In a very similar process to a seafaring ship’s captain, pilots and their aircraft, crew, passengers and cargo will be subjected to the laws and requirements of the land they are operating over or into. Regulations, procedures and services vary by region and country. To minimize the impact of these variables and provide safe, secure and uneventful service, flight departments must put considerable effort into advanced planning and developing contingencies. This requires planning, ingenuity and resourcefulness on the part of the pilots, dispatchers and support staff.

Commentary provided by this guide will help pilots; dispatchers and operations personnel to better understand the details and procedures required in the whole of international operations. Ample charts, diagrams, graphics and references are used through this guide. An interested pilot can use this study guide to open the recommended document, refer to the subjects and pages as indicated in the footnotes then read the source material for themselves.

This guide is for training and reference purposes and is designed for use by pilots of various experience levels, operating business class aircraft in international operations. We take great effort to insure the accuracy and legitimacy of the information presented here. This information has been thoroughly researched and vetted by International Flight Resources, LLC. A list of reference material used appears at the end of this guide for your use.

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Despite our best efforts, some inaccuracies may occur due to the changing and developing nature of international flight operations. We cannot make a full and complete warranty of all the information presented here. By utilizing this training guide, one agrees to abide by the terms and conditions outlined in this notification. For any errors, omissions, or comments please contact us using the information provided below.

Sincerely;

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For most navigational purposes, the earth is assumed to be a perfect sphere, although in reality it is not. Measured at the equator, the earth is approximately 6,378,137 meters in diameter, while the polar diameter is approximately 6,356,752.3142 meters. The difference in these diameters is 21,384.6858 meters. This deviation from exactly round is caused by a combination of the earth’s rotation and its structural flexibility. This difference is usually expressed as a mathematical formula and can be used to express the ellipticity of the Earth for very accurate calculations.

Earth Reference System

The geometric nature of a sphere is such that any point on it is exactly like any other point. There is neither beginning nor ending. In order that defined points may be described (on the sphere we call Earth), lines of reference and a system of coordinates to locate positions on the earth is necessary.

The Earth rotates on its north-south axis. The points at which this axis of rotation meets the perimeter of the sphere are known as the North Pole and the South Pole. Lines radiating out from these poles divide the sphere into 360 degrees and are known as Meridians of Longitude. The meridian that runs through Greenwich, England is sometimes referred to as the Prime Meridian. The numerical designation is actually the zero meridian. Longitude is counted east and west from this meridian through 180°. The Greenwich meridian is the 0° longitude on one side of the earth and, after crossing the poles, it becomes the 180th Meridian... 180° east or west of the 0° “Prime” meridian.

Midway between the North and South poles, perpendicular to the rotational axis, the Equator is defined. Latitude is expressed as degrees either north or south of the Equator. Lines that form circles around the globe, parallel to the Equator are known as Parallels of Latitude. The numerical designation for the Equator is “Zero” degrees. Moving north or south from the Equator increases the numerical designation until at the poles. The North Pole is labeled “90 Degrees North Latitude” and the South Pole is labeled “90 South Latitude”.

Latitude is measured in degrees up to 90, and longitude is expressed in degrees up to 180. The total number of degrees in any one circle is always 360. A degree (either Latitude or Longitude) may be subdivided into smaller units by dividing each degree into 60 minutes (’) of arc. Each minute may be further subdivided into 60 seconds (”) of arc.
This is confusing to many pilots because on Jeppesen enroute charts and most FMS computers, measurement expressed in degrees, minutes, and tenths of minutes. Latitude is always given before longitude. Here is an example:

The definition of the nautical mile as the length of 1 minute of latitude. The modern definition is 1852.0 meters exactly, and the circumference of the Earth is taken to be 21,602.518 NM, or 40,007.863 km. The statute mile of 5280 feet doesn't fit any of these schemes. A nautical mile is 6076.2 feet or about 1.15 statute miles.

Historically, great navigational problem was how to find longitude. Latitude was fairly easy to calculate by star sightings. Decades of celestial observations were performed to chart longitude, with very limited success. When the sun passes directly overhead your current location, the local solar time is 1200 noon. A Navigator then notes the Greenwich Mean Time at that instant on the ships chronometer. Remembering that 15 degrees of longitude is equivalent to one hour of time, the difference in the compared Local to GMT gives us the longitude.

The difficulty was building a clock that kept accurate time at sea. It had to account for large temperature changes, barometric pressure changes, and the swaying motion of an ocean going vessel. The British inventor John Harrison built such a clock in the late 18th century. On a five-month voyage in 1761, the clock was shown to err by only 1.25 deg of longitude, a time error of about 4 min.

Simply stated, Parallels of Latitude define the "Up and Down" and Meridians of Longitude define the "Left and Right" on Earth. Using Degrees, Minutes and tenths of Seconds to numerically designate a location on a particular line of Longitude and Latitude, any point can be located on the globe using this co-ordinate system.

