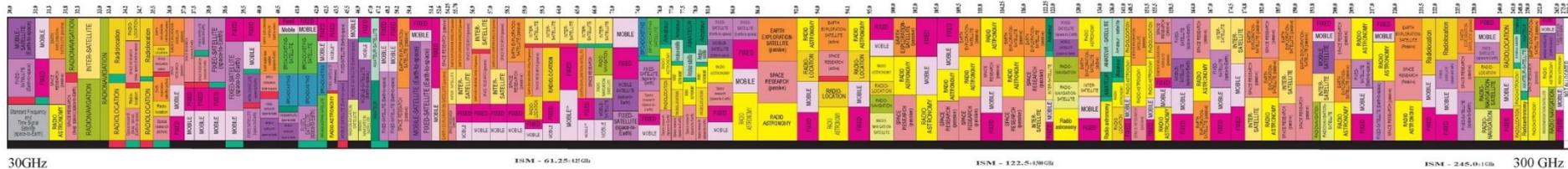




# National Science Foundation

## Electromagnetic Spectrum Management Division of Astronomical Sciences



January 23, 2020

Report to the Astronomy and Astrophysics Advisory Committee (AAAC)



The 2020s:  
A decade with  
new opportunities



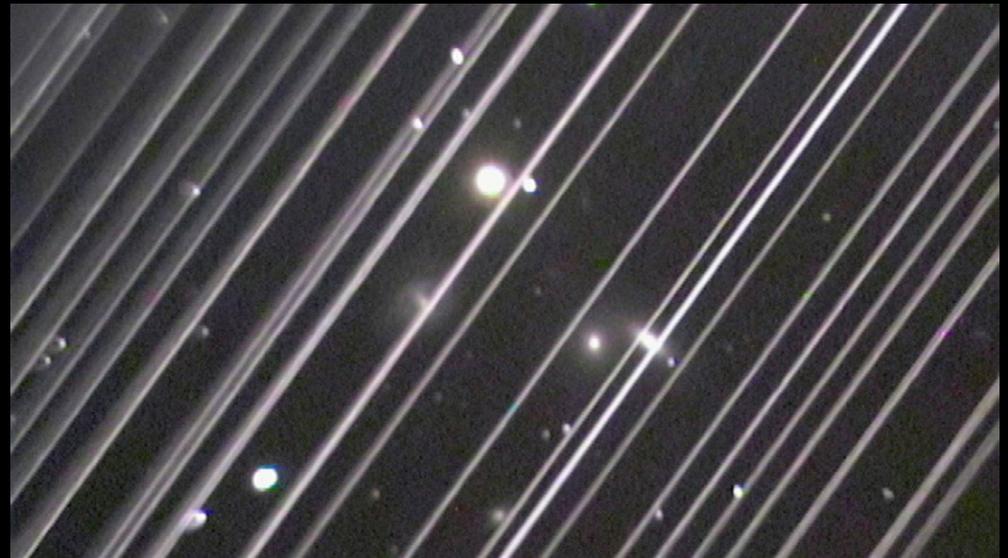
*Credit: LSST*



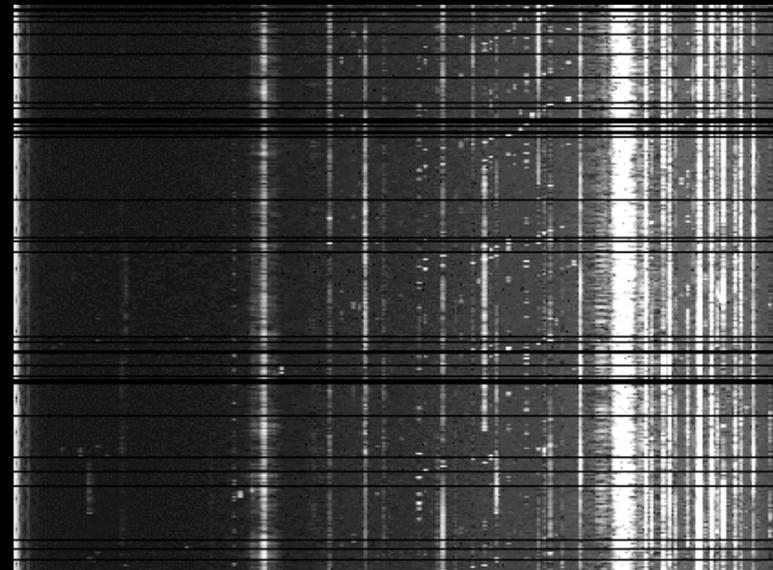
*Credit: almaobservatory.org*



The 2020s:  
A decade with  
new opportunities  
*and*  
**new challenges**



**optical interference**



**radio interference**



## AAAC 2018 report

Report of the Astronomy and Astrophysics  
Advisory Committee

March 15, 2018



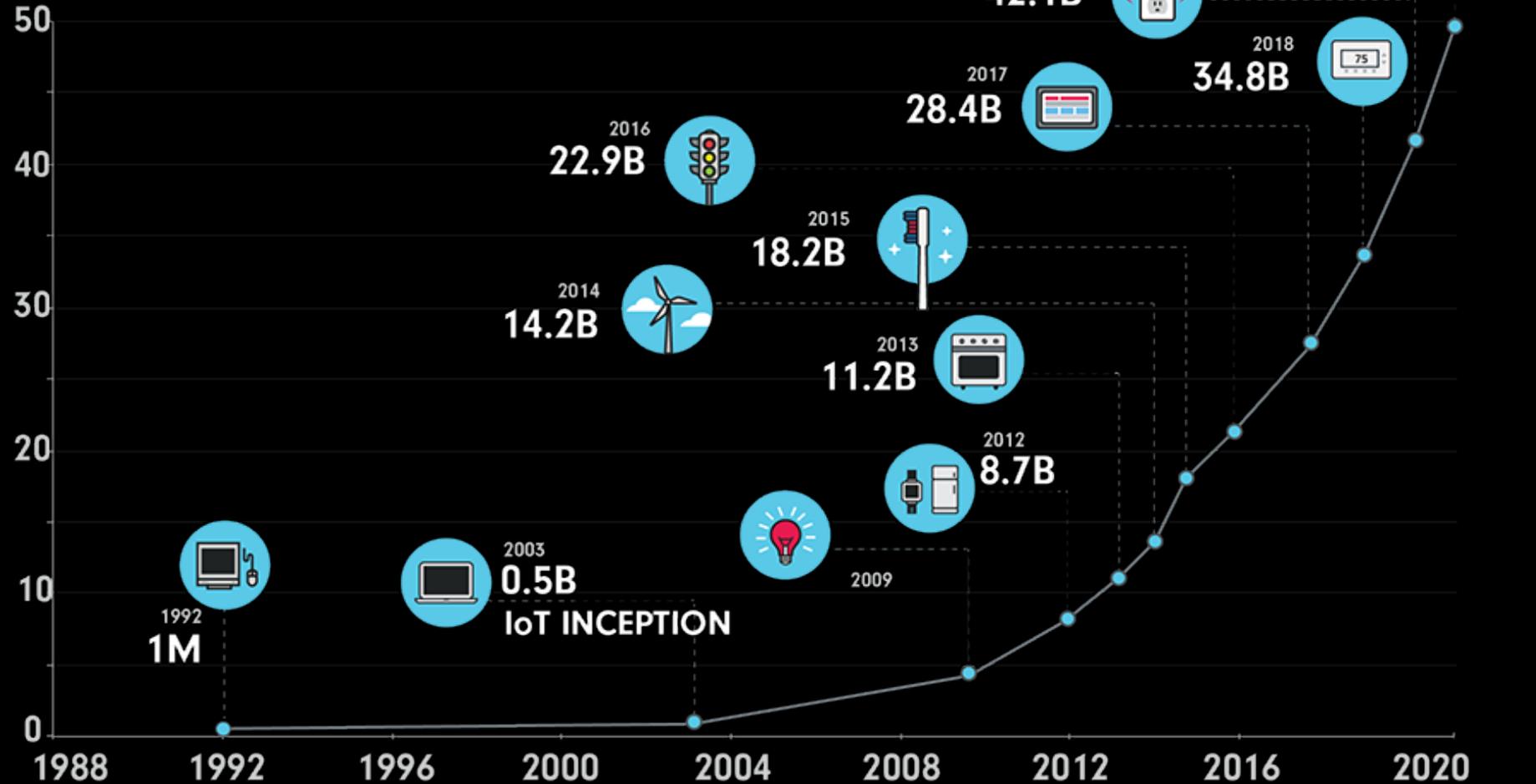
Image credit: Robin Dienel courtesy of the Carnegie Institution of Science.

...the original protected frequency regions have been eroded both from external challenges, as well as significant out-of-band emission from competing sources and harmonics overlapping with key astronomical lines.

The original protected frequencies do not include emission lines that have become increasingly important as astrophysical diagnostics since the 1970's, nor do the protected frequencies encompass known lines that are redshifted out of the protected bands.

# Demand for spectrum is unrelenting

BILLIONS OF DEVICES





# 2019 AAAC report

**Finding (12):** Competing interests continue to provide a severe and unrelenting threat to astronomers' ability to detect electromagnetic signals from space. Without clean access to these wavelengths, the ability of astronomers to obtain fundamental knowledge about the universe is profoundly impaired. This is particularly important as time-variable astronomy gains visibility (for example in detecting gravitational wave counterparts or other multi-messenger astronomy activities). Mobile and transient noise sources form a large and growing threat.

**Finding (13):** The resources currently available to the NSF and NASA are not sufficient to protect essential astronomical wavelengths in an arena of competing commercial interests with deep financial support and professional lobbyists.

