ngvla

Next Generation Very Large Array

Supplementary Topics

ngVLA Project Team (NRAO)

NSF AUI NRAO

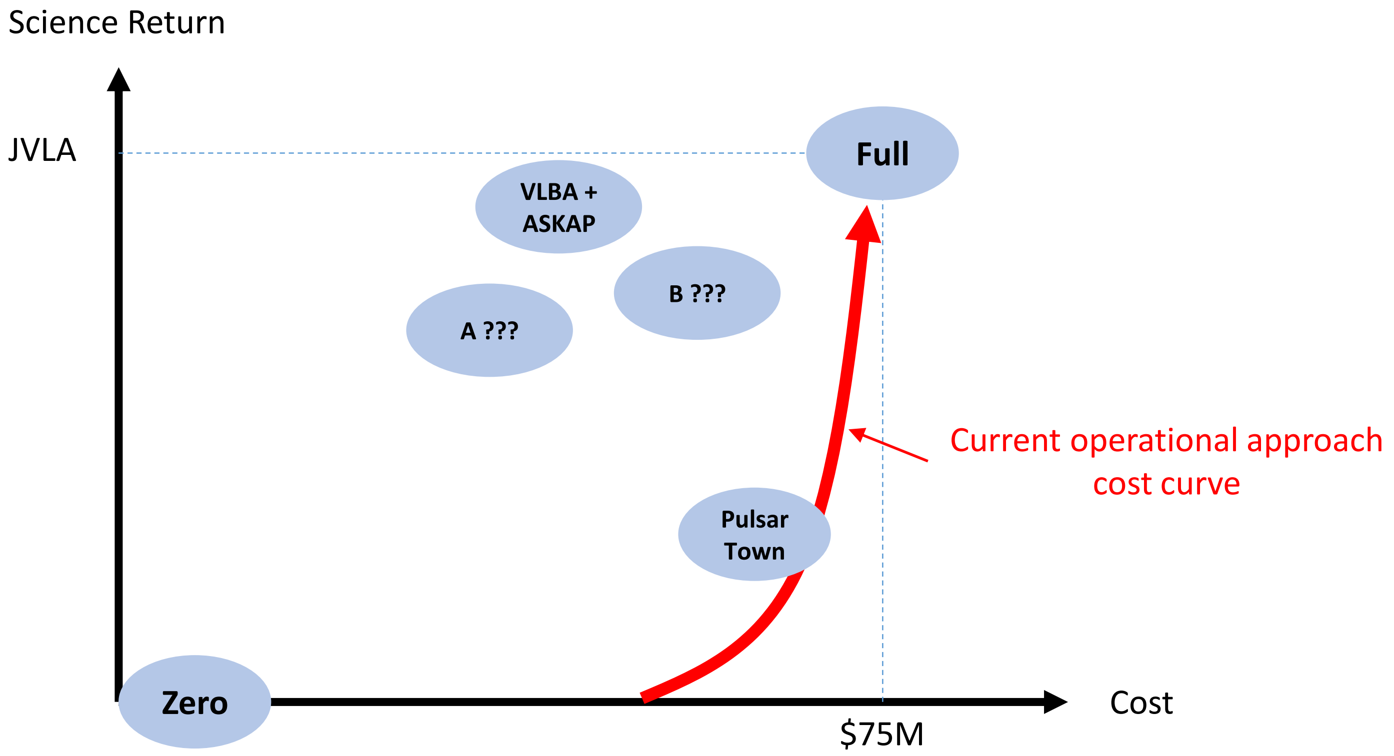
- JVLA-ngVLA Transition
- SKA Complementarity & Alliance
- ngVLA Human Resources
- Environmental
- RFI
- Programmatics

JVLA-ngVLA Transition

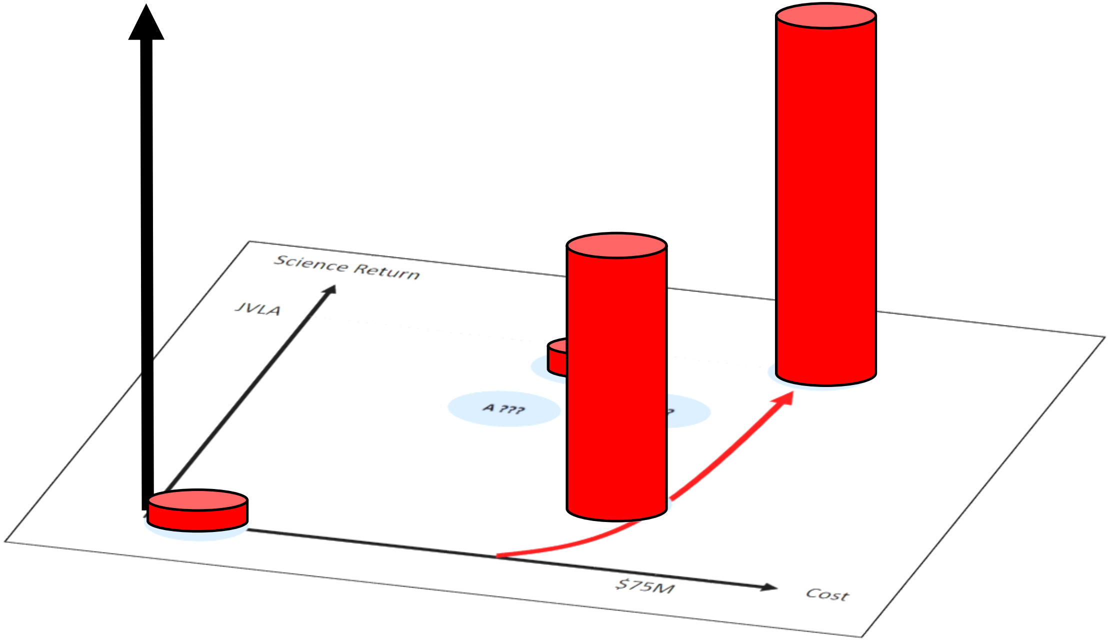
Transition

- Getting from JVLA (2023) to ngVLA (2028) – challenging.
- Preliminary analysis (NM) – current operations ~incompressible.
- Parameters to consider:
  - Science capability loss to community – 2020s
  - Resources ($$, human capital)
  - Impacts on construction project
  - Brittle vs fluid planning complexities
  - Delineating stakeholder requirements vs desirements
  - …

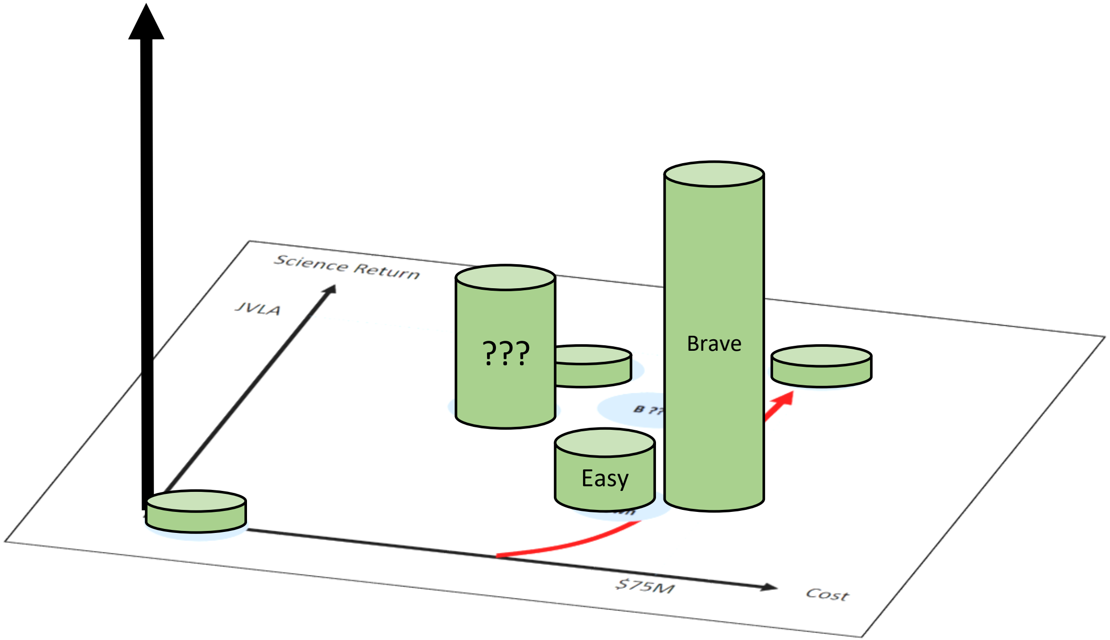
Analysis: 2024-2028



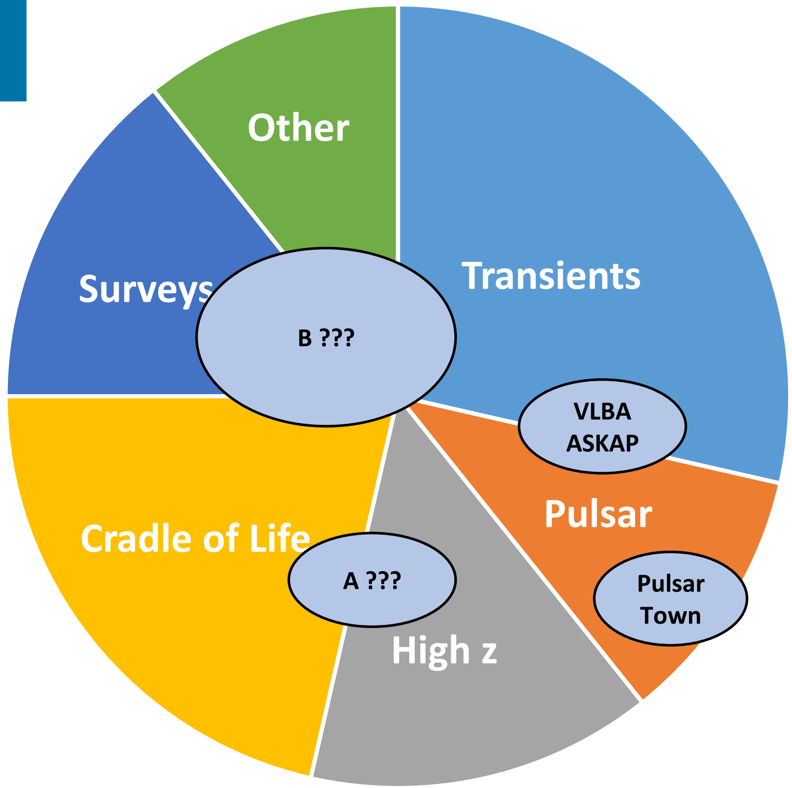
Human Capital Challenge – Workforce, recruiting etc.