**Direction Finding Definitions**

Direction is the position of one point in space relative to another without reference to the distance between them. A compass rose, represents the horizon divided into 360°. Generally, in navigation, unless otherwise stated, directions are called true directions.

Course is the intended horizontal direction of travel. Heading is the actual orientation of the longitudinal axis of the aircraft at any instant, while course is the direction intended to be made good. Wind correction angle is the difference.

Track is the actual horizontal direction made by the aircraft over the earth. Bearing is the horizontal direction of one terrestrial point from another. If the reference direction is the heading of the aircraft, the bearing is called a relative bearing (RB).

**Great Circle vs. Rumb Line**

A great circle is defined as a circle on the surface of a sphere whose center and radius are those of the sphere itself. This means that the arc of a great circle is the shortest distance between two points on a sphere, just as a straight line is the shortest distance between two points on a flat surface, (plane.) The
Direction of the great circle is constantly changing as progress is made along the route and is different at every point along the great circle. Flying such a route requires constant change of direction and would be difficult to fly under ordinary conditions.

A line that makes the same angle with each meridian is called a rhumb line. An aircraft holding a constant true heading would be flying a rhumb line. Flying this sort of path results in a greater distance traveled, but it is easier to steer. Between two points on the earth, the great circle is shorter than the rhumb line, but the difference is negligible for short distances (except in high latitudes) or if the line approximates a meridian or the equator.

Datums and the World Geodetic Survey-1984 Database
All coordinates from charts and satellite positioning systems are tied to an individual mathematical model of the earth called a datum. Maps made by a given country can choose to utilize various and different datums. Latitude and longitude measured directly from observation of stars (called an astronomic coordinate) will be consistent, but it may not match the map datum in your hand. Without knowledge of the datum used to establish a particular map or surveyed coordinate, the coordinate is suspect at best. The US Department of Defense adopted a datum in 1987 called World Geodetic System 84 (WGS 84). This global datum is a system that models the entire planet vice one country or region. The initial implementation of WGS-84 was realized from a set of more than a thousand terrestrial sites, which coordinates were derived from Transit observations. WGS 84 positions may be computed from global positioning system (GPS) equipment to a very precise level of accuracy, well under half a meter anywhere in the world.

World Parameters of the Earth 1990, PZ-90
The Russian Federation's navigation satellite system is know as “GLONASS”. GLONASS uses a coordinate datum named "PZ-90". PZ-90 uses the location of the North Pole is given as an average of its position from 1990 to 1995. This is in contrast to WGS 84, which uses the location of the North Pole in 1984. Since 2014, PZ-90 version PZ-90.11 and is aligned to the International Terrestrial Reference System within a few centimeters.

Time
In today’s world of navigation, time is still the key parameter. Each global positioning system satellite uses four cesium clocks, with errors of 1 sec per 1 million years; the clocks are corrected for the speed of the satellite using Albert Einstein’s theory of relativity. The ability of a global positioning system satellite to keep accurate time enables flight crews to know their positions to within 300 ft. With additional augmentation, this can be reduced to less than 1 ft. Universal Time Coordinated (UTC) is the time standard used in aviation for flight plans, weather forecasts and navigation. UTC is used to avoid confusion about time zones and daylight saving time. Greenwich Mean Time (GMT) and “Zulu Time"
are older references to the same “Prime Meridian” time. The meridian at Greenwich is the logical selection for this reference, as it is the origin for the measurement of Greenwich hour angle (GHA) and the determination of longitude. GMT is mean solar time measured from the lower branch of the Greenwich meridian westward through 360° to the upper branch of the hour circle passing through the mean sun.

Another way of saying this is that if you were standing on the Prime Meridian at noon, the Sun would be directly above your head. This is UTC 1200. At UTC 0000, the Sun would be directly below your feet in the same location. Just as UTC/GMT is mean solar time measured with reference to the Greenwich meridian, local mean time (LMT) is mean solar time measured with reference to the observer’s meridian. For an observer at the Greenwich meridian, UTC/GMT is LMT. The angular/time difference between this observation and what you observe in your location, can be used to determine longitude. Navigators use LMT to compute local sunrise, sunset, twilight, moonrise, and moonset at various latitudes along a given meridian.

The Sun travels at a constant rate, covering 360° of arc in 24 hours, 15° in 1 hour. This divides the world into 24 zones, each zone being 15° of longitude wide. Each zone uses the LMT of its central meridian. A few areas of the world are further divided and use half-hour increments from GMT. Some examples include India, Bangladesh, Newfoundland, Venezuela and parts of Australia and Thailand.

The zones are designated by numbers from 0 to 12 and –12, each indicating the number of hours that must be added or subtracted to local zone time (LZT) to obtain GMT. Since the time is earlier in the zones west of Greenwich, the numbers of these zones are plus; in those zones east of Greenwich, the numbers are minus.

