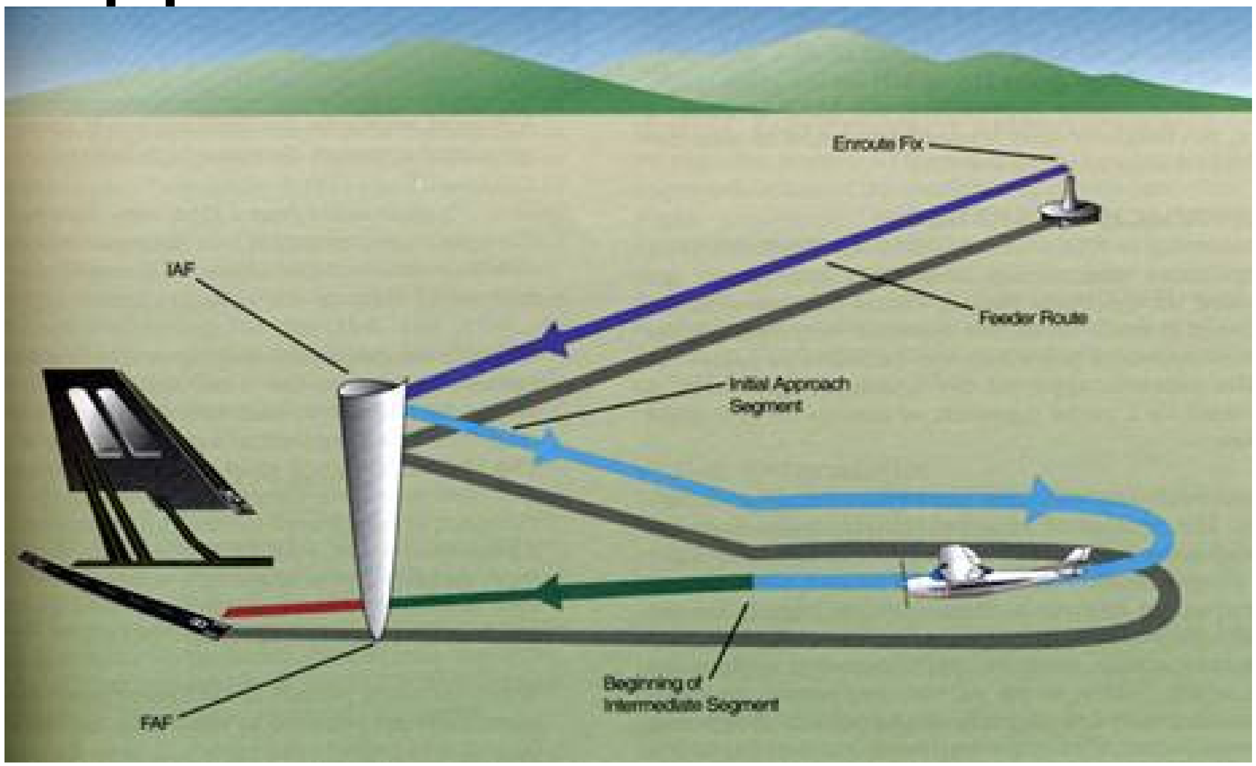
Approach Considerations



Approach Planning
Anatomy of an Instrument Approach
Types of Instrument Approaches
NDB and VOR Technology
ILS Technology
GPS Technology

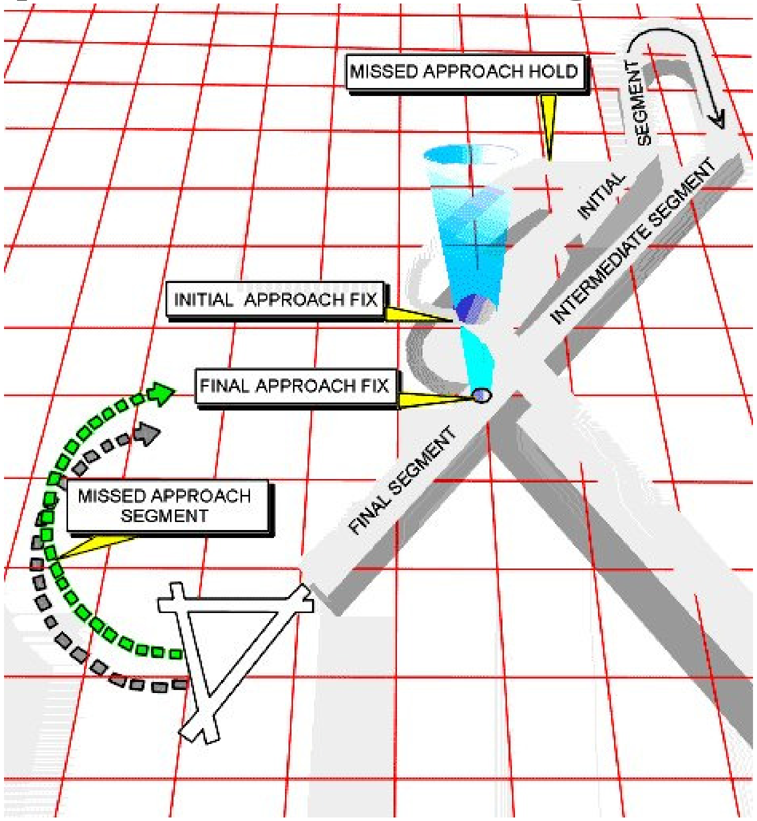
Approach Planning

Depending on speed of the aircraft, availability of weather information, and the complexity of the approach procedure or special terrain avoidance procedures for the airport of intended landing, the in-flight planning phase of an instrument approach can begin as far as 100-200 nautical miles (NM) from the destination. Some of the approach planning should be accomplished during preflight. In general, there are five steps that most operators incorporate into their flight standards manuals for the in-flight planning phase of an instrument approach:

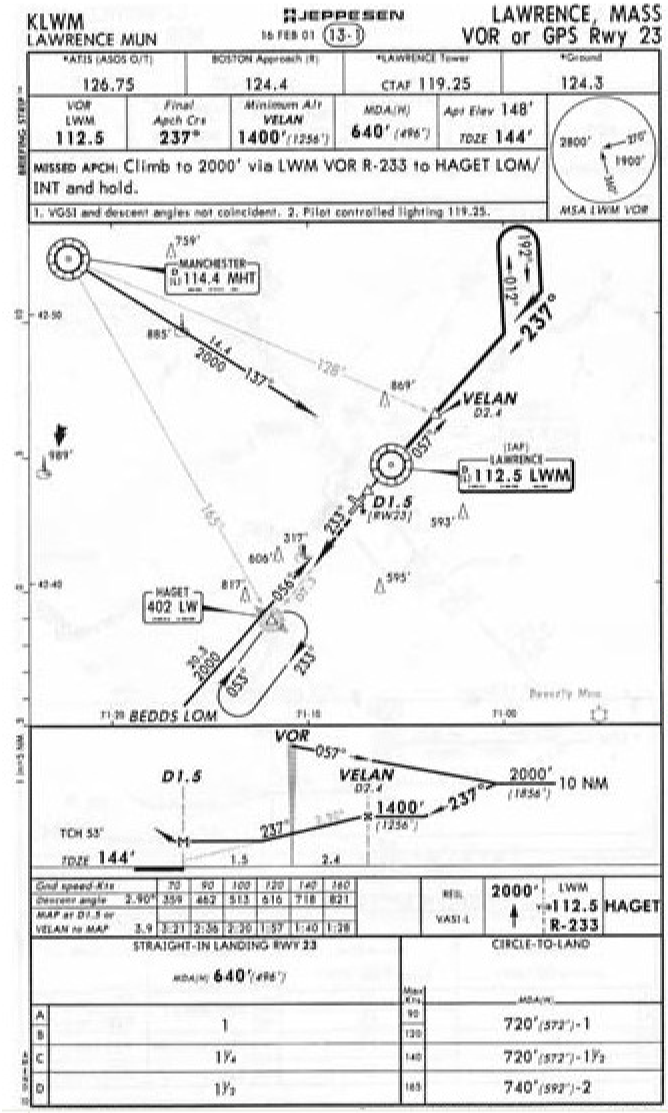
- **Gathering weather information, field conditions, and Notices to Airmen (NOTAMs) for the airport of intended landing.**
- **Calculation of performance data, approach speeds, and thrust/power settings.**
- **Flight deck navigation/communication and automation setup.**
- **Instrument approach procedure (IAP) review and, for flight crews, IAP briefing.**
- **Operational review and, for flight crews, operational briefing**.

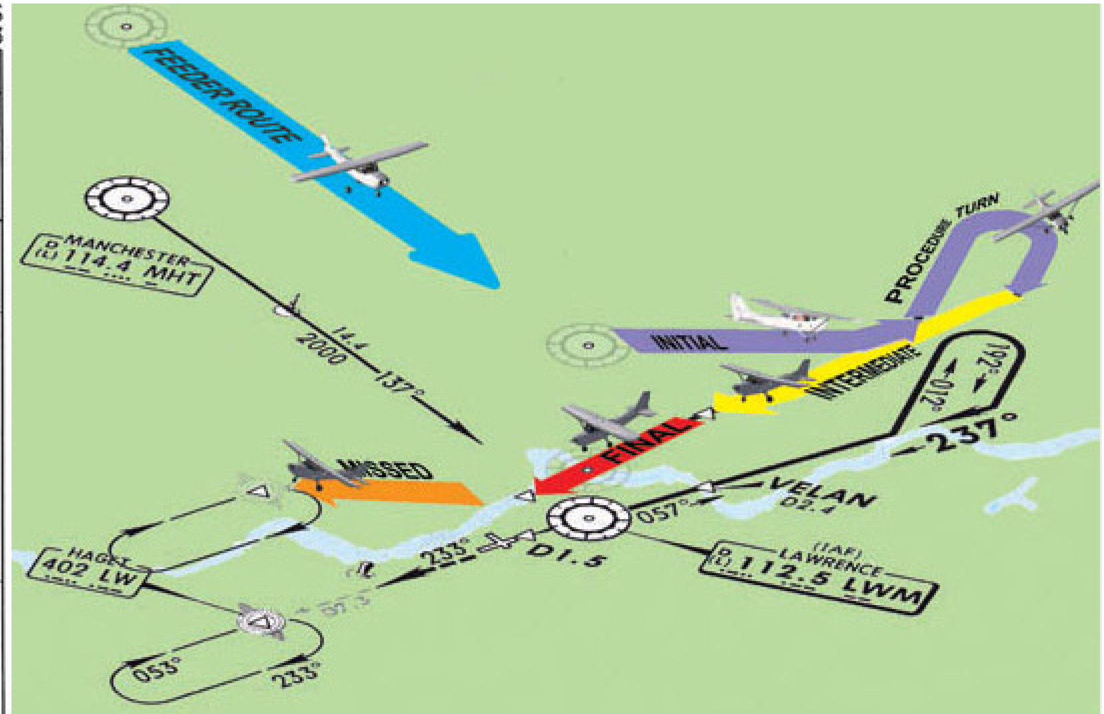
Although often modified to suit each individual operator, these five steps form the basic framework for the in-flight planning phase of an instrument approach

Approach Segments



- Feeder Route
- Initial Approach Segment
- Procedure Turn Segment (sometimes)
- Intermediate Approach Segment
- Final Approach Segment
- Missed Approach Segment





The segments of the approach:

