# 1559-1610 MHz

## 1. Band Introduction

The 1559-1610 MHz band is a shared band internationally allocated to the radionavigation-satellite service (RNSS) in the space-to-earth and space-to-space directions. Global Navigation Satellite Systems (GNSS) is the standard generic term for radionavigation-satellite systems that provide autonomous geo-spatial positioning with global coverage. The GNSS allows receivers to determine their location (longitude, latitude, and altitude) using signals transmitted from satellites.

The 1575.42 MHz ± 12 MHz frequency is used to transmit the Global Positioning System (GPS) radionavigation-satellite service L1 signal for military, aviation, space, and commercial applications.

The other components of the GNSS that currently or plan to transmit navigation signals in the 1559-1610 MHz band include: the Russian Federation Global Navigation Satellite System, the European Union Galileo, Japan's Quasi Zenith Satellite System, and China's Compass.

The Federal Aviation Administration operates ground reference stations used by the Wide Area Augmentation System (WAAS) developed to augment the GPS, with the goal of improving its accuracy, integrity, and availability. The FAA is also developing the Local Area Augmentation System, an augmentation to GPS that focuses its service on the airport area. The U. S. Coast Guard operates the Nationwide Differential GPS (NDGPS) that broadcast corrections, which can be used by a ground-based GPS receiver to improve accuracy, integrity, and availability of position location.

# 2. Allocations

## 2a. Allocation Table

The frequency allocation table shown below is extracted from the Manual of Regulations & Procedures for Federal Radio Frequency Management, Chapter 4 – Allocations, Allotments and Plans.

***Table of Frequency Allocations***

***United States Table***

| Federal Table | Non-Federal Table | FCC Rule Part(s) |
|---|---|---|
| 1559-1610<br>AERONAUTICAL RADIONAVIGATION<br>RADIONAVIGATION-SATELLITE (space-to-Earth)<br>(space-to-space)<br>5.341 US208 US260 US343 | | Aviation (87) |

## 2b. Additional Allocation Table Information

**5.341** In the bands 1 400-1 727 MHz, 101-120 GHz and 197-220 GHz, passive research is being conducted by some countries in a programme for the search for intentional emissions of extraterrestrial origin.

**US208** Planning and use of the band 1559-1626.5 MHz necessitate the development of technical and/or operational sharing criteria to ensure the maximum degree of electromagnetic compatibility with existing and planned systems within the band.

**US260** Aeronautical mobile communications which are an integral part of aeronautical radionavigation systems may be satisfied in the bands 1559-1626.5 MHz, 5000-5250 MHz and 15.4-15.7 GHz.

**US343** Differential-Global-Positioning-System (DGPS) Stations, limited to ground-based transmitters, may be authorized on a primary basis in the bands 108-117.975 and 1559-1610 MHz for the specific purpose of transmitting DGPS information intended for aircraft navigation. Such use shall be in accordance with ITU Resolution 413 (WRC-03).

# 3. Federal Agency Use

## 3a. Federal Agency Frequency Assignments Table

The following table identifies the frequency band, types of allocations, types of applications, and the number of frequency assignments by agency.