If travelling west from Greenwich around the world and setting a watch back an hour for each time zone, the watch would have been set back a total of 24 hours on arriving back at Greenwich, and the date would be 1 day behind. A day must be added somewhere if going around the world to the west and a day must be lost if going around to the east. The 180° meridian (opposite the world from the Prime Meridian) is the international dateline where a day is gained or lost. The local civil date changes at 2400 or midnight.

Proper operation of a correctly functioning Long Range Navigation System (LRNS) will ensure that the aircraft follows its cleared track. Aircraft clock errors resulting in position report time errors can therefore lead to an erosion of actual longitudinal separations between aircraft along the same track. An example of this is found inside an Organized Track Systems (OTS). It is important that the time reference system to be used during the flight is accurately synchronized to UTC and that the calculation of waypoint ETAs and the reporting of waypoint ATAs are always referenced to this system.
Many modern aircraft master clocks (typically the FMS) can only be reset while the aircraft is on the ground. Thus the pre-flight procedures for international flight must include a UTC time check and resynchronization of the aircraft master clock. Acceptable time sources for this purpose are:

- **GPS (Corrected to UTC)** - Available at all times to those crews who can access time via approved on-board GPS equipment.
- **WWV - National Institute of Standards** WWV operates continually H24 on 2500, 5000, 10,000, 15,000 and 20,000 kHz (AM/SSB) and provides UTC (voice) once every minute.
- **CHU - National Research Council (NRC - Ottawa, Canada)** - CHU operates continually H24 on 3330, 7335 and 14,670 kHz (SSB) and provides UTC (voice) once every minute (English even minutes, French odd minutes).
- **BBC - British Broadcasting Corporation** transmits the Greenwich time signal (referenced to UTC) once every hour on most frequencies.

**Class I vs. Class II Navigation**

**Definitions**

To comprehend the FAA’s definition of Class I or Class II navigation, we must first understand the concept of operational service volume. Operational service volume is the volume of airspace surrounding an ICAO standard airways navigation facility that is available for operational use. Within that area, a signal of usable strength exists and conforms to flight inspection signal strength and course quality standards, including frequency protection. This describes a three-dimensional volume of airspace. ICAO standard NAVAIDs are VOR, VOR/DME and NDB. Global Navigation Satellite System (GNSS) is also an approved ICAO NAVAID and is applicable in both Class I and Class II navigation areas. Class I navigation is any en route flight operation that is entirely within operational service volumes of ICAO standard NAVAIDs.

Class II navigation is any en route operation not categorized as Class I navigation and includes any operation, or portion of an operation, that takes place outside the operational service volumes of ICAO standard NAVAIDs. Class II navigation involves operations conducted in areas where the signals in space from ICAO standard NAVAIDs do not meet flight inspection signal strength, course quality, and frequency protection standards. Class II navigation includes transoceanic operations and operations in desolate/remote land areas. Operators must use long-range navigation systems (LRNS) (GNSS, LORAN-C, and Inertial Reference System (IRS). Other approved procedures may include dead reckoning (DR), pilotage or flight navigator.

**Long-Range Navigation via Inertial Navigation System**

Inertial Reference Units (IRUs) are self-contained systems comprised of gyros and accelerometers that provide aircraft attitude (pitch, roll, and heading), position, and velocity information in response to signals resulting from inertial effects on system components. The basic principle behind inertial navigation is a continuously running Dead Reckoning (DR) plot starting from a known point. Present Position is calculated from the direction and speed traveled since starting navigation.
INS combines the components of an IRU with an internal navigation computer. By programming a series of waypoints, these systems will navigate along a predetermined track. Once aligned with a known position, IRS’s continuously calculate position and velocity. Accelerations are detected by the three linear accelerometers. Changes in vector direction are detected as sensors detect changes in gyroscope orientation, correction signals are generated to reorient the stable platform to the original position and determine new vector direction. INS requires no other inputs. It avoids all environmental inputs, such as indicated or true airspeed, magnetic heading, drift, and winds that are necessary for dead reckoning.

IRS position accuracy decays with time and are not self-correcting. This degradation is known as “drift.” INS maintains its accuracy for short flights without position updates; however, longer flights may require periodic inflight updates. It is possible to introduce errors in an attempt to improve accuracy by in-flight updating. During preflight, care should be taken and SOP’s established to ensure that pilots insert the accurate present position information into the INS. Most INSs will automatically detect large errors in present position during alignment. Large errors in present position longitude may exist without activating a warning indication.

When cross-checking present position coordinates, be alert for the correct hemispheric indicator (that is, N., S., E., W.) as well as the correct numerical values. If large tracking errors occur, they may significantly degrade aircraft safety and separation criteria. As a guide to flightcrews, some operators consider that unless the ground facility provides a precise check and unless the error is fairly significant (for example, more than 6 NM or 2 NM/hour), it is preferable to retain the error rather than update.

