2700-2900 MHz

1. Band Introduction

The 2700-2900 MHz band is used by federal agencies for operating various types of radar systems that perform missions critical to safe and reliable air traffic control (ATC) and accurate weather monitoring in the United States. This includes airport surveillance radar (ASR) systems and meteorological radars. The ASR systems are operated by the Federal Aviation Administration (FAA) and the Department of Defense (DOD) to monitor national airspace for cooperative and non-cooperative targets in and around airports. The ASRs also have weather-monitoring functions. The National Weather Service (NWS), FAA, and DOD also operate a network of Next Generation Weather Radar (NEXRAD) systems in this band throughout the United States. NEXRAD provides quantitative and automated real-time information on storms, precipitation, hurricanes, and other important weather information (such as rainfall amounts and rates, wind velocity, wind direction, hail, and snow) with higher spatial and temporal resolution than previous weather radar systems.

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
(NTIA Manual, Sept. 2017)

Federal Table	Non-Federal Table	FCC Rule Parts(s)
2700-2900 MHz METEOROLOGICAL AIDS AERONAUTICAL RADIONAVIGATION 5.337 US18 Radiolocation G2 5.423 G15	2700-2900 MHz 5.423 US18	Aviation (87)

2b. Additional Allocation Table Information (Footnotes)

5.337 The use of the bands 1300-1350 MHz, 2700-2900 MHz and 9000-9200 MHz by the aeronautical radionavigation service is restricted to ground-based radars and to associated airborne transponders which transmit only on frequencies in these bands and only when actuated by radars operating in the same band.

5.423 In the band 2700-2900 MHz, ground-based radars used for meteorological purposes are authorized to operate on a basis of equality with stations of the aeronautical radionavigation service.

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.

G15 Use of the band 2700-2900 MHz by the military fixed and shipborne air defense radiolocation installations will be fully coordinated with the meteorological aids and aeronautical radionavigation services. The military air defense installations will be moved from the band 2700-2900 MHz at the earliest practicable date. Until such time as military air defense installations can be accommodated satisfactorily elsewhere in the spectrum, such operations will, insofar as practicable, be adjusted to meet the requirements of the aeronautical radionavigation service.

US18 In the bands 9-14 kHz, 90-110 kHz, 190-415 kHz, 510-535 kHz, and 2700-2900 MHz, navigation aids in the U.S. and its insular areas are normally operated by the Federal Government. However, authorizations may be made by the FCC for non-Federal operations in these bands subject to the conclusion of appropriate arrangements between the FCC and the Federal agencies concerned and upon special showing of need for service which the Federal Government is not yet prepared to render.

3. Federal Agency Use

This section shows the spectrum use by the federal agencies based on unclassified frequency assignment data. Care must be taken in evaluating bands strictly on the basis of assignment counts or percentages of assignments.

The assignment counts are based on mapping station classes to a particular service as mentioned in the *Manual of Regulations and Procedures for Federal Radio Frequency Management,* Table 6.1.4 Services, Station Classes, and Stations. The total counts may be higher than the actual number of assignments as a single assignment may have more than one station class.

The number of actual systems, or number of equipment, may exceed and sometimes far exceed, the number of frequency assignments in a band. A frequency assignment may represent a local, state, regional or nationwide authorization, and/or a band assignment. Further, assignment counts could change daily. The agencies also operate ultra-wideband (UWB) systems in the federal bands under very specific rules and regulations for a variety of purposes and functions, and they can have station classes that are radiolocation and mobile radiolocation. The UWB systems are not included in these counts or charts; due to their wide bandwidths, their assignments could appear in bands not allocated to the radiolocation or mobile radiolocation services.

3a. Federal Agency Frequency Assignments Table

Table 1 below identifies, for the 2700-2900 MHz band, the number of frequency assignments by agency according to radio service(s).