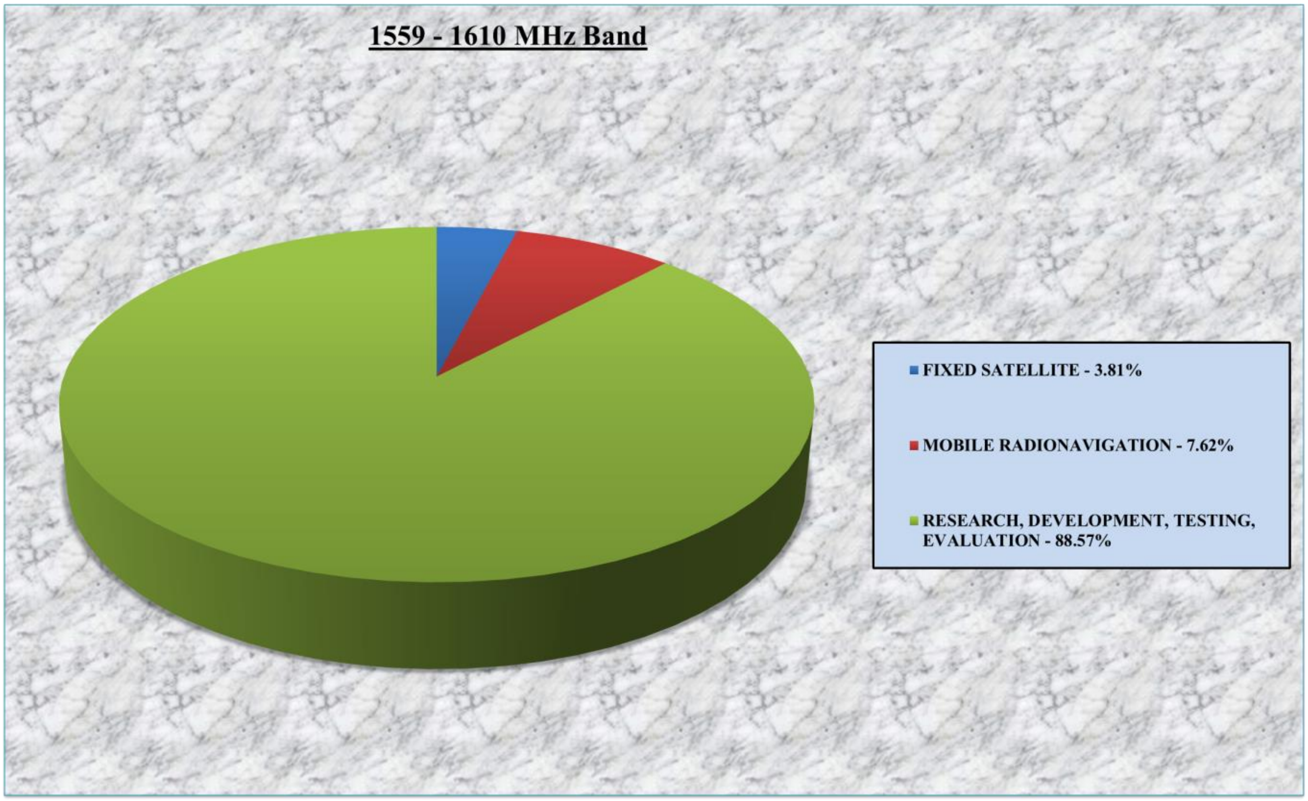
***Federal Frequency Assignment Table***

| 1559-1610 MHz Band | | | | | | | |
|---|---|---|---|---|---|---|---|
| SHARED BAND | | | | | | | |
| | AERONAUTICAL RADIONAVIGATION RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) | | | | | | |
| | TYPE OF APPLICATION | | | | | | |
| AGENCY | RADIONAVIGATION-SATELLITE | MOBILE RADIONAVIGATION | | | | RESEARCH DEVELOPMENT TESTING EVALUATION | TOTAL |
| AF | 2 | 2 | | | | 33 | 37 |
| AR | | | | | | 13 | 13 |
| CG | | | | | | 28 | 28 |
| DOC | 2 | | | | | 1 | 3 |
| FAA | | | | | | 1 | 1 |
| N | | 3 | | | | 16 | 19 |
| NASA | | 1 | | | | 9 | 10 |
| MC | | 2 | | | | 1 | 3 |
| TRAN | | | | | | 1 | 1 |
| TOTAL | 4 | 8 | | | | 103 | 114 |
| The number of actual systems, ornumber of equipments, may exceed and sometimes far exceed, the number of frequency assignments in a band. Also, al frequency assignment may represent, a local, state, regional or nationwide authorization. Therefore, care must be taken in evaluating bands strictly on the basis of assignment counts or percentages of assignments. | | | | | | | |

***Table 1***

### 3b. Percentage of Frequency Assignments Chart

The following chart displays the percentage of assignments for the applications listed in the chart legend below for the frequency band – 1559.0 – 1610.0 MHz. The greatest number of assignments is associated with research, development, testing, and evaluation.




