Geographical Reference System (GREFS)

Time, distance, direction, speed, and location are all based on a reference to two points, the north and south poles of the earth. This reference system is a standard to be used for measurement no matter where you are, in the city or in the country, on land or on water, in the air or on the ground, or what you are doing (traveling, planning, or budgeting).

Any measurement needs a reference system. Business models and databases are measurements and reference systems, plans and budgets are measurements and reference systems. A good measurement needs a reference system.

Navigation Model[1]

Time, distance, direction, speed, and location

Intro

Basic to the study of navigation is an understanding of certain terms which could be called the dimensions of navigation. These so-called dimensions of position, direction, distance, and time are basic references used by the air navigator. A clear understanding of these dimensions as they relate to navigation is necessary to provide the navigator with a means of expressing and accomplishing the practical aspects of air navigation. These terms are defined as follows:

- **Position**

Position is a point defined by stated or implied coordinates. Though frequently qualified by such adjectives as “estimated,” “dead reckoning,” “no wind,” and so forth, the word “position” always refers to some place that can be identified. It is obvious that a navigator must know his position before he can direct the aircraft to another position or in another direction.

- **Direction**

Direction is ht position of one point in space relative to another without reference to the distance between them. Direction is not in itself an angle, but it is often measured in terms of its angular distance from a reference direction.

- **Distance**

Distance is the spatial separation between two points and is measured by the length of a line joining them. On a plane surface, this is a simple problem. However, consider distance on a sphere, where the separation between points may be expressed as a variety of curves. It is essential that the navigator decide exactly “how” the distance is to be measured. The length of the line, once the path or direction of the line has been determined, can be expressed in various units; e.g., miles, yards, and so forth.

[1] AFM 51-40, Navair 00-80V-49, Flying Training Air Navigation, 1July 1973, Departments of the Air Force and the Navy

Graphical Reference Systems

- **Time**

Time is defined in many ways, but those definitions used in navigation consist mainly of two: (1) the hour of the day and (2) an elapsed interval.

The methods of expressing position, direction, distance, and time are covered fully in appropriate chapters. It is desirable at this time to emphasize that these terms, and others similar to them, represent definite quantities or conditions which may be measured in several different ways. For example, the position of an aircraft may be expressed in coordinates such as at certain latitude and longitude. The position may also be expressed as being 10 miles south of a certain city. The study of navigation demands that the navigator learn how to measure quantities such as those just defined and how to apply the units by which they are expressed.

Earth's Size and Shape

For most navigational purposes, the earth is assumed to be a perfect sphere, although in reality it is not. Inspection of the earth's crust reveals that there is a height variation of approximately 12 miles from the top of the tallest mountain to the bottom of the deepest point in the ocean. Smaller variations in the surface (valleys, mountains, oceans, etc.) cause an irregular appearance.

Measured at the equator, the earth is approximately 6,887.91 nautical miles in diameter, while the polar diameter is approximately 6,864.57 nautical miles. The difference I the se diameters is 23.34 nautical miles, and this difference may be used to express the ellipticity of the earth. It is sometimes expressed as a ratio between the difference and the equatorial diameter:

Ellipticity = 22.34 over 6,887.91 = 1 over 295.

Since the equatorial diameter exceeds the polar diameter by only 1 part in 295, the earth is very nearly spherical. A symmetrical body having the same dimensions as the earth, but with a smooth surface, is called an oblate spheroid.

Location

The nature of a sphere is such that any point on it is exactly like any other point. There is neither beginning or ending as far as differentiation of points is concerned. In order that points may be located on the earth, some points or lines of reference are necessary so that other points may be located with regard to them. Thus the location of New York City, with reference to Washington DC, is stated as a number of miles in a certain direction from Washington. Any point on the earth can be located in this manner.

Such a system, however, does not lend itself readily to navigation, for it would be difficult to locate a point precisely in mid-Pacific without any nearby known geographic features to use for reference. A system of coordinates has been developed to locate positions on the earth by means of imaginary reference lines. These lines are known as parallels of latitude and meridians of longitude.

