1164-1215 MHz

1. Band Introduction

The Federal Government operates aeronautical radionavigation and radionavigation-satellite systems in the space-to-earth and space-to-space direction in the 1164-1215 MHz band. Ground-based and airborne systems that operate in this band control civilian and military aircraft in the National Air Space (NAS). The Distance Measuring Equipment (DME) system and its military version, the Tactical Air Navigation (TACAN) system operates throughout the band. Global Navigation Satellite System (GNSS) is the standard generic term for systems operating in the radionavigation-satellite service (RNSS) that provide autonomous geo-spatial positioning with global coverage. In the United States such systems are referred to as Positioning, Navigation, and Timing (PNT) systems. These systems allow receivers to determine their location (longitude, latitude and altitude) using signals transmitted from satellites and provide precise timing for a multitude of users worldwide. The Department of Defense (DoD) operates a communication system, the Joint Tactical Information Distribution System (JTIDS) in this band on a coordinated basis.

2. Allocations

2a. Allocation Table

The frequency allocation table shown below is extracted from the Manual of Regulations and 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)
1164-1215 AERONAUTICAL RADIONAVIGATION 5.328 RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) 5.328A US224		Aviation (87)

2b. Additional Allocation Table Information

5.328 The use of the band 960-1215 MHz by the aeronautical radionavigation service is reserved on a worldwide basis for the operation and development of airborne electronic aids to air navigation and any directly associated ground-based facilities.

5.328A Stations in the radionavigation-satellite service in the band 1 164-1 215 MHz shall operate in accordance with the provisions of Resolution 609 (WRC-03) and shall not claim protection from stations in the aeronautical radionavigation service in the band

960-1 215 MHz. No. 5.43A does not apply. The provisions of No. 21.18 shall apply. (WRC-03).

US224 Federal systems utilizing spread spectrum techniques for terrestrial communication, navigation and identification may be authorized to operate in the band 960-1215 MHz on the condition that harmful interference will not be caused to the aeronautical radionavigation service. These systems will be handled on a case-by-case basis. Such systems shall be subject to a review at the national level for operational requirements and electromagnetic compatibility prior to development, procurement or modification.

3. Federal Agency Use

3a. Federal Agency Frequency Assignments Table

The following table identifies the frequency band, type(s) of allocation(s), types of application, and the number of frequency assignments in the Government Master File (GMF) by agency. Use of the 1164-1188 MHz band by the U.S. GPS is coordinated with other international RNSS systems through bi-lateral or multilateral agreements with other nations so that the various global systems operate so as not to interfere with each other. Such agreements are crucial given the intensive use of this band by global RNSS systems and the missions and functions such systems support globally. The Federal and non-Federal GNSS receivers associated with this system operate throughout the country but do not require a frequency assignment in the GMF. Therefore, they are not reflected in GMF data.

