Airplane IFR Quick-Review

LOGGING INSTRUMENT TIME §61.51

A person may log instrument time only for that flight time when the person operates the aircraft *solely by reference to instruments* under **actual or simulated instrument flight conditions.**

An authorized instructor may log instrument time ***when*** **conducting instrument flight instruction** in **actual instrument flight conditions**.

To **meet recent instrument experience requirements**, the following information must be recorded in the person's logbook:

- **Location & type** of **each instrument approach** accomplished, and
- **The name of the safety pilot**, if required

Use of full flight simulator, FTD, or ATD for acquiring instrument aeronautical experience:

- For training towards a certificate or rating, an authorized instructor is present to observe and signs the person's logbook to verify the time and content of the session.
- For IFR recency requirements, log:
  - Training device, time and content.

RECENCY OF EXPERIENCE

- To act as **PIC under IFR** or in weather conditions less than the minimums for VFR- **"6 HITS"** – **Within 6 cal. months preceding the month of flight**:
  - **6 instrument approaches**
  - **Holding procedures & tasks**
  - **Intercepting & Tracking courses t**hrough the use of **navigational electronic systems**
  - The above **can be completed in a FFS, ATD, or FTD** provided the device represents the **category of aircraft** for the i**nstrument rating privileges** to be maintained and the pilot performs the tasks and iterations **in simulated instrument conditions**. A **flight instructor is not needed**
- **Not current looking back 6 months?** You can still log the required "6 HITS" with a safety pilot (under simulated conditions), examiner or instructor.
  - Safety pilot requirements
    - At least a private pilot with appropriate category and class.
    - Have adequate vision forward and to each side of the aircraft.
    - Aircraft must have a dual control system.
- **Not current looking back 12 months?**
  - **Instrument Proficiency Check (IPC)** by a CFII, examiner, or other approved person is required. Guidelines are in the ACS.
  - Some IPC tasks, but not all, can be conducted in a FTD or ATD. (Refer to the ACS)
- **To carry passengers as PIC**
  - **3 takeoffs & landings** in **category, class and type** (if type rating req.) In the **last 90 days**.
  - At periods between 1 hour after sunset to 1 hour before sunrise: 3 takeoffs & landings to full stop within 1 hour after sunset to 1 hour before sunrise.
- **To act as PIC** - **Flight review** in the last **24 Calendar months** (see FAR for exceptions).

(§61.56, §91.109, §61.57, Instrument- Airplane ACS)

AIRPLANE-INSTRUMENT RATING MINIMUM AERONAUTICAL EXPERIENCE

- 50 hours X-Country PIC time
  - Of which ,10 hours in airplanes.
- 40 hours actual or simulated instrument time
  - Of which, 15 hours with CFII.
    - Including one X-Country flight of:
      - 250 NM along airways or by directed ATC routing.
      - An instrument approach at each airport.
      - 3 different kinds of approaches using navigation systems.
      - With a filed IFR flight plan.
    - 3 Hours instrument flight training in last 2 Calendar months prior to practical test
- Use of approved full flight simulator or FTD, if trained by authorized instructor:
  - Max. 30 hours if instrument time completed under part 142
  - Max 20 hours if not completed under 142
- Use of FAA approved Aviation Training Device, if trained by an authorized instructor:
  - Max.10 hours of instrument time if Basic ATD
  - Max. 20 hours of instrument time if Advanced ATD
- No more than 20 hours of total instrument time can be credited in a full flight simulator, FTD or ATD, except the 30 hours exception under part 142 mentioned above.

§61.65

PERSONAL DOCUMENTS REQUIRED FOR FLIGHT

- **Pilot Certificate**
- **Medical certificate** (or US Driver's license as permitted by §61.113 & §61.23)
- **Authorized photo ID (passport, driver's license, etc)**
- **Restricted Radiotelephone Operator Permit (For flights outside the US)**

§61.3, §61.113, §61.23, ICAO Article 29

AIRCRAFT DOCUMENTS REQUIRED FOR FLIGHT
A.R.R.O.W –

A - Airworthiness certificate
R - Registration certificate
R - Radio station license (for flights outside the US)
O - Operating limitations & information (in AFM)
W - Weight & Balance data (aircraft specific)

(§21.5, §91.103, §91.9, §91.203, ICAO Article 29)

AIRCRAFT MAINTENANCE INSPECTIONS REQUIRED FOR IFR:
A.V.I.A.T.E.S –

- **A - Airworthiness Directive (AD)** required inspections. (§39)
- **V - VOR check every 30 days.** (For IFR; §91.171)
- **I - Inspections:** (§91.409)
  - **Annual inspection - 12 Cal. Months** (all aircraft).
  - **100-hour (time-in-service) inspection required if:**
    - **Carrying a person for hire** (other than crew member), or
    - **Flight instructing for hire** in an aircraft provided by the person giving the instruction.
    - "For hire" refers to the person , not the aircraft.
      - Flight school providing airplane + instructor for hire: 100-hours required
      - Student-owned aircraft: 100-hours not required.
      - Rental (no pilot or instructor): 100-hr not required.
    - The 100-hr inspection may be exceeded by up to 10 hours if aircraft is enroute to a place where it can be done. This additional time must be included in computing the next 100-hours inspection.
    - An annual inspection can substitute for the 100-hour if done within 100 hours of time-in-service.
  - A **progressive inspection** schedule, if specifically approved by the FAA, may replace the annual and 100 hour inspections.
- **A - Altimeter, automatic altitude reporting** (used by transponder) **& static system every 24 calendar months.** (For IFR in controlled airspace; §91.411)
- **T - Transponder every 24 calendar months.** (§91.413)
- **E - ELT** (§91.207)
  - **inspected every 12 calendar months**.
  - **Battery must be replaced after more than 1 hour of cumulative transmitter use or if 50% of its useful life has expired** (or, for rechargeable batteries, 50% of the useful life of charge has expired).
- **S - Supplemental Type Certificate (STC)** required inspections.

PREFLIGHT SELF-ASSESSMENT:
I.M S.A.F.E –

- **I - Illness** - Do I have any symptoms?
- **M - Medication** - Have I taken prescription or over-the-counter drugs?
- **S - Stress** - Am I under psychological pressure, worried about finances, health or family discord?
- **A - Alcohol** - No drinking within 8 hours. ("8 hours bottle to throttle"). No more than .04% of alcohol in blood.
- **F - Fatigue** - Am I tired / adequately rested?
- **E - Emotion** - Am I emotionally upset?

(§91.17, AIM 8-1-1)

PREFLIGHT INFO REQUIRED FOR IFR:
N.W K.R.A.F.T – (§91.103)

- **N - NOTAMs.**
- **W - Weather reports and forecasts.**
- **K - Known traffic delays as advised by ATC.**
- **R - Runway length of intended use.**
- **A - Alternatives available** if flight cannot be completed as planned.
- **F - Fuel requirements**
- **T - Takeoff and landing performance data.**

RISK MANAGEMENT & PERSONAL MINIMUMS
P.A.V.E –

- **P - Pilot** (general health, physical / mental / emotional state, proficiency, currency)
- **A - Aircraft** (airworthiness, equipment, performance)
- **V - EnVironment** (weather hazards, terrain, airports / runways to be used & other conditions)
- **E - External pressure** (meetings, people waiting at destination, etc.)

(Pilot's Handbook of Aeronautical Knowledge)

DECISION MAKING
D.E.C.I.D.E –

- **D - Detect** that a change has occurred.
- **E - Estimate** the need to counter the change.
- **C - Choose** a desirable outcome.
- **I - Identify** solutions.
- **D - Do** the necessary actions.
- **E - Evaluate** the effects of the actions

(Pilot's Handbook of Aeronautical Knowledge)

PASSENGER BRIEFING
S.A.F.E.T.Y –

- **S**
  - **Seat belts fastened** for taxi, takeoff, landing.
  - **Shoulder harness fastened** for takeoff, landing.
  - **Seat position** adjusted and locked in place
- **A**
  - **Air vents location and operation**
  - **All environmental controls** (discussed)
  - **Action in case of any passenger discomfort**
- **F**
  - **Fire extinguisher** (location and operation)
- **E**
  - **Exit doors** (how to secure; how to open)
  - **Emergency evacuation plan**
  - **Emergency/survival kit** (location and contents)
- **T**
  - **Traffic** (scanning, spotting, notifying pilot)
  - **Talking, sterile flight deck expectations**
- **Y**
  - **Your questions? Speak up!**

(Pilot's Handbook of Aeronautical Knowledge)

TAXI BRIEFING
A.R.C.H –

- **A - Assigned / planned runway.**
- **R - Route.**
- **C - Crossings and hold short instructions**.
- **H - Hot spots & Hazards** (e.g., NOTAMs, closed taxiways/ runways, surface condition).

TAKEOFF BRIEFING

D.E.P.A.R.T.S –

D - Departure review (e.g. takeoff type, initial heading, first fix & course, clearance readout).

E - Establish Expectations (e.g., flying pilot, PIC, positive transfer of controls).

P - Plan / special considerations (e.g., weather, visibility, terrain, unfamiliar field, inoperative equipment / MELs).

A - Alternate (takeoff alternate, if needed, or return plan)

R - Runway conditions and length.

T - Trouble / Tactics (e.g., rejected takeoff, engine failure).

S - Speak up! Questions / concerns?

IFR FLIGHT PLAN

- **Requirement**: no person may operate an aircraft **in controlled airspace under IFR** unless that person has:
  - **Filed an IFR flight plan**; and
  - Received an appropriate **ATC clearance.**
- It **is legal to fly IFR in uncontrolled airspace** (class G) **without a flight plan or clearance**. However, once airborne, you **must remain in uncontrolled airspace until you file a flight plan and get an ATC clearance** to enter the controlled airspace.

§91.173

- **How to file an IFR flight plan?**
  - **FSS**
    - by phone (1-800-WX-BRIEF)
- over the radio (GCO/RCO frequencies)
    - In person.
  - **Online**
    - www.1800wxbrief.com (Leido)
    - www.fltplan.com (Garmin)
  - **EFB** (e.g., Foreflight)
  - With **ATC** (over radio, or phone if no other mean available)
- **File at least 30 minutes prior to estimated departure**. Non-scheduled flights **above FL230 should be filed at least 4 hours** before est. departure time. (AIM 5-1-8)
- **Flight plan cancelation** (AIM 5-1-15)
  - **Towered airports** - automatically cancelled by ATC upon landing.
  - **Non-towered airports** - Pilot must contact ATC / FCC to cancel (by radio or phone)
  - **Can cancel anytime in flight if out of IMC and out of class A airspace.**
- **Preferred IFR Routes** are published in the Chart Supplement U.S. It is to the pilot's advantage to file a preferred route if available. (AIM 5-1-8)

IFR MINIMUM FUEL REQUIREMENTS §91.167

Fuel from **departure** to **destination** airport + **Fuel from destination to most distant alternate** (if alternate required) + **45 Minutes calculated at normal cruise**

*Other fuel requirements exist for 121, 135, Flag and supplemental operations

NEED A DESTINATION ALTERNATE? "1-2-3" RULE –

A destination alternate is always required, unless:

- **An instrument approach is published and available for the destination, AND,**
- For **at least 1 hour before to 1 hour after ETA:**
  - **Ceiling** will be **at least 2000'** above airport elevation; and
  - **Visibility** will be **at least 3 SM.**

§91.169

YES

MIN WX CONDITIONS REQUIRED AT AN AIRPORT TO LIST IT AS AN ALTERNATE

The alternate airport minima published in the procedure charts, **or**, **if none**:

- **Precision approach**:
  600 ft ceiling and 2 SM visibility.
- **Non-precision approach**:
  800 ft ceiling and 2 SM visibility.
- **No instrument approach available at the alternate**:
  Ceiling & visibility must allow descent from MEA, approach and landing under VFR.

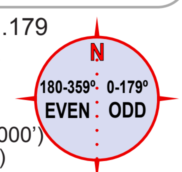
§91.169

FILING AN ALTERNATE - GPS CONSIDERATIONS

- **Equipped with a non-WAAS GPS?** You can flight plan based on GPS approaches at either the destination or the alternate, but **not at both.**
- **WAAS Without baro-VNAV**? May base the flight plan on use of LNAV approaches at both the destination and alternate.
- **WAAS with baro-VNAV**? May base the flight plan on use of LNAV/VNAV or RNP 0.3 at both the destination and the alternate.

