960-1164 MHz

1. Band Introduction

The 960-1164 MHz band is part of the 960-1215 MHz band allocated on a primary basis to the Federal Government for the aeronautical radionavigation service (ARNS). The Federal Aviation Administration (FAA) domestically manages the 960-1164 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. The Air Traffic Control Radar Beacon System (ATCRBS) and the Mode Select (Mode S) system have a ground-based and airborne component and operate on the frequencies of 1030 MHz and 1090 MHz. Identification Friend or Foe (IFF) system is the primary positive means of aircraft identification in air defense operations. An IFF transponder receives interrogation pulses at one frequency (1030 MHz), and sends the reply pulses at a different frequency (1090 MHz). Proper use of IFF facilitates rapid engagement of enemy aircraft, conserves air defense assets, and reduces risk to friendly aircraft. The Traffic Alert and Collision Avoidance System (TCAS) operates at 1030 and 1090 MHz and is independent of any ground system. The International Telecommunication Union 2007 World Radiocommunication Conference allocated the band 960-1164 MHz to aeronautical mobile (route) service (AM(R)S).[1] The Automatic Dependent Surveillance-Broadcast (ADS-B) system and the Universal Access Transceiver (UAT) operate on the frequencies of 978 MHz and 1090 MHz. In addition to the ARNS and AM(R)S systems, the Department of Defense (DOD) operates a communication system, the Joint Tactical Information Distribution System (JTIDS) in this band on a coordinated basis.

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[1] International Telecommunications Union- Radio Regulation 5.387.

2. Allocations

2a. Allocation Table

The frequency allocation table shown below is extracted from the NTIA 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)
960-1164 AERONAUTICAL RADIONAVIGATION 5.328 US224 US400		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.

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.

US400 The use of the center frequency 978 MHz may be authorized to Universal Access Transceiver (UAT) stations on a primary basis for the specific purpose of transmitting datalink information in support of the Automatic Dependent Surveillance – Broadcast (ADS-B) Service, Traffic Information Services – Broadcast (TIS-B), and Flight Information – Broadcast (FIS-B).

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.

