A109 BASIC NAVIGATION

References: FAA-H-8083-25A, Pilot's Handbook of Aeronautical Knowledge, Chapter 15 (pgs 1-9)

INTRODUCTION
The objective of the lesson is to be able to describe elements of VFR navigation (pilotage, dead reckoning, and radio navigation), and properly interpret an aeronautical chart given a legend.

Air navigation is the process of piloting an airplane from one geographic position to another while monitoring one's position as the flight progresses. It introduces the need for planning, which includes:

- plotting the course on an aeronautical chart,
- selecting checkpoints,
- measuring distances,
- obtaining pertinent weather information, and
- computing flight time, headings, and fuel requirements.

This lesson introduces the fundamentals of navigation which will provide the foundation for further aviation development.

The following methods of navigation are used in this lesson:

Pilotage — navigation by reference to visible landmarks.
Dead reckoning — computations of direction and distance from a known position.
Radio navigation — the use of radio aids.

For navigation, a pilot needs to know the following:

- ✈ Starting point (point of departure)
- ✈ Ending point (final destination)
- ✈ Distance to travel
- ✈ Aircraft speed
- ✈ Aircraft fuel capacity/ burn rate
- ✈ Aircraft load (people and equipment)

With this information, flight planning can commence and the flight crew will determine:

- ✈ Direction of travel
- ✈ Time enroute
- ✈ Fuel burned
- ✈ Aircraft weight and balance

PILOTAGE
Pilotage is the use of visible landmarks to maintain a desired course, and is the basic form of navigation for the beginning pilot operating under Visual Flight Rules (VFR). Visible landmarks which can be identified on aeronautical charts help the pilot to proceed from one check point to the next.

The aeronautical charts most commonly used by VFR pilots are:

- VFR Sectional Aeronautical Chart
- VFR Terminal Area Chart
- World Aeronautical Chart

All three charts include aeronautical information such as airports, airways, special use airspace, and other pertinent data which use National Aeronautical Charting Office (NACO) symbols

The scale of the VFR Sectional Aeronautical Chart is 1:500,000 (1 inch = 6.86 NM). Designed for visual navigation of aircraft in VFR conditions, this chart portrays terrain relief, airspace and checkpoints such as airports, populated places, roads, railroads, and other distinctive landmarks. These charts have the best detail and are revised every 6 months.

Information found on the VFR Terminal Area Chart is similar to that found on the VFR Sectional Chart, but the scale on this chart is 1:250,000 (1 inch = 3.43 NM). These charts are for a specific city with Class B airspace. They show much detail, but have small coverage. The Denver Terminal Area Chart also contains a panel depicting the Colorado Springs and Pueblo area.

The World Aeronautical Chart has a scale of 1:1,000,000 (1 inch = 13.72 NM), which is more convenient for use in navigation by high speed aircraft. It depicts airports, cities, railroads, and distinctive landmarks, etc., but does not include airspace specifics. These charts have less detail and are revised no more than once a year.

NOTE: The AF normally makes use of less detailed charts. However, the increase use of “Falcon View” mapping software has increased the detail on VFR charts available to the DoD.

Every chart uses a geographic reference system for identifying locations. There are three types of “north” that may be used.

- True north
- Magnetic north
- Grid or map north

LATITUDE AND LONGITUDE

The true north position on the earth utilizes meridians of longitude and parallels of latitude to precisely locate any point.

Equidistant from the poles is an imaginary circle called the **equator**. The lines running east and west, parallel to the equator are called parallels of latitude, and are used to measure angular distance north or south of the equator. From the equator to either pole is 90°, with 0° being at the equator; while 90° north latitude describes the location of the North Pole.

Lines called meridians of longitude are drawn from pole to pole at right angles to the equator. The **prime meridian**, used as the zero degree line, passes through Greenwich, England. From this line, measurements are made in degrees both easterly and westerly up to 180°.

Any specific geographical point can be located by reference to its longitude and latitude. For example, Washington, D.C. is approximately 39° north of the equator and 77° west of the prime meridian and would be stated as N39° W77°. Note that latitude is stated first.

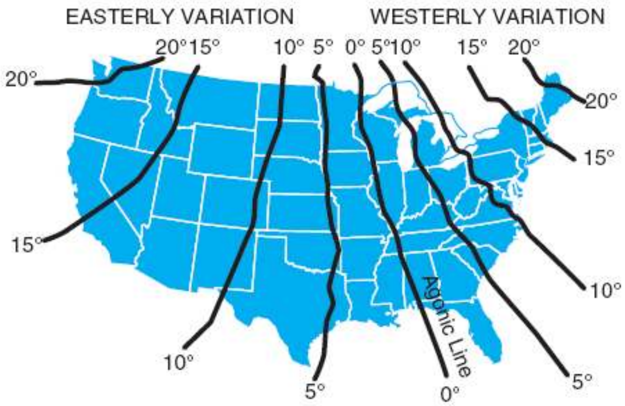
In order to describe a location more precisely, each degree (°) is subdivided into 60 minutes (') and each minute further divided into 60 seconds ("), although seconds are not shown. Thus, the location of the airport at Elk City, Oklahoma is described as being at N35°25'55" W99°23'15" (35 degrees, 25 minutes, 55 seconds north latitude; 99 degrees, 23 minutes, 15 seconds west longitude). Degrees of west longitude increase from east to west. Degrees of north latitude increase from south to north.

MAGNETIC VARIATION

- True North: where longitudinal meridians converge
- Magnetic North: attracts the needle of a compass
- Magnetic Variation: angular difference between true north and magnetic north

The North Pole where all meridians converge is **true north**. The North Pole which attracts the needle of a compass is **magnetic north**. These two poles are not in the same place. At any point where magnetic north and true north are in line with each other, the compass needle points both to magnetic north and true north. The line along which this occurs is known as the **agonic line**. When positioned west of the agonic line, a compass will point right (east) of true north. When positioned east of the agonic line, a compass will point left (west) of true north. This angular difference between true north and magnetic north is called **magnetic variation (VAR)**. West of the agonic line, variation is "easterly." East of the agonic line, variation is "westerly."

