2025-2110 MHz

1. Band Introduction

The National Aeronautics and Space Administration (NASA) operates earth stations in this band for tracking and command of manned and unmanned Earth-orbiting satellites and space vehicles either for Earth-to-space links for satellites in all types of orbits or through space-to-space links using the Tracking Data and Relay Satellite System (TDRSS). These earth stations control ninety domestic and international space missions including the Space Shuttle, the Hubble Space Telescope, and the International Space Station.[1] The National Oceanic and Atmospheric Administration (NOAA) operates earth stations in this band to control the Geostationary Operational Environmental Satellite (GOES) and Polar Operational Environmental Satellite (POES) meteorological satellite systems.[2] The data collected by the sensors on the GOES and POES systems are used by the National Weather Service (NWS) for short-term and long-term weather monitoring and forecasts. This is a shared frequency band that is used by non-Federal fixed and transportable Electronic News Gathering (ENG) 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

Federal	Non-Federal	FCC Rule Part(s)
2025-2110 SPACE OPERATION (Earth-to-space) (space-to-space) EARTH EXPLORATION-SATELLITE (Earth-to-space) (space-to-space) SPACE RESEARCH (Earth-to-space) (space-to-space) 5.391 5.392 US90 US222 US346 US347 US393	2025-2110 FIXED NG118 MOBILE 5.391 5.392 US90 US222 US346 US347 US393	 TV Auxiliary Broadcasting (74F) Cable TV Relay (78) Local TV Transmission (101J)

[1] Information on NASA space missions is available at https://www.spacecomm.nasa.gov/spacecomm/programs/tdrsS/default.cfm

[2] Information on NOAA space systems is available at http://www.economics.noaa.gov/?goal=climate

2b. Additional Allocation Table Information

5.391 In making assignments to the mobile service in the bands 2 025-2 110 MHz and 2 200- 2 290 MHz, administrations shall not introduce high-density mobile systems, as described in Recommendation ITU-R SA.1154, and shall take that Recommendation into account for the introduction of any other type of mobile system. (WRC-97)

5.392 Administrations are urged to take all practicable measures to ensure that space-to-space transmissions between two or more non-geostationary satellites, in the space research, space operations and Earth exploration-satellite services in the bands 2 025-2 110 MHz and 2 200-2 290 MHz, shall not impose any constraints on Earth-to-space, space-to-Earth and other space- to-space transmissions of those services and in those bands between geostationary and non-geostationary satellites.

NG118 In the bands 2025-2110 MHz, 6875-7125 MHz, and 12.7-13.25 GHz, television translator relay stations may be authorized to use frequencies on a secondary basis to other stations in the Television Broadcast Auxiliary Service that are operating in accordance with the Table of Frequency Allocations.

US90 In the band 2025-2110 MHz, the power flux-density at the Earth's surface produced by emissions from a space station in the space operation, Earth exploration-satellite, or space research service that is transmitting in the space-to-space direction, for all conditions and all methods of modulation, shall not exceed the following values in any 4 kHz sub-band:
(a) -154 dBW/m^2 for angles of arrival above the horizontal plane (δ) of 0° to 5°,
(b) -154 + 0.5(δ-5) dBW/m^2 for δ of 5° to 25°, and
(c) -144 dBW/m^2 for δ of 25° to 90°.

US222 In the band 2025-2035 MHz, geostationary operational environmental satellite (GOES) earth stations in the space research and Earth exploration-satellite services may be authorized on a coequal basis for Earth-to-space transmissions for tracking, telemetry, and telecommand at Honolulu, HI (21° 21' 12" N, 157° 52' 36" W); Seattle, WA (47° 34' 15" N, 122° 33' 10" W); and Wallops Island, VA (37° 56' 44" N, 75° 27' 42" W).
US346 Except as provided for below and by footnote US222, Federal use of the band 2025-2110 MHz by the space operation service (Earth-to-space), Earth exploration-satellite service (Earth-to-space), and space research service (Earth-to-space) shall not constrain the deployment of the Television Broadcast Auxiliary Service, the Cable Television Relay Service, or the Local Television Transmission Service. To facilitate compatible operations between non-Federal terrestrial receiving stations at fixed sites and Federal earth station transmitters, coordination is required. To facilitate compatible operations between non-Federal terrestrial transmitting stations and Federal spacecraft receivers, the terrestrial transmitters in the band 2025-2110 MHz shall not be high-density systems (see Recommendations ITU-R SA.1154 and ITU-R F.1247). Military satellite control stations at the following sites shall operate on a co-equal, primary basis with non-Federal operations:

Facility	**Coordinates**	
Naval Satellite Control Network, Prospect Harbor, ME	44° 24' 16" N	068° 00' 46" W
New Hampshire Tracking Station, New Boston AFS, NH	42° 56' 52" N	071° 37' 36" W
Eastern Vehicle Check-out Facility & GPS Ground Antenna & Monitoring Station, Cape Canaveral, FL	28° 29' 09" N	080° 34' 33" W
Buckley AFB, CO	39° 42' 55" N	104° 46' 36" W
Colorado Tracking Station, Schriever AFB, CO	38° 48' 21" N	104° 31' 43" W
Kirtland AFB, NM	34° 59' 46" N	106° 30' 28" W
Camp Parks Communications Annex, Pleasanton, CA	37° 43' 51" N	121° 52' 50" W
Naval Satellite Control Network, Laguna Peak, CA	34° 06' 31" N	119° 03' 53" W
Vandenberg Tracking Station, Vandenberg AFB, CA	34° 49' 21" N	120° 30' 07" W
Hawaii Tracking Station, Kaena Pt, Oahu, HI	21° 33' 44" N	158° 14' 31" W
Guam Tracking Stations, Anderson AFB, and Naval CTS, Guam	13° 36' 54" N	144° 51' 18" E

US347 In the band 2025-2110 MHz, non-Federal Earth-to-space and space-to-space transmissions may be authorized in the space research and Earth exploration-satellite services subject to such conditions as may be applied on a case-by-case basis. Such transmissions shall not cause harmful interference to Federal and non-Federal stations operating in accordance with the Table of Frequency Allocations.

US393 In the band 2025-2110 MHz, the military services may operate stations in the fixed and mobile except aeronautical mobile services on a secondary and coordinated basis at the following sites:

Site	**Coordinates**	**Radius of Operation (km)**
Nellis AFB, NV	36° 14' N 115° 02' W	80
China Lake, CA	35° 41' N 117° 41' W	50
Ft. Irwin, CA	35° 16' N 116° 41' W	50
Pacific Missile Test Range/Pt. Mugu, CA	34° 07' N 119° 30' W	80
Yuma, AZ	32° 32' N 113° 58' W	80
White Sands Missile Range, NM	33° 00' N 106° 30' W	80