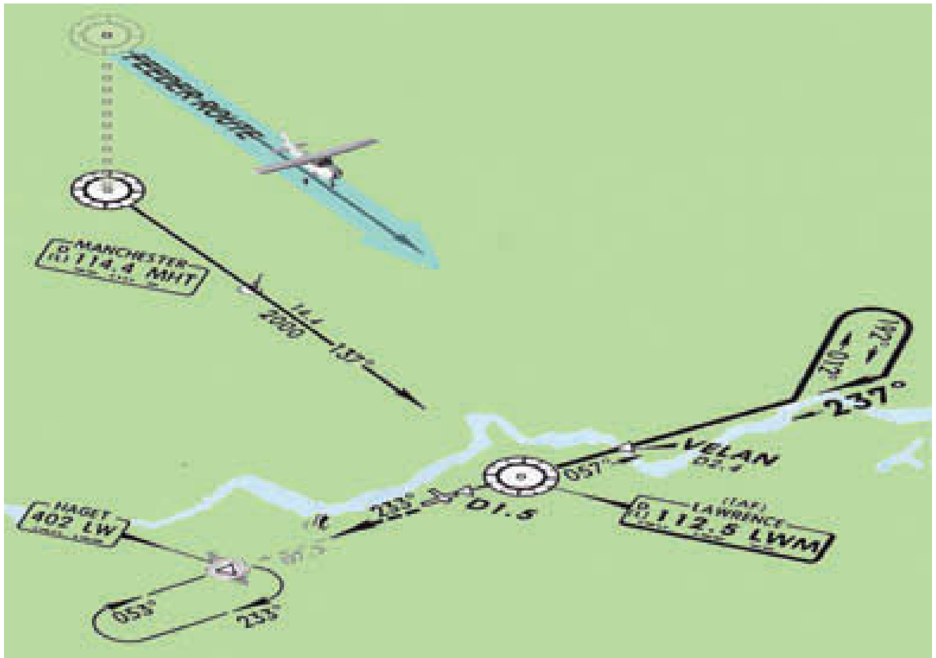
1. Feeder
2. Initial
3. Procedure Turn
4. Intermediate
5. Final
6. Missed

Feeder Approach Segment

The procedure outlined below assumes the "full approach," meaning that the pilot can fly the entire thing without assistance from any air traffic control. This would be unusual in most actual instrument conditions. Instead, ATC is likely to give the pilot vectors to the final approach course, pointing the aircraft to a place where, in this example, it could intercept the 237º TO course toward the VOR. A reason to follow a feeder route and procedure turn would be for practice, or if there were a lost communications situation.

1. Feeder Route:

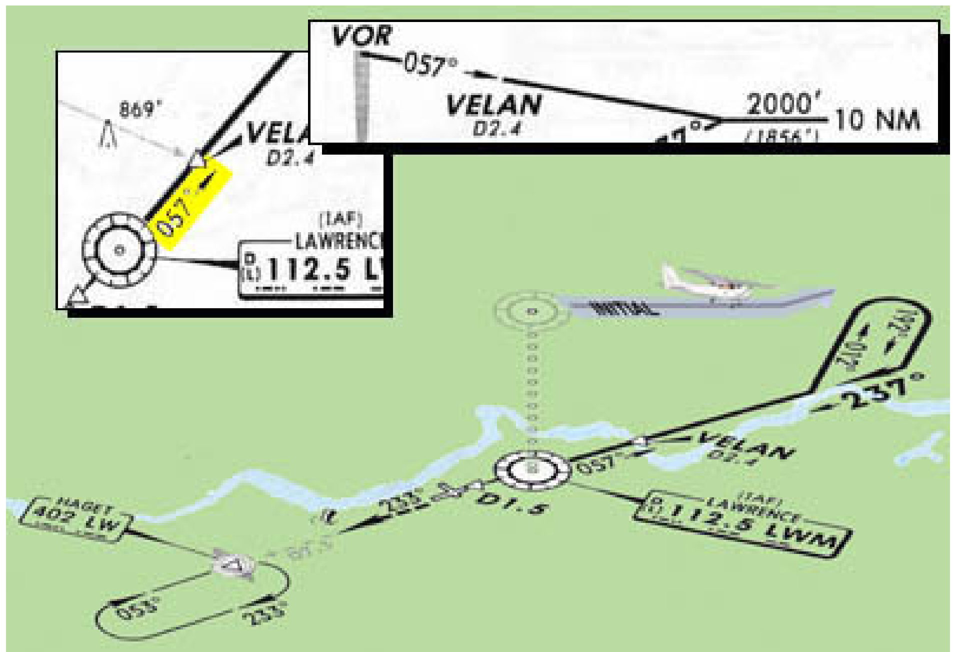
Again, this wouldn't be necessary if Boston Approach were giving vectors to final, but in the case of a pilot-navigated full approach, it could start from the Manchester VOR. From there, fly the feeder route: the MHT 137º radial to the LWM VOR.



Initial Approach Segment

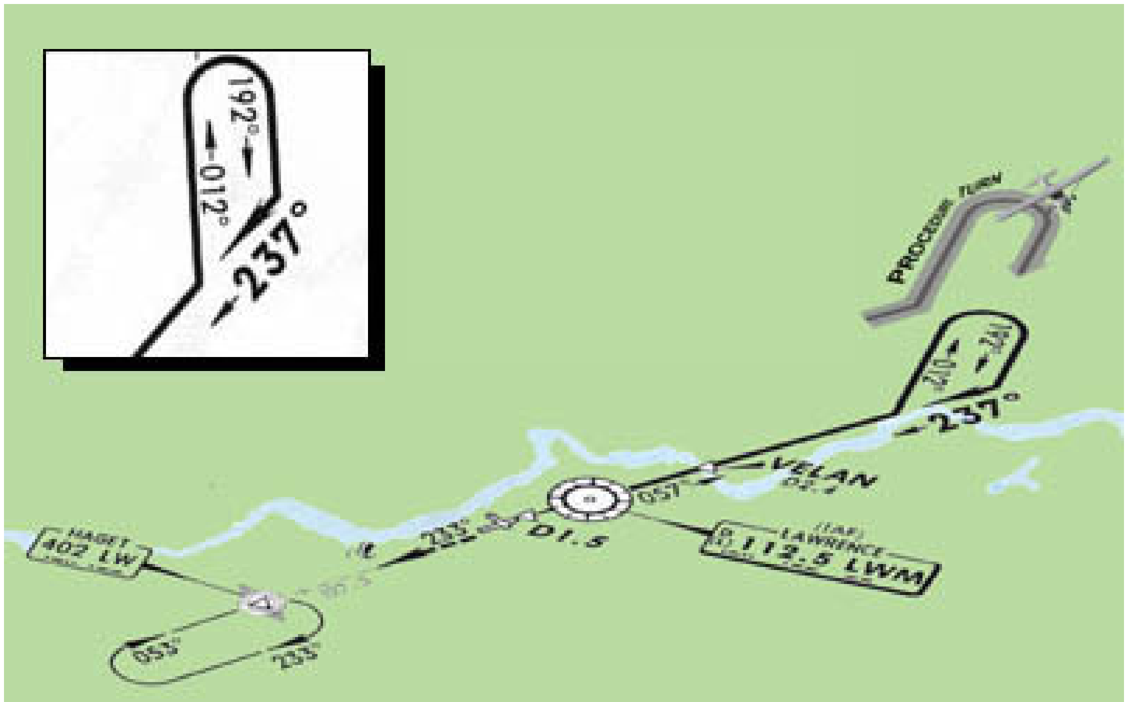
The purpose of this segment is to align the aircraft with the approach course. It is accomplished by using a arc procedure, a course reversal such as a procedure turn (next slide), a holding pattern, or by following a route that intersects the Final Approach Course. The initial approach segment begins at an Initial Approach Fix (IAF) and Usually ends where it joins the intermediate approach segment. The letters IAF on the approach chart indicates the location of an IAF.