The amount and direction of variation is depicted on sectional charts as dashed magenta colored lines connecting points of equal variation, called isogonic lines.



A course measured on a sectional chart is a true course: it is measured from a meridian, which runs from the South Pole to the North Pole. Since a magnetic compass is used to maintain a course while flying, this true course must now be converted to a **magnetic course (MC)**. This conversion is made by either adding or subtracting the variation.

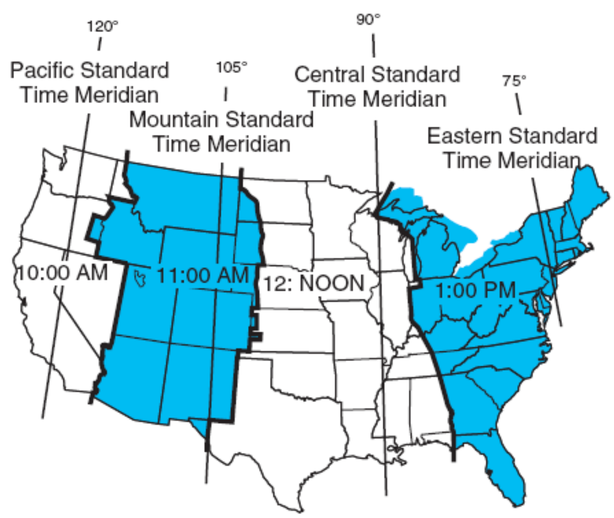
To convert a true course to a magnetic course, subtract easterly variation, and add westerly variation: "East is least, west is best." TC ± VAR = MC

TIME ZONES

Time is measured in relation to the rotation of the earth. A day is defined as the time required for the earth to make one complete revolution of 360°. Since the day is divided into 24 hours, it follows that the earth revolves at the rate of 15° each hour. A time zone is approximately 15° of longitude in width, with the first zone centered on the meridian of Greenwich. Each zone uses the local time of its central meridian.

For example, when the sun is above the 90th meridian, it is noon central standard time (CST). At the same time it is 6 p.m. Greenwich, 11 a.m. mountain standard time (MST), and 1 p.m. eastern standard time (EST). When daylight saving time (DST) is in effect, the sun is over the 75th meridian at noon CST.

Most aviation operations time is expressed in terms of the 24-hour clock, (for example, 8 a.m. is expressed as 0800; 2 p.m. is 1400; 11 p.m. is 2300) and may be either local or **Coordinated Universal Time (UTC)**. UTC is the time at the prime meridian and is represented in aviation operations by the letter "Z," referred to as "**Zulu time**." For example, 1500Z would be read as "one five zero zero Zulu."



To convert from this time, a pilot should do the following:
Eastern Standard Time..........Subtract 5 hours
Central Standard Time..........Subtract 6 hours
Mountain Standard Time...... Subtract 7 hours
Pacific Standard Time.......... Subtract 8 hours
Subtract 1 hour less during daylight saving time (summer months)

NOTAMS and weather reports will be obtained in UTC.

AERONAUTICAL CHART INTERPRETATION

The discussions and examples in this section are based on the Sectional Aeronautical Charts. These charts include the most current data and are at a scale (1:500,000) most beneficial to pilots flying under Visual Flight Rules. A pilot should have little difficulty in reading these charts which are, in many respects, similar to automobile road maps.

The chart legend lists various aeronautical symbols as well as information concerning terrain and contour elevations. You may identify aeronautical, topographical, and obstruction symbols (such as radio and television towers) by referring to the legend. Many landmarks which can be easily recognized from the air, such as stadiums, pumping stations, refineries, etc., are identified by brief descriptions adjacent to small black squares marking their exact locations. The depictions of many items larger than scale are exaggerated on the charts for improved legibility.

CHART HEADING

The chart heading includes the title of the chart. Each chart is named for a major city within its area of coverage. The heading also shows the effective date for use and the expiration date of the chart.

79TH EDITION EFFECTIVE 0901Z 31 JUL 2008
TO 0901Z 15 JAN 2009

Includes airspace amendments effective 31 JUL 2008
and all other aeronautical data received by 5 JUN 2008

Information on this chart will change; consolidated updates of chart changes are available every 56 days in the AIRPORT/FACILITY DIRECTORY Chart Bulletin section (online at www.naco.faa.gov). Also consult appropriate NOTICES TO AIRMEN (NOTAMs) and other FLIGHT INFORMATION PUBLICATIONS (FLIPs) for the latest changes.

ATC FREQUENCY TABLES

There are tables on the edges of the chart that list the frequencies and hours of operation for the Control Towers and Approach Control.

CONTROL TOWER FREQUENCIES ON DENVER SECTIONAL CHART

Airports with control towers are indicated on the face of the chart by the letters CT followed by the primary VHF local control frequency (ies). Information for each tower is listed in the table below. Operational hours are local time. The primary VHF and UHF local control frequencies are listed. An asterisk (*) indicates the part-time tower frequency is remoted to a collocated full-time FSS for use as Local Airport Advisory (LAA) during hours the tower is closed. The primary VHF and UHF ground control frequencies are listed.

Automatic Terminal Information Service (ATIS) frequencies shown on the face of the chart are primary arrival VHF/UHF frequencies. All ATIS frequencies are listed in the table below. ATIS operational hours may differ from tower operational hours.

ASR and/or PAR indicate Radar Instrument Approach available.

"MON-FRI" indicates Monday through Friday.