The operating checklists and SOP’s should include a means of ensuring that the INS is ready to navigate and that the operator activated the navigation mode prior to moving the aircraft. Any movement of the aircraft prior to activating the navigation mode may induce very large errors that only ground realignment can correct. After placing the system in the navigation mode, check the INS groundspeed when the aircraft is stationary. An erroneous reading of more than a few knots may indicate a faulty or less reliable unit. If this occurs, check the malfunction codes.

**Long-Range Navigation via Global Positioning System/GNSS**

The Global Positioning System is a satellite–based radio navigation system, which broadcasts a signal that is used by receivers to determine precise position anywhere in the world. The receiver tracks multiple satellites and determines a pseudo-range measurement that is then used to determine the user location. A minimum of four satellites is necessary to establish an accurate three-dimensional position. Deployment of the NAVSTAR GPS constellation of satellites began with the first launch in 1977.
Other space-based systems such as Russian GLONAS, or the forthcoming EU Galileo system all function on the same principles. The Department of Defense (DOD) is responsible for operating the GPS satellite constellation and monitors the GPS satellites to ensure proper operation.

By measuring the difference between signal transmission and reception times and multiplying that time interval by the speed of light, range to the satellite can be determined. In a general sense, this is very similar to the way TACAN DME functions, with one important difference. TACAN DME is an active system, a signal must be sent from the aircraft to the selected TACAN ground station. GPS is a passive system; no signal is transmitted by the aircraft avionics to the satellite.

With two satellites in view, the user’s position is somewhere on the circle representing the intersection of two spheres. A third satellite provides an additional sphere of position whose intersection with the other two defines a three-dimensional navigation fix with timing errors. A fourth allows us to eliminate most of the timing errors. The GPS/GNSS receiver verifies the integrity (usability) of the signals received from the GPS constellation through receiver autonomous integrity monitoring (RAIM) to determine if a satellite is providing corrupted information. RAIM is necessary since delays of up to two hours can occur before an erroneous satellite transmission can be detected and corrected by the satellite control segment. The RAIM function is also referred to as fault detection.

At least one satellite, in addition to those required for navigation, must be in view for the receiver to perform the RAIM function. RAIM needs a minimum of 5 satellites in view, or 4 satellites and a barometric altimeter (baro-aiding) to detect an integrity anomaly. Another capability, fault exclusion, refers to the ability of the receiver to exclude a failed satellite from the position solution. When GNSS equipment is not using integrity information from Wide-Area Augmentation Signal (WAAS) or Local-area Augmentation System (LAAS), the GPS navigation receiver using RAIM provides GPS signal integrity monitoring. RAIM needs 6 satellites in view (or 5 satellites with baro-aiding) to isolate the corrupt satellite signal and remove it from the navigation solution.

This is called Fault Detection and Exclusion (FDE). FDE is the capability of GPS to detect a satellite failure that affects navigation and automatically excludes that satellite from the navigation solution. All operators using GPS as the only LRNSs when Class II navigation requires two LRNSs must utilize an FAA-approved FDE prediction program for the installed GPS equipment that is capable of predicting, prior to departure, the maximum outage duration of the loss of fault exclusion, the loss of fault detection, and the loss of navigation function for flight on a specified route.

This FDE prediction program must use the same FDE algorithm employed by the installed GPS equipment and must provide the capability to manually designate satellites that are scheduled to be unavailable. The status of GPS satellites is broadcast as part of the data message transmitted by the GPS satellites. GPS status information is also available by means of the U.S. Coast Guard navigation information service, Notice to Airmen (NOTAM) system.

Prior to departure, the operator must use the FDE prediction program to demonstrate that there are no outages in the capability to navigate the specified route of flight and the FDE prediction program determines whether the GPS constellation is robust enough to provide a navigation solution for the specified route of flight. Any predicted satellite outages that affect the capability of GPS equipment to provide the navigation function on the specified route of flight requires cancellation, delay, or rerouting of the flight.
For Class II navigation requiring the use of two LRNSs, a single GPS IFR authorized navigation system in conjunction with another approved LRNS; such as an inertial system is commonplace. If using two GPS IFR systems for both of the required LRNSs, a fault detection and exclusion (FDE) availability prediction for both GPS units is required to be satisfactorily accomplished prior to approved flight. Once the navigation function is verified and the equipment can navigate on the specified route of flight, the operator must use the FDE prediction program to demonstrate that the maximum outage of the capability of the equipment to provide fault exclusion for the specified route of flight does not exceed the acceptable duration.

The acceptable FDE outage duration is equal to the time it would take to exit the protected airspace, assuming a 35 NM per hour cross-track navigation system error growth rate when starting from the center of the route. For example, a 60 NM lateral separation minimum yields 51 minutes acceptable duration (30 NM divided by 35 NM per hour). If the fault exclusion outage exceeds the acceptable duration, the operator must cancel, delay, or re-route the flight.