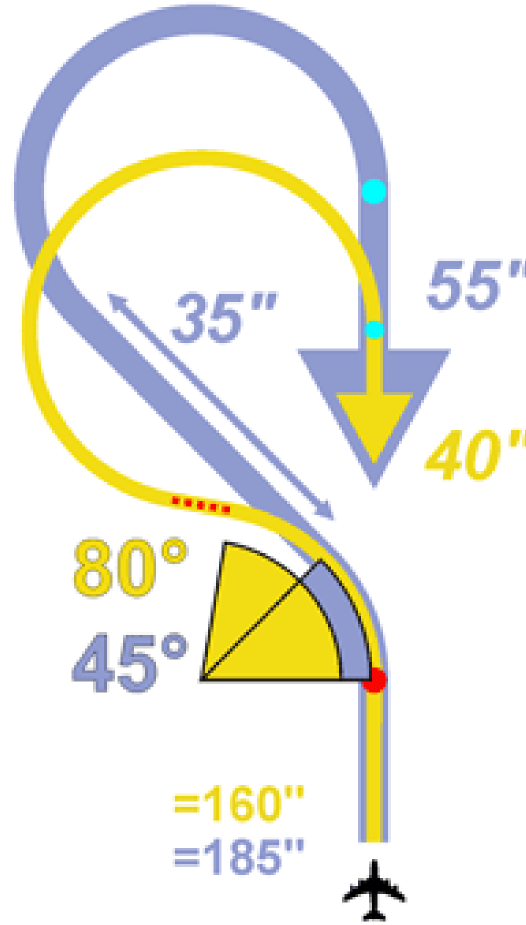
The initial approach begins while crossing over the VOR. Set the OBS to 057º and intercept this radial. Descend to 2000 feet. Fly out for a few miles in preparation for the procedure turn.



Procedure Turn

sometimes



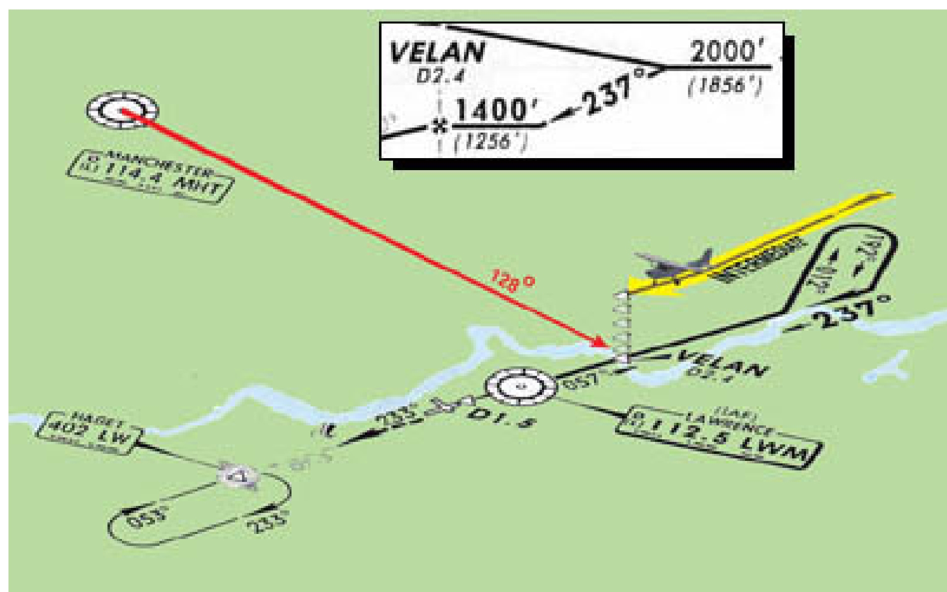


A procedure turn will get the plane back on the inbound course. Turn left to a heading of 012º , and fly for a minute (more or less, depending on wind). Then, make a standard rate turn to the right, completely around to a heading of 192º . Twist the OBS to 237. As the CDI centers, turn inbound to track the 237º TO course.

Intermediate Approach Segment

This segment is designed to position the aircraft with the final descent of the airport. During this segment typical there is reduction in airspeed to or near the approach speed complete the before landing checklist, and make a final review of the approach procedure and applicable minimums. It aligns 30 degrees of the final approach course, begins at the intermediate fix (IF), or intermediate point, and ends at the beginning of the final approach segment.