CONTROL TOWER	OPERATES	TWR FREQ	GND CON	ATIS	ASR/PAR
ASPEN-PITKIN CO/SARDY	0700-2200	118.65 288.3	121.9	120.4	
BUCKLEY AFB	0630-2230 TUE-SAT 0800-1600 SUN-MON	121.0 291.675	121.6 275.8	119.675 259.3	
BUTTS AAF (FORT CARSON)	CONTINUOUS EXC THANKSGIVING, CHRISTMAS & NEW YEARS DAY	125.5 229.4 239.3		108.8	
CENTENNIAL	CONTINUOUS	118.9	121.8	120.3	
COLORADO SPRINGS	CONTINUOUS	119.9 360.6 (W) 133.15 335.55 (E)	121.7 348.6	125.0 254.3	
DENVER INTL	CONTINUOUS	124.3 256.85 (RWYS 08/26 & 17L/35R) 132.35 273.55 (RWY 07/25) 133.3 322.45 (RWY 17R/35L) 135.3 351.95 (RWYS 16L/34R & 16R/34L)	121.85 377.1 (RWYS 08/26, 17L/35R & 17R/35L) 127.5 380.3 (RWYS 07/25, 16L/34R & 16R/34L)	125.6 379.9 (ARR) 134.025 (DEP)	
EAGLE CO RGNL	0700-1900	119.8	121.8	135.575	
FOUR CORNERS RGNL	0600-2200	118.9 257.8	121.7	127.15	
FRONT RANGE	0700-2100	120.2	124.7	119.025	
GRAND JUNCTION RGNL	0600-2200	118.1 257.8	121.7 257.8	118.55	
PUEBLO MEML	0600-2200	119.1 257.8	121.9	125.25	ASR
ROCKY MOUNTAIN	0600-2200	118.6 233.7	121.7	126.25	
SANTA FE	0700-2100	119.5 239.3	121.7	128.55	
USAF ACADEMY	SR-SS MON-FRI SAT 0700-1400 CLSD SUN & HOL	124.15 320.1	118.125	128.525 269.375	

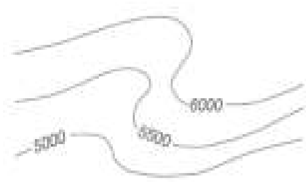
SPECIAL USE AIRSPACE
There are also tables that list the various Special Use Airspace (SUA) areas that are depicted on the chart. The list includes the number of the area, altitude, time of use, the controlling agency and the radio frequencies.

U.S. P–PROHIBITED, R–RESTRICTED, A–ALERT, W–WARNING, MOA–MILITARY OPERATIONS AREA

NUMBER	ALTITUDE	TIME OF USE	CONTROLLING AGENCY/ CONTACT FACILITY	FREQUENCIES
R-2601A	TO BUT NOT INCL 12,500	0500-2400 MON-FRI †1HR IN ADVANCE	DENVER CNTR	128.375 379.95
R-2601B	12,500 TO BUT NOT INCL 22,500	BY NOTAM 1HR IN ADVANCE	DENVER CNTR	128.375 379.95
R-2602	TO 1,000 AGL	CONTINUOUS	DENVER CNTR	
R-5101	TO 12,000	CONTINUOUS	NO A/G	
R-6413	UNLIMITED	BY NOTAM 48 HRS IN ADVANCE	DENVER CNTR	134.5 327.8
A-260	TO 17,500	SR-SS	NO A/G	
A-639A,B	3000 AGL TO 12,000	SR-SS MON-FRI EXC HOL †DAYLIGHT ONLY	NO A/G	

TOPOGRAPHY
A VFR Sectional Aeronautical Chart is a pictorial representation of a portion of the Earth's surface upon which lines and symbols in a variety of colors represent features and/or details that can be seen on the Earth's surface. Contour lines, shaded relief, color tints, obstruction symbols, and maximum elevation figures are all used to show topographical information. Explanations and examples may be found in the chart legend. Pilots should become familiar with all of the information provided in each Sectional Chart Legend.

TERRAIN AND OBSTRUCTIONS
The elevation and configuration of the Earth's surface are certainly of prime importance to pilots. Cartographers devote a great deal of attention to showing relief and obstruction data in a clear and concise manner. Five different techniques are used to show this information: Contour lines, shaded relief, color tints, obstruction symbols, and Maximum Elevation Figures. (MEF)



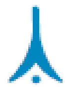
1. Contour lines are lines connecting points on the Earth of equal elevation. On Sectional Aeronautical Charts, basic contours are spaced at 500 foot intervals. Intermediate contours may also be shown at 250 foot intervals in moderately level or gently rolling areas. Occasionally, auxiliary contours at 50, 100, 125, or 150 foot intervals may be used to portray smaller relief features in areas of relatively low relief. The pattern of these lines and their spacing gives the pilot a visual concept of the terrain. Widely spaced contours represent gentle slopes, while closely spaced contours represent steep slopes.

2. Shaded relief is a depiction of how the terrain might appear from the air. The cartographer shades the areas that would appear in shadow if illuminated by a light from the northwest. Studies have indicated that our visual perception has been conditioned to this view.

3. Color tints are used to depict bands of elevation. These colors range from light green for the lowest elevations to brown for the higher elevations.

4. Obstruction symbols are used to depict man-made vertical features that may affect the National Airspace System. NACO maintains a file of over 90,000 obstacles in the United States, Canada, the Caribbean and Mexico. Each obstacle is evaluated by cartographers before it is added to the visual charts. When the position or elevation of an obstacle is unverified, it is marked UC (under construction or reported but not verified).

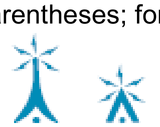
Generally, only man-made structures extending more than 200 feet above ground level (AGL) are charted. Objects 200 feet or less are charted only if they are considered hazardous obstructions; for example, an obstruction is much higher than the surrounding terrain or very near an airport. Examples of features considered obstacles to low level flight are antennas, tanks, factories, lookout towers, and smoke-stacks.

Obstacles less than 1000 feet AGL are shown by the symbol . Obstacles 1000' and higher AGL are shown by the symbol . Man-made features which can be seen clearly from the air and can be used as checkpoints may be represented with pictorial symbols shown in black with the required elevation data in blue.