A critical aspect of any GPS installation is the installation of the antenna. Shadowing by the aircraft structure can adversely affect the operation of the GPS equipment. Electrical noise or static in the vicinity of the antenna can adversely affect the performance of the system. The operator must ensure that they properly install and maintain the equipment. No special maintenance requirements, other than the standard practices currently applicable to navigation or landing systems, are unique to GPS.

**International Measurement Units**

**United States and the Federal Aviation Administration**

The United States uses “Customary Units” as a system of measurements commonly used in the United States. Many U.S. units are virtually identical to their imperial counterparts. The U.S. does not primarily use “Standard Units” otherwise referred to as Metric. Aviation has undergone a significant amount of conversion to SI units of measure. The United States converted to the METAR for weather reporting temperature in 1996. Aviation and Maritime transportation use Nautical miles and Knots to describe distances and speed. These are non-SI unit accepted for use in the SI.

**International Civil Aviation Organization, Annex 5**

The name SI is derived from “Système International d’Unités”. The system evolved from units of length and mass (metre and kilogram), which were created by members of the Paris Academy of Sciences and adopted by the French National Assembly in 1795. The original system became known as the metric system. This term is now often used as a synonym for "SI". ICAO uses Nautical miles and Knots to describe distances and speed for aviation definitions. US “Feet” has almost worldwide acceptance for use in measuring vertical displacement. These are non-SI unit accepted for use in the SI.

**Conversions**

ICAO Annex 5 has a ready source of conversion factors for translating from US to Metric. The factors are written as a number greater than 1 and less than 10 with six or less decimal places. For example, to convert Knots to Meters/Second; multiply the Knots by .5144444.
Aeronautical Charts

Basic Construction Principles

A map or chart is a small-scale representation on a plane of the surface of the earth or some portion of it. The chart projection forms the basic structure on which a chart is built and determines the fundamental characteristics of the finished chart. There are many difficulties that must be resolved when representing a portion of the surface of a sphere upon a flat plane. Two of these are distortion and perspective. Distortion cannot be entirely avoided, but it can be controlled and systematized to some extent in the drawing of a chart. Surfaces that can be spread out in a plane without stretching or tearing, such as a cone or cylinder, are called developable. Surfaces, and those like the sphere or spheroid that cannot be formed into a plane without distortion are called non-developable. The ideal chart projection would portray the features of the earth in their true relationship to each other. On a flat chart, it is impossible to preserve constant scale and true direction in all directions at all points.

The characteristics most commonly desired in a chart projection are conformality, constant scale, great circles as straight lines, rhumb lines as straight lines, true azimuth, and geographic position easily located. Conformality means the scale at any given point is, for a short distance, equal in all directions. For conformality, the outline of areas on the chart must conform in shape to the feature being portrayed.

Since the meridians and parallels of earth intersect at right angles, the longitude and latitude lines on all conformal projections must exhibit this same perpendicular characteristic. This facilitates the plotting of points by geographic coordinates. The property of constant scale throughout the entire chart is but impossible to obtain as it would require the scale to be the same at all points and in all directions throughout the chart.

The rhumb line and the great circle are the two curves that a pilot might wish to have represented on a map as straight lines. The only projection that shows all rhumb lines as straight lines is the Mercator. The only projection that shows all great circles as straight lines is the gnomonic projection. However, this is not a conformal projection and cannot be used directly for obtaining direction or distance. No conformal chart represents all great circles as straight lines.

The Mercator projection is constructed by means of a mathematical transformation and cannot be obtained directly by graphical means. The distinguishing feature of the Mercator projection among cylindrical projections is: At any latitude the ratio of expansion of both meridians and parallels is the same, preserving the relationship existing on the earth. This expansion is equal to the secant of the latitude, with a small correction for the ellipticity of the earth. Since expansion is the same in all directions and since all directions and all angles are correctly represented, the projection is conformal.
Rhumb lines appear as straight lines and their directions can be measured directly on the chart. Distance can also be measured directly, but not by a single distance scale on the entire chart. Great circles appear as curved lines, concave to the equator or convex to the nearest pole. The shapes of small areas are very nearly correct, but are of increased size unless they are near the equator.

The Mercator projection has the disadvantage that measuring large distances accurately is difficult and pilots must apply conversion angle to great circle bearing before plotting. This projection is useless above 80° N or below 80° S since the poles cannot be shown.

Aeronautical charts are produced on many different types of projections. Since the demand for variety in charts is so great and the properties of the projections vary greatly, there is no one projection satisfying all navigation needs. The projection that most nearly answers all of the navigator’s problems is the Lambert conformal, and this projection is the one most widely used for aeronautical charts. An aeronautical chart of some projection and scale can be obtained for any portion of the earth.