Report of the Astronomy and Astrophysics  
Advisory Committee

April 26, 2019

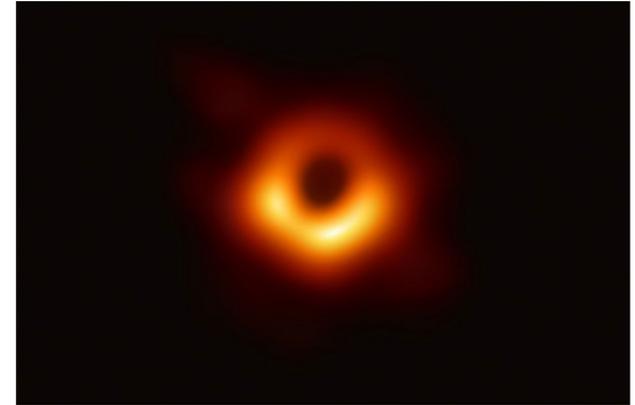


Image credit: Event Horizon Telescope Collaboration



# Epoch of Reionization

HI: 21 cm -> 1.5 m

Freq ~ 1420 MHz -> 200 MHz

$$1 + z = \frac{f_{\text{emit}}}{f_{\text{obsv}}}$$

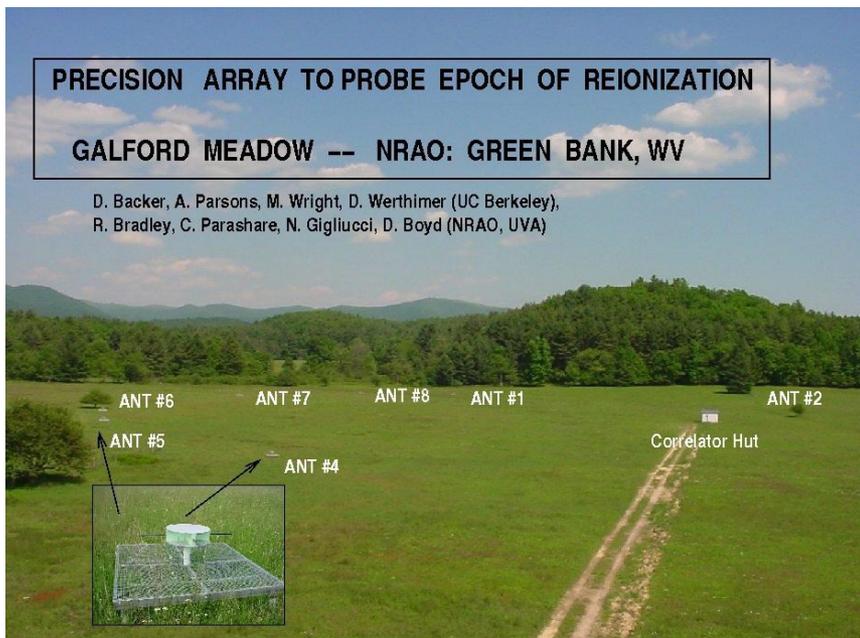


Image Credit: w.astro.berkeley.edu

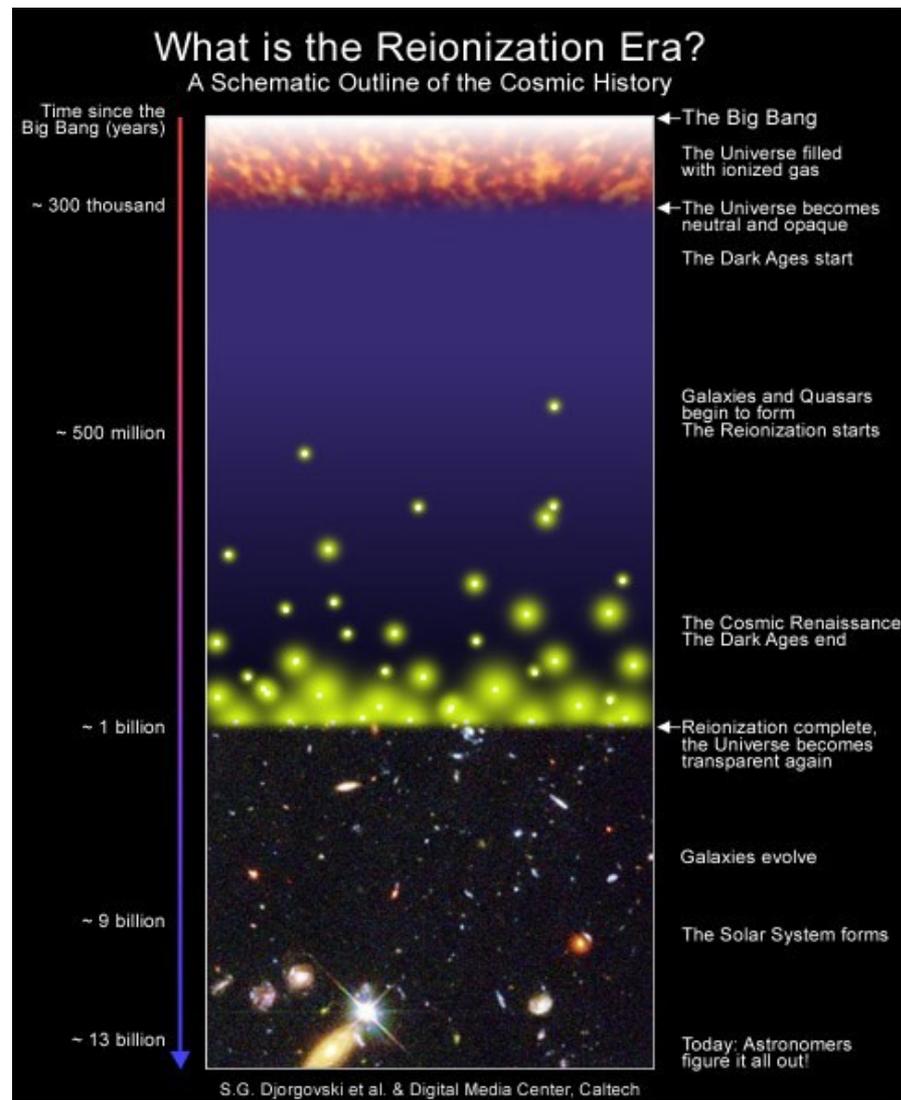


Image Credit: Djorgovski et al. (Caltech); [www.haystack.mit.edu](http://www.haystack.mit.edu)



# UNITED STATES FREQUENCY ALLOCATIONS

## THE RADIO SPECTRUM

**RADIO SERVICES COLOR LEGEND**

AERIAL TELETYPE	AIR NAVIGATION	RADIO ASTRONOMY
MARITIME MOBILE SATELLITE	LAND MOBILE	SATELLITE TELEVISION
AERONAUTICAL TELEPHONE	LAND MOBILE SATELLITE	RADIOLOCATION
NAVSTAR	MARITIME MOBILE SATELLITE	SATELLITE TELEVISION
MARITIME SATELLITE	MARITIME MOBILE SATELLITE	RADIOLOCATION SATELLITE
BROADCASTING	MARITIME RADIOLOCATION	RADIOLOCATION SATELLITE
BROADCASTING SATELLITE	METEOROLOGICAL	SPACE OPERATION
SATELLITE TELEVISION	METEOROLOGICAL SATELLITE	SPACE RESEARCH
FIXED	MOBILE	STANDARD FREQUENCY AND TIME SIGNALS
BROADCAST SATELLITE	MOBILE SATELLITE	STANDARD FREQUENCY AND TIME SIGNALS

**ACTIVITY CODE**

FEDERAL EXCLUSIVE    FEDERAL/CONFEDERAL SHARED

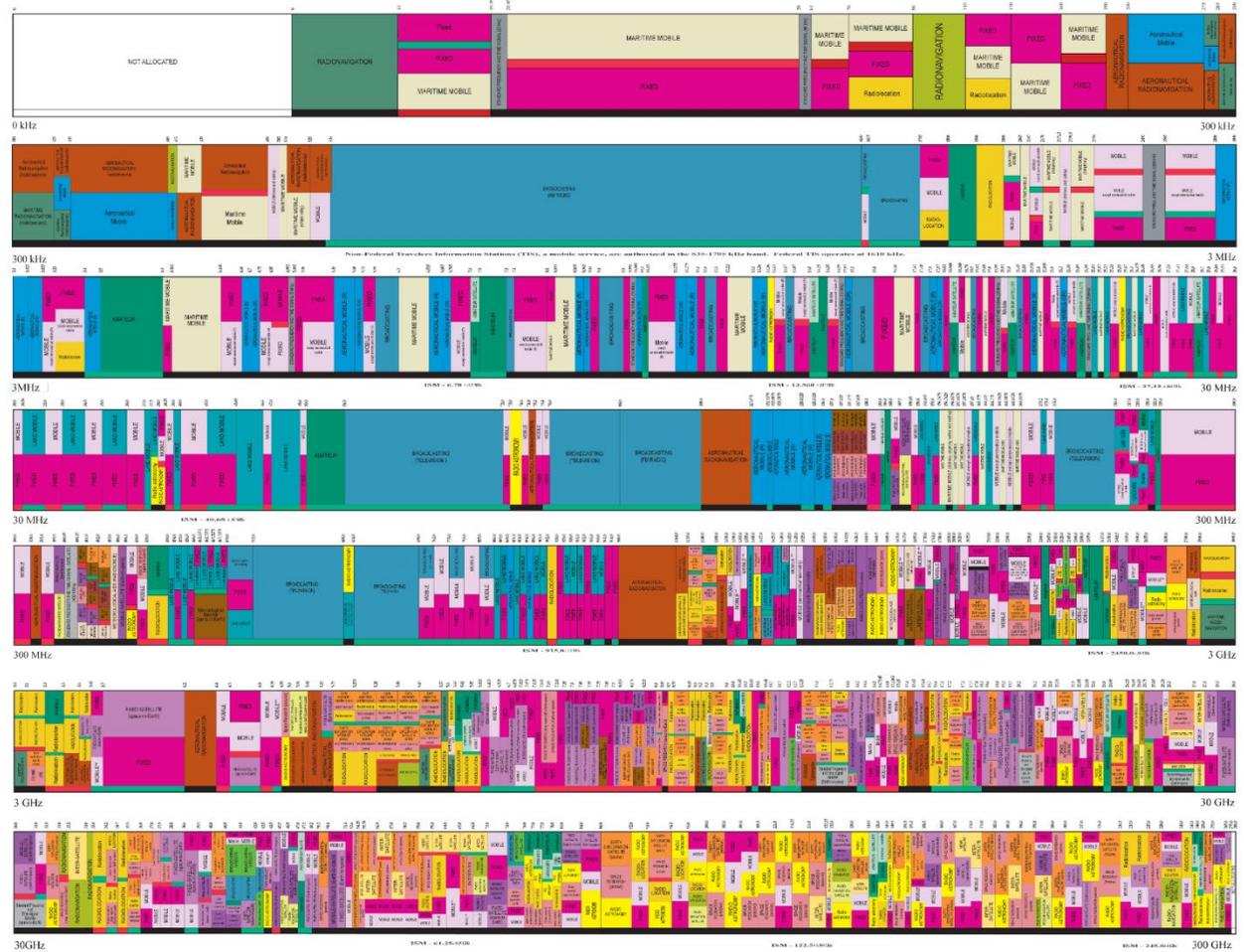
NON-FEDERAL EXCLUSIVE

**ALLOCATION USAGE DESIGNATION**

SERVICE	EXAMPLE	DESCRIPTION
Primary	Fixed	Capital Cities
Secondary	Mobile	Land Mobile and Mobile Mobile