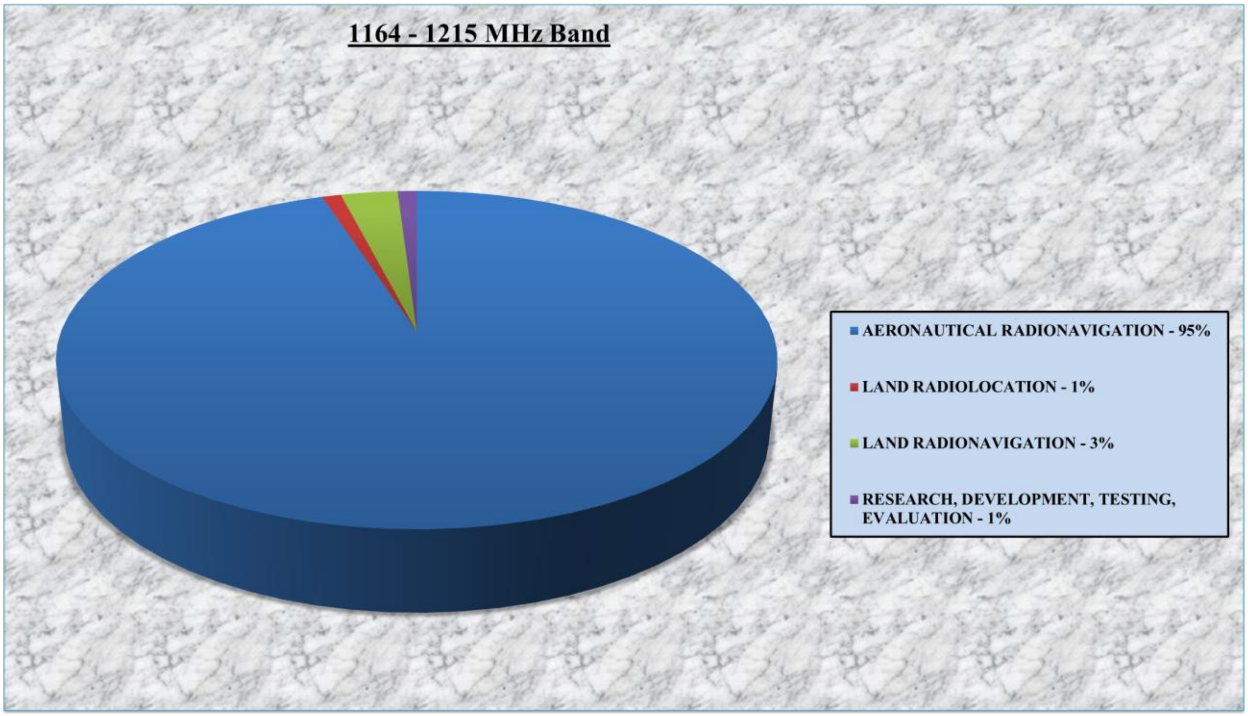
Federal Frequency Assignment Table

1164-1215 MHz Band						
SHARED BAND						
	AERONAUTICAL RADIONAVIGATION					
	RADIONAVIGATION-SATELLITE (space-to-Earth)(space-to-space)					
	AERONAUTICAL RADIONAVIGATION	LAND RADIOLOCATION	LAND RADIONAVIGATION	RADIONAVIGATION SATELLITE	RESEARCH DEVELOPMENT TESTING	TOTAL
AF	24	1	8	1	3	37
AR	1		1			2
DOC				1		1
DOI	1					1
FAA	547		5		1	553
MC	1	1	1			3
N	8	5	4		2	19
NASA	3					3
TOTAL	585	7	19	1	6	619

The number of actual systems, or number of equipments, may exceed and sometimes far exceed, the number of frequency assignments in a band. Also, a 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.

3b. Percentage of Frequency Assignments Chart

The following chart displays the percentage of frequency assignments for the systems operating in the frequency band 1164-1215 MHz. The greatest use in the band is aeronautical radionavigation. The receivers operating in the RNSS are not reflected in the GMF or elsewhere, therefore the actual use of the band could be mischaracterized if a measure of such use relied only on frequency assignments.



4. Frequency Band Analysis By Application

4a. Aeronautical Radionavigation Service

The aeronautical radionavigation service (ARNS) is a radionavigation service intended for the benefit and the safe operation of aircraft. There are two types of aeronautical radionavigation systems primarily used to ensure safety of flight and to support precision approach and landing of aircraft. These systems operate throughout the 1164-1215 MHz band.

Distance Measuring Equipment and Tactical Air Navigation Systems

Distance Measuring Equipment (DME) and Tactical Air Navigation Systems (TACAN) are very similar in their functional performance. DME systems operate between the bands 962-1213 MHz and are usually co-located with a very high frequency (VHF) Omni-directional Range (VOR) operating in the band 108-118 MHz to provide the distance and azimuth from the aircraft to the DME transmitter. The Doppler VOR/DME ground station (pictured below) is the second generation VOR, providing improved signal quality and accuracy.

An important requirement is a frequency separation of 63 MHz between the interrogation and the reply frequency. This accommodates the pulse-pair shaping and signal processing bandwidth necessary to achieve individual system integrity. This procedure leaves only 126 possible frequency pairs throughout the band 962-1213 MHz.

