400.15–401 MHz

1. Band Introduction

A number of Federal agencies operate radiosondes in this band within the meteorological aids service. These devices are launched from sites across the country and provide atmospheric observations. These observations provide critical data used in the around-the-clock weather forecasting service, flood warning, and meteorological research studies. The collected data is shared among various Federal agencies, state and local governments, academic research programs, and private weather forecasting firms (e.g., the Weather Channel). In addition to the radiosonde operations in this band, the Department of Commerce National Oceanic and Atmospheric Administration (NOAA) operates dropsondes launched from aircraft to collect time critical meteorological data used for hurricane prediction models. Because of national- and agency-specific meteorological functions and requirements, the Federal Government is the largest user of meteorological aids equipment.

The National Aeronautics and Space Administration (NASA) operates a wireless video system employing helmet-mounted cameras for Space Shuttle and International Space Station extra-vehicular activities. This system includes a command link operating in the 400.15 – 401 MHz band under the space research service for the control of these helmet-mounted cameras. NASA also operates a communications system in the 400.15 – 401 MHz band under the space research service that transfers relative navigation data and other telemetry between the International Space Station and the SpaceX Dragon spacecraft during the Dragon spacecraft's approach and departure. Finally, NASA will be launching the Firefly satellite in 2013 to look specifically for gamma-ray flashes coming from the atmosphere. These terrestrial gamma-ray flashes are a phenomenon that is linked with lightning. The Firefly satellite will detect the gamma-ray flashes and lightning events and transmit the measurement data to its associated earth station using its assigned downlink frequency in the 400.15-401 MHz band.

The Navy operates two experimental satellites in the 400.15 to 401 MHz band. The TACSAT-4 satellite was developed to experiment with advanced satellite communications (SATCOM) capabilities. The GLADIS satellite was developed to experiment with providing enhanced maritime domain awareness and safety.

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)
400.15-401 METEOROLOGICAL AIDS (radiosonde) US70 METEOROLOGICAL-SATELLITE (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) US319 US320 US324 SPACE RESEARCH (space-to-Earth) 5.263 Space operation (space-to-Earth) 5.264	400.15-401 METEOROLOGICAL AIDS (radiosonde) US70 MOBILE-SATELLITE (space-to-Earth) US319 US320 US324 SPACE RESEARCH (space-to-Earth) 5.263 Space operation (space-to-Earth) 5.264	Satellite Communications (25)

2b. Additional Allocation Table Information

The United States and International footnotes applicable to the 400.15 – 401.0 MHz band listed below are extracted from the NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management, Chapter 4 – Allocations, Allotments and Plans.

US70 The meteorological aids service allocation in the band 400.15-406.0 MHz does not preclude the operation therein of associated ground transmitters.

US319 In the bands 137-138 MHz, 148-149.9 MHz, 149.9-150.05 MHz, 399.9-400.05 MHz, 400.15-401 MHz, 1610-1626.5 MHz, and 2483.5-2500 MHz, Federal stations in the mobile-satellite service shall be limited to earth stations operating with non-Federal space stations.

US320 The use of the bands 137-138 MHz, 148-150.05 MHz, 399.9-400.05 MHz, and 400.15-401 MHz by the mobile-satellite service is limited to non-voice, non-geostationary satellite systems and may include satellite links between land earth stations at fixed locations.

US324 In the band 400.15-401 MHz, Federal and non-Federal satellite systems shall be subject to electromagnetic compatibility analysis and coordination.

5.263 The band 400.15-401 MHz is also allocated to the space research service in the space- to-space direction for communications with manned space vehicles. In this application, the space research service will not be regarded as a safety service.

5.264 The use of the band 400.15-401 MHz by the mobile-satellite service is subject to coordination under No. **9.11A**. The power flux-density limit indicated in Annex **1** of Appendix **5** shall apply until such time as a competent world radiocommunication conference revises it.

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 by agency.