Once a day, the earth rotates o its north-south axis which is terminated by the e two poles. The equator is constructed at the midpoint of this axis at right angles to it. A great

circle drawn through the poles is called a meridian and an infinite number of great circles may be constructed in this manner. Each meridian is divided into four quadrants by the equator and the poles. Since a circle is arbitrarily divided into 360 degrees, each of these quadrants therefore contains 90 degrees.

Take a point on one of these meridians 30 degrees north of the equator. Through this point pass a plane perpendicular to the north-south axis of rotation. This plane will be parallel to the plane of the equator or will intersect the earth in a small circle called a parallel or parallel of latitude. The particular parallel of latitude chosen is at 30N, and every point on this parallel will be at 30N. In the same way other parallels can be constructed at any desired latitude, such as 10 degrees, 40 degrees, etc.

Bear in mind that the equator is drawn as the great circle midway between the poles, that the parallels of latitude are small circles constructed with reference to the equator, and that there are definitely located small circles parallel to the equator. The angular distance measured on a meridian north or south of the equator is known as latitude and forms one component of the coordinate (?) system.

Longitude. The latitude of a point can be sown as 20 N or 20 S of the equator, but there is no way of knowing whether one point is east or west of another. This difficulty is resolved by use of the other component of the coordinate system, longitude, which is the measurement of this east-west distance.

There is not, as with latitude, an natural starting point for numbering. such as the equator. The solution has been to select an arbitrary starting point. A great many places have been used, but when the English speaking people began to make charts, they chose the meridian through their principal observatory in Greenwich, England, as the origin for counting longitude, and this point has now been adopted by most other countries of the world. This Greenwich meridian is sometimes called the prime or first meridian, though actually it is the zero meridian. Longitude is counted east and west from this meridian through 180 degrees. Thus, the Greenwich meridian is the 0 degree longitude on one side of the earth, and after crossing the poles, it becomes the 180th meridian, (180 degrees east or west of the 0-degree meridian).

Summary. If a globe has the circles of latitude and longitude drawn upon it according to the principles described, and the latitude and longitude of a certain place have been determined by observation, this point can be located on he globe in its proper position. In this way, a globe can be formed that resembles a small scale copy of the spherical earth .

It may be well to point out here some of the measurements used in the coordinates system. Latitude is expressed in degrees up to 90, and longitude is expressed in degrees up to 180. the total number of degrees in any one circle can not exceed 360. A degree of arc 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. Measurement may also be made, if desired, in degrees, minutes, and tenths of minutes.

A position on the surface of the earth is expressed in terms of latitude and longitude. Latitude is expressed as being either north or south of the equator, and longitude as either east or west of the prime meridian.

Distance

Distance as previously defined is measured by the length of a line joining two points. In navigation the most common unit for measuring distances is the nautical mile. For most practical navigation purposes, all of the following units are used interchangeably as the equivalent of one nautical mile:

- 6,076.10 feet (nautical mile).
- One minute of arch of a great circle on a sphere having an area equal to that of the earth.
- 6,087.08 feet. One minute of arc on the earth's equator (geographic mile).
- One minute of arc on a meridian (one minute of latitude).
- Two thousand yards (for short distances).

Navigation is done in terms of nautical miles. However, it is sometimes necessary to convert statute and nautical miles. This conversion is easily made with the following ratio: In a given distance: Number of statute miles over number of nautical miles = 76 over 66.

Speed

Closely related to the concept of distance is speed, which determines the rate of change of position. Speed is usually expressed in miles per hour, this being either statute miles per hour or nautical miles per hour. if the measure of distance is nautical miles, it is customary to speak of speed in terms of knots. Thus, a speed of 200 knots and a speed of 200 nautical miles per hour are the same thing. It is incorrect to say 200 knots per hour unless referring to acceleration.