The Lambert Conformal Conic Projection is of the conical type in which the meridians are straight lines that meet at a common point beyond the limits of the chart and parallels are concentric circles, the center of each being the point of intersection of the meridians. Meridians and parallels intersect at right angles. Angles formed by any two lines or curves on the earth’s surface are correctly represented. The projection may be developed by either the graphic or mathematical method.

The chief use of the Lambert Conformal Conic Projection is in mapping areas of small latitudinal width but great longitudinal extent. No projection can be both conformal and equal area but, by limiting latitudinal width, scale error is decreased to the extent the projection gives very nearly an equal area representation in addition to the inherent quality of conformality. This makes the projection very useful for aeronautical charts. Advantages of the Lambert conformal conic projection are: Great circles are approximated by Rumb “straight” lines, areas of small latitudinal width, and scale is nearly constant. Positions are easily plotted and read in terms of latitude and longitude and distance may be measured quite accurately.

Obviously, charts are much smaller than the area they represent. The ratio between any given unit of length on a chart and the true distance it represents on the earth is the scale of the chart. The scale varies, and may vary greatly from one part of the chart to another. Charts are made to various scales for different purposes. If a chart is to show the whole world and yet not be too large, it must be drawn to small scale. If a chart is to show much detail, it must be drawn to a large scale; then it shows a smaller area than does a chart of the same size drawn to a small scale.
The scale of a chart may be given by a simple statement, such as 1-inch equals 10 miles. On aeronautical charts, the scale is indicated in one of two ways: representative fraction or graphic scale. The scale may be given as a representative fraction, such as 1:500,000 or 1/500,000. This means one of any unit on the chart represents 500,000 of the same unit on the earth. The graphic scale may be shown by a graduated line. It usually is found printed along the border of a chart.

Take a measurement on the chart and compare it with the graphic scale of miles. The number of miles the measurement represents on the earth may be read directly from the graphic scale on the chart. The distance between parallels of latitude also provides a convenient scale for distance measurement. One degree of latitude always equals 60 NM and 1 minute of latitude always equals 1 NM.

Symbols are used for easy identification of information portrayed on aeronautical charts. While these symbols may vary slightly between various projections, the amount of variance is slight and, once the basic symbol is understood, variations of it are easy to identify. A chart legend is the key to explaining the meaning of the relief, culture, hydrography, vegetation, and aeronautical symbols.

**Federal Aviation Administration, FAA Charts**

**Tactical Pilotage Charts (TPC Charts)**
The Tactical Pilot Chart is designed for high-speed, low-altitude radar, and visual navigation. Information includes visual and radio aids to navigation, airports, Airways, restricted areas, obstructions and other pertinent data for aircraft from low to medium altitudes. It is designed to assist close air operations by providing visual and radar navigation information.

**Jet NavigationCharts (JNC Charts)**
The primary purpose of the Jet Navigation Chart is to support high-altitude strategic aircraft. Information considerations are selected to support celestial, radar, and dead reckoning navigation. The topographical information includes city tints, principal roads, railroads, distinctive landmarks, drainage patterns and relief.

**World Aeronautical Chart (WAC).**
WACs cover land areas for navigation by moderate speed aircraft operating at high altitudes. The FAA has stopped production of these charts in 2015.

**North Pacific Route Charts**
These charts are designed for FAA controllers to monitor transoceanic flights. They show established intercontinental air routes, including reporting points with geographic positions. Commonly used by pilots for plotting purposes.

**North Atlantic Route Chart**
Designed for FAA controllers to monitor transatlantic flights, this 5–color chart shows oceanic control areas, coastal navigation aids, oceanic reporting points, and NAVAID geographic coordinates. Commonly used by pilots for plotting purposes.
Airport/Facility Directory (A/FD)
This is a 7-volume (light green colored) booklet series contains data on airports, seaplane bases, heliports, NAV-AIDs, communications data, weather data sources, airspace, special notices, and operational procedures. Coverage includes the conterminous U.S., Puerto Rico, and the Virgin Islands. The A/FD shows data that cannot be readily depicted in graphic form like airport hours of operations, types of fuel available, runway widths, lighting codes, etc.

Chart Supplement Alaska.
This is a civil/military flight information publication issued by FAA every 56 days. It is a single volume (salmon colored) booklet designed for use with appropriate IFR or VFR charts. The Supplement Alaska contains an A/FD, airport sketches, communications data, weather data sources, airspace, listing of navigational facilities, and special notices and procedures.

Chart Supplement Pacific
This supplement is designed for use with appropriate VFR or IFR enroute charts. Included in this one-volume (light blue colored) booklet are the A/FD, communications data, weather data sources, airspace, navigational facilities, special notices, and Pacific area procedures. IAP charts, DP charts, STAR charts, airport diagrams, radar minimums, and supporting data for the Hawaiian and Pacific Islands are included.