Table 1

Federal Frequency Assignment Table (Unclassified)

Agency	Aeronautical Radionavigation	Radiolocation	Research Development Testing Evaluation	Meteorological Aids	Radionavigation	Maritime Mobile	Mobile	Total
Air Force	171	9	58	21	NA	NA	NA	259
Army	382	8	8	3	8	NA	2	404
Commerce	NA	NA	6	124	NA	NA	NA	130
Energy	NA	NA	1	NA	NA	NA	NA	1
Federal Aviation Administration	623	NA	14	23	NA	NA	NA	660
Marine Corps	132	NA	NA	NA	NA	NA	NA	132
Navy	120	NA	25	NA	NA	34	NA	179
National Aeronautics and Space Administration	NA	NA	NA	8	NA	NA	NA	8
National Science Foundation	NA	NA	NA	4	NA	NA	NA	4
Total	1428	10	112	183	8	34	2	1777

Note: NA is not applicable as there are no assignments.

3b. Percentage of Frequency Assignments Chart

Figure 1 below displays the percentage of frequency assignments in the Government Master File (GMF) for the systems operating in the 2700-2900 MHz frequency band.

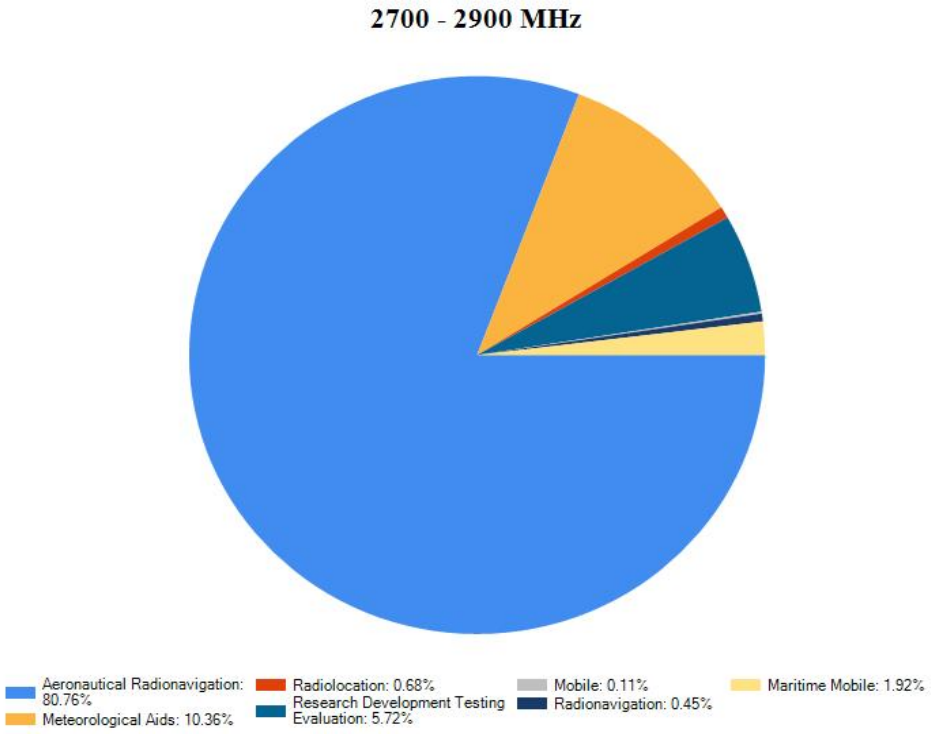


Figure 1. Assignment Data by Radio Service.

3c. Spectrum Usage in the 2700-2900 MHz Band

Based on the GMF frequency assignment data, NTIA performed a study of systems in the 2700-2900 MHz band and several other bands to determine spectrum use contours for sharing potential. The report can be downloaded at the following location: https://www.ntia.doc.gov/files/ntia/publications/ntia_quant_assessment_report-no_appendices.pdf.

4. Frequency Band Analysis by Application

4a. Aeronautical Radionavigation

The FAA and DOD operate ASR systems in the 2700-2900 MHz band. The ASR systems operate in this region of the radio frequency spectrum because of the low external noise and the angular resolution necessary for medium-range aircraft detection that can be attained using

reasonably sized antennas. These systems detect and display the position of aircraft in the terminal area around commercial and military airports.[1] The ASR is a mainstay of air traffic management around major airports. The FAA operates ASR systems at over 250 airports for management and control of aircraft in terminal airspace. The DOD operates approximately 150 ASR systems.

