OTAMs
- **E**verything Pertinent to Flight
- **W**eather
- **K**nown ATC Delays
- **R**unway Lengths
- **A**lternatives Available
- **F**uel Requirements
- **T**akeoff & Landing Distances

Risk Management

D.E.C.I.D.E.

- **D**etect
- **E**stimate
- **C**hose
- **I**dentify
- **D**o
- **E**valuate

P.P.P.

- **P**erceive
- **P**rocess
- **P**erform

P.P.P.P.P.

- **P**lan
- **P**lane
- **P**ilot
- **P**assengers
- **P**rogramming

IFR Departure Clearance Items

C.R.A.F.T.

- **C**learance Limit
- **R**oute
- **A**ltitude
- **F**requency
- **T**ransponder Code

Mandatory Reporting Under IFR

M.A.R.V.E.L.O.U.S. V.F.R. C.500

* = Required only when not in radar contact

- **M**issed Approach (AIM 5-3-3)
- **A**irspeed ±10 or 5% Change of Filed TAS, whichever is greater (AIM 5-3-3)
- **R**eaching a Holding Fix (AIM 5-3-3)
- **V**FR on Top and Altitude Change During (AIM 5-3-3)
- ***E**TA Change ±2 min (AIM 5-3-3)
- **L**eaving a Holding Fix (AIM 5-3-3)
- ***O**uter Marker (AIM 5-3-3)
- ***U**nforecasted Weather (§91.183)
- **S**afety of Flight (§91.183)
- **V**acating an Altitude (AIM 5-3-3)
- ***F**inal Approach Fix (AIM 5-3-3)
- **R**adio/Navigation Failure (§91.187 & AIM 5-3-3)
- ***C**ompulsory Reporting Points (§91.183)
- **500** – Unable to Climb or Descend 500 fpm (AIM 5-3-3)

Crossing a Fix for Procedure Turn or Hold

5 T's

- Turn
- Timer
- Tune/Twist
- Throttle
- Talk

Position Reporting (AIM 5-3-2)

A.T.P.A.T.E.T.A.

- **A**ircraft ID
- **T**ime
- **P**osition
- **A**ltitude
- **T**ype of Flight Plan
- **E**TA
- **T**he Next Fix
- **A**ny Pertinent Remarks

When Not to Fly a Procedure Turn (§91.175, AIM 5-4-9)

S.H.A.R.P.T.T.

- **S**traight in Approach
- **H**olding in Lieu of a Procedure Turn
- **A**rc
- **R**adar Vectored to Final Approach Course
- No**P**T Depicted on Chart
- **T**imed Approach
- **T**eardrop Course Reversal

Magnetic Compass Errors

V.D.M.O.N.A.

- **V**ariation
- **D**eviation
- **M**agnetic Dip
- **O**scillation
- **N**orthernly Turning Errors
  - U.N.O.S.
    - ▶**U**ndershoot
    - ▶**N**orth
    - ▶**O**vershoot
    - ▶**S**outh
- **A**cceleration/Deceleration Errors
  - A.N.D.S.
    - ▶**A**ccelerate
    - ▶**N**orth
    - ▶**D**ecelerate
    - ▶**S**outh

Recent Flight Experience (§61.57)

"no person may act as a pilot in command of an aircraft carrying passengers—unless"

- Passenger Carry Requirements
  - ▶General Experience (a)
    - ■ In order to carry passengers during daytime
      - ◆ 3 takeoffs and landings as PIC in the preceding 90 days prior to carrying passengers
        - For day currency, touch and goes are permitted in tricycle gear aircraft
        - Acted as sole manipulator of the flight controls (i)
        - If tailwheel the landings must be to a full stop (ii)

- Must be in the same category, class, and type (if type rating is required) (ii)

▶Night Takeoff and Landing Experience
- In order to carry passengers during 1 hour after sunset to 1 hour before sunrise
  - 3 takeoffs and landings as PIC in the preceding 90 days prior to carrying passengers
    - For night currency and landings must be to a full stop
    - Acted as sole manipulator of the flight controls (i)
    - Must be in the same category, class, and type (if type rating is required)

❖Instrument Experience
6.6.H.I.T.S.

▶Within **6** calendar months preceding the month of the flight under simulated or actual instrument conditions must have logged:
- **6** Instrument Approaches
- **H**olding Procedures and Tasks
- **I**ntercepting and **T**racking courses through the use of Navigational Electronic **S**ystems

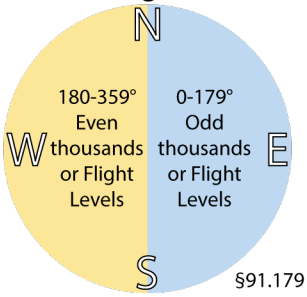
▶A pilot may accomplish these requirements in a full flight simulator, flight training device, or aviation training device provided it represents the category of aircraft for the instrument rating privileges to be maintained and the pilot performs the tasks and iterations in simulated instrument conditions.

❖Instrument Proficiency Check

▶If a pilot has failed to meet the instrument experience requirements for more than 6 calendar months, they can reestablish instrument currency only by completing an instrument proficiency check. Which must include the following:
- Air Traffic Control Clearances and Procedures
- Flight by Reference to Instruments
- Navigation Systems
- Instrument Approach Procedures
- Emergency Operations
- Postflight Procedures

▶The proficiency check must be done in the appropriate aircraft category and performed by:
- Examiner
- Military Check Pilot
- Company Check Pilot
- Authorized Instructor
- Person Approved by the FAA to Conduct Instrument Practical Tests

IFR Cruising Altitudes
Based on Magnetic Course



IFR Minimum Altitudes (§91.177, AIM 5-6-16)

❖Minimum Prescribed, or if none

▶Mountainous area: 2,000 feet above the highest obstacle within a horizontal distance of 4 nautical miles from the course to be flown

▶Non-mountainous area: 1,000 feet above the highest obstacle within a horizontal distance of 4 nautical miles from the course to be flown

IFR Fuel Requirements (§91.167)

❖No person may operate a civil aircraft in IFR conditions unless it carries enough fuel to

▶Complete the flight to the first airport of intended landing;

▶Fly from that airport to the alternate; and

▶Fly after that for 45 minutes at normal cruising speed

IFR Flight Planning (§91.169)

❖You ALWAYS need an alternate unless the airport has an instrument approach and the weather is above the 1-123 rule.
1-123 Rule

▶**1** hour before and for **1** hour after the ETA, the ceiling must be at least

▶**2,000** feet above the airport elevation and the visibility must at least

▶**3** Statute Miles
- This means if weather reports are less than 2,000 ft ceilings **OR** less than 3 statute miles visibility, you must file for an alternate

❖What qualifies as an alternate airport?

▶No person may include an alternate airport in an IFR flight plan unless appropriate weather reports or weather forecasts, or a combination of them, indicate that, at the ETA at the alternate airport, the ceiling and visibility at that airport will be at or above the following weather minima:
- For precision approach, ceiling 600 feet and visibility 2 statute miles
- For nonprecision approach, ceiling 800 feet and visibility 2 statute miles
- For no instrument approach procedure at the alternate, ceiling and visibility must allow for a visual descent from the MEA and landing under basic VFR

❖AIM 1-1-18(c)(9)(a)

▶If the aircraft is equipped with WAAS, and there are no predicted WAAS outages (Check NOTAMs) at either the destination or the alternate, you are allowed to have only GPS based approaches.

❖AIM 1-1-17(5)(c)

▶If the aircraft has RAIM+FDE you can have one of the other. The destination OR the alternate can have only GPS based approaches, but the other must have a ground-based approach system.

Lost Communications (§91.185)

❖VFR Conditions, if failure occurs in VFR conditions, or VFR is encountered after failure, continue the flight under VFR and land as so as practicable

❖IFR Conditions, if failure occurs in IFR conditions

▶Route (fly in the order of the following)
A.V.E. F.
- **A**ssigned Route in last ATC clearance
- **V**ectored Route to the fix, route, or airway specified in the vector clearance
- **E**xpected Route in further clearance
- **F**iled Route in the flight plan

▶Altitude (fly the highest of the following)

M.E.A.
- **M**inimum Altitude for IFR operations
- **E**xpected Altitude in further clearance
- **A**ssigned Altitude in last ATC clearance

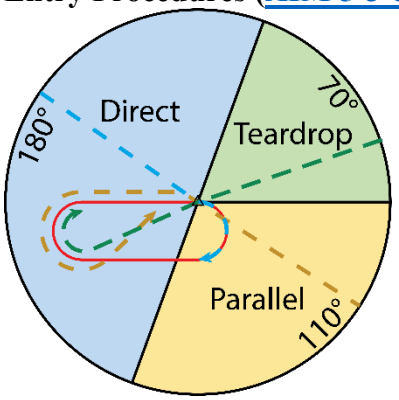
▶Clearance Limit
- If clearance limit is a fix from which an approach begins
  - ◆If expect further clearance is received, commence descent as closely as possible
  - ◆If expect further clearance is not received, commence descent as closely as possible to filed ETA
- If clearance limit is not a fix from which an approach begins
  - ◆If expect further clearance is received, leave clearance limit at EFC time and proceed to a fix from which an approach begins
  - ◆If expect further clearance is not received, leave clearance limit then proceed to a fix from which an approach begins and begin descent as close as possible to filed ETA

IFR Takeoff Minimums (§91.175)
❖Part 91
▶Zero foot ceilings and zero visibility
❖Parts 121, 125,129, or 135
▶Refer to 14 CFR 97 for each airport
▶If not prescribed in §97;
- Two Engines or Less: 1 SM Visibility
- More Than Two Engines: ½ SM Visibility
- Helicopters: ½ SM visibility

Category Speeds and Circling (§97.3)
❖Based on VREF, or 1.3 V_{SO} at maimum certificated landing weight if VREF not specified

Category	Speed	Circling Distance
A	<90 knots	1.3 nm
B	90-120 knots	1.5 nm
C	121-140 knots	1.7 nm
D	141-165 knots	2.3 nm
E	165+ knots	4.5 nm

Standard Climb Gradient (AIM 5-2-9)
❖200 feet per nautical mile
❖$\left(\frac{Groundspeed}{60}\right) * climb\ gradient = fpm$

Entry Procedures (AIM 5-3-8)


