Airplane IFR quick-review sheets

Min. aeronautical experience required for an airplane instrument rating:

- 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 inst. App. At each airport
      - 3 different kinds of approaches using nav. systems
      - With a filed IFR flight plan
  - 3 hours in last 2 cal. Months prior to the practical test

(§61.65)

Personal documents required for flight:

- Pilot certificate
- Medical certificate
- Authorized photo ID (passport, driver's license, etc)
- Restricted radiotelephone operator license (for flights outside the U.S.)

(§61.3 and FCC)

Aircraft documents required for flight:

A.R.R.O.W-

- **A**- Airworthiness certificate
- **R**-Registration certificate
- **R**-Radio station license (for international flights)
- **O**-Operating limitations & AFM
- **W**-Weight & Balance data

(§21.5, §91.103, §91.9, §91.203, FCC form 605)

Aircraft maintenance inspections required for IFR:

A.V.I.A.T.E-

- **A**-Annual inspection every 12 cal. Months (§91.409)
- **V**-VOR every 30 days (§91.171)
- **I**-100 hour inspection (§91.409)
- **A**-Altimeter, altitude reporting and static system every 24 cal. months (§91.413)
- **T**-Transponder every 24 months (§91.413)
- **E**-ELT every 12 months (§91.207)

Preflight info required for IFR: (§91.103)

W.K.R.A.F.T-

- **W- W**eather reports and forecasts.
- **K- K**nown traffic delays as advised by ATC.
- **R- R**unway length of intended use.
- **A- A**lternatives available if flight cannot be completed as planned.
- **F- F**uel requirements
- **T- T**akeoff and landing performance data.

Preflight self-assessment:

I.M S.A.F.E-

- **I**- **I**llness
- **M**- **M**edication
- **S**- **S**tress
- **A**- **A**lcohol ("8 hours bottle to throttle"; no more than .04% of alcohol in blood)
- **F**- **F**atigue
- **E**- **E**motion

Risk management & personal minimums

P.A.V.E-

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

Logging instrument time-

*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.*

Instrument PIC recency of experience:

- Last 6 calendar months (under actual/simulated instrument or Flight Training Device/simulator, in the same aircraft category), logged: ("6 HITS")
  - **6** instrument approaches.
  - **H**olding procedures & tasks.
  - **I**ntercept & **T**rack courses through the use of electronic navigation **S**ystems.
- **Or**, using an ATD (basically an **approved** PC-based flight simulator + hardware) in the last 2 calendar months prior to the flight:
  - 3 hours instrument experience.
  - Holding procedures & tasks.
  - 6 instrument approaches.
  - 2 unusual attitude recoveries in a descending Vne condition.
  - 2 unusual attitude recoveries in an ascending stall speed condition.
- Not current looking back 6 months? You can still log the requirements (6 HITS) and get current with a safety pilot (under simulated conditions), instructor or pilot examiner.
- The safety pilot must be at least a private pilot with the appropriate category and class. He must have adequate vision forward and to each side of the aircraft. When using a safety pilot, the aircraft must have dual-control system.
- Looking back 12 cal. months not current? You need an Instrument Proficiency Check (IPC) by a CFII, examiner or approved person.
- Certain IPC tasks, found in a table at the end of the instrument PTS, can be completed in an approved flight simulator or FTD. However, a full IPC can only be conducted in certain full-motion simulators or in the actual aircraft, since some tasks (such as circling maneuvers) cannot be completed on low-end FTDs and simulators.
- **To carry passengers as PIC**
  - 3 takeoffs and landings in last 90 days in the same category, class and type (if type rating required).
  - At periods between 1 hour after sunset to 1 hour before sunrise: 3 takeoffs and landings to a full stop during 1 hour after sunset to 1 hour before sunrise in the last 90 days.
- **To act as PIC** – flight review in the last 24 cal. Months (see FAR for exceptions)

(§61.56, §91.109, §61.57)

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Form Approved: OMB No. 2120-0026

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

FLIGHT PLAN

(FAA USE ONLY) ☐ PILOT BRIEFING ☐ VNR ☐ STOPOVER | TIME STARTED | SPECIALIST INITIALS

1. TYPE: VFR / IFR / DVFR | 2. AIRCRAFT IDENTIFICATION | 3. AIRCRAFT TYPE / SPECIAL EQUIPMENT | 4. TRUE AIRSPEED KTS | 5. DEPARTURE POINT | 6. DEPARTURE TIME: PROPOSED (Z) / ACTUAL (Z) | 7. CRUISING ALTITUDE