The height of the obstacle AGL and the elevation of the top of the obstacle above mean sea level (MSL) are shown when known or when they can be reliably determined by the cartographer. The height AGL is shown in parentheses below the elevation MSL at the top of the obstacle (650). In extremely congested areas the AGL values may be omitted to avoid confusion.

Obstacles are portrayed wherever possible. Since legibility would be impaired if all obstacles within city complexes or within high density groups of obstacles were portrayed, only the highest obstacle in an area is shown using 

, the group obstacle symbol.

Obstacles under construction are indicated by the letters immediately adjacent to the symbol. If available, the AGL height of the obstruction is shown in parentheses; for example, (1501). Obstacles with high intensity strobe lighting systems are shown as: 

5. The Maximum Elevation Figure (MEF) represents the altitude needed to clear all obstacles in the area bounded by lines of latitude and longitude called a quadrangle. These lines on Sectional Aeronautical Charts are the ticked lines dividing each 30 minutes of latitude and each 30 minutes of longitude. MEFs are shown over land masses as well as over open water areas containing man-made obstacles such as oil rigs.

ATTENTION

THIS CHART CONTAINS MAXIMUM ELEVATION FIGURES (MEF).
The Maximum Elevation Figures shown in quadrangles bounded by ticked lines of latitude and longitude are represented in THOUSANDS and HUNDREDS of feet above mean sea level. The MEF is based on information available concerning the highest known feature in each quadrangle, including terrain and obstructions (trees, towers, antennas, etc.).

Example: 12,500 feet . . . . 12^5

AIRPORTS

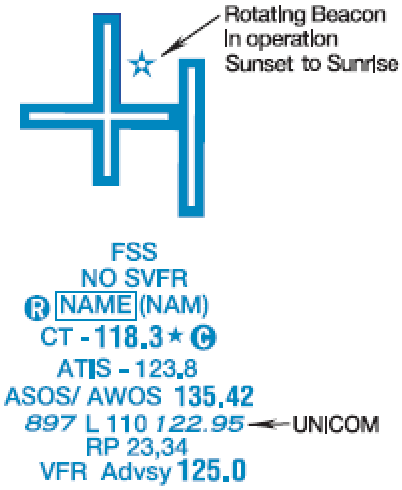
Airports are very important symbols on aeronautical charts. Therefore, much information is included in the symbology and in the information blocks near the airport symbol. The chart legend explains most of the symbols that are used.

The elevation of an airport is the highest point on the usable portion of the landing areas. Runway length is the length of the longest active runway including displaced thresholds and excluding overruns. Runway length is shown to the nearest 100 feet, using 70 as the division point; a runway 8070' long is charted as 81, and a runway 8069' long is charted as 80.

Airports with control towers, and their related information, are shown in blue. All other airports, and their related information, are shown in magenta (reddish purple). The symbol indicates the existence of a rotating or flashing airport beacon operating continuously sunset to sunrise.

The symbol "L" indicates that runway lights are on during hours of darkness. The "*L" indicates that the pilot must consult another source (e.g., the Airport/Facility Directory) to determine runway lighting limitations, such as: available on request (by radio call, letter, phone, etc), part-time lighting or pilot/airport controlled lighting.

The lighted runway may not be the longest runway available, and may not be lighted full length. A detailed description of airport and air navigation lighting aids available at each airport can be found in the Airport/Facility Directory. The Aeronautical Information Manual thoroughly explains the types and uses of airport lighting aids.



FSS - Flight Service Station on field

NO SVFR - Airports where fixed wing special visual flight rules operations are prohibited (shown above airport name) F.A.R. 91

(box) - Indicates F.A.R. 93 Special Air Traffic Rules and Airport Traffic Patterns

(R) - Airport Surveillance Radar (Not shown on WAC)

(NAM) - Location Identifier (Not shown on WAC)

CT - 118.3 - Control Tower (CT) - primary frequency

★ - Star indicates operation part-time. See tower frequencies tabulation for hours of operation

(C) - Indicates Common Traffic Advisory Frequencies (CTAF) (Not shown on WAC)

ATIS 123.8 - Automatic Terminal Information Service

ASOS/ AWOS 135.42 - Automated Surface Weather Observing Systems (Shown when full-time ATIS is not available) Some ASOS/AWOS facilities may not be located at airport. (Not shown on WAC)

897 - Elevation in feet

L - Lighting in operation Sunset to Sunrise

*L - Lighting limitations exist; refer to Airport/Facility Directory.

110 - Length of longest runway in hundreds of feet; usable length may be less.

UNICOM - Aeronautical advisory station ("U" only on WAC)

RP 23,34 - Runways with Right Traffic Patterns (public use) (Not shown on WAC)

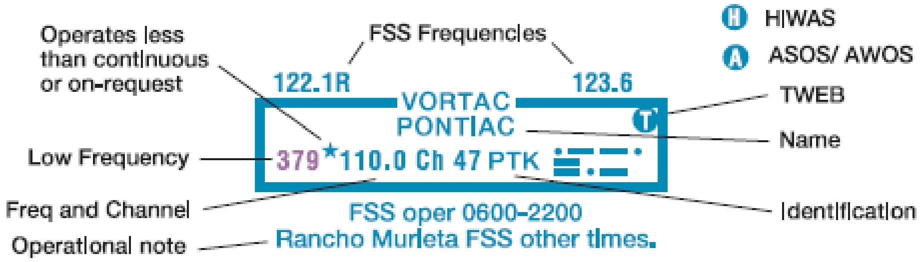
RP* - (See Airport/Facility Directory)

VFR Advsy 125.0 - VFR Advisory Service shown where ATIS is not available and frequency is other than primary CT frequency.