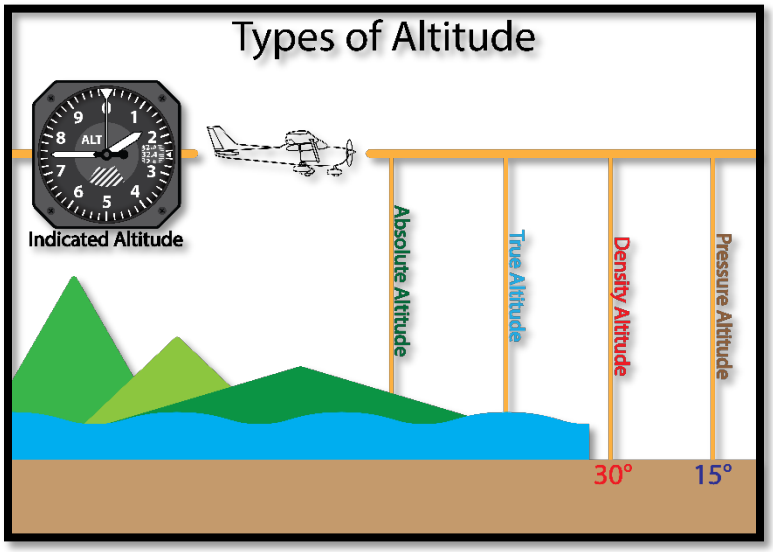
Holding Speeds (AIM 5-3-8)

Altitude (MSL)	Airspeed (KIAS)
MHA - 6,000’	200
6,001’ – 14,000’	230
14,001’ and above	265

Holding Times (AIM 5-3-8)
❖Inbound Leg
▶At or below 14,000’ MSL
- 1 Minute

▶Above 14,000’ MSL
- 1.5 Minutes

*Initial outbound leg should be flown for the 1 minute or 1.5 minutes. Timing for subsequent outbound legs should be adjusted as necessary to achieve proper inbound leg time.
❖Outbound Leg
▶Timing begins over/abeam the fix, whichever occurs last. If abeam position cannot be determined, start timing when turn to outbound is completed



Types of Altitudes (PHAK 8-6)
❖Indicated – read directly from the altimeter
❖Absolute – vertical distance between the aircraft and terrain, expressed as above ground level (AGL)
❖True – vertical distance of aircraft above sea level, expressed as mean sea level (MSL)
❖Pressure – height above standard datum
❖Density – pressure altitude corrected for non-standard temperature

Types of Airspeeds (PHAK 8-8)
❖Indicated – read directly from the airspeed indicator
❖Calibrated – indicated airspeed corrected for installation and instrument error
❖True – calibrated airspeed corrected for altitude and nonstandard temperature (actual airspeed of aircraft through the air)
❖Groundspeed – true airspeed corrected for wind, actual speed of the aircraft over the ground

NOTAM’s (AIM 5-1-3)
S.M. P.F.D.
❖**S**AA
▶“Special Activity Airspace”
▶Issued when active outside published scheduled times.
❖**M**ilitary
▶Pertains to U.S. military navigational aids/airports
❖**P**ointer
▶“Points out”

- ▶Issued by FSS to point out another NOTAM

❖**F**DC
- ▶**"**Flight Data Center"
- ▶Issued when necessary to disseminate regulatory information
- ▶i.e. TFR's, amendments to IAP's and aeronautical charts

❖**D**
- ▶"Distant"
- ▶Issued to disseminate information for navigational facilities
- ▶i.e. taxiway closures, personnel and equipment near or crossing runways

Ways to file a Flight Plan (IFR)

❖Flight Service (1-800-WXBRIEF)
❖ARTCC
❖ATC/Tower
❖Flight Service Station (FSS)
❖Apps or Web Services (i.e. Foreflight)

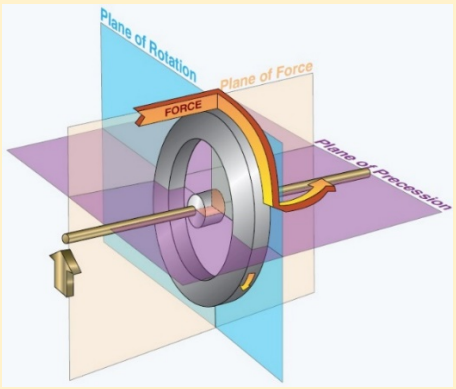
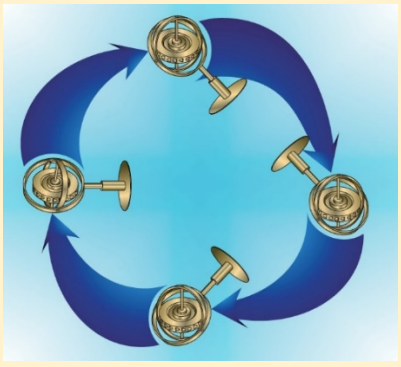
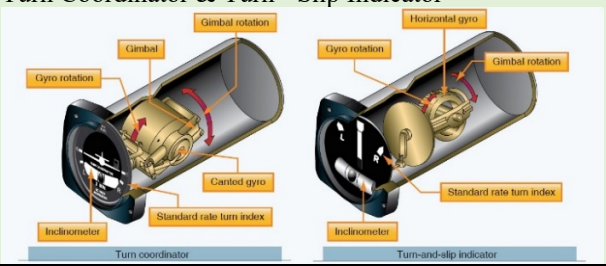
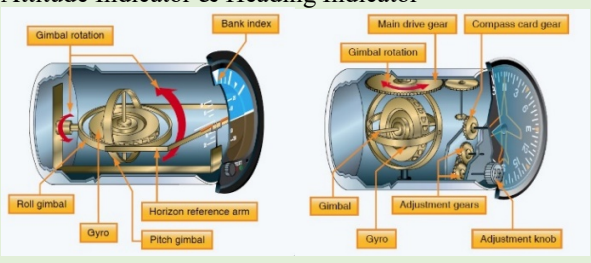
Fundamental Skills for Instrument Flying

❖Instrument Cross-Check – developing a scan technique to effectively check flight instruments.
- ▶Scanning Techniques
  - ■ Hub and Spoke – attitude indicator is the hub and the rest of the instruments are the spokes. The scan works by checking the attitude indicator between checking other instruments
  - ■ Rectangle – scans the top three instruments, then the bottom three and repeat.
- ▶Common Errors
  - ■ Fixation – staring at one instrument for too long can cause the pilot to lose track of other aspects of flight. (ie. Focusing on the altimeter because the plane is below the designated altitude, but then losing track of the heading or airspeed.)
  - ■ Omission – scanning some of the instruments but not all of the flight instruments can cause the pilot to not maintain positive aircraft control. (ie. Pilot thinking they are flying straight because of the attitude indicator is displaying straight and level, but due to winds the plane is slowly getting off course because the pilot is skipping their check of the horizontal direction indicator)
  - ■ Emphasis – each instrument provides information to more than one aspect of flight. It is easier to understand and check the airspeed indicator to maintain an airspeed than to also check the power setting and pitch which also affect airspeed. So a pilot can fall into the trap of only checking the airspeed indicator for airspeed, but may be constantly changing settings because they don't understand that pitch attitude and power settings also help with this.

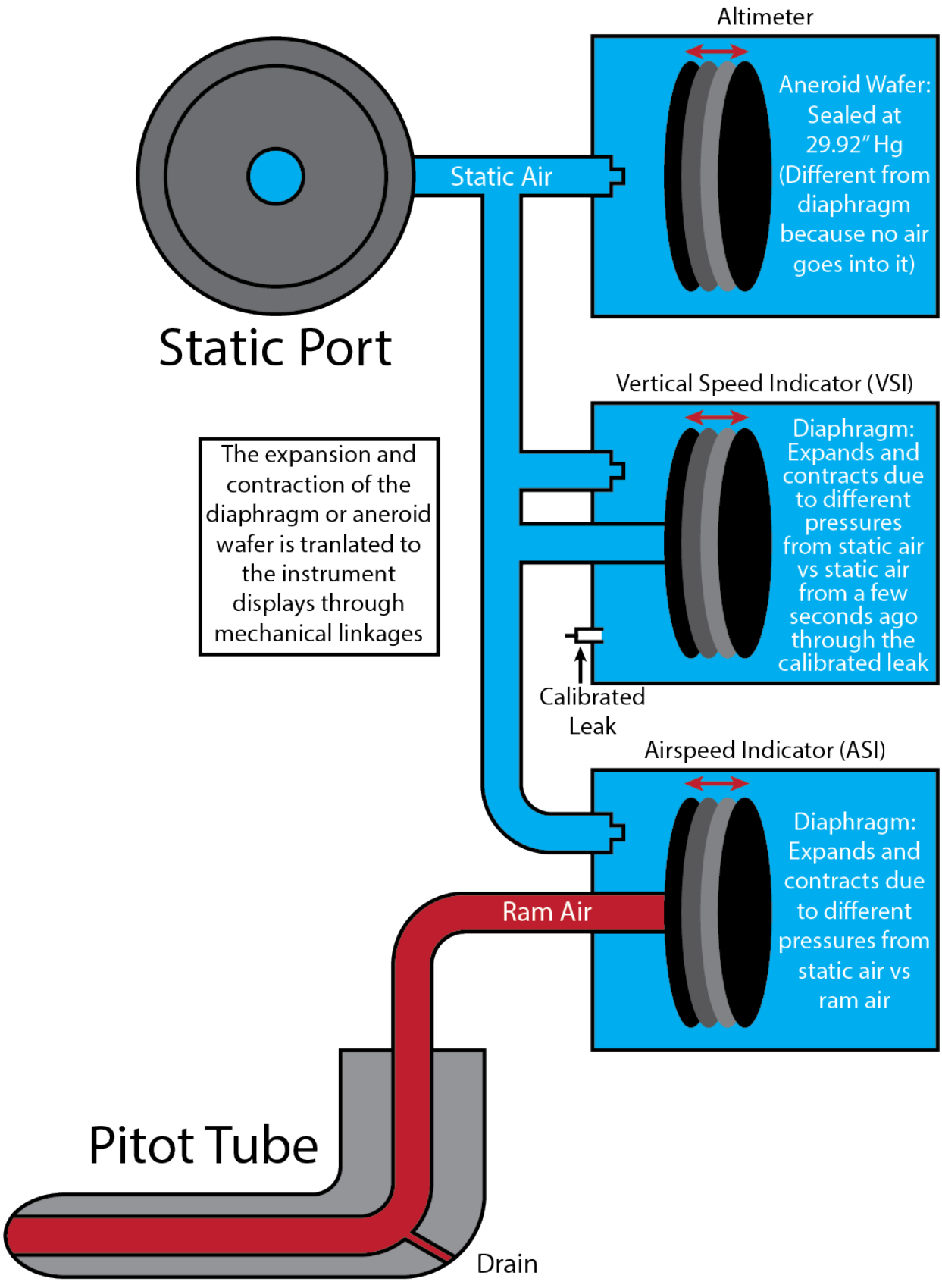
❖Instrument Interpretation – is developed through understanding the construction and operation of the flight instruments. When the pilot understands how flight instruments work and what they are saying, then the pilot can effectively apply corrections and know when an instrument fails or is not operating correctly.
❖Positive Aircraft Control – after checking and interpreting flight instruments can a pilot apply the flight corrections need to maintain control of the aircraft.