8. ROUTE OF FLIGHT

9. DESTINATION (Name of airport and city) | 10. EST. TIME ENROUTE: HOURS / MINUTES | 11. REMARKS

12. FUEL ON BOARD: HOURS / MINUTES | 13. ALTERNATE AIRPORT(S) | 14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE | 15. NUMBER ABOARD

17. DESTINATION CONTACT/TELEPHONE (OPTIONAL)

16. COLOR OF AIRCRAFT

CIVIL AIRCRAFT PILOTS. FAR Part 91 requires you file an IFR flight plan to operate under instrument flight rules in controlled airspace. Failure to file could result in a civil penalty not to exceed $1,000 for each violation (Section 901 of the Federal Aviation Act of 1958, as amended). Filing of a VFR flight plan is recommended as a good operating practice. See also Part 99 for requirements concerning DVFR flight plans.

FAA Form 7233-1 (8-82)
Electronic Version (Adobe)

CLOSE VFR FLIGHT PLAN WITH ______________ FSS ON ARRIVAL

IFR flight plan

- ❖ Required before entering **controlled airspace** under **IFR** (a clearance is also required) (§91.173)
- ❖ How to file?
  - FSS (in person, radio or phone)
  - DUATS (online)
  - Through radio/phone with ATC
  - File at least 30 min. prior to est. departure time
- ❖ Stored in the system for 1.5 hours from proposed time of departure.
- ❖ Cancelation (AIM 5-1-14)
  - Towered airports – automatically canceled by ATC upon landing.
  - Non-towered airports – you must contact ATC/FSS to cancel.
  - Can cancel anytime not in IMC and outside class A airspace.
- ❖ Preferred IFR routes are published in the Airport/Facility Directory (AFD). If a preferred route is published to your destination, you should file it in your flight plan.

Obstacle Departure Procedures (ODP) (AIM 5-2-8)
- ❖ Only provides obstruction clearance.
- ❖ May be flown without an ATC clearance unless a SID or other instructions are assigned. (e.g. radar vectors)
- ❖ Graphic ODP denote "Obstacle" in the chart title.
- ❖ All new RNAV ODPs are available in graphical form.
- ❖ Found in the front of NACO chart booklets, arranged alphabetically by city name.
- ❖ Jeppesen charts show ODPs under the airport diagram (x0-9) page, or, at larger airports, on a separate chart.

Standard Instrument Departures (SID) (AIM 5-2-8)
- ❖ Provide obstruction clearance and helps reducing radio congestion and workload by simplifying ATC clearances.
- ❖ Pilot NAV SIDs – Pilot navigates by charted routes with minimal radio instructions.
- ❖ Vector SIDs –Navigation is based on radar vectors. Routes are not printed on the chart.
- ❖ Some SIDs depict non-standard radio failure procedures.
- ❖ File "NO SIDs" in the remarks of your flight plan if you choose not to use them.
- ❖ RNAV SIDs and all graphical RNAV ODPs require RNAV 1 performance. (±1 NM for 95% of the total flight time).

Standard Terminal Arrivals (STAR) (AIM 5-4-1)
- ❖ Serves as a transition from the en route structure to a point from which an approach can begin.
- ❖ Transitions routes connect en route fixes to the basic STAR procedure.
- ❖ Usually named according to the fix at which the basic procedure begins.
- ❖ As with SIDs, you may state "No STARs" in your flight plan remark section if you choose not to use them.
- ❖ RNAV STARS require RNAV 1 performance.

IFR minimum altitudes

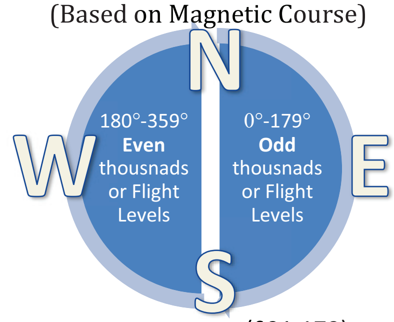
Minimum prescribed, or if none:

Mountainous areas: 2,000ft above highest obstacle within 4NM of course.

Non-mountainous areas: 1,000ft above highest obstacle within 4NM of course. (§91.177)

IFR cruising altitudes

(Based on Magnetic Course)



(§91.179)

IFR minimum fuel requirements (§91.167)

Fuel from departure airport to destination **+** Fuel from destination to alternate (if required) **+** :45 Minutes of fuel at normal cruise

Do you need an alternate?