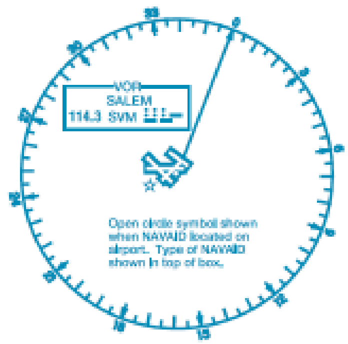
RADIO AIDS TO NAVIGATION

On visual charts, information about radio aids to navigation is boxed, as illustrated. Duplication of data is avoided. When two or more radio aids in a general area have the same name with different frequencies, TACAN channel numbers, or identification letters, and no misinterpretation can result, the name of the radio aid may be indicated only once within the identification box.

VHF/UHF radio aids to navigation names and identification boxes (shown in blue) take precedence. Only those items that are different (e.g., frequency, Morse Code) are repeated in the box in the appropriate color. The choice of separate or combined boxes is made in each case on the basis of economy of space and clear identification of the radio aids.

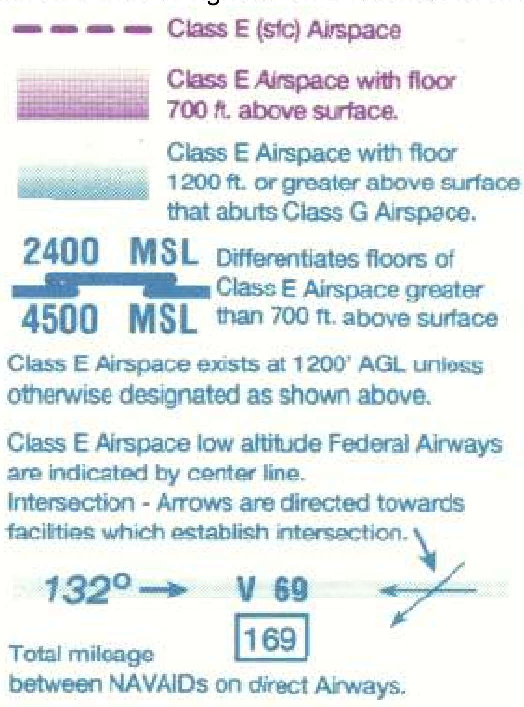


Radio aids to navigation located on an airport depicted by the pattern symbol may not always be shown by the appropriate symbol. A small open circle indicates the NAVAID location when co-located with an airport symbol. The type of radio aid to navigation may be indicated by letter identification; e.g., VOR, VORTAC, etc., positioned on and breaking the top line of the identification box.

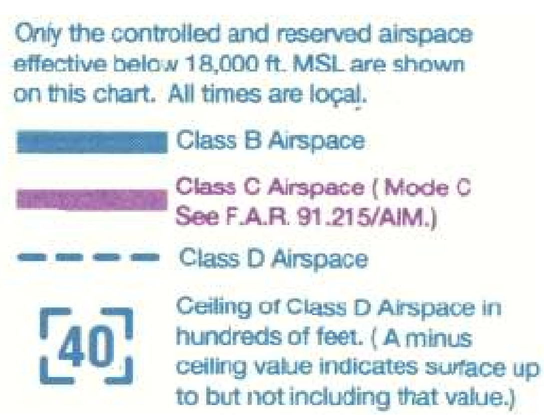


CONTROLLED AIRSPACE
Controlled airspace consists of those areas where some or all aircraft may be subject to Air Traffic Control, such as Class B, Class C, Class D and Class E airspace.

The lateral and vertical limits of all controlled airspace up to but not including 18,000 feet are shown by narrow bands of vignette on Sectional Aeronautical Charts and Terminal Area Charts.



Controlled airspace floors of 700 feet above the ground are defined by a magenta vignette; floors other than 700 feet that abut uncontrolled airspace are defined by a blue vignette; differing floors greater than 700 feet above the ground are annotated by a symbol and a number indicating the floor. If the ceiling is less than 18,000 feet MSL, the value (prefixed by the word "ceiling") is shown along the limits of the controlled airspace. These limits are shown with the same symbol indicated above.



Class B Airspace is shown in abbreviated form on World Aeronautical Charts (WAC). The Sectional Aeronautical Charts and Terminal Area Charts (TAC) show Class B airspace in greater detail. The MSL ceiling and floor altitudes of each sector are shown in solid blue figures with the last two digits eliminated: 90/20 Radials and arcs used to define Class B airspace are prominently shown on Terminal Area Charts. Detailed rules and requirements associated with the particular Class B airspace are shown. The name by which the Class B airspace is identified is shown as: LAS VEGAS CLASS B

Class C Airspace is shown in abbreviated form on World Aeronautical Charts. The Sectional Aeronautical Charts and Terminal Area Charts show Class C airspace in greater detail.

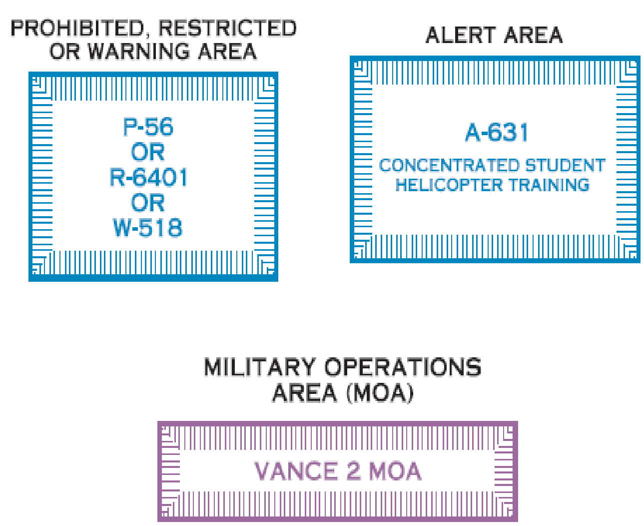
The MSL ceiling and floor altitudes of each sector are shown in solid magenta figures with the last two digits eliminated 70/15. The following figures identify a sector that extends from the surface to the base of the Class B airspace T/SFC. The name by which the Class C airspace is identified is shown as BURBANK CLASS C. Separate notes, enclosed in magenta boxes, give the approach control frequencies to be used by arriving VFR aircraft to establish two-way radio communication before entering the Class C airspace generally within 20 NM: CTC BURBANK APP WITHIN 20 NM ON 124.6 395.9

Class D Airspace is symbolized by a blue dashed line. Class D airspace that operates less than continuously is indicated by a note. Ceilings of Class D airspace that are shown with a minus in front of the figure is used to indicate "from surface to, but not including."