3. Federal Agency Use

3a. Federal Agency Frequency Assignments Table

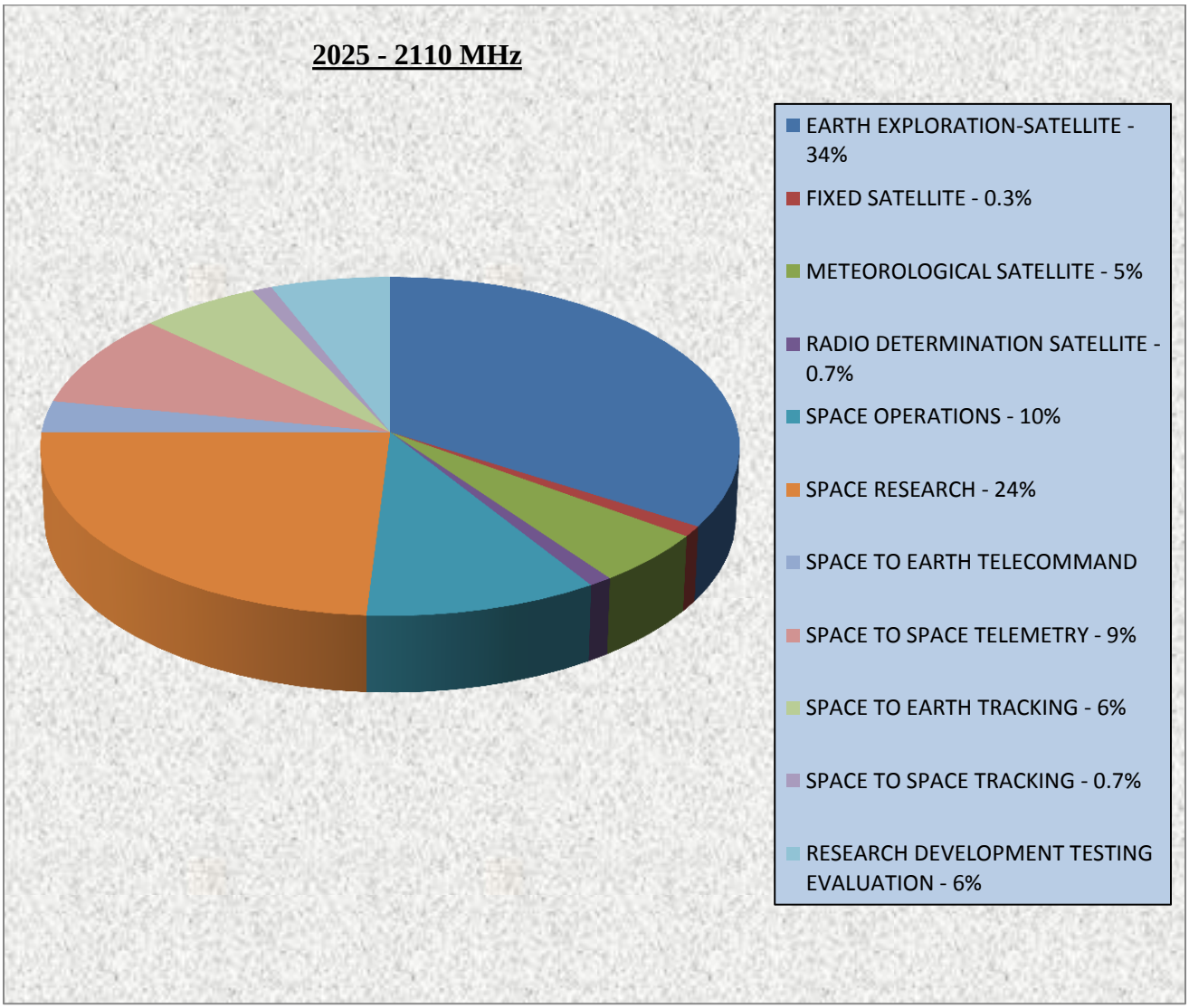
The following table identifies the frequency band, types of allocations, types of applications, and the number of frequency assignments by agency.

Federal Frequency Assignment Table

2025-2110 MHz Band													
SHARED BAND													
	EARTH EXPLORATION-SATELLITE (Earth-to-space) (space-to-space) FIXED MOBILE SPACE OPERATION (Earth-to-space) (space-to-space) SPACE RESEARCH (Earth-to-space) (space-to-space)												
	TYPE OF APPLICATION												
AGENCY	EARTH EXPLORATION SATELLITE	FIXED SATELLITE	METEOROLOGICAL SATELLITE	RADIO DETERMINATION SATELLITE	SPACE OPERATIONS	SPACE RESEARCH	SPACE TO EARTH TELECOMMAND	SPACE TO SPACE TELEMETRY	SPACE TO EARTH TRACKING	SPACE TO SPACE TRACKING	SPACE TO SPACE TELEMETRY	RESEARCH DEVELOPMENT TESTING EVALUATION	TOTAL
AF												7	7
DOC	26		14	1	2	6	11	1	2	1	1		65
DOE	1				1								2
N												2	2
NASA	74	1		1	24	59	15		15	1	1	8	199
TOTAL	101	1	14	2	27	65	26	1	17	2	2	17	275
The number of actual systems, or number 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 in the Government Master File (GMF) for the systems operating in the band 2025-2110 MHz.



4. Frequency Band Analysis

The earth stations that provide the primary command and control for the U.S. civil space programs operate in the 2025-2110 MHz band. The tracking, and command operations performed by the earth stations in this band control and monitor a satellite's electrical function and orbit and allow information to be transmitted to the satellite that can alter the electrical function of the spacecraft and, if necessary, adjust its orbit. The Federal satellites that depend on this band for tracking and control are used for space research,

space operations, and Earth exploration applications. The physics of this frequency range allow for communications through the atmosphere in all weather conditions and provides the capability to establish communications with a satellite that has lost its ability to orient itself.

NASA operates earth stations in this band that are used as the primary telecommand communications for the control of their satellites as well as those associated with foreign space agency missions. NASA operates control links directly from earth stations and space-to-space links between geostationary and non-geostationary satellites via the TDRSS for low Earth orbiting spacecraft.[3] The earth stations operating in this band are used to support approximately ninety NASA space research missions including the Space Shuttle, Hubble Space Telescope and the International Space Station.[4] Many of the spacecraft controlled by the earth stations operating in the 2025-2110 MHz band collect data used to monitor climate change, severe weather, the atmosphere, the oceans, sea ice and glaciers, and the land surface. The locations of NASA earth-station facilities are shown in Table 1.

Table 1. NASA earth-station locations

City	State	Latitude	Longitude
COLD BAY	AK	551126N	1624224W
FAIRBANKS	AK	645131N	1475127W
FAIRBANKS	AK	645133N	1475119W
FAIRBANKS	AK	645820N	1473103W
FAIRBANKS	AK	645838N	1473054W
NORTH POLE	AK	644800N	1473000W
NORTH POLE	AK	644818N	1473000W
POKER FLAT	AK	650600N	1472730W
POKER FLAT	AK	650600N	1473000W
POKER FLAT	AK	650700N	1472742W
POKER FLAT	AK	650700N	1472742W
POKER FLAT	AK	650700N	1470300W
POKER FLAT	AK	650702N	1472733W

[3] TDRSS is a network of communications satellites and ground stations used by NASA for space communications. TDRSS was designed to replace an existing network of ground stations that had supported all of NASA's manned flight missions. The prime design goal was to increase the time spacecraft were in communication with the ground and improve the amount of data that could be transferred.

[4] http://www.nasa.gov/missions/current/index.html.

City	State	Latitude	Longitude
POKER FLAT	AK	650704N	1472601W
POKER FLAT	AK	650825N	1473042W
POKER FLAT	AK	650825N	1472742W
POKER FLAT 11 MTR	AK	650600N	1470300W
MCMURDO	ANTR	775021S	1664001E
MCMURDO STATION	ANTR	774800S	1664200E
BERKELEY	CA	375248N	1221438W
EDWARDS	CA	345729N	1175442W
EL SEGUNDO	CA	335547N	1182320W
GOLDSTONE	CA	351454N	1164728W
GOLDSTONE	CA	351800N	1165400W
GOLDSTONE	CA	352000N	1165030W
GOLDSTONE	CA	352024N	1165229W
GOLDSTONE	CA	352025N	1165227W
GOLDSTONE	CA	352030N	1165225W
GOLDSTONE	CA	352030N	1165222W
GOLDSTONE	CA	352533N	1165319W
GOLDSTONE DSS 14	CA	352533N	1165323W
GOLDSTONE DSS 16	CA	352030N	1165225W
GOLDSTONE DSS 27	CA	351418N	1164644W
GOLDSTONE DSS24	CA	352023N	1165229W
GOLDSTONE DSS27	CA	351418N	1164636W
TABLE MOUNTAIN	CA	342256N	1174056W
KENNEDY SPACE CENTER	FL	283000N	0804130W
MERRITT ISLAND	FL	283030N	0804137W
MERRITT ISLAND	FL	283030N	0804136W
MIAMI	FL	254358N	0800947W
NEW SMYRNA BEACH	FL	290300N	0805330W
NEW SMYRNA BEACH	FL	290300N	0805300W
NEW SMYRNA BEACH	FL	290300N	0805300W
FINEGAYAN	GUM	133655N	1445122E
KOKEE PARK	HI	220723N	1593955W
SOUTH POINT	HI	190000N	1553600W
SOUTH POINT	HI	190048N	1553947W

