3300-3500 MHz

1. Band Introduction

The Department of Defense (DoD) uses the band 3300-3500 MHz for operating various types of shipborne, land-based, and aeronautical mobile radar systems for national defense purposes.

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)
3300-3500 RADIOLOCATION US108 G2 US342	3300-3500 Amateur Radiolocation US108 5.282 US342	Private Land Mobile (90) Amateur (97)

2b. Additional Allocation Table Information

G2 In the bands 216.965-216.995 MHz, 420-450 MHz (except as provided for in G129), 890-902 MHz, 928-942 MHz, 1300-1390 MHz, 2310-2390 MHz, 2417-2450 MHz, 2700-2900 MHz, 3300-3500 MHz (except as provided for in US108), 5650-5925 MHz, and 9000-9200 MHz, use of the Federal radiolocation service is restricted to the military services.

US108 In the bands 3300-3500 MHz and 10-10.5 GHz, survey operations, using transmitters with a peak power not to exceed five watts into the antenna, may be authorized for Federal and non-Federal use on a secondary basis to other Federal radiolocation operations.

US342 In making assignments to stations of other services to which the bands:

13360-13410 kHz 42.77-42.87 GHz*

25550-25670 kHz 43.07-43.17 GHz*
37.5-38.25 MHz 43.37-43.47 GHz*
322-328.6 MHz* 48.94-49.04 GHz*
1330-1400 MHz* 76-86 GHz
1610.6-1613.8 MHz* 92-94 GHz
1660-1660.5 MHz* 94.1-100 GHz
1668.4-1670 MHz* 102-109.5 GHz
3260-3267 MHz* 111.8-114.25 GHz
3332-3339 MHz* 128.33-128.59 GHz*
3345.8-3352.5 MHz* 129.23-129.49 GHz*
4825-4835 MHz* 130-134 GHz
4950-4990 MHz 136-148.5 GHz
6650-6675.2 MHz* 151.5-158.5 GHz
14.47-14.5 GHz* 168.59-168.93 GHz*
22.01-22.21 GHz* 171.11-171.45 GHz*
22.21-22.5 GHz 172.31-172.65 GHz*
22.81-22.86 GHz* 173.52-173.85 GHz*
23.07-23.12 GHz* 195.75-196.15 GHz*
31.2-31.3 GHz 209-226 GHz
36.43-36.5 GHz* 241-250 GHz
42.5-43.5 GHz 252-275 GHz

are allocated (*indicates radio astronomy use for spectral line observations), all practicable steps shall be taken to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (*see* ITU *Radio Regulations* at Nos. 4.5 and 4.6 and Article 29).

5.282 In the bands 435-438 MHz, 1 260-1 270 MHz, 2 400-2 450 MHz, 3 400-3 410 MHz (in Regions 2 and 3 only) and 5 650-5 670 MHz, the amateur-satellite service may operate subject to not causing harmful interference to other services operating in accordance with the Table (see No. 5.43). Administrations authorizing such use shall ensure that any harmful interference caused by emissions from a station in the amateur-satellite service is immediately eliminated in accordance with the provisions of No. 25.11. The use of the bands 1 260-1 270 MHz and 5 650-5 670 MHz by the amateur-satellite service is limited to the Earth-to-space direction.