New Technology – Near-term Work



Science Modes



- Period = 2024-2028
- Transients, ngVLA-related
- High-z
- Pulsars
- …

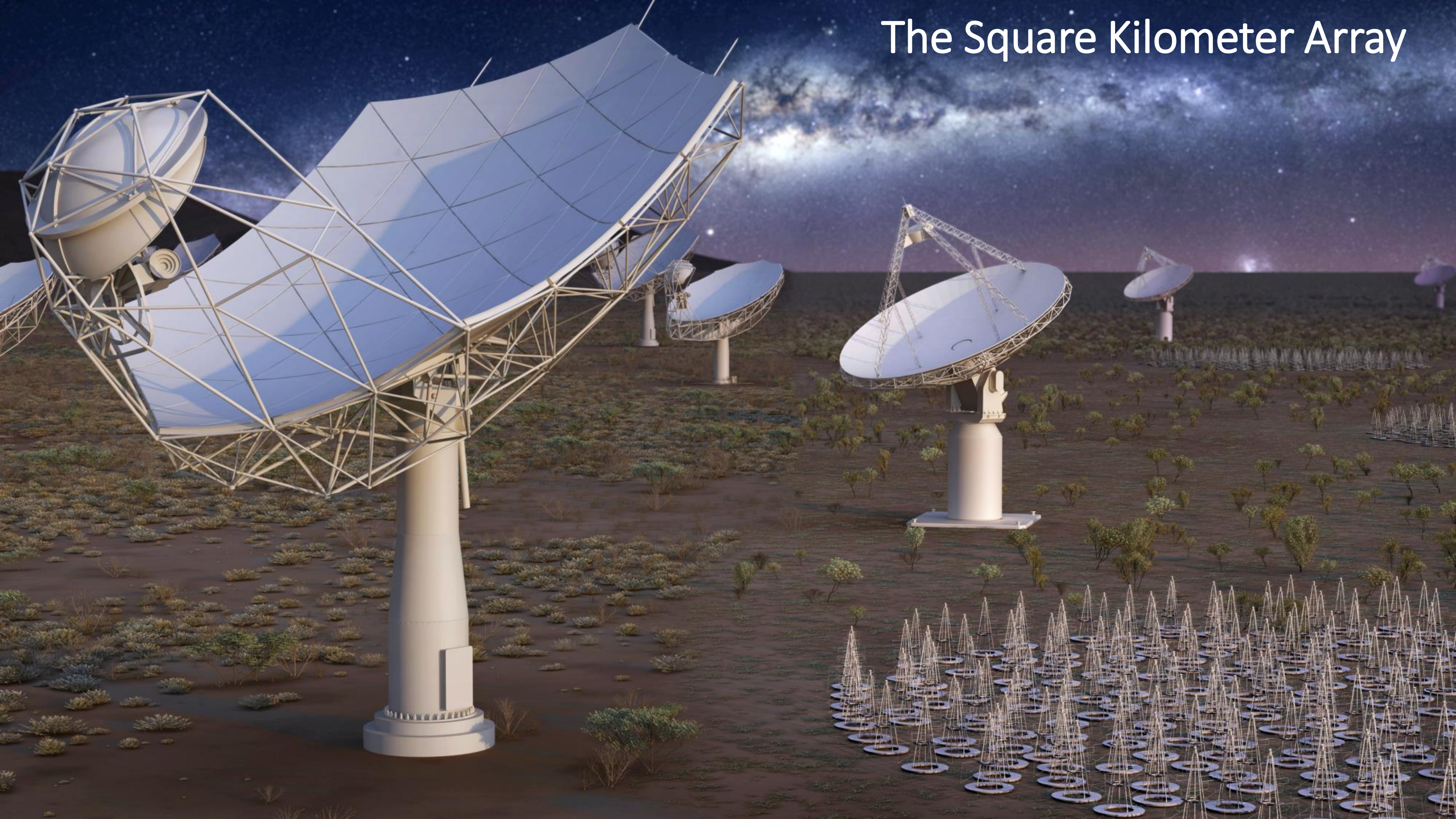
- Different modes satisfy different science communities
- 1:1 mode (EVLA)?
- Other telescopes?

Transition Process

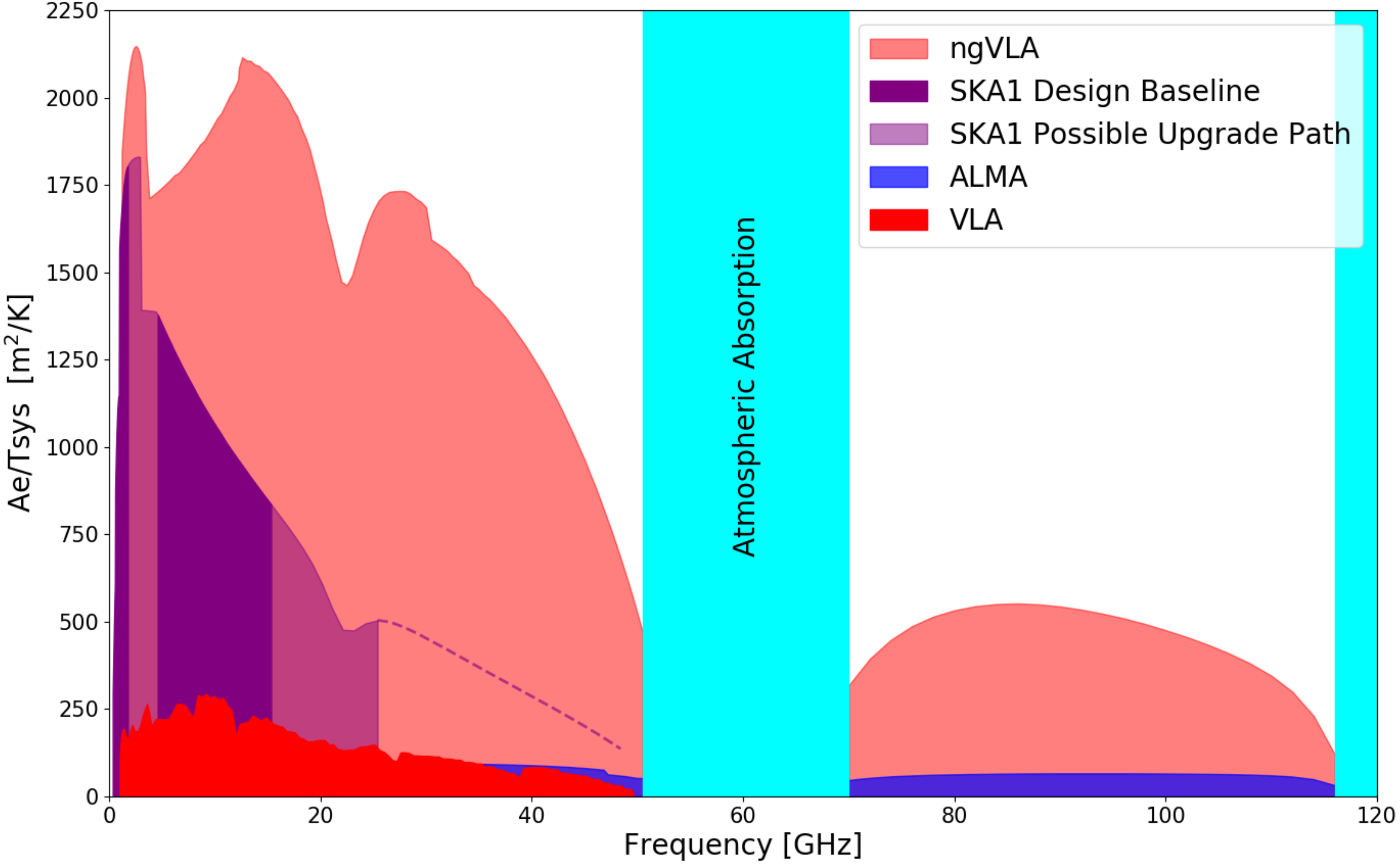
- Define Working Group (NRAO + SAC + TAC + UC + ??)
- WG: Define stakeholders, parameters of interest, metrics.
- Define environment, assumptions, initial mode options
  (+ NRAO quantitatively analyze)
- Preliminary review/analysis of process, modes // iterate $\rightarrow$ "Transition Options Plan" (TOP)
- NRC Blue-ribbon panel – review TOP mode options, technical evaluations, science promise - prioritize TOP options.
- Deliverable: Recommendations to Project baseline.
- Timing: Define WG post-ASTRO2020 activity.

SKA Complementarity & Alliance

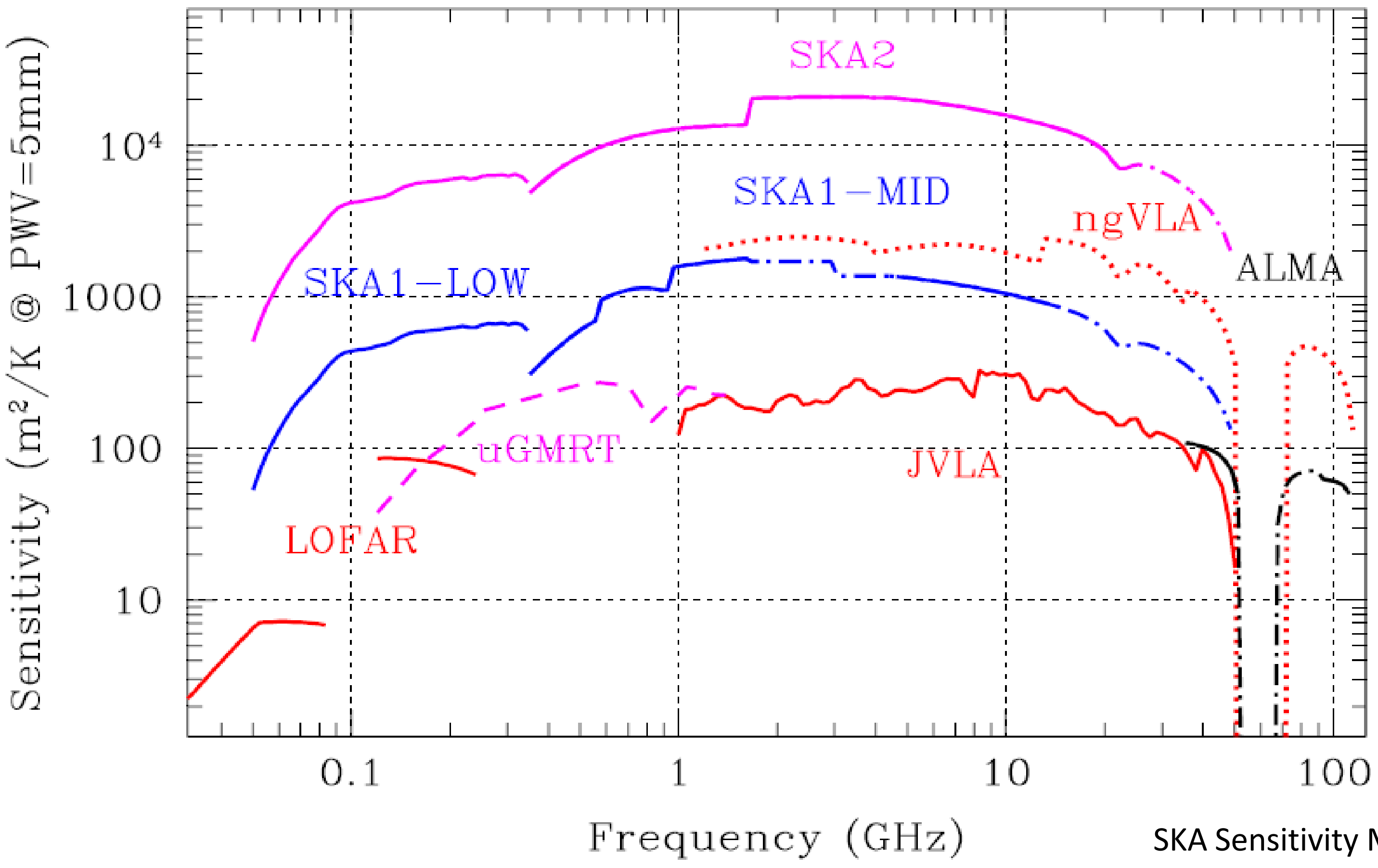
The Square Kilometer Array



- Long history together… parted ways ~2010.
- Currently: external participation in SKAPO, ongoing sw initiative, some technology investments benefits going both ways.
- Anticipated: CASA software will be integral part of early SKA.
- No obvious path to SKA1 participation for US community.
- US science environment, culture… different drivers, expectations.
- SKA, ngVLA, ALMA – complementary research instruments…
- June: Summit meeting between NRAO & SKAPO discussed formation of a "Future Radio Alliance" – SKA and ngVLA communities accessing each others facilities when completed.
- Outcome sought: preservation of open skies; US access to SKA1 (pulsar, EOR community benefits).



ngVLA
SKA1 Design Baseline
SKA1 Possible Upgrade Path
ALMA
VLA
Atmospheric Absorption
Ae/Tsys [m^2/K]
Frequency [GHz]
0
250
500
750
1000
1250
1500
1750
2000
2250
0
20
40
60
80
100
120



SKA Sensitivity Memo - Braun

SKA and ngVLA Key Science Drivers

Cosmic Dawn/EoR

Cradle of Life

(3cm)