City	State	Latitude	Longitude
SOUTH POINT	HI	190050N	1553947W
SOUTH POINT	HI	190050N	1553948W
SOUTH POINT	HI	190613N	1553947W
GREENBELT	MD	390112N	0764941W
LAUREL	MD	391003N	0765356W
LAUREL	MD	391100N	0765400W
KWAJALEIN ISLAND	MHL	084301N	1674301E
BLUE MESA	NM	322941N	1070944W
WHITE SANDS	NM	323230N	1063643W
WHITE SANDS	NM	323240N	1063648W
WHITESANDS	NM	322059N	1063631W
SVALBARD	NOR	781349N	0152334E
CLEVELAND	OH	412450N	0815153W
MAYAGUEZ	PR	181242N	0670813W
WALLOPS	VA	375530N	0752835W
WALLOPS 11 MTR	VA	375538N	0752831W
WALLOPS ISLAND	VA	375000N	0752830W
WALLOPS ISLAND	VA	375523N	0752839W
WALLOPS ISLAND	VA	375525N	0752834W
WALLOPS ISLAND	VA	375538N	0752830W
WALLOPS ISLAND	VA	375545N	0752835W
WALLOPS ISLAND	VA	375649N	0752638W
FAIRMONT	WV	391536N	0800636W

The U.S. National Meteorological Satellite System is composed of the GOES and POES series of satellites. NOAA operates earth stations in this band that are used as the primary telecommand communications for the control of these meteorological satellites. The measurements performed by the GOES and POES provide meteorological, environmental, and climate data used by the NWS, other Federal agencies, and member nations of the World Meteorological Organization. This data is also the basis of the satellite products produced continuously for public use. The locations of the Department of Commerce earth-station facilities are shown in Table 2.

Table 2. Locations of NOAA Facilities

City	State	Latitude	Longitude
FAIRBANKS	AK	645820N	1473059W

City	State	Latitude	Longitude
FAIRBANKS	AK	645822N	1473004W
FAIRBANKS	AK	645838N	1473054W
FAIRBANKS	AK	645840N	1472940W
GOLDSTONE DSS 16	CA	352030N	1165225W
GOLDSTONE DSS 24	CA	352024N	1165229W
GOLDSTONE DSS 27	CA	351418N	1164636W
RICHMOND	FL	253600N	0802400W
GUAM SEISMIC OBSERVATORY	GUM	133218N	1445442E
AHUA KILAUEA	HI	192256N	1551608W
HAWAII NATIONAL PARK	HI	192524N	1551727W
KAMUELA	HI	200036N	1554006W
SANDHILL KILAUEA	HI	192345N	1551739W
SVALBARD	NOR	781354N	0152440E
WALLOPS	VA	375644N	0752742W
WALLOPS	VA	375648N	0752733W
WALLOPS ISLAND	VA	375644N	0752740W
WALLOPS ISLAND	VA	375645N	0752738W
WALLOPS ISLAND	VA	375645N	0752742W
WALLOPS ISLAND	VA	375645N	0752740W
WALLOPS ISLAND	VA	375647N	0752745W
WALLOPS ISLAND	VA	375647N	0752743W
WALLOPS ISLAND	VA	375647N	0752738W
WALLOPS ISLAND	VA	375648N	0752736W
WALLOPS ISLAND	VA	375648N	0752733W

In accordance with footnote US346 the Department of Defense (DoD) operates earth stations in the 2025-2110 MHz band on a co-primary basis with non-Federal fixed and transportable ENG systems. The earth stations contained in this footnote are shown in Table 3.[5]

Table 3. DoD Earth Station Facilities in the 2025-2110 MHz Band

Facility	Latitude	Longitude
Naval Satellite Control Network, Prospect Harbor, ME	44º 24’ 16’’ N	068º 00’ 46’’ W
New Hampshire Tracking Station, New Boston AFS, NH	42º 56’ 52’’ N	071º 37’ 36’’ W
Eastern Vehicle Check-out Facility and GPS Ground Control Antenna and Monitoring Station, Cape Canaveral, FL	28º 29’ 09’’ N	080º 34’ 33’’ W

[5] NTIA Manual §4.1.3 at 4-145.

Buckley Air Force Base, CO	39º 42’ 55’’ N	104º 46’ 36’’ W
Colorado Tracking Station, Schriever Air Force Base, CO	38º 48’ 21’’ N	104º 31’ 43’’ W
Kirtland Air Force Base, NM	34º 59’ 46’’ N	106º 30’ 28’’ W
Camp Parks Communications Annex, Pleasanton, CA	37º 43’ 51’’ N	121º 52’ 50’’ W
Naval Satellite Control Network, Laguna Park, CA	34º 06’ 31’’ N	119º 03’ 53’’ W
Vandenberg Tracking Station, Vandenberg Air Force Base, CA	34º 49’ 21’’ N	120º 30’ 07’’ W
Hawaii Tracking Station, Kaena Point, Oahu, HI	21º 33’ 44’’ N	158º 14’ 31’’ W
Guam Tracking Stations, Anderson Air Force Base and Naval CTS, Guam	13º 36’ 54’’ N	144º 51’ 18’’ E

The DoD and the Society of Broadcast Engineers have developed a Memorandum of Understanding describing the frequency sharing arrangements between the earth stations and the ENG systems operating in the 2025-2110 MHz band.[6] Although the DoD currently has no assignments at these locations, some satellites already deployed will use these ground stations as will future DoD satellites.

The GMF contains approximately 30 assignments that allow equipment to be used on an experimental basis. However, these assignments are only allowed to operate on a non-interference basis and as such are not included in the following analysis.

The DoD has four assignments under footnote US393 that are allowed to operate on a secondary and coordinated basis. Given the small number and secondary service, these assignments were not considered in the following analysis.

Though the band is allocated to various space service applications for transmissions in the Earth-to-space and space-to-space directions, several geostationary satellites in conjunction with TDRSS operate in the space-to-Earth direction. The frequency assignments for these space applications are permitted on an unprotected non-interference basis. These satellites transmit to ground station receivers located at Merritt Island, FL, Greenbelt, MD, White Sands Missile Range, NM, Finegayan, GUM, and American Samoa and are used for test and simulation associated with tracking and command functions for TDRSS.

4a. Frequency Use

There is a critical relationship between the uplink and downlink frequencies used by the NASA and NOAA satellites. In order to acquire and accurately track orbiting satellites a specific ratio between the uplink and downlink is used that allows precision Doppler tracking of mission range and range rate information. The frequency range corresponding to the 2025-2110 MHz uplink band is the 2200-2290 MHz downlink band.

[6] The ENG operations include systems operating in the Television Broadcast Auxiliary Service, the Cable Television Relay Service, and the Local Television Transmission Service. ENG operations include news vans, and sky traffic aircraft that feed receive sites, which in turn relay the signal to television stations.

Almost all of the satellite transponders are designed with this turn-around-ratio as an integral part of its satellite operation because of the low cost and proven reliability.[7] Any impact to spectrum in the 2025-2110 MHz will impact an equal amount of spectrum in the 2200-2290 MHz band.

Figure 1 shows the distribution of GMF frequency assignments in the 2025-2110 MHz band divided into 5-MHz segments. When a frequency assignment overlapped multiple segments, the assignment was counted in each segment. In cases where an assignment is authorized to operate anywhere in the 2025-2110 MHz band, it was counted in every 5-MHz segment.