3. Federal Agency Use

3a. Federal Agency Frequency Assignments Table

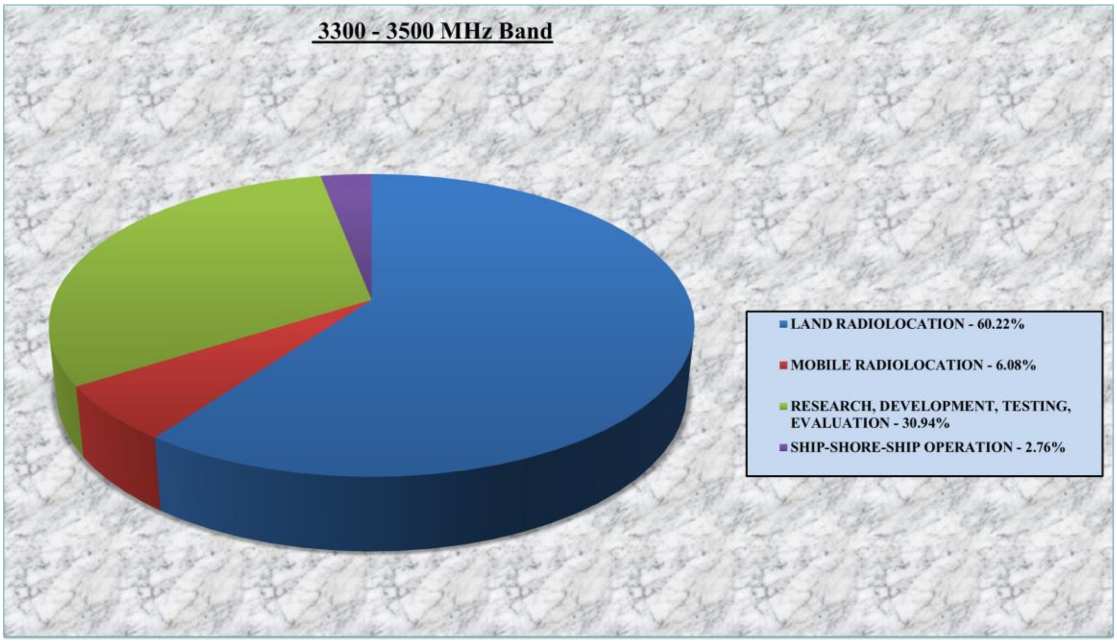
The following table identifies the frequency band, types of allocations, types of applications, and the number of frequency assignments by agency.

Federal Frequency Assignment Table

3300-3500 MHz Band					
SHARED BAND					
	AMATEUR RADIOLOCATION				
	TYPE OF APPLICATION				
AGENCY	SHIP-SHORE-SHIP	LAND RADIOLOCATION	MOBILE RADIOLOCATION	RESEARCH DEVELOPMENT TESTING EVALUATION	TOTAL
AF		1	11	12	24
AR		108		37	145
N	5			7	12
TOTAL	5	109	11	56	181
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					

3b. Percentage of Frequency Assignments Chart

The following chart displays the percentage of frequency assignments in the Government Master File (GMF) for the systems operating in the frequency band 3300 – 3500 MHz.



4. Frequency Band Analysis By Application

4a. Shipborne Radiolocation

The DoD uses the 3300-3500 MHz band along the coasts of the United States, as well as on the high seas, for ship-based, three-dimensional air search and surveillance radar systems to provide accurate information on aircraft and missiles. These high-powered radar systems detect airborne objects, and measure target altitude, range, and bearing. Some of the airborne targets are small and some targets are detected at ranges as great as 300 nautical miles. Radar systems operate in the radiolocation service.

The Navy employs mobile radars throughout this band for maritime and aeronautical mobile operations in the Pacific and Atlantic Ocean areas. These radars are used as distance measurement equipment to provide high accuracy distance information. The Navy also operates these radars in port for test and measurement in support of sea operations and navigation.

The U.S. Navy makes use of this band for sea radiolocation operations, including threat identification and tracking.

ITU-R Recommendation M.1465-1 provides technical characteristics for radiolocation radars in this frequency range. Table 1 summarizes the frequency range, peak power, mainbeam antenna gain, maximum EIRP and duty cycle for a ship-based radar operating in the band 3300-3500 MHz.[1]

Table 1. Characteristics of Shipborne Radiolocation Radars

Parameter	Ship systems
	B
Use	Surface and air search
Modulation	Q7N
Tuning range (GHz)	3.1-3.5
Tx power into antenna (kW) (Peak)	4 000-6 400
Pulse width (μs)	6.4-51.2
Repetition rate (kHz)	0.152-6.0
Compression ratio	64-512
Type of compression	CPFSK
Duty cycle (%)	0.8-2.0
Tx bandwidth (MHz) (–3 dB)	4
Antenna gain (dBi)	42
Antenna type	PA
Beamwidth (H,V) (degrees)	1.7, 1.7
Vertical scan type	Random
Maximum vertical scan (degrees)	90

[1] *See*, Recommendation ITU-R M.1465-1, "Characteristics of and protection criteria for radars operating in the radiodetermination service in the frequency band 3 100-3 700 MHz" (Geneva, 2007).