Surface Class E Airspace is symbolized by a magenta dashed line. Class E airspace that operates less than continuously is indicated by a note.

SPECIAL USE AIRSPACE (SUA)

Special Use Airspace confines certain flight activities and restricts entry or cautions other aircraft operating within specific boundaries. Special Use Airspace areas are depicted on visual aeronautical charts. Special Use Airspace is shown in its entirety (within the limits of the chart), even when it overlaps, adjoins, or when an area is designated within another area. The areas are identified by type and identifying name or number, positioned either within or immediately adjacent to the area.



OTHER AIRSPACE AREAS

Mode C Required Airspace
Airspace from the surface to 10,000' MSL within 30 nm radius of the primary airport(s) for which a Class B airspace is designated, is depicted by a solid magenta line.

Mode C is also depicted within 10 nm of any airport listed in Appendix D of FAR 91.215. Mode C is required but not depicted for operations within and above all Class C airspace up to 10,000' MSL. Enroute Mode C requirements (at and above 10,000' MSL except in airspace at and below 2,500 ft AGL) are not depicted. See FAR 91.215 and the Aeronautical Information Manual (AIM).

FAR 93
Airports and heliports where Federal Aviation Regulation (FAR 93) special air traffic rules and airport traffic patterns apply are shown by "boxing" the airport name.

FAR 91
Airports where fixed wing special visual flight rules operations are prohibited (FAR 91) are shown with the type "NO SVFR" above the airport name.

National Security Areas are indicated on VFR charts with a broken magenta line. Unauthorized aircraft are requested to remain clear of these areas.

Terminal Radar Service Areas (TRSAs) are shown in their entirety, symbolized by a screened black outline of the entire area including the various sectors within the area.

The outer limit of the entire TRSA is a continuous screened black line. The various sectors within the TRSA are symbolized by slightly narrower screened black lines. Each sector altitude is identified in solid black color by the MSL ceiling and floor values of the respective sector, eliminating the last two digits. A leader line is used when the altitude values must be positioned outside the respective sectors because of space limitations. The TRSA name is shown near the north position of the TRSA. Associated frequencies are listed in a table on the chart border.

Military Training Routes (MTRs) are shown on Sectional and Terminal Area Charts and are identified by the route designator. Route designators are shown in solid black on the route centerline, positioned along the route for continuity.

The designator IR or VR is not repeated when two or more routes are established over the same airspace, e.g., IR201-205-227. Routes numbered 001 to 099 are shown as IR1 or VR99, eliminating the initial zeros. Direction of flight along the route is indicated by small arrowheads adjacent to and in conjunction with each route designator. The following note appears on all Sectional Aeronautical Charts and VFR Terminal Area Charts covering the conterminous United States.

MILITARY TRAINING ROUTES (MTRs)

All IR and VR MTRs are shown, and may extend from the surface upwards. Only the route centerline, direction of flight along the route and the route designator are depicted - route widths and altitudes are not shown.

Since these routes are subject to change every 56 days, and the charts are reissued every 6 months, you are cautioned and advised to contact the nearest FSS for route dimensions and current status for those routes affecting your flight.

Routes with a change in the alignment of the charted route centerline will be indicated in the Aeronautical Chart Bulletin of the Airport/Facility Directory.

Military Pilots refer to Area Planning AP/1B Military Training Route North and South America for current routes.

There are IFR (IR) and VFR (VR) routes as follows: Route identification: a. Routes at or below 1,500 feet AGL (with no segment above 1,500 feet) are identified by four-digit numbers; e.g., VR1007, etc. These routes are generally developed for flight under Visual Flight Rules. b. Routes above 1,500 feet AGL (some segments of these routes may be below 1,500 feet) are identified by three-digit or less numbers; e.g., IR21, VR302, etc. These routes are developed for flight under Instrument Flight Rules. Route widths vary for each MTR and can extend several miles on either side of the charted MTR centerline. Detailed route width information is available in the Flight Information Publication (FLIP) AP/1B (a Department of Defense publication), or in the Digital Aeronautical Chart Supplement (DACS).

Special Military Activity areas are indicated on the Sectional charts by a boxed note in black type. The note contains radio frequency information for obtaining area activity status.

SPECIAL MILITARY ACTIVITY
CONTACT MOBILE FSS
ON 123.6
FOR ACTIVITY STATUS

TERMINAL AREA CHART (TAC) COVERAGE
Terminal area chart coverage is shown on appropriate Sectional charts by a 1/4" masked line as indicated below. Within this area, pilots should use TACs which provide greater detail and clarity of information. A note to this effect appears near the masked boundary line.

LOS ANGELES TERMINAL AREA
Pilots are encouraged to use the Los Angeles VFR
Terminal Area Chart for flights at or below 10,000'

MAGNETIC DEVIATION
The magnetic compass is affected by influences within the aircraft such as electrical circuits, radios, engines, magnetized metal parts, etc., which cause the compass needle to be deflected from its normal reading. This deflection is known as **deviation (DEV)**, and it must be applied to convert a magnetic course to a **compass course (CC)** to make it usable in flight.

Deviation, which is different for each aircraft, may also vary for different courses in the same airplane. To let the pilot know the appropriate correction, a correction card is mounted near the compass.