("1-2-3" or "1-2003" rule) §91.169

- If within **1 hour before to 1 hour after ETA** forecasted weather is less then:

  2000 ft ceiling and/or

  3 SM visibility

  you need an alternate!

Yes. minimum weather conditions required at an airport to list it as an alternate:

The alternate airport minima **specified in the procedures**, or, if none:

- **Precision approach**:
  600 ft ceiling and 2 SM visibility
- **Non-precision approach**: (must be other than non-WAAS GPS)
  800 ft ceiling and 2 SM visibility
- **No instrument approach at the alternate**:
  ceiling & visibility allowing descent from MEA, approach and landing under basic VFR.

Basic IFR departure clearance items

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 4-4-3, 5-2-5, 5-2-6)

Mandatory reports under IFR

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

- **M-M**issed approach (AIM 5-3-3)
- **A-A**irspeed ±10kt / 5% change of filed TAS (AIM 5-3-3)
- **R-R**eaching a holding fix (report time & altitude) (AIM 5-3-3)
- **V-V**FR on top (AIM 5-3-3)
- **E*-E**TA change ±3 min (AIM 5-3-3)
- **L-L**eaving a holding fix/point (AIM 5-3-3)
- **O*-O**uter marker (AIM 5-3-3)
- **U-U**nforecasted weather (§91.183)
- **S-S**afety of flight (§91.183)
- **V-V**acating an altitude/FL (AIM 5-3-3)
- **F*-F**inal approach fix (AIM 5-3-3)
- **R-R**adio/Nav failure (§91.187)
- **C*-C**ompulsory reporting points ▲ (§91.183)
- **500**-unable climb/descent **500** fpm (AIM 5-3-3)

***required only in a non-radar environment** (including ATC radar failure)

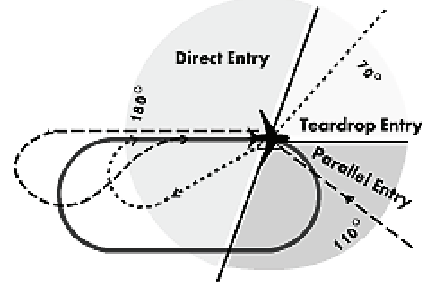
Position reports items

- Aircraft ID
- Position
- Time
- Altitude/flight level
- Type of flight plan (except for communicating with ARTCC/approach control)
- ETA
- The name only of the next succeeding reporting point along the route of flight
- Any pertinent remarks

IFR takeoff minimums (§91.175)

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

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



Holding pattern timing

- 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.

Max holding speeds

- Up to 6000' MSL – 200 KIAS
- 6001'-14,000' MSL – 230 KIAS
- Above 14,000' MSL – 265 KIAS
- May be restricted to 175 KIAS on some inst. approach procedures.
- At Airforce fields – 310 KIAS*
- At Navy fields – 230 KIAS*

*Unless otherwise depicted.

(AIM 5-3-7)

IFR altitudes

- ***DA/H*** – **D**escent **A**ltitude/**H**eight.
- ***MAA*** – **M**aximum **A**uthorized **A**ltitude.
- ***MCA*** – **M**inimum **C**rossing **A**ltitude.
- ***MDA/H*** – **M**inimum **D**escent **A**ltitude/**H**eight.
- ***MEA*** – **M**inimum **E**n route **A**ltitude. Assures navigation coverage and 1000' (non-mountainous terrain) or 2000' (mountainous) obstacle clearance.
- ***MOCA*** – **M**inimum **O**bstruction **C**learance **A**ltitude. Provides navigation coverage **and** obstacle clearance within 22 NM of the NAVAID.
- ***MORA*** – **M**inimum **O**ff-**R**oute **A**ltitude. (Jeppesen charts). Including grid and route MORA.
- ***MRA*** – **M**inimum **R**eception **A**ltitude
- ***MVA*** – **M**inimum **V**ectoring **A**ltitude.
- ***OROCA*** – **O**ff-**R**oute **O**bstruction **C**learance **A**ltitude (NACO charts). Assures obstacle clearance within 4NM of course. 1000' over non-mountainous terrain; 2000' over mountainous terrain.