AIM 1-1-17b.5, 1-1-18c.9, 1-2-3d

IFR CRUISING ALTITUDES §91.179



Uncontrolled airspace –

Based on magnetic course:

Below FL290

0º-179º ODD thousands (below 18,000') **or Flight Levels** (at or above FL180)

180º-359º EVEN thousands (below 18,000') **or Flight Levels** (at or above FL180)

Above FL290 (in non-RVSM)

0º-179º Flight Levels at 4,000' increments starting at FL290 (e.g., FL 290, 330, 370)

180º-359º Flight Levels at 4,000' increments starting at FL310 (e.g., FL 310, 350, 390)

Above FL290-FL410 (in RVSM)

0º-179º Odd Flight Levels at 2,000' intervals starting at FL290 (e.g., FL 290, 310, 330)

180º-359º Even Flight Levels at 2,000' intervals starting at FL300 (e.g., FL 300, 320, 340)

Controlled airspace –
IFR Cruising altitudes are as assigned by ATC.

IFR TAKEOFF MINIMUMS (§91.175)

No T/O minimums mandated for part 91 operations.
Part 121, 125, 129, 135:

- Prescribed T/O minimums for the runway, or, if none:
- 1-2 engines airplanes: 1 SM visibility
- More than 2 engines: ½ SM visibility

T **Non-Standard TO mins / Departure Procedures**.

A **Non-Standard IFR alternate minimums exist**.

A NA **Alternate minimums not authorized** due to unmonitored facility or the absence of weather reporting service.

DEPARTURE PROCEDURES (DP)

AIM 5-2-9

- **Ensures obstacle clearance, provided:**
  - the airplane **crossed the departure end of the runway at least 35 ft AGL**,
  - reaches **400 ft AGL before turning**, and
  - **climbs at least 200 Feet per NM (FPNM), or as published otherwise on the chart.**
    - **FPNM to feet-per-minute conversion:**

```
fpm = FPNM * Groundspeed / 60
```

- Pilots are **encouraged** to **file a DP** at **night**, during **marginal VMC** or **IMC**.
- **Two types of DP**
  - **Obstacle Departure Procedure (ODP)**
    - Provides **only obstacle clearance.**
    - **Graphic ODPs** will have "**(OBSTACLE)**" **printed in the chart title**.
    - **Printed either textually or graphically.**
  - **Standard Instrument Departure (SID)**
    - In addition to **obstacle clearance it reduces pilot and controller workload by simplifying ATC clearances and minimizing radio communications**.
    - Some SIDs may depict special **radio failure procedures**.
    - **Always printed graphically**.
- **DP are also categorized by equipment** required:
  - **Non-RNAV DP** - for use by aircraft equipped with ground-based navigation (i.e., VOR, DME, NDB).
  - **RNAV DP** - for aircraft equipped with RNAV equipment (e.g., GPS, VOR/DME, DME/DME). Require at least RNAV 1 performance. Identified with the word "RNAV" in the title.
  - **RADAR DP** - ATC radar vectors to an ATS route, NAVAID, or fix are used after departure. RADAR DPs are annotated "RADAR REQUIRED."
- **You are not required to accept a DP**. To avoid getting one, state **"NO SIDs"** in remarks section of flight plan.
- Transition routes connect the end of the basic SID procedure to the en route structure.

IFR DEPARTURE CLEARANCE

C.R.A.F.T –

- **C - Clearance limit**.
- **R - Route**.
- **A - Altitude**.
- **F - Frequency (for departure)**.
- **T - Transponder code**.

Clearance void time – The time at which your clearance is void and after which you may not takeoff. You must notify ATC within 30 min after the void time if you did not depart.

"Hold for release" – You may not takeoff until being released for IFR departure.

Release time – The earliest time the aircraft may depart under IFR.

Expect Departure Clearance Time (EDCT) – A runway release time given under traffic management programs in busy airports. Aircraft are expected to depart no earlier and no later than 5 minutes from the EDCT.

Abbreviated departure clearance – "Cleared (...) as filed (...)"
(AIM 5-2-6)

STANDARD TERMINAL ARRIVAL (STAR)

- Serves as **a transition between the en route structure and a point from which an approach to landing can be made**.
- **Transition routes** connect **en route fixes** to the basic **STAR procedure**.
- Usually **named according to the fix at which the basic procedure begins**.
- As with a SID, you can state **"NO STARs"** in the remarks section of the flight plan, **to avoid getting a clearance containing a STAR**.
- **RNAV STARs** require **RNAV 1** performance.

IFR ALTITUDES

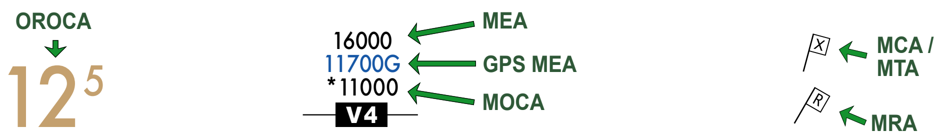
MIN IFR ALTITUDES (§91.177)

- **Except for takeoff or landing**, or otherwise authorized by the FAA, **no person may operate an aircraft under IFR below** -
  - **Minimum altitudes prescribed** for **the flown segment**, **or if none**:
  - **Mountainous areas**: **2,000 ft** above the **highest obstacle within a horizontal distance of 4 NM** from the course.
  - **Non-mountainous areas**: **1,000 ft** above the highest obstacle within **4 NM** from the course.

IFR ALTITUDES - CONTINUED (§91.177, Pilot/Controller Glossary)

- **DA / H - D**ecision **A**ltitude **/ H**eight: the Altitude (MSL) / Height (above runway threshold), on an instrument approach procedure at which the pilot must decide whether to continue the approach or go around.
- **MAA** - **M**aximum **A**uthorized **A**ltitude. Annotated "MAA-17000" (17,000ft as an example) on IFR charts.
- **MCA** - **M**inimum **C**rossing **A**ltitude
- **MDA / H** - **M**inimum **D**ecent **A**ltitude **/ H**eight: The lowest Altitude (MSL) / Height (above runway threshold) to which descent is authorized on a non-precision approach until the pilot sees the visual references required for landing.
- **MEA** - **M**inimum **E**n route **A**ltitude: The lowest published altitude between radio fixes which assures acceptable navigational signal coverage and meets obstacle clearance requirements. An MEA gap establishes an area of loss in navigational coverage and annotated "MEA GAP" on IFR charts.
- **MOCA** - **M**inimum **O**bstruction **C**learance **A**ltitude: Provides obstacle clearance and navigation coverage only up to 22 NM of the VOR.
  - ▷ **If both an MEA and a MOCA are prescribed** for a particular route segment, **a person may operate** an aircraft **lower than the MEA down to, but not below the MOCA, provided the applicable navigation signals are available**. For aircraft **using VOR for navigation**, **this applies only when the aircraft is within 22 NM of the VOR**. (§91.177)
- **MORA** - **M**inimum **O**ff **R**oute **A**ltitude (Jeppesen):
  - ▷ **Route MORA** provides obstruction clearance within 10NM to either side of airway centerlines and within a 10NM radius at the ends of airways.
  - ▷ **Grid MORA** provide obstruction clearance within a latitude / longitude grid block.
- **MRA** - **M**inimum **R**eception **A**ltitude
- **MTA** - **M**inimum **T**urning **A**ltitude: Provides vertical and lateral obstacle clearance in turns over certain fixes. Annotated with the MCA X icon and a note describing the restriction.
- **MVA** - **M**inimum **V**ectoring **A**ltitude: The lowest altitude at which an IFR aircraft will be vectored by a radar controller, except as otherwise authorized for radar approaches, departures, and missed approaches. MVAs may be lower than the minimum altitudes depicted on aeronautical charts, such as MEAs or MOCAs.
- **OROCA** - **O**ff **R**oute **O**bstruction **C**learance **A**ltitude: Provides obstruction clearance with a 1,000 ft buffer in non-mountainous terrain areas and 2,000 ft in mountainous areas. OROCA may not provide navigation or communication signal coverage.

*Designated mountainous areas are defined in 14 CFR part 95 by lat / long coordinates.



FLIGHT INSTRUMENTS

GYROSCOPIC INSTRUMENTS

- **Two principles** of a gyroscope: **Rigidity in space** and **precession**.
- **Attitude indicator** – operates on the principle of **rigidity in space**. Shows **bank and pitch information**. Older AIs may have a tumble limit. Should show correct attitude within 5 minutes of starting the engine. Normally vacuum-driven in GA aircraft, may be electrical in others. May have small acceleration/deceleration errors (accelerate-slight pitch up, decelerate- pitch down) and roll-out errors (following a 180 turn shows a slight turn to the opposite direction).
- **Heading indicator** – operates on the principle of **rigidity in space**. It only reflects changes in heading, but cannot measure the heading directly. You have to calibrate it with a magnetic compass in order for it to indicate correctly. HIs may be slaved to a magnetic heading source, such as a flux gate, and sync automatically to the present heading. Normally powered by the vacuum system in on GA aircraft.
- **Turn indicators** – operates on the principle of **precession**.
  - ▷ **Turn coordinators** show rate-of-turn and rate of roll.
  - ▷ **Turn-and-slip indicators** show rate-of-turn only.

PITOT-STATIC INSTRUMENTS

ALTIMETER

- An **aneroid barometer** that shows the height above a given pressure level, based on standard pressure lapse rate of 1000' per inch of mercury.
- A stack of sealed aneroid wafers expand and contract with changes in atmospheric pressure received from the static port.
- A **mechanical linkage** between the aneroid and the display translates the sensed pressure to an altitude indication.
- An **altimeter setting knob** (on a "sensitive altimeter", which are most aircraft altimeters) allows the pilot to adjust the current pressure to the current altimeter setting published locally (available from ATIS, METAR or ATC).
- The pressure setting is displayed in the "**Kollsman Window**" in mb and/or inches of mercury (Hg)
- In the US, when operating below 18,000' MSL **regularly set the altimeter to a station within 100 NM**. Above 18,000' MSL, the altimeter should be set to the standard sea level pressure of 29.92" Hg, and operate in Flight Levels (FL).
- "**High to Low - Watch out below!**". Use caution when flying from high pressure to low pressure areas. If altimeter setting is not updated, altitude will indicate higher, causing the pilot to fly lower than desired. Flying from **hot to cold** areas results in the same error.

TYPES OF ALTITUDES

- **Indicated altitude** – Uncorrected altitude indicated on the dial when set to local pressure setting (QNH).
- **Pressure altitude** – Altitude above the standard 29.92. Hg plane. (QNE). Used when flying above the transition altitude (18,000' in the US)
- **Density altitude** – Pressure alt. corrected for nonstandard temperature. Used for performance calculations.
- **True altitude** – Actual altitude above Mean Sea Level (MSL).
- **Absolute altitude** – Height above airport elevation (QFE).

VERTICAL SPEED INDICATOR (VSI)

- Indicates **rate-of-climb** in fpm (accurate after a 6-9 sec. lag), and **rate trend** (immediately with rate change).
- A diaphragm inside the instrument is connected directly to the static source.
- The area outside the diaphragm also receives static pressure, but via a calibrated leak (a restricted orifice).
- This configuration essentially responds to static pressure change over time.
- As the diaphragm expands or contracts, a mechanical linkage moves the pointer needle to display the current rate of climb to the pilot.
- **Instantaneous VSI** (IVSI) solves the lag issue with the addition of vertical accelerometers.

AIRSPEED INDICATOR (ASI)

- The airspeed indicator measures the difference between impact (ram) air pressure from the pitot tube and ambient pressure from the static port. The result pressure is called dynamic pressure and corresponds to airspeed.
  - ▷ Dynamic Pressure (airspeed) = Impact Pressure – Static pressure.
- A diaphragm in the instrument receives ram pressure from the pitot tube. The area outside the diaphragm is sealed and connected to the static port. A mechanical linkage converts the expansion and contraction of the diaphragm to airspeed shown on the display dial.

TYPES OF SPEEDS

- **Indicated airspeed (IAS)** – indicated on the airspeed indicator
- **Calibrated airspeed (CAS)** – IAS corrected for instrument & position errors.
- **Equivalent airspeed (EAS)** – CAS corrected for compressibility error.
- **True airspeed (TAS)** – Actual speed through the air. EAS corrected for nonstandard temperature and pressure
- **Mach number** – The ratio of TAS to the local speed of sound.
- **Ground speed** – Actual speed over the ground. TAS corrected for wind conditions.