DME allows aircraft to fly safe, accurate paths during the en-route, terminal, landing, missed approach and departure phases of flight. The system provides aircraft pilots with the slant range to a ground-based transponder station. The ground-based transponder system is air-initiated, with the airborne transmitter interrogating a transponder, and calculating range from the time difference between the initiation of the interrogation and receipt of the reply. The maximum range for high altitude service (18 km) is 240 km and for low altitude, service (5.5 km) the distance is 74 km. The maximum range for the standard terminal service is 46 km for an altitude of 3.7 km.

TACAN is a tactical air navigation system for the military services used ashore, afloat, and airborne. TACAN is primarily collocated with the civil VOR stations (VORTAC facilities) to enable military aircraft to operate in the National Airspace System (NAS) and to provide DME information to civil users.

The Navy, Coast Guard, and Military Sealift Command (MSC) operate several hundred sea-based TACAN stations. The FAA operates approximately 60 VOR, 405 VOR/DME, and 590 VORTAC ground stations, as well as another 30 DMEs. Other Federal agencies, state and local governments, and private entities also own some of these facilities.

Doppler-VOR/DME Ground Station

4b. Aeronautical, Maritime, and Land Mobile Operations

In the band 960-1215 MHz, the DoD operates the Joint Tactical Information Distribution System (JTIDS) and the Multifunctional Information Distribution System (MIDS), which is a major communications system used by U.S. and North Atlantic Treaty Organization (NATO) forces to provide tactical, secure, jam-resistant voice and data communications and general situational awareness information. JTIDS has been operational since 1981 and utilized by the Air Force, Navy, Army, and their allies to support voice and data communications needs. JTIDS is authorized to operate in the 960-1164 MHz band on the condition that it may not cause harmful interference to current or future ARNS or AM(R)S systems authorized to operate in the band. MIDS also operates in this band and is part of a major international program.[1] JTIDS and MIDS are designed to provide situational awareness in a hostile (i.e., jammed) radio frequency environment.

[1] JTIDS and the MIDS are identical at the radio frequency level and are part of a family of radio equipment implementing what is referred to as Link 16.

The DoD and the FAA have developed agreements to assure spectrum access and to maintain mutual compatibility between JTIDS/MIDS and the ARNS systems operating in the band.[2]

Since all of the ARNS systems operating in the 1164-1125 MHz transmit pulsed signals compatible operation can be achieved by limiting the duty cycle of JTIDS/MIDS transmissions.[3]

4c. Radionavigation-Satellite (Space-to-Earth) Service

The U.S. Global Positioning System (GPS) is the only fully operational Global Navigation-Satellite System (GNSS).[4] 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 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 civil 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. GPS satellites transmitting the L5 signal will be launched starting in 2010.[5]

The Federal Radionavigation Plan (FRP) 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.[5] The FRP also describes requirements of civil and military users for radionavigation services based upon the technical and operational performance needed for military missions, transportation safety, and economic efficiency.

The 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).

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[2] *See* NTIA Manual at § 4.3.17.

[3] Compatible JTIDS/MIDS operation is authorized in the United States through the control, monitoring, supervision, and management of pulse densities, referred to as pulse de-confliction.

[5] For more information on GPS modernization go to the Department of Commerce Office of Space Commercialization website at http://www.space.commerce.gov/gps/modernization.shtml#signals.

[5] The Federal Radionavigation Plan is published annually by the Department of Defense, Department of Homeland Security, and Department of Transportation.

The L1 and L5 radionavigation signals are used by aviation receivers during all phases of flight. The L1, L2, and L5 radionavigation signals can be used by military and commercial-grade receivers.

As part of the GPS modernization program the L5 radionavigation signal is transmitted in the 1176.45 ± 12 MHz segment of the 1164-1215 MHz RNSS band that is reserved for aviation services. The L5 radionavigation signal was designed to support safety-of-life transportation and other high-performance applications. Aircraft will use the L5 in combination with the L1 Course Acquisition (C/A) radionavigation signal to improve accuracy via ionospheric correction, and to improve robustness through signal redundancy.[6] The L5 radionavigation signal will increase capacity, fuel efficiency, and safety in the U.S. airspace, railroads, waterways and highways. Beyond transportation, the L5 radionavigation signal will provide users worldwide with the most advanced civilian signal. When used in combination with L1 C/A and civil signal on L2 (L2C) will provide a highly robust service that may enable sub-meter accuracy without augmentations.