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	1¼

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Lost communications procedure (§91.185)

Altitude to fly	Route to fly
M.E.A –*fly the highest among*: **M** – **M**inimum altitude prescribed for IFR **E** – **E**xpected (e.g. "expect 5000ft after 10 minutes") **A** – last altitude **A**ssigned by ATC	A.V.E.F – select route *by the following order:* **A** –**A**ssigned route, if none: **V** –**V**ectored (fly to the fix/route/airway last vectored to), if none: **E** –last **E**xpected route by ATC, if none: **F** – **F**iled route

Leaving the clearance limit

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

- *Yes* → Start descent and approach as close as possible to the EFC, or ETA (if no EFC given)
- *No* → At EFC or clearance limit (if no EFC given), proceed to a fix from which an approach begins and start the approach

Do not fly a procedure turn when:

(§91.175, AIM 5-4-9)

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

S- **S**traight in approach.
H- **H**olding in lieu of a procedure turn.
A- **A**rc
R- **R**adar vectored to final app course.
P- No**P**T depicted on chart.
T- **T**imed approach**.**
T- **T**eardrop course reversal.

Instrument approach types:

Precision (lateral + vertical course guidance):

- ILS-Instrument Landing System
- MLS-Microwave Landing System
- PAR-Precision Approach Radar
- GLS-GNSS Landing System
- TLS- Transponder Landing System

Non-precision (lateral course guidance only):

- VOR
- NDB
- RNAV/GNSS (LNAV minimums)
- LOC
- LDA-Localizer-type Directional Aid. Identical to a localizer but is not aligned with the runway.
- SDF-Simplified Directional Facility. width: 6° or 12°. May be either aligned or not with the runway.
- ASR-Approach Surveillance Radar

APV (**AP**proach with **V**ertical guidance). Has glide slope but does not meet ICAO **precision** app. standards:

- RNAV/GNSS (LNAV/VNAV, LPV, baro-VNAV minimums)
- LDA with a glide slope

When can you descend to next instrument approach segment?

When cleared for the approach **and** established on a segment of a published approach or route.
(AIM 5-4-7)

Standard rate turn angle of bank calculation

```
TAS / 10 + 5
```

Example: 120 KTAS-

```
120 KTAS / 10 + 5 = 17° of bank
```

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

All three conditions must be met:

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)
   a. The approach light system, except you may descend below 100 feet above the touchdown zone only if the red terminating bars or the red side row bars are also visible and identifiable.
   b. The threshold.
   c. The threshold markings.
   d. The threshold lights.
   e. The runway end identifier lights.
   f. The visual approach slope indicator.
   g. The touchdown zone or its markings.
   h. The touchdown zone lights.
   i. The runway or runway markings.
   j. The runway lights.

Aircraft approach categories

CAT	1.3Vso (Knots)	Radius for circling maneuver
A	<90	1.3 NM
B	91-120	1.5 NM
C	121-140	1.7 NM
D	141-165	2.3 NM
E	>165	4.5 NM

Visual Descent point (VDP)

A defined point on the final approach course of a non-precision straight-in approach procedure from which normal descent from the MDA to the runway touchdown point may begin provided adequate visual reference is established.

If not equipped to identify the VDP, fly the approach as if no VDP was published.

When a VDP is not published you can use this formula to calculate it:

```
VDP (in NM from threshold) = HAT/300, or
10% of HAT = seconds to subtract from time to MAP
```

Approach clearances

- **Contact approach**
  - Must be specifically requested by the pilot.(It cannot be initiated by ATC)
  - Requires at least 1SM reported ground visibility and the aircraft to remain clear of clouds.
  - Available only at airports with approved instrument approach procedures.
- **Visual approach**
  - Initiated by either ATC or the pilot.
  - Requires at least 1000' ceiling and 3SM visibility. (IFR under VMC)
  - Pilot must have either the airport or the traffic to follow in sight.

Minimum equipment required for flight (§91.205)

For VFR day flight:
A T.O.M.A.T.O F.L.A.M.E.S-
A-Altimeter

T- Tachometer for each engine.
O- Oil temp 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