Parameter	Ship systems
	B
Vertical scan rate (degrees/s)	Not available
Horizontal scan type	Rotating
Maximum horizontal scan (degrees)	360
Horizontal scan rate (degrees/s)	Not applicable
Polarization	V
Rx sensitivity (dBm)	Not available
S/*N* criteria (dB)	Not available
Rx noise figure (dB)	5.0
Rx RF bandwidth (MHz) (–3 dB)	Not available
Rx IF bandwidth (MHz) (–3 dB)	10
Deployment area	Worldwide
CPFSK: Continuous-phase FSK PA: Phased array	

The radiolocation radars in this band are nearly always mobile (on ships transiting littoral waters), and there is no way to know exactly where and when they will operate or what frequencies they will use. There is a limited amount of information on these radars in the GMF.

4b. Land-Based Radiolocation

The DoD uses the 3300-3500 MHz band throughout the United States for transportable and land-based three-dimensional air search and surveillance radar systems to provide accurate information on artillery or rockets and their launch sites. These high-powered radar systems detect airborne objects, and measure target altitude, range, and bearing. Some of the airborne targets are small and some targets are detected at ranges as great as 300 nautical miles.

The Army operates transportable radiolocation radars in the 3300-3500 MHz band for test ranges. In Hawaii and Washington, the Army conducts training on artillery locating/battlefield radar systems.

ITU-R Recommendation M.1465-1 provides technical characteristics for land-based radars. Table 2 summarizes the tuning range, frequency at horizon, peak power, emission 3 dB bandwidth, mainbeam antenna gain, maximum EIRP, and duty cycle for land-based radars operating in the band 3300-3500 MHz.[2] Though Rec. M.1465-1 indicates the tuning range for these systems is from 3100-3700 MHz, some land-based radiolocation radars in the United States have more narrow frequency tuning ranges (for example, an upper frequency limit of 3500 MHz).

Table 2. Basic Characteristics of Land-Based Radiolocation Radars

Parameter	Land-based systems	
	A	B
Use	Surface and air search	Surface search
Modulation	P0N/Q3N	P0N
Tuning range (GHz)	3.1-3.7	
Tx power into antenna (kW) (Peak)	640	1 000
Pulse width (μs)	160-1 000	1.0-15
Repetition rate (kHz)	0.020-2	0.536
Compression ratio	48 000	Not applicable
Type of compression	Not available	Not applicable
Duty cycle (%)	2-32	0.005-0.8
Tx bandwidth (MHz) (–3 dB)	25/300	2
Antenna gain (dBi)	39	40
Antenna type	Parabolic	
Beamwidth (H,V) (degrees)	1.72	1.05, 2.2
Vertical scan type	Not available	Not applicable
Maximum vertical scan (degrees)	93.5	Not applicable

[2] *Ibid.*

Parameter	Land-based systems	
	A	B
Vertical scan rate (degrees/s)	15	Not applicable
Horizontal scan type	Not applicable	Rotating
Maximum horizontal scan (degrees)	360	
Horizontal scan rate (degrees/s)	15	25.7
Polarization	RHCP	V
Rx sensitivity (dBm)	Not available	–112
S/*N* criteria (dB)	Not applicable	0
Rx noise figure (dB)	3.1	4.0
Rx RF bandwidth (MHz) (–3 dB)	Not available	2.0
Rx IF bandwidth (MHz) (–3 dB)	380	0.67
Deployment area	Worldwide	Worldwide

The land-based radiolocation radars are likely to operate only a small percentage of time except in a few fixed areas.

A more detailed description of the technical characteristics of shipborne and land-based radiolocation radars that operate in the band 3300-3500 MHz can be found in ITU-R Recommendation M.1465-1.[3]

4c. Aeronautical Mobile Radiolocation

Air Force also uses this band throughout the United States and Possessions (US&P) for radar that assists with formation flying, airlift, and airdrop stationkeeping purposes.[4]

U.S. Air Force Station Keeping Equipment (SKE), are used to enhance flight safety as well as facilitate the management of cargo multi-ship formations. SKE formations can range in size from a single two-ship element to multi-element formations. The operator selects the desired formation position prior to takeoff and the SKE system uses pulsed radio frequency signals to maintain that position. SKE is installed on cargo aircraft.

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[3] *Ibid*.

[4] See, " Stationkeeping Gen VI - SKE Sustainment Program For C-130H Stationkeeping System". DRS Defense Solutions. URL: http://www.drs-ds.com/Products/Avionics/PDF/SKEC130.pdf

The Zone Marker and the Miniaturized Zone Marker are operated in conjunction with SKE equipment. The Zone Marker is a ground-based transceiver used to provide a ground reference point to enhance aircraft navigation.