Planet Formation

(3, 7, 10mm)

Extragalactic Molecular Gas

Extragalactic Continuum Studies

Transient / FRB Searches

Prebiotics

Pulsars Searches & Timing

GC Pulsars

Cosmic Magnetism

Stellar-Mass Black Holes

Cosmology

Low & High-z HI

Local Group HI

LIGO/LISA Follow-Up

SKA and ngVLA Key Science

Science Objective	SWG	High Priority Science Objective Number	Mode	Frequency: Range Low - High	Observing Area: Total Area	Observing Area: Angular Resolution Min:Max	Integr: Total (hr)	ngVLA Band
EoR - Imaging AASKA14:001	CD/EoR	1	Imaging	50 - 200 MHz	100 deg2	10:1000 arcsec	5000	
EoR - Power Spectra AASKA14:001	CD/EoR	2	imaging/Power Spectrum	50 - 200 MHz	1000 deg2	10:1000 arcsec	5000	
			imaging/Power Spectrum	50 - 200 MHz	10000 deg2	10:1000 arcsec	5000	
Pulsar Searching AASKA14:040	Pulsars	4	Non-Imaging	150 - 350 MHz	30000 deg2	320 arcsec	12750	
			Non-Imaging	650 - 950 MHz	2400 deg2	105 arcsec	800	
			Non-Imaging	1250 - 1550 MHz	2400 deg2	60 arcsec	2400	1
Pulsar Timing AASKA14:037	Pulsars	5	Non-Imaging	150 - 350 MHz	0.9 arcmin2	8 arcsec	4300	
			Non-Imaging	950 - 1760 MHz	0.7 arcmin2	7 arcsec	1600	1
HI - High z AASKA14:128	HI	13	Imaging	790 - 950 MHz	5.4 deg2	3:5 arcsec	5000	
HI - Low z AASKA14:129	HI	14	Imaging	1300 - 1400 MHz	3.8 deg2	3:5 arcsec	2000	1
HI - Galaxy AASKA14:130	HI	15	Imaging	1415 - 1425 MHz	1080 deg2	5:60 arcsec	12600	1
Transients - FRB AASKA14:055	Transients	18	Non-imaging/ Commensal	650 - 950 MHz	30000 deg2	105 arcsec	10000	
CoL - Planet formation AASKA14:117	Cradle of Life	22	Imaging	8 - 12 GHz	0.05 deg2	0.04:1 arcsec	6000	2
Magnetism - RM-grid AASKA14:092	Magnetism	27	Imaging	1000 - 1700 MHz	31000 deg2	2 arcsec	10000	1
Cosmology - High z IM AASKA14:019	Cosmology	32	Auto-Correl/ Commensal	350 - 1050 MHz	30000 deg2	1.7 deg	10000	
Cosmology - ISW, Dipole AASKA14:018, 032	Cosmology	33	Imaging	1000 - 1700 MHz	31000 deg2	2 arcsec	10000	1
Continuum - SFR(z) AASKA14:067	Continuum	37 + 38	Imaging	1000 - 1700 MHz	1000 deg2	0.5:1 arcsec	10000	1
			Imaging	1000 - 1700 MHz	7.8 deg2	0.5:1 arcsec	2000	1
			Imaging	1000 - 1700 MHz	0.38 deg2	0.5:1 arcsec	2000	1
			Imaging	7 - 11 GHz	0.5 deg2	0.05:1 arcsec	1000	2
			Imaging	7 - 11 GHz	30 arcmin2	0.05:1 arcsec	1000	2

- 13 SKA high-priority science objectives (HPSOs) requiring ~21 observations
  - Of these, 12 overlap with (non-optimized) ngVLA frequency Bands (i.e., 9 at L-band, 3 at X-band)
  - U.S. Community focused on higher frequencies
    - Strong bridge to ALMA science
    - 25% of 2019B GBT proposals asked for 3mm obs!
  - Most are survey driven, requiring 10's to 10's of thousand deg^2 mapped and >1000 hr on sky.
    - ***TBD is a set of KSPs – ~50% of first 5yr science***
    - Large area maps not major part of ngVLA Key Science
    - Highly complimentary to ngVLA for follow-up

Global Alliance Options

- Meeting in Iceland – NRAU/AUI, NSF, SKAO Board + Project Office - June 2019.
- Presentation of project statuses, areas of collaboration.
- Scientific opportunities & technical synergies apparent.
- Planned: meeting late 2020/early 2021.
- Alliance complexities:
  - Key issue: Open-skies policy differences – ngVLA vs SKA.
  - Access to NRAO (NSF US) instruments – "Reciprocity" as per AAAC
  - Value of anticipated NRAO technical deliverables to SKA?
  - Open-skies vs Value-based time allocation schemes.
  - SKA: compression of minor partner time allocations (beyond 5%).

ngvla
Next Generation Very Large Array

AAAC 2014

<u>2014 Astronomy and Astrophysics Advisory Committee recommendations on Principles for Access to Large Federally Funded Astrophysics Projects and Facilities</u>[1]

In its 2013 annual report[2], the Astronomy and Astrophysics Advisory Committee (AAAC) recommended that "Negotiations towards the coordination of projects or the development of partnerships should proceed on the basis of the principles of reciprocal participation and mutually agreed sharing of costs and responsibilities." In the current environment of complex partnerships there is a need to articulate the principles that enable the best science within constrained resources in order to realize large astrophysics projects and facilities for the benefit of the global astrophysics community.

The AAAC recommends that the Office of Science and Technology Policy (OSTP) Division of Science, the NASA Astrophysics Division, NSF Division of Astronomical Sciences, and DOE Office of High Energy Physics, in regards to large astrophysics projects and facilities:

- apply the following principles to all projects and facilities that are funded by these organizations

1. THE PRIMARY GOAL OF THE ASTROPHYSICS COMMUNITY IS TO PRODUCE THE BEST UNDERSTANDING OF OUR UNIVERSE: Implementation of large astrophysics projects and facilities should be organized so as to enable the best use of their resources. A balance must be struck between preserving the opportunity for the implementing consortium and the funding partners to reap the benefits of the resulting data, and participation by the wider community, to ensure the best science possible.

2. GLOBAL COORDINATION: Nations and funding partners will achieve greater advances in astrophysics when community-wide coordination and collaboration allow resources to be used efficiently, effectively, and without unnecessary duplication. Coordination could

[1] These principles are presented in the 2014 AAAC report. The full report can be found at: http://www.nsf.gov/mps/ast/aaac/reports/annual/aaac_2014_report.pdf

[2] http://www.nsf.gov/mps/ast/aaac/reports/annual/aaac_2013_130308finalreport.pdf

1

mean jointly developing an astrophysics project as a partnership or choosing unique astrophysics projects that are complementary.

3. OPEN DATA: The best science occurs when an open data policy enables the global astrophysics community, the broader science community, and the public to extend the science outcomes of the project. A period of limited access to data for the implementing consortium or the funding partners to reap the benefits of their investment is reasonable. However, policies and funding should ensure that large projects make standard data products and analysis tools publicly available in a timely and useable manner.

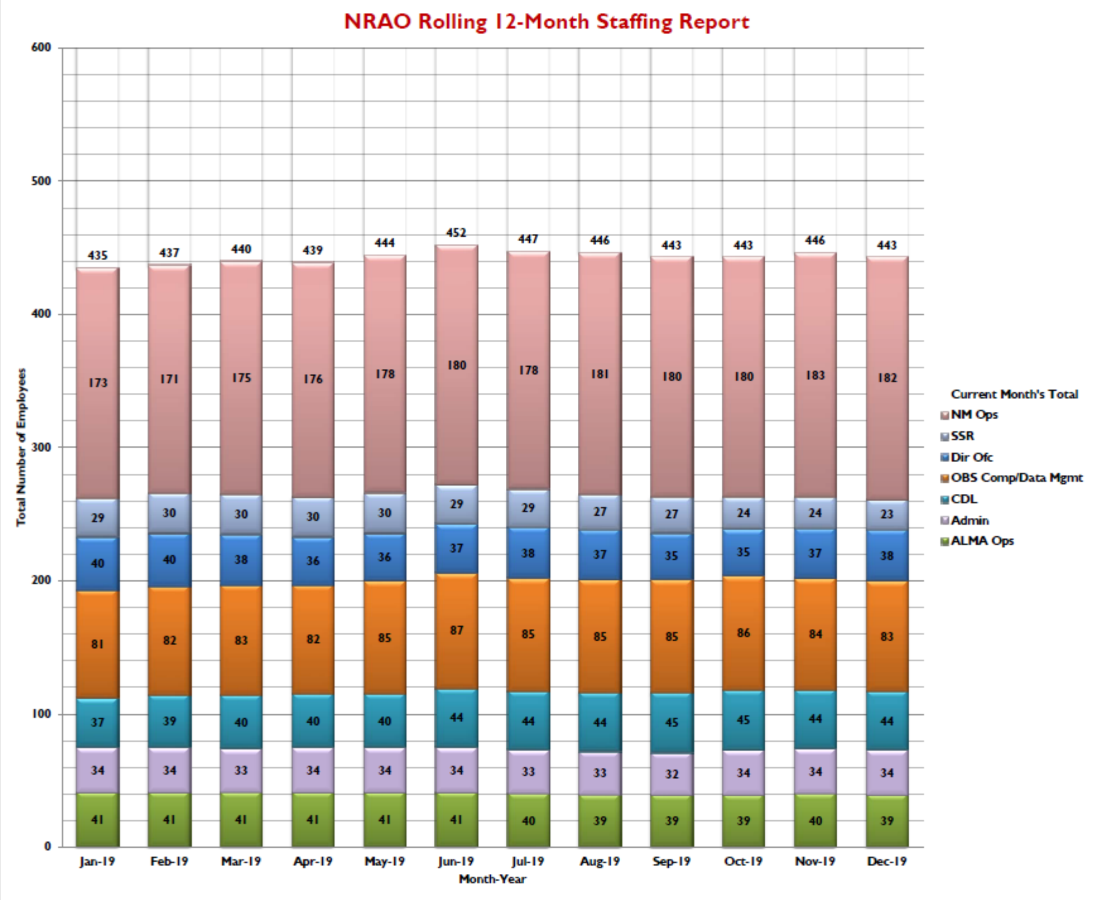
4. OPEN ACCESS: The best science relies upon selecting the most compelling astrophysics investigations. Access to a large astrophysics project or facility (typically observing time) should be allocated through an open, merit-based process, recognizing that some level of preferred access may be reasonable for the implementing consortium and the funding partners to reap the benefits of their telescope investments. Calls for proposals extending beyond the implementing consortium should be open to the global astrophysics

The AAAC believes that addressing these principles will lead to the most productive scientific use of the current and coming generations of large astrophysics projects and facilities. We understand that there may be grounds for justifiable deviations from these principles, such as treaty obligations or statutory restrictions. However, by formulating these principles, and recommending that any rational for deviation must be explicitly articulated, we hope to create a climate in which the best possible science can be achieved.