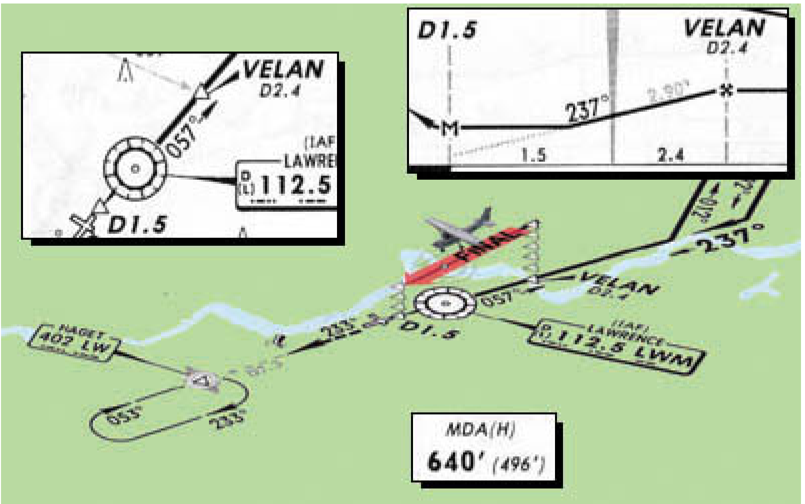
Established inbound, descend to 1400 feet. (This is a good time to do a prelanding checklist). Fly to the final approach fix: VELAN intersection, identified by the 2.4 DME from LWM, or by the MHT 128º radial.



Final Approach Segment

Purpose of this segment is to allow safe navigation to a point which, if the required visual references are available, then you may proceed the approach to a landing. If you cannot see the required visual cues at the missed approach point, then you must execute a missed approach procedure. This segment begins where The aircraft incepts the glideslope at the minimum glideslope intercept altitude. *For a **non-precision** approach, the segment begins either at the designated **Final Approach Fix (FAF***) or at the point where you are established on the final approach course. Where the FAF is not designated, such as a on-airport VOR or NDB, this is typically where the procedure turn intersects the final approach course inbound. The point is referred to as the ***Final Approach Point (FAP). Also a FAP is dessignated for PRECISION APPROACHES, and a FAF is the same location but for NON-PRECISION APPROACHES.***

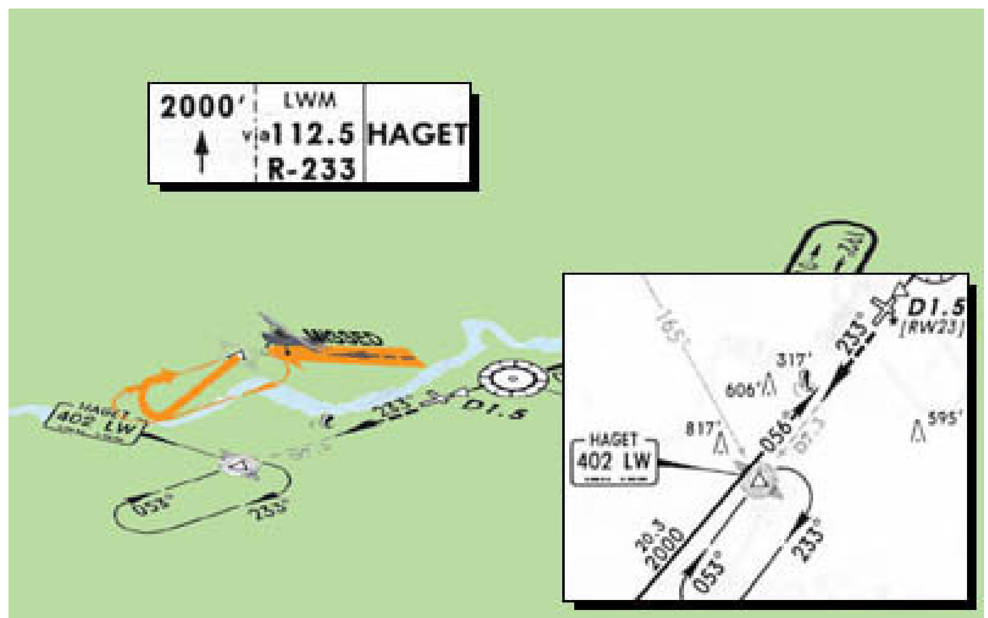
From VELAN, track to fly the 237º TO course over the VOR, while descending to 640 feet. It will be 2.4 NMs from VELAN to the VOR; the TO/FROM indicator will flip, and then it's another 1.5 nm to the missed approach point - just over the runway threshold.



Missed Approach Segment

The Missed Approach segment is to allow the pilot to safely navigate from the Missed Approach Point (MAP) to a point where you can decide on another approach or continuation to an alternate airport. The segment begins at the missed approach point (MAP) and ends at a designated point such as an initial approach or enroute fix. It depends on the type of approach. Example, during a precision approach the MAP occurs when you reach a designated altitude on the glideslope call the Decision Altitude (DA). For non-precision approaches, the missed approach point occurs at a fix or navaid, or after a specific period of time has elapse after you cross the final approach fix (FAF)

If you break out of the clouds and can see the runway in time to make a normal descent and landing, then land. If not, than at the MAP you must execute a missed approach. The instructions tell you to climb to 2000 feet and follow the LWM VOR 233º radial to HAGET outer marker and hold there. Either a parallel or teardrop entry into the hold would be appropriate.



Types of Instrument Approaches

https://en.wikipedia.org/wiki/Instrument_approach

Approach types Non-Precision vs Precision –Precision has vertical guidance.

VOR, VOR/DME
LOC
ILS
GPS, GPS/LPV
NDB

What are LNAV/VNAV, LPV and LP approaches?
LNAV is a non-precision approach. It uses GPS and/or WAAS for lateral navigation, but there's no vertical guidance. Typically it takes you down to 400 ft.
LNAV/VNAV again is a non-precision approach. It provides lateral guidance from the GPS or WAAS receiver and vertical guidance from a barometric altimeter or the WAAS. Without WAAS, you must have a VNAV altimeter. Decision altitude is typically around 350 ft.
LPV LPV is a non-precision approach. It stands for Localizer Performance with Vertical Guidance and uses the WAAS GPS only. It is the most desired approach that you can be offered. It typically takes you down to 200-250 ft decision height.
LP. It is a future approach that will use the high precision of LPV for lateral guidance, and a barometric altimeter for vertical. Runways where obstacles or infrastructure limits are, vertically guided approaches cannot be published.