Flight Instruments

❖Gyroscopic Principles

	Precession	Rigidity in Space
Definition	A force applied is felt 90° in the direction of rotation 	Gyroscope resists motion and stays fixed in the plane of motion that it is spinning 
How	The slow rotation of the gyroscope about another axis due to torque (the force applied on the gyroscope from a turn)	Due to angular momentum of the spinning gyro, it stays vertically aligned and the plane moves around the gyroscope providing pitch and roll
Instruments	Turn Coordinator & Turn - Slip Indicator 	Attitude Indicator & Heading Indicator 

Pitot-Static System



❖Electronic Flight Instruments
- ▶Attitude Heading Reference System (AHRS) - Provides attitude and heading information most commonly through solid state gyros and sensors.
- ▶Air Data Computers (ADC) - Provides airspeed, altimeter, vertical speed indicator (VSI), outside air temperature (OAT), and true airspeed. Takes the place of the classic pitot static system.
- ▶Flight director - Provides attitude information direction by displaying command bars to align the attitude indicator with.
- ▶Flight Management System (FMS) - Provides navigation to the flight director and autopilot through inputted information (ie. GPS)
- ▶Primary Flight Displays (PFD) - Provides the display for the primary flight instruments.
- ▶Multi-Function Displays (MFD) - Provides multiple different displays such as: moving map, engine instruments, navigation, weather, and backup to the PFD.

Instrument Departure Procedures (AIM 5-2-9)

❖Obstacle Departure Procedures (ODP)
- ▶Used to assist pilots in obstacle clearance
- ▶Printed either textually or graphically
  - ■Textual in nature
- ▶Do not include ATC-related climb requirements
  - ■Converting ft/nm to fpm
    - ◆$\frac{Groundspeed}{60} = \frac{Nautical\ Mile}{1\ min}\ Then \frac{Nautical\ Miles}{1\ min} * \frac{Feet}{Nautical\ Mile} = Feet\ per\ minute$
    - ◆$Example\ if\ groundspeed\ is\ 90: \frac{90}{60} = 1.5nm\ per\ min\ Then\ \frac{1.5\ nm}{1\ min} * \frac{200ft}{1\ nm} = 300fpm$
- ▶Designed for the easiest route of flight to an en route structure or a climb to an altitude safe for IFR flight.
- ▶Developed when obstructions penetrate the 40:1 rule for obstacle clearance surface (OCS)
  - ■Gradient begins from Departure End of the Runway (DER)
- ▶En Route Operations
  - ■Non-mountainous: 25 NM for 1,000ft of ROC
  - ■Mountainous: 46 NM for 2,000 of ROC
- ▶Found in U.S. Terminal Procedures Publication (TPP)
- ▶Pilot can fly ODP without ATC authorization and must determine if an ODP be flown, ATC will not assign ODP unless necessary for aircraft separation.

❖Standard Instrument Departure (SID)
- ▶ATC-requested and developed departure route
  - ■Typically for busy terminal areas
- ▶Always printed graphically
- ▶Designed at the request of ATC to increase capacity of airspace, control flow of traffic with minimal communication, and reduce noise impact on the environment
- ▶Obstacle protection is always considered in SID routes, but the main idea is to reduce ATC/pilot workload while providing seamless transitions to the en route structure
- ▶ATC clearance is required to fly a SID
- ▶"NO SIDs" in remarks for flight plan if
  - ■Cannot comply with SID
  - ■Do not possess the graphical SID or;
  - ■Simply do not wish to us SIDs
- ▶Found in U.S. Terminal Procedures Publication (TPP)
- ▶Use of SIDs decreases clearance delivery time and simplifies departure

❖Diverse Vector Area (DVA)
- ▶ATC can establish minimum vectoring altitude (MVA) based on terrain and obstacle clearance and it provides ATC with an option to vector aircraft around
- ▶However, sometimes it is necessary for ATC to vector aircraft below MVA to assist the flow of traffic
- ▶Established below MVA or minimum IFR altitude (MIA) in a radar environment at the request of ATC
- ▶Noted in the Takeoff Minimums and ODP section of TPP

❖Visual Climb Over Airport (VCOA)
- ▶Required to notify ATC
- ▶For IFR aircraft, operating in VMC to climb up to the instrument altitude
- ▶Departure option developed when obstacles farther than 3 SM from the airport require a climb gradient more than 200 ft/nm

Instrument En Route Procedures (IPH Chapter 2)

❖Airways

❖Air Route Traffic Control Centers (ARTCC)
- ▶Provide air traffic control to aircraft operating under IFR during en route phase
- ▶Workload permitting – provide advisories/assistance for aircraft operating under VFR
- ▶Referred to as "Centers"
- ▶Largest component of the NAS
- ▶Divided into Sectors with unique radio frequencies
  - ■Low Altitude Sectors
  - ■Intermediate Altitude Sectors
  - ■High Altitude Sectors
  - ■Ultra High Altitude Sectors

❖Safe Separation
- ▶Laterally – 5 miles
- ▶Vertically
  - ■1,000ft
    - ◆Below FL290
    - ◆RVSM compliant FL290 – FL410
  - ■2,000ft
    - ◆FL290 and above

❖Preferred IFR Routes
- ▶Established between airports to increase efficiency and capacity
- ▶Clearances issued based on these routes
- ▶Listed in the Chart Supplement

❖Tower En Route Control (TEC Route)
- ▶Established to increases efficiency and reduce communication requirements
- ▶For aircraft proceeding to and from metropolitan areas
- ▶Links approach control areas
  - ■Uses existing airways to fly under IFR without leaving an approach control airspace

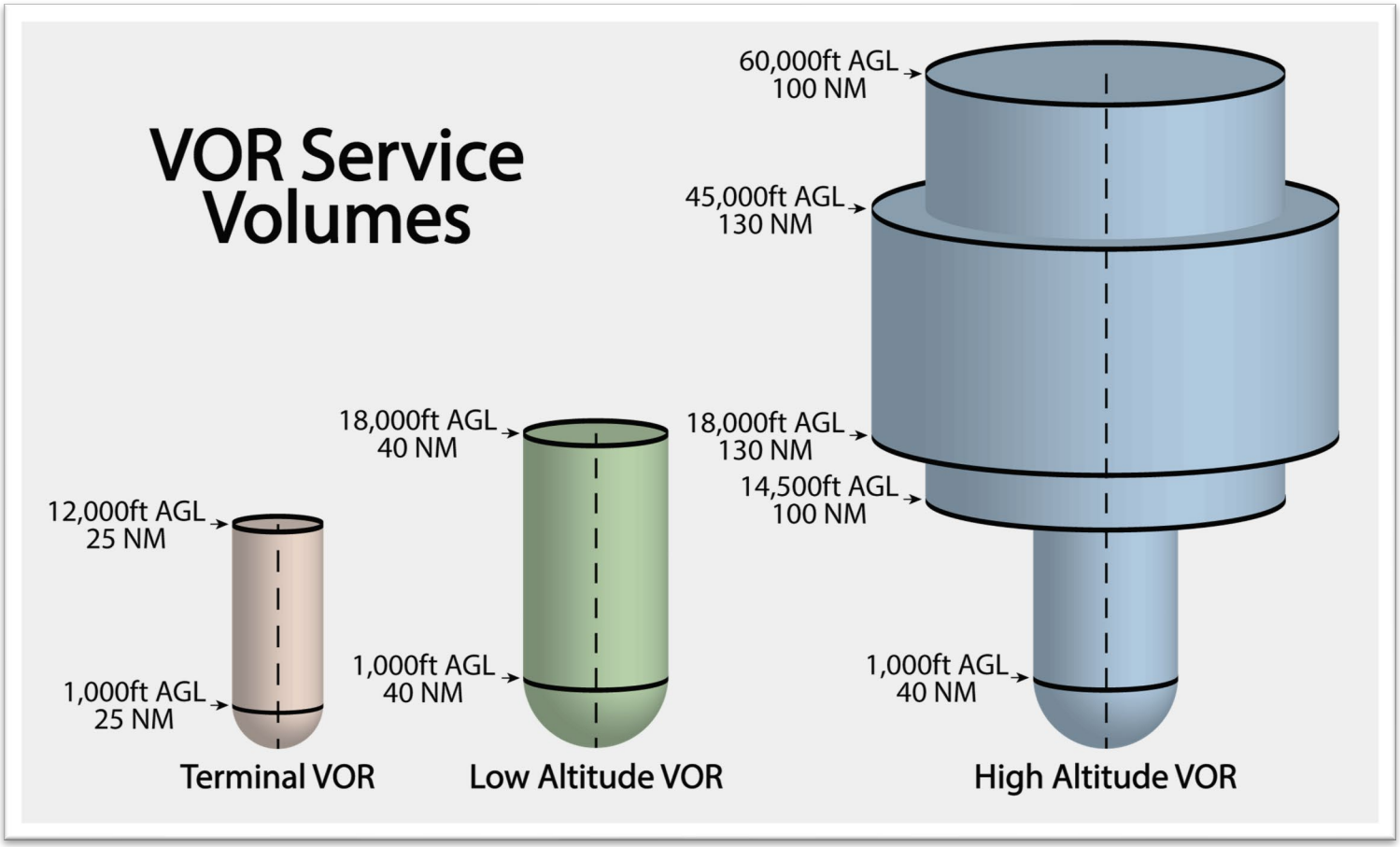
❖Airways
- ▶Three Dimensional Highways
  - ■First Level
    - ◆Low Altitude Airways
    - ◆Start with the letter "V"
    - ◆Called "Victor" Airways