International Civil Aviation Organization, ICAO Charts
Even though a country is an ICAO member nation, it may not fully comply with all ICAO technical manuals. ICAO Annex 15 directs ICAO member nations to identify in their Aeronautical Information Publication, (AIP) all exceptions to ICAO Standards And Recommended Practices, (SARPs.) The short story, an individual State can do as they wish inside their borders and does NOT “have to” publish any notice of the differences with ICAO.

Since November 2010 Contracting States to ICAO should be standardized as to charting symbology, colors and naming conventions. Contracting States are to provide all information relating to its own territory that is necessary to enable the Standards of ICAO Annex 4 to be met. This means that ICAO countries are to ensure the availability of charts in whichever of the following ways is appropriate for a particular chart or single sheet of a chart series. This includes the availability of charts in electronic format.

➢ Produce the chart or sheet itself; or
➢ Arrange for its production by another Contracting State or by an agency; or
➢ Provide another Contracting State prepared to accept an obligation to produce the chart or sheet with the data necessary for its production.

Country Specific Charts
NAV CANADA has recently purchased an aeronautical database system designed specifically for this purpose and compliant with International Civil Aviation Organization (ICAO) standards. Aeronautical data that was formerly held in a number of diverse databases has been migrated to this new system. This has provided the opportunity to screen and revalidate the data and resolve any inconsistencies. The VFR Navigation Chart (VNC) is used by VFR pilots on short to extended cross-country flights at low to medium altitudes and at low to medium airspeeds. The chart displays aeronautical information and sufficient topographic detail to facilitate air navigation through the use of a unique color scheme, layer tinting, and shaded relief.
Enroute Low Altitude charts (LO) depict aeronautical radio information, airways system, controlled/uncontrolled airspace structure, special use airspace, communication stations and selected aerodromes. Vertical coverage is from the surface up to, but not including 18,000’ MSL.

Enroute High Altitude charts (HI) depict aeronautical navigation information, airways system, special use airspace, and communication stations critical for flight in the high level structure. Vertical coverage is from 18,000’ MSL and above.

**Commercial Providers**

Many commercial providers of charts are available to the international pilot. Concerns over data verification and types of information presented to the pilot are valid. Due diligence should be exercised and reputable sources sought.

**Navigation Log, Preparation and Usage**

In its simplest form this is a record of the time, distance and heading to the next waypoint. A “Nav Log” is usually part of a computerized flight plan and under normal circumstances is a logical and systematic tracking the flight’s progress and recording the data. This information is then kept with the plotting chart as part of the Journey Logbook. Abnormal situations such as an oceanic re-route or a long-range navigation failure can drive the pilot to manually complete a navigation log and/or use the data derived for DR navigation. Many different forms for this are available for this purpose. One such header is depicted above here and can be found in Appendix A. Similar to what you did in “Pilot Training 101” proper completion of a Navigation Log requires certain information on the routing.

Start with your oceanic crossing clearance. The clearance is made up of three parts route, altitude and an assigned Mach number or filed True Air Speed. Below here is a list of information needed to complete the Navigation Log and usual places to find the information.

<table>
<thead>
<tr>
<th>Data Item</th>
<th>Location</th>
</tr>
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<tbody>
<tr>
<td>Waypoint coordinates</td>
<td>Oceanic Clearance</td>
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<tr>
<td>Distance between waypoints</td>
<td>Plotting Chart or FMS</td>
</tr>
<tr>
<td>True course</td>
<td>Plotting Chart or FMS</td>
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<tr>
<td>Magnetic variation</td>
<td>Plotting Chart, Orientation Chart or FMS</td>
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<tr>
<td>Cruise altitude</td>
<td>Oceanic Clearance</td>
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<tr>
<td>Temperature at altitude</td>
<td>Winds Aloft Chart or Aircraft Direct Reading</td>
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<tr>
<td>Winds at cruise altitude</td>
<td>Winds Aloft Chart or FMS</td>
</tr>
<tr>
<td>True airspeed</td>
<td>Oceanic Clearance or filed TAS</td>
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<tr>
<td>Drift correction</td>
<td>CR2/E6B Computer or Calculator</td>
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<tr>
<td>Headwind or tailwind component</td>
<td>CR2/E6B Computer or Calculator</td>
</tr>
<tr>
<td>Groundspeed</td>
<td>CR2/E6B Computer or Calculator</td>
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</tbody>
</table>
Route
The route will give you the waypoint coordinates. These can be extracted from the FMS or by plotting them on the plotting chart. Enter the waypoint FMS names on the Navigation Log for each leg of the crossing. The next step is to find the average Magnetic Heading. Start with the True Course between individual leg waypoints. This is easily done using your plotting chart. To average the True Course changes over a long distance, measure the true course at the midpoint between two waypoints. Enter this information into the block on the right-side of the navigation log form. After the True course is found, determine the variation at the midpoint between the waypoints defining the route. Apply this to the True Course to find Magnetic Course. Note this number for the next step.

