Postgraduate Certificate in Marine Navigation and Nautical Technology

Satellite and Space-based Navigation Systems

Satellite and Space-based Navigation Systems are essential components of modern marine navigation. These systems use a network of satellites and ground stations to provide accurate position, velocity, and time (PVT) information to users worldwide. In this explanation, we will discuss key terms and vocabulary related to satellite and space-based navigation systems, including Global Navigation Satellite Systems (GNSS), Global Positioning System (GPS), Galileo, GLONASS, Beidou, and Differential GPS (DGPS).

Global Navigation Satellite Systems (GNSS)

GNSS refers to a network of satellites and ground stations that provide global navigation and positioning services. Currently, there are four operational GNSS systems: GPS, Galileo, GLONASS, and Beidou.

Global Positioning System (GPS)

GPS is a satellite-based navigation system operated by the United States government. It provides precise PVT information to users worldwide. The system consists of three segments: space, control, and user. The space segment includes 31 operational satellites in medium Earth orbit (MEO) at an altitude of approximately 20,200 km. The control segment consists of ground stations that monitor and control the satellites. The user segment includes GPS receivers that track the satellites and calculate the user's position.

Galileo

Galileo is the European Union's GNSS system. It provides accurate PVT information to users worldwide. The system consists of 26 operational satellites in MEO at an altitude of approximately 23,222 km. Galileo offers several advantages over GPS, including improved accuracy, availability, and robustness.

GLONASS

GLONASS is Russia's GNSS system. It provides accurate PVT information to users worldwide. The system consists of 24 operational satellites in MEO at an altitude of approximately 19,100 km. GLONASS offers several advantages over GPS, including improved coverage in high latitudes and better signal stability in urban canyons.

Beidou

Beidou is China's GNSS system. It provides accurate PVT information to users worldwide. The system

consists of 30 operational satellites in MEO, geostationary Earth orbit (GEO), and inclined geosynchronous orbit (IGSO) at altitudes ranging from 35,786 km to 58,786 km. Beidou offers several advantages over GPS, including improved accuracy, availability, and compatibility with other GNSS systems.

Differential GPS (DGPS)

DGPS is a technique that improves the accuracy of GPS positioning by using a reference station with a known position to correct GPS errors. The reference station transmits correction messages to GPS receivers in the vicinity, which can then use these messages to improve their positioning accuracy. DGPS can achieve positioning accuracy of better than 1 meter in ideal conditions.

Pseudorange

Pseudorange is the measured distance between a GPS satellite and a GPS receiver. It is called a pseudorange because it is not a true range but rather a measurement that includes errors due to satellite clock bias, ionosphere and troposphere delays, and receiver noise.

Satellite Clock Bias

Satellite clock bias is the difference between the satellite's reported time and the true time. Satellite clocks are subject to errors due to aging, temperature, and other factors. These errors can cause the satellite's reported time to drift, leading to errors in the calculated pseudorange.

Ionosphere and Troposphere Delays

The ionosphere and troposphere are layers of the Earth's atmosphere that can affect GPS signals. The ionosphere, located between 50 and 1000 km above the Earth's surface, contains free electrons that can delay GPS signals. The troposphere, located between 0 and 10 km above the Earth's surface, contains water vapor and other gases that can also delay GPS signals.

Receiver Noise

Receiver noise is the random variation in the GPS receiver's measurements due to thermal and electronic noise. Receiver noise can cause errors in the calculated pseudorange.

Ephemeris

Ephemeris is the precise orbit information for a GPS satellite. It includes the satellite's position, velocity, and clock corrections. The GPS control segment broadcasts ephemeris data to GPS satellites, which then transmit it to GPS receivers.

Almanac

Almanac is coarse orbit information for all GPS satellites. It includes the satellite's approximate position, clock corrections, and ionosphere and troposphere delay information. The GPS control segment broadcasts almanac data to GPS satellites, which then transmit it to GPS receivers.

Satellite Visibility

Satellite visibility is the ability of a GPS receiver to see and track GPS satellites. A GPS receiver typically needs to see at least four satellites to calculate its position. The number of visible satellites depends on several factors, including the user's location, the time of day, and the satellite constellation.

Multipath

Multipath is a phenomenon that occurs when GPS signals are reflected off nearby objects before reaching the GPS receiver. This can cause errors in the calculated pseudorange and lead to positioning errors.

Selective Availability

Selective Availability (SA) is a technique used by the GPS control segment to degrade the accuracy of GPS positioning for unauthorized users. SA introduces intentional errors in the satellite clock bias and ephemeris data, which can reduce the accuracy of GPS positioning to several hundred meters. SA was turned off in 2000, but other techniques, such as Anti-Spoofing (AS), can still degrade GPS accuracy for unauthorized users.

Geodetic Datum

A geodetic datum is a reference system used to define the Earth's shape and orientation. A datum includes a reference ellipsoid, a coordinate system, and a set of reference points. GPS receivers use a geodetic datum to convert GPS coordinates into a local coordinate system.

Wide Area Augmentation System (WAAS)

WAAS is a system that uses a network of ground stations and satellites to improve the accuracy and reliability of GPS positioning. WAAS provides correction messages to GPS receivers in the vicinity, which can then use these messages to improve their positioning accuracy. WAAS can achieve positioning accuracy of better than 1 meter in ideal conditions.

In summary, satellite and space-based navigation systems are essential components of modern marine navigation. These systems use a network of satellites and ground stations to provide accurate PVT

information to users worldwide. Key terms and vocabulary related to satellite and space-based navigation systems include GNSS, GPS, Galileo, GLONASS, Beidou, DGPS, pseudorange, satellite clock bias, ionosphere and troposphere delays, receiver noise, ephemeris, almanac, satellite visibility, multipath, selective availability, geodetic datum, and WAAS. Understanding these concepts is crucial for safe and efficient marine navigation.