- 1,200ft AGL up to but not including 18,000ft MSL
- Second Level
  - High Altitude Airways
  - Start with the letter "J"
  - Called "Jet Routes"
  - 18,000ft MSL – FL450
- Third Level
  - Random Operations
  - Above FL450

▶Types of Airways
- VHF Omnidirectional Range or VOR (Low Victor Airways & High Jet Routes)
- Nondirectional Beacon (NDB) (Low to Medium Frequency)
- Area Navigation (RNAV)

❖Navigational Systems

▶Ground Based or NAVAIDs
- VOR (AIM 1-1-3)
  - Oriented to magnetic north and transmits 360 courses around the station known as radials
  - Each station has a unique Morse code identifier
    - If it cannot be identified, it means it is out of service
  - How it works
    - Transmits two radio signals:
      - ➢ Reference Phase – constant radio wave in all directions
      - ➢ Variable Phase – spiral radio wave from the station
      - ➢ These two waves together provide 360 unique combinations and create the radials
  - Types of VORs
    - VOR
    - VOR/DME
      - ➢ VOR & DME
      - ➢ Provides VOR Azimuth and VOR DME
    - VORTAC
      - ➢ VOR & TACAN
      - ➢ Provides VOR Azimuth, TACAN Azimuth, and TACAN DME
  - How to Intercept a Radial
    - Determine difference between radial to be intercepted and the radial the aircraft is currently on
    - Double the difference and add or subtract to current heading
    - Tune the desired radial
    - Turn to the interception heading
    - Fly interception heading until CDI needle starts to center and start turning toward the magnetic heading corresponding with the radial
  - $Time\ to\ Station = \frac{Seconds\ for\ Bearing\ Change}{Degrees\ of\ Bearing\ Change}$
  - $Distance\ to\ Station = \frac{TAS * Minutes\ for\ Bearing\ Change}{Degrees\ of\ Bearing\ Change}$
  - $Distance\ off\ Course = \frac{Miles\ from\ Station}{60} * Degrees\ off\ course$
  - Full scale deflection = 10°



- ◆ Errors
  - Cone of Confusion (AIM 4-5-6)
  - Line of Sight (AIM 1-1-3)
  - Reverse Sensing (IFH 9-14)
  - Service Volumes (AIM 1-1-8)
  - RPM Error (AIM 1-1-3)
- ◆ VOR Accuracy Check (§91.171)
  B.A.D.V.A.G.
  - **B**ench Check Repair Station (+/- 4°)
  - **A**bove a Prominent Landmark on an Airway (+/- 6°)
  - **D**ual VOR (within 4° of each other)
  - **V**OT (+/- 4°)
    - ➢ 180° = TO flag (Cessna 182)
  - **A**irborne Checkpoint (+/- 6°)
    - ➢ Found in Chart Supplement
  - **G**round Check Signal (+/- 4°)

- ◆ Logging VOR Check (§91.171)
  D.E.P.S.
  - **D**ate
  - **E**rror
  - **P**lace
  - **S**ignature

*If done by a bench check repair station, must be logged in aircraft logbook, or other record by repair station with bearing transmitted and the date.

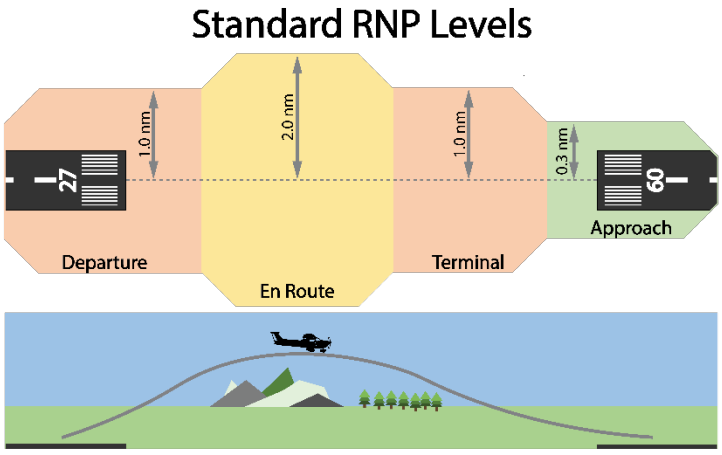
- ■ NDB (AIM 1-1-2)
- ■ Tactical Air Navigation (TACAN) (AIM 1-1-4)
- ■ Distance Measuring Equipment (DME) (AIM 1-1-7)
  - ◆ Pulse type navigation system that displays to the pilot distance information between the aircraft and station or waypoint
  - ◆ Sends out a radio wave and measures the time for it to come back to the aircraft and converts that time to nautical miles
  - ◆ DME Arc
    - Many instrument approach procedures (IAPs) use them to follow an arc path around a station
    - How to fly
      - ➢ Track inbound radial
      - ➢ Approximately ½ mile from the DME for the arc, turn 90° in the direction of the arc
      - ➢ Turn heading bug 10° in the opposite direction from the previous turn and tune to a radial 10° from the previous
      - ➢ Continue Turn 10 Tune 10, and monitor aircraft position and correct for wind
  - ◆ Errors
    - Line of Sight
      - ➢ Obstacles can block DME signal
    - Slant Range
      - ➢ DME is the actual slant distance from the aircraft to the station, rather than the horizontal distance from the aircrafts position to the station

*Slant Range Error does not occur with GPS DME distances

- ■ ILS Localizer

▶ Satellite Based

- ■ Area Navigation (RNAV)
  - ◆ Allows a pilot to fly a route without the need to overfly NAVAIDs, but using waypoints
- ■ Global Positioning System (GPS)
  - ◆ Space-based radio navigation system to determine precise positions almost anywhere in the world



  - ◆ Components (IFH 9-25)
    - Space
      - ➢ Over 30 Navigation System using Timing and Ranging (NAVSTAR) Satellites in 6 orbital planes
      - ➢ Space 60° apart at 11,000 miles above the Earth to provide complete coverage
      - ➢ Arranged so that 5 satellites are in range at any time on Earth
      - ➢ Each satellite broadcasts their location and timing
        - ▪ Aircraft receiver uses this information to determine its location (trilateration)
    - Control
      - ➢ Ground based monitoring stations that ensure satellite accuracy
      - ➢ 5 monitoring stations
      - ➢ 3 ground antennas
      - ➢ 1 master control station
    - User
      - ➢ Aircraft antennas and receivers/processors provide positioning, velocity, and timing
      - ➢ GPS equipment for IFR must be meet Technical Standard Order standards or better (TSO C-129)
  - ◆ Technical (AIM 1-1-17)
    - If receiving under 5 satellites, annunciator will show "LOI/INTEG"
      - ➢ 3 Satellites = 2D
      - ➢ 4 Satellites = 3D
      - ➢ 5 Satellites = RAIM + FD (Fault Detection)
      - ➢ 6 Satellites = RAIM + FDE (Fault Detection Exclusion)
  - ◆ Receiver Autonomous Integrity Monitoring (RAIM)
    - GPS receiver verifies the integrity of the signal from the GPS constellation
    - Need a minimum of 5 satellites or 4 satellites with a barometric altimeter baro-aiding to detect an integrity anomaly
    - 6 satellites or 5 satellites with baro-aiding to isolate a corrupt satellite and remove it from navigation (FDE)
  - ◆ Wide Area Augmentation System (WAAS)
    - Provides enhanced information to GPS receivers to increase accuracy and integrity of position

- Components
  - ➢ 38 Wide Area Reference Stations (WRS)
    - Receive GPS signals to detect errors
  - ➢ 3 Wide Area Master Stations (WMS)
    - Collects GPS information from WRS to remove errors
  - ➢ 6 GEO Uplink Subsystems
    - Sends the information from the WMS to the GEO satellites as navigation payloads
  - ➢ 3 Geostationary Satellites (GEO)
    - Navigation payloads are broadcast on a GPS like signal across the NAS. The WAAS receivers process this information to augment position estimates and increase accuracy.

❖Required Navigation Performance (RNP Scaling)(IFH 9-44)
- ▶Specified performance necessary for operation in a defined airspace
  - On-board monitoring and alerting is also required
  - RNP is RNAV with on-board monitoring and alerting
- ▶RNP defines the total system error (TSE) that is allowed in the lateral and longitudinal dimensions
  - The RNP value specified guarantees accuracy within that value for 95% of the flight time.

❖Cruise Clearance (AIM 4-4-3)
- ▶The term "cruise" may be used instead of "MAINTAIN" to assign a block of airspace to a pilot from the minimum IFR altitude up to and including the altitude specified in the cruise clearance. The pilot may level off at any intermediate altitude within this block of airspace. Climb/descent within the block is to be made at the discretion of the pilot. However, once the pilot starts descent and verbally reports leaving an altitude in the block, the pilot may not return to that altitude without additional ATC clearance.