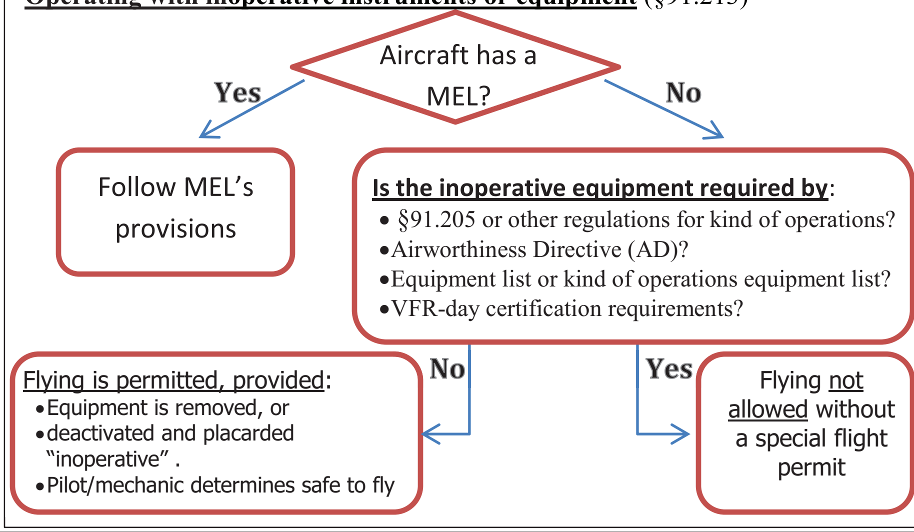
F- Fuel quantity gauge for each tank
L- Landing gear position lights (if retractable gear)
A- Anticolision lights (aircraft certificated after March 11, 1996)
M- Magnetic direction indicator
E- ELT, if required by §91.207
S- Safety belts / **s**houlder harnesses

For VFR night flight:
All VFR day equipment +
F.L.A.P.S-
F- Fuses (spare set)
L- Landing light (if for hire)
A- Anticolision light
P- Position lights (navigation lights)
S- Source of power (such as battery)

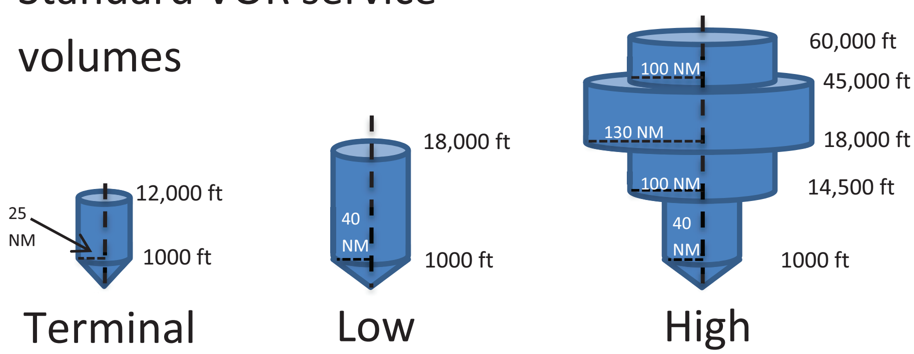
For IFR day: all VFR day equipment + G.R.A.B C.A.R.D
For IFR night: all VFR day + VFR night equipment + G.R.A.B C.A.R.D-
G- Generator/alternator
R- Radios (two way and navigational equipment appropriate for the ground facilities to be used)
A- Altimeter(sensitive) adjustable for barometric pressure
B- Ball (slip-skid indicator)

C- Clock (shows hours minutes and seconds and installed as part of aircraft equipment.)
A- Attitude indicator
R- Rate of turn indicator
D- Directional gyro (Heading indicator)

Operating with inoperative instruments or equipment (§91.213)



Standard VOR service volumes



VOR:

- VOR- **V**HF **O**mni directional **R**ange
- 108.0 to 117.95 MHz excluding frequencies at the 108.10-111.95 range with odd tenths.
- Full scale deflection: 10°
- Distance off course = 200 ft per dot per NM from VOR station.
- Distance to station = TAS X minutes for bearing change /degrees of bearing change
- Time to station = Seconds for bearing change /degrees of bearing change
- Standard service volumes do not apply to published routes.

VOR limitations:

- Cone of confusion.
- Reverse sensing.(if used incorrectly)
- Requires line of site to station.

VOR receiver checks: (§91.171)
Every 30 calendar days.

- **VOT** ±4°
- **Repair station** ±4°
- VOR **ground checkpoint** ±4°
- VOR **airborne checkpoint** ±6°
- **Dual VOR** cross-check ±4°
- **Above a prominent ground landmark** on a selected radial at least 20 NM from a VOR, flying at a "reasonably low altitude" ±6°

VOR check signoff: (§91.171)
D.E.P.S

- **D- D**ate
- **E- E**rror
- **P- P**lace
- **S- S**ignature

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.
- The time passed is used by the airborne unit to calculate the slant range distance from the aircraft to the station.
- Slant range error is negligible at 1 NM from the DME station per every 1000ft.