This chart is a graphic representation of the U.S. Table of Frequency Allocations and is not a legal document. It is intended for informational purposes only. For the most current and complete information, please refer to the U.S. Table of Frequency Allocations, published by the Federal Communications Commission (FCC) and available at [www.fcc.gov](http://www.fcc.gov). The chart is subject to change without notice. It is not intended to be used for legal purposes.

**U.S. DEPARTMENT OF COMMERCE**  
**National Telecommunications and Information Administration**  
 Office of Spectrum Management  
 JANUARY 2016



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# UNITED STATES FREQUENCY ALLOCATIONS

## THE RADIO SPECTRUM

### RADIO SERVICES COLOR LEGEND

- |  |  |  |
|--|--|--|
| <span style="color: blue;">■</span> AERONAUTICAL MOBILE                | <span style="color: yellow;">■</span> AIR-SATELLITE                | <span style="color: yellow;">■</span> RADIO ASTRONOMY                            |
| <span style="color: lightblue;">■</span> AERONAUTICAL MOBILE SATELLITE | <span style="color: cyan;">■</span> LAND MOBILE                    | <span style="color: orange;">■</span> COSMOTHEORETICAL SATELLITE                 |
| <span style="color: brown;">■</span> AERONAUTICAL MOBILE SERVICE       | <span style="color: lightblue;">■</span> LAND MOBILE SATELLITE     | <span style="color: yellow;">■</span> RADIOLOCATION                              |
| <span style="color: green;">■</span> AMATEUR                           | <span style="color: lightgreen;">■</span> MARITIME MOBILE          | <span style="color: yellow;">■</span> RADIO SCIENCE SATELLITE                    |
| <span style="color: lightgreen;">■</span> AMATEUR SATELLITE            | <span style="color: teal;">■</span> MARITIME MOBILE SATELLITE      | <span style="color: green;">■</span> RADIO NAVIGATION                            |
| <span style="color: blue;">■</span> BROADCASTING                       | <span style="color: green;">■</span> MARITIME RADIO NAVIGATION     | <span style="color: yellow;">■</span> RADIO INVESTIGATION SATELLITE              |
| <span style="color: green;">■</span> BROADCASTING SATELLITE            | <span style="color: lightgreen;">■</span> METEOROLOGICAL           | <span style="color: red;">■</span> SPACE OPERATION                               |
| <span style="color: orange;">■</span> DATA RELAYATION SATELLITE        | <span style="color: lightgreen;">■</span> METEOROLOGICAL SATELLITE | <span style="color: red;">■</span> SPACE RESEARCH                                |
| <span style="color: pink;">■</span> FIXED                              | <span style="color: purple;">■</span> MOBILE                       | <span style="color: grey;">■</span> STANDARD FREQUENCY AND TIME SIGNAL           |
| <span style="color: purple;">■</span> FIXED SATELLITE                  | <span style="color: purple;">■</span> MOBILE SATELLITE             | <span style="color: grey;">■</span> STANDARD FREQUENCY AND TIME SIGNAL SATELLITE |

### ACTIVITY CODE

- |  |   |
|--|---|
| <span style="color: red;">■</span> FEDERAL EXCLUSIVE       | <span style="color: black;">■</span> FEDERAL/CONFIDENTIAL |
| <span style="color: green;">■</span> NON-FEDERAL EXCLUSIVE |   |

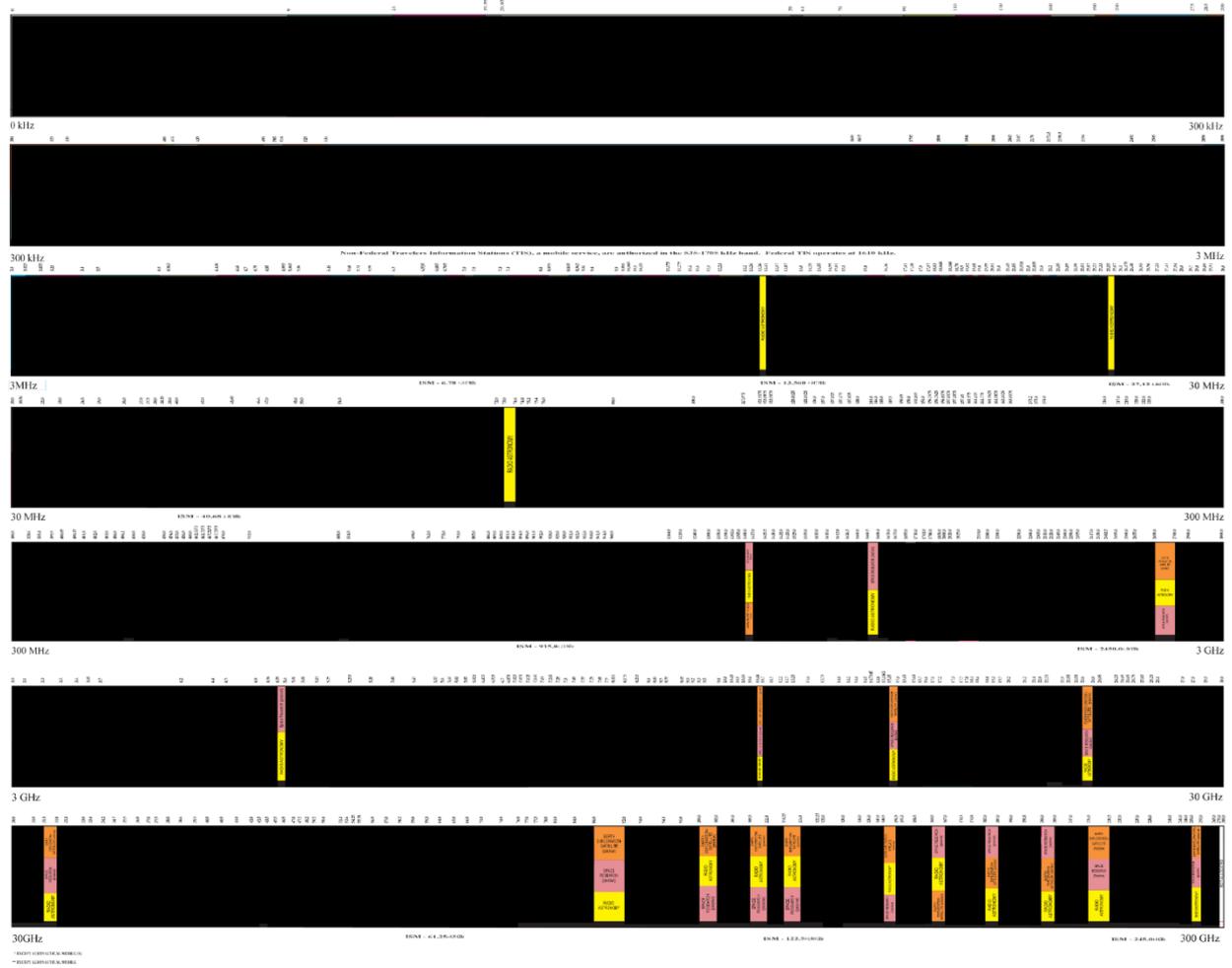
### ALLOCATION USAGE DESIGNATION

SERVICE	EXAMPLE	DESCRIPTION
Primary	Fixed	Equal Access
Secondary	Mobile	Land Mobile and Land Mobile Mobile

This chart is a graphic representation of the U.S. Table of Frequency Allocations in the 30 kHz and 30 GHz bands. It is not a legal document. For a complete and current listing of the U.S. Table of Frequency Allocations, please refer to the U.S. Table of Frequency Allocations, published by the Federal Communications Commission (FCC).

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 National Telecommunications and Information Administration  
 Office of Spectrum Management  
**JANUARY 2016**

NSF logo and other small text at the bottom left.



NSF logo and other small text at the bottom right.