STATIC PORT BLOCKAGE

- **Airspeed indicator** – Indicates correctly only at the blockage altitude.
  - ▷ Higher altitudes → airspeed indicates lower than it should.
  - ▷ Lower altitudes → Indicates higher than it should.
- **Altimeter** – will freeze on the altitude where it was blocked.
- **VSI** – freezes on zero.
  - ▷ After verifying a blockage in the static port, you should use an alternate static source or break the VSI window (in which case, expect reverse VSI information).
- When using the **alternate static source** (a lower static pressure is measured):
  - ▷ **Airspeed indicator** – indicate a faster speed than it should.
  - ▷ **Altimeter** – indicate higher than it should.
  - ▷ **VSI** – momentarily show a climb.

AIRSPEED INDICATOR MARKINGS

- **White arc** - Flap operating range. Starts at Vs0; ends at Vfe
- **Green arc** - Normal operating range.Starts at Vs1; ends at Vno
- **Yellow arc** - Caution range. Fly only in smooth air and only with caution.
- **Red line** - Vne

V-SPEEDS

- **Va** - Design maneuvering speed
- **Vs** - Stall speed, clean config.
- **Vs0** - Stall speed landing config.
- **Vs1** - Stall speed specific config.
- **Vfe** - Max flap extended speed.
- **Vno** - Max structural cruise speed
- **Vne** - Never Exceed Speed
- **Vx** - Best angle of climb
- **Vy** - Best rate of climb

PITOT TUBE BLOCKAGE

The **only instrument affected** is the **airspeed indicator**.

- Ram air inlet clogged and drain hole open? Airspeed drops to zero.
- Both air inlet and drain hole are clogged? The airspeed indicator will act as an altimeter, and will no longer be reliable.
- When suspecting a pitot blockage, consider the use of pitot heat to melt ice that may have formed in or on the pitot tube.

GENERIC INSTRUMENT TAXI CHECK

- Airspeed – 0 KIAS.
- Turn coordinator – ball centered and wings level when not turning. On turns: shows turn in correct direction, ball goes to opposite direction of the turn.
- Attitude – Correct pitch attitude and bank angle ±°5 within 5 minutes of engine start (if vacuum).
- Heading indicator – Set and shows correct headings.
- Altimeter – Set to local altimeter settings or to airport elevation (§91.121). Shows surveyed elevation ±75 ft (AIM 7-2-3).
- VSI – 0 fpm.
- Magnetic compass – swings freely, full of fluid, shows known headings and deviation card is installed. Marker beacons – Tested.
- NAV & Comm – Set.
- GPS – Checked and set.
- EFIS cockpits – Check PFD/MFD/EICAS for 'X's, messages, warnings and removed symbols.

MAGNETIC COMPASS ERRORS & LIMITATIONS – D.V M.O.N.A

- **D**- Deviation
- **V**- Variation
- **M**- Magnetic dip
- **O**- Oscillation
- **N**- North/south turn errors - Northern hemisphere: **UNOS** **U**ndershoot **N**orth/ **O**vershoot **S**outh
- **A**- Acceleration errors - Northern hemisphere: **ANDS** **A**ccelerate **N**orth/ **D**ecelerate **S**outh

ELECTRONIC FLIGHT INSTRUMENTS

- **Attitude Heading Reference Systems (AHRS)** – Provides more accurate and reliable attitude and heading data than traditional separate gyro systems. The first AHRS units were very expensive and relied on laser gyros and flux valves. Today they are based on solid state technologies (no moving parts) and are cheaper, smaller and easier to maintain.
- **Air Data Computers (ADC)** – replaces the mechanical pitot-static instruments. The ADC receives inputs from the pitot, static and outside temperature ports and computes airspeed, true airspeed, vertical speed and altitude.
- **Flight director** – computes and displays command bars over the attitude indicator to assist the pilot in flying selected heading, course or vertical speed.
- **Flight Management System (FMS)** – Receives inputs from various sensors and provides guidance to the autopilot and flight director throughout the flight. The FMS also automatically monitors and selects the most appropriate navigation source for accurate positioning. (GPS, VOR/DME, INS etc.)
- **Electronic Flight Instrument Systems (EFIS)** – AKA “Glass cockpit”.
- **Primary Flight Displays (PFD)** – Displays flight data such as attitude, altitude, airspeed, VSI and heading as well as rate tapes.
- **Multi-Function Displays (MFD)** – Displays a variety of information such as moving maps, aircraft system status, weather and traffic. It may also be used as a backup for other displays, such as the PFD or EICAS.

MINIMUM EQUIPMENT REQUIRED FOR FLIGHT (§91.205)

For VFR day:

A T.O.M.A.T.O F.L.A.M.E.S –

A - Altimeter

T - Tachometer for each engine.
O - Oil temperature indicator for each engine.
M - Manifold pressure gauge for each altitude engine.
A - Airspeed indicator.
T - Temperature gauge for each liquid cooled engine.
O - Oil pressure gauge for each engine.

F - Fuel quantity gauge for each tank.
L - Landing gear position lights (if retractable gear).
A - Anticollision lights (for aircraft certified after March 11, 1996).
M - Magnetic direction indicator (magnetic compass).
E - ELT, if required by §91.207.
S - Safety belt / shoulder harness.

For VFR night:

All VFR day equipment + FLAPS

F.L.A.P.S –

F - Fuses (spare set).
L - Landing light (if for hire) .
A - Anticollision lights.
P - Position lights (navigation lights).
S - Source of electrical power (i.e., battery).

If operating for hire over water and beyond power-off gliding distance from shore: (unless part 121)

- **An approved floatation device for each occupant**
- **At least one pyrotechnic signaling device**

Flight at and above FL240:

When using VOR for navigation, DME or RNAV is also required.

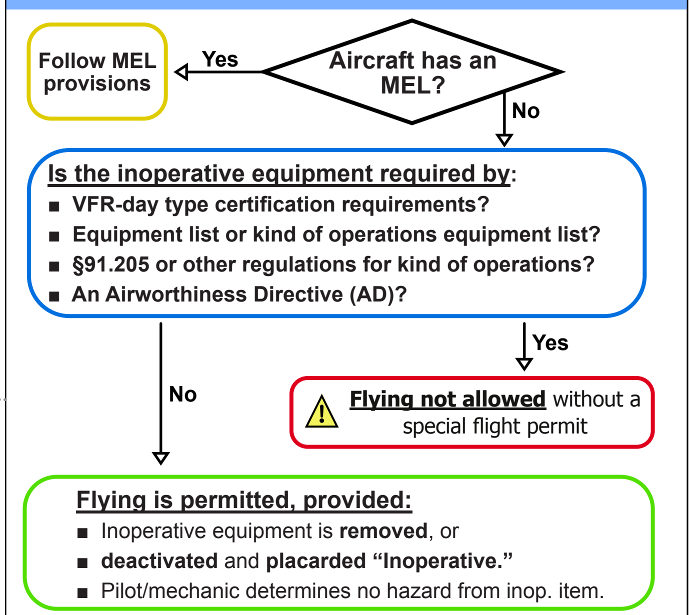
For IFR day: all VFR day equipment + GRABCARD

For IFR night: all VFR day + VFR night + GRABCARD

G.R.A.B.C.A.R.D –

G - Generator / alternator.
R - Radios. Two-way radio communication & navigational equipment suitable for the route to be flown.
A - Altimeter (**sensitive,** adjustable for barometric pressure)
B - Ball (slip-skid indicator).
C - Clock. Shows hours, minutes and seconds with sweep-second pointer or digital representation. Installed as part of aircraft equipment.
A - Attitude indicator.
R - Rate-of-turn indicator.
D - Directional gyro (heading indicator).

OPERATING WITH INOPERATIVE ITEMS (§91.213)



RADIO NAVIGATION

DISTANCE MEASURING EQUIPMENT (DME)

- **962-1213 MHz** (**UHF**).
- Normally tuned automatically with a paired VHF station (VOR/LOC).
- The Airborne DME unit transmits an interrogation signal.
- The ground DME facility receives and replies to the interrogation.
- Airborne unit calculates the **slant range** distance to the station based on the reply time.
- Due to slant range error, when flying overhead the station, DME indication is not "0".
- Slant range error is negligible at 1 NM from the DME station per every 1000ft. For example, at 5000 ft, slant range error is negligible when further than 5 NM of the station.

NON-DIRECTIONAL BEACON (NDB)

- Operates at the 190-535 kHz range (can receive and point towards commercial radio AM station at 550 -1650 kHz).
- Low to medium frequency band.
- ADF (Automatic Direction Finder) in aircraft points towards the NDB station.
- Magnetic Bearing = Magnetic Heading + Relative Bearing

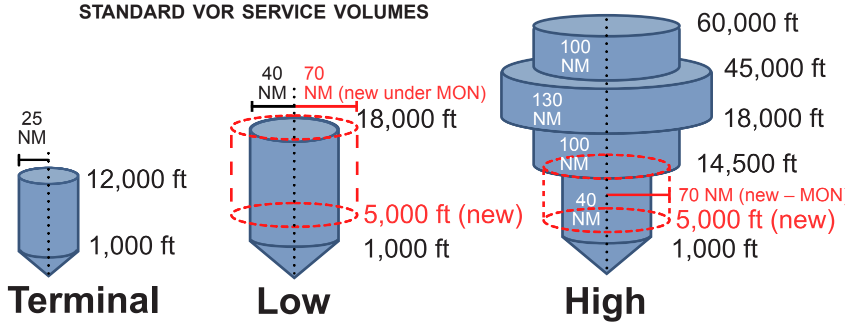
NDB Service Volume Classes	
Compass Locator	15 NM
Medium High (MH)	25 NM
High (H)	50 NM (or less, as published in NOTAM or Chart Supplement)
High High (HH)	75 NM

COMPASS LOCATOR

A low-powered NDB transmitter (at least 25 Watts and 15NM range) installed at the OM or the MM on some ILS approaches.

VHF OMNI DIRECTIONAL RANGE (VOR)

STANDARD VOR SERVICE VOLUMES



- **108.0 to 117.95 MHz**, excluding 108.10-111.95 with odd tenths (reserved for LOC frequencies).
- **Full scale deflection: 10º**.
- **Standard service volumes do not apply to published routes**.
- Pilot must **verify correct and usable VOR** station with morse **ID** before using it.
- The **VOR MON** (VOR **M**inimum **O**perational **N**etwork) program ensures that as old VORs are decommissioned, a **MON airport** (i.e.,equipped with legacy ILS or VOR approach) is available within 100 NM regardless of aircraft position in the CONUS.

VOR limitations

- Cone of confusion
- Reverse sensing (if used incorrectly)
- Requires line-of-sight between aircraft and station.

VOR Receiver Checks (§91.171)

- Perform every 30 calendar days
  - **VOT** ±4º
  - **Repair Station** ±4º
  - VOR **ground checkpoint** ±4º
  - VOR **airborne checkpoint** ±6º
  - **Dual VOR** cross-check ±4º
  - Above a **prominent ground landmark** on a selected radial at least 20 NM from a VOR, flying at a "reasonable low altitude" ±6º

VOR Check sign-off (§91.171)

D.E.P.S –
D - Date
E - Error (bearing error)
P - Place
S - Signature

AREA NAVIGATION (RNAV)

- Allows navigation on any desired path without the need to overfly ground-based facilities.
- **Types**:
  - Global Navigation Satellite System (**GNSS**) (e.g., **GPS**, Galileo, GLONASS, BeiDou)
  - VOR/DME RNAV
  - DME/DME RNAV
  - Inertial Reference Unit / System (IRU/ IRS)
- **RNAV VNAV - V**ertical **NAV**igation guidance.
- **BARO-VNAV** - An RNAV system that uses the barometric altitude to compute vertical guidance for the pilot.
- Published RNAV routes include Q (FL180 to FL450) and T (1,200 AGL to 18,000 MSL) routes and are designated RNAV 1 unless charted otherwise.
- Magnetic Reference Bearing (MRB) - the published bearing between two waypoints on an RNAV route.

REQUIRED NAVIGATION PERFORMANCE (RNP)

- RNP is:
  - **A statement of navigation equipment and service performance**.
  - **RNAV with navigation monitoring and alerting**.
- **All RNAV approaches are RNP approaches**
  - Most US RNP approaches are titled "**RNAV (GPS)**".
  - US Approaches with "**RNAV (RNP)**" in the title are "**AR**" (**Authorization Required**) approaches, which **require special FAA approval for the crew, aircraft and operation**.
  - **In other countries**, **all RNP approaches may have "RNP" in the title**, even those that do not require special authorization.

RNP approach minimas and equipment:

- **GLS** DA minimas using **GBAS** (formerly **LAAS**)
- **LP** MDA or **LPV** DA minimas require **RNP** achieved by **WAAS**.
- **LNAV / VNAV** DA achieved by VNAV-approved WAAS, or BARO-VNAV systems.
- **LNAV** MDA - achieved by a basic, **unaugmented** IFR-approved GPS.