NDB:

- **N**on-**D**irectional **B**eacon
- 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

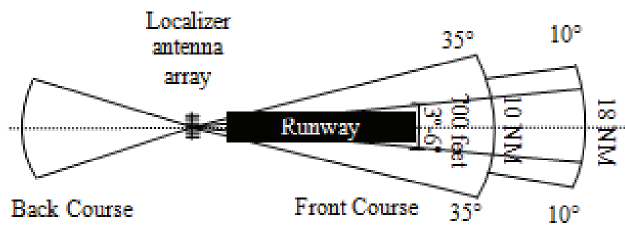
NDB service volume classes:

Compass Locator	15NM
Medium High (MH)	25NM
High (H)	50NM (may be less, as published in a NOTAM or the A/FD
High High (HH)	75NM

Instrument Landing System (ILS)

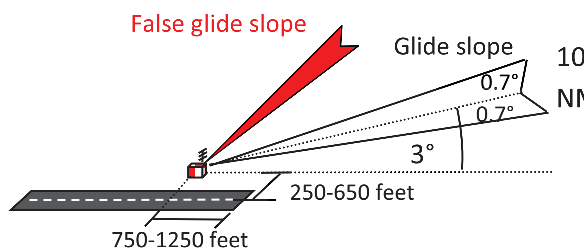
Localizer

- Frequency range: 108.1 to 111.95 MHz with odd tenths only.
- 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, which is 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

- Frequency range: 329.3 to 335 MHz (UHF) (GS is automatically tuned with localizer frequency).
- Width: 1.4 degree (full deflection is 0.7º either direction).
- Range: typically up to 10 NM.
- Slope: 2.5°-3.5°.
- Errors: False glide slope above normal glide slope.



Marker beacons

- Provides 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. ".. .."

Compass locator

Low-power NDB transmitter (at least 25 Watts and 15NM range) installed together with the OM or the MM on some ILS approaches.

Approach Light System (ALS)

- Helps the transition between radio-guided flights into a visual approach.
- Can help in estimating flight visibility if you know the dimensions of the specific ALS configuration.

ILS Category	Visibility (RVR)	DH
CAT I	2400' or 1800'	200'
CAT II	1200'	100'
CAT IIIa	>700'	<100' or no DH
CAT IIIb	150'-700'	<50' or no DH
CAT IIIc	0	No DH

Rate of decent for a 3° glide slope:

`ground speed X 5 = vs to maintain;`

Or,

`10 X ground speed / 2 = VS`

Example: 120 KT X 5 = 600 fpm or,

10 X 120 KT / 2 = 600 fpm

How far out to start a descent? (3° glide)

`Altitude to lose / 300`

Example: 6000' to lose, start descent 20 NM out.

(6000/300 = 20 NM)

Convert climb gradient from ft/NM to fpm

`ft/nm requirement X NM per Minute`

Ex.: DP requires 300 ft/NM climb.

Your ground speed is 120KT, which is 2NM per minute (120 KT / 60 min = 2 NM per min).

300 x 2 = 600 fpm

Area navigation (RNAV)

- Allows navigation on any desired course and does not require flying to or from any ground facility.
- Types:
  - Global Navigation Satellite System (GNSS)
    - GPS (USA)
    - Galileo (EU)
    - GLONASS (Russia)
  - VOR/DME RNAV
  - DME/DME RNAV (uses two DME signals to find position)
  - Inertial Reference Unit / System (IRU/ IRS)
  - Long Range Navigation (LORAN)
- Required Navigation Performance (RNP)
  - A statement of required navigation accuracy at a given airspace and of available aircraft capability.
  - Aircraft capability + level of service = access
  - En route – RNP 2.0 (2NM accuracy 95% of the flight time)
  - Terminal & Departure – RNP 1.0 (1NM accuracy 95% of the flight time)
  - Approach – RNP 0.3 (0.3NM accuracy 95% of the flight time)
- RNAV VNAV – provides Vertical NAVigation guidance.
- 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/GPS/GNSS route.

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 time lapse between the transmission broadcast (as obtained from the atomic clocks on the satellite) to the time it was received by the aircraft receiver, is translated into distance (pseudo-range). Using one satellite, the aircraft could virtually be on any point on a sphere surrounding the satellite, with the calculated 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.
- Airborne GPS units use great-circle courses for navigation.
- GPS CDI deflection shows distance off course in miles, unlike a VOR CDI, which reflects an angular distance off course in degrees.
- 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 alternatively, 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.
- An IFR-certified GPS may be used to substitute an ADF or DME but not for NDB approaches without a GPS overlay (without a "or GPS" in title).
- Check GPS NOTAMS before the flight and use RAIM prediction if available on your receiver.
- 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.
  - Wide Area Augmentation System (WAAS) – Errors are broadcasted back to a satellite and from there to aircraft equipped with GPS WAAS receivers. Covers a wide area. Allows for APV approaches such as LPV and LNAV/VNAV.
  - Local Area Augmentation System (LAAS) – Errors are broadcasted via VHF to LAAS-enabled GPS receivers. More accurate than WAAS but covers a much smaller geographical area. Allows for category I and above approaches if equipped.