Non-Precision approaches and systems

- VHF omnidirectional range (VOR)
- Tactical Air Navigation (TACAN)
- Non-directional beacon (NDB) – ground-based transmitter for aircraft equipped with an Automatic Direction Finder (ADF).
- Simplified Directional Facility (SDF)
- Satellite navigation systems, including the American Global Positioning System (GPS) (with or without vertical navigation capability, which usually requires extra precision typically afforded by using Wide Area Augmentation System (WAAS), European Geostationary Navigation Overlay Service (EGNOS), or other signal correction systems). Unavailable if Receiver autonomous integrity monitoring detects problems with GPS satellites
- Required navigation performance (RNP) A system that utilizes on-board performance monitoring through the aircraft's flight management system
- Localizer
- Localizer Type Directional Aid (LDA)
- Surveillance radar approach (SRA) – (known in some countries as an ASR approach)
- Airport surveillance radar (ASR) – military designation for SRA

Precision approaches and systems

Ground Controlled Approach (GCA) - mostly military

GNSS Landing System (GLS)

Instrument landing system (ILS)

Joint Precision Approach and Landing System (JPALS)

Local Area Augmentation System (LAAS) – a ground-based augmentation system (GBAS) for GNSS

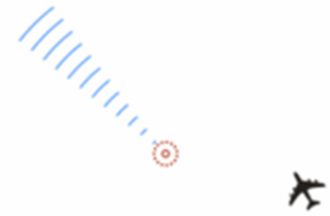
Localizer Performance with Vertical guidance (LPV)

Microwave landing system (MLS)

Precision approach radar (PAR) – military

Transponder landing system (TLS)

VOR Technology



US VOR Standard Service

Class Designator	**Dimensions**
T (Terminal)	From 1,000 feet above ground level (AGL) up to and including 12,000 feet AGL at radial distances out to 25 NM.
L (Low Altitude)	From 1,000 feet AGL up to and including 18,000 feet AGL at radial distances out to 40 NM.
H (High Altitude)	From 1,000 feet AGL up to and including 14,500 feet AGL at radial distances out to 40 NM. From 14,500 AGL up to and including 18,000 feet at radial distances out to 100 NM. From 18,000 feet AGL up to and including 45,000 feet AGL at radial distances out to 130 NM. From 45,000 feet AGL up to and including 60,000 feet at radial distances out to 100 NM.

VOR Accuracy and Reliability

Accuracy and reliability

The predictable accuracy of the VOR system is ±1.4°. However, test data indicate that 99.94% of the time a VOR system has less than ±0.35° of error. Internal monitoring of a VOR station will shut it down, or change-over to a Standby system if the station error exceeds some limit. A Doppler VOR beacon will typically change-over or shutdown when the bearing error exceeds 1.0°.

National air space authorities may often set tighter limits. For instance, in Australia, a Primary Alarm limit may be set as low as ±0.5° on some Doppler VOR beacons.

ARINC January 30, 2002 states that receiver accuracy should be within 0.4° with a statistical probability of 95% under various conditions. Any receiver compliant to this standard should meet or exceed these tolerances.

Testing

Before using a VOR indicator for the first time, it can be tested and calibrated at an airport with a *VOR test facility*, or VOT.

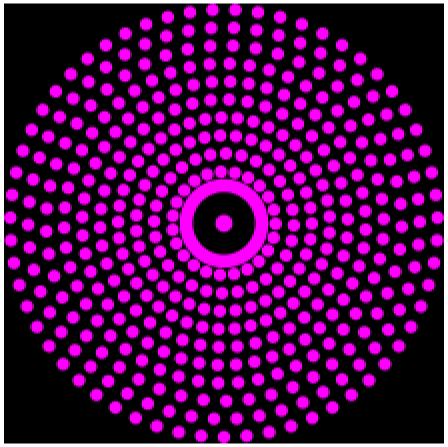
A VOT differs from a VOR in that it replaces the variable directional signal with another omnidirectional signal, in a sense transmitting a 360° radial in all directions. The NAV receiver is tuned to the VOT frequency, then the OBS is rotated until the needle is centered. If the indicator reads within four degrees of 000 with the FROM flag visible or 180 with the TO flag visible, it is considered usable for navigation.

The FAA requires testing and calibration of a VOR indicator no more than 30 days before any flight under IFR

FUTURE?

It's possible that space-based GNSS navigational systems such as the Global Positioning System, which have a lower transmitter cost per customer and provide distance and altitude data, will eventually replace VOR systems