# UNITED STATES FREQUENCY ALLOCATIONS

## THE RADIO SPECTRUM

**RADIO SERVICES COLOR LEGEND**

AERIAL TELETYPE	AIR-TO-AIR	RADIO ASTRONOMY
MANUFACTURED MOBILE SATELLITE	LAND MOBILE	AERIAL TELETYPE SATELLITE
AIRBORNE ACTUAL AIRBORNE MOBILE	LAND MOBILE SATELLITE	RADIO EDUCATION
AIRBORNE	MARITIME MOBILE	AERIAL TELETYPE SATELLITE
MARITIME SATELLITE	MARITIME MOBILE SATELLITE	RADIO NAVIGATION
BROADCASTING	MARITIME RADIO NAVIGATION	RADIO NAVIGATION SATELLITE
BROADCASTING SATELLITE	METEOROLOGICAL	SPACE OPERATION
SPACE OPERATION SATELLITE	METEOROLOGICAL SATELLITE	SPACE RESEARCH
FIXED	MOBILE	STANDARD FREQUENCY AND TIME SIGNAL
FIXED SATELLITE	MOBILE SATELLITE	STANDARD FREQUENCY AND TIME SIGNAL SATELLITE

**ACTIVITY CODE**

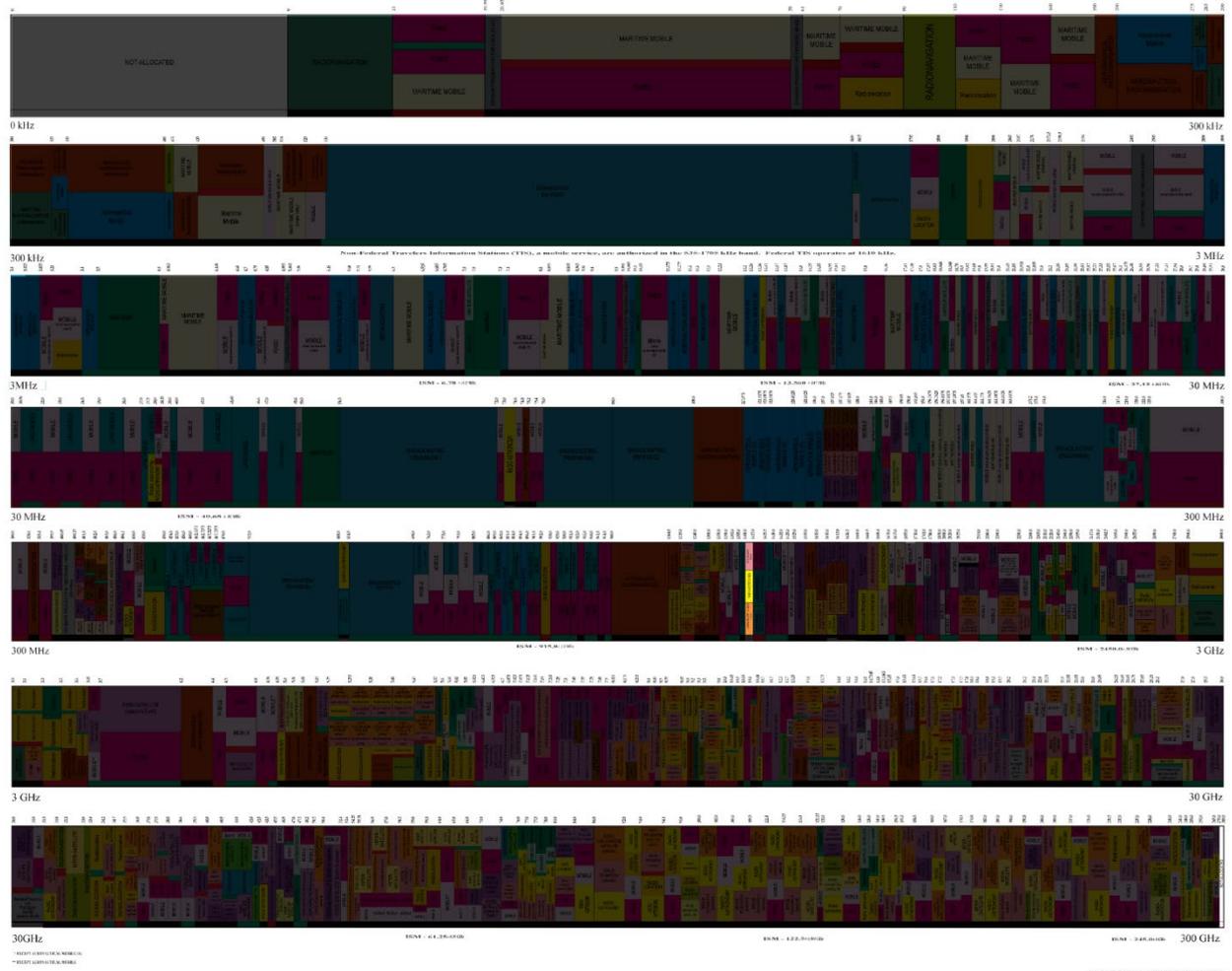
FEDERAL EXCLUSIVE	FEDERAL/CONFIDENTIAL
NON-FEDERAL EXCLUSIVE	

**ALLOCATION USAGE DESIGNATION**

SERVICE	EXAMPLE	DESCRIPTION
Primary	Fixed	Equal Access
Secondary	Mobile	Land Mobile and Mobile Mobile

This chart is a graphic representation of the U.S. Table of Frequency Allocations in Part 1 of the Table of Frequency Allocations, which is published in the Federal Register. It is not a legal document. It is intended to provide a visual summary of the information contained in the Table of Frequency Allocations. It is not intended to be used as a legal reference for the Table of Frequency Allocations.

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# UNITED STATES FREQUENCY ALLOCATIONS

## THE RADIO SPECTRUM

**RADIO SERVICES COLOR LEGEND**

AIR/NAVIAL MOBILE	AIR/NAVIAL MOBILE SATELLITE	RADIO ASTRONOMY
AIR/NAVIAL MOBILE SATELLITE	LAND MOBILE	AERONAUTICAL MOBILE
AERONAUTICAL MOBILE	LAND MOBILE SATELLITE	RADIOLOCATION
AMATEUR	MARITIME MOBILE	AERONAUTICAL MOBILE SATELLITE
MARITIME MOBILE SATELLITE	MARITIME MOBILE SATELLITE	RADIOLOCATION
BROADCASTING	MARITIME RADIOLOCATION	RADIOLOCATION SATELLITE
BROADCASTING SATELLITE	METEOROLOGICAL	SPACE OPERATION
SPACE OPERATION SATELLITE	METEOROLOGICAL SATELLITE	SPACE RESEARCH
FIXED	MOBILE	STANDARD FREQUENCY AND TIME SIGNAL
STANDARD FREQUENCY AND TIME SIGNAL	MOBILE SATELLITE	STANDARD FREQUENCY AND TIME SIGNAL SATELLITE

**ACTIVITY CODE**

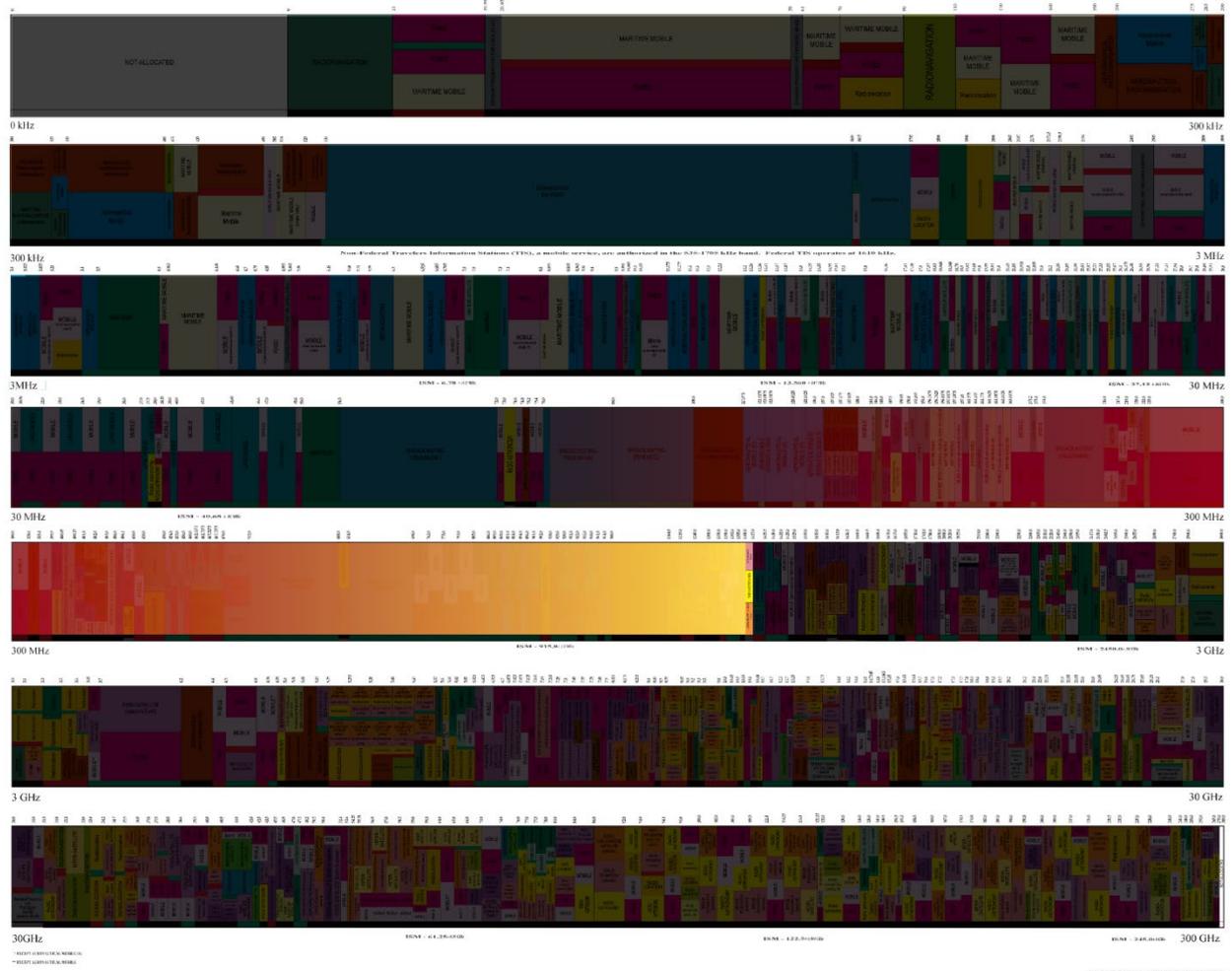
FEDERAL EXCLUSIVE	FEDERAL/CONFIDENTIAL
NON-FEDERAL EXCLUSIVE	

**ALLOCATION USAGE DESIGNATION**

SERVICE	EXAMPLE	DESCRIPTION
Primary	Fixed	Fixed Station
Secondary	Mobile	Land Mobile and Mobile Station

This chart is a graphic representation of the U.S. Table of Frequency Allocations in ITU and FCC Tables. It is not a legal document. For more information, please refer to the U.S. Table of Frequency Allocations in ITU and FCC Tables. Tables are subject to change and are not intended to be used as a legal document.