2

6. RECIPROCITY: The best science occurs when nations and other funding partners of large astrophysics projects and facilities practice reciprocity with the wider scientific community. Nations and funding partners whose scientists expect access to external resources (for example, funding, data, access, observing time, or consortium membership) should offer access to their own resources

ngVLA Human Resources



	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19
NM Ops	173	171	175	176	178	180	178	181	180	180	183	182
SSR	29	30	30	30	30	29	29	27	27	24	24	23
Dir Ofc	40	40	38	36	36	37	38	37	35	35	37	38
OBS Comp/Data Mgmt	81	82	83	82	85	87	85	85	85	86	84	83
CDL	37	39	40	40	40	44	44	44	45	45	44	44
Admin	34	34	33	34	34	34	33	33	32	34	34	34
ALMA Ops	41	41	41	41	41	41	40	39	39	39	40	39
Total	435	437	440	439	444	452	447	446	443	443	446	443

ngvla
Next Generation Very Large Array

WBS #	WBS	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	Grand Total
1.1	Project Management & Administration	-	-	-	-	-	-	-	-	-	-	**-**
1.2	Systems Engineering	-	-	-	-	-	-	-	-	-	-	**-**
1.3	Assembly, Integration & Verification	-	-	-	-	-	-	-	-	-	-	**-**
1.4	Commissioning & Scientific Validation	-	-	-	-	-	-	-	-	-	-	**-**
1.8.1	Antenna SEIT/PM	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	**22.5**
1.8.2	Main Array Antenna		-	-	-	-	-	-	-	-		**-**
1.8.3	Long Baseline Antenna							-	-	-	-	**-**
1.8.4	Short Baseline Antenna				-	-	-					**-**
1.9.1	Antenna Electronics SEIT/PM	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	**30.0**
1.9.2	Front End	3.9	3.6	4.8	6.6	6.4	6.4	6.4	4.5	4.5	4.5	**51.7**
1.9.3	Cryogenic System	2.1	2.1	2.1	2.1	2.0	2.0	2.0	2.0	2.0	2.0	**20.4**
1.9.4	Integrated Receiver Digitizer	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	**30.0**
1.9.5	Monitor & Control System	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	**29.0**
1.9.6	Power Supply System	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	**17.5**
1.9.7	Bins, Modules & Racks	2.8	2.8	2.9	2.9	2.9	2.9	2.9	3.0	2.8	2.8	**28.7**
1.9.8	Environmental Control	1.4	1.4	2.6	2.7	2.7	2.7	2.7	2.7	1.3	3.0	**23.4**
1.9.9	Water Vapor Radiometer	2.2	2.8	2.9	2.9	2.9	2.9	2.9	3.0	2.8	2.8	**28.2**
1.10.1	LORT SEIT/PM	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**10.0**
1.10.2	Central Time & Frequency References	3.2	1.7									**4.9**
1.10.3	Reference Distribution	1.7	1.7	2.7	2.7	1.6	-	-	-	-		**10.3**
1.10.4	Antenna Time & Frequency References	3.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	**22.0**
1.11.1	CSP SEIT/PM	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	**30.0**
1.11.2	Correlator and Beamformer	-	-	-	-	-	-	-				**-**
1.11.3	Pulsar Engine					-	-	-				**-**
1.11.4	Digital Back End	3.5	3.5	3.5	3.5	3.2	3.1	3.1	3.1	3.1	3.1	**32.7**
1.12.1	CSW SEIT/PM	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	**20.0**
1.12.2	Proposal Management System	0.9	2.1	2.5	2.4	2.1	1.8	1.5	1.2	0.9	0.4	**15.8**
1.12.3	Online Sytem	14.6	32.9	39.2	38.4	33.9	28.6	23.6	19.2	14.0	5.9	**250.3**
1.12.4	Offline System	7.4	16.7	19.8	19.4	17.2	14.5	12.0	9.7	7.1	3.0	**126.8**
1.12.5	Maintenance Support & Development	1.4	3.1	3.7	3.6	3.2	2.7	2.2	1.8	1.3	0.6	**23.8**
1.12.6	Processing Center		-	-	-							**-**
1.12.7	Data Archives			-	-	-	-	-	-	-	-	**-**
1.13	IT Infrastructure							-	-	-	-	**-**
1.14	Array Infrastructure	8.0	8.0	12.0	12.0	12.0	8.0	7.0	5.0	5.0	5.0	**82.0**
1.15	Ops Buildings	-	-	-	-			-		-		**-**
1.16	Land Acquisition & Regulatory Compliance	5.0	7.0	8.0	10.0	10.0	10.0	10.0	10.0	8.0	6.0	**84.0**
1.18	Safety	-	-	-	-	-	-	-	-	-	-	**-**
Grand Total		**79.1**	**111.4**	**127.6**	**130.4**	**121.4**	**106.7**	**97.5**	**86.2**	**73.7**	**59.9**	**993.9**

WBS #	WBS	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	Grand Total
Grand Total		**79.1**	**111.4**	**127.6**	**130.4**	**121.4**	**106.7**	**97.5**	**86.2**	**73.7**	**59.9**	**993.9**

- Figures do not include indirect staffing (+30%)
- NM Ops – currently ~200
- Two-year ramp to recruit

Steady State Operations

WBS #	ELEMENT	COST (BY2018$)	FTE
1	ngVLA Operations	$ 92,655,156	398
1.1	Administration Ops	$ 7,406,823	6
1.2	Science Ops	$ 9,835,102	57
1.3	Array Ops	$ 1,779,355	17
1.4	Maintenance Center	$ 16,069,529	144
1.5	Repair Center	$ 18,814,310	122
1.6	SoftwareOps	$ 8,701,953	52
1.7	IT Ops	$ 22,029,311	0
1.8	Development Ops	$ 8,018,774	0

Human Resources Issues

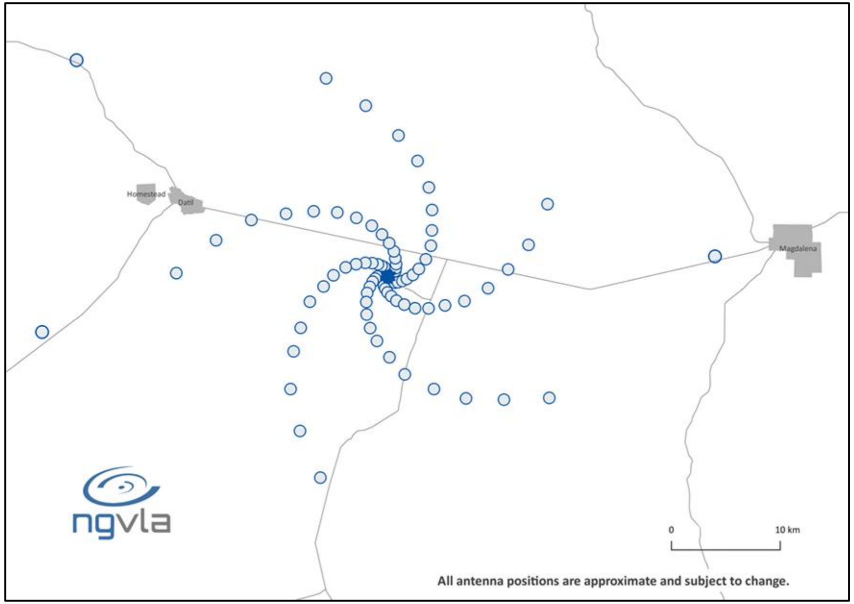
- Recruiting & retention increasingly difficult in certain job families – engineers(hw, sw), project management, IT.
- Strategies
  - ngVLA Project Office – Albuquerque
  - Distributed effort across NRAO sites (ALMA approach)
  - Amalgamation of key activities e.g. Science Operations
  - Comparisons of Salaries/Benefits w/ industry
- Issues can be amplified by Transition option.

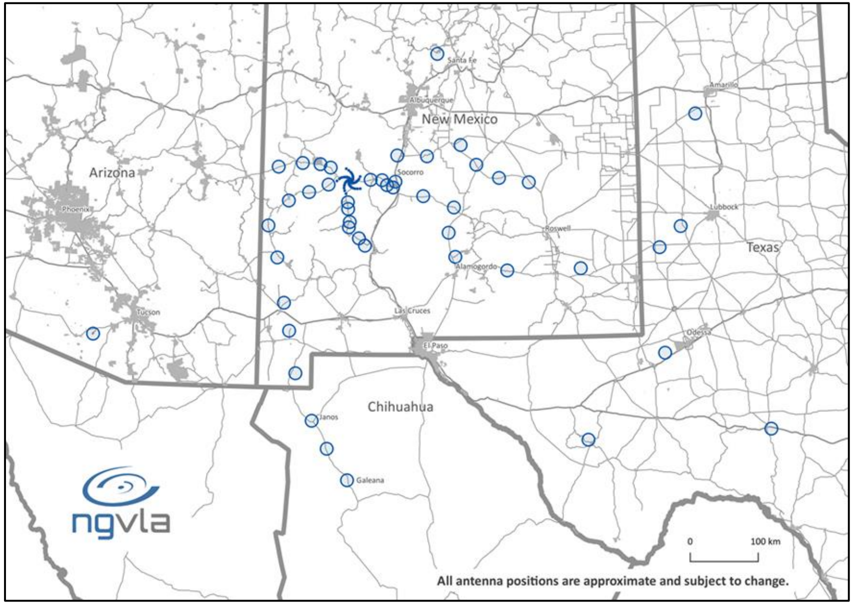
Environmental/Regulatory

ngVLA Deployment

- Project will require EIS covering activities at core site (Plains of San Agustin) plus 30-50 other locations.
- Core site
  - Est: Approximately twice the current disturbance (pads, roads vs rail)
  - Cattle ranches, privately-owned properties.
  - Outreach with local community underway.
- Remote sites
  - Typically 1-3 acre sites, located near power/fiber.
  - Considerable flexibility in placement (configuration process)
  - Minimal environmental impacts (by design)

ngVLA – Physical Layout





EIS

- Standard areas to be considered
  - Archaeological/Historical
  - Endangered Species
  - Air/Water Quality
  - Visual
  - Social
  - Resource impacts
- Reexamined 1970s EIS report. Initial analyses completed. OK.
- NSF interactions begin this spring.
- Positive expression of support from local community.