To determine the actual compass reading to be followed during flight, it is necessary to apply the corrections for both variation and deviation:

True Course ± Variation = Magnetic Course ± Deviation = Compass Course
TC ± VAR = MC ± DEV = CC

VFR CRUISING ALTITUDES
Cruising altitudes are based on the magnetic course of the aircraft.
- Apply when flying at or above 3,000 feet AGL.
- Magnetic Course 0° to 179°, fly at odd thousands plus 500 feet. For example, 5,500', 9,500' and 13,500'.
- Magnetic Course 180° to 359°, fly at even thousands plus 500 feet. For example, 6,500', 8,500' and 12,500'.

DEAD RECKONING
Dead reckoning is the method used for determining position with a heading indicator and calculations based on speed, elapsed time, and wind effect from a known position. The instruments used for dead reckoning navigation include the outside air temperature gauge, the airspeed indicator, the altimeter, the clock and the magnetic compass system or slaved gyro system. These instruments provide information

concerning direction, airspeed, altitude and time and must be correctly interpreted for successful navigation.

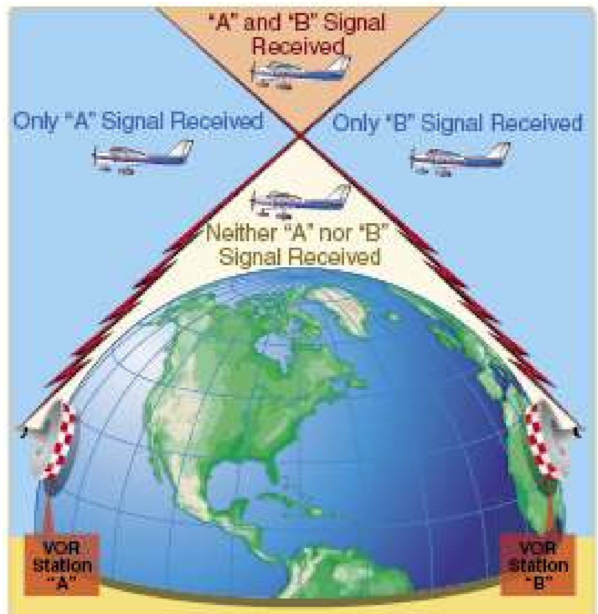
RADIO NAVIGATION

Advances in navigational radio receivers installed in airplanes, the development of aeronautical charts which show the exact location of ground transmitting stations and their frequencies, along with refined cockpit instrumentation make it possible for pilots to navigate with precision to almost any point desired. Although precision in navigation is obtainable through the proper use of this equipment, beginning pilots should use this equipment to supplement navigation by visual reference to the ground (pilotage). This method provides the pilot with an effective safeguard against disorientation in the event of radio malfunction. There are two radio navigation systems installed in the DA-20. These are:

- VHF Omnidirectional Range (VOR): While the actual VOR ground station is not utilized in the IFS program a general understating of ground based navigational aids will assist you in understanding how the Pueblo VOR is used to navigate in the local area
- Global Positioning System (GPS): Is the primary navigational aid used at IFS.

Very High Frequency (VHF) Omnidirectional Range (VOR)

The VOR system is present in three slightly different navigation aids (NAVAIDs): VOR, VOR/DME, and VORTAC. We will refer to the ground based NAVAID generically as a VOR for the remainder of this discussion and assume it provides both magnetic bearing information to and from the station as well as distance measuring (DME) information.



The prefix "omni-" means all, and an omnidirectional range is a VHF radio transmitting ground station that projects straight line courses (radials) from the station in all directions. From a top view, it can be visualized as being similar to the spokes from the hub of a wheel. The distance VOR radials are projected depends upon the power output of the transmitter. The course or radials projected from the station are referenced to magnetic north. Therefore, a radial is defined as a line of magnetic bearing extending outward from the VOR station. Radials are identified by numbers beginning with 001, which is 1° east of magnetic north, and progress in sequence through all the degrees of a circle until reaching 360. To aid in orientation, a compass rose reference to magnetic north is superimposed on aeronautical charts at the station location.

Because the equipment is VHF, the signals transmitted are subject to line-of-sight restrictions. Therefore, its range varies in direct proportion to the altitude of receiving equipment. Generally, the reception range of the signals at an altitude of 1,000 feet above ground level (AGL) is about 40 to 45 miles. This distance increases with altitude.

GLOBAL POSITIONING SYSTEM (GPS)

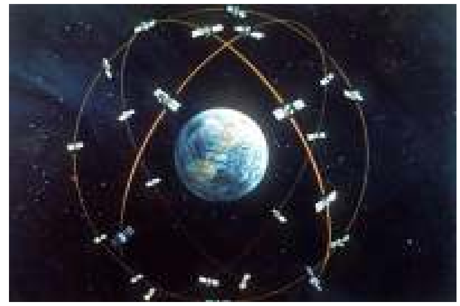
GPS is a United States satellite-based radio navigational, positioning, and time transfer system operated by the Department of Defense (DOD). The system provides highly accurate position and velocity information and precise time on a continuous global basis to an unlimited number of properly-equipped users. The GPS constellation of 24 satellites is designed so that a minimum of five are always observable by a user anywhere on earth. The

GPS receiver uses data from a minimum of four satellites to yield a three-dimensional position (latitude, longitude, and altitude) and time solution.

The Three Segments of the GPS System

- Space Segment
- User Segment
- Control Segment

SPACE SEGMENT The space segment is a network of satellites who's orbits are arranged so that at least six satellites are always within line of sight from almost everywhere on Earth's surface. The system requires 24 operational satellites for worldwide coverage, but the constellation normally contains more that 24 operational satellites with airborne spares.



Satellites are equipped with very precise clocks that keep accurate time to within three nanoseconds. This precision timing is important because the receiver must determine exactly how long it takes for signals to travel from each GPS satellite to receiver.

USER SEGMENT In general, GPS receivers are composed of an antenna, tuned to the frequencies transmitted by the satellites, receiver-processors, highly-stable clock, and a display for providing location, speed, etc. to the user. The unit computes the location of the GPS receiver by triangulating among the several satellites being received. The GPS receiver has to see at least four satellites to compute a three dimensional position (it can compute lateral position with only three satellites but no altitude). The navigation capabilities of the GPS system are normally only limited by the sophistication of the receiver.