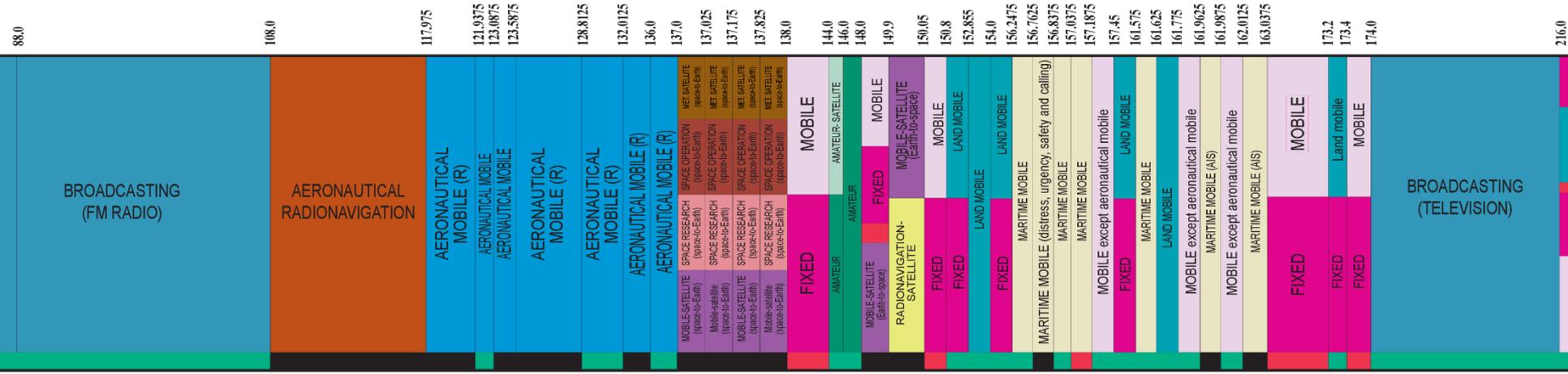
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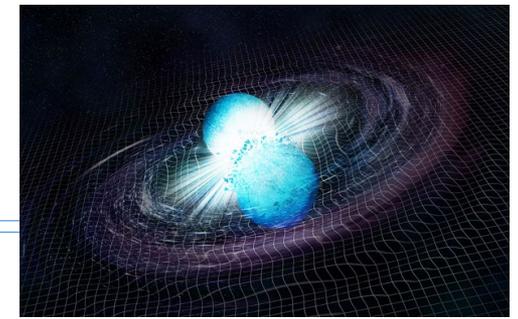


# Epoch of Reionization





# Importance of EM Access



10  $\mu$ Jy at 3 GHz  $\sim$ 2 weeks

2 GHz BW ( $\sim$ 1.4 GHz after RFI excision)

<50 MHz is  
RAS primary



VLA Observation September 7, 2017

## GW170817

Image Credits: Hallinan et al., Science (16 Oct 2017)

To achieve 2  $\mu$ Jy RMS  
requires integration time on source of:

**2 GHz bandwidth:**

5.5 hours

**1.4 GHz bandwidth:**

6 hours

**50 MHz bandwidth:**

185 hours (more than one week)

VLA Exposure Calculator	
Array Configuration	A
Number of Antennas	25
Polarization Setup	<input type="radio"/> Single <input checked="" type="radio"/> Dual
Type of Image Weighting	<input checked="" type="radio"/> Natural <input type="radio"/> Robust
Representative Frequency	3.0000 GHz
Receiver Band	S
Approximate Beam Size	0.977"
Digital Samplers	<input type="radio"/> 3 bit <input checked="" type="radio"/> 8 bit
Elevation	Medium (25-50 degrees)
Average Weather	Autumn
Calculation Type	<input checked="" type="radio"/> Time <input type="radio"/> BW <input type="radio"/> Noise/Tb
Time on Source (UT)	1.1248w
Total Time (UT)	1.4184w
Bandwidth (Frequency)	50.0000 MHz
Bandwidth (Velocity)	4,996.5410 km/s
RMS Noise (units/beam)	2.0000 $\mu$ Jy



### Exposure is too long

That is a lot of VLA time on one source. You may want to change your values for noise and bandwidth.



# NSF-funded Astronomy research relies on access to electromagnetic spectrum

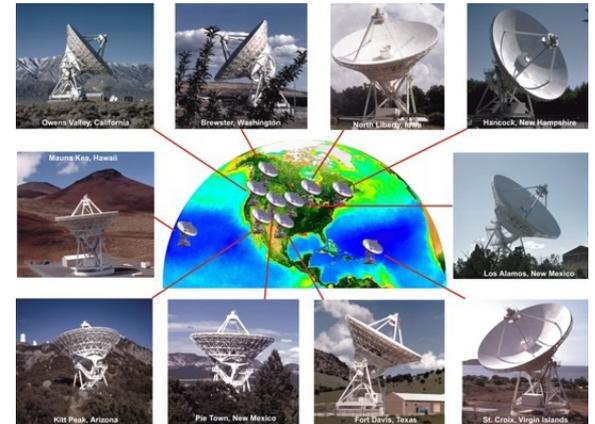
ESM resides in MPS/AST because historically spectrum usage has been focused primarily around the needs of a few large facilities and the National Radio Quiet Zone.



Arecibo Observatory, Puerto Rico



Very Large Array, NM



Very Long Baseline Array



Green Bank Observatory  
National Radio Quiet Zone



# Domestic and International Impact



Image credit: [almaobservatory.org](http://almaobservatory.org)

- The United States has significant scientific assets / large facilities outside of its national borders.
- Observatories tend to be in geographically remote sites, but radio emission from moving emitters: car radars, satellites and high altitude delivery systems will be an increasing challenge.



# National Radio Quiet Zone

- NRQZ (established 1958) **needs updated protections** from airborne transmitters; other radio telescopes need also need newly established coordination zones.
- We need **new quiet/coordination zones** for coordinating access to wider bandwidths for the VLA, Arecibo, VLBA, ALMA and other facilities



## Description

The National Radio Quiet Zone (NRQZ) was established by the Federal Communications Commission (FCC) in [Docket No. 11745](#) (November 19, 1958) and by the Interdepartment Radio Advisory Committee (IRAC) in Document 3867/2 (March 26, 1958) to minimize possible harmful interference to the National Radio Astronomy Observatory (NRAO) in Green Bank, WV and the radio receiving facilities for the United States Navy in Sugar Grove, WV. The NRQZ is bounded by NAD-83 meridians of longitude at 78d 29m 59.0s W and 80d 29m 59.2s W and latitudes of 37d 30m 0.4s N and 39d 15m 0.4s N, and encloses a land area of approximately 13,000 square miles near the state border between Virginia and West Virginia.

Credit: Green Bank Observatory



Credit: NRAO



# 2019 AAAC report

**Recommendation (14):** Given their common interests in access to the spectrum, NASA and NSF should enhance their collaboration with each other and with other groups, including international agencies and commercial interests, to protect the accessibility of essential astronomical wavelengths to researchers.

**Recommendation (15):** Efforts, ideally coordinated with all three agencies, should be made to increase awareness of spectrum management issues among astronomers, the general public, and government agencies. Possible agents for meeting this recommendation might include the NSF-funded national facilities for operations at radio and optical wavelengths. Efforts to engage and coordinate with other international agencies should continue.

Report of the Astronomy and Astrophysics  
Advisory Committee

April 26, 2019

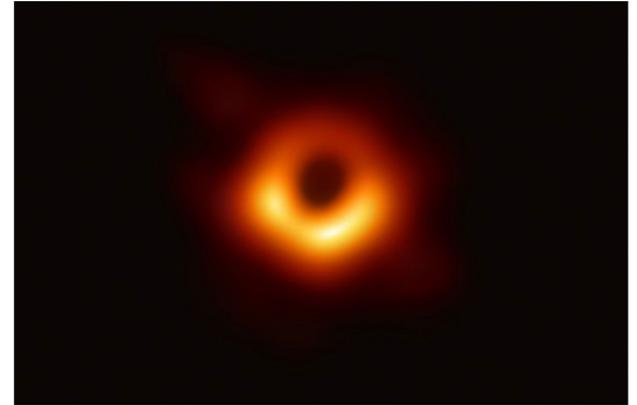


Image credit: Event Horizon Telescope Collaboration



# ESM Office Actions

- I. **Outreach - Presented at the AAS 235<sup>th</sup> meeting**
- II. **Ongoing regular meetings with NASA and NOAA**
- III. **Represented U.S. scientific interests at the World Radio Conference 2019, beginning WRC-23 prep cycle**
- IV. **Stepping into a role to consider the optical impacts from satellites as well as the radio impacts**
- V. **NSF-wide Coordination Group**

**Are you losing DATA to RFI?**

The radio spectrum is regulated, and radio astronomical observations are protected by law.

A regulatory framework governs the use of the radio spectrum on domestic and international scales. NSF works at both levels.

UNITED STATES PROPERTY MARKING

Frequency bands are allocated to radiocommunication services. That includes radio astronomy. Some of the most important bands are set aside for astronomical use. Others are shared. NSF facilitates both, and helps to protect astronomy from interference.

NSF seeks to protect and innovate on spectrum issues.

We work with regulators, federal agencies, companies, scientists, and national/international organizations to protect the spectrum interests of NSF research.

NSF is the primary voice for the spectrum needs of ground-based radio astronomy in the United States. In helping to protect spectrum set aside or used by radio astronomy, NSF works to defend the interests of individual astronomers and billion-dollar facilities alike.