Radio Frequency Interference Concerns

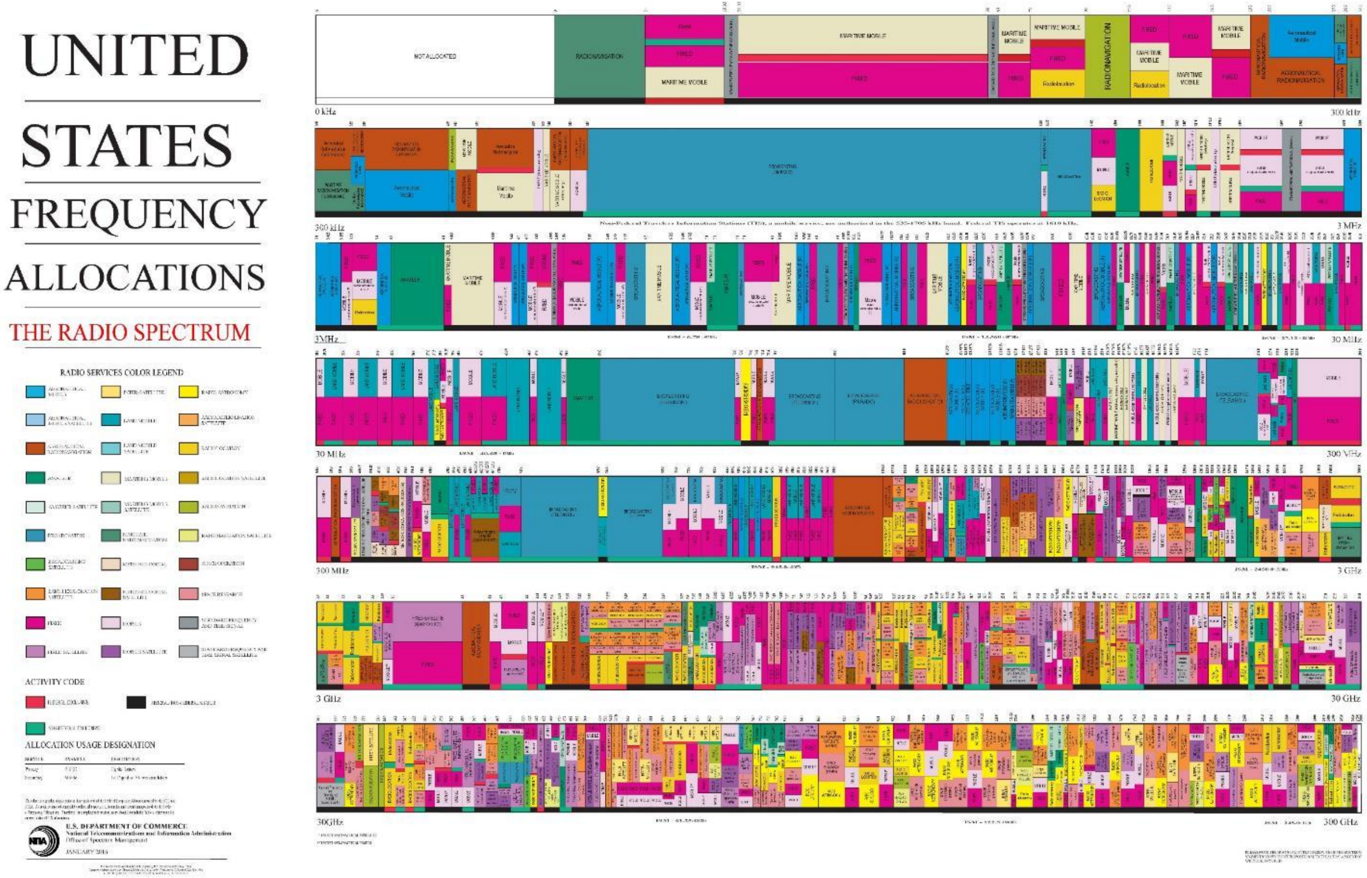
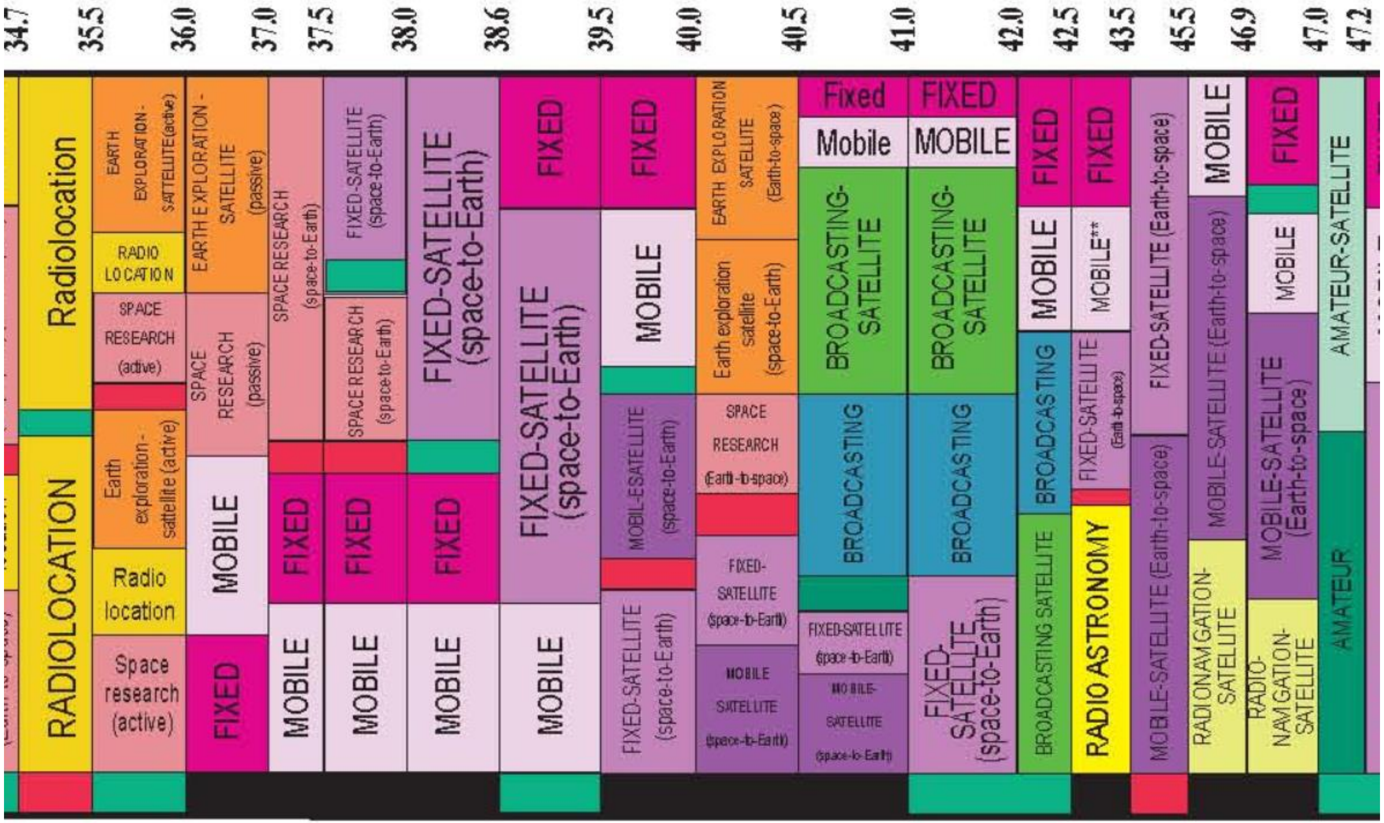

UNITED
STATES
FREQUENCY
ALLOCATIONS
THE RADIO SPECTRUM
RADIO SERVICES COLOR LEGEND
ACTIVITY CODE
ALLOCATION USAGE DESIGNATION
U.S. DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Office of Spectrum Management
0 kHz
300 kHz
300 kHz
3 MHz
3 MHz
30 MHz
30 MHz
300 MHz
300 MHz
3 GHz
3 GHz
30 GHz
30GHz
300 GHz
NOT ALLOCATED
RADIONAVIGATION
MARITIME MOBILE
FIXED
RADIOLOCATION

TABLE 1.1 Scientifically Relevant Services

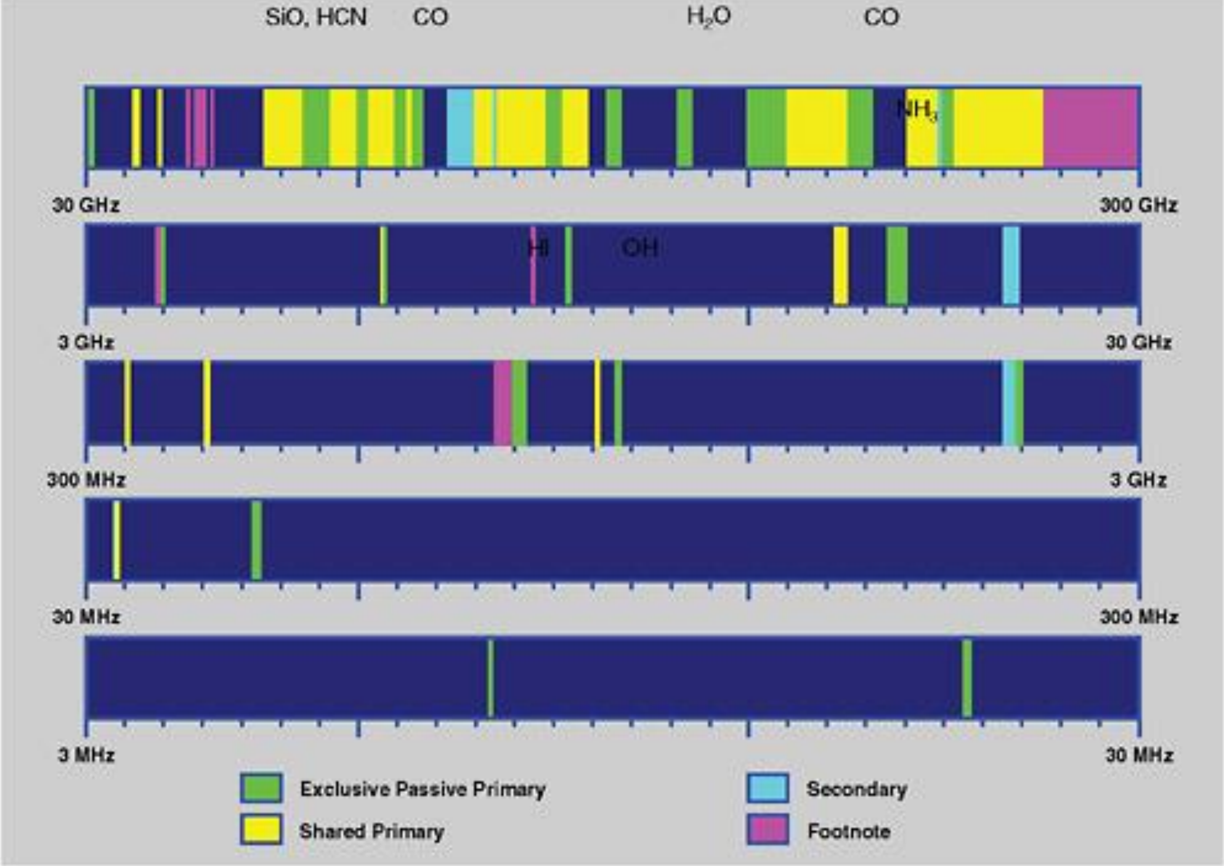
Service	Abbreviation	Description of Service
Earth Exploration Satellite Service	EESS	Remote sensing from orbit, both active and passive, and the data downlinks from these satellites
International Global Navigation Satellite System (GNSS) Service	IGS	Accurate position and timing data
Meteorological Aids Service	MetAids	Radio communications for meteorology, e.g., weather balloons
Meteorological Satellite Service	MetSat	Weather satellites
Radio Astronomy Service	RAS	Passive ground-based observations for the reception of radio waves of cosmic origin
Space Operations Service	SOS	Radio communications concerned exclusively with the operation of spacecraft—in particular, space tracking, space telemetry, and space telecommand
Space Research Service	SRS	Science satellite telemetry and data downlinks, space-based radio astronomy, and other services

https://www.nap.edu/catalog/11719/handbook-of-frequency-allocations-and-spectrum-protection-for-scientific-uses