The FAA and DOD have been using different variants of the ASR systems for over 50 years to monitor the national airspace around commercial and military airports. The FAA and DOD have continuously upgraded the ASR systems to improve reliability. The versions of the ASR systems currently operating in the 2700-2900 MHz band include the ASR 8, 9, and ASR-11. The ASR-11 provides six-level weather monitoring capability that will result in significant improvement in situational awareness for both controllers and pilots. ASR-11 systems are already operational at some airports. The DOD operates ASR systems at military airports and airfields.

ASR systems are capable of tuning throughout the entire 2700-2900 MHz band and can employ either one or two operational frequencies. Some ASR systems use two operational frequencies to mitigate the effects of multipath, signal fading and other propagation effects to enhance aircraft detection and tracking capabilities, while some single frequency ASR systems have a reserve frequency in addition to the operational frequency.[2] The reserve frequency is only used if a problem occurs with the operational frequency. In order to resolve range ambiguities and improve correlation, the multiple frequency ASR systems transmit combinations of short and long pulses on different frequencies. Some of the ASR systems used by the DOD also employ frequency hopping techniques.

As a general rule, other radar systems operating in the 2700-2900 MHz band are not permitted to be located within radio line-of-sight of an ASR system, unless there is a 10 MHz separation between their operating frequencies.

In order to detect targets while using a lower-transmitter power, the ASR-11 must operate at a duty cycle approximately 100 times higher than that of the older ASR systems that use the tube driven output devices. This means that the ASR-11 occupies the spectrum 100 times longer than the older ASR systems, which could increase the frequency and/or distance separation

[1] The terminal area includes the runways, taxiways, the approach, and departure routes and adjacent holding areas in the skies around the airport.

[2] The reserve frequency is referred to as "hot stand-by." The signal on a hot stand-by frequency is always active, but not transmitted, and has the ability to be transmitted within minutes if a problem occurs on the operational frequency.

requirements necessary for compatible operation with other radar systems operating in the band.[3] The ASR systems only transmit for a small fraction of time, and they spend a majority of their time receiving the weak reflected signals from aircraft that are being monitored.

A more detailed description of the general technical characteristics of aeronautical radionavigation radar systems that operate in the 2700-2900 MHz band can be found in Recommendation ITU-R M.1464-2.[4]

ASR systems use a continually rotating antenna mounted on a tower to transmit pulsed radio frequency signals that are reflected from the surface of aircraft. The antennas are mounted on towers to provide an unobstructed view of the airspace they are monitoring. The antennas are slightly angled upward to remove the effects of local obstructions (e.g., ground clutter) that would otherwise degrade its performance.

In addition to the operational ASR systems in the 2700-2900 MHz band, the FAA has frequency assignments for research and development purposes to examine hardware and software improvements for ASR systems. The FAA also develops and tests new ASR systems in the band before they are operationally deployed. The research and development includes examining new waveforms and testing new signal processing techniques. The frequency assignments for these research and development efforts are limited to the FAA Technical Center in Atlantic City, NJ and the Aeronautical Center located in Oklahoma City, OK. The usage of the radar systems for research and development are carefully coordinated to ensure that they do not cause interference to operational radar systems.