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)
- 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).

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 – Shows correct airspeed as long as you maintain the same altitude at which the blockage occurred. At higher altitudes airspeed will indicate lower than it should. At lower altitudes – 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 that case, expect reverse VSI information).

When using the alternate static source (a lower static pressure is measured):
Airspeed indicator – indicate faster than it should.
Altimeter – indicate higher than it should.
VSI – momentarily show a climb.

Pitot blockage:

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

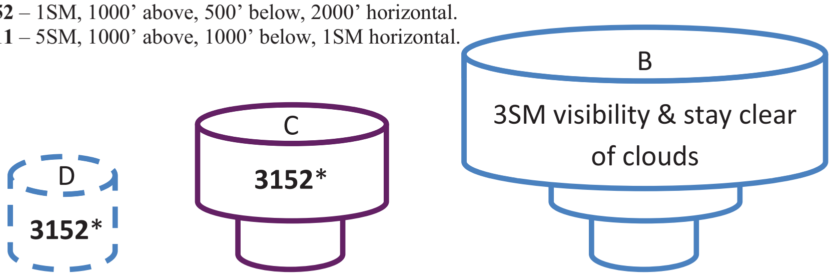
Ram air inlet is clogged and drain hole open – Airspeed will drop to zero.

Both air inlet and drain hole are clogged – The airspeed indicator will act as an altimeter, and will no longer be reliable.

When you suspect a pitot blockage, consider the use of pitot heat to melt ice that may have formed in or on the pitot tube.

Basic VFR weather minimums (§91.155)

*Min visibility & distance from clouds:
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 above 10,000' MSL and class G above 10,000' MSL **and** 1,200' AGL
5111*

10,000' MSL

Class G above 1200' AGL but below 10,000' MSL
Day: **1152***.
Night: **3152***

Class E below 10,000' MSL
3152*

1,200' AGL

G below 1200' AGL
Day: 1SM clear of clouds
Night: **3152*** or 1SM clear of clouds if in a traffic pattern within ½ SM from the runway.

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 turning on 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. Some HIs are slaved to a magnetic heading source, such as a flux gate, and sync automatically to the correct heading. Normally powered by the vacuum system in on GA aircraft.
- Turn indicators – operates on the principle of precision.
  - Turn coordinators show rate-of-turn and rate of roll.
  - Turn-and-slip indicators show rate-of-turn only.

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.

Magnetic compass errors & limitations:
D.V.M.O.N.A
D- **D**eviation
V- **V**ariation
M- **M**agnetic dip
O- **O**scillation
N- **N**orth/south turn errors
(Northern hemisphere: **UNOS**
Undershoot **N**orth/ **O**vershoot **S**outh)
A- **A**cceleration errors
(Northern hemisphere: **ANDS**
Accelerate **N**orth/ **D**ecelerate **S**outh)

Generic instrument taxi cockpit check *You should tailor it to your aircraft & operations
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.
Heading indicator – Set and shows correct headings.
Altimeter – Set to local altimeter settings or field elevation. Shows correct field elevation ±75 feet.
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 and removed symbols.

En route weather information sources

- En route Flight Advisory Service (EFAS) – 122.0 MHz at 5,000-17,500 MSL. Other frequencies are available above 18,000. EFAS is called "flight watch" over the radio.
- 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.
- Hazardous Inflight Weather Advisory Service (HIWAS) – Hazardous and urgent weather information broadcasted over select VOR stations. Contains a summary of any AIRMETs, SIGMETs, convective SIGMETs and Center Weather Advisories (CWA) and urgent PIREPs.
- DATALINK – Displays textual and graphical weather information obtained via ground stations (such as FISDL) or satellites. You should pay attention to coverage gaps and the age of the information.
- Automatic Terminal Information Service (ATIS)
- Automated Surface Observation System (ASOS)
- Automated Weather Observation System (AWOS)
- 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