ITU-R Recommendation M.1465-1 provides technical characteristics for land-based radars. Table 3 summarizes the tuning range, frequency at horizon, peak power, emission 3 dB bandwidth, mainbeam antenna gain, maximum EIRP, and duty cycle for the land-based radars operating in the band 3300-3500 MHz.[5] Though Rec. M.1465-1 indicates the tuning range for these systems is from 3100-3700 MHz, some airborne radiolocation radars in the United States have more narrow frequency tuning ranges (for example, an upper frequency limit of 3450 MHz).

Table 3. Basic Characteristics of Airborne Radiolocation Radars

Parameter	Airborne system
	A
Use	Surface and air search
Modulation	Q7N
Tuning range (GHz)	3.1-3.7
Tx power into antenna (kW) (Peak)	1 000
Pulse width (μs)	1.25[(1)]
Repetition rate (kHz)	2
Compression ratio	250
Type of compression	Not available
Duty cycle (%)	5
Tx bandwidth (MHz) (–3 dB)	> 30
Antenna gain (dBi)	40
Antenna type	SWA
Beamwidth (H,V) (degrees)	1.2, 6.0
Vertical scan type	Not available
Maximum vertical scan (degrees)	± 60

[5] *See supra*, n. 1.

Parameter	Airborne system
	A
Vertical scan rate (degrees/s)	Not available
Horizontal scan type	Rotating
Maximum horizontal scan (degrees)	360
Horizontal scan rate (degrees/s)	36
Polarization	Not available
Rx sensitivity (dBm)	Not available
S/*N* criteria (dB)	Not available
Rx noise figure (dB)	3
Rx RF bandwidth (MHz) (–3 dB)	Not available
Rx IF bandwidth (MHz) (–3 dB)	1
Deployment area	Worldwide
(1) 100 ns compressed.	
SWA: Slotted waveguide array	

4d. Frequency Use

Radiolocation radars operate with a high degree of mutual compatibility with other radars in the 3300-3500 MHz band. This is due to their receivers' capability to preferentially detect the echoes of their own transmitters and to reject pulse echoes of other radars.[6, 7] This immunity to low duty cycle pulsed emissions allows radar systems to operate compatibly in the band, whereas other non-pulsed signals would cause interference. Given that these radars are used on ships where location information is either unknown or constantly changing it is difficult to quantify their spectrum use.

[6] *See*, "Effects of RF interference on radar receivers", NTIA Technical Report TR-06-444, Sep. 2006. URL: http://www.its.bldrdoc.gov/pub/ntia-rpt/06-444/

[7] Duty cycle is a measure of the fraction of the time that a radar is transmitting in relation to the overall time between pulses. The maximum duty cycle occurs with the longest pulse width and the maximum number of pulses per second.

Many older radar systems use high power tube output devices to generate short duration pulses transmitted at a low duty cycle.[8] Newer radar systems use solid state output devices to generate pulses. Radars using solid state devices must transmit longer duration pulses as compared to radars using high power tube output devices. The longer duration pulses, increase the transmit duty cycle of the radar system. As the duty cycle for a radar increases, the distance and frequency separation requirements for compatible operation among radar system will also tend to increase. To overcome possible interference from other radars, frequency hopping and frequency agility features can be employed. Radars using klystrons or magnetrons tube based output devices are fixed tuned at the factory and cannot be easily re-tuned to other operating frequencies. There are also other components associated with the tube based systems such as the output filters or diplexers that must also be re-tuned when the operating frequency is changed. Radars using solid state output devices have the capability to be re-tuned are more easily and quickly.

5. Planned Use

The DoD employs radar systems in the 3300-3500 MHz band for critical national security applications such as long-range air search and surveillance radars, missile and aircraft surveillance radars, and associated radar target tracking applications. The U.S. Government has invested billions of dollars in these systems. These are critical national security applications, and safety-of-life systems, and the associated spectrum requirements to support such systems will continue for the foreseeable future.

The DoD also expects to increase use of the 3300-3500 MHz band in the future. Thus, continued access to the 3300-3500 MHz band is critical to national defense, safety, and security for the foreseeable future.

[8] Magnetrons and klystrons are examples of tube-type output devices used in older radar systems.