Direction

Remember that direction is the position of one point in space relative to another without reference to the distance between them. The time-honored point system for specifying a direction as north , north-northwest, northwest, west-northwest, west, etc., is not adequate for modern navigation. It has been replaced for most purposes by a numerical system.

The numerical system divides the horizon into 360 degrees starting with north as 000 degrees, and continuing clockwise through east 090 degrees, south 180 degrees, west 270 degrees, and back to north.

The circle, called a compass rose, represents the horizon divided into 360 degrees. The nearly vertical lines in the illustration are meridians drawn as straight lines with the meridian of position A passing through 000 degrees and 180 degrees of the compass

rose. Position B lies as a true direction of 062 degrees from A, and position C is at a true direction of 295 degrees from A.

Since determination of direction is now of the most important parts of the navigator's work, the various terms involved should be clearly understood. Generally, in navigation unless otherwise stated, all directions are called true directions.

- Course is the intended horizontal direction of travel.
- Heading is the horizontal direction in which an aircraft is pointed.
- Track is the actual horizontal direction made.
- Bearing is the horizontal direction of one terrestrial point from another. Bearings are usually expressed in terms of one of two reference directions (1) true north, or (2) the direction in which the aircraft is pointed. If true north is the reference direction, the bearing is called a true bearing. If the reference direction is the heading of the aircraft, the bearing is called a relative bearing.

Time

Defined two ways

Time is defined in many ways, but those definitions used in navigation consist mainly of two: (1) the hour of the day and (2) an elapsed interval.

Measurement

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Business Model - An Extended Navigation Model

Measurement

Measurement is just as important in managing a business as it is in navigation. Businesses share measurement standards with navigation, which can be extended to provide complete business measurement standards, or a complete "business modeling standard".

Integration

Business models are composed of many views of a business; from sales and marketing to production operations to planning and control to accounting and forecasting. A business modeling standard will integrate these views like the measurements in navigation are integrated. For example: a mile is one minute on the circle between the north and south poles, or one minute on the equator, or 2,000 yards. From yards we get

to feet and inches, and from minutes we get to hours and days. Businesses measurement is very similar to measurements in navigation. Businesses also measure time and completion milestones.

Common reference system

Therefore, business measurement requires a common and simple reference system, like the one used for navigation. For the same reason you need a common reference when you are out in the middle of the pacific, far away from any physical reference points, you need to know where you are in relation to things you can't see when making business decisions. Like the reference lines on a map for a specific trip, a common reference system must be integrated into business "navigation".

Same map used for planning and control.

In navigation you plot a specific course on a standard map. Then, as you travel you measure actual time and results and, at the same time, make corrections back to course, using the map to document and communicate the decision. In business you can also model your specific business on a standard map and make corrections to course as you measure time and results, using the business model to generate documents which communicate the decision.

Both navigation and business "maps" include planning and control information. Both are used as planning and control tools. Both include a course plotted through milestones and objectives.

User view of the business model

Like an electronic navigation system which instantly displays a new course into the pilot's view, the business model will generate displays and documents which also communicate a new course.

Extension

Time, distance, direction, speed, and location extended by two "threefold operators", present, past, and future; and, objective, control, and activity; which are mapped to an outline of the business model in standard textbooks.

Time

Past

Objective

Effectiveness measures

Control

Control Measures

Graphical Reference Systems

Activity

Efficiency Measures

Present

Objective

Effectiveness measures

Control

Control Measures

Activity

Efficiency Measures

Future

Objective

Effectiveness measures

Control

Control Measures

Activity

Efficiency Measures

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Business Standards (List) Outlines

Relationship Diagrams

Flow Diagrams

Consolidated Conceptual Model

Data Identity

Data Classification

Data Definitions

System Design/ Re-engineering

Purpose Statement

Matrix mapping back to diagram objects.

Interface/ Distribution Model

Data Warehouse

Data Marts

Middleware

Indexing/ Analysis Model

Outlines

Bookmarks