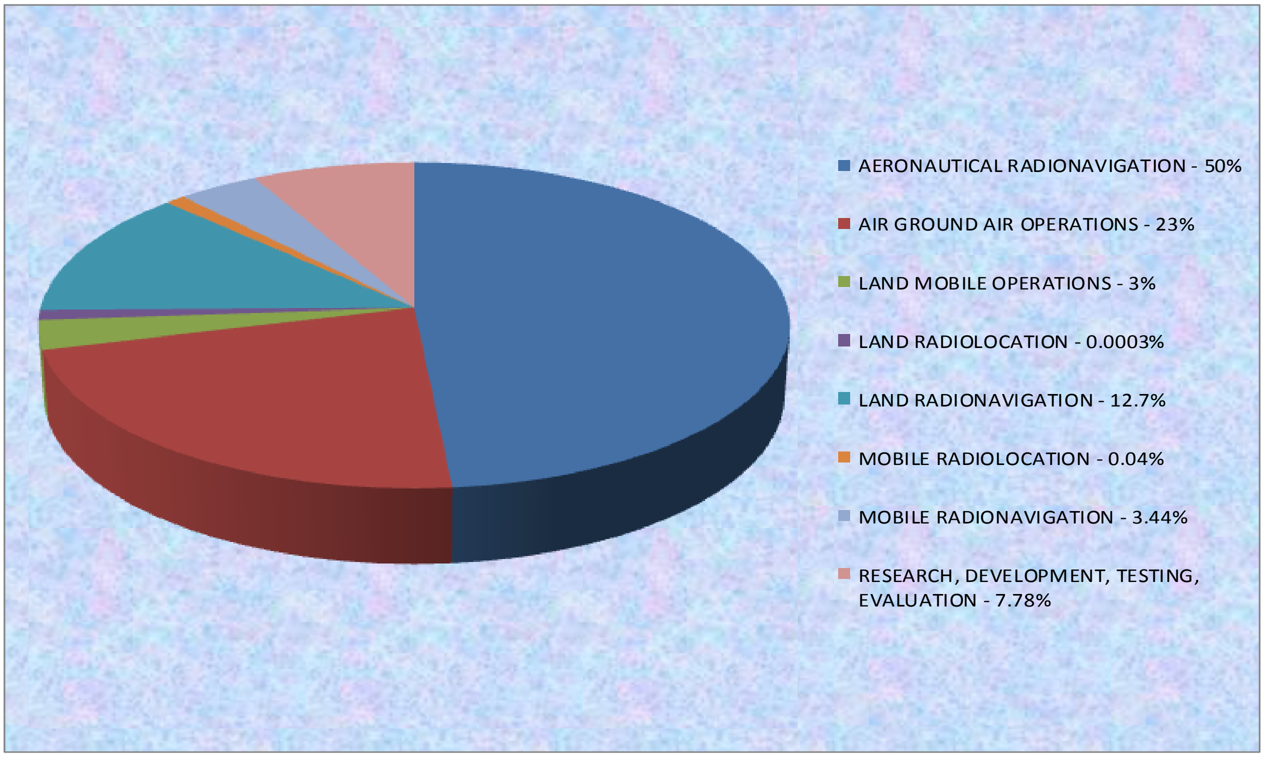
Federal Frequency Assignment Table

960 - 1164 MHz Band									
SHARED BAND									
	AERONAUTICAL RADIONAVIGATION								
	TYPE OF APPLICATION								
AGENCY	AERONAUTICAL RADIONAVIGATION	AIR GROUND AIR OPERATIONS	LAND MOBILE OPERATIONS	LAND RADIOLOCATION	LAND RADIONAVIGATION	MOBILE RADIOLOCATION	MOBILE RADIONAVIGATION	RESEARCH DEVELOPMENT TESTING EVALUATION	TOTAL
AF	385	49	83	1	116		44	220	898
AR	52	2	15		119		5	60	253
CG	50				2	4	8		64
DHS	1							2	3
DOE	1	1			1				3
FAA	2088	1218			426			24	3756
MC	79	1	1		21		5	2	109
N	174	2	54		29	22	132	125	538
NASA	1				1				2
TOTAL	2831	1273	153	1	715	26	194	433	5626

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 authrozation. 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 in the GMF for the systems operating in the frequency band 960.0-1164.0 MHz.



4. Frequency Band Analysis By Application

The systems operating in this band consists of the aeronautical mobile (route) service (AM(R)S) andaeronautical radionavigation service (ARNS) in the International Radio Regulations (RR). The AM(R)S and ARNS are safety services as defined in the RR, "Any radiocommunication service used permanently or temporarily for the safeguarding of human life and property."

4a. Aeronautical Radionavigation Service

The ARNS is a radionavigation service intended for the benefit and the safe operation of aircraft. There are numerous 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 960-1164 MHz band.

4b. Distance Measuring Equipment and Tactical Air Navigation Systems

DME and 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. 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 and VOR operate in paired channels so at any given location, both the VOR and DME proposed assignments must “pass” their channel planning criteria. This puts additional constraints on DME assignments.

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 (18km) 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 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.

Secondary Surveillance Radar (SSR) and Traffic Alert and Collision Avoidance System (TCAS)

Two types of ARNS systems operate at 1030 and 1090 MHz: SSR (which includes ATCRBS and Mode S), and TCAS.[2] SSR provides cooperative surveillance information

[2] RTCA Special Committee 185, *Aeronautical Spectrum Planning for 1997–2010*, RTCA/DO-237, 27 January 1997.

from appropriately equipped aircraft. An SSR can function either as a stand-alone system, or in conjunction with primary long range and terminal surveillance radars. SSR operation requires an uplink interrogation, a reception and response by a cooperative airborne transponder, and reception of the transponder's downlink reply. The transponder's response identifies the aircraft and is ordinarily much stronger than the reflection that the primary surveillance radar receives. All SSR systems use 1030 MHz as the uplink frequency from a ground-based interrogator, and 1090 MHz as the downlink frequency from an airborne transponder. The emission bandwidth mask for SSR systems (ATCRBS or Mode S interrogators) transmitting on 1030 MHz is 21.5 MHz. The -20 dB bandwidth mask for SSR systems transmitting on 1090 MHz is 14 MHz. This includes Mode S, Extended Squitter (1090ES), Mode S replies, and ATCRBS replies.

The FAA uses ATCRBS in conjunction with the Airport Surveillance Radar (ASR) and Air Route Surveillance Radar (ARSR) systems to monitor and track aircraft during en-route and approach phases of flight. ATCRBS monitors aircraft on the ground as they traverse taxiways around the airport. The nominal maximum range for the system is 370 km when used in conjunction with an ARSR system and about 110 km when used in conjunction with an ASR system. ATCRBS can function either as a stand-alone system, or in conjunction with primary long range and terminal surveillance radars. ATCRBS operation requires an uplink interrogation, a reception and response by a cooperative airborne transponder, and reception of the transponder's downlink reply. The transponder's response identifies the aircraft and is ordinarily much stronger than the reflection that the primary surveillance radar receives.