GLOBAL POSITIONING SYSTEM (GPS)

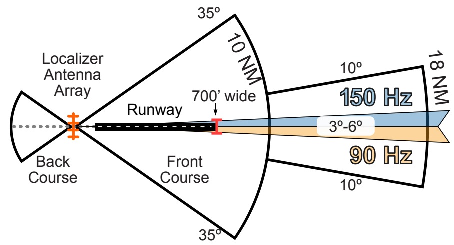
- **GPS** is a **Global Navigation Satellite System (GNSS)** operated **by the United States**.
- The constellation consists of a minimum of 24 satellites (with some spares) orbiting above the earth at 10,900 NM. The system is designed so that at least 5 satellites are in view at any given location on earth.
- The Aircraft's GPS receiver calculates the distance to a GPS satellite based on the time lapse since the broadcast timestamp (obtained from an atomic clock onboard the satellite) and the time it received the signal.
- Using only one satellite, the aircraft could virtually be on any point on a sphere surrounding the satellite, with the calculated distance ("pseudo-range") as the sphere's radius.
- The GPS receiver uses the intersection of spheres, from multiple satellites, to calculate the aircraft's geographical position. Course and speed data are computed from aircraft position changes.
- At least **3 satellites are required for 2D** position. (latitude and longitude); at least **4 satellites are required for 3D** position. (latitude, longitude and altitude).
- **Receiver Autonomous Integrity Monitoring (RAIM)** is a function of GPS receivers that monitors the integrity of the satellite signals.
  - RAIM (fault detection) requires a minimum of 5 satellites, or, 4 satellites + an altimeter input (baro-aided RAIM)
  - To eliminate a corrupt satellite (fault exclusion), RAIM needs an additional satellite (total of 6 or 5 + baro-aid)
- A database loaded into the receiver unit contains navigational data such as: airports, navaids, routes, waypoints and instrument procedures.
- Airborne GPS units use **great-circle navigation**.
- **GPS CDI** deflection shows **distance**, unlike a VOR's CDI, which presents an **angular distance** off course in degrees.
- GPS can substitute ADF or DME, except for ADF substitution on NDB approaches without a GPS overlay ("or GPS" in title).
- **Check GPS NOTAMS before the flight** and use **RAIM prediction** if available on your receiver.
- **GPS Augmentation systems, or Differential GPS (DGPS)** – Improves the accuracy of GPS by measuring errors received by reference stations at known geographical locations and then broadcasting those errors to supported GPS receivers.
  - **Satellite Based Augmentation System (SBAS)**
    - **Wide Area Augmentation System (WAAS)** in the US; **EGNOS** in **Europe**.
    - Ground stations (Wide-area Reference Stations and Wide-area Master Stations) measure GPS errors and produce correction signals. These corrections are broadcasted back to the satellite segment from which they are bounced back to aircraft GPS WAAS receivers to improve **accuracy, integrity** and **availability monitoring** for GPS navigation**.**
    - **Covers a wide area**.
    - Facilitates **APV approaches** such as **LPV** and **LNAV/VNAV and LP approaches**.
  - **Ground Based Augmentation System (GBAS)**
    - Formerly named **Local Area Augmentation System (LAAS)** in the US. Now replaced with the ICAO term "GBAS."
    - Errors are broadcasted **via VHF** to GBAS-enabled GPS receivers.
    - GBAS is **more accurate than WAAS** but **covers a much smaller geographical area**.
    - Allows for **category I** and above approaches to **GLS DA** minima.

Understanding the difference between RNAV, GNSS, GPS, PBN and RNP

- **Area Navigation (RNAV)**
  - RNAV is a system that enables navigation between any two points without the need to overfly ground-based stations.
- **GNSS** is a broad term for satellite-based RNAV systems.
  - **GPS** is the GNSS operated by the USA. Other examples are GLONASS by Russia and Galileo by the EU.
- **Performance Based Navigation (PBN)**
  - PBN is a general basis for navigation equipment standards, in terms of accuracy, integrity, continuity, availability and functionality for specific operation contexts (e.g., final approach, enroute, missed approach).
- **Required Navigation Performance (RNP)**
  - **RNP** is a specific **statement of PBN** for the flight segment and aircraft capability.
  - **RNP** is also defined as **RNAV + navigation monitoring and alerting functionality**.
    - Receiver Autonomous Integrity Monitoring (RAIM) or built-in monitoring in WAAS provide this capability.
  - **En route – RNP 2.0 (2 NM accuracy 95% of the flight time)**
  - **Terminal & Departure – RNP 1.0 (1 NM accuracy 95% of the flight time)**
  - **Final Approach – RNP 0.3 (0.3 NM accuracy 95% of flight time)**
  - **Advanced RNP (A-RNP) - is a higher RNP standard mandatory for RNP AR, that require capability for:** (AIM 1-2-2)
    - Radius-to-Fix (RF) legs
    - Scaleable RNP (meaning RNP accuracy can change value), and
    - Parallel offset flight path generation

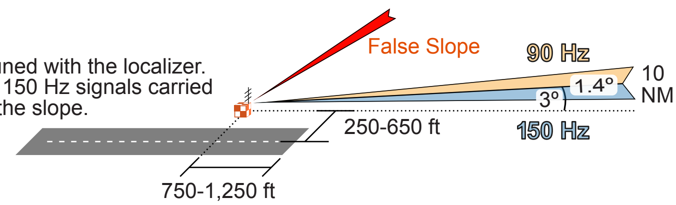
INSTRUMENT LANDING SYSTEM (ILS)

LOCALIZER (AIM 1-1-9)



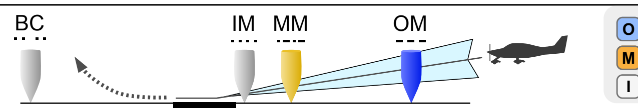
- Provides **lateral course guidance.**
- **Frequencies**: 108.1 - 111.95 MHz with odd tenths only. 90 and 150 Hz signals are carried over the VHF frequency and used by the receiver interpret the aircraft's lateral position.
- **Width**: Between 3°-6° so that the width at the threshold would be 700 feet. Usually 5° total width. (2.5 full deflection to each side, 4 times more sensitive than a VOR).
- **Coverage range**: 35° to each side of the centerline for the first 10NM and 10° up to 18NM from the antenna and up to an altitude of 4500'.

GLIDE SLOPE (AIM 1-1-9)



- Provides **vertical course guidance.**
- **Frequencies**: 329.3 to 335 MHz (UHF) ,automatically tuned with the localizer. Vertical position is interpreted by the intensity of 90 and 150 Hz signals carried over the UHF frequency and directed above and under the slope.
- **Width**: 1.4° (full deflection is 0.7° either direction).
- **Range**: typically up to 10 NM.
- **Slope**: typically 3°.
- **Errors**: **False glide slope** above normal glide slope.

MARKER BEACONS



- Provide **range information** over specific points along the approach. Transmits at 75 MHz.
- **Outer marker**: 4-7 miles out. Indicate the position at which the aircraft should intercept the GS at the appropriate interception altitude ±50ft. BLUE. "- - -"
- **Middle marker**: ~3500ft from the runway. Indicates the approximate point where the GS meets the decision height. Usually 200ft above the touchdown zone elevation. AMBER. ". - . -"
- **Inner marker**: between the MM and runway threshold. Indicates the point where the glide slope meets the DH on a CAT II ILS approach. WHITE ". . ."
- **Back course marker**: Indicates the FAF on selected back course approaches. Not a part of the ILS approach. WHITE ".. .."

APPROACH LIGHT SYSTEMS (ALS) (AIM 2-1-1)

- Provides basic **visible means to transition between instrument-guided flight into a visual approach**.
- ALS **extends from the landing threshold into the approach area** up to:
  - ▷ **2,400-3,000** feet for **precision instrument runways**, and
  - ▷ **1,400-1,500** feet for **non-precision instrument runways**.
- May include **sequenced flashing lights**, which appear to the pilot as a ball of light traveling towards the runway at twice a second (AKA "The Rabbit").
- The visible parts of the ALS configuration can help the pilot estimate flight visibility.

ILS Category	Visibility	DH
CAT I	2,400' or 1,800'	200'
CAT II	1,200'	100'
CAT IIIa	>700'	<100' or no DH
CAT IIIb	150'-700'	<50' or no DH
CAT IIIc	0'	No DH

ATTITUDE INSTRUMENT FLYING

Basic attitude instrument flying skills:
- Cross Check
- Instrument interpretation
- Aircraft Control

Common Errors:
- Fixation
- Omission
- Emphasis

- **Control & Performance Method** – Divides the cockpit panel by **control instruments** and **performance instruments**. First, set the power and attitude, then monitor the performance and make adjustments.
  - ▷ **Control instruments**
    - □ Power - Tachometer, Manifold pressure, EPR, N1, etc.
    - □ Attitude - Attitude Indicator
  - ▷ **Performance Instruments**
    - □ Pitch: altimeter, airspeed and VSI
    - □ Bank: Heading Indicator, Turn Coordinator, and magnetic compass
- **Primary & Supporting Method** – Divides the cockpit panel by **Pitch, Bank, and Power instruments**.
  - ▷ **Pitch instruments**: Attitude Indicator, Altimeter, Airspeed Ind., and VSI.
  - ▷ **Bank instruments**: Attitude ind., Heading ind., Mag. Compass, and Turn Coordinator.
  - ▷ **Power instruments**: Airspeed, Tachometer, Manifold pressure
  - ▷ For a specific maneuver, primary instruments provide the most essential information for pitch, bank and power while supporting Instruments back up and supplement the information presented by the primary instruments.
  - ▷ Example, for a constant rate climb with a standard rate turn –
    - □ Primary: Pitch - VSI; Bank - Turn Coordinator; Power - RPM / MP
    - □ Secondary: Pitch - ASI; attitude, Bank - AI, HI, Mag. Compass; Power - ASI

MANDATORY REPORTS UNDER IFR

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

(AIM 5-3-3, §91.183, §91.187)

- **Missed approach**
- **Airspeed ±10 kts / 5%** change of filed **TAS** (whichever is greater)
- **Reaching a holding fix** (report **time & altitude**)
- **VFR on top** when an **altitude change will be made.**
- **ETA changed ±2 min, or ±3 min in North Atlantic (NAT) ***
- **Leaving a holding fix/point**
- **Outer marker (or fix used in lieu of it) ***
- **Un-forecasted weather**
- **Safety of flight** (any other information related to safety of flight)
- **Vacating an altitude/FL**
- **Final Approach fix ***
- **Radio/Nav/approach equipment failure** (§91.187)
- **Compulsory reporting points ▲ *** (§91.183)
- **500 - unable climb/descent 500 fpm**

*** Required only in non-radar environments** (including ATC radar failure)

POSITION REPORT ITEMS REQUIRED IN NON-RADAR ENVIRONMENT

(§91.183, AIM 5-3-2)

- Aircraft **ID**.
- **Position**.
- **Time**.
- **Altitude**.
- **Type of flight plan** (except when communicating with ARTCC / Approach control).
- **ETA and name of next reporting fix**.
- **Name only of the next succeeding point** along the route of flight.
- Any pertinent **remarks**.

HOLDING PATTERN TIMING

- Start timing outbound abeam/over the fix (whichever is later). Or, if the abeam point cannot be determined, start the time at the completion of the outbound turn.
- Adjust the outbound leg so the inbound leg takes:
  - ▷ **At or below 14,000' MSL – 1 minute**
  - ▷ **Above 14,000' MSL – 1.5 minutes**
  - ▷ DME/GPS holds – fly the outbound leg to the specified distance from the fix/waypoint.

HOLDING PATTERNS

(AIM 5-3-8)

- ATC may assign holding instructions to delay or separate traffic in the air for reasons such as weather or airport closures.