NDB Technology



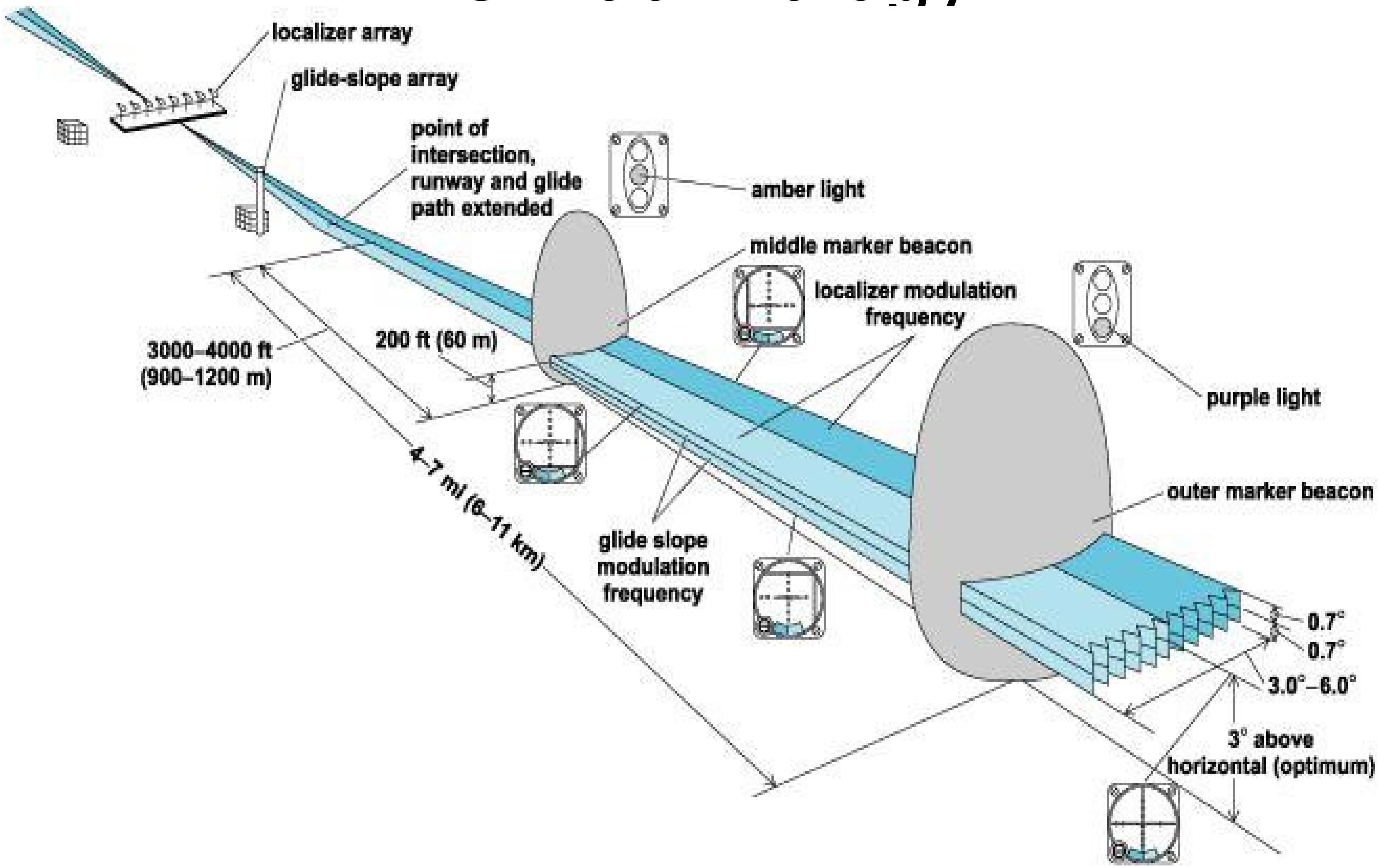
NDBs typically operate in the frequency range from 190 kHz to 535 kHz (although they are allocated frequencies from 190 to 1750 kHz) and transmit a carrier modulated by either 400 or 1020 Hz. NDBs can also be co-located with a DME in a similar installation for the ILS as the outer marker, only in this case, they function as the inner marker. NDB owners are mostly governmental agencies and airport authorities.

NDB radiators are vertically polarised. NDB antennas are usually too short for resonance at the frequency they operate – typically perhaps 20m length compared to a wavelength around 1000m. Therefore they require a suitable matching network that may consist of an inductor and a capacitor to "tune" the antenna. Vertical NDB antennas may also have a 'top hat', which is an umbrella-like structure designed to add loading at the end and improve its radiating efficiency. Usually aground plane or counterpoise is connected underneath the antenna.

NDB Adverse Effects

- **Night effect**: radio waves reflected back by the ionosphere can cause signal strength fluctuations 30 to 60 nautical miles (54 to 108 km) from the transmitter, especially just before sunrise and just after sunset (more common on frequencies above 350 kHz)
- **Terrain effect**: high terrain like mountains and cliffs can reflect radio waves, giving erroneous readings; magnetic deposits can also cause erroneous readings
- **Electrical effect**: electrical storms, and sometimes also electrical interference (from a ground-based source or from a source within the aircraft) can cause the ADF needle to deflect towards the electrical source
- **Shoreline effect**: low-frequency radio waves will refract or bend near a shoreline, especially if they are close to parallel to it
- **Bank effect**: when the aircraft is banked, the needle reading will be offset

ILS Technology



ILS Components

An ILS consists of two independent sub-systems. The localizer provides lateral guidance; the glide slope provides vertical guidance.

Localizer **(LOC, or LLZ until ICAO designated LOC** as the official acronym). The pilot controls the aircraft so that the indicator remains centered on the display (i.e., it provides lateral guidance). Full-scale deflection of the instrument corresponds to a 15.5%.

Glide slope (GS) or **glide path** (GP)
A glide slope station uses an antenna array sited to one side of the runway touchdown zone. The GS signal is transmitted on a carrier frequency using a technique similar to that for the localizer. The center of the glide slope signal is arranged to define a glide path of approximately 3° above horizontal (ground level). The beam is 1.4° deep (0.7° below the glide-path center and 0.7° above).

Marker beacons

Marker Beacons operating at a carrier frequency of 75 MHz are provided. When the transmission from a marker beacon is received it activates an indicator on the pilot's instrument panel and the tone of the beacon is audible to the pilot. The distance from the runway at which this indication should be received is published in the documentation for that approach, together with the height at which the aircraft should be if correctly established on the ILS. This provides a check on the correct function of the glide slope. In modern ILS installations, a DME is installed, co-located with the ILS, to augment or replace marker beacons. A DME continuously displays the aircraft's distance to the runway.

Types of Beacons

<u>Three types</u>: **Outer,** Middle, Inner

The ***<u>outer marker</u>*** is normally located 7.2 kilometres (3.9 nmi; **4.5 mi**) from the threshold, except that where this distance is not practical, the outer marker may be located between 6.5 and 11.1 kilometres (3.5 and 6.0 nmi; 4.0 and 6.9 mi) from the threshold. The modulation is repeated *Morse-style dashes of a 400 Hz tone* (--) ("M"). The cockpit indicator is a blue lamp that flashes in unison with the received audio code. The purpose of this beacon is to provide height, distance, and equipment functioning checks to aircraft on intermediate and final approach. In the United States, a NDB is often combined with the outer marker beacon in the ILS approach (called a Locator Outer Marker, or LOM). In Canada, low-powered NDBs have replaced marker beacons entirely.