4b. Meteorological Aids

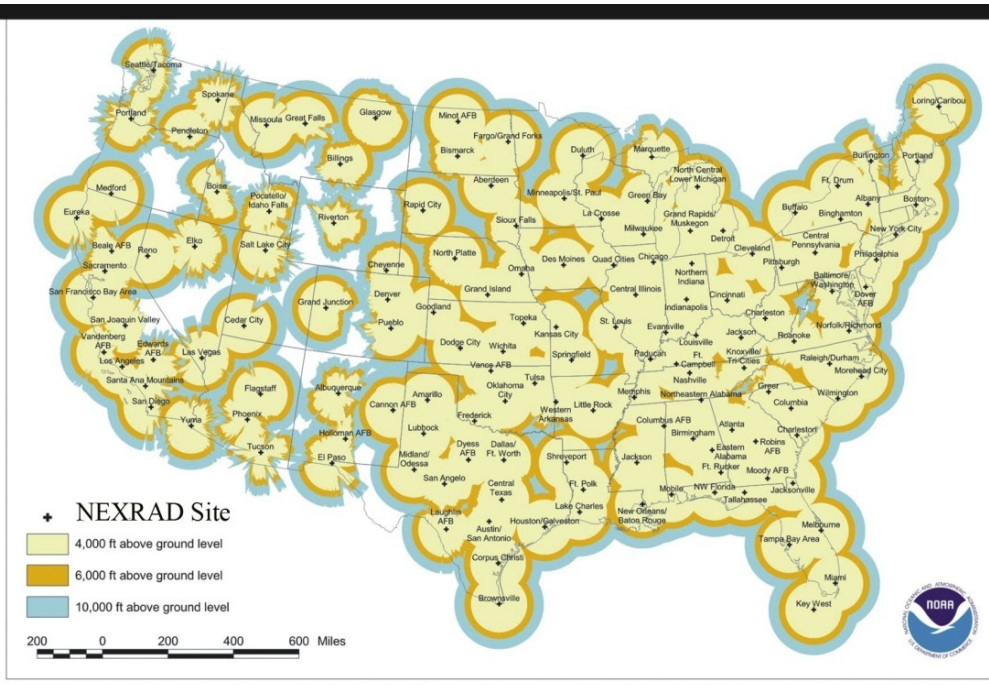
The NWS, FAA, and DOD operate radar systems in this band under the meteorological aids service. The NEXRAD is a joint program initiated by the FAA and DOD consisting of 159 operational sites within the contiguous United States with radars that provide weather monitoring capabilities. The NEXRAD collects data by transmitting a pulsed radio frequency signal that bounces off the raindrops and returns to the radar. The returned signal conveys three important properties: 1) the time it takes for the signal to bounce off the raindrops and return determines the distance from the storm to the radar, and thus the location of the storm; 2) the strength of the returned signal, also known as reflectivity, is proportional to the size and number of raindrops in

[3] Some radar systems use waveforms where the duty cycle can vary, which will enhance compatibility with other radars, eliminate possible tracking errors, and allows the radar to have selectable operating ranges.

[4] Recommendation ITU-R M.1464-2, *Characteristics of radiolocation radars, and characteristics and protection criteria for sharing studies for aeronautical radionavigation and meteorological radars in the radiodetermination service operating in the band 2700 -2900 MHz* (2/2015).

the storm; and 3) the frequency of the returned signal reveals whether the winds are moving toward or away from the radar, as well as the speed.

The NEXRAD data is converted into visual images and used by the NWS forecasters, the FAA, and the military to provide weather information to the nation. In addition, selected visual images are made available on the internet and shown on television weather broadcasts. Local and national television meteorologists use NEXRAD data to keep their viewers informed of real-time weather conditions.[5] NEXRAD data is also used by private companies and studied by university researchers to improve forecasts. Weather forecasters use the continuous, immediate weather information provided by NEXRAD to track storms and warn the public of dangerous weather conditions. NEXRAD allows forecasters to see all types of weather and provide advanced warning for thunderstorms, hail, tornadoes, hurricanes, wildfires, flash floods, snow, and freezing precipitation. The ability of NEXRAD to detect wind patterns in storms and predict real time rainfall amounts provides significant improvements over previous weather radar systems. The NEXRAD operates continuously, and provides severe weather coverage out to 125 statute miles and storm tracking out to 250 statute miles. A map showing the coverage of the NEXRAD network is provided in Figure 2a and Figure 2b.[6]



Doppler weather radar coverage of CONUS at 4,000, 6,000, and 10,000 feet above radar ground elevation from the nationwide network of WSR-88Ds (Next Generation Weather Radars). (Courtesy of SRI International)

[5] Even if a television station has its own weather radar, it will often use regional NEXRAD data to provide a broader view of the weather approaching its area.

[6] A description of the NEXRAD coverage plots can be found at http://www.roc.noaa.gov/WSR88D/Maps.aspx.