ATCRBS uses a ground-based interrogator that transmits pulses via a 1030-MHz uplink to airborne transponders, which reply via a 1090-MHz downlink. ATCRBS interrogations transmit from a ground-based directional SSR antenna beam that rotates along with the primary radar antenna (if one is present).
As the beam rotates toward the azimuth at which the aircraft is located, the airborne transponder begins to receive interrogations, which result in transponder replies. ATCRBS interrogates every aircraft that is within the beamwidth of the ground-based interrogator antenna.

Similar to ATCRBS, Mode S provides cooperative surveillance information from appropriately equipped aircraft. Mode S can function either as a stand-alone system, or in conjunction with primary long range and terminal surveillance radars. Mode S operation requires an uplink interrogation, a reception and response by a cooperative airborne transponder, and reception of the transponder's downlink reply. The transponder's response identifies the aircraft and is ordinarily much stronger than the reflection that the primary surveillance radar receives. Unlike ATCRBS, which interrogates all aircraft within its operating range, Mode S selectively interrogates aircraft. The ground-based interrogators in Mode S transmit at 1030 MHz and receive the replies from transponders operating at 1090 MHz.

With 1090 extended squitter (ES), the existing Mode S transponder (or a standalone 1090 MHz transmitter) supports a message type known as the ES message. It is a periodic message that provides position, velocity, heading, time, and, in the future, intent. The basic ES does not offer intent since current flight management systems do not provide such data – called trajectory change points. To enable an aircraft to send an extended squitter message, modification to the transponder is necessary and aircraft position and other status information would route to the transponder. ATC ground stations and TCAS equipped aircraft already operate 1090 MHz receivers and would only require enhancements to accept and process the additional information.

Identification Friend or Foe (IFF) is a two-channel system, with one frequency (1030 MHz) used for the interrogating signals and another (1090 MHz) for the reply. Each channel operates with 6 MHz spacing. The system is further broken down into four modes of operation, two for both military and civilian aircraft and two strictly for military use. FAA regulations require that all aircraft, military or civilian, flying at an altitude of 10,000 feet or higher in U.S. controlled airspace, must be equipped with an operating IFF transponder system capable of automatic altitude reporting (this is the reason that two of the modes are used by both military and civilian aircraft).

The Traffic Alert and Collision Avoidance System (TCAS) is an airborne system developed by the FAA that operates independently from the ground-based Air Traffic Control (ATC) system. The DOD also uses TCAS in conjunction with SSR's on these same frequencies. TCAS increases cockpit awareness of proximate aircraft by scanning the vicinity through interrogating the transponders of other aircraft. It then uses the received transponder signals to compute distance, bearing and altitude relative to the own aircraft. Pilots utilize the traffic alerts of potential threats and respond to resolution advisories that supply maneuver guidance to help pilots achieve separation from other aircraft.

To ensure that the recommended maneuvers of two TCAS-equipped aircraft do not conflict, the resolution advisories are coordinated using air-to-air Mode S data link communications. TCAS operates at 1030 and 1090 MHz and is independent of any ground system.

4c. Air and Land Mobile Operations

Joint Tactical Information Distribution System (JTIDS) and the Multifunctional Information Distribution System (MIDS)

In the band 960-1215 MHz, the DOD operates the Joint Tactical Information Distribution System (JTIDS), 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. The Multifunctional Information Distribution System (MIDS) also operates in this band and is part of a major international program.[3] JTIDS and MIDS are designed to provide situational awareness in a hostile (i.e., jammed) radio frequency environment by using Time Division Multiple Access, frequency hopping and error correction techniques. The DOD and the FAA have developed agreements to assure spectrum access and to maintain mutual compatibility between JTIDS/MIDS and the ARNS and AM(R)S systems operating in the band.[4]

Since all of the ARNS and AM(R)S systems operating in the 960-1164 MHz transmit pulsed signals compatible operation can be achieved by limiting the duty cycle of JTIDS/MIDS transmissions.[5]

4d. Aeronautical Mobile (Route) Service (Air Ground Air Operations)

The aeronautical mobile (route) service (AM(R)S) is defined as an aeronautical mobile service reserved for communications relating to safety and regularity of flight, primarily along national or international civil air routes.[6]

The use of the 960-1164 MHz band for the AM(R)S is reserved on a worldwide basis for operation and development of airborne electronic aids to air navigation and any directly

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[3] 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.