Types of Beacons

Three types: Outer, **Middle**, Inner

The **middle marker** should be located so as to indicate, in low visibility conditions, the missed approach point, and the point that visual contact with the runway is imminent, ideally at a distance of approximately 3,500 ft (1,100 m) from the threshold. The modulation is repeated *alternating Morse-style dots and dashes of a 1.3 kHz tone at the rate of two per second* (·-·-) ("Ä" or "AA"). The cockpit indicator is an amber lamp that flashes in unison with the received audio code. In the United States, middle markers are not required so many of them have been decommissioned.

Types of Beacons

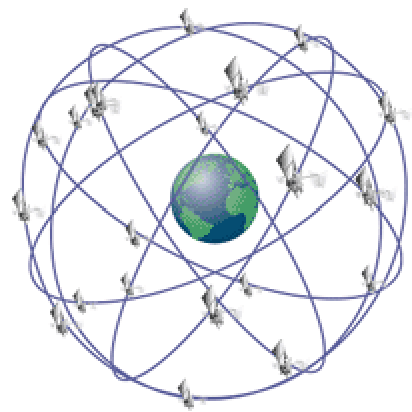
Three types: Outer, Middle, **Inner**

The **inner marker**, when installed, shall be located so as to indicate in low visibility conditions the imminence of arrival at the runway threshold. This is typically the position of an aircraft on the ILS as it reaches Category II minima, ideally at a distance of approximately 1,000 ft (300 m) from the threshold. The modulation is repeated *Morse-style dots at 3 kHz* (····) ("H"). The cockpit indicator is a white lamp that flashes in unison with the received audio code

ILS Categories for precision instrument approach and landing

Approach category	Decision height or alert height (minimum above runway threshold or touchdown zone)	Runway visual range (RVR)	Visibility minimum	Notes
I	200 ft (61 m)[8]	550 m or 1,800 ft[8](1,200 ft is approved at some airports[9]), increased to 800 m for single crew operations	800 m (1,600 ft or 1,200 ft in Canada)[10]	Either visibility not less than 800 m or 2,400 ft or a runway visual range (RVR) not less than 550 meters (1,800 ft) on runway with touchdown zone and centerline lighting. FAA Order 8400.13D allows for special authorization of CAT I ILS approaches to a decision height of 150 feet (46 m) with RVR ≥ 1,400 feet (430 m).[11] The aircraft and crew must be approved for CAT II operations and a heads-up display in CAT II or III mode must be used to the decision height. CAT II/III missed approach criteria apply.[11]
II	100 ft (30 m)[8]	1,200 feet (370 m)[8]	N/A	ICAO and FAA: 350 meters (1,150 ft) or JAA: 300 meters (980 ft).[7]
IIIa	No DH[8]	600 feet (180 m)[8]	N/A	
IIIb	No DH[8]	150 feet (46 m)[8]	N/A	
IIIc	No DH[8]	No RVR[8]	N/A	As of 2012 this category is not yet in operation anywhere in the world as it requires guidance to taxi in zero visibility as well. **Category IIIc** is not mentioned in EU-OPS.

GPS Technology



The Global Positioning System (GPS) is a space-based radio-navigation system consisting of a constellation of satellites and a network of ground stations used for monitoring and control. Currently 32 GPS satellites orbit the Earth at an altitude of approximately 11,000 miles providing users with accurate information on position, velocity, and time anywhere in the world and in all weather conditions.

GPS Technology

What's the signal?

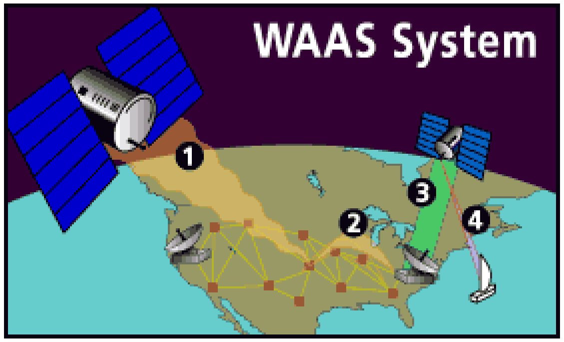
GPS satellites transmit two low power radio signals, designated L1 and L2. Civilian GPS uses the L1 frequency of 1575.42 MHz in the UHF band. The signals travel by line of sight, meaning they will pass through clouds, glass and plastic but will not go through most solid objects such as buildings and mountains.

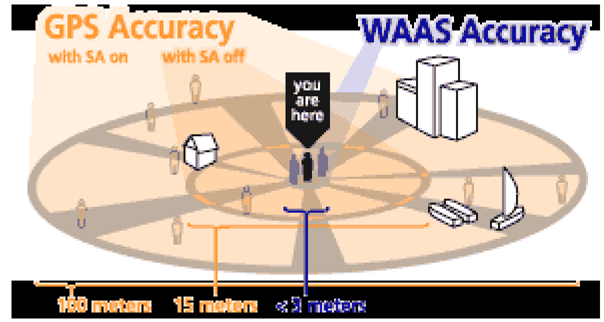
A GPS signal contains three different bits of information - a *pseudorandom code*, ephemeris data and almanac data.

Pseudorandom code is simply an I.D. code that identifies which satellite is transmitting information. You can view this number on your Garmin GPS unit's satellite page, as it identifies which satellites it's receiving.

Ephemeris data, which is constantly transmitted by each satellite, contains important information about the status of the satellite (healthy or unhealthy), current date and time. This part of the signal is essential for determining a position.

The almanac data tells the GPS receiver where each GPS satellite should be at any time throughout the day. Each satellite transmits almanac data showing the orbital information for that satellite and for every other satellite in the system.





WAAS, **Wide Area Augmentation System,** consists of ***multiple ground reference stations*** positioned across the U.S. that monitor GPS satellite data. Two master stations, located on either coast, collect data from the reference stations and create a GPS correction message. This correction accounts for GPS satellite orbit and clock drift plus signal delays caused by the atmosphere and ionosphere. The corrected differential message is then broadcast through 1 of 2 geostationary satellites, or satellites with a fixed position over the equator. The information is compatible with the basic GPS signal structure, which means any WAAS-enabled GPS receiver can read the signal.

Accuracy

15 m: Typical GPS position accuracy without SA.
3-5 m: Typical differential GPS (DGPS) position accuracy.
< 3 m: Typical WAAS position accuracy