❖IFR Altitudes (Aeronautical Chart User's Guide pg. 64-66, 106 & AIM 5-4-5)
- ▶Minimum Enroute Altitude (MEA) – lowest published altitude between radio fixes that assures navigational signal coverage and obstacle clearance requirements.
- ▶Minimum Reception Altitude (MRA) – lowest published altitude that a navigational signal can be received for the route and for off-course NAVAID facilities to determine a fix.
- ▶Maximum Authorized Altitude (MAA) – highest published altitude for an airspace structure or route segment that assures adequate reception of navigational signals.
- ▶Minimum Obstruction Clearance Altitude (MOCA) – lowest published altitude between VOR airway fixes that meets obstacle clearance requirements within 22 NM or 25 mi of the NAVAID.
- ▶Minimum Turning Altitude (MTA) – lowest published altitude providing vertical and lateral obstruction clearance based on turn criteria over fixes, NAVAIDs, waypoints, and on charted route segments.
  - Turn area provides obstacle clearance for both turning prior to the fix and turning after crossing the fix.
- ▶Minimum Crossing Altitude (MCA) – lowest published altitude at fixes as which the aircraft must cross when proceeding in the direction of a higher minimum enroute IFR altitude.
- ▶Minimum Safe Altitude (MSA) – published for emergencies only in Instrument Approach Procedures (IAPs) except when approaches use a Terminal Arrival Area (TAA). Provide 1000ft clearance over all obstructions, but do not assure navigational signal coverage.
- ▶Terminal Arrival Area (TAA) – lowest published altitude with standard obstacle clearances when operating within the TAA boundaries. Provides transition from the enroute structure to the terminal environment with little pilot/ATC interactions for aircraft equipped with RNAV systems.
  - Standard TAAs have three areas: straight-in, left base, and right base
- ▶Minimum Vectoring Altitude (MVA) – established for ATC where there are numerous different minimum IFR altitudes, and provides 1000ft obstacle clearance in non-mountainous areas and 2000ft obstacle clearance in mountainous areas.
  - 1000ft obstacle clearance may be used in mountainous areas if the airport has Airport Surveillance Radar (ASR).
- ▶Off Route Obstruction Clearance Altitude (OROCA) – highest possible obstruction elevation including both terrain and other vertical obstructions (towers, trees, etc.). Similar to Maximum Elevation Figures (MEFs) on VFR sectionals, but with additional obstacle clearance tolerances
  - 1000ft in non-mountainous regions
  - 2000ft in mountainous regions
  - Shown in 30 x 30 minute quadrants including obstruction data 4 NM outside the quadrant

Instrument Approach Procedures

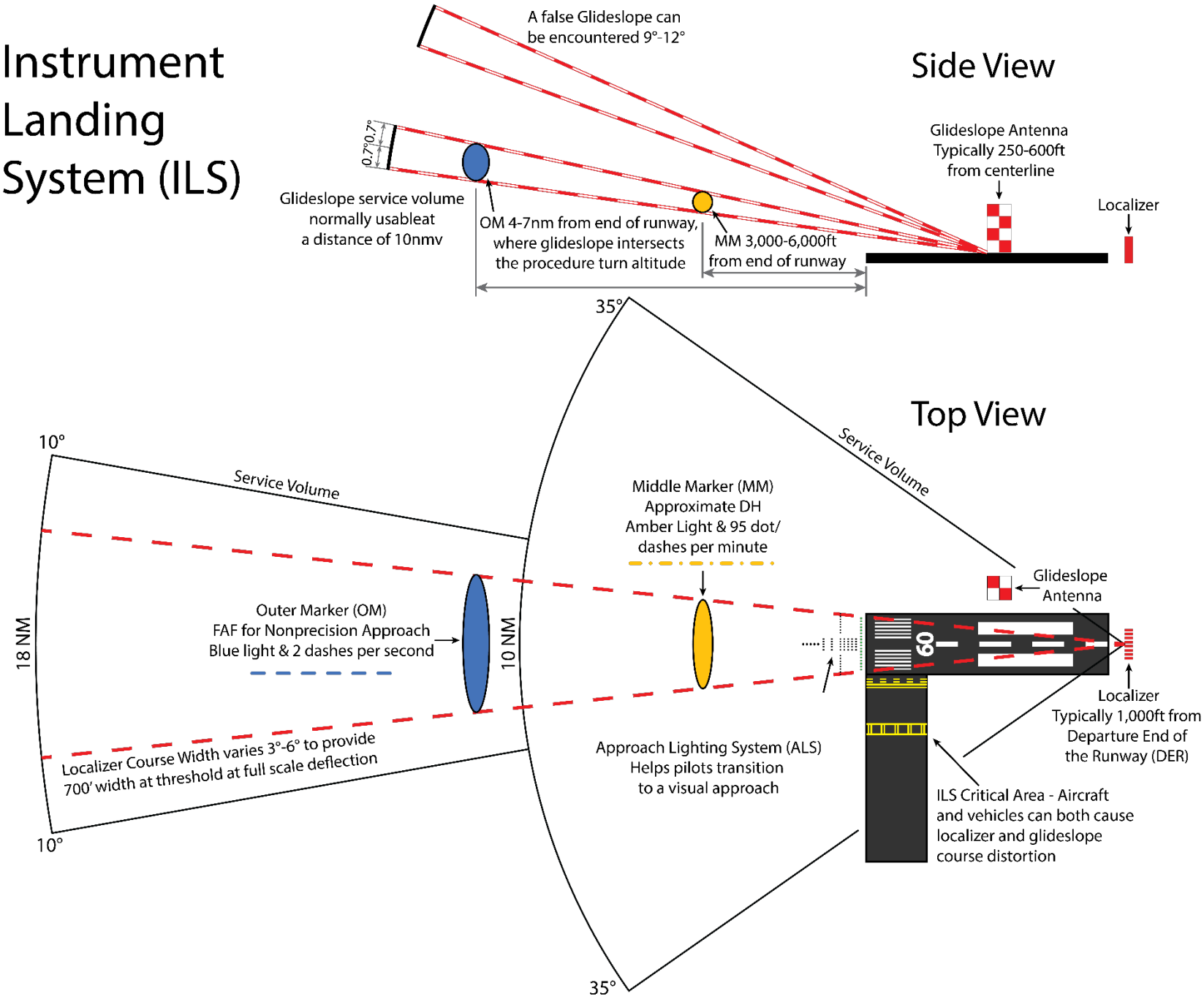
❖Operating below DA/DH or MDA (§91.175c)
- ▶No pilot may operate an aircraft below the authorized MDA or continue an approach below the DA/DH unless
  - The aircraft is continuously in a position from which a descent to a landing on the intended runway can be made at anormal rate of descent using normal maneuvers.
  - The flight visibility is not less than the visibility prescribed in the standard instrument approach being used; and
    - ◆ AIM 5-4-20

RVR	Visibility (statute miles)
1600	1/4
2400	1/2
3200	5/8
4000	3/4
4500	7/8
5000	1
6000	1 ¼

*When converting RVR values that are not listed, do not interpolate, use the next value (ie. 1800 RVR = 1/2sm)

  - At least one of the following visual references for the intended runway is distinctly visible and identifiable to the pilot:
    1. The approach light system, except that the pilot may not descend below 100 feet above the touchdown zone elevation unless the red terminating bards or the red side row bars are also distinctly visible and identifiable
    2. The threshold
    3. The threshold markings
    4. The threshold lights
    5. The runway end identifier lights
    6. The visual glideslope indicator

Instrument Landing System (ILS)



7. The touchdown zone or touchdown zone markings
8. The touchdown zone lights
9. The runway or runway markings
10. The runway lights

❖Instrument Landing System (ILS) (IFH 9-36)
- ▶Guidance Information
  - ■ Localizer
    - ◆ What: provides lateral guidance
    - ◆ Where: departure end of runway
    - ◆ How: transmits two radio signals at different frequencies. Receiver in the plane uses these two separate frequencies to determine left of course, right of course, or in the middle on course.
    - ◆ When the localizer fails an ILS approach is not authorized
  - ■ Glide Slope
    - ◆ What: provides vertical guidance
    - ◆ Where: offset from runway centerline 250 to 600 feet, usually about abeam thousand footers
    - ◆ How: transmits a radio signal that is usually about 1.4 degrees tall vertically
    - ◆ When the glideslope fails, the ILS approach downgrades to a nonprecision LOC approach
- ▶Range Information
  - ■ Marker Beacon
    - ◆ Provides information about where the plane is along the approach
    - ◆ Three different markers
      - Outer Marker (OM)
        - ➢ 4-7nm from end of runway
        - ➢ FAF for nonprecision approach
        - ➢ Blue light
        - ➢ Code: – – – –
      - Middle Marker (MM)
        - ➢ Approximately 3,000-6,000ft from threshold, or about DA/DH
        - ➢ Amber light
        - ➢ Code: – • – •
      - Inner Marker (IM)
        - ➢ Only for Cat II ILS
        - ➢ Located between MM and landing threshold at the DH for the Cat II ILS approach
        - ➢ White Light
        - ➢ Code: • • • •
  - ■ DME
    - ◆ May be used in lieu of the OM, and to establish other fixes on the approach
- ▶Visual Information
  - ■ Approach Lights
  - ■ Touchdown and Centerline Lights
  - ■ Runway Lights
- ▶Errors
  - ■ Reflection (ILS Critical Area)
    - ◆ Hard surfaces such as aircraft and buildings can interfere with the ILS radio signals affecting the signal the aircraft receives
  - ■ False Glideslope
    - ◆ Aircraft can receive a false glideslope at 9°-12° above the normal glideslope
    - ◆ Glideslope intercept altitudes prevent this error
  - ■ Line of Sight

❖RNAV Approaches
- ▶LNAV – lateral navigation, nonprecision (only RAIM required, not WAAS)
- ▶LNAV+V – lateral navigation with advisory vertical navigation, nonprecision (requires WAAS)
- ▶LNAV/VNAV – lateral navigation, vertical navigation, nonprecision (requires WAAS)
- ▶LP – localizer performance, nonprecision (requires WAAS)
- ▶LPV – localizer performance with vertical navigation, nonprecision (requires WAAS)

❖Visual Approaches (AIM 5-4-23) -conducted on an IFR flight plan and authorizes a pilot to proceed visually and clear of clouds to the airport. The pilot must have either the airport or the preceding identified aircraft in sight. This approach must be authorized and controlled by the appropriate air traffic control facility. Reported weather at the airport must have a ceiling at or above 1,000 feet and visibility 3 miles or greater. When conducting visual approaches, pilots are encouraged to use other available navigational aids to assist in positive lateral and vertical alignment with the runway.

❖Contact Approach (AIM 5-4-25)
- ▶An IFR approach where not flying a specific procedure. Required to have 1SM visibility and remain clear of clouds. When trying to do a visual approach but because of haze or other conditions you cannot see the airport you can request a contact approach to continue inbound to the airport. Pilots have to request it.