**World Radiocommunication Conference**

Many users share the radio spectrum. Worldwide, the use of the spectrum is coordinated by the International Telecommunication Union, and updated at World Radiocommunication Conferences every four years.

Issues on the agenda of each Conference are set by the previous Conference. Four years of technical studies in sub-groups culminate in changes to the International Radio Regulations (a treaty between 193 member nations). These are many radio services, most of which transmit radio energy and which may interfere with radio astronomical observations. Satellites, high-altitude platforms, cellphones, and car radars are just some of the challenges.

Compared with most radio receivers, radio astronomy systems are phenomenally sensitive. That makes them especially susceptible to interference, and in need of both technical and regulatory protection.

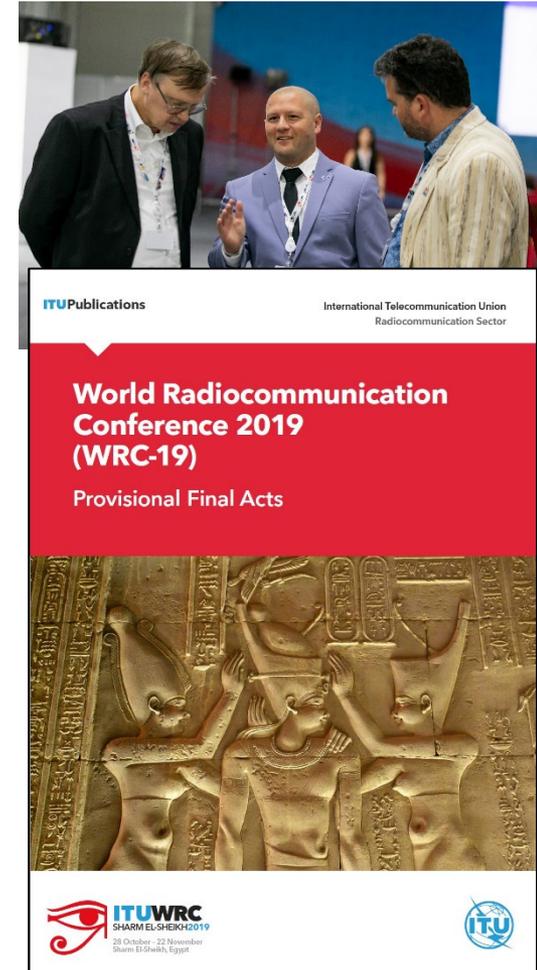
Over 2000 delegates from around the world attend each Conference, representing countries, companies, and organizations. In four weeks, they complete their work.



# World Radiocommunication Conference



- Treaty conference convened every four years
- Just completed; held in Egypt, Oct-Nov, 2019



*The National  
Academies of*

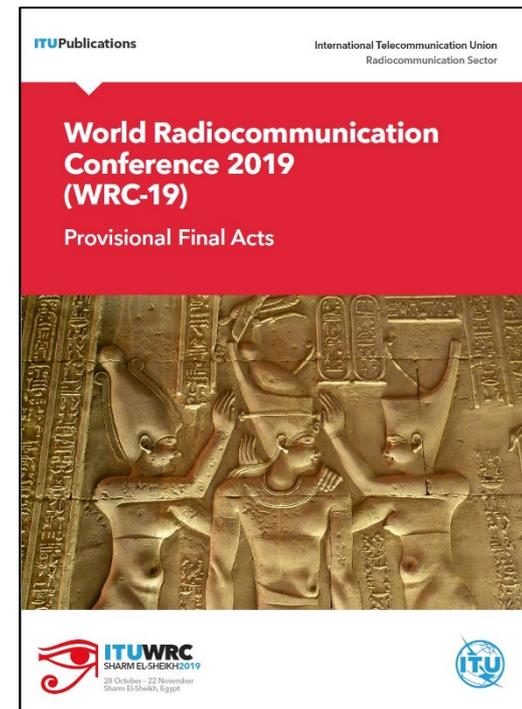
SCIENCES  
ENGINEERING  
MEDICINE

BOARD ON PHYSICS AND ASTRONOMY  
Division on Engineering and Physical Sciences



# World Radiocommunication Conference

- **Astronomy outcomes at WRC-19:**
  - 275 – 450 GHz protections for RAS from FSS/LMR
  - Protection of 1610-1613 MHz
  - Language for development of a recommendation for protection of RAS sites from 5G (especially at 24 and 42 GHz)
  - RAS protections from HAPS (coordination distances required)
  - Still ambiguous how RAS limits are treated from out-of-band emissions from nearby services



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Academies of*

SCIENCES  
ENGINEERING  
MEDICINE

BOARD ON PHYSICS AND ASTRONOMY  
Division on Engineering and Physical Sciences



# World Radiocommunication Conference

## Key WRC-2019 Outcomes

---

- IMT (Mobile Broadband)
  - Identification in 24.25-27.25 GHz, 37-43.5 GHz
    - In-band and adjacent to radio astronomy frequencies
    - Further ITU documentation for protection to be developed
  - Modifications to numerous country footnotes adding IMT identification
- High-altitude platforms
  - Identification in 21.4-22 GHz, 24.25-25.24 GHz, 31-31.3 GHz, 38-39.5 GHz
  - Significant protections for radio astronomy (more strict than Recommendation ITU-R RA.739-2)
- 275-450 GHz terrestrial operation
  - 275-296 GHz, 306-313 GHz, 318-333 GHz and 356-450 GHz identified for land-mobile and fixed service applications
  - Means to protect radio astronomy assets indicated as necessary



# World Radiocommunication Conference

## Key WRC-2019 Outcomes

---

- GMDSS identification for Iridium system (1616-1626 MHz)
  - Out of band interference from Iridium system into OH maser band (1610-1613 MHz) noted for more than two decades
  - Significant discussion at WRC-19 revolved around resolving ongoing interference situation
- End result:
  - GMDSS operation allowed in frequency band 1621.35-1626 GHz
  - Restrictions on out-of-band emissions greatly strengthened
  - Radio astronomy limits incorporated into the radio regulations for emissions into the OH maser band
  - Several loopholes in compliance were fixed



# World Radiocommunication Conference

## WRC-23 Agenda

---

- The most challenging issues from a radio astronomy perspective were redirected to the WRC-27 agenda
- Issues of interest on WRC-23 agenda:
  - IMT (Mobile Broadband) in 3300-3400 MHz, 3600-3800 MHz, 6425-7 025 MHz, 7025-7125 MHz and 10.0-10.5 GHz
  - Use of high-altitude platforms for provision of IMT services in 694-960 MHz, 1710-1885 MHz, 2500-2690 MHz
  - Sub-orbital vehicles (frequencies to be determined; of interest to NASA)
  - More GMDSS
  - Upgrade of SRS allocation in 14.8-15.35 GHz
  - Review of frequency allocations for EESS (passive) in the frequency range 231.5-252 GHz
  - Space weather sensors



# World Radiocommunication Conference

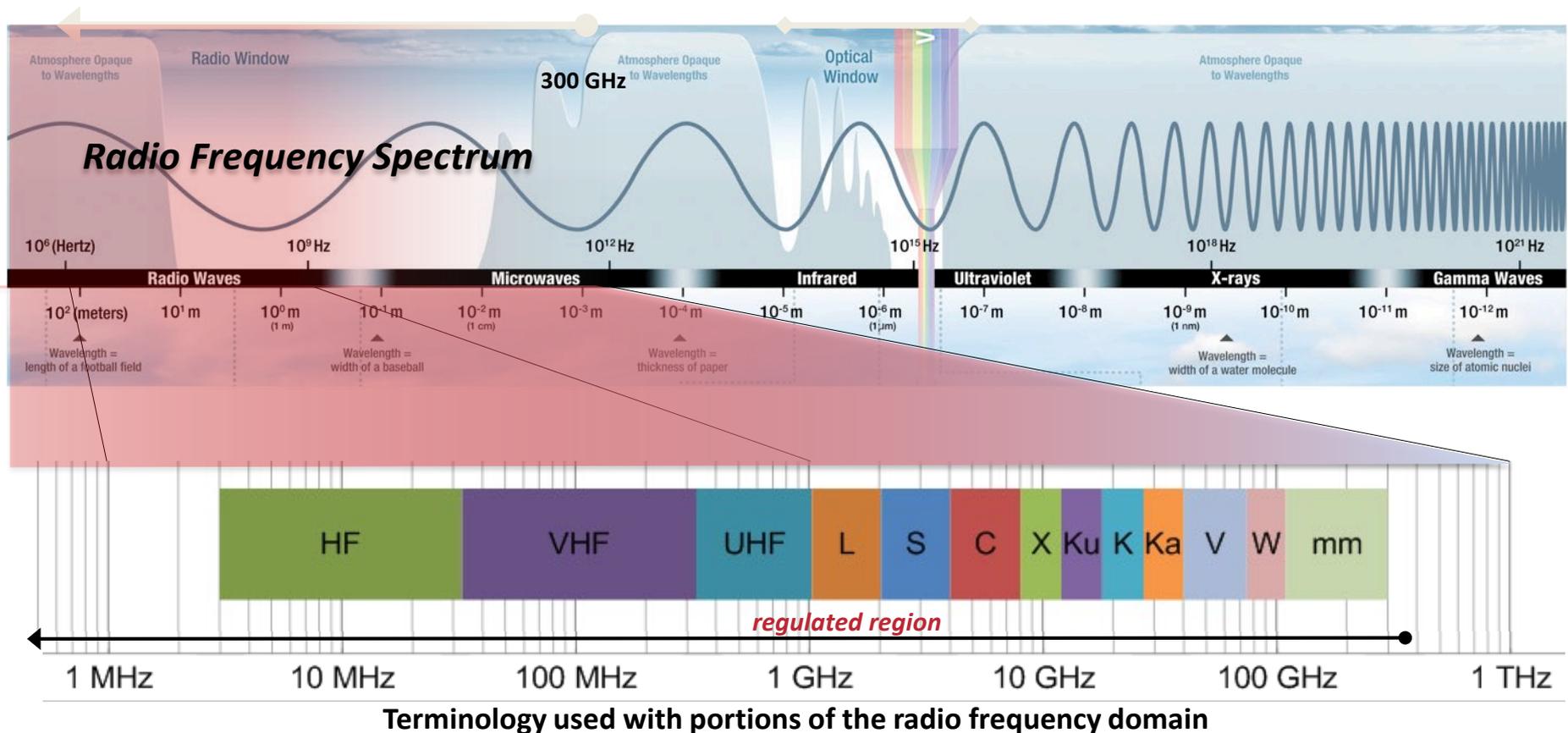
## WRC-27 Agenda

---

- Approaching cautiously; these issues may never be studied
- Items of concern:
  - New allocations and identifications to the radiolocation service in 275-700 GHz
  - ESIMs in 37.5-39.5 GHz (space-to-Earth), 40.5-42.5 GHz (space-to-Earth), 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space)
  - Fixed satellite service allocations in 43.5-45.5 GHz, 71-76 GHz, 81-86 GHz
  - Space-to-space inter-satellite links in 1525-1544 MHz, 1545-1559 MHz, 1610-1645.5, 1646.5-1660.5 MHz, and 2483.5-2500 MHz
  - IMT studies in 1300-1350 MHz