CONTROL SEGMENT The Control Segment of GPS consists of:

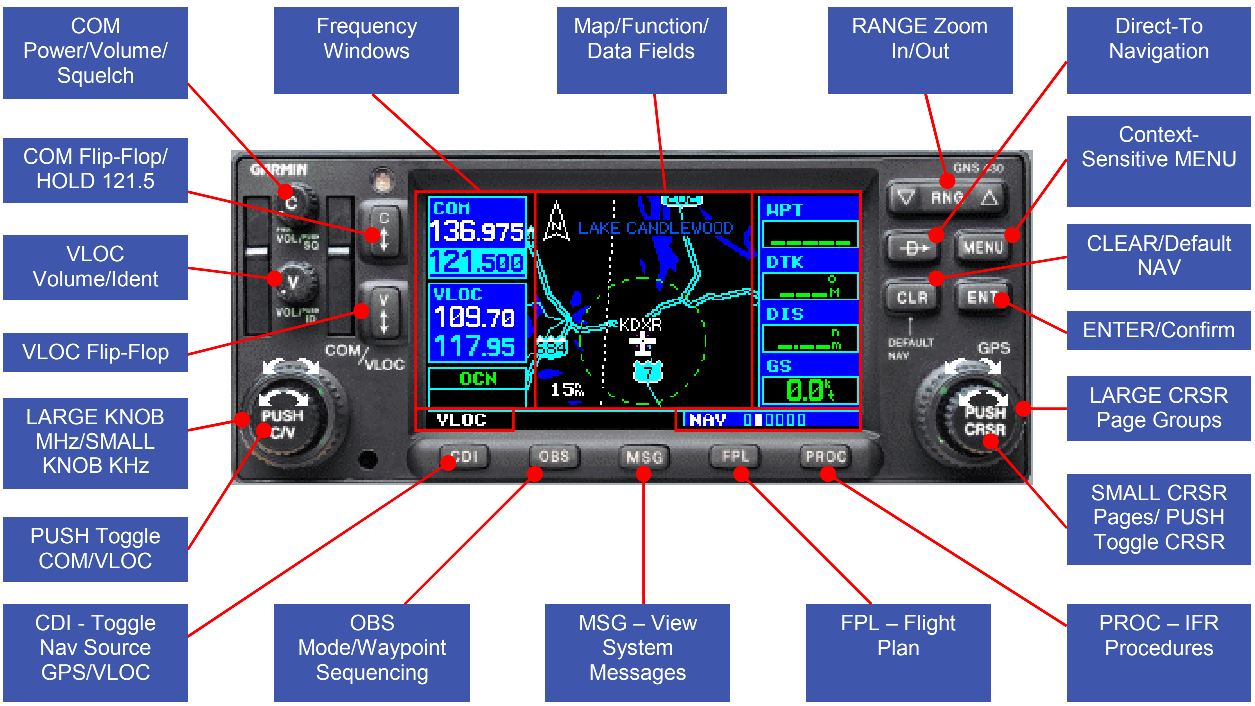
- Monitor Stations (six stations): Each monitor station checks the exact altitude, position, speed and overall heath of the orbiting satellites. This information is then sent to the Master Control Station.
- Master Control Station (Schriever Air Force Base): this station uses the data from the monitoring stations to calculate deviations such as clock errors and then sends the appropriate corrective information back to that satellite. It also may need to reposition the satellite when necessary.

Additionally the health of the satellite system must be known by the user to determine potential navigation accuracy. This is accomplished both by the Monitor Stations and by the receiver unit itself. Errors detected by the monitor stations will be published in Air Route Traffic Control Center (ARTCC) NOTAMs which should be checked as part of preflight planning. These NOTAMs typically only alert the user to potential errors. The user must use the receiver unit to ultimately determine the suitability of the system for navigation. This is typically for precision navigation such as a GPS approach and is not used in the IFS program.

GNS 430 OPERATION

Advances in navigation radio receivers, the development of aeronautical charts which show the exact location of ground transmitting stations, along with refined cockpit instrumentation make it possible for pilots to navigate with precision to almost any point desired. Although precision in navigation is obtainable through the proper use of this equipment, beginning pilots should use this equipment to supplement navigation by visual reference to the ground (pilotage). This method provides the pilot with an effective safeguard against disorientation in the event of radio malfunction.

GNS 430 KEY FUNCTIONS



When you turn the power ON, the radio performs a self-test. Instrument Panel Self Test - Compare the GPS screen with panel instruments. Everything OK? Press ENT.

The CDI key switches between GPS and VLOC inputs for the CDI. The selected navigation source is displayed just above the CDI key. ***CAUTION:*** Selecting the wrong CDI source is a common but serious problem.

Press the Direct-To key. The Direct-To page appears, with the cursor on the waypoint identifier.

GPS Data Entry - Entering waypoints and other data into the GPS is a three step process.

1. Enter identifier letters and numbers
2. Confirm it is the correct waypoint.
3. Activate the waypoint for navigation.

Enter Waypoint Identifier - The large right knob moves the cursor about the page. The small right knob selects individual characters.

If you do not see the cursor, press the small right knob momentarily. The cursor allows you to enter data and/or make a selection from a list of options.

Confirm Waypoint - Press ENT.
Activate Waypoint - Press ENT again.

The selected course is displayed as a magenta line, and the CDI indicates the direct course to the waypoint.

Display Map Page - Turn the small right knob one click clockwise. The Map page is displayed. It is the second page in the NAV page group as indicated below the map. The Map page shows the active waypoint identifier, track and distance, and ground speed.

Use the RNG key to change the map scale. The up arrow zooms out, the down arrow zooms in. The current map scale is shown at the lower left corner of the map.

Display Nearest Airport Page - Turn the large right knob to select the NRST page group. NRST will appear in the lower right corner of the screen.