ngvla
Next Generation Very Large Array



NSF AUI NRAO

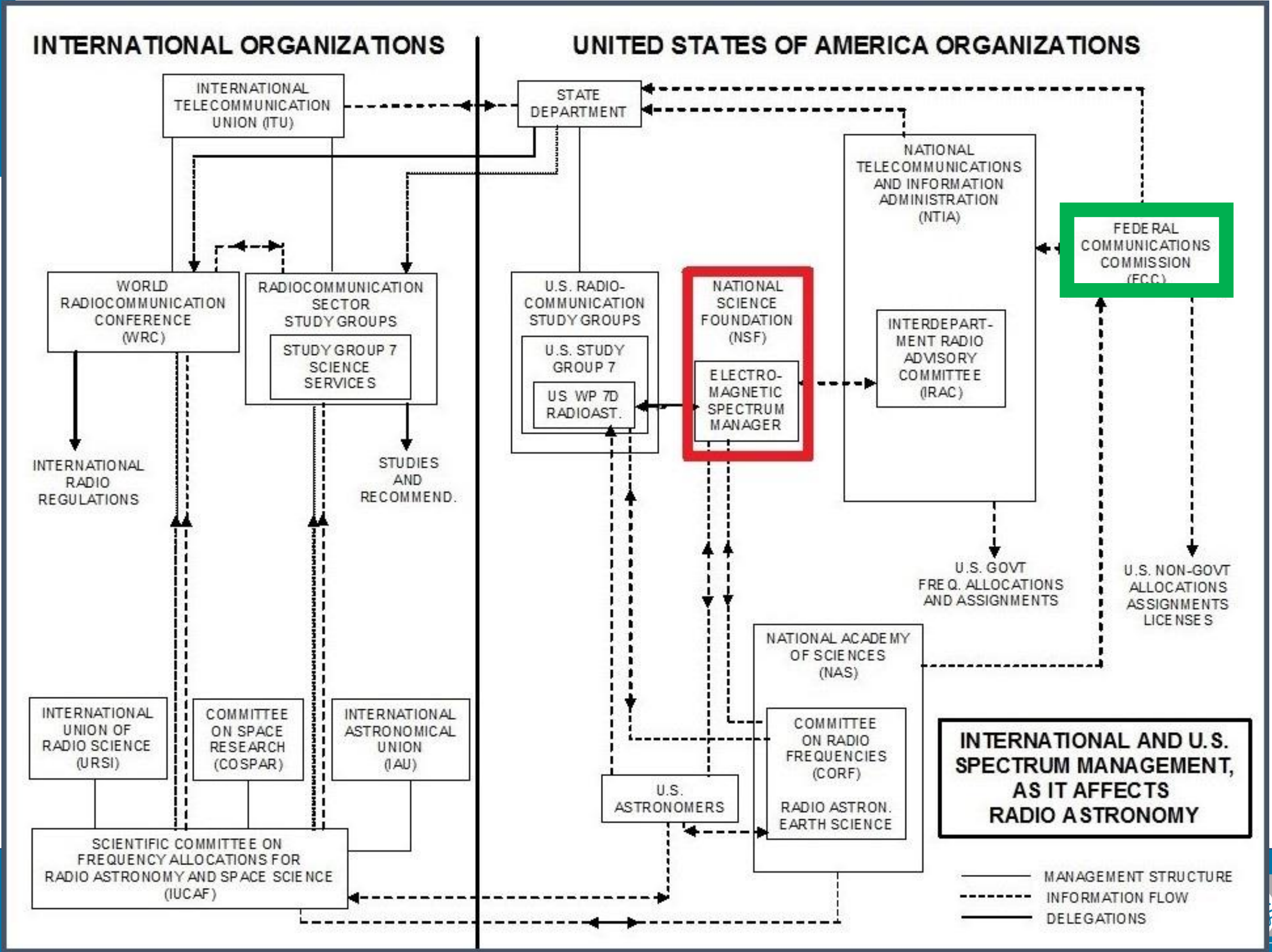


Radio Astronomy Frequency Allocations in the United States

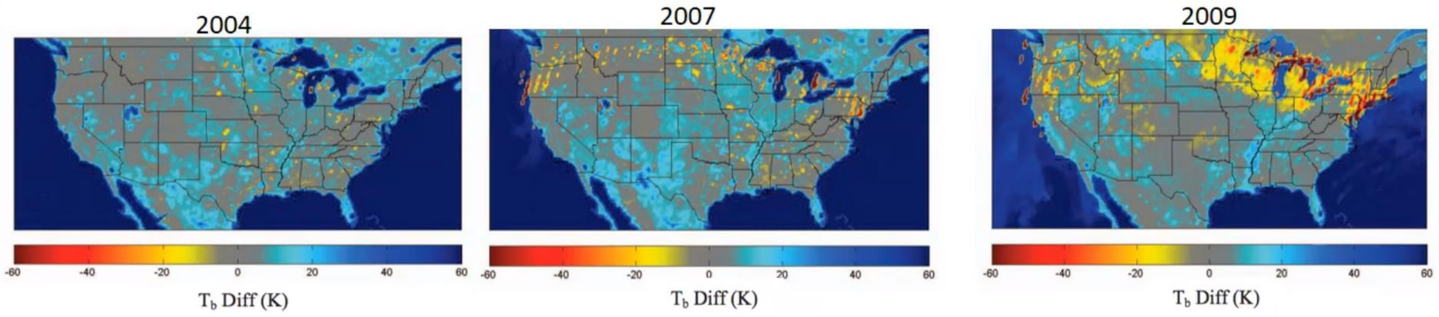
NAP(2010)

Scientific Use of Spectrum

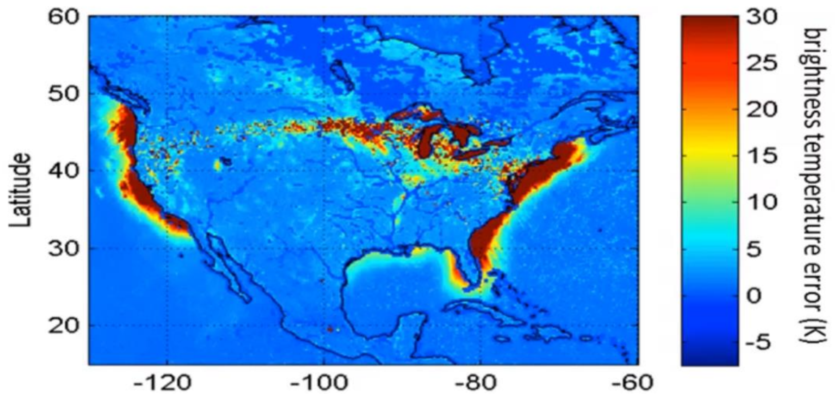
- Management responsibility of the National Science Foundation (Ashley Zauderer/Jonathan Williams NSF/ESM), alongside other bodies, committees – CORF and equivalents internationally.
- Several profound changes approaching:
  - 5G
  - ngso constellations SpaceX, OneWeb, etc.
  - IOT
  - Data Revolution
- Impacts and collisions inevitable – strong recommendations by NSF/other committees & stakeholders to examines issues, predictable actions by FCC to implement.
- Radio astronomy – next generation of projects under threat.


INTERNATIONAL ORGANIZATIONS
UNITED STATES OF AMERICA ORGANIZATIONS
INTERNATIONAL TELECOMMUNICATION UNION (ITU)
STATE DEPARTMENT
NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION (NTIA)
FEDERAL COMMUNICATIONS COMMISSION (FCC)
WORLD RADIOCOMMUNICATION CONFERENCE (WRC)
RADIOCOMMUNICATION SECTOR STUDY GROUPS
STUDY GROUP 7 SCIENCE SERVICES
U.S. RADIO-COMMUNICATION STUDY GROUPS
U.S. STUDY GROUP 7
US WP 7D RADIOAST.
NATIONAL SCIENCE FOUNDATION (NSF)
ELECTRO-MAGNETIC SPECTRUM MANAGER
INTERDEPART-MENT RADIO ADVISORY COMMITTEE (IRAC)
INTERNATIONAL RADIO REGULATIONS
STUDIES AND RECOMMEND.
U.S. GOVT FREQ. ALLOCATIONS AND ASSIGNMENTS
U.S. NON-GOVT ALLOCATIONS ASSIGNMENTS LICENSES
NATIONAL ACADEMY OF SCIENCES (NAS)
COMMITTEE ON RADIO FREQUENCIES (CORF)
RADIO ASTRON. EARTH SCIENCE
INTERNATIONAL UNION OF RADIO SCIENCE (URSI)
COMMITTEE ON SPACE RESEARCH (COSPAR)
INTERNATIONAL ASTRONOMICAL UNION (IAU)
U.S. ASTRONOMERS
SCIENTIFIC COMMITTEE ON FREQUENCY ALLOCATIONS FOR RADIO ASTRONOMY AND SPACE SCIENCE (IUCAF)
INTERNATIONAL AND U.S. SPECTRUM MANAGEMENT, AS IT AFFECTS RADIO ASTRONOMY
MANAGEMENT STRUCTURE
INFORMATION FLOW
DELEGATIONS

Passive Remote Sensing and Interference



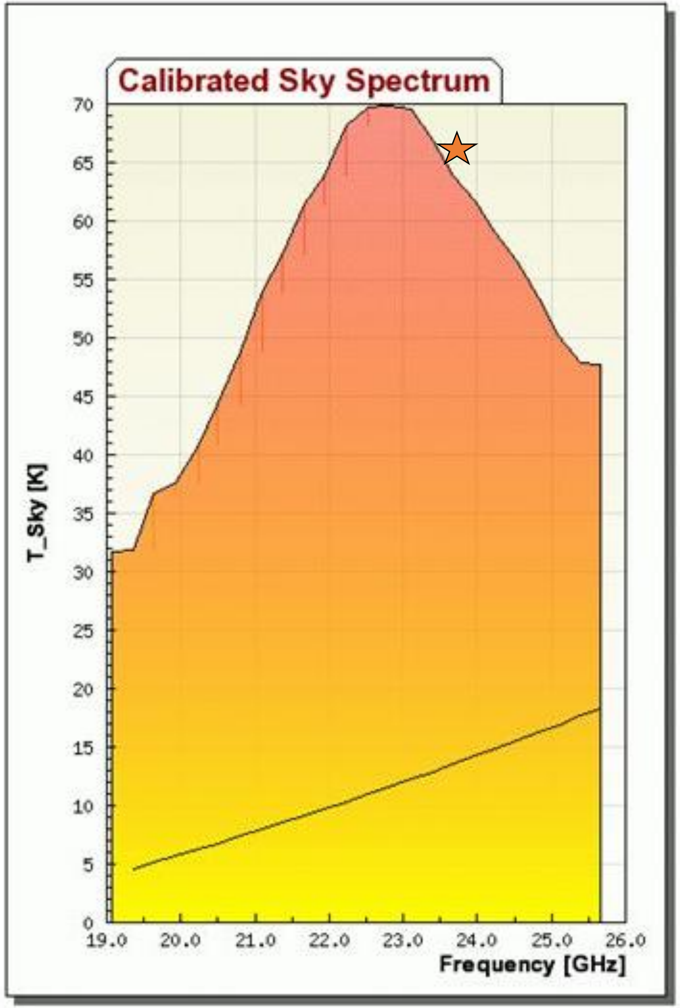
18 GHz
DirecTV
Impact



*courtesy, McKague et al.
** courtesy, D. Draper

1

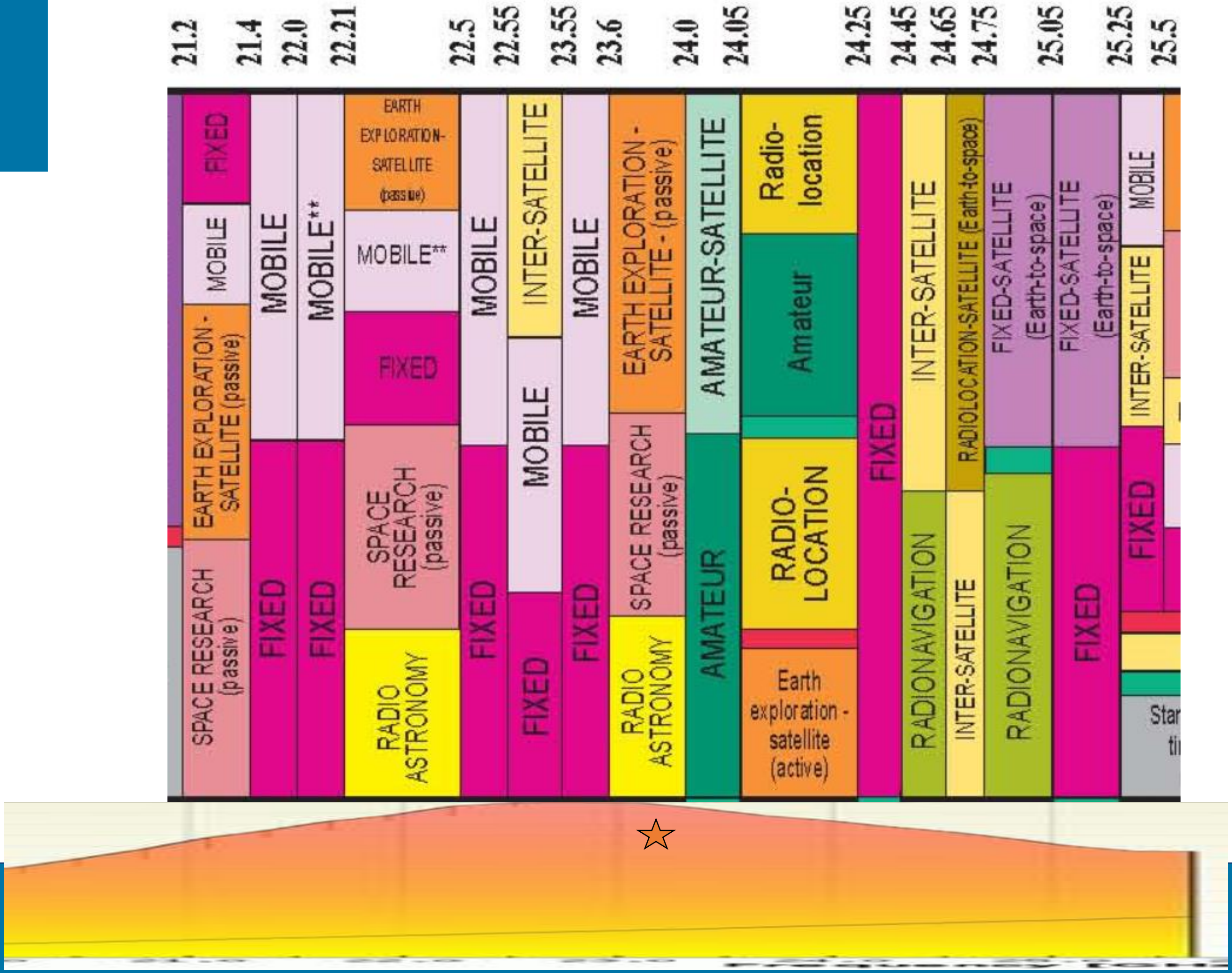
Reflections from DTV satellites can effectively blind microwave radiometers. Source: AMS meeting panel discussion, "The Wizard Behind the Curtain?—The Important, Diverse, and Often Hidden Role of Spectrum Allocation for Current and Future Environmental Satellites and Water, Weather, and Climate"