❖Radar Approach (AIM 5-4-11)
- ▶Requires radio transmitter and receiver
  - ■ Not common but can be used in an emergency
  - ■ ATC provides range/azimuth information
  - ■ Aircraft will be vectored to FAC, advised of MDA's and when the MAP is at the runway
    - ◆ Airport Surveillance Radar (ASR): nonprecision and provides azimuth only
    - ◆ Precision Approach Radar (PAR) provides elevation guidance
    - ◆ Non-gyro approach allows ATC to advise on when to start/stop turns

❖Approach Plate Symbology

Flight Categories

Category	Visibility		Ceiling
VFR	>5sm	and	> 3,000ft
MVFR	3 to 5sm	and/or	1,000 to 3,000ft
IFR	1 to < 3sm	and/or	500 to < 1,000ft
LIFR	< 1sm	and/or	< 500ft

Drugs & Alcohol (§91.17, §61.15)

❖Drugs (FAA AME Guide, FAA Over the Counter Med Guide)
- ▶Must be approved by the FAA for flight activity
- ▶Must not affect flight performance
- ▶Always consult an Aviation Medical Examiner (AME)
- ▶Antihistamine with impairing properties, is the most common drug found in pilots who have died in aviation accidents

❖Alcohol
- ▶8 hours "bottle to throttle"
- ▶Must have less than 0.04 blood alcohol level
- ▶Must not be under the influence of alcohol

- Effects
  - Impaired Efficiency
  - Impaired Coordination
  - Deteriorated Performance
  - Diminished Memory
  - Impaired Judgement
  - Reduced Visual Field
  - Decreased Sense of Responsibility
  - Lower Attention Span

Aviation Weather Services (PHAK Chapter 13, AC 00-45H, AIM Chapter 7)

❖Service Outlets
- Flight Service Station (FSS) – a primary source for preflight weather information. A preflight weather briefing can be obtained from 1-800-WX BRIEF. It also provides inflight weather briefing services and weather advisories to flights within the FSS area of responsibility.
- Telephone Information Briefing Service (TIBS) – an automated telephone recording of meteorological and aeronautical information. Designed to be a preliminary briefing tool and does not replace a standard briefing. Phone numbers for TIBS are listed in the Chart Supplement.

❖Weather Briefings
- Standard Briefing – this provides the most information and should be obtained before each flight. It provides information pertaining to your flight:
  - Adverse conditions
  - If VFR flight is recommended or not
  - Synopsis – the larger weather picture
  - Current Conditions – not included if departure is more than 2 hours away
  - En Route Forecast – summary of weather forecast for route of flight
  - Destination Forecast – expected weather for destination airport at ETA
  - Winds and Temperatures Aloft
  - Notices to Airmen (NOTAM)
  - ATC Delays
  - Other Information – any additional information requested
- Abbreviated Briefing – a shortened version of a standard briefing. Used to update previous briefings if flight is delayed.
- Outlook Briefing – should be used when departure is 6 or more hours away. Good source for flight planning.

❖Aviation Weather Reports
- Aviation Routine Weather Report (METAR) – surface weather observations posted in a standard international code, usually updated hourly. If significant changes occur between scheduled times a METAR SPECI will be issued.
- Pilot Weather Reports (PIREPs) – observations from pilots about the actual current conditions in the air. Pilots are encouraged to report unexpected weather conditions to FSS or ATC.

❖Aviation Weather Forecasts
- Terminal Aerodrome Forecasts (TAF) – weather report for a five-statute mile radius around an airport. Valid for 24- or 30-hour time periods and updated four times a day or every 6 hours.
- Area Forecasts (FA) – gives an idea of the general weather conditions, clouds, and visual meteorological conditions over large areas including several states. There are 6 areas for the continental US.
- Inflight Weather Advisories – provided to aircraft while en route. They are also available to pilots before departure for flight planning
  - AIRMET – adverse weather conditions that may affect the safety of flight
    - Issued as needed and valid for 6 hours
    - S (IFR) – Extensive mountain obscuration, ceilings less than 1000 feet and/or visibility less than 3 statute miles affecting over 50% of the area at one time
    - T (Turbulence) – Moderate Turbulence, surface winds of 30 knots or more
    - Z (Icing) – Moderate icing, and freezing levels
  - SIGMET – adverse weather conditions that will likely affect the safety of flight
    - Issued as needed and valid for 4 hours (Hurricanes are valid for 6 hours)
    - Severe icing not associated with thunderstorms
    - Severe or extreme turbulence or clear air turbulence (CAT) not associated with thunderstorms
    - Dust storms or sandstorms reducing visibility below 3 statute miles
    - Volcanic ash
  - Convective SIGMET – adverse weather conditions that will affect the safety of flight
    - Issued as needed and valid for 2 hours
    - Implies severe or greater turbulence, severe icing, and low-level wind shear
    - Severe thunderstorms due to:
    - Surface winds 50 knots or greater
    - Hail ¾ inches or greater at the surface
    - Embedded Thunderstorms
    - Squall Lines
    - Tornadoes
    - Thunderstorms covering 40% or more of 3,000 square miles or greater
- Winds and Temperature Aloft Forecast (FB) – provide wind and temperature forecasts in thousand-foot increments at specific locations. Forecasts are made twice a day.
  - Above FL240 temperatures are always negative
  - If winds are greater ≥100 knots, then 50 is added to the wind direction, and you have to add 100 to the wind speed
    - i.e. 845043
      - 84 = 340 degrees (Wind direction based on true North)
      - 50 = 150 knots (Wind speed)
      - 43 = -43 degrees (Temperature is Celsius)
  - Winds not reported at levels that are within 1,500 feet of station
  - Temperatures are not reported at levels within 2,500 feet of station

❖Weather Charts
- Surface Analysis Chart – it depicts the current surface weather. Shows areas of high and low pressure, fronts, temperatures, dew points, wind directions and speeds, local weather, and visual obstructions. Updated every 3 hours

- Weather Depiction Chart – details surface conditions from METARs and other surface observations. Provides graphical display of where IFR, VFR, and MVFR weather is. Updated every 3 hours.
- Low-Level Significant Weather Prognostic Chart – forecast of aviation weather hazards, used to give guidance to VFR pilots. Includes fronts, isobars, cloud coverage, and precipitation areas. Provides information from the surface to FL240. Issued 4 times a day and is divided into a 12- and 24-hour forecast.
- Radar Summary Chart – observation derived from national radar network that shows a graphic display of radar weather reports. Issued hourly.

Aviation Weather Observations

❖METAR
- provides surface observations for a terminal (5sm circle around the airport).
- Includes:
  - Airport Identifier
  - Time of Observation
  - Wind
  - Visibility
  - Runway Visual Range (RVR)
  - Present Weather Phenomena
  - Sky Conditions
  - Temperature
  - Dewpoint
  - Altimeter Setting
  - Remarks
- SPECI
  - Wind Shift
    - Wind direction changes by 45 degrees or more, in less than 15 minutes and the wind speed is 10 knots or more throughout the wind shift.
  - Visibility
    - Surface visibility, as reported in the body of the report, decreases to less than, or if below, increases to equal to or exceeding:
      - 3 miles
      - 2 miles
      - 1 mile
    - The lowest standard instrument approach procedure minimum. If none published, use ½ mile
  - Runway Visual Range (RVR)
    - The highest value from the designated RVR runway decreases to less than, or if below, increases to equal to or exceeding 2,400 feet during the preceding 10 minutes.
  - Tornado
    - Funnel Cloud, or Waterspout
    - Is observed
    - Disappears, or ends
  - Thunderstorm
    - Begins (a SPECI is not required to report the beginning of a new thunderstorm if one is currently reported)
    - Ends
  - Precipitation
    - Hail begins or ends
    - Freezing precipitation begins, ends, or changes intensity
    - Ice pellets begin, end, or change intensity
  - Squalls
    - When a squall occurs.
  - Ceiling
    - The ceiling (rounded to reportable values) forms or dissipates below, decreases to less than, or if below, increases to equal to or exceeding:
    - 3,000 feet
    - 1,500 feet
    - 1,000 feet
    - 500 feet
    - The lowest standard instrument approach procedure minimums. If none published, use 200 feet.
  - Sky Condition
    - A layer of clouds or obscurations aloft drops below 1,000 feet
  - Volcanic Eruption
    - When an eruption is first noted.
  - Aircraft Mishap
    - Upon notification of an aircraft mishap unless there has been an intervening observation.
  - Miscellaneous
    - Any other meteorological situation designated by the responsible agency of which, in the opinion of the observer, is critical.

❖PIREP

❖RADAR
- NEXRAD
- Terminal Doppler Weather Radar (TDWR)
- Surveillance
- Airborne
- For air traffic controllers who manage arriving and departing flights in the terminal area, TDWRs provide vital information and warnings about
  - Hazardous Wind Shear Conditions
  - Precipitation
  - Gust Fronts
  - Microbursts

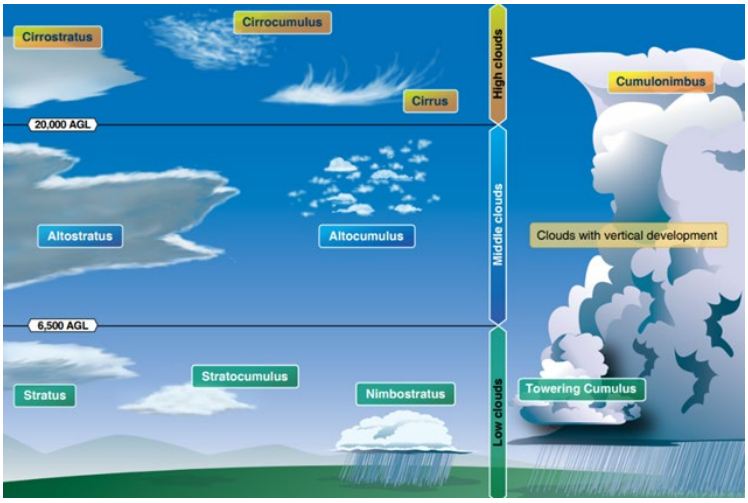
❖Satellite Imagery

Weather Theory (PHAK Chapter 12, AC 00-6B, AIM Chapter 7)

❖Atmosphere – blanket of air made up of a mixture of gases
- 78% Nitrogen
- 21% Oxygen
- 1% Trace gases (Argon, Carbon Dioxide)

❖Atmospheric Pressure
- Measured in inches of mercury (“Hg) or millibars (mb)
- Standard Sea Level Pressure (SLP) is 29.92”Hg or 1,013.2 mb
- Standard Temperature is 15°C or 59°F
- Generally atmospheric pressure decreases 1 “Hg per 1,000 feet of increase in altitude

❖Atmospheric Stability
- Stability depends on the atmospheres ability to resist vertical motion
- Average rate of temperature change is 2°C (3.5°F) per 1,000 feet
- Dry adiabatic lapse rate is 3°C (5.4°F) per 1,000 feet
- Moist adiabatic lapse rate is from 1.1°C to 2.8°C (2°F to 5°F) per 1,000 feet



- ▶Combination of moisture and temperature determine the stability of air
- ▶Inversion – anomaly where there is an increase in temperature with altitude