## 4. Frequency Band Analysis By Application

### 4a. Radionavigation-Satellite (Space-to-Earth) Service

The 1559-1610 MHz band is internationally allocated to the radionavigation-satellite service (RNSS) in the space-to-earth and space-to-space directions. Global Navigation Satellite Systems (GNSS) is the standard generic term for radionavigation-satellite systems that provide autonomous geo-spatial positioning with global coverage. The GNSS allows receivers to determine their location (longitude, latitude, and altitude) using signals transmitted from satellites.

As shown in the Table 1 most of the frequency assignments are being used for research and development activities. However, the predominate use of the 1559-1610 MHz band is for the U.S. Global Positioning System (GPS). The Federal and civilian GNSS receivers associated with this system operate throughout the country but do not require a frequency assignment in the Government Master File (GMF). Therefore, they are not reflected in GMF data.

As of 2010, GPS is the only fully operational GNSS.[1] GPS is a dual-use, space-based, radionavigation service that provides access to precise positioning, navigation, and timing (PNT) on a continuous, worldwide basis, regardless of weather conditions. The GPS constellation nominally consists of at least twenty-four satellites in non-geostationary orbit (altitude of 20,200 km) that transmit encrypted signals, which are used by U.S. and allied military forces, and unencrypted signals, which are used worldwide in a myriad of government, public and private infrastructures, public safety, commercial, consumer, and scientific applications, including critical safety-of-life operations. GPS has become an integral component of the global information infrastructure and is being used in non-federal applications such as: aeronautical, maritime, and ground-based navigation; surveying; construction; precision agriculture; timing synchronization (e.g., telecommunications, digital television, power distribution, banking, Internet); emergency medical response and disaster management; and search and rescue operations. Today there are millions of GPS receivers in use around the world.

The Federal Radionavigation Plan provides a detailed description of how the Federal agencies use the GPS service for aviation, maritime, space and land navigation. Non-navigation applications such as geodesy and surveying, mapping and charting, agriculture and natural resources, Geographic Information Systems, meteorological and timing are also described.[2] The requirements of non-federal and military users for radionavigation services based upon the technical and operational performance needed for military missions, transportation safety, and economic efficiency are also described.

The RNSS frequency requirements for GPS are based upon an assessment of user accuracy requirements, space-to-Earth propagation delay resolution, multipath suppression, and equipment cost and configurations. Three carrier frequencies are centered at 1575.42 MHz (GPS L1 signal), 1227.6 MHz (GPS L2 signal), and 1176.45 MHz (GPS L5 signal). The L1 and L5 radionavigation signals are used by aviation receivers during all phases of flight. The L1, L2, and L5 radionavigation signals are used by commercial-grade receivers. The L1 and L2 radionavigation signals are used by the military. Implementation of the L5 signal began in 2009.

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[1] Current information on the Global Positioning System is available at http://www.navcen.uscg.gov/gps/geninfo/.

[2] 2008 Federal Radionavigation Plan (Published by the Department of Defense, Department of Homeland Security, and Department of Transportation) available at www.navcen.uscg.gov.

The GPS L1 radionavigation signal is transmitted in the 1575.42 ± 12 MHz segment of the 1559-1610 MHz RNSS band. On the L1 carrier frequency two radionavigation signals are currently transmitted: the L1 Coarse/Acquisition (C/A) code signal and the L1 Precision (P(Y)) code signal. The GPS provides two levels of service: Standard Positioning Service (SPS) which uses the C/A code on the L1 carrier frequency and the Precision Positioning Service (PPS) which uses the P(Y) code on both the L1 and L2 carrier frequencies. The L1 radionavigation signal is used to resolve a user's location to within 22 meters. A second radionavigation signal transmitted on the L2 carrier frequency provides receivers the necessary frequency diversity and wider bandwidth for increased range accuracy for Earth-to-space propagation delay resolution and for multipath suppression to increase the total accuracy by an order of magnitude.[3]