Non-charted holding clearance items:

- ▷ **Direction** of hold from the fix (e.g., N, W, S, NE)
- ▷ **Holding Fix**
- ▷ **Radial, course, airway, or route** on which to hold.
- ▷ **Leg length** in **miles** (if DME or RNAV) **or minutes** otherwise.
- ▷ **Direction of turns** (**if left**). Otherwise, **right turns are standard**.
- ▷ **Expect Further Clearance (EFC)** time

Charted holding clearance items

- ▷ **Holding Fix**
- ▷ **Direction** of hold from fix (e.g., N, W, S, E)
- ▷ **EFC**

- **Start speed reduction 3 minutes before reaching the hold fix.**
- **Actions at hold fix and each turn point 5 Ts**
  - ▷ **Turn**
  - ▷ **Time**
  - ▷ **Twist**
  - ▷ **Throttle**
  - ▷ **Talk**

MAKE ALL HOLD TURNS:

- 3° per second, or
- 30° bank angle, or
- 25° bank angle if using a Flight Director system

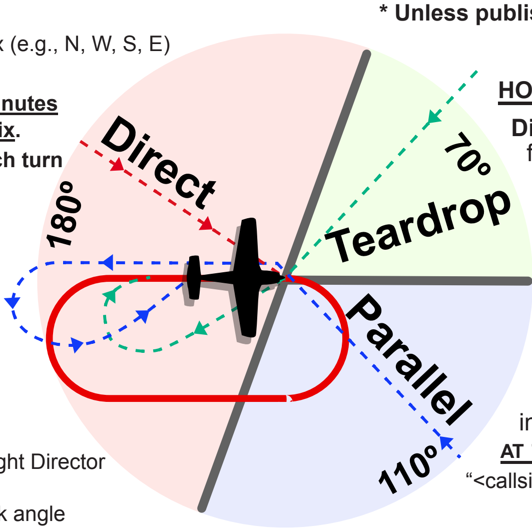
*Whichever uses the least bank angle

HOLDING SPEEDS

- May be restricted to 175 kts on some instrument approach procedures

ALTITUDE (MSL)	MAX AIRSPEED (KTS)
6,000' or below	200 kts
6001 - 14,000	230 kts
14,001 and above	265 kts
Air Force fields	310 kts *
Navy Fields	230 kts *

*** Unless published otherwise.**



HOLDING ENTRY

Direct - Upon crossing the fix turn to follow the holding pattern

Parallel - Upon crossing the fix, turn to a heading parallel to the holding course outbound for 1 minute. Then turn into the hold pattern to intercept the inbound course.

Teardrop - Upon crossing the fix, turn outbound to a heading 30° into the pattern. Fly it for 1 minute, then turn in the direction of the hold turns to intercept the inbound course.

AT THE HOLD FIX, REPORT TO ATC:

"<callsign> Over <place><altitude> at <time>"

LOST COMMUNICATIONS PROCEDURE (§91.185)

ALTITUDE TO FLY	ROUTE TO FLY
FLY THE HIGHEST OF:	**SELECT THE ROUTE BY THIS ORDER:**
M.E.A –	**A.V.E.F –**
■ **M - M**inimum altitude prescribed for IFR	■ **A - A**ssigned route, if none:
■ **E - E**xpected (as in: "Expect 5000 10 min after departure")	■ **V - V**ectored (fly to fix/route/airway last vectored to), if none:
■ **A - A**ssigned. Last altitude assigned by ATC.	■ **E -** Last **E**xpected route by ATC, if none:
	■ **F - F**iled route

LEAVING THE CLEARANCE LIMIT (§91.185)

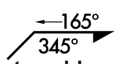
Is the clearance limit a fix from which an approach begins?

Yes → **<u>Start descent and approach</u> as close <u>as possible to the EFC, or ETA</u> (if no EFC given)**

No → **<u>At EFC or clearance limit</u> (if no EFC given), proceed to a <u>fix from which an approach begins</u> and <u>start the approach</u>**

PROCEDURE TURN

(§91.175, AIM 5-4-9)



- **A PT is a maneuver that enables:**
  - ▷ **Course reversal.**
  - ▷ **A descent from from IAF.**
  - ▷ **Inbound course interception.**
- **Max speed - 200 kts.**
- **Remain within the charted distance** ("Remain within _ NM" note), typically 10 NM, and **comply with published altitudes** for **obstacle clearance**.
- The shape of the maneuver is mandatory if a teardrop or holding-in-lieu-of a PT is published. Otherwise, only the direction of the turn is mandatory.
- **A <u>teardrop procedure</u> may be published in lieu of a PT.** In that case:
  - ▷ <u>No IF published</u>? Intermediate segment begins 10 miles prior to the final approach fix.
  - ▷ <u>Nav facility located on the airport</u>? Final approach starts at completion of the teardrop turn. However, the final approach segment begins on the final approach course 10 miles from the facility.
- A **PT** or **hold-in-lieu-of-PT <u>is mandatory</u>** when depicted on the approach chart. However, it is **<u>not permitted</u>** when: **<u>No PT depicted on the chart</u>**, <u>radar vectors to final</u> or when <u>conducting a timed approach</u> from a holding fix.

<u>DO NOT</u> FLY A PROCEDURE TURN WHEN:
S.H.A.R.P.T.T –

- **S**traight-in approach clearance.
- **H**olding in lieu of a procedure turn.
- DME **A**rc.
- **R**adar vectors to final.
- No **P**T depicted on chart.
- **T**imed approach from a hold fix.
- **T**eardrop course reversal.

Instrument approach types

- **<u>Precision</u>**
  Lateral + vertical guidance to a DA.
  - ▷ **ILS** - **I**nstrument **L**anding **S**ystem
  - ▷ **MLS** - **M**icrowave **L**anding **S**ystem
  - ▷ **PAR** - **P**recision **A**pproach **R**adar
  - ▷ **GLS** - **G**BAS **L**anding **S**ystem
  - ▷ **TLS** - **T**ransponder **L**anding **S**ystem
- **<u>Non-Precision</u>**
  lateral guidance only. Flown to MDA.
  - ▷ **VOR**
  - ▷ **NDB**
  - ▷ **RNAV / RNP** to **LNAV** or **LP** Minima
  - ▷ **LOC** - Localizer
  - ▷ **LDA** - **L**ocalizer-type **D**irectional **A**id. Identical to a LOC but not aligned with the runway.
  - ▷ **SDF** - **S**implified **D**irectional **F**acility. Similar to a LOC with 6° or 12° width. May be aligned or not with the runway.
  - ▷ **ASR** - **A**pproach **S**urveillance **R**adar
- **<u>Approach with Vertical Guidance</u>** (APV).
  A **precision-like** approach, flown to a DA with lateral + vertical guidance, but does not meet precision approach standards.
  - ▷ **RNAV / GNSS** (i.e, **LNAV/VNAV** and **LPV** minima)
  - ▷ **LDA with Glide Slope**

<u>Approach Clearances</u>

- **When can you descend to the next instrument approach segment?**
  - ▷ When cleared for the approach and established on a segment of a published approach or route. (AIM 5-5-4)
- **Contact approach** (AIM 5-5-3)
  - ▷ Requested by the pilot in lieu of an instrument approach. (Cannot be initiated by ATC)
  - ▷ Requires at least 1SM ground visibility and remain clear of clouds.
  - ▷ Only at airports with approved instrument approach procedures.
  - ▷ Pilot assumes responsibility for obstruction clearance.
- **Visual approach** (AIM 5-5-11)
  - ▷ <u>Initiated</u> by either <u>ATC or the pilot.</u>
  - ▷ Requires at least <u>1000' ceiling and 3SM visibility.</u> (IFR under VMC)
  - ▷ Pilot <u>must have either the airport or the traffic to follow in sight.</u>
  - ▷ <u>Pilot</u> is <u>responsible</u> for <u>visual separation from traffic to follow.</u>

<u>Missed Approach</u> (AIM 5-5-5)

- Execute a missed approach when:
  - ▷ Arrival at MAP or DH with insufficient visual reference to runway environment.
  - ▷ A safe approach is not possible.
  - ▷ Instructed to do so by ATC.

When can you descend below MDA / DA? (§91.175)

1. The aircraft is **continuously in a position** from which **a descent to a landing on the intended runway** can be made at a **normal rate of descent using normal maneuvers**.
2. The **flight visibility** (or the enhanced flight visibility, if equipped) is **not less than the visibility prescribed in the standard instrument approach** being used.
3. **At least one** of the following **visual references** for the intended runway is **distinctly visible and identifiable to the pilot**: (except for CAT II & III approaches)
   i. The **approach light system**, except that **the pilot may not descend below 100 feet above the touchdown zone elevation using the approach lights as a reference unless the red terminating bars or the red side row bars are also distinctly visible and identifiable**.
   ii. The **threshold**.
   iii. The **threshold markings**.
   iv. The **threshold lights**.
   v. The **runway end identifier lights**.
   vi. The **visual glideslope indicator**.
   vii. The **touchdown zone** or **touchdown zone markings**.
   viii. The **touchdown zone lights**.
   ix. The **runway** or **runway markings**.
   x. The **runway lights**.

VISUAL DESCENT POINT (VDP) (AIM 5-4-5)

- A defined point on the final approach course of a **non-precision straight-in approach** procedure f**rom which normal descent from the MDA to the runway touchdown point may begin**, provided adequate visual reference is established.
- Identified by a 'V' symbol on the descent profile.
- If not equipped to identify the VDP, fly the approach as if no VDP was published.
- Do not descend below the MDA prior to reaching the VDP.
- Calculate VDP, when not published: **By distance: VDP (in NM from threshold) = MDH / 300**

Example: Given MDH is 600 ft, **how far** is the VDP from the threshold?

```
VDP = 600 / 300 = 2 NM
Start the descent 2 NM from the threshold.
```

By time: MDH / 10 = seconds to subtract from time between FAF and MAP

Example: Given MDH is 500 ft, FAF to MAP is 4:00, **when** would you be over the VDP and start the descent from MDA/H?

```
500 / 10 = 50 seconds. 4:00 - 0:50 = 3:10
Start the descent at 3:10 (time from FAF)
```

VISUAL DESCENT ANGLE (VDA) (AIM 5-4-5)

- A computed glide path from the FAF to the runway's TCH published for non-precision approaches. Typically 3º.
- FAA policy is to publish a VDA/TCH on all non-precision approaches except those published in conjunction with vertically guided minimums (i.e., ILS or LOC RWY XX) or no FAF procedures without a stepdown fix (i.e., on-airport VOR or NDB). A VDA does not guarantee obstacle protection below the MDA in the visual segment. The presence of a VDA does not change any non-precision approach requirements.
- VDAs are **advisory only**, pilots must still **comply with all published altitudes** on the procedure.

Rate of Descent for a 3º Glide Path

```
VS (fpm) = Ground Speed X (10 / 2), or
VS (fpm) = Ground Speed X 5
```

Example:

```
120 kts X (10 / 2) = 120 kts X 5 = 600 fpm
```

How Far to Start a Descent for a 3º Glide Path?

```
TOD = Altitude to lose (ft) / 300
```

Example, on approach

800 ft to lose MDA to TCH:

```
800/300 = 2.67 NM
```

Start descent 2.67 NM from the runway threshold.

Example

Cruising at FL350, ATC: "...cross LGA VOR at FL240":

```
Altitude to lose = 35,000 - 24,000 = 11,000 ft
11000/300 = 36.67 NM
```

Start descent 36.67 NM from LGA VOR

Other Glide Path Angles

```
Descent gradient (%) = tan(descent angle) X 100
```

Descent angle	Gradient (%) = tan(angle)
2º	3.5%
3º	5.2%
4º	7%
5º	8.7%

```
VS (fpm) = Groundspeed X Descent Gradient (%)
TOD = Altitude to lose / (glidepath angle *100)
```

Example

At FL350, ATC:"...cross LGA OR at FL240", pilot elects a steep 4º slope, 380 kts GS:

```
VS = 380 X 7 = 2660 fpm
TOD = 11000 / 400 = 27.5 NM
```

Start the descent 27.5NM from LGA at 2800 fpm

AIRSPACE

Class A (AIM 3-2-2)

- **Controlled** airspace from 18,000' MSL to FL600 within the 48 contiguous states and Alaska. Includes the airspace within 12 NM of the shoreline as well as designated international airspace beyond the 12 NM distance.
- IFR only unless otherwise authorized.

Class B (AIM 3-2-3, §91.126)

- **Controlled airspace** surrounding the nation's **busiest airports**.
- Usually extends from the surface up to 10,000' MSL.
- The shape of each class B is specifically tailored for its environment.
- Consist of a surface area and two or more layers (resembling an upside-down wedding cake).
- Requires two-way radio communications.
- ATC separates both VFR and IFR traffic.
- Requires ATC clearance to enter. VFR pilots must make sure they hear a clearance to "Enter Class B". IFR pilots will typically already have this clearance as part of their ATC clearance picked up before or after takeoff.
- A Mode-C transponder and ADS-B Out equipment are required within a 30 NM radius (the "Mode-C Veil").