❖Moisture – Every 20°F increase in temperature doubles the amount of moisture the air can hold. Every decrease of 20°F cuts the capacity in half

❖Humidity – amount of water vapor present in the atmosphere

❖Relative Humidity – actual amount of moisture in the air compared to the total amount of moisture the air could hold at that temperature

❖Temperature/Dew Point – this relationship defines the concept of relative humidity

- ▶Dew Point – temperature at which the air can no longer hold moisture
  - ■ When temperature reaches the dew point the air is completely saturated and moisture begins to condense in the form of fog, dew, frost, clouds, rain, or snow

❖Fog – cloud on the surface

- ▶Radiation Fog – cool air over warm surface
- ▶Advection Fog – warm, moist air over cool surface
- ▶Upslope Fog – warm, moist, stable air forced upslope and cools
- ▶Steam Fog – cold, dry air over warm water
- ▶Ice Fog – water sublimates to ice in the air

Ceiling – lowest layer of clouds reported as broken or overcast, or vertical visibility into an obscuration like fog or haze

❖Visibility – greatest horizontal distance at which prominent objects can be viewed with the naked eye

❖Wind – motion of air relative to Earth's surface

- ▶Three forces that affect wind
  - ■ Pressure Gradient Force – pressure difference, wind speed is directly related to the pressure gradient force. Closely space together isobars indicate strong winds
  - ■ Coriolis Force – due to rotation of the earth it causes a force at a right angle to the wind direction and directly proportional to wind speed. As windspeed increases, Coriolis force increases.
  - ■ Friction – Between the wind and the surface there is friction that acts opposite the wind direction.
- ▶Patterns
  - ■ High-Pressure (OCD) – associated with cold air masses, fast moving, unstable with good visibility
  - ■ Outward
  - ■ Clockwise (clock high, counter low)
  - ■ Descending
- ▶Low-Pressure (ICU) – associated with warm air masses, slow moving, stable, and poor visibility
  - ■ Inward
  - ■ Counter-clockwise (clock high, counter low)
  - ■ Upward

❖Windshear – sudden, dramatic shift in windspeed, direction or both. Can cause severe changes in aircraft performance

❖Air Masses – large bodies or air that take on characteristics of an area

❖Fronts – boundary layer between two different air masses

- ▶Warm Front – occurs when a warm air mass of air moves and replaces a body of colder air
  - ■ Slow moving (10-25mph)
  - ■ Steady precipitation
  - ■ Stable air – poor visibility, stratus clouds
  - ■ Slides over the top of the colder air mass
- ▶Cold Front – occurs when a cold air mass moves and replaces a body of warmer air
  - ■ Fast moving (25-30mph)
  - ■ Showery precipitation
  - ■ Unstable air – good visibility, vertical movement, cumulous clouds
  - ■ Plows under the warmer air mass
- ▶Stationary Front – cold and warm air mass don't move and have characteristics of both warm and cold fronts
- ▶Occluded Front – when a fast-moving cold front catches up with a slow-moving warm front
  - ■ Cold Front Occlusion – when the cold front is colder than the air mass ahead of the warm front
    - ◆ Characteristics of both warm and cold fronts
  - ■ Warm Front Occlusion – when the cold front is warmer than the air mass ahead of the warm front
    - ◆ Most violent, embedded thunderstorms, squall lines

❖Thunderstorms – contain most hazards to flight, flight within 20 miles should be avoided, and do not fly under them

- ▶Recipe: moisture, unstable air, and lifting action
- ▶Stages:
  - ■ Cumulous – updrafts
  - ■ Mature – rain begins to fall, updrafts and downdrafts
  - ■ Dissipating – downdrafts, anvil formation
- ▶Hazards:
  - ■ Lighting, squall lines, tornadoes, turbulence, icing, hail, engine water ingestions, ceiling and visibility

❖Microbursts – small scale intense downdrafts that cause both vertical and horizontal Windshear

- ▶Usually less than 1 mile in diameter as it descends from the cloud base to about 1,000 to 3,000 feet above the ground, then it transitions to horizontal outflow to approximately 2 ½ miles in diameter
- ▶Up to 6,000 feet per minute (fpm) downdrafts
- ▶Up to 45 knot horizontal winds, resulting in up to 90 knot shear
- ▶Virga is an indication of a microburst
- ▶Blowing dust is also an indication
- ▶Seldom last longer than 15 minutes

❖Frost – formation of thing ice crystals. Can significantly reduce lift and cause the boundary layer to separate at a lower angle of attack (AOA). Do not fly when frost is present on the aircraft.

- ▶Icing (IFH 4-13) – one of the greatest hazards to flight

- Types:
  - Structural – accumulation on the exterior of the aircraft
    - Clear Ice – glossy, transparent
  - Mixed Ice – combination of clear and rime
  - Rime – rough, milky, opaque

Outside Air Temperature	Icing Type
0°C to -10°C	Clear
-10°C to -15°C	Mixed (clear and rime)
-15°C to -20°C	Rime

❖Turbulence – flow of wind changing from its equilibrium
- Maintain pitch attitude at or below VA

Human Factors (PHAK Chapter 17)

❖Hypoxia – means "reduced oxygen" or "not enough oxygen"
- Symptoms
  - Cyanosis
  - Headache
  - Euphoria
  - Impaired Judgement
  - Decreased response to stimuli and increased reaction time
  - Visual Impairment
  - Drowsiness
  - Lightheaded or Dizzy
  - Tingling Sensations
  - Numbness
- Hypoxia and Hyperventilation have common symptoms, but when in doubt treat for hypoxia first.
- Hypoxic Hypoxia – lack of oxygen to the body as a whole.
- Hypemic Hypoxia – means "not enough blood," lack of oxygen in the blood or ability to transport it to the body's cells.
- Stagnant Hypoxia – means "not flowing," oxygen rich blood is not flowing to a part of the body.
- Histotoxic Hypoxia – cells inability to effectively use oxygen. Caused by alcohol or drugs.

❖Hyperventilation – lack of carbon dioxide in the blood caused by excessive breathing
- Symptoms
  - Visual Impairment
  - Unconsciousness
  - Lightheaded or Dizzy
  - Tingling Sensations
  - Hot & Cold Sensations
  - Muscle Spasms
- Hypoxia and Hyperventilation have common symptoms, but when in doubt treat for hypoxia first.
- Treatment
  - Descend to a lower altitude
  - Use supplemental oxygen

❖Middle Ear & Sinus
- Climbs and descents cause a pressure difference from inside the body to the outside. If pressure builds inside the body without equalizing it can cause severe pain
- Eustachian tube allows for air pressure to equalize in the middle ear
- Small openings connect sinuses and nasal passages that allow to equalize pressure
- Do not fly with an upper respiratory infection or nasal allergic condition

❖Spatial Disorientation – lack of awareness to the position, attitude, or movement of an aircraft
- Vestibular System – semicircular canals in the inner ear are positioned with three axes to sense yaw, pitch, and roll
  - Vestibular Illusions
    - The Leans – occurs when making a sudden return to level flight after a gradual and prolonged turn. After returning to level flight it may cause an illusion that the aircraft is banking in the opposite direction.
    - Coriolis Illusion – occurs when in a prolonged turn and the fluid in the inner ear moves at the same speed as the canal, then a movement of the head in a different direction can send that fluid moving creating the illusion of moving, turning, or accelerating in a different direction
    - Graveyard Spiral – occurs when in prolonged coordinated constant rate turn pilot may have the illusion of not turning. Returning to level flight, the pilot will then feel a sensation of turning in the opposite direction and incorrectly responds by entering the turn again. With the loss of altitude due to the turn, the pilot compensates by pulling back on the controls. This tightens up the turn into a spiral.
    - Somatogravic Illusion – rapid acceleration causes the same sensation as tilting the head backwards. This gives the illusion of being a nose high attitude. The pilot could incorrectly push the nose forward. The opposite is also true for rapid deceleration.
    - Inversion Illusion – a sudden change from a climb to straight and level flight can create the illusion of tumbling backwards. The pilot could incorrectly push the aircraft into a nose low attitude which could make the illusion worse.
    - Elevator Illusion – a sudden upward vertical acceleration from an updraft gives the illusion of being in climb. The pilot could incorrectly push the aircraft into a nose low attitude. The opposite is also true for a sudden downward vertical acceleration.

Corrective Action: TRUST YOUR INSTRUMENTS, not your body's sensations
- Somatosensory System – nerves in the skin, muscles, and joints that combined with hearing help sense the body's position based on gravity, feeling, and sound ("flying by the seat of your pants")
  - No illusions and typically reliable
- Visual System – eyes sense the body's position based on what is seen
  - Visual Illusions
    - False Horizon – due to several potential causes of obscuring the horizon (fog and night with city lights) it can create the illusion of a false horizon and the pilot could incorrectly align the aircraft with the false horizon and potentially a dangerous attitude.
    - Autokinesis – occurs when flying at night and stationary light appears to start moving when staring at it for long periods of time. The pilot could incorrectly align the aircraft the perceived moving light.
- Motion Sickness – caused when the brain receives conflicting signals about the orientation of the body.
  - Symptoms
    - General Discomfort
    - Nausea
    - Dizziness
    - Paleness
    - Sweating
    - Vomiting

❖Carbon Monoxide Poisoning
- Carbon Monoxide is an odorless colorless gas that bonds 200 times more likely to hemoglobin than oxygen.
- Carbon Monoxide can reach the cockpit through small heaters and exhaust leaks.