Currently, military GPS users are provided P(Y) code signals on the L1 and L2 carrier frequencies. These signals will be supplanted in the future by the M-Code, the next generation military radionavigation signal. GPS satellites began transmitting the M-Code in September 2006. The M-Code will significantly improve exclusivity of access because, in addition to being encrypted, it will be spectrally separate from the civilian radionavigation signals.[4]

The other operating component of the GNSS is the Russian Federation Global Navigation Satellite System (GLONASS) that operates in the 1598.0625-1605.375 MHz band.[5] Planned future RNSS systems include the European Union's Galileo operating in the 1559-1594 MHz segment of the RNSS band; and Japan's Quasi Zenith Satellite System (QZSS) and China's Compass with radionavigation signals centered at 1574.42 MHz. India plans to implement a Regional Navigation Satellite System (IRNSS) in the 1575.42 ± 12 MHz segment of the RNSS band. As part of the GNSS, receivers that take advantage of these systems may benefit from additional satellite signals, increased redundancy and improved performance over that obtained from just one system alone.[6]

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[3] Any combination of two or more signals can be used to provide the necessary frequency diversity and wider bandwidth for increased range accuracy for Earth-to-space propagation delay resolution and redundancy.

[4] The M-Code is transmitted in the same L1 and L2 carrier frequencies already in use by the previous military code, the P(Y)-code. The new signal is shaped to place most of its energy at the edges (away from the existing P(Y) and C/A signals).

[5] Some legacy GLONASS satellites may operate up to 1615.5 MHz.

[6] The Russian GLONASS is a GNSS in the process of being restored to full operation. The European Union Galileo system is a GNSS in initial deployment phase, scheduled to be operational in 2013. The People's Republic of China has indicated it will expand its regional Beidou navigation system into the global Compass navigation system by 2015.

As part of the GPS modernization program a new civilian use signal (L1C) is transmitted on the same L1 carrier frequency (1575.42 MHz) that currently contains the C/A signal used by all current GPS users. The new L1C will provide better performance than the current C/A code signal to support future civilian receiver applications.[7] The L1C is a radionavigation signal designed specifically to enable interoperability between GPS and international RNSS systems. The United States and Europe originally developed the L1C as a common civil signal for GPS and Galileo. Other countries operating RNSS systems are adopting the L1C radionavigation signal as a future standard for international interoperability. Japan's QZSS and India's IRNSS plan to transmit the L1C radionavigation signal. The United States will launch the first GPS satellite transmitting the L1C radionavigation signal in the 2016 timeframe.[8]

In addition to the GPS service, the Federal Aviation Administration (FAA) operates the Wide Area Augmentation System (WAAS), which augments the signals provided by GPS and provides the additional accuracy, integrity, and availability necessary to enable users to rely on GPS for all phases of flight. WAAS is based on a network of approximately 25 ground reference stations that covers a very large service area in the United States. Signals from GPS satellites are received by wide area ground reference stations (WRSs). Each of these precisely surveyed reference stations receive GPS signals and determine if any errors exist. These WRSs are linked to form the U.S. WAAS network. Each WRS in the network relays the data to the Wide area Master Station (WMS) where correction information is computed. The WMS calculates correction algorithms, and assesses the integrity of the system. Currently, this information is broadcast from the WAAS geostationary satellites to WRS receivers and WAAS enabled receivers using the radionavigation signals transmitted in the L1 and L2 frequency bands.[9]

The FAA is also developing the Local Area Augmentation System (LAAS). The LAAS is an augmentation to GPS that focuses its service on the airport area (approximately 20 to 30 mile radius). The LAAS receives signals in the L1 frequency band and broadcasts a correction message via a very high frequency radio data link from a ground-based

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[7] *Id.* at 3-7.

[8] For more information on GPS modernization, *See* Department of Commerce Office of Space Commercialization is available at http://www.space.commerce.gov/gps/modernization.shtml.