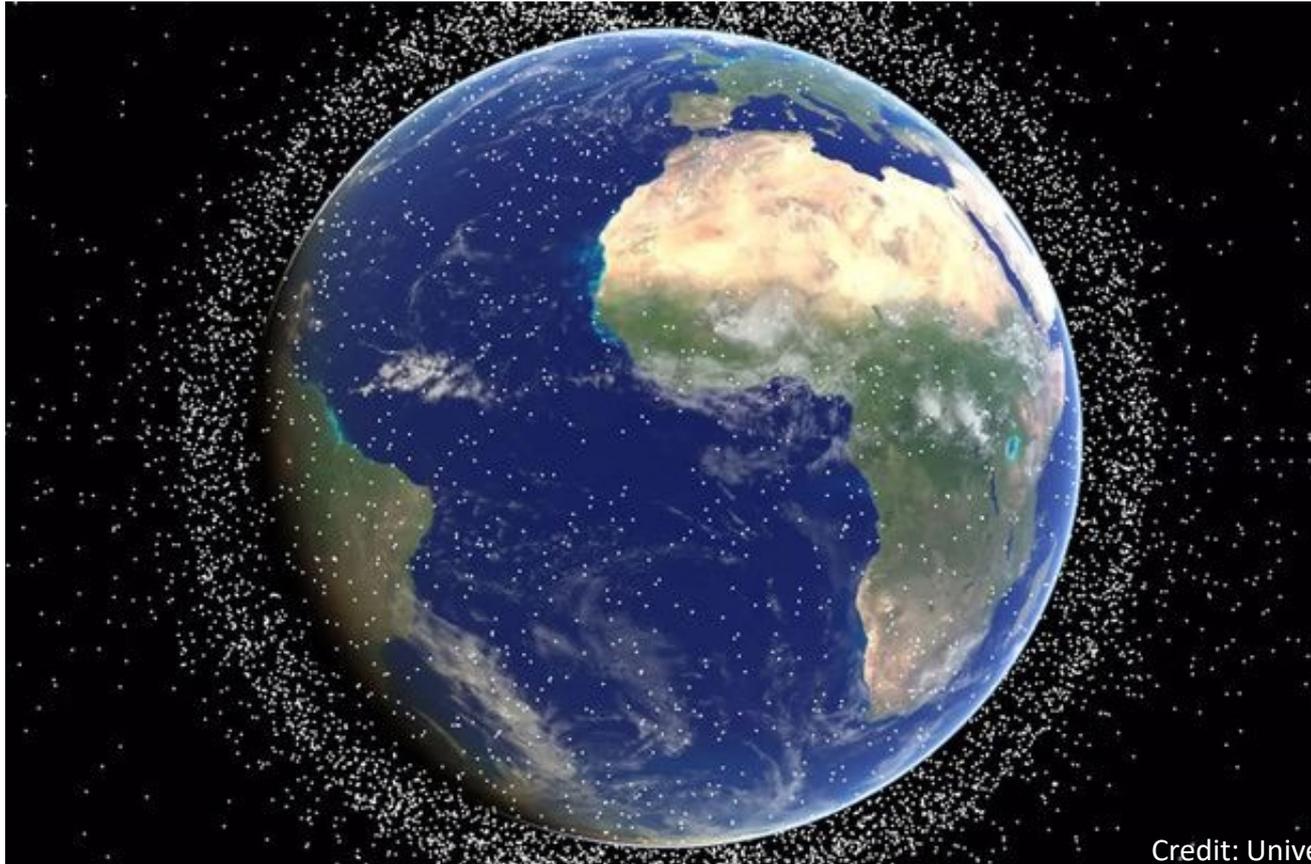
## Scientists use the entire spectrum but only 8.3 kHz to 275 GHz is regulated:

- **Radio Frequency Spectrum:** frequency region of the EM Spectrum that is managed via international and national laws and regulations
- Limited regulations in the near-infrared and optical region (e.g., laser coordination & safety standards)



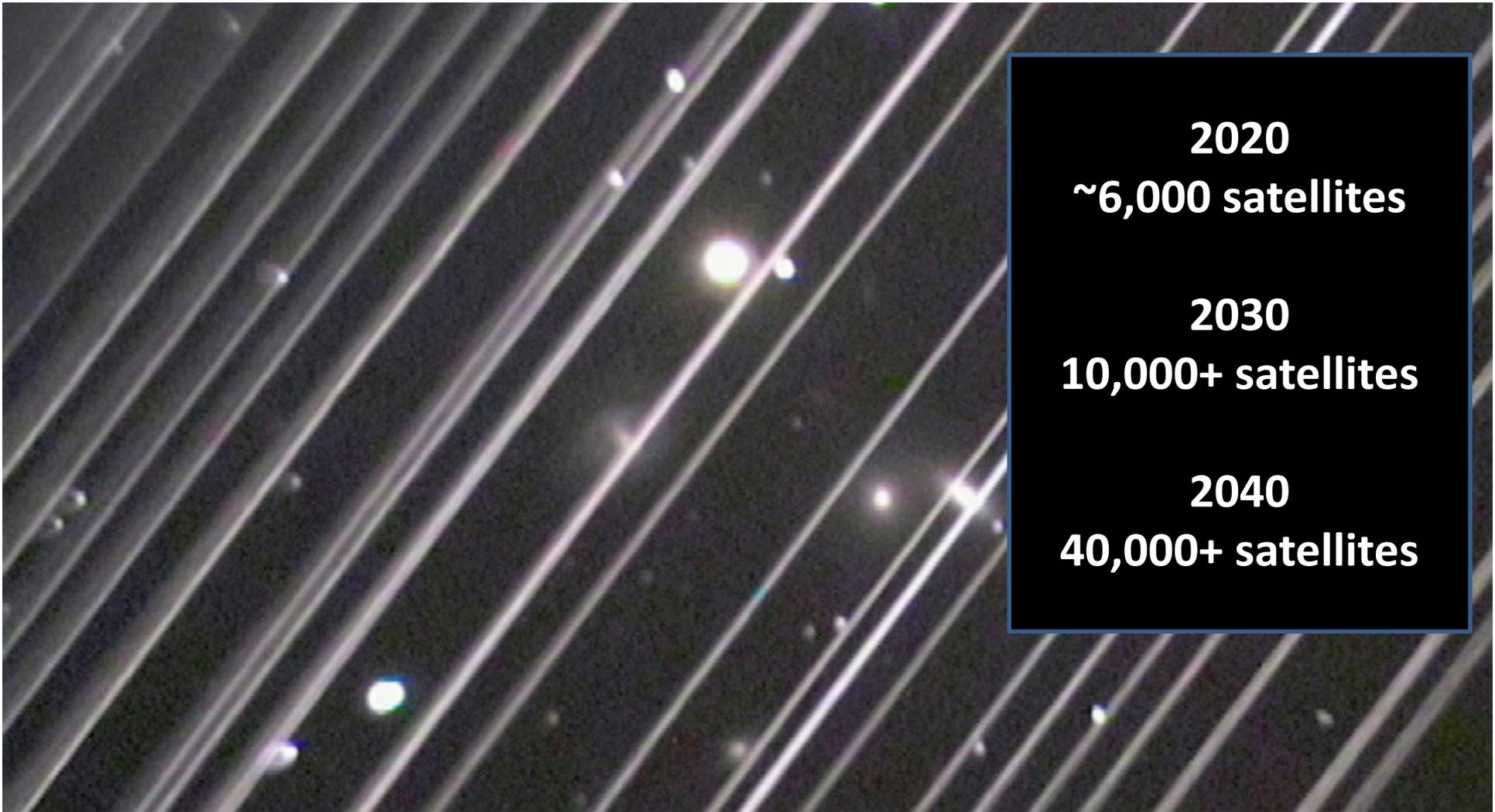
## What is coming?