- ❖Stress – body's response to physical and psychological demands. Causing a release of hormones, increase in metabolism, blood sugar, heart rate, respiration, and blood pressure.
  - ▶Acute
    - ■ Short term, "fight or flight"
    - ■ Healthy person can usually cope
  - ▶Chronic
    - ■ Long Term
    - ■ Exceeds the ability for an individual to cope
    - ■ Not safe to fly
    - ■ Consistent acute stress can develop into chronic stress
- ❖Fatigue – associated with pilot error due to the effects that include degradation of attention, concentration, impaired coordination, and decreased ability to communicate
  - ▶Acute
    - ■ Short term, normal occurrence is everyday living
    - ■ Rest and 8 hours of sleep ordinarily cures acute fatigue
    - ■ Skill Fatigue
      - ◆ Timing Disruption – performing tasks as usual, but the timing is off.
      - ◆ Disruption of the Perceptual Field – focusing on the center of vision and neglecting peripheral vision
    - ■ Causes
      - ◆ Mild Hypoxia
      - ◆ Physical Stress
      - ◆ Psychological Stress
  - ▶Chronic
    - ■ Long term, usually has psychological roots
    - ■ Continuous high stress levels produce chronic fatigue
    - ■ Not relieved by proper diet, adequate rest and sleep
    - ■ Usually requires treatment by a physician
- ❖Hypothermia – critical loss of heat from the body
  - ▶Symptoms
    - ■ Cyanosis
    - ■ Goosebumps
    - ■ Shivering
- ❖Optical Illusions
  - ▶Runway Width Illusion
    - ■ Narrower than usual runways have the illusion that the aircraft is higher than it actually is, causing a lower than normal approach
    - ■ Wider than usual runways have the illusion that the aircraft is lower than it actually is, causing a higher than normal approach
  - ▶Runway & Terrain Slope Illusion
    - ■ Upsloping runways have the illusion that the aircraft is higher than it actually is, causing a lower than normal approach
    - ■ Down sloping runways have the illusion that the aircraft is lower than it actually is, causing a higher than normal approach
  - ▶Featureless Terrain Illusion
    - ■ Absence of ground terrain features has the illusion that the aircraft is at a higher altitude than it actually is, causing a lower than normal approach
  - ▶Water Refraction
    - ■ Rain on the windscreen has the illusion of being at a higher altitude than normal, due to the horizon appearing lower than it is
  - ▶Haze
    - ■ Has the illusion of being at a greater distance and altitude from the runway, causing a lower than normal approach
  - ▶Fog
    - ■ Has the illusion of pitching up, causing the pilot to steepen the approach
  - ▶Ground Lighting Illusions
    - ■ Lights in a straight path, such as road lights or moving trains have the illusion of appearing like a runway or approach lights

Corrective Action: Anticipate illusions and TRUST YOUR INSTRUMENTS

- ❖Altitude-Induced Decompression Sickness (DCS)
  - ▶Occurs when exposed to low barometric pressures that causes nitrogen to turn into a gas and bubbles form in different areas of the body.
    - ■ Treatment
      - ◆ Oxygen Mask with 100% oxygen
      - ◆ Emergency Descent and land as soon as possible
      - ◆ Areas of joint pain keep still, do not work the pain
      - ◆ Upon landing seek medical attention
  - ▶Scuba Diving – subjects the body to increased pressure, putting more dissolved nitrogen into the body
    - ■ Uncontrolled Ascent
      - ◆ Wait 12 hours after diving to fly at altitude up to 8,000ft MSL (not pressurized cabin altitude)
    - ■ Controlled Ascent
      - ◆ Wait 24 hours after diving to fly at altitudes above 8,000ft MSL (not pressurized cabin altitude)

Abbreviations

AAUP ..... Attention All Users Page
AC ..... Advisory Circular
ADF ..... Automatic Direction Finder
ADIZ ..... Air Defense Identification Zone
AFH ..... Airplane Flying Handbook
AFIS ..... Automatic Flight Information Service
AIM ..... Aeronautical Information Manual
ALS ..... Approach Light System
ALSF ..... Approach Light System with Sequenced Flashing Lights
AOB ..... At-Or-Below
AP ..... Autopilot System
APCH ..... Approach
APP CON ..... Approach Control
AR ..... Authorization Required
ARR ..... Arrival
ARTCC ..... Air Route Traffic Control Center
ASOS ..... Automated Surface Observation System
ASR/PAR ..... Published Radar Minimums at this Airport
ASSC ..... Airport Surface Surveillance Systems
ATIS ..... Automatic Terminal Information Service
AUNICOM ..... Automated UNICOM
AWOS ..... Automated Weather Observing System
AZ ..... Azimuth
Baro VNAV ..... Barometric Vertical Navigation
BC ..... Back Course
BND ..... Bound
C ..... Circling
CAT ..... Category
CCW ..... Counter-Clockwise
CDI ..... Course Deviation Indicator
Chan ..... Channel
CIFP ..... Coded Instrument Flight Procedures
CIR ..... Circling
CLNC DEL ..... Clearance Delivery
CNF ..... Computer Navigation Fix
CPDLC ..... Controlled Pilot Data Link Communication
CRS ..... Course
CTAF ..... Common Traffic Advisory Frequency
CW ..... Clockwise
D-ATIS ..... Digital-Automatic Terminal Information Service
DA ..... Decision Altitude
DEP CON ..... Departure Control
DER ..... Departure End of Runway
DH ..... Decision Height
DME ..... Distance Measuring Equipment
DTHR ..... Displaced Threshold
DVA ..... Diverse Vector Area
ELEV ..... Elevation
EMAS ..... Engineered Material Arresting System
FAF ..... Final Approach Fix
FAR ..... Federal Aviation Regulation
FD ..... Flight Director
FM ..... Fan Marker
FMS ..... Flight Management System
GBAS ..... Ground Based Augmentation System
GCO ..... Ground Communications Outlet
GLS ..... Ground Based Augmentation System Landing System
GND CON ..... Ground Control
GP ..... Glidepath
GPI ..... Ground Point of Interception
GPS ..... Global Positioning System
GS ..... Glide Slope
HAA ..... Height Above Airport
HAL ..... Height Above Landing
HAT ..... Height Above Touchdown
HATh ..... Height Above Threshold
HCH ..... Heliport Crossing Height
HGS ..... Head-up Guidance System
HIRL ..... High Intensity Runway Lights
HUD ..... Head-up Display
IAF ..... Initial Approach Fix
IAP ..... Instrument Approach Procedure
ICAO ..... International Civil Aviation Organization
IF ..... Intermediate Fix
IFH ..... Instrument Flying Handbook
IM ..... Inner Marker
IMC ..... Instrument Meteorological Conditions
INOP ..... Inoperative
INT ..... Intersection
IPH ..... Instrument Procedures Handbook
K ..... Knots
KIAS ..... Knots Indicated Airspeed
LAAS ..... Local Area Augmentation System
LDA ..... Localizer Type Directional Aid
Ldg ..... Landing
LIRL ..... Low Intensity Runway Lights
LNAV ..... Lateral Navigation
LNAV+V ..... Lateral Navigation with Advisory Vertical Guidance
LNAV/VNAV .... Lateral Navigation with Vertical Navigation
LOC ..... Localizer
LOM ..... Locator Outer Marker
LP ..... Localizer Performance

LPV ..... Localizer Performance with Vertical Guidance
LR..... Lead Radial. Provides at least 2nm of lead to assist in turning onto the intermediate/final course.
MAA..... Maximum Authorized Altitude
MALS..... Medium Intensity Approach Light System
MALSF..... Medium Approach Lighting System with Sequenced Flashers
MALSR ..... Medium Approach Lighting System with RAIL
MAP ..... Missed Approach Point
MCA..... Minimum Crossing Altitude
MDA..... Minimum Descent Altitude
MEA ..... Minimum Enroute Altitude
MIRL ..... Medium Intensity Runway Lights
MM..... Middle Marker
MOA..... Military Operations Area
MOCA ..... Minimum Obstruction Clearance Altitude
MRA..... Minimum Reception Altitude
MSA ..... Minimum Safe Altitude
MTA ..... Minimum Turning Altitude
MVA..... Minimum Vectoring Altitude
N/A ..... Not Applicable
NA ..... Not Authorized
NDB ..... Non-directional Radio Beacon
NM ..... Nautical Mile
NoPT ..... No Procedure Turn Required (Procedure turn shall not be executed without ATC clearance)
ODALS..... Omnidirectional Approach Light System
ODP..... Obstacle Departure Procedure
OM ..... Outer Marker
OROCA ..... Off-Route Obstacle Clearance Altitude
PAPI ..... Precision Approach Path Indicator
PAR ..... Precision Approach Radar
PBN ..... Performance Based Navigation
PDC ..... Pre-Departure Clearance
PHAK ..... Pilots Handbook of Aeronautical Knowledge
PRM ..... Precision Runway Monitor
R ..... Radial
RA ..... Radio Altimeter setting height
RAIL..... Runway Alignment Indicator Lights
RAIM ..... Receiver Autonomous Integrity Monitoring
RCLS..... Runway Centerline Light System
REIL ..... Runway End Identifier Lights
RF ..... Radius-to-Fix
RLLS ..... Runway Lead-in Light System
RNAV..... Area Navigation
RNP ..... Required Navigation Performance
RPI ..... Runway Point of Intercept(ion)
RRL..... Runway Remaining Lights
Rwy..... Runway
RVR ..... Runway Visual Range
S ..... Straight-in
SALS..... Short Approach Light system
SALSF ..... Short Approach Lighting system with Sequenced Flashing Lights
SBAS ..... Satellite Based Augmentation System
SDF ..... Simplified Directional Facility
SID..... Standard Instrument Departure
SM..... Statute Mile
SOIA ..... Simultaneous Offset Instrument Approach
SR-SS..... Sunrise-Sunset
SSALF ..... Simplified Short Approach Lighting System with Sequenced Flashers
SSALR..... Simplified Short Approach Light System with RAIL
SSALS ..... Simplified Short Approach Lighting System
STAR ..... Standard Terminal Arrival Route
TAA ..... Terminal Arrival Area
TAC ..... TACAN
TCAS ..... Traffic Alert and Collision Avoidance System
TCH ..... Threshold Crossing Height
TDZ..... Touchdown Zone
TDZE ..... Touchdown Zone Elevation
TDZ/CL ..... Touchdown Zone and Runway Centerline Lighting
TDZL ..... Touchdown Zone Lights
TERPS ..... United Stated Standard for Terminal Instrument Procedures
THR ..... Threshold
TODA ..... Takeoff Distance Available
TORA ..... Takeoff Run Available
TR ..... Track
UHF ..... Ultra High Frequency (300-3000MHz)
UNICOM ..... Universal Communications
VASI..... Visual Approach Slope Indicator
VCOA ..... Visual Climb Over Airport
VDP ..... Visual Descent Point
VGSI..... Visual Glide Slope Indicator
VHF ..... Very Hight Frequency (30-300MHz)
VMC ..... Visual Meteorological Conditions
VNAV..... Vertical Navigation
VOR..... VHF Omnidirectional Range
VORTAC..... VOR and TACAN
VOT ..... VOR Test Facility
WAAS..... Wide Area Augmentation System
WP/WPT ..... Waypoint (RNAV)
WX..... Weather