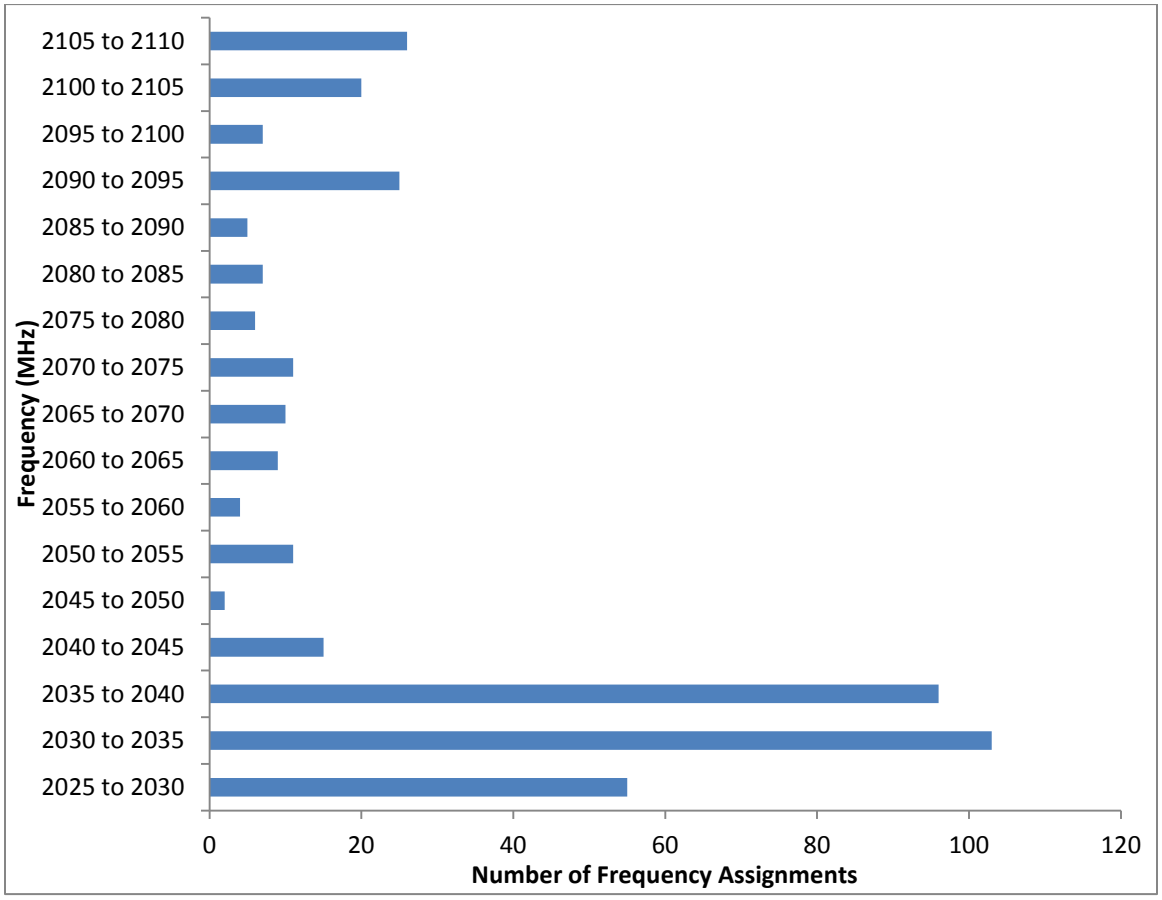


Figure 1. Distribution of Frequency Assignments in the 2025-2110 MHz Band

[7] A transponder is an automatic electronic monitoring or control device that receives, cross-examines, amplifies and retransmits the arriving signal. It is primarily implemented in wireless communication. The word "Transponder" itself is a combination of two words; transmitter and responder.

4b. Technical Characteristics

There are several hundred frequency assignments in the GMF for earth stations transmitting from over fifty locations to numerous non-geostationary Earth exploration satellites and spacecraft. Many of these earth stations communicate with multiple geostationary and non-geostationary satellites. The earth stations operating in this band may use different power levels and bandwidths to communicate with these satellites.

Figures 2 through 4 show the distribution of transmitter power, bandwidth, and antenna gain, respectively, for space service frequency assignments in the 2025-2210 MHz band. In each of these figures, the number of assignments may be different because, an individual frequency assignment may have multiple power levels, bandwidths, or antenna gain values authorized.