Class C (AIM 3-2-4)

- **Controlled airspace** around towered airports with certain number of IFR operations or passenger volume.
- Typical inner area is a 5 NM radius surrounding its primary airport, extending up to 4,000' above airport height.
- A 10 NM radius shelf area typically extends from no lower than 1,200' up to 4,000' above airport height.
- A non-charted outer area extends up to 20 NM from the primary airport.
- ATC Provides VFR/ IFR traffic separation in the outer area if two-way radio communication is established and in the Class C airspace itself.
- Requires two-way radio communication, a Mode-C transponder and ADS-B Out equipment.

Class D (AIM 3-2-5)

- Controlled airspace extending from the surface to 2,500' above airport height.
- Usually shaped as a cylinder with a 4 NM radius from the primary airport.
- Requires two-way radio communication.

Class E (AIM 3-2-6)

- **Controlled airspace** not designated as A, B, C, or D.
- May or may not be associated with an airport.
- Requires Mode-C transponder and ADS-B Out equipment at and above 10,000' MSL within the 48 contiguous states and D.C, excluding at or below 2,500' AGL.
- Requires ADS-B Out at and above 3,000' MSL over the Gulf of Mexico from the U.S. coast out to 12 NM.
- **Types of Class E**:
  - ▷ Surface area designated for an airport.
  - ▷ Extension to a surface area of Class B, C, or D.
  - ▷ Transition area. Class E beginning at 700' or 1200' AGL used to transition to/from a terminal or en-route environment.
  - ▷ En-route domestic areas

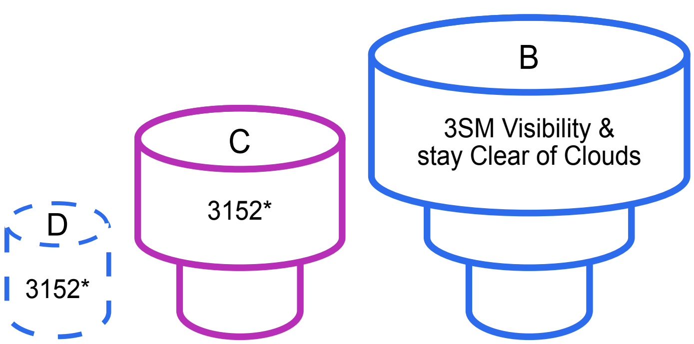
Class G (AIM 3-3)

- **Uncontrolled airspace.** Class G airspace is generally any airspace that has not been designated as Class A, B, C, D, or E.

BASIC VFR WEATHER MINIMUMS (§91.155)

*** Minimum visibility & distance from clouds mnemonics:**

3152 – 3SM, 1000' above, 500' below, 2000' horizontal.
1152 – 1SM, 1000' above, 500' below, 2000' horizontal.
5111 – 5SM, 1000' above, 1000' below, 1SM horizontal.



Class A: IFR only

Class E at or above 10,000' MSL & Class G at / above 10,000' MSL & 1,200' AGL:
5111 *

10,000' MSL

Class E below 10,000' MSL: 3152 *

Class G above 1,200' AGL but below 10,000' MSL: Day: 1152 *   Night: 3152 *

1,200' AGL

Class G at or below 1,200' AGL:
Day: 1 SM clear of clouds
Night: 3152 * or 1SM Clear of Clouds if in a traffic pattern within ½ SM from a runway.

Surface

- Except as provided in §91.157 (SVFR), **no person may operate an aircraft beneath the ceiling under VFR within the lateral boundaries** of **controlled airspace** designated to the **surface for an airport when the ceiling is less than 1,000 feet**.
- Except as provided in §91.157 (SVFR), **no person may take off** or **land** an aircraft, **or enter the traffic pattern** of an airport, **under VFR**, within the lateral boundaries of the surface areas of **Class B, C, D, or E airspace designated for an airport**:
  - ▷ Unless **ground visibility** at the airport is **at least 3 SM**, or
  - ▷ If ground visibility is not reported at that airport, unless flight visibility during takeoff or landing, or while operating in the traffic pattern is at least 3 SM.
- For the purpose of this section, **an aircraft operating at the base altitude of a Class E** airspace area **is considered to be within the airspace directly below that area**.

SPECIAL USE AIRSPACE

Prohibited Areas (§91.133, AIM 3-4-2)

- **Flight is prohibited** unless permission is granted by the using or controlling agency, as appropriate.
- Prohibited airspace exists due to security or other reasons associated with the national welfare.
- Example: Prohibited airspace P-56A over the White House.

Restricted Areas (§91.133, AIM 3-4-3)

- Flight is **not completely prohibited**, **but is subject to restrictions** due to **hazards to aircraft** such as artillery firing, aerial gunnery, or guided missiles.
- No person may operate an aircraft within a restricted area contrary to the restrictions imposed, unless that person has the permission of the using or controlling agency.
- If the restricted airspace is **not active** and has been released to the controlling agency (FAA), **ATC will allow the aircraft to operate in the restricted airspace without a specific clearance to do so.**
- If the restricted airspace **is active**, and has not been released to the controlling agency (FAA), **ATC will issue a clearance** which will **ensure the aircraft avoids the restricted airspace** unless it is on an approved altitude reservation mission or has obtained its own permission to operate in the airspace and so informs the controlling agency.

Warning Areas (AIM 3-4-4)

- Extends **3 NM outward from the coast of the U.S.**
- Contains **activity that may be hazardous** to aircraft.
- The purpose of warning areas is to warn nonparticipating aircraft of the potential hazard.
- May be located on domestic or international water, or both.

Military Operating Areas (MOA) (AIM 3-4-5)

- Established for the purpose of separating certain military training activities from IFR traffic.
- When a MOA is in use, nonparticipating IFR aircraft may be cleared through it if IFR separation can be provided. Otherwise, ATC will reroute or restrict the traffic.
- Example activities in an MOA: air combat tactics, air intercepts, aerobatics, formation training, and low-altitude tactics.
- Pilots operating under VFR should exercise extreme caution when operating within an active MOA. Therefore, pilots should contact any FSS within 100 miles of the area to obtain accurate real-time information concerning the MOA hours of operation. Prior to entering an active MOA, pilots should contact the controlling agency for traffic advisories.

Alert Areas (AIM 3-4-6)

- Depicted on charts to inform pilots of high volume of pilot training or an unusual type of aerial activity.
- Pilots transitioning the area are equally responsible for collision avoidance.

Controlled Firing Areas (AIM 3-4-7)

- Contain activities that, if not conducted in a controlled environment, may be hazardous to nonparticipating aircraft.
- Activities are suspended immediately when a spotter aircraft, radar or ground lookout positions indicate an aircraft might be approaching the area.
- CFAs are not charted because they do not cause a nonparticipating aircraft to change its flight path.

Military Training Routes (MTR) (AIM 3-5-2)

- IFR MTRs (IR) are typically above 1,500' AGL, while VFR MTRs (VR) are below 1,500' AGL.
- Generally, MTRs are established below 10,000 ft at speeds in excess of 250 knots. However, route segments may exist at higher altitudes.
- Route identification
  - ▷ MTRs with no segments above 1,500' AGL are identified by 4 digits; e.g., IR1206, VR1207.
  - ▷ MTRs that include one or more segments above 1,500' AGL are identified by three digits; e.g., IR206, VR207.

Air Defense Identification Zone (ADIZ) (AIM 5-6)

- An area of airspace over land or water, in which the ready identification, location, and control of all aircraft (except DoD and law enforcement aircraft) is required in the interest of national security.
- Requirements to operate within an ADIZ:
  - ▷ An operable Transponder with altitude encoding.
  - ▷ Two-way radio communication with he appropriate aeronautical facility.
  - ▷ File an IFR or Defense VFR (DVFR) Flight Plan
  - ▷ Depart within 5 minutes of flight plan's estimated departure time (exempt in Alaska info facility exists for filing, file immediately after departure or when within range of an appropriate facility).

Temporary Flight Restrictions (TFR) (AIM 3-5-3)

- Defined in Flight Data Center (FDC) NOTAMs
- TFR NOTAMs begin with the phrase: "FLIGHT RESTRICTIONS."
- Current TFRs are found at: www.tfr.faa.gov.
- Some reasons the FAA may establish a TFR:
  - ▷ Protect persons or property in the air or on the surface from hazards by low flying aircraft.
  - ▷ Provide a safe environment for disaster relief aircraft.
  - ▷ Prevent an unsafe congestion of sightseeing aircraft around an event of high public interest.
  - ▷ Protect declared national disasters for humanitarian reasons in the State of Hawaii.
  - ▷ Protect the President, Vice President, or other public figures.
  - ▷ Provide a safe environment for space agency operations.

Special Flight Rules Area (SFRA) (AIM 3-5-7)

- An airspace of defined dimensions above land areas or territorial waters, where special air traffic rules have been established for.
- Each person operating in a SATR (Special Air Traffic Rules) or SFRA must adhere to the special air traffic rules in 14 CFR Part 93, unless otherwise authorized or required by ATC.
- Example: The Washington DC Metropolitan SFRA.

MAX AIRCRAFT AIRSPEEDS IN THE U.S. (§91.117)

- **Mach 1.0** (speed of sound): above 10,000' MSL. (§91.817)
- **250 kts**: below 10,000' MSL.
- **200 kts**: under Class B, or within a VFR corridor thought Class B.
- **200 kts**: at or below 2,500' within 4 NM of the primary airport of a Class C or D airspace.
- **If the aircraft minimum safe airspeed for any particular operation is greater than the max speed prescribed above, the aircraft may be operated at that minimum speed**.

WEATHER

WEATHER INFORMATION SOURCES

- **Flight Service Station (FSS)**
- **NOAA's Aviation Weather Center Website https://www.aviationweather.gov/**
- Flight planning websites such as www.1800wxbrief.com and www.fltplan.com
- EFB software (i.e., ForeFlight, Jeppesen FlightDeck Pro)
- **Transcribed Weather Broadcast (TWEB)** – Available in Alaska only. A recorded broadcast over selected L/MF and VOR facilities of weather information for the local area.
- **Flight Information Services-Broadcast (FIS-B)** – A ground information data link service, provided through the **ADS-B** service network over 978 UAT MHz. Provides aviation weather and aeronautical information on cockpit displays. Some information available on FIS-B:
  - METAR, TAF, NEXRAD, AIRMET, SIGMETs and convective SIGMETs
  - TFR, Special Use Airspace updates and NOTAMs (FDC and distant)
  - PIREPs
- **Automatic Terminal Information Service (ATIS)** – A continuous broadcast of local airport weather and NOTAMs. Updated hourly, normally at 55 minutes passed the hour. Special updates issued outside the regular hourly cycle when needed. ATIS is published over the radio and, in locations with D-ATIS, via data link (ACARS).
- **Automated Surface Observation System (ASOS)** – Typically update hourly
- **Automated Weather Observation System (AWOS)** – Update every minute
- **ATC** - Center weather advisories are issued by ARTCC to alert pilots of existing or anticipated adverse weather conditions. ARTCC will also broadcast severe forecast alerts (AWW), convective SIGMETs and SIGMETs on all of its frequencies except for the emergency frequency (121.5 MHz).
- **Onboard weather radar**
- **Onboard lightning detector**
- **XM Satellite weather service**
- **ACARS**

WEATHER PRODUCTS

- **AIRMET (WA)** –
  - An advisory of **significant weather phenomena** at **lower intensities than those which require the issuance of SIGMETs**. These conditions **may affect all aircraft** but are **potentially hazardous to aircraft with limited capability**.
  - **Valid for 6 hours**.
  - **AIRMET (T)** - describes **moderate turbulence**, sustained surface **winds of 30 knots or greater**, **and/or non-convective low-level wind shear**.
  - **AIRMET (Z)** - describes **moderate icing** and provides freezing level heights.
  - **AIRMET (S)** - describes **IFR conditions** and/or extensive **mountain obscurations**.
  - **Graphical AIRMETs** (AIRMET G) – found at www.aviationweather.gov
- **SIGMET (WS)** –
  - A **non-scheduled inflight advisory** with a **maximum forecast period of 4 hours**. Advises of non-convective weather potentially hazardous to all types of aircraft. A SIGMET is issued when the following is expected to occur:
  - **Severe icing not associated with thunderstorms**
  - **Severe** or **extreme turbulence** or **Clear Air Turbulence (CAT) not associated with thunderstorms**.
  - **Dust storms**, **sandstorms** lowering surface **visibility below 3 miles**.
- **Convective SIGMET (WST)** –
  - An **inflight advisory** of **convective weather significant** to the safety of **all aircraft**.
  - Issued **hourly at 55 minutes** past the hour for the **western (W), eastern (E) and central (C)** USA.
    - **Not issued for Alaska or Hawaii.**
  - **Valid for 2 hours**.
  - Contains either **an observation and a forecast or only a forecast**.
  - **Issued for any of the following**:
    - **Severe thunderstorms** due to:
      - **Surface winds greater or equal to 50 knots**
      - **Hail at the surface greater than 3/4 inch in diameter**
    - **Tornadoes**
    - **Embedded thunderstorms** of any intensity level
    - A **line of thunderstorms** at least **60 miles long** with thunderstorms affecting at least **40% of its length**
    - Thunderstorms producing **heavy or greater precipitation** (**VIP level 4**) affecting **at least 40% of an area of at least 3000 square miles**.
  - **Any Convective SIGMET implies severe or greater turbulence, severe icing, and low level wind shear.**
- **International SIGMET**
  - Issued **outside the Contiguous USA** and **follow ICAO coding standards**.