There are several future RNSS systems that plan to transmit radionavigation signals in the 1164-1215 MHz band. The European Union's Galileo plans on transmitting a radionavigation signal in the 1164-1188 MHz segment of the RNSS band. Japan's Quasi Zenith Satellite System (QZSS) plans on transmitting a radionavigation signal centered at 1176.45 MHz. China's Compass plans on transmitting a radionavigation signal centered at 1191.75 MHz. India plans to implement a Regional Navigation Satellite System (IRNSS) in the 1176.45 ± 12 MHz segment of the RNSS band. GNSS receivers may benefit from additional satellite signals, increased redundancy and improved performance over that obtained from just one system alone.[7]

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. 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

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[6] 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.

[7] The Russian GLONASS is a GNSS in the process of being restored to full operation. The European Union Galileo system is a GNSS in the initial deployment phase, and is 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.

assesses the integrity of the system. This information is broadcast from the WAAS satellites on the GPS L1 and L5 frequency bands.

Currently, the WRS receivers use the radionavigation signals transmitted in the L1 and L2 RNSS frequency bands. The WRSs will also use the radionavigation signal transmitted in the L5 frequency band.

GNSS receivers on the ground with a fixed position using the L1 and L5 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. The National Aeronautics and Space Administration (NASA) conducts research and development in a number of GPS application areas in the space, aeronautics, and terrestrial environments. NASA uses the RNSS bands, where GPS service operates space-to-Earth, as a critical enabler for space operations and science missions. NASA is also investing in Augmentation Services to GPS, including supporting the continued development of the International GNSS Service (IGS) and the Global Differential GPS System (GDGPS). The data received from the IGS network of 350 GPS monitoring stations is providing data products on a daily basis that are distributed via the Internet for users worldwide, including more than 200 government agencies, universities, research institutions, and scientific organizations worldwide, with products including measurement of Earth crustal movement at the centimeter per year level. A possible byproduct of this research could be the eventual development of reliable techniques to be used for earthquake early warning and prediction. The GDGPS system is a high accuracy GPS augmentation system to support the real-time positioning, timing, and determination requirements of NASA science missions.

In addition, GPS is used during launches to provide position updates and improve the precision of the Inertial Navigation Systems that guide the vehicle from the surface to orbit.

4d. Radionavigation-Satellite (Space-to-Space) Service

GNSS receivers used for spaceborne applications will operate in the 1176.45 ± 12 MHz segment of the 1164-1215 MHz RNSS band. The primary navigation function for NASA missions is performed through communication channel tracking by NASA’s Ground and Space Networks, and ground-based trajectory analysis of observables. Individual missions may opt for autonomous navigation capabilities through on-board processing of inertial measurements, celestial measurements, and radiometric signals including GPS. The U.S. space community also uses GPS in a number of spacecraft and science instrument applications.

Onboard the satellite, GNSS receivers are used to determine satellite position as an input to navigation software that calculates and propagates the satellite’s orbit. GNSS receivers also provide accurate time synchronization for satellites as well as spacecraft attitude determination. 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 satellites use GNSS receivers for precise positioning in support of onboard science instruments with the goal of achieving centimeter level accuracy.

5. Planned Use

The spectrum requirements for DME and TACAN systems to support navigation within the NAS will continue for the foreseeable future.

The DoD will continue to operate the JTIDS/MIDS for aeronautical, maritime, and land based tactical communications in the band on a coordinated basis for the foreseeable future.

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 the following requirements to support specific GNSS systems:

- 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 and the importance of GPS to the U.S. critical infrastructure, on-going access to, and sustainment of, spectrum the L5 radionavigation signal in the 1164-1215 MHz RNSS band will be crucial to a multitude of users in multiple sectors (e.g., military, civil, commercial, and scientific).
- The spectrum for the WAAS GPS-augmentation systems will be needed indefinitely.
- The use of GPS for spaceborne applications is expected to continue indefinitely
- The use of GPS for accurate and reliable timing applications critical to the national infrastructure will 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.