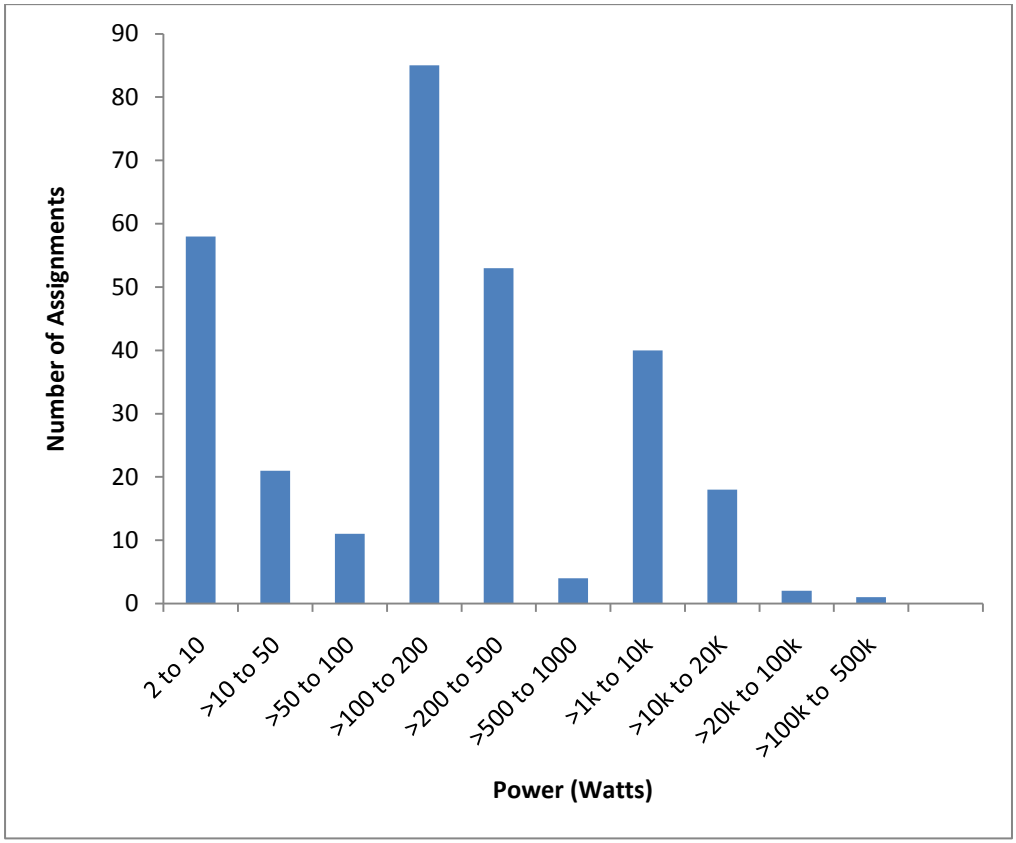


Figure 2. Distribution of Transmitter Power Levels in the 2025-2110 MHz Band

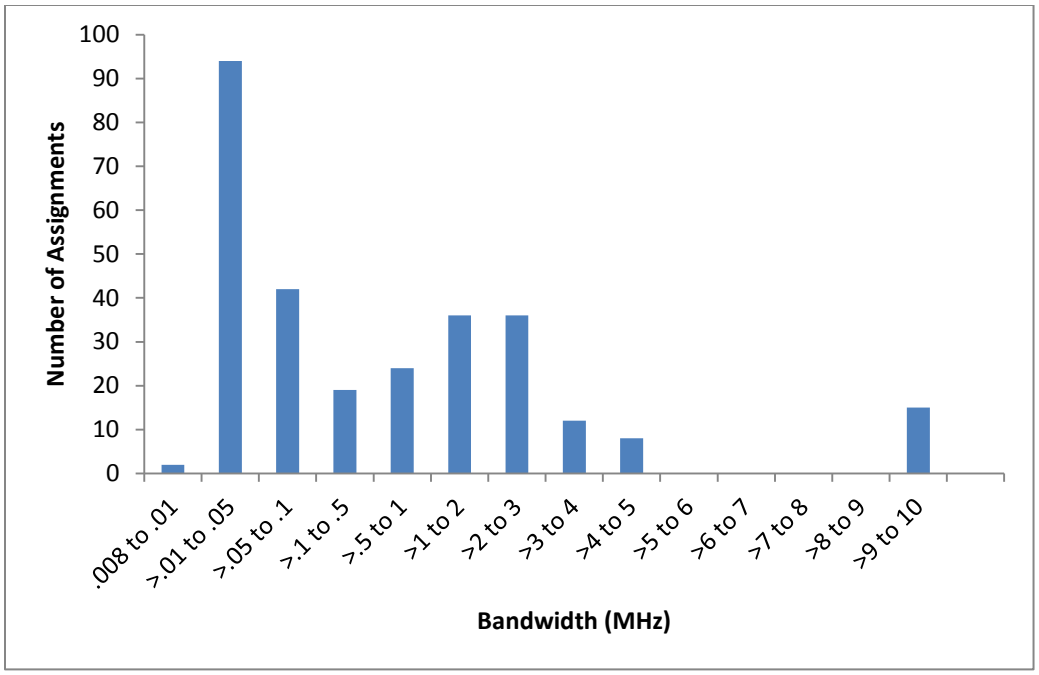


Figure 3. Distribution of Transmitter Bandwidths in the 2025-2210 MHz Band

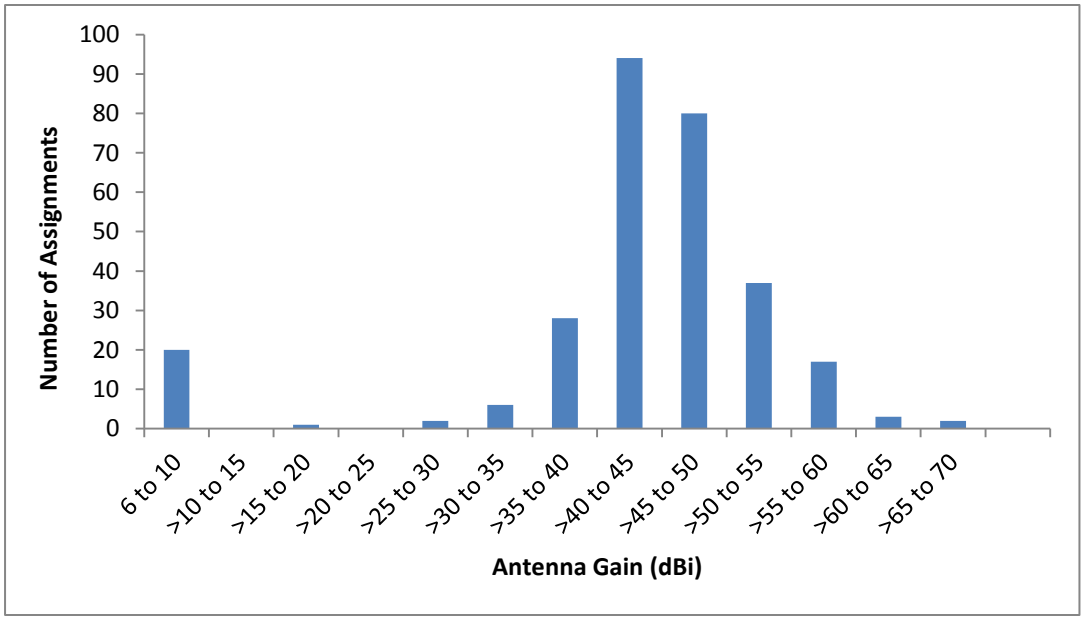


Figure 4. Distribution of Antenna Gain in the 2025-2110 MHz Band

4c. Spectrum Contours

The contours below assume a mobile receiver with a 1 MHz bandwidth, a two meter antenna height, and an antenna gain of 0 dBi. The interference criteria used was an increase in the noise floor of the receiver of 1 dB. The thermal noise floor of this ideal receiver would be -114 dBm and therefore, a one dB increase in the noise floor would result in an interference threshold of -120 dBm. Using the recorded power, location, and bandwidth of these earth stations, a terrain dependent propagation model was used to develop spectrum contours that indicate the minimum required separation distance to preclude an increase in the thermal noise floor of the mobile receiver of 1 dB. A 0 dBi sidelobe antenna gain was used for the earth station transmitters in the analysis since the earth stations are uplinks and are pointed upwards the sky and not directly at the horizon. The statistical and environmental parameters used with the terrain profile to calculate the propagation loss and plot the contours are shown in Table 4.

Table 4. Propagation Model Parameters

Parameter	Value
Refractivity	301 N-units
Conductivity	0.005 S/M
Permittivity	15
Humidity	10
Reliability	50 percent
Confidence	50 percent
Radio Climate	Continental Temperate
Antenna Polarization	Vertical
Transmit Antenna Height (terrain elevation and antenna height)	Extracted from Terrain Database and GMF
Receive Antenna Height	2 meters (above ground level)

Contours below also include contours for each transmitting earth station using the maximum power listed in the GMF. In the case of Military Satellite Control Stations listed in Table 3, the contours were generated using a power of 20 kW, 14.5 dBi sidelobe

antenna gain, and a 20 MHz bandwidth.[8] The antenna height was assumed to be 8 meters which is similar to other DoD earth stations.[9]

There are cases where multiple frequency assignments are represented by what appears to be a single contour but is actually a composite of multiple overlapping contours. For example, there are sixty four frequency assignments located at nineteen unique locations on the Wallops Island, VA. earth station contour shown at the bottom of Figure 7.

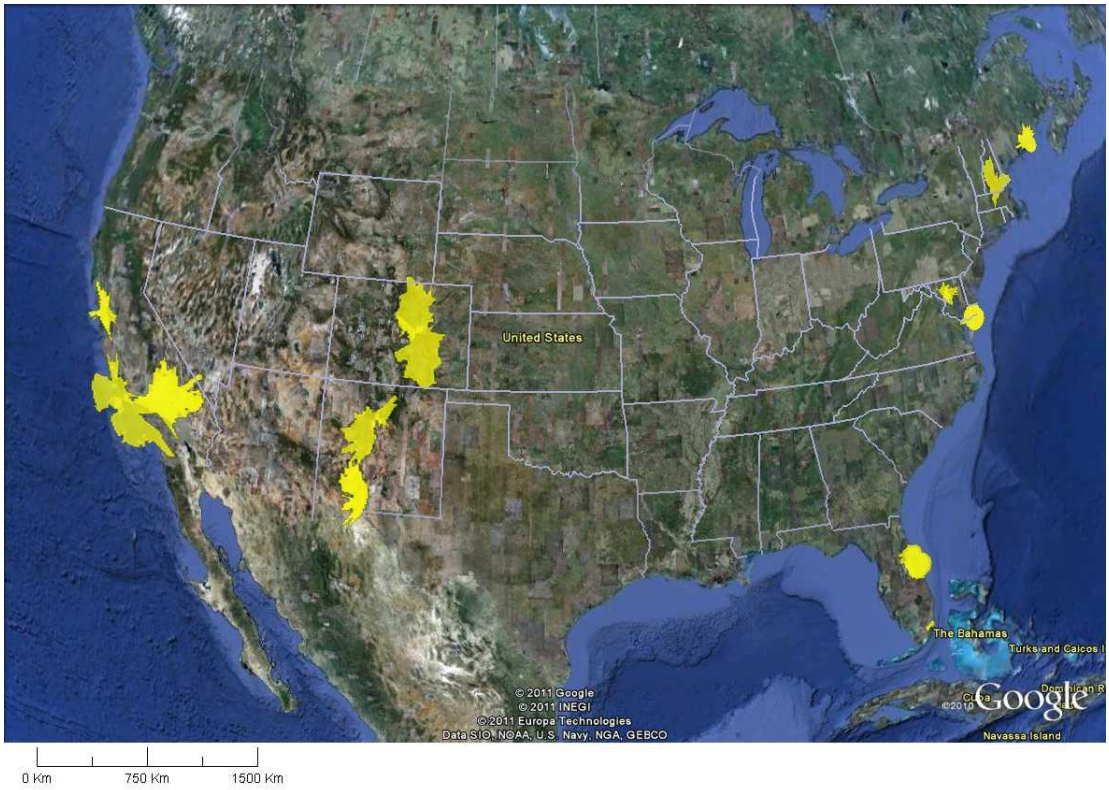


Figure 5. Transmitting Earth Stations – Continental United States

[8] The sidelobe antenna gain is based on a 5-degree elevation angle (θ), and a standard earth-station antenna elevation pattern of. 32-25 Log θ.

[9] The letter D is shown beside the contours to indicate that a DoD earth station from Table 3 is within the contour.

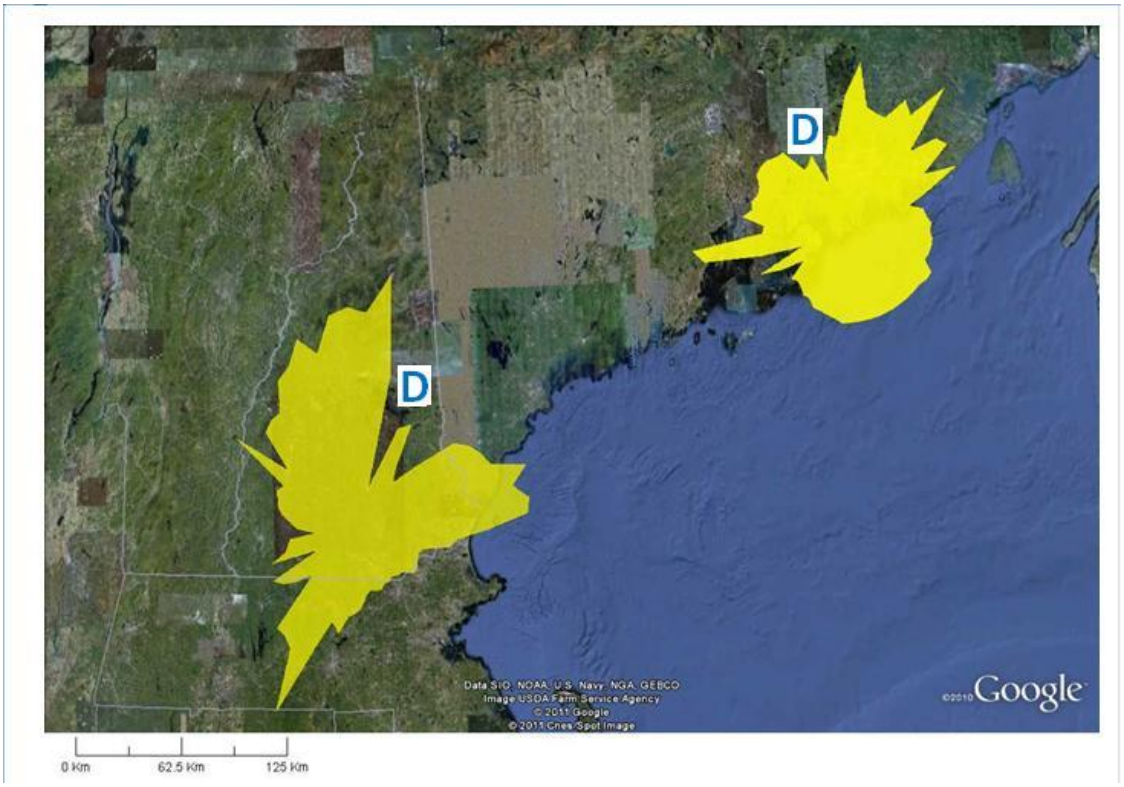


Figure 6. Transmitting Earth Stations - Northeast United States

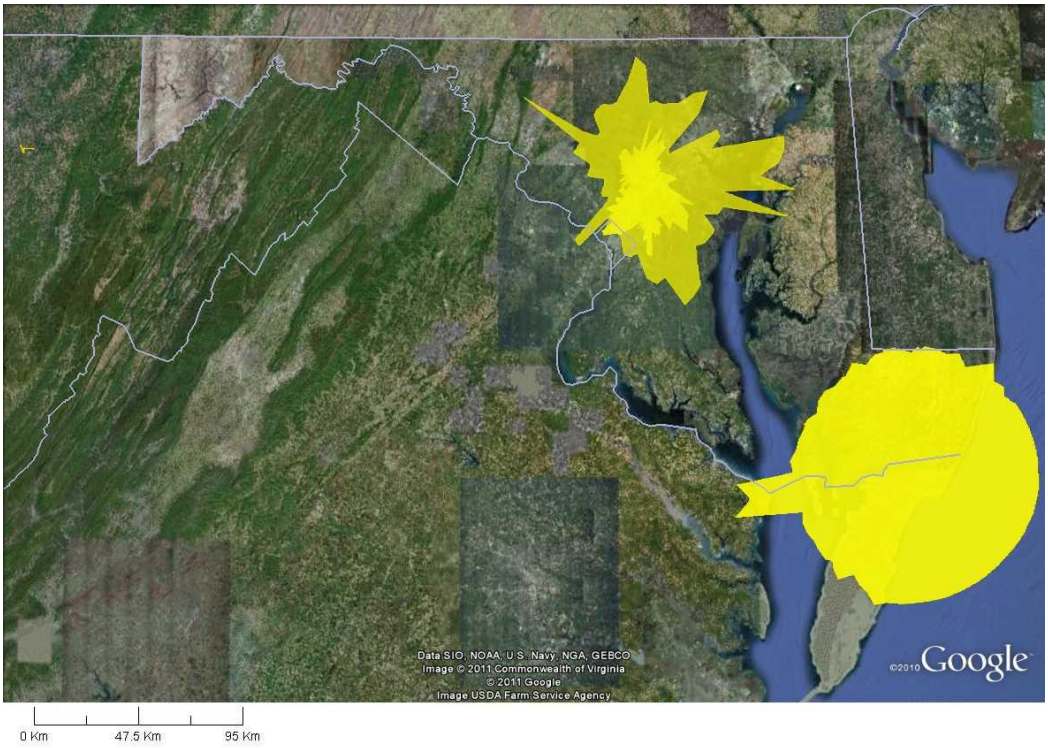


Figure 7. Transmitting Earth Stations – Eastern United States

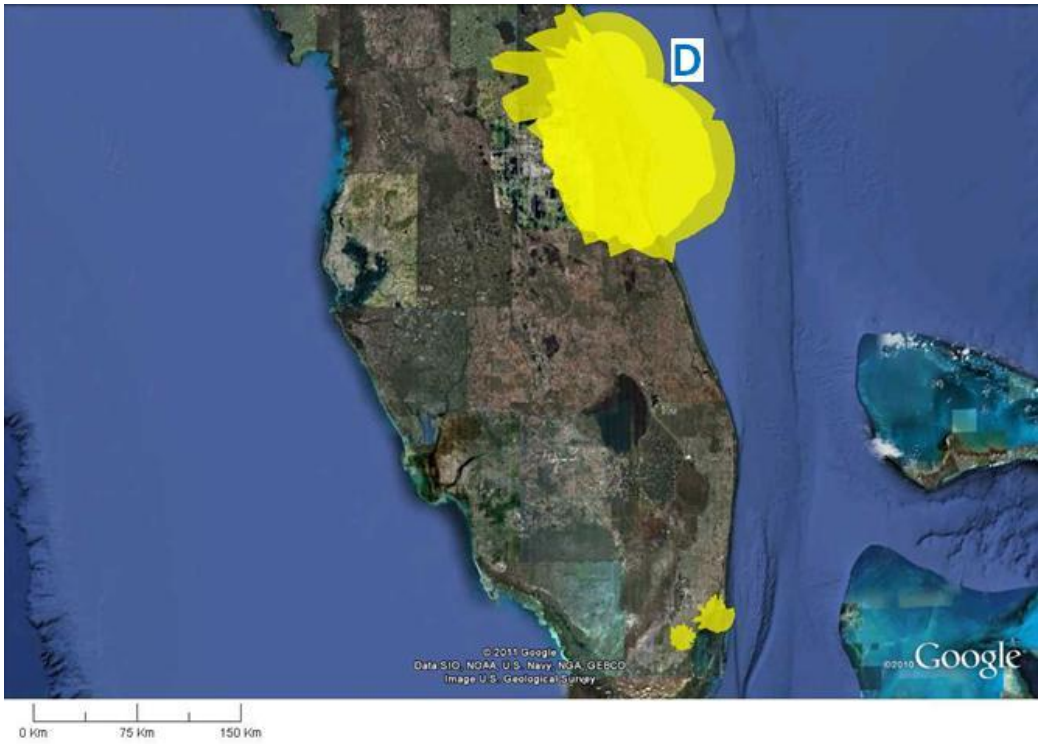


Figure 8. Transmitting Earth Stations – Southeast United States

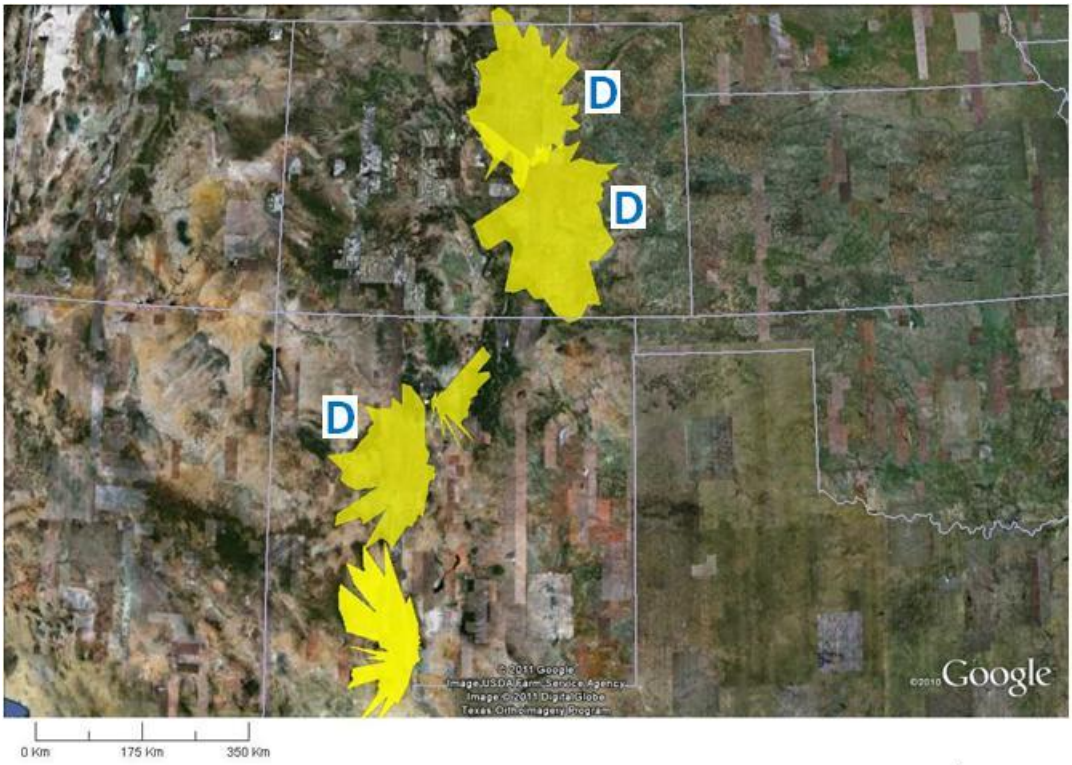


Figure 9. Transmitting Earth Stations – Central United States

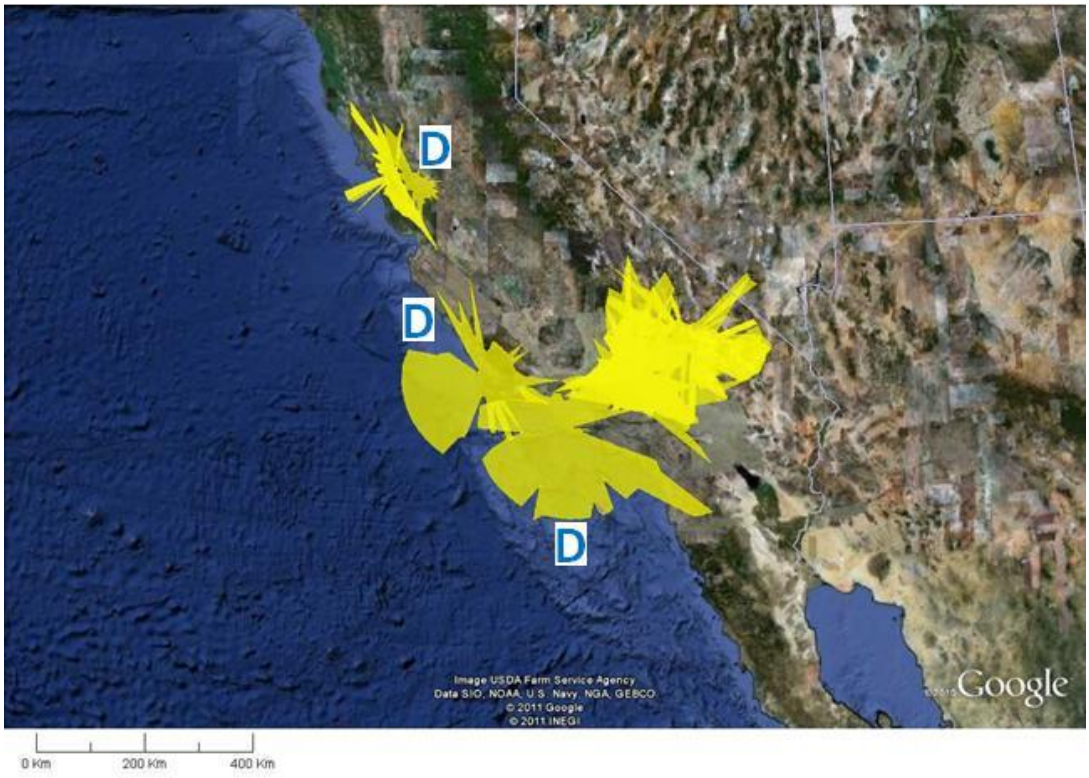


Figure 10. Transmitting Earth Stations – Western United States

Figure 11. Transmitting Earth Stations – Alaska

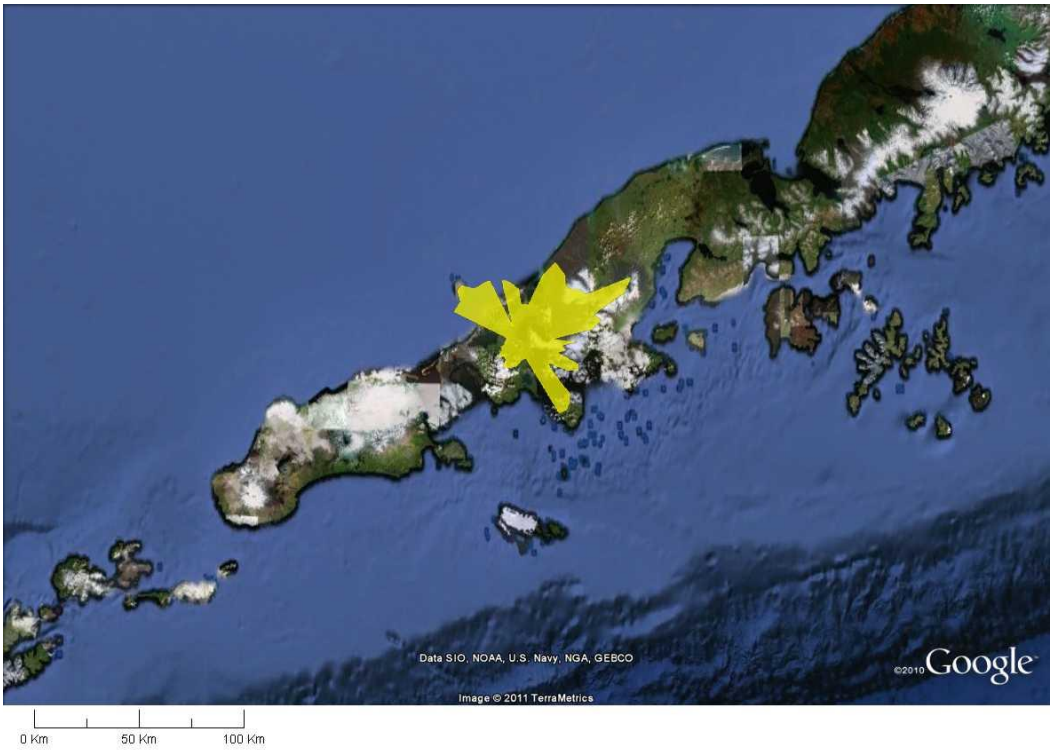


Figure 12. Transmitting Earth Stations – Alaska

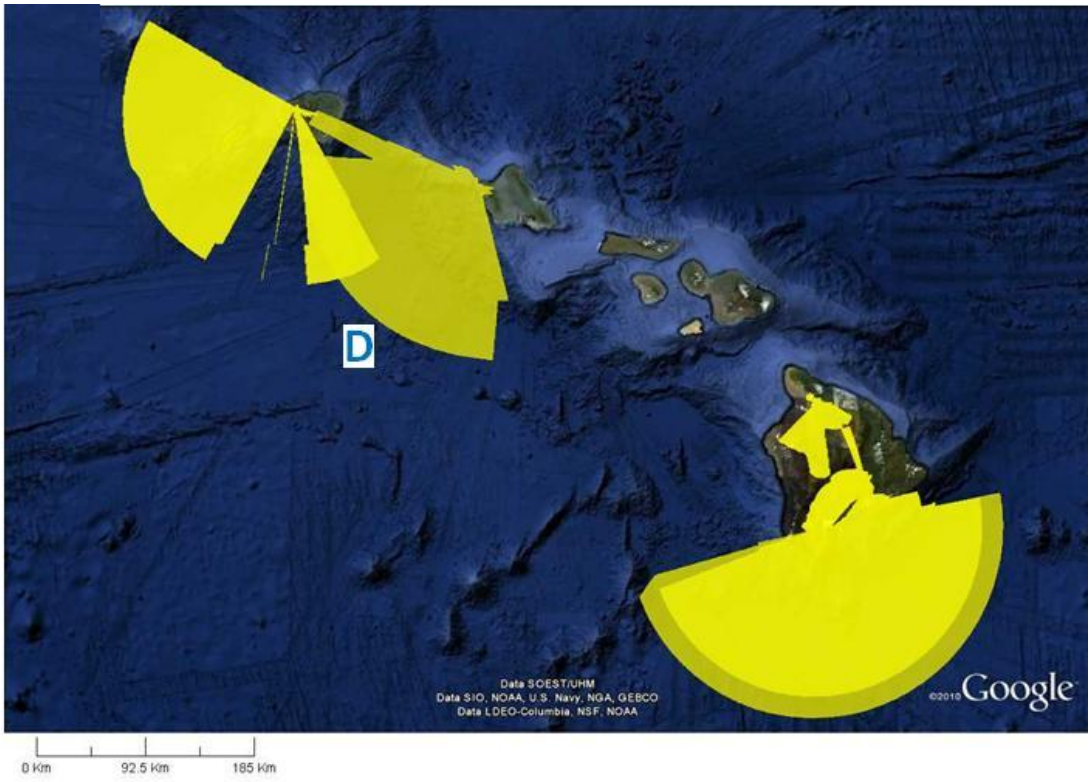


Figure 13. Transmitting Earth Stations – Hawaii

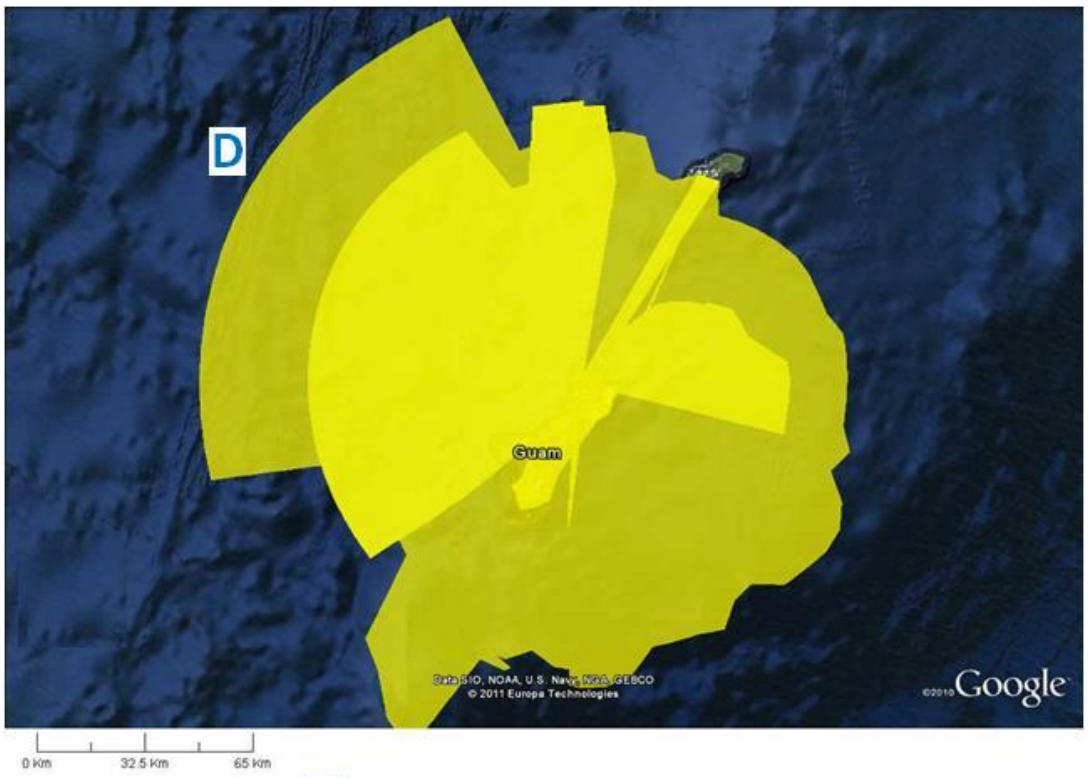


Figure 14. Transmitting Earth Stations - Guam

5. Planned Use

The earth stations operating in the 2025-2110 MHz band provides the primary backbone control link for the civil National Space Program.

Earth stations performing tracking, telemetry, and command functions for Federal space research and meteorological satellites will continue to operate in this band for the foreseeable future.

The earth stations that provide tracking, telemetry, and command for the GOES and POES systems will continue to operate in this band for the foreseeable future.

The TDRSS constellation of satellites and associated ground facilities provide tracking and data acquisition services and will continue to operate in this band for the foreseeable future.

The use of the 2025-2110 MHz band for earth stations that control military satellite systems is expected to increase in the future.