[4] *See* NTIA Manual at § 4.3.17.

[5] 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.

[6] This service does not include personal communications to or from the passengers, such as telephone calls by passengers.

ground-based facilities.[7] The AM(R)S systems in this band must meet International Civil Aviation Organization requirements and gives operational precedence to ARNS systems.

UAT provides a number of aeronautical services including Automatic Dependent Surveillance – Broadcast (ADS-B), Traffic Information Service – Broadcast (TIS-B), Automatic Dependent Surveillance – Rebroadcast (ADS-R), and Flight Information Service – Broadcast (FIS-B). The FAA operates the Automatic Dependent Surveillance-Broadcast (ADS-B) system, which generates onboard position information from onboard navigation systems, and transmits such position information to the ground. This system is under deployment and will enhance the nation's air traffic control system from one that relies on radar technology to a system that uses precise location data from the global satellite network. ADS-B is also crucial component of the nation's Next-Generation Air Transportation System (NextGen) - a scalable network-centric architecture in which everyone has easy access to the same air traffic information at the same time. When fully implemented, NextGen will safely allow more aircraft to fly closer to each other on more direct routes, reducing delays.

ADS-B avionics broadcast a radio transmission approximately once per second containing the aircraft's position, velocity, identification, and other information. Since the Global Positioning System derives the aircraft’s position, the position information broadcast to ADS-B receivers is highly accurate. ADS-B-equipped aircraft with cockpit displays can receive ADS-B reports from other suitably equipped aircraft within reception range (nominally 200 nautical miles). Additionally, ground-based transceivers (GBT) receive these broadcasts to provide air traffic surveillance services, along with fleet operator monitoring of aircraft.

In the United States, two different data links utilize ADS-B: 1090 MHz extended squitter (1090 ES) and the universal access transceiver (UAT) operating at 978 MHz with a 1 MHz bandwidth. The 1090 ES link is for air transport aircraft and above, whereas the UAT link is for general aviation aircraft. From a controller or pilot standpoint, the two links operate similarly.

In addition to ADS-B, these data links also support broadcast uplink services. Both UAT and 1090 ES support Traffic Information Service-Broadcast (TIS-B) and the UAT link supports Flight Information Services-Broadcast (FIS-B).

TIS-B is the broadcast of traffic information to ADS-B-equipped aircraft from ADS-B GBTs. The source of this traffic information derives from air traffic surveillance radars. TIS-B provides ADS-B-equipped aircraft with a more complete traffic picture in

[7] *See*, ITU Radio Regulations, Art. 5, §§ 5.327A, 5.328 and 5.328A (Geneva, 2008).

situations where not all nearby aircraft are equipped with ADS-B. This advisory-only application will enhance a pilot's visual acquisition of other traffic.
TIS-B service is becoming available in selected locations where there is both adequate radar surveillance coverage and adequate broadcast coverage from GBTs.

FIS-B is the ground-to-air broadcast of meteorological and aeronautical information. FIS-B products may be in the form of text or viewed graphically. FIS-B allows the pilot to passively collect and display weather and other operational data. FIS-B reception by aircrafts is line of sight and is available for reception within 200 nautical miles (nominal range) of each UAT GBT.

To date, installation of 37 GBT sites is complete. This includes 15 in Alaska and 22 in the 48 contiguous states, mainly along the east coast and in the area around Phoenix, AZ. All GBTs provide broadcast services. Those in Alaska additionally provide air traffic services. In the western area of Alaska around Bethel, the Anchorage Air Route Traffic Control Center (ARTCC) has been using ADS-B as an approved source of ATC surveillance outside radar coverage since January 1, 2001. The FAA funded Capstone Program has equipped over 200 commercial aircraft in southwest Alaska with ADS-B avionics. Plans are underway to expand the area of ADS-B surveillance coverage to other portions of Alaska and further examine the benefits of this new technology.

5. Planned Use:

The spectrum requirements for the ATCRBS, Mode-S, and TCAS on 1030 MHz and 1090 MHz expect to continue for more than ten years.

Overall, the band 960-1164 MHz maintains operations by the military and civilian communities for critical safety-of-life radionavigation services. The military and civilian communities will continue to rely on these critical operations for the long term.