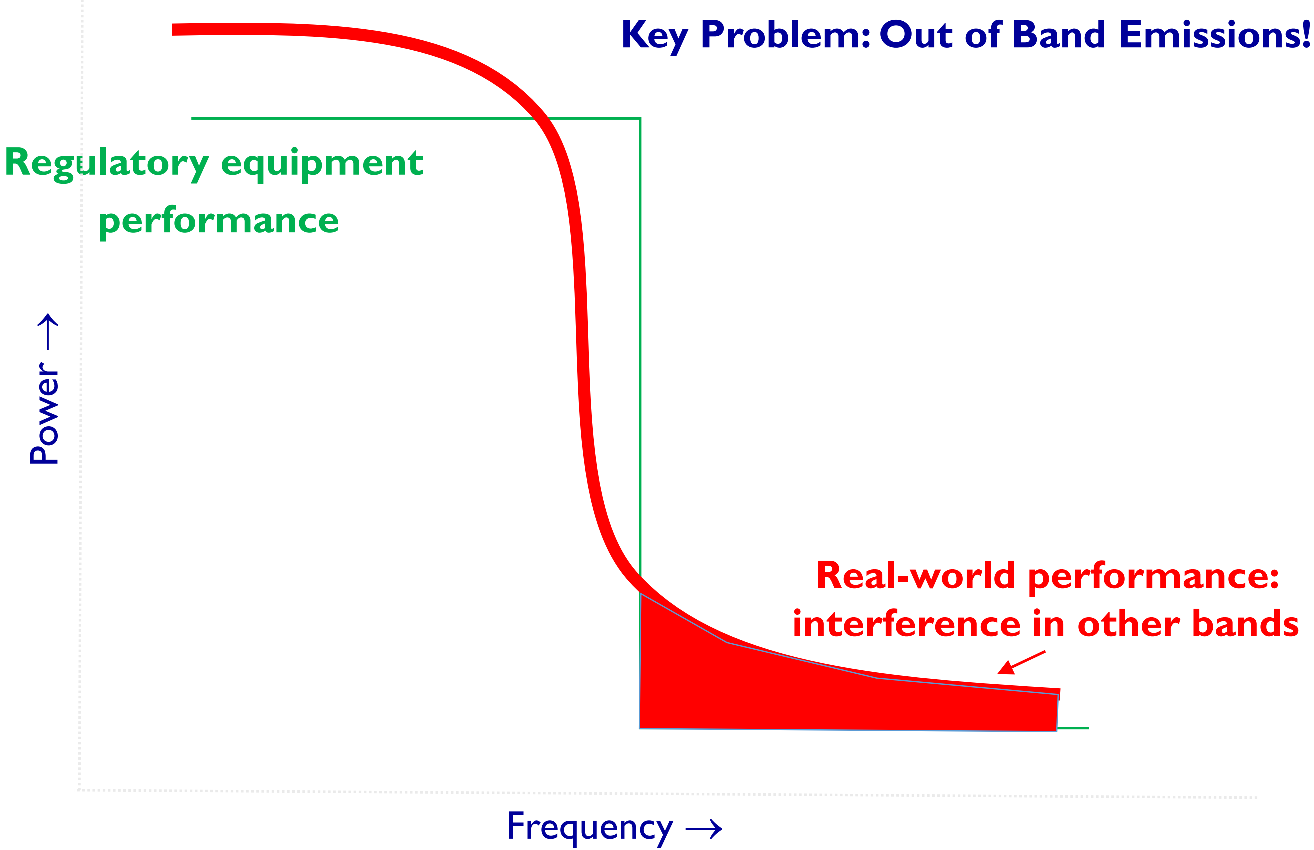
Recent FCC 5G allocation – 24 GHz

Water Observations at 23.8 GHz

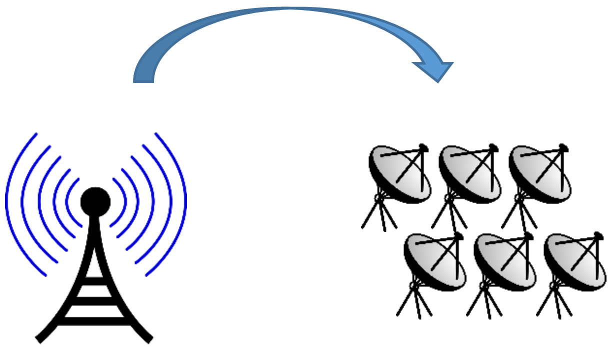
Used by Earth-sensing satellites to detect water in Earth's atmosphere: critical for weather predictions


21.2
21.4
22.0
22.21
22.5
22.55
23.55
23.6
24.0
24.05
24.25
24.45
24.65
24.75
25.05
25.25
25.5
FIXED
MOBILE
EARTH EXPLORATION - SATELLITE (passive)
SPACE RESEARCH (passive)
MOBILE
FIXED
MOBILE**
FIXED
EARTH EXPLORATION-SATELLITE (passive)
MOBILE**
FIXED
SPACE RESEARCH (passive)
RADIO ASTRONOMY
MOBILE
FIXED
INTER-SATELLITE
MOBILE
FIXED
MOBILE
FIXED
EARTH EXPLORATION - SATELLITE - (passive)
SPACE RESEARCH (passive)
RADIO ASTRONOMY
AMATEUR-SATELLITE
AMATEUR
Radio-location
Amateur
RADIO-LOCATION
Earth exploration - satellite (active)
FIXED
INTER-SATELLITE
RADIONAVIGATION
RADIOLOCATION-SATELLITE (Earth-to-space)
INTER-SATELLITE
FIXED-SATELLITE (Earth-to-space)
RADIONAVIGATION
FIXED-SATELLITE (Earth-to-space)
FIXED
MOBILE
INTER-SATELLITE
FIXED

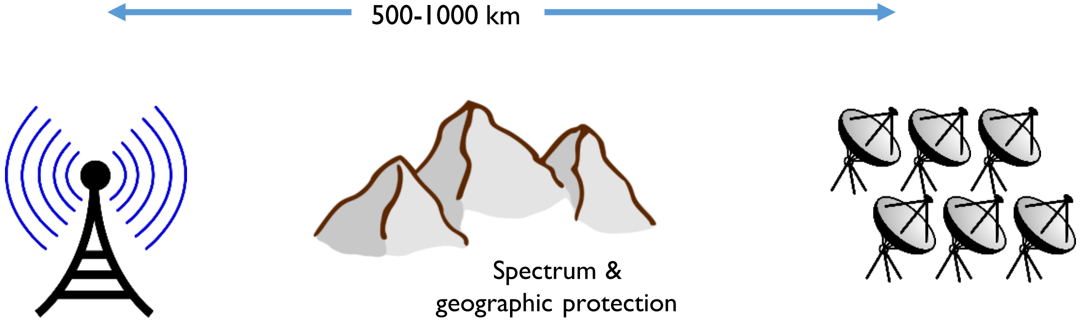
Key Problem: Out of Band Emissions!

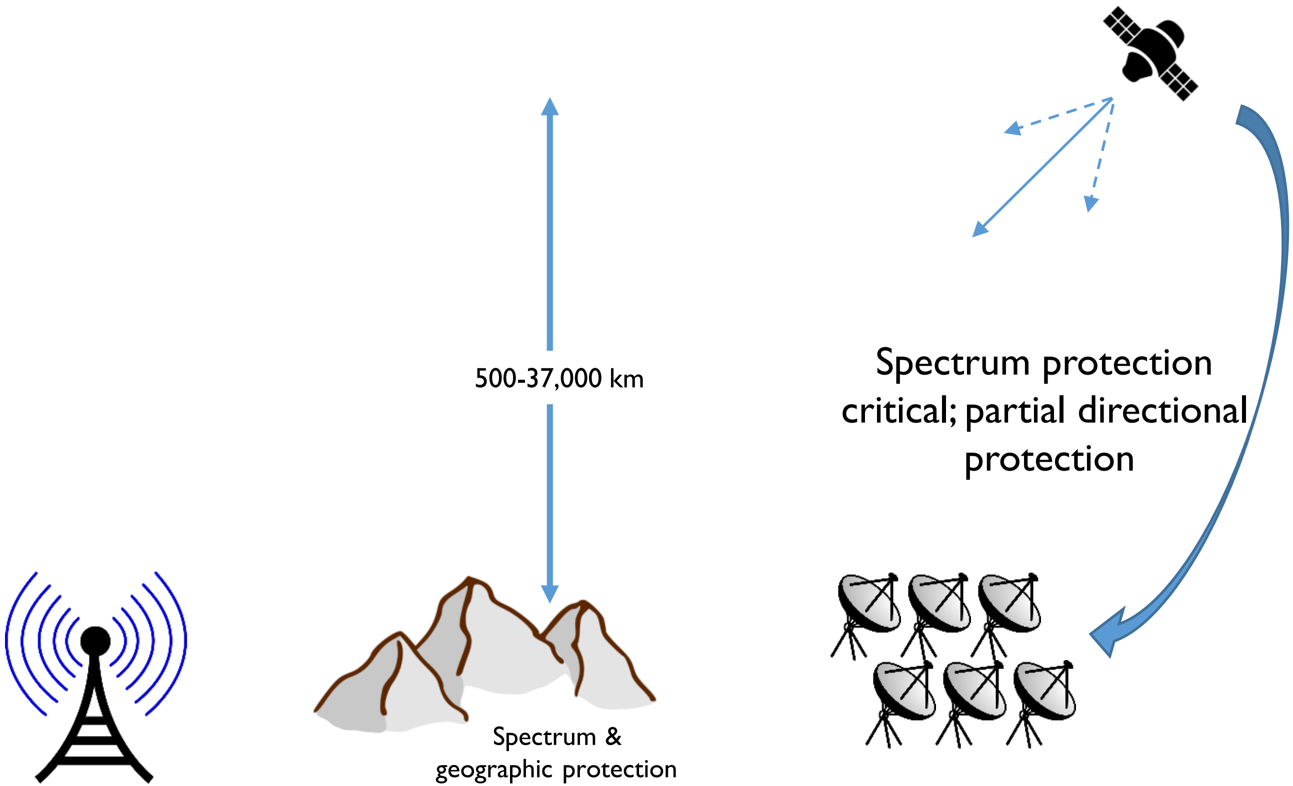


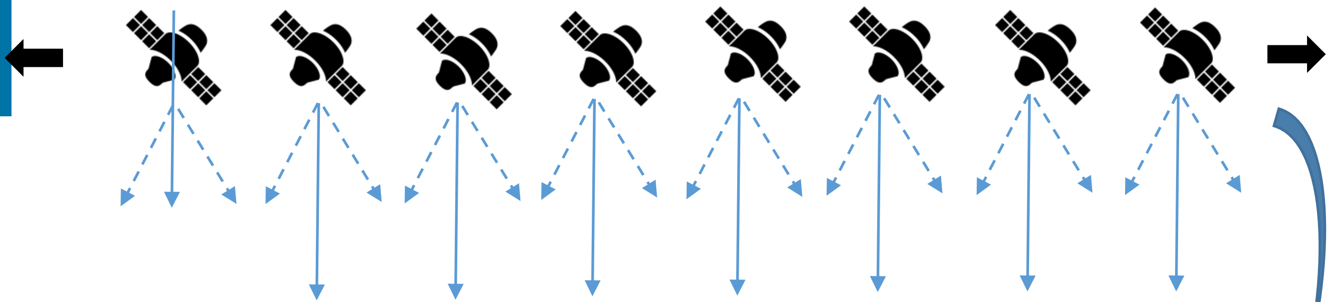
Spectrum protection critical



10-100s km

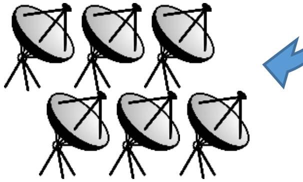

500-1000 km
Spectrum &
geographic protection


500-37,000 km
Spectrum protection critical; partial directional protection
Spectrum &
geographic protection