Figure 2a. NEXRAD Coverage in the United States

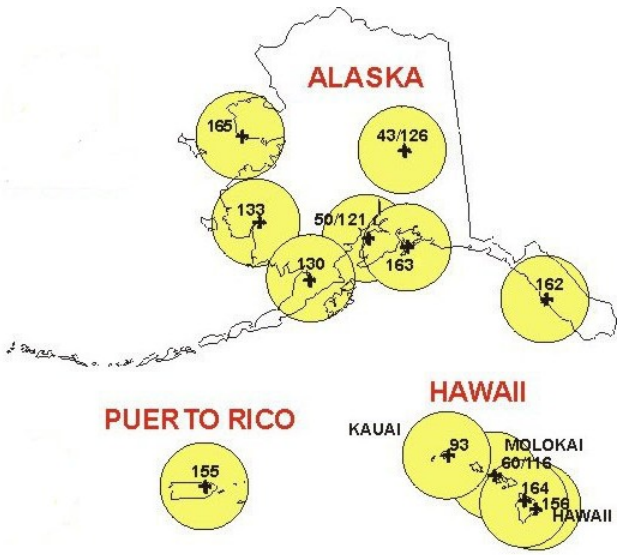


Figure 2b. NEXRAD Coverage in the United States

Other meteorological aids systems besides NEXRAD operate in this band; but they are only used at test ranges in small numbers.

A typical NEXRAD installation is shown in Figure 3. Each NEXRAD site is unique in terms of how the radar is located and arranged to reduce interference and clutter from the local terrain and other radar systems operating in the band.

Figure 3. Typical NEXRAD Installation

4c. Radiolocation (Radars)

The DOD has frequency assignments in the 2700-2900 MHz band for radar systems operating under the radiolocation service. In addition to the operational radar systems in the 2700-2900 MHz band, the DOD has frequency assignments for research and development purposes to examine hardware and software improvements for military systems. The research and development includes examining new waveforms, testing new signal processing techniques, and other various aspects of radar design and development. The frequency assignments for these research and development radar systems are limited to military test ranges and training facilities throughout the United States. The usage of the radar systems for research and development are carefully coordinated to ensure that they do not cause harmful interference to operational radar systems.

4d. Maritime Mobile

There are assignments for a system in the maritime mobile service in the 2700-2900 MHz band, even though there is no allocation for this service in the table of frequency allocations. The system is used at a limited number of locations for testing and calibrating shipboard systems. The system transmits from a fixed shore station to the ship as it maneuvers in off-shore scenarios. Its usage is carefully coordinated.

4e. Frequency Coordination in the 2700-2900 MHz Band

In the 2700-2900 MHz band there are hundreds of high power radar systems operating across the country. In some cases near large population centers with airports, multiple radar systems must operate in close proximity. Compatible operation between different types of radar systems is accomplished through careful design of the radar receivers, frequency selection, and NTIA regulations. The radar receivers use various types of circuitry and signal processing to reduce or eliminate the effects of pulsed interference from other radars.[7] The careful assignment of frequencies for radars operating in this band is crucial to prevent interference to and from other radar systems. The NWS, FAA, and DOD carefully choose and coordinate the frequencies for each system that operates in this band. Radar systems that operate in the 2700-2900 MHz band must also comply with the NTIA Radar Spectrum Engineering Criteria (RSEC).[8] The RSEC regulates how much bandwidth radars are permitted to use, based on the parameters of the transmitted pulses and the amount of unwanted or spurious emissions they emit. The NTIA regulations place design criteria on radars operating in the 2700-2900 MHz band that is stricter than criteria in other bands to facilitate compatibility and spectrum sharing.

5. Planned Use

There are not any viable or feasible technologies that can replace the radar systems operating in the 2700-2900 MHz band, which would meet the safety-of-life and other requirements for air traffic control, weather surveillance, and national security-related missions.

The FAA and DOD use of the ASR systems in the 2700-2900 MHz band will remain the same for the foreseeable future.

The existing NEXRAD systems in the 2700-2900 MHz band will continue to operate for the foreseeable future. There are no new NEXRAD installations planned at this time.

Access to this band for tactical radar systems is critical to national defense and will continue for the foreseeable future.

[7] These techniques are not effective in mitigating the effects of interference from continuous signals such as those generated by communication systems as discussed in NTIA Report TR-06-444, *Effects of RF Interference on Radar Receivers* (September 2006) available at www.its.bldrdoc.gov/publications.

[8] National Telecommunications and Information Administration, *Manual of Regulations and Procedures for Federal Radio Frequency Management*, Chapter 5. The radars operating in the 2700-2900 MHz band must comply with RSEC Category D.