WEATHER PRODUCTS - CONTINUED

- In the US, international SIGMETs are **issued for** areas that include **Alaska, Hawaii, portions of the Atlantic and Pacific Oceans, and the Gulf of Mexico**.
- Criteria for international SIGMETs:
  - **Thunderstorms** occurring in lines, **embedded** in **clouds**, or in large areas producing **tornadoes** or **large hail**.
  - **Tropical cyclones**
  - **Severe icing**
  - **Severe** or **extreme turbulence**
  - **Dust storms** and **sandstorms** lowering surface **visibility** to **less than 3 miles**
  - **Volcanic ash**

- **PIREP (UA)** & **Urgent PIREP (UUA)** – pilot weather reports.
- **METAR** – Aviation routine weather show surface weather observations in a standard international format. Scheduled METARs are published every hour. Non-scheduled METARS (**SPECI**) are issued when there is a significant change in one or more reported element since the last scheduled METAR.
- **TAF** – Terminal Aerodrome Forecast. Weather forecast for 5SM radius area around the station. Issued 4 times a day, every six hours and normally covers a 24 or 30 hour forecast period. TAF amendments (TAF **AMD**) supersede previous TAFs.
- **Surface analysis chart** –Generated from surface station reports. Shows pressure systems, isobars, fronts, airmass boundaries (e.g,: dry lines and outflow boundaries) and station information (e.g,: wind, temperature/dew point, sky coverage, and precipitation). Issued every 3 hours. (or every 6 hours in Hawaii and tropical and Oceanic regions). A **Unified Surface Analysis Chart** is produced every 6 hours and combines the analysis from the 4 centers (OPC, WPC, NHC and HFO)
- **Radar summary chart (SD)** – Depicts precipitation type, intensity, coverage, movement, echoes, and maximum tops. Issued hourly
- **Wind & temp aloft forecasts (FB)** – Issued 4 times daily for various altitudes and flight levels.
  Winds at altitude up to 1500' AGL and temperatures at up to 2500' AGL are not shown.
  Format: **DDff±tt**, where DD = wind direction; ff = wind speed; tt = temperature. Light and variable winds: 9900. Winds between 100-199 Kt are coded by adding 5 to the first digit of the wind direction.
  Above FL240 temperatures are negative and the minus sign (-) is omitted.
  Examples:
  1312+05: winds 130 / 12 kt, 5°C.
  7525-02: winds 250 / 125 kt, -2° C.
- **Low level significant weather chart** – Forecasts significant weather conditions for a 12 and 24 hour period from the surface to 400 mb level (24,000 ft). Issued 4 times a day. Depicts weather categories (IFR, MVFR and VFR), turbulence and freezing levels.
- **Mid-level significant weather chart** – Forecasts of significant weather at various altitudes and flight levels from 10,000' MSL to FL450. Shows: thunderstorms, jet streams, tropopause height, tropical cyclones, moderate and severe icing conditions, moderate or severe turbulence, cloud coverage and type, volcanic ash and areas of released radioactive materials. Issued 4 times a day for the North Atlantic Region.
- **High-level significant weather charts** – Depicts forecasts of significant weather phenomena for FL250 to FL630. Shows: coverage bases and tops of thunderstorms and CB clouds, moderate and severe turbulence, jet streams, tropopause heights, tropical cyclones, severe squall lines, volcanic eruption sites, widespread sand and dust storms. Issued 4 times a day.
- **Convective outlook (AC)** – Available in both graphical and textual format. A 3-day forecast of convective activity. Convective areas are classified as marginal (MRGL), slight (SLGT), enhanced (ENH), moderate (MDT), and high (HIGH) risk for severe weather. Issuance: day 1 – 5 times a day, day 2 – twice a day, day 3 – once a day. Available on www.spc.noaa.gov.
- **Weather satellite** images:
  - **Visible**
    - Helps in identifying cloud coverage based on visible light reflection.
    - Not useful for identifying cloud height.
  - **Infrared** (Color or B/W)
    - Measure cloud top temperature
    - Highest clouds appear bright white.
    - Middle clouds are in shades of gray
    - Low clouds and fog are dark gray,
  - **Water vapor**
    - Shows areas of moist and dry air in shades of gray from white to black.
    - Moist air areas are depicted as bright white
    - Dry air is depicted in black.
- **Next Generation Weather Radar (NEXRAD)** products. Examples:
  - **Base reflectivity** - echo intensities in dBZ. Available for several elevation tilt angles.
  - **Echo tops** - color coded echo top heights.
  - **Composite reflectivity** - Reveals highest reflectivity of all echos, helps in examining storm structure features and the intensity of storms.
  - **1 and 3-hour precipitation**
- **Ceiling & Visibility Charts**- Shows ceiling based on surface observations. This online tool phased out the older weather depiction chart and is now replaced with the HEMS tool at www.aviationweather.gov/hemst
- **Graphical turbulence Guidance (GTG)** tool at www.aviationweather.gov/turbulence/gtg – Shows color coded turbulence forecast based on aircraft category, altitude and time.

WEATHER HAZARDS

THUNDERSTORMS

The Three Conditions Required for the formation of Thunderstorms:

1. Sufficient **water vapor** (moisture).
2. An **unstable temperature lapse rate**. Stability is the resistance of the atmosphere to upwards or downwards displacement. An unstable lapse rate allows any air mass displacement to further grow vertically.
3. An initial **uplifting force** (e.g., front passages, orthographic lifting by typography, heating from below, etc.).

Three Stages in Thunderstorm Lifecycle:

1. **Cumulus** (3-5 mile height) – The lifting action of the air begins, growth rate may exceed 3000 fpm.
2. **Mature** (5-10 miles height) – Begins when precipitation starts falling from the cloud base. Updraft at this stage may exceed 6000 fpm. Downdrafts may exceed 2500 fpm. All **thunderstorm hazards are at their greatest intensity at the mature stage**.
3. **Dissipating** (5-7 miles height) – Characterized by strong downdrafts and the cell dying rapidly.

Thunderstorm Hazards:

- Limited visibility
- Wind shear
- Strong updrafts / downdrafts
- Icing
- Hailstones
- Heavy rain
- Severe turbulence
- Lightning strikes and tornadoes.

FOG

A cloud that begins within 50 ft of the surface.

Fog occurs when:

- The air **temperature near the ground reaches its dew point**, or
- when the **dew point is raised to the existing temperature** by **added moisture** to the air.

Types of fog

- **Radiation fog** – Occurs at calm, clear nights when the ground cools rapidly due to the release of ground radiation.
- **Advection fog** – Warm, moist air moves over a cold surface. Winds are required for advection fog to form.
- **Ice fog** – Forms when the temperature is much below freezing and water vapor turns directly into ice crystals. Ice fog is common in the arctic regions, but also occurs in mid-latitudes.
- **Upslope fog** – Moist, stable air is forced up a terrain slope and cooled down to its dew point by adiabatic cooling.
- **Steam fog** – Cold, dry air moves over warm water. Moisture is added to the airmass and steam fog forms.

ICING

- **Structural Ice**. Two conditions for formation: **1. Visible moisture** (i.e., rain, cloud droplets), and **2. Aircraft surface temperature below freezing**.
  - ▷ **Clear ice**– The most dangerous type. Heavy, hard and difficult to remove. Forms when water drops freeze slowly as a smooth sheet of solid ice. Usually occurs at temperatures close to the freezing point (-10° to 0° C) by large supercooled drops of water
  - ▷ **Rime ice** – Opaque, white, rough ice formed by small supercooled water drops freezing quickly. Occurs at lower temperatures than clear ice.
  - ▷ **Mixed ice** – Clear and rime ice formed simultaneously.
- **Instrument ice** – Structural ice forming over aircraft instruments and sensors, such as pitot and static.
- **Induction ice** – ice reducing the amount of air for the engine intake.
- **Intake ice** – Blocks the engine intake.
- **Carburetor ice** – May form due to the steep temperature drop in the carburetor Venturi. Typical conditions are outside air temperatures of -7° to 21° C and a high relative humidity (above 80%).
- **Frost** – Ice crystals caused by sublimation when both the temperature and the dew point are below freezing.

AEROMEDICAL (Pilot Handbook of Aeronautical Knowledge)

- **Hypoxia** - Insufficient supply of oxygen to the body cells.
  - **Hypoxic hypoxia** – Insufficient supply of O2 to the body as a whole. As altitude increases, O2 percentage of the atmosphere is constant, but its pressure decreases. The reduced pressure becomes insufficient for the O2 molecules to pass through the respiratory system's membranes.
  - **Hypemic hypoxia** – Inability of the blood to carry the O2 molecules. It may be a result of insufficient blood (bleeding or blood donation), anemia or CO poisoning.
  - **Histotoxic hypoxia** – Inability of the body cells to affectively use the O2 supplied by the blood. This can be caused by use of alcohol or drugs.
  - **Stagnant hypoxia** - Caused by the blood not flowing efficiently. Can be caused by heart problems, excessive acceleration (Gs), shock or a constricted blood vessel. Cold temperatures can restrict circulation and decrease blood supplied to the extremities.
- **Hyperventilation** – A condition which occurs when excessive amount of CO2 is eliminated from the body as a result of breathing too rapidly. Symptoms may be similar to those of hypoxia. Breathing into a paper bag or talking aloud helps recovery from hyperventilation.
- **Decompression sickness** – Inert gasses (mainly nitrogen) are released rapidly from solution in the body tissues and fluids as a result of low barometric pressure. The gasses form bubbles that may harm the body in several ways. The most common result of decompression sickness is joint pain ("**the bends**"). To help prevent the bends after SCUBA diving: **wait at least 12 hours after diving that does not require a controlled ascent (non-decompression stop diving) for flights up to 8000 ft MSL; wait 24 hours for flights above 8000 ft or after any diving that required a controlled ascent** (**decompression stop diving)**.

Oxygen requirements (§91.211, Note: see §121.327-121.333 & §135.89, §135.157 for 121/135 operations O2 rules)

- **Unpressurized cabins**
  - Cabin pressure altitudes **above 12,500** to **14,000' MSL (including)** – The required minimum **flight crew must be provided** with **and** must **use** supplemental **O2** for periods of flight over **30 minutes at these altitudes**.
  - Cabin pressure altitudes **above 14,000'** – The required minimum **flight crew** must be **provided with and must use** supplemental **O2 the entire flight time at these altitudes**.
  - Cabin pressure altitudes above 15,000' MSL – Each occupant must be provided with supplemental O2.
- **Pressurized cabins**
  - **Above FL250** - **an addition of at least 10 minutes** of supplemental **O2** for **each occupant** is required.
  - **Above FL350** - **one pilot at the controls must wear and use** an **O2 mask unless two pilots are at the control with quick-donning masks and the aircraft is at or below FL410**.
  - **If one pilot leaves the controls above FL350**, the **other pilot must wear and use** his **O2 mask regardless if** it's a **quick donning** type.
- **Middle Ear & Sinus blockage**
  - Air pressure in the middle ear and sinuses normally equalizes with external air through the nasal passages.
  - Allergies, colds or sinus infections may block these small opening and prevent the pressure from equalizing.
  - If the air gets trapped, it may cause extreme pain, reduction in hearing or damage to the ear drums. This effect is usually most severe during descend.
  - To relieve this condition, try the "**Valsalva Maneuver**": pinch your nostrils and **gently** try to blow air out of your nose. This forces air through the Eustachian tube into the middle ear. It may not work if the pilot has a cold, sinus or ear infection, or a sore throat.
  - Consider seeing a physician if the condition doesn't clear after the flight.
- **Spatial disorientation and illusions**
  - 3 systems the body uses for spatial orientation
    - **Vestibular System** - Consists of organs in the inner ear
      - **3 semicircular canals** sense movement in 3 axes: **pitch, roll and yaw**. The canals are filled with fluid, which moves against tiny sensory hairs as the head is moved. The brain gets these signals and interprets a sensation of movement.
      - **2 otolith organs**, the utricle and saccule, sense **acceleration** in the horizontal and vertical planes.
    - **Somatosensory System** - Consists of nerves in the skin, muscles and joints.
    - **Visual System** - Visual cues from our eyes help the brain figure out spatial orientation.
  - **Vestibular Illusions**
    - **The leans** - After leveling the wings following a prolonged turn, pilot may feel that the aircraft is banked in the opposite direction of the turn.
    - **Coriolis Illusion** - After a prolonged turn, the fluid in the ear canal moves at same speed as the canal. A head movement on a different plane will cause the fluid to start moving and result in a false sensation of acceleration or turning on a different axis.
    - **Graveyard Spiral** - A pilot in a prolonged, coordinated constant-rate turn may experience the illusion of not turning. After leveling the wings, the pilot may feel the sensation of turning to the other direction ("the leans"), causing the pilot to turn back in the original direction. Since a higher angle of attack is required during a turn to remain level, the pilot may notice a loss of altitude and apply back force on the elevator. This may tighten the spiral and increase the loss of altitude.
    - **Somatogravic Illusion** - Rapid acceleration stimulates the inner ear otolith organs in the same way as tilting the head backwards. This may create the illusion of a higher pitch angle. Deceleration causes the opposite illusion – the sensation of tilting the head forward and the aircraft being in a nose-low attitude.