[9] Examples of satellites that transmit WAAS signals are Galaxy 15, Anik F1R, and Inmarsat-4 F3.

transmitter.[10] LAAS is expected to yield the extremely high accuracy, availability, and integrity necessary for precision approaches. Airports with the need for precise surface area navigation may also use the accuracy of LAAS for position determination of aircraft.

The U. S. Coast Guard operates the Nationwide Differential GPS (NDGPS) a system of 87 reference stations that receive both the L1 and L2 radionavigation signals and broadcast corrections, which can be used by a GPS receiver to improve accuracy, integrity, and availability of GPS position location. NDGPS is used in a myriad of applications including maritime navigation, positive train control, precision farming, dredging, graphic information systems, and surveying. Differential GPS uses the fixed location of a reference station to determine the inaccuracy of the satellite signal.[11] The location derived from the satellite signal is compared to the reference station. That difference, or inaccuracy, can then be transmitted to GPS receivers. By comparing the inaccuracy to the satellite signal, the GPS receivers can then accurately determine their location.[12] Approximately 92 percent of the lower 48 states have coverage from a single NDGPS broadcast station and 65 percent have coverage from two stations.[13]

GNSS receivers on the ground with a fixed position using the L1 radionavigation signal can also be used to calculate the precise time as a reference for scientific experiments. GPS-provided time and frequency has become a critical component of our national infrastructure supporting telecommunications systems, power grids, and many military applications. GPS is extensively used for the synchronization needed for commercial communication networks.

### 4b. Radionavigation-Satellite (Space-to-Space) Service

GNSS receivers used for spaceborne applications operate in the1575.42 ± 12 MHz segment of the 1559-1610 MHz RNSS band. The U.S. space community uses GPS to support space and earth science missions as well as human space exploration missions in orbit and during re-entry and landing. The spaceborne use of GNSS receivers combines the ability to sense space vehicle trajectory, attitude, time, and relative ranging between vehicles into one package, resulting in a reduction of the sensor complement employed on spacecraft and significant reductions in space vehicle operations cost. Research

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[10] The LAAS correction messages are transmitted in the 108-118 MHz frequency band.

[11] Positive train control is a system of monitoring and controlling train movements to provide increased safety.

[12] The closer to the broadcast station transmitter the more accurate the determination. Using current techniques, this correction is most accurate near the NDGPS facilities (approximately 1 m) and degrades up to 3 m at the edge of the coverage area, which is up to 402 kilometers away.

[13] Information on NDGPS can be found at http://www.navcen.uscg.gov/AccessASP/NDgpsReportAllSites.asp.

satellites use GNSS receivers for precise positioning in support of onboard science instruments with the goal of achieving centimeter level accuracy.

## 5. Planned Use

Multiple radionavigation signals allow Federal and non-Federal users to obtain greater precision and availability at lower cost than achievable with augmentation systems. However, the different radionavigation signals combined with augmentation signals for even greater precision and reliability will support applications with some of the greatest potential benefits. The long-term spectrum requirements for the RNSS are driven by requirements to support specific GNSS systems. Trends towards more accurate and reliable satellite-based technologies are making some older systems obsolete, potentially reducing the current and future spectrum needs in several frequency bands.

GPS will be the primary Federally-provided radionavigation system for the foreseeable future. GPS will be augmented and improved to satisfy future civil and military requirements for accuracy, availability, continuity, coverage, and integrity.

Federal and civilian use of the GPS-based navigation system will continue to grow and this will require spectrum availability for the foreseeable future.

Given the large GPS-user growth projections on-going access to spectrum for the L1 radionavigation signal in the 1559-1610 MHz band will be needed indefinitely.

The spectrum for the L1 radionavigation signal used by all GPS and augmentation system (WAAS, LAAS, and NDGPS) receivers will be needed indefinitely.

The use of GPS for spaceborne applications is expected to increase and continue indefinitely.

The use of GPS as a source for accurate and reliable timing applications is expected to continue indefinitely.

GNSS systems are operated or planned by other nations, and it is critical that the agreements and cooperation including spectrum access continue to allow systems to operate compatibly. It is expected that commercial GNSS receivers will be capable of utilizing signals from these foreign satellites.