- **Convective SIGMET (WST)** - An inflight advisory of convective weather significant to all aircraft. Issued hourly at 55 minutes past the hour. Valid for 2 hours. Contains either an observation and a forecast or only a forecast. Convective SIGMETs are issued for any of the following:
  - Severe thunderstorms due to:
    - i. Surface winds greater or equal to 50 knots
    - ii. Hail at the surface greater than 3/4 inch in diameter
  - Tornadoes
  - Embedded thunderstorms
  - A line of thunderstorms at least 60 miles long affecting 40% of its length
  - Thunderstorms producing heavy or greater precipitation affecting more than 40% of an area of at least 3000 square miles.
  - Convective SIGMETs always implies severe or greater turbulence, severe icing, or low level wind shear.
- **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.
  - Volcanic ash
- **AIRMET (WA)**- An advisory of significant weather phenomena at lower intensities than those which require the issuance of SIGMETs. These weather conditions can 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 http:// aviationweather.gov
- **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 cover a 24 or 30 hour forecast period. TAF amendments (TAF AMD) supersede the previous TAF.
- **Aviation Area Forecast (FA)** - A forecast of weather condition over an area of several states. When there isn't a TAF available for your route, check the FAs together with SIGMETs, AIRMETs and other information. Area forecasts are issued 3 times a day (or 4 times for the Caribbean, Alaska and Hawaii regions).
- **Surface analysis chart** –Generated from surface station reports. Shows pressure systems, isobars, fronts, airmass boundaries (such as: drylines and outflow boundaries) and station information (such as: wind, temperature/dew point, sky coverage, and precipitation). Issued every 3 hours. (Hawaii, tropical and Oceanic regions every 6 hours)
- **Weather depiction chart** - Just like the surface analysis chart, it is generated from surface station observations. Depicts areas of VFR (at least 3000' ceiling and 5SM visibility), Marginal VFR (1000'-3000' ceiling and/or 3-5SM visibility, shown as contoured areas) and IFR (less than 1000' ceiling and/or 3SM visibility, shown as shaded areas). It also shows basic METAR information at selected stations (visibility, sky coverage, ceilings and obstructions to visibility). Issued every 3 hours, starting at 01:00Z.
- **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 different altitudes and flight levels. Winds within 1500' AGL and temperatures within 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. Examples:1312+05 = winds 130 at 12 kt temperature =5° C. 7525-02 = winds 250 at 122 kt temperature -02° C. Above FL240 temperatures are negative and the minus sign (-) is omitted.
- **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** – Depict 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 slight (SLGT), moderate (MDT), and high (HIGH) risk for severe thunderstorms. Issuance: day 1 – 5 times a day, day 2 – twice a day, day 3 – once a day.

Conditions necessary for the formation of thunderstorms

1. Sufficient water vapor (humidity)
2. An unstable temperature lapse rate
3. An initial uplifting force (such as: front passage, mountains, heating from below, etc.)

Thunderstorm hazards - Limited visibility, wind shear, strong updrafts and downdrafts, icing, hailstones, heavy rain, severe turbulence, lightning strikes and tornadoes.

Life cycle of a thunderstorm

- **Cumulus stage** (3-5 mile height) – lifting action of the air begins. Growth rate may exceed 3000 fpm.
- **Mature stage** (5-10 miles height) – begins when precipitation has become to fall 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.
- **Dissipating stage** (5-7 miles height) – characterized by strong downdrafts and the cell is dying rapidly.

Fog – A cloud that begins within 50 ft of the surface. 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.

- 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. 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 (AC 91-74, AC 00-6A)

- **Structural ice** – Two conditions for formation: 1.Visible moisture (clouds, fog, precipitation) 2. Aircraft surface temperature below freezing.
  - Clear ice– 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 then clear ice does.
  - 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.

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 to a body tissue. Can be caused by heart problems, excessive acceleration (Gs), shock or a constricted blood vessel.

Oxygen requirements (§91.211)

Note: O2 requirements below are for operations under part 91. Part 121 and 135 requirements are different.

- Cabin pressure altitudes 12,500-14,000ft - crew must use supplemental O2 for periods of flight over 30 minutes at these altitudes.
- Cabin pressure altitudes above 14,000ft – crew must be provided with and use supplemental O2 the entire flight time at these altitudes.
- Cabin pressure altitudes above 15,000ft – 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.

Hyperventilation – A condition which occurs when excessive amount of is eliminated from the body as a result 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") but it can damage other important tissues, including the brain. Decompression sickness is more likely after scuba diving, where the body is subject to higher pressures. Wait at least 12 hours after scuba diving if your flight is up to 8000ft cabin altitude, or 24 hours for higher cabin altitudes.