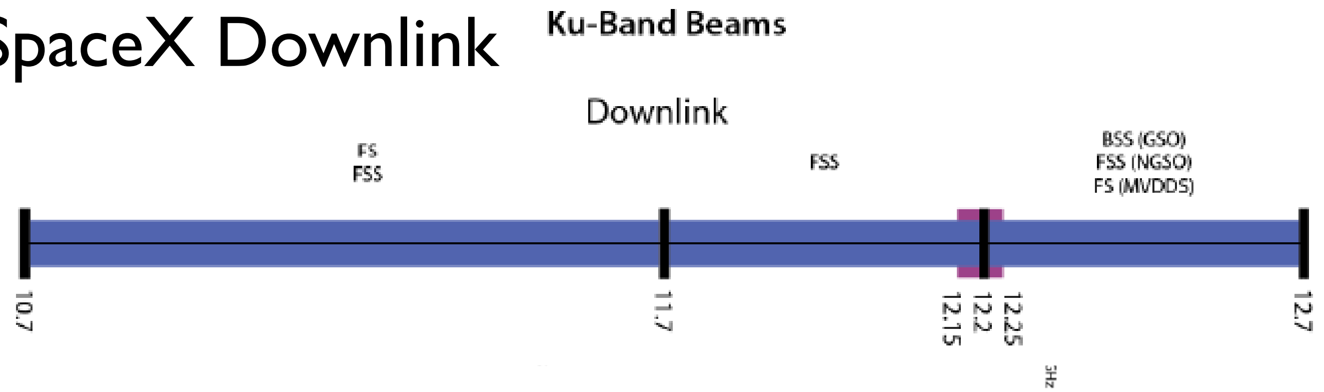


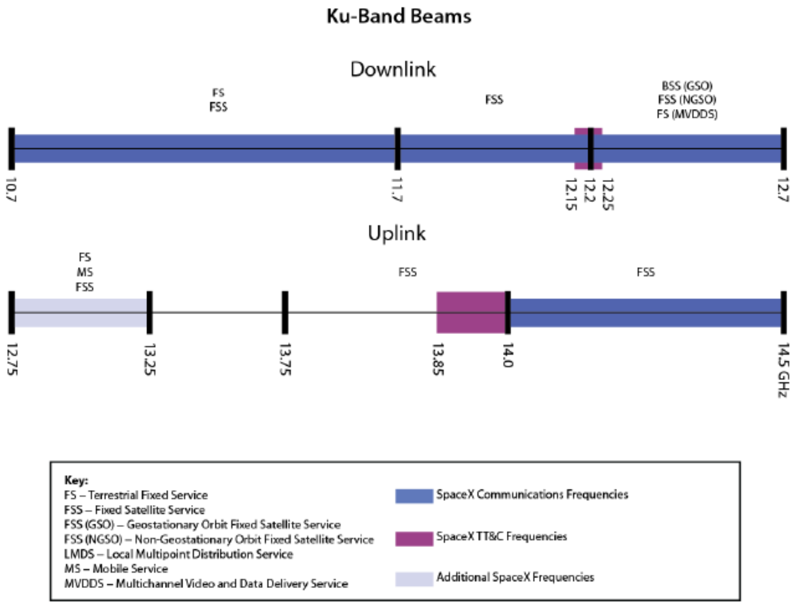
Spectrum protection MORE
critical given loss of directional filtering
spatial summation
in sidelobes is complex & variable

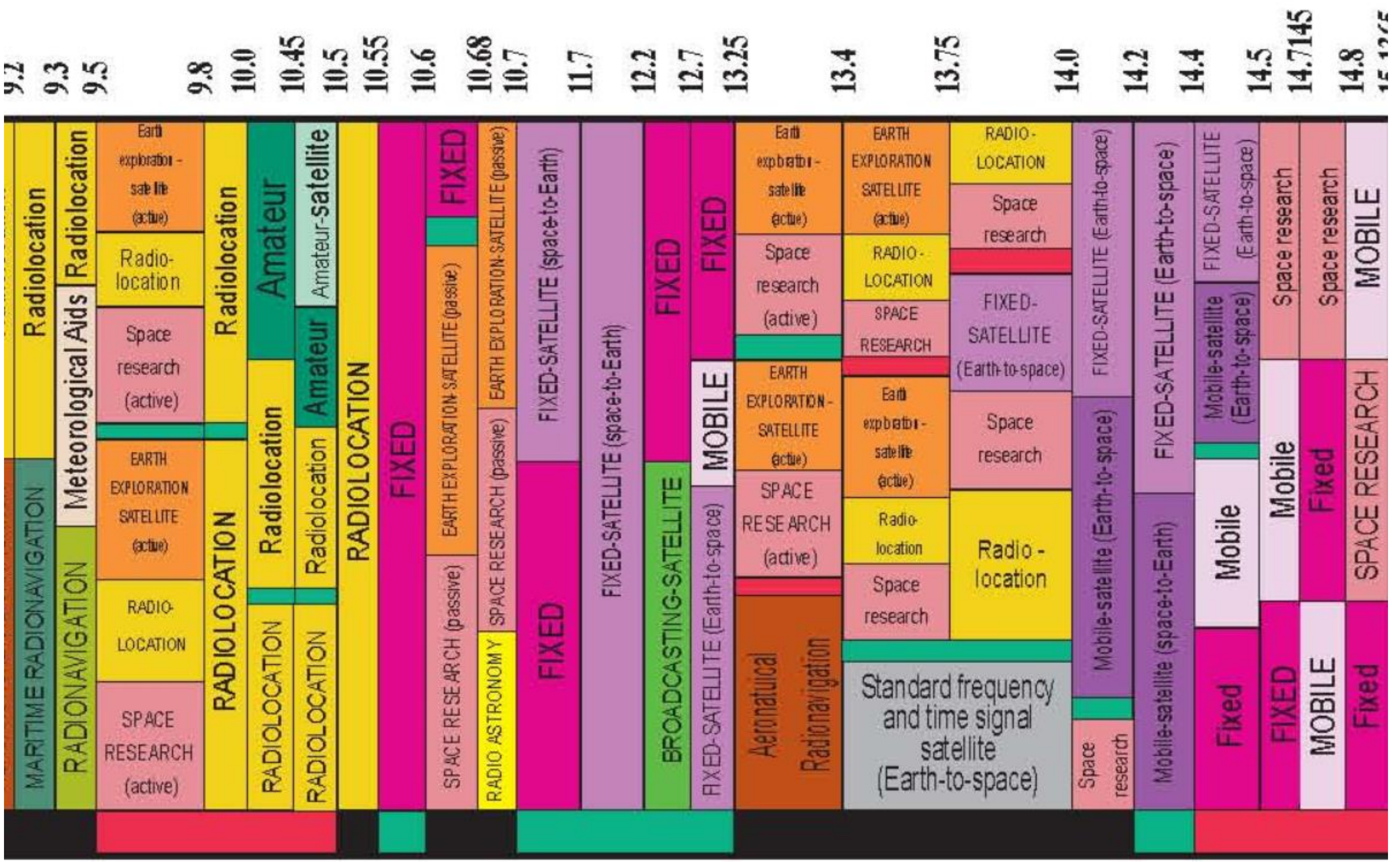
Spectrum &
geographic protection

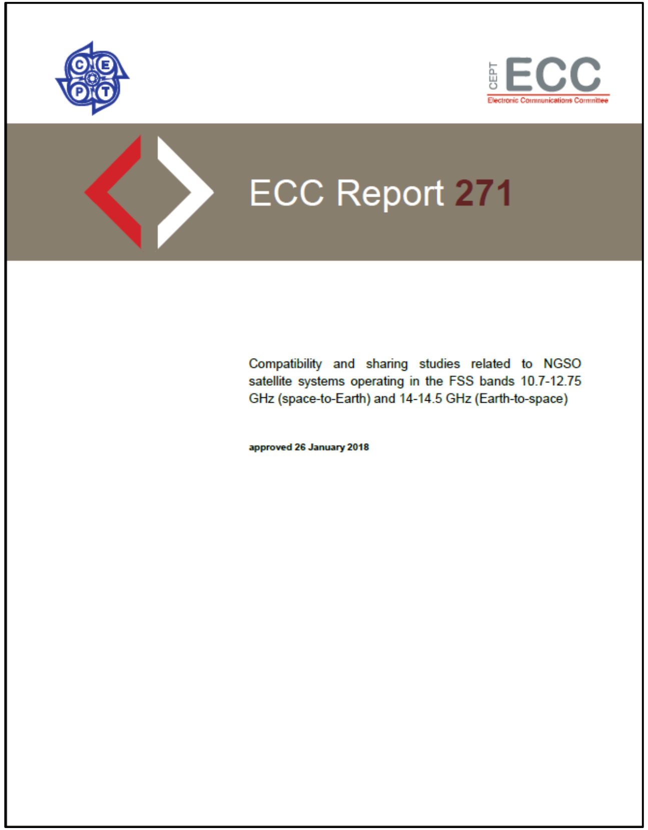


SpaceX Downlink






9.2
9.3
9.5
9.8
10.0
10.45
10.5
10.55
10.6
10.68
10.7
11.7
12.2
12.7
13.25
13.4
13.75
14.0
14.2
14.4
14.5
14.7145
14.8
Radiolocation
MARITIME RADIONAVIGATION
Radiolocation
Meteorological Aids
RADIONAVIGATION
Earth exploration - satellite (active)
Radio-location
Space research (active)
EARTH EXPLORATION SATELLITE (active)
RADIO-LOCATION
SPACE RESEARCH (active)
Radiolocation
RADIOLOCATION
Amateur
Radiolocation
RADIOLOCATION
Amateur-Satellite
Amateur
Radiolocation
RADIOLOCATION
RADIOLOCATION
FIXED
FIXED
EARTH EXPLORATION-SATELLITE (passive)
SPACE RESEARCH (passive)
EARTH EXPLORATION-SATELLITE (passive)
SPACE RESEARCH (passive)
RADIO ASTRONOMY
FIXED-SATELLITE (space-to-Earth)
FIXED
FIXED-SATELLITE (space-to-Earth)
FIXED
BROADCASTING-SATELLITE
FIXED
MOBILE
FIXED-SATELLITE (Earth-to-space)
Earth exploration - satellite (active)
Space research (active)
EARTH EXPLORATION - SATELLITE (active)
SPACE RESEARCH (active)
Aeronautical Radionavigation
EARTH EXPLORATION SATELLITE (active)
RADIO-LOCATION
SPACE RESEARCH
Earth exploration - satellite (active)
Radio-location
Space research
RADIO-LOCATION
Space research
FIXED-SATELLITE (Earth-to-space)
Space research
Radio-location
Standard frequency and time signal satellite (Earth-to-space)
FIXED-SATELLITE (Earth-to-space)
Mobile-satellite (Earth-to-space)
Space research
FIXED-SATELLITE (Earth-to-space)
Mobile-satellite (space-to-Earth)
FIXED-SATELLITE (Earth-to-space)
Mobile-satellite (Earth-to-space)
Mobile
Fixed
Space research
Mobile
FIXED
Space research
Fixed
MOBILE
MOBILE
SPACE RESEARCH
Fixed