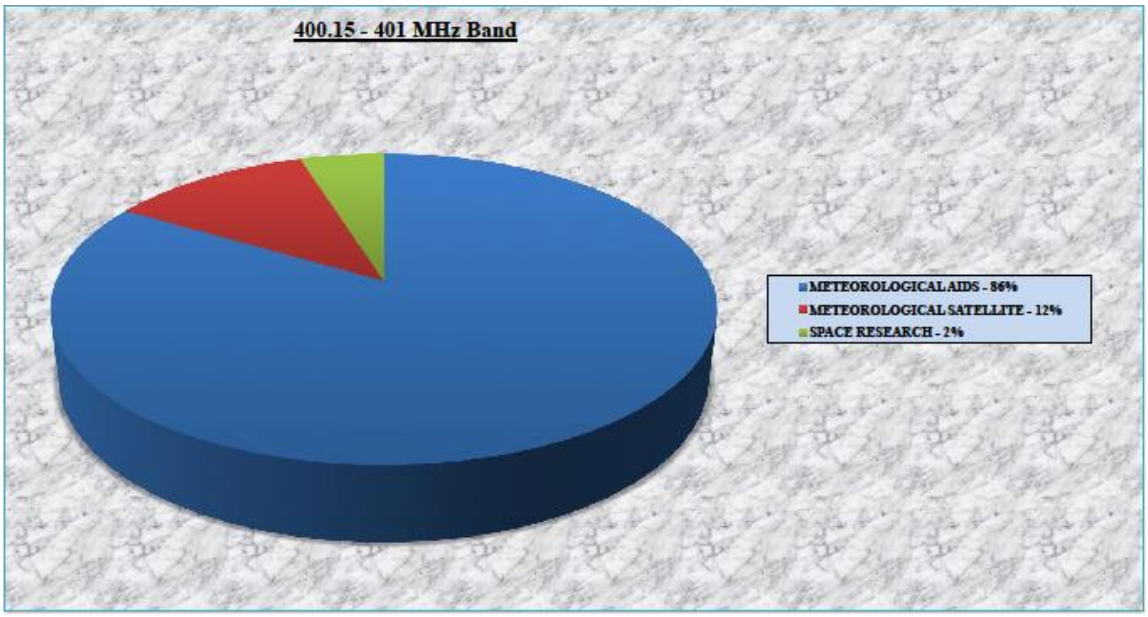
Federal Frequency Assignment Table

400.15 - 401 MHz Band						
SHARED BAND						
	METEOROLOGICAL AIDS (radiosonde) **METEOROLOGICAL-SATELLITE (space-to-Earth)** **MOBILE-SATELLITE (space-to-Earth)** **SPACE RESEARCH (space-to-Earth)(space-to-space)** **SPACE OPERATION (space-to-Earth)**					
	TYPE OF APPLICATION					
AGENCY	**METEOROLOGICAL AIDS**	**SPACE RESEARCH**	**METEOROLOGICAL SATELLITE**			**TOTAL**
AF	**2**		**1**			**3**
AR	**2**					**2**
DOC	**18**					**18**
DOE	**8**					**8**
N	**7**		**2**			**9**
NASA		**3**				**3**
TOTAL	**37**	**3**	**3**			**43**

The number of actual systems, or number of equipment, 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 percentage of frequency assignments for the radio services that operate in the 400.15 – 401.00 MHz frequency band is shown below.



4. Frequency Band Analysis By Application

4a. Meteorological Aids (Radiosonde)

The meteorological aids service is a radiocommunication service used for meteorological observations and exploration. The National Weather Service (NWS) of the National Oceanic and Atmospheric Administration is responsible for observing and reporting weather, issuing forecasts, and warning of weather and flood conditions affecting national safety, welfare, and the economy. The equipment employed in the meteorological aids (radiosonde) service provide many of these observations and continue to provide critical data used for around-the-clock weather forecasting service, flood warning, and meteorological research studies.[1] The NWS operates a synoptic network of 102 stations, where radiosondes are launched at 0000 and 1200 Coordinated Universal Time to provide an instantaneous snapshot of the atmosphere.[2] Radiosondes

1. In the course of a 24-hour-per-day, year round operation, the National Meteorological Center receives approximately 50,000 surface observation reports from land stations, 3000 reports from ships, 4100 upper air observations, and between 3000 and 4000 reports from aircraft. *See* United States Department of Commerce, FCM P1-1992, *Federal Plan for Meteorological Services and Supporting Research* (1992), at A-4.

2. Radiosondes are sensor packages lifted through the atmosphere by a balloon that transmit atmospheric data to a ground station receiver where the data is processed, and meteorological data products are produced.

are used to monitor atmospheric conditions such as temperature, pressure, humidity, wind speed, and wind direction. The information collected by radiosondes supports weather models for forecasting, and atmospheric and climatologic research, including national and international research related to global climate change. The collected data is shared among various Federal agencies, state and local governments, academic research programs, and private weather forecasting firms (e.g., the Weather Channel). Data collected by radiosondes that provides medium range information on weather related events (e.g., rainfall, wind speed and direction, severe weather events) is critical to agencies supporting homeland security missions. Because of national and agency-specific meteorological functions and requirements, the Federal Government is the largest user of meteorological aids equipment. There are approximately 80,000 radiosondes flown in the United States each year for synoptic operations. The radiosonde flight can last in excess of two hours, and during this time the radiosonde can ascend to over 35 kilometers (approximately 115,000 feet) and drift more than 200 kilometers (approximately 125 miles) from the release point.