- Constellations of thousands of NGSO satellites (10-50+ GHz transmitters) such that from any location you would always “see” at least one and up to 3 or 4 satellites or more!
- Mobile telecommunications (5G, IMT)
- High altitude platform systems



Credit: Univer





Optical image of NGC 5353/4 galaxy group (25 May 2019)

Image Credit: Victoria Girgis / Lowell Observatory

<https://www.iau.org/public/images/detail/ann19035a/>





# Summary

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- **Keep protected allocations as RFI-free as possible**
  - *Emissions may be prohibited at certain frequencies, out-of-band emissions can still be problematic*
    - *New challenges above the regulated regime (above 275 GHz, into optical)*
- **Utilize technology developments and advancements to increase spectrum availability, esp. in strategic geographic locations**
  - *Research in RFI excision techniques and receiver technology*
  - *Astronomy needs enhanced ESM geographical protections*
    - *a new coordinated quiet zone for the upcoming decade (VLA has no quiet zone, NRQZ in WV does not protect from airborne emitters)*
- **Coordination – internal at NSF and external stakeholders**
  - *Spectrum sharing*
  - *Costs must be considered; resources required for dynamic sharing*
- **Educational opportunity - Increased awareness of the spectrum as a finite resource**



# Questions?

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**Jonathan Williams**

[jonwilli@nsf.gov](mailto:jonwilli@nsf.gov)



**Ashley Zauderer**

[bezauder@nsf.gov](mailto:bezauder@nsf.gov)

**Thank you**



# NSF Coordination Group on Electromagnetic Spectrum Management

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**Jim Ulvestad**

**Chief Officer for Research Facilities,  
Office of the Director**



**Jonathan Williams**

**Coordination Group Chairman**

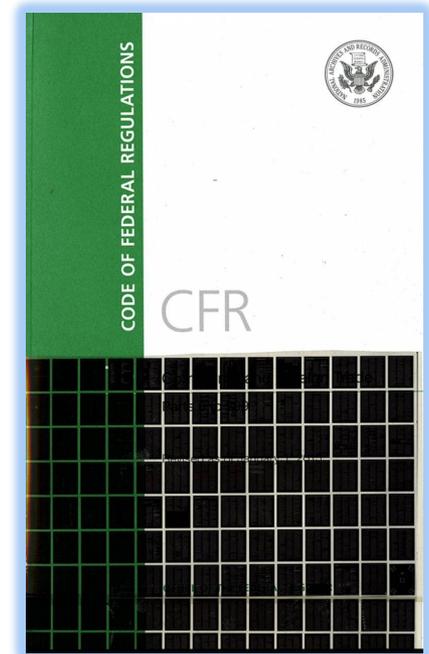
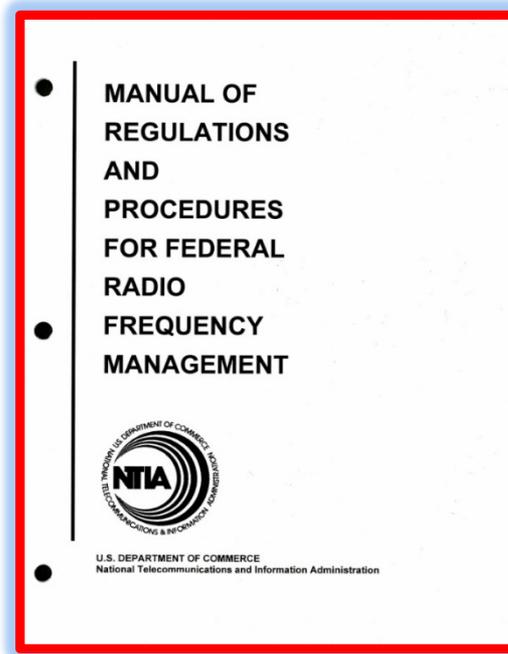
## **NSF Coordination Group includes representation from**

- Mathematical and Physical Sciences
- Geosciences
- Computer and Information Science and Engineering
- Engineering
- Biological Sciences
- Social and Behavioral Sciences
- Education and Human Resources
- Office of the General Counsel
- Office of International Science and Engineering



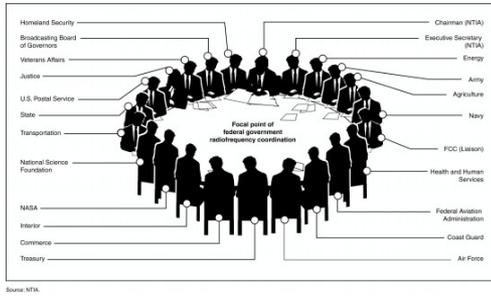
# Allocations and Coordination

- Radio Regulations:
  - (1) International (ITU-R Radio Regulations; [www.itu.int](http://www.itu.int))
  - (2) Regional (bilateral agreements)
  - (3) National (USA: NTIA - [www.ntia.doc.gov](http://www.ntia.doc.gov); FCC - [www.fcc.gov](http://www.fcc.gov))





# NSF ESM Unit Activities



- Represent NSF as a Federal Agency to the National Telecommunications and Information Administration
  - 10 subcommittees including
    - IRAC
    - FAS (NRQZ coordination)



## OAS | CITEL

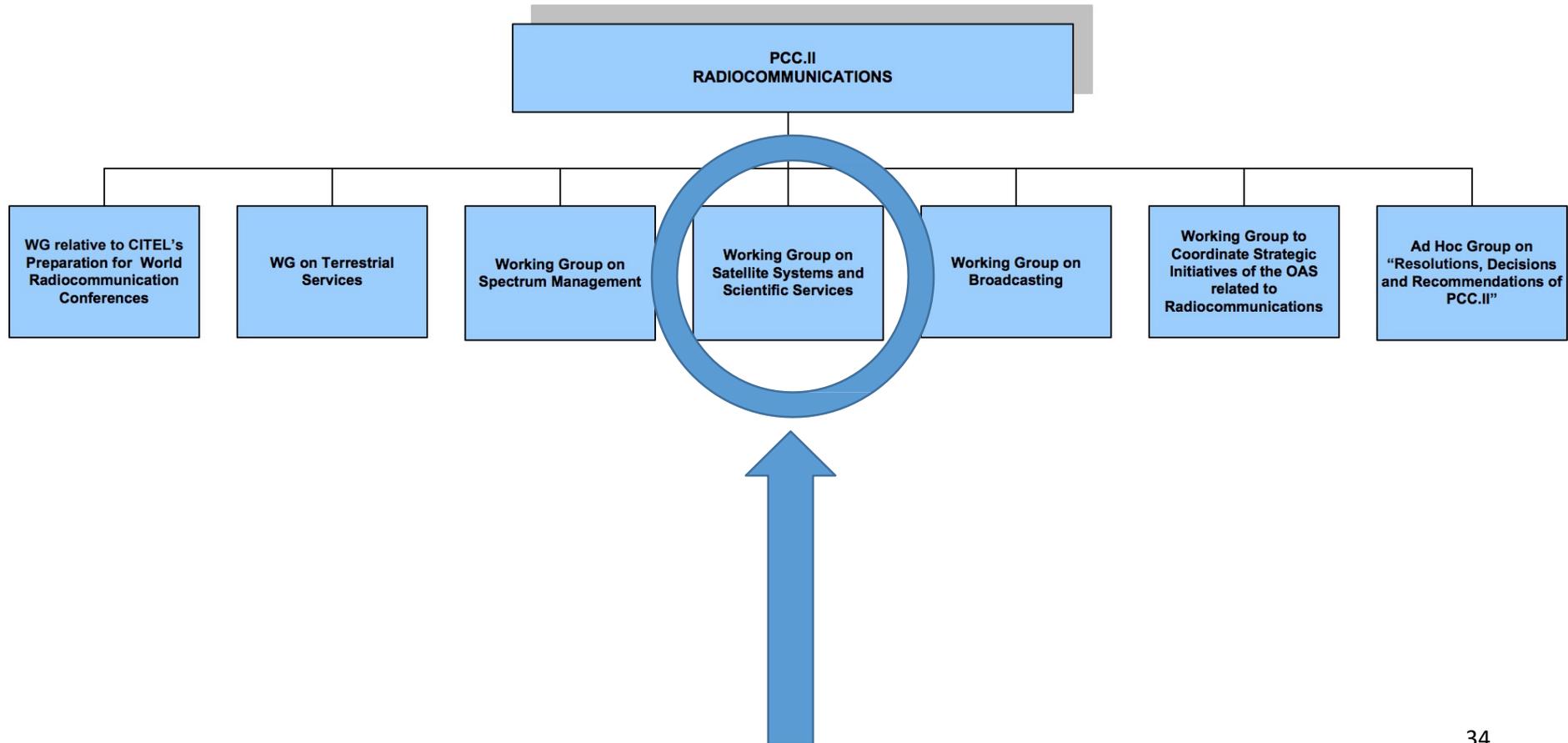
- Representation on official U.S. Delegations to the Inter-American Telecommunications Commission (CITEL) of the Organization of American States (OAS)



- Representation on official U.S. Delegations to the International Telecommunication Union's World Radiocommunication Conference (WRC 2019), including leading 7D – Radio Astronomy

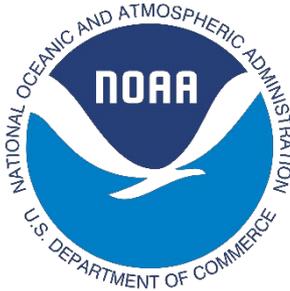
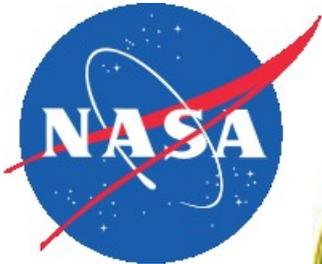


# OAS | CITEL





# NSF ESM Unit Activities



Federal  
Communications  
Commission

- At NSF – Coordination with other Directorates and Divisions with spectrum needs, and manage spectrum related grants portfolio, including the National Academies of Sciences Committee on Radio Frequencies (CORF)
- Coordinate with other US Agencies, especially science agencies
- Interface with commercial interests to advocate for their taking “practicable” steps to not cause interference to passive services

# JWST plans to use the Ka-band downlink...

<b>Name:</b>	Ka-Band Transmitter
<b>Frequency:</b>	25.9 GHz
<b>Emission Designators:</b>	56M0G1D, 28M0G1D, 14M0G1D
<b>Service Directions:</b>	<ul style="list-style-type: none"><li>• Space to Earth</li><li>• Deep Space</li></ul>
<b>Radio Services:</b>	<ul style="list-style-type: none"><li>• Space Research</li></ul>
<b>Station Classes:</b>	<ul style="list-style-type: none"><li>• EH - Space Research (Space)</li></ul>
<b>Earth Stations:</b>	<ul style="list-style-type: none"><li>• Canberra (AUS)</li><li>• Goldstone (CA)</li><li>• Robledo de Chavela (E) (Madrid)</li></ul>
<b>Asset Type:</b>	Emitter
<b>DBIU:</b>	03/30/2021