SPATIAL DISORIENTATION AND ILLUSIONS - CONTINUED

- **Inversion Illusion** - An abrupt change from climb to straight and level may create the illusion of tumbling backwards due to the fluid movement in the otolith organs.
- **Elevator Illusion** - An abrupt upward vertical acceleration may create the illusion a climb, due to fluid movement in the otolith organs.

▷ **Visual Illusions**

- **False Horizon** - An illusion in which the pilot may misidentify the horizon line. May be caused by sloping cloud formation, an obscured horizon, an aurora borealis, dark night with scattered lights and stars or the geometry of the ground
- **Autokinesis** - Staring at a stationary point of light in a dark or featureless scene for a prolonged period of time may cause the light to appear to be moving. A pilot may attempt to align the aircraft with the perceived moving light, resulting in loss of control.

▷ **Optical Illusions**

- **Runway Width Illusion** - A narrow runway may create the illusion that the aircraft is higher than it actually is. A wide runway may cause the opposite effect of the aircraft flying too low.
- **Runway and Terrain Slope Illusion** - An uplosping terrain or runway may create the illusion that the aircraft is at a higher altitude than it actually is.
- **Featureless Terrain Illusion** - Also known as "**black hole approach**." Flying over featureless or dark areas, such as in an overwater approach, can create the illusion that the aircraft is at a higher altitude than it actually is and may lead the pilot to fly at a lower altitude than desired.
- **Water Refraction** - Rain on the windscreen can create an illusion of being at a higher altitude due to the horizon appearing lower than it is. This can result in the pilot flying a lower approach.
- **Haze** - Shooting an approach in haze may create the illusion that the runway is further that it actually is, or that the aircraft is higher than it actually is.
- **Fog** - Flying into fog may create an illusion of a nose-up motion.
- **Ground Lighting Illusion** - Lights along a straight path, such as a road or lights on moving trains, can be mistaken for runway and approach lights. Bright runway and approach lighting systems, especially where few lights illuminate the surrounding terrain, may create the illusion that the runway is closer than it actually is. This may result in the pilot flying a higher approach than desired.

Coping with spatial disorientation (Pilot Handbook of Aeronautical Knowledge)

1. Understand the causes of the illusions that may affect you as a pilot and stay alert for them when flying.
2. Obtain and understand relevant preflight weather information.
3. Maintain instrument proficiency and obtain training if needed before flying in marginal or instrument conditions.
4. Do not fly into adverse weather conditions or into adverse weather conditions, dark or featureless areas unless instrument proficient.
5. When using outside visual references, ensure they are reliable, fixed points on the earth's surface.
6. Avoid sudden head movements, particularly during takeoff, turns, and approaches to landing.
7. Be physically tuned for flight into reduced visibility. Ensure proper rest, adequate diet, and, if flying at night, allow for night adaptation. Remember that illness, medication, alcohol, fatigue, sleep loss, and mild hypoxia are likely to increase susceptibility to spatial disorientation.
8. Most importantly, **become proficient in the use of flight instruments and rely upon them. Trust the instruments and disregard your sensory perceptions**.

TABLES & REFERENCES

RNP Approach Minima – supported equipment					
Minima	**GLS (DA)**	**LPV (DA)**	**LP (MDA)**	**LNAV / VNAV (DA)**	**LNAV (MDA)**
Approach Type	Precision	APV	Non-precision	APV	Non-precision
GBAS (formerly LAAS)	✓	✓	✓	✓	✓
WAAS		✓	✓	✓	✓
GPS + Baro VNAV				✓	✓
Basic IFR GPS					✓

TABLES & REFERENCES - CONTINUED

VOR Time & Distance

Distance off course = 200 ft per dot per NM from VOR

Distance to station = TAS X min between bearings / degrees of BRG change.

Time (minutes) to station = Seconds for BRG change / degrees of BRG change

Standard Rate Turn - Angle of Bank Calculation

(KTAS / 10) X 1.5

Example: 120 KTAS
(120 / 10) x 1.5 = 12 x 1.5 = 18º of bank

RVR (ft)	Visibility (SM)
1,600	1/4
2,400	1/2
3,200	5/8
4,000	3/4
4,500	7/8
5,000	1
6,000	1-1/4

Aircraft Approach Categories

CAT	1.3Vso (kts)	Standard (old) circling maneuver radius (NM)
A	< 90	1.3
B	91-120	1.5
C	121-140	1.7
D	141-165	2.3
E	> 165	4.5

Expanded Circling Approach Maneuvering Radius
Identified by **C** on FAA approach charts.
For procedures developed after late 2012. (AIM 5-4-20)

Circling MDA (MSL)	A	B	C	D	E
1000 or less	1.3	1.7	2.7	3.6	4.5
1001-3000	1.3	1.8	2.8	3.7	4.6
3001-5000 ft	1.3	1.8	2.9	3.8	4.8
5001-7000 ft	1.3	1.9	3.0	4.0	5.0
7001-9000 ft	1.4	2.0	3.2	4.2	5.3
9001 and above	1.4	2.1	3.3	4.4	5.5

Special VFR (SVFR) (91.157) –

An **ATC clearance** allowing operation under **VFR** with weather conditions lower than the standard VFR minimums prescribed in 91.155.

SVFR is available **below 10,000 MSL** within the airspace contained by the **upward extension of the lateral boundaries of the controlled airspace designated to the surface of an airport**.

Requires at least **1 SM** (as officially reported) and that the aircraft remains **clear of clouds**.

For **night SVFR** (sunset to sunrise), **an Instrument rating and instrument-equipped aircraft are required**.

Flight Categories Used in AWC Weather Products

Category	Color	Ceiling		Visibility
LIFR (Low IFR)	**Magenta**	Less than 500'	and/or	Less than 1 SM
IFR (Instrument Flight Rules)	**Red**	500' to below1,000' ft AGL	and/or	1 SM to less than 3 SM
MVFR (Marginal VFR)	**Blue**	1,000'-3,000' AGL	and/or	3 to 5 SM
VFR (Visual Flight Rules)	**Green**	Greater than 3000' AGL	and	Greater than 5 SM

NOTES:
By definition, IFR is ceiling less than 1,000' AGL and/or visibility less than 3 miles while LIFR is a sub-category of IFR.
By definition, VFR is ceiling greater than or equal to 3,000' AGL and visibility greater than or equal to 5 SM while MVFR is a subcategory of VFR.
Sources: https://aviationweather.gov/taf/help?page=plot and AIM 7-1-7

Term	Definition
AATD	Advanced Aviation Training Device
AAWU	Alaskan Aviation Weather Unit
AC	Advisory Circular
ACS	Airman Certification Standards
AD	Airworthiness Directive
ADC	Air Data Computer
ADM	Aeronautical Decision Making
ADS-B	Automatic Dependent Surveillance-Broadcast
AFM	Airplane Flight Manual
AGL	Above Ground Level
AHRS	Attitude Heading Reference System
AI	Attitude Indicator
AIM	Aeronautical Information Manual
ALS	Approach Light System
ALSF	Approach Light System with Sequence Flashing Lights (e.g, ALSF-1, ALSF-2)
APV	Approach with Vertical guidance
ARTCC	Air Route Traffic Control Center (“Center”)
ASI	Airspeed Indicator
ASOS	Automated Surface Observation System
ASR	Approach Surveillance Radar
ATC	Air Traffic Control
ATD	Aviation Training Device
ATIS	Automatic Terminal Information Service
AWC	Aviation Weather Center
AWOS	Automated Weather Observation System
BATD	Basic Aviation Training Device
DA	Decision Altitude
DH	Decision Height
DME	Distance Measuring Equipment
DP	Departure Procedure
EDCT	Expect Departure Clearance Time
EFB	Electronic Flight Bag
ELT	Emergency Locator Transmitter
ETA	Estimated Time of Arrival
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FCC	Federal Communications Commission
FFS	Full Flight Simulator
FIS-B	Flight Information Services-Broadcast
FL	Flight Level
fpm	Feet per Minute
FPNM	Feet per Nautical Mile
FSS	Flight Service Station

Term	Definition
FTD	Flight Training Device
GBAS	Ground Based Augmentation System (i.e, LAAS)
GP	Glide Path
HFO	Weather Forecast Office Honolulu
HI	Heading Indicator
IAF	Initial Approach Fix
ICAO	International Civil Aviation Organization
IF	Intermediate Fix
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IM	Inner Marker
IMC	Instrument Meteorological Conditions
IPC	Instrument Proficiency Check
KTAS	Knots True Airspeed
Kts	Knots. NM / hour.
LAAS	Local Area Augmentation System
LDA	Localizer Type Directional Aid.
LIFR	Low IFR
LNAV	Lateral Navigation
LOC	Localizer
LP	Localizer Performance RNAV / RNP approach
LPV	Localizer Precision with Vertical Guidance approach
MAA	Maximum Authorized Altitude
MALSR	Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights
MAP	Missed Approach Point
MCA	Minim Crossing Altitude
MDA	Minimum Descent Altitude
MDH	Minimum Descent Height
MEA	Minimum Enroute Altitude
MEL	Minimum Equipment List
MFD	Multi Function Display
MLS	Microwave Landing System
MM	Middle Marker
MOCA	Minimum Obstruction Clearance Altitude
MON	VOR Minimum Operational Network program
MORA	Minimum Off Route Altitude (Jeppesen)
MRA	Minimum Reception Altitude
MSL	Mean Sea Level
MVFR	Marginal VFR
NDB	Non-Directional Beacon
NHC	National Hurricane Center
NMC	National Meteorological Center

Term	Definition
NOTAM	Notice to Airmen
ODALS	Omni-Directional Approach Lighting System
ODP	Obstacle Departure Procedure
OM	Outer Marker
OPC	Ocean Prediction Center
PAPI	Precision Approach Path Indicator
PAR	Precision Approach Radar
PFD	Primary Flight Display
PIC	Pilot-in-Command
PIREP	Pilot Report
RAIM	Receiver Autonomous Integrity Monitoring
REIL	Runway End Identifier Lights
RNAV	Area Navigation
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minimum
SBAS	Satellite-based Augmentation System (e.g., WAAS, EGNOS)
SDF	Simplified Directional Facility
SID	Standard Instrument Departure
STAR	Standard Terminal Arrival
STC	Supplemental Type Certificate
SVFR	Special VFR
TCH	Threshold Crossing Height
TDZL	Touchdown Zone Lights
TIBS	Telephone Information Briefing Service
TLS	Transponder Landing System
TOC	Top of Climb
TOD	Top of Descent
TWEB	Transcribed Weather Broadcast
UAT	Universal Access Transceiver
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VIP	Video Integrator Processor
VMC	Visual Meteorological Conditions
VNAV	Vertical Navigation
VOR	VHF Omnidirectional Range
VORTAC	VHF Omnidirectional Range Tactical Air Navigation (VOR+TACAN)
VS	Vertical Speed
VSI	Vertical Speed Indicator
WAAS	Wide Area Augmentation System
WPC	Weather Prediction Center
Wx	Weather

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