The Air Force and the National Aeronautics and Space Administration (NASA) operate the Automated Meteorological Profiling System (AMPS) to conduct upper air measurements in support of space launch operations at Cape Canaveral and Vandenberg Air Force Base. AMPS uses radiosondes to measure the horizontal winds, air temperature and humidity from the surface of the Earth to an altitude of approximately 100,000 feet. The data collected by the AMPS radiosondes is used by weather personnel for the planning and execution of space launches and missile testing. Each launch vehicle has specific tolerances for surface wind speeds and temperatures, and for winds aloft, that must be considered just prior to launch. The amount of cloud cover, temperature variation with height, and the presence of thunderstorms in vicinity of the launch area are significant due to the potential for the launch vehicle being damaged or destroyed by lightning strikes. In the event of a launch mishap, ground personnel are at risk of being exposed to clouds of toxic hydrazine gas used in rocket fuel. Wind information is used to model how this toxic cloud may be dispersed after a mishap, thus aiding in planning any emergency response that might be necessary.

The military agencies use radiosonde systems with both fixed and mobile ground stations to support research and development, operational testing and training, and field exercises. The Air Force operates a radiosonde system at the Nevada Test and Training Range. The Army operates a mobile meteorological system at the Aberdeen Proving Ground, in Aberdeen, Maryland. The Navy operates a radiosonde system at the Naval Weapons Center in California and at the Pacific Missile Test Range Facility in Hawaii. The radiosonde systems operated by the military agencies are used on a regular basis.

The Department of Energy (DOE) operates radiosondes as part of the Atmospheric Radiation Measurement (ARM) program. The ARM program is a multi-laboratory, interagency program contributing to national and international research efforts related to global climate change. A primary objective of the ARM program is improving the scientific understanding of the fundamental physics related to interactions between clouds

and radiative feedback processes in the atmosphere. The ARM program focuses on obtaining continuous field measurements and providing data products that promote the advancement of climate models. Radiosondes launched from fixed and mobile stations measure atmospheric temperature and water vapor profiles. This data is used to validate radar and satellite observations. The ARM mobile facility instrumentation can move via flat-bed trunk/trailer to remote locations for short duration experiments. The frequency assignments for the ARM program authorize systems to operate on a nationwide basis. The ARM program radiosondes are used intermittently each week. DOE also operates radiosondes to collect meteorological data for special air pollution studies at the Argonne National Laboratory in Illinois. This system is used intermittently each week. The Department of Commerce, in conjunction with the DOE, operates radiosonde systems at the National Reactor Test Site in Idaho in support of nuclear reactor test activities**.**

The National Hurricane Center and NWS make use of dropsondes for the collection of time critical meteorological data for the Airborne Vertical Air Profiling System (AVAPS).[3] This system is designed to collect process and transmit vertical atmospheric soundings during a hurricane. Dropsondes are capable of data collection from flight level to within a few meters of the earth's surface. The dropsonde is released from the aircraft, and it measures and transmits back to the aircraft the pressure, temperature, humidity, and Doppler frequency shifts during its descent to the earth. The horizontal and vertical wind components are computed using the measured Doppler frequency shifts. The data is transmitted to the National Centers for Environmental Prediction and the National Hurricane Center for use in hurricane prediction models. This data is also provided to hurricane forecasters, providing real-time observations depicting the synoptic patterns surrounding the hurricane. This system is used during severe weather events.

Radiosondes are low-cost devices, typically flown once and lost. Tens of thousands of radiosonde flights take place in the United States each year; therefore, the production costs are an important consideration when determining how spectrally efficient the radiosonde transmitters are made. During a radiosonde flight, the air temperature varies greatly with altitude. This temperature variation affects the radiosonde transmitter electronics, causing the transmitted signal to drift in frequency over the duration of the flight. Radiosondes currently in use employ either low-cost analog or digital transmitters to communicate with their respective ground station receivers. The radiosondes using an analog transmitter typically have a signal bandwidth of 300 kHz; however, the need to account for the transmitted signal's frequency drift requires a total required bandwidth of 1 MHz. Digital radiosonde transmitters have greater frequency stability and only require a total bandwidth of 240 kHz.