Using the wind side of a CR-2/E-6B computer or electronic calculator find the Wind Correction Angle and headwind/tailwind component for the leg. Be sure to use the TAS for your True Mach number and winds/temp for the cleared altitude. Apply the wind drift correction to the magnetic course found above and you have the Average Magnetic Heading. Enter this information into the block on the right-side of the navigation log form.

Altitude and Speed
At your cleared altitude, determine the temperature and winds for each leg from the winds aloft chart and use the assigned Mach number (or filed TAS if not assigned a Mach Number). From the last step in the “Route” section, the headwind/tailwind component calculated there can be applied to TAS to find the Ground Speed. Use this speed to estimate the time enroute between the waypoints and fuel consumption.

Plotting Chart, Requirements and Usage
A simple plotting chart provides a visual presentation of the intended route which, is defined otherwise only in terms of navigational co-ordinates. Plotting the intended route on a chart may reveal errors and discrepancies in the navigational co-ordinates which can then be corrected immediately. As the flight progresses, plotting the aircraft’s present position on this chart will also serve the purpose of a navigation cross check, provided that the scale is suitable.

During flight in Class II navigation, each operator’s long-range navigation program (LRNP) will require the standardized application of disciplined, systematic cross-checking of navigation information. For example The plotting chart must include, at a minimum: The route of the currently effective ATC clearance, clearly depicted waypoints using standardized symbology and plotted positions at least once and hour. It is useful and common to include graphic depictions of all ETPs. This plotting is usually accomplished 10minutes or 2” after passing each oceanic waypoint so as to capture and mitigate any deviation before 25NM (Gross Navigation Error defined).
FAA Advisory Circular AC 91-70A sets forth a method of compliance in turbojet operations, where the route segment between the operational service volume of ICAO standard ground-based NAVAIDs exceeds 725 NM, require plotting procedures. Turboprop operations, where the route segment between the operational service volume of ICAO standard ground-based NAVAIDs exceeds 450 NM, require plotting procedures. Please see Chapter 11 for a detailed discussion of plotting.

The FAA requires crews to reliably fix their position once each hour while in Class II Navigation. The most common method to comply with this is to use a plotting chart. Regardless of the type of LRNS in use, plotting the route will increase SA and thru a visual presentation of the intended route, reveal errors or discrepancies in the navigational coordinates. Pilots can then correct the problems before such errors can cause a deviation from the ATC cleared route. As the flight progresses, plotting the position approximately 10 minutes after passing each waypoint helps confirm that the flight is on course. If the plotted position indicates off track, the flight may have deviated unintentionally and the flight crew should investigate at once.
1. Sample Navigation/Communication Log
2. Visibility/Temperature and ROC Wind Speed Conversions
3. Sample ICAO Flight Plan Form
4. Weather Deviation Guide
5. General Oceanic/Remote Procedures Guide
6. Sample International Trip Planning Guide
7. PANS-Ops vs. TERPS Cockpit Guide
<table>
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<tr>
<th>&quot;ATC Clears Callign&quot;</th>
<th>&quot;To&quot;</th>
<th>&quot;Via&quot;</th>
<th>&quot;FLT LEVEL: MACH DECIMAL&quot;</th>
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<th>HF Primary Frequency</th>
<th>HF Alternate Frequency</th>
<th>SELCAL Check</th>
<th>NAV ACCURACY CHECK ENTRY</th>
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<td>NAV ACCURACY CHECK EXIT</td>
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*Reference ICAO Annex 5, FAA AIM, USAF Pamphlet 11-

| Rate of Climb/Descent, Windspeed |
|---|---|---|
| Feet per Minute | Meters per Second | Knots |
| 100 | 0.51 | 1 |
| 200 | 1.02 | 2 |
| 300 | 1.52 | 3 |
| 400 | 2.03 | 4 |
| 500 | 2.54 | 5 |
| 600 | 3.05 | 6 |
| 700 | 3.56 | 7 |
| 800 | 4.06 | 8 |
| 900 | 4.57 | 9 |
| 1000 | 5.08 | 10 |
| 1100 | 5.59 | 11 |
| 1200 | 6.10 | 12 |
| 1300 | 6.60 | 13 |
| 1400 | 7.11 | 14 |
| 1500 | 7.62 | 15 |
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| 1700 | 8.64 | 17 |
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| 1900 | 9.65 | 19 |
| 2000 | 10.16 | 20 |
| 2100 | 10.67 | 21 |
| 2200 | 11.18 | 22 |
| 2300 | 11.68 | 23 |
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| 2600 | 13.21 | 26 |
| 2700 | 13.72 | 27 |
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| 2900 | 14.73 | 29 |
| 3000 | 15.24 | 30 |
| 3500 | 17.78 | 35 |
| 4000 | 20.32 | 40 |
| 4500 | 22.86 | 45 |
| 5000 | 25.40 | 50 |
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