Transmitter power levels for radiosondes operating in the 400.15 – 401.00 MHz band typically range from 200 to 250 milliwatts.

3. Dropsondes are sensor packages dropped from aircraft and atmospheric data is transmitted to an aircraft receiver where the data is processed, and meteorological data products are produced.

4b. Space Research (Space-to-Space)[4]

NASA operates three data communications systems in the 400.15 – 401.00 MHz frequency band that are used for space research operations. One of these systems is the command link of the wireless video system (WVS) on the Space Shuttle Orbiter and the International Space Station (ISS) located in non-geostationary orbit around the Earth. Video data from cameras mounted on the astronaut's helmet is transmitted to crewmembers inside the Orbiter or the ISS to observe the astronaut's activities. These cameras are controlled by a command signal transmitted from the ISS or the Orbiter. The WVS command link signal is transmitted at a power level of 3 milliwatts, over a bandwidth of 800 kHz. This system is used on an intermittent basis when astronauts are conducting spacewalks.

Another system that NASA operates in this band is the Commercial Orbital Transportation Services (COTS) Ultra High Frequency (UHF) Communications Unit (CUCU). The CUCU is used as the primary relative navigation data and other telemetry data transfer system for rendezvous and proximity operations around the ISS. Communications between the SpaceX Dragon spacecraft and the ISS using the CUCU is required in order for the Dragon spacecraft to determine a navigation solution during approach to and departure from the ISS. The CUCU on the ISS transmits at 2.5 Watts, and the CUCU on the Dragon spacecraft transmits at 1.45 Watts. Their transmissions occupy a bandwidth of 338 kHz. This system is used for approximately 8 hours during the Dragon spacecraft's approach to the ISS, and for approximately 4 hours during the Dragon spacecraft's departure.

The third data communications system that NASA operates in the 400.15-401 MHz band for space research operations is the Firefly satellite downlink. NASA will be launching the Firefly satellite in 2013 to look specifically for gamma-ray flashes coming from the atmosphere. These terrestrial gamma-ray flashes are a phenomenon that is linked with lightning. Firefly is expected provide the first direct evidence for a relationship between lightning and terrestrial gamma-ray flashes. Identifying the source of terrestrial gamma-ray flashes is an important step toward understanding the physics of lightning and its effect on the Earth's atmosphere. The Firefly satellite's instruments will detect the gamma-ray flashes and lightning events and transmit the measurement data to its associated earth station. The downlink transmission is at a power level of 2.5 Watts and occupies a bandwidth of 50 kHz.

4c. Meteorological-Satellite (Space-to-Earth)

The Navy operates the TACSAT-4 satellite to experiment with advanced SATCOM capabilities. The satellite receives terrestrial sensor data and transmits this data to mobile earth stations. The TACSAT-4 satellite downlink transmissions are in the 400.15 to 401 MHz band.

4. International footnote 5.263 states that the band 400.15-401 MHz is also allocated to the space research service in the space- to-space direction for communications with manned space vehicles.

The Navy also operates the GLADIS satellite to experiment with providing enhanced maritime domain awareness and safety. The satellite receives data from widely distributed sensors and transmits this data to ground terminals.

4d. Mobile-Satellite (Space-to-Earth)

There are currently no Federal mobile-satellite systems operating in the 400.15 – 401 MHz band. There are frequency assignments in this band for research development test and evaluation activities associated with mobile-satellite systems.

4e. Space Operation (Space-to-Earth)

The Federal Government is not using the 400.15-401 MHz band for space operations at this time.

5. Planned Use

The future spectrum requirements for radiosonde and dropsonde operations in the 400.15 – 401.00 MHz band are expected to remain unchanged.

The future spectrum requirements for space research operations in the 400.15 – 401.00 MHz band are expected to remain unchanged through 2014. Beyond that, the NASA Firefly mission is expected to be complete and should no longer require spectrum in this band. The future spectrum requirements for the other NASA systems operating in this band are expected to remain unchanged.

The future spectrum requirements for meteorological satellite operations in the 400.15 – 401.00 MHz band are expected to remain unchanged.

There are no plans to operate mobile-satellite systems in the 400.15-401 MHz band.

There are no plans to operate systems in the space operation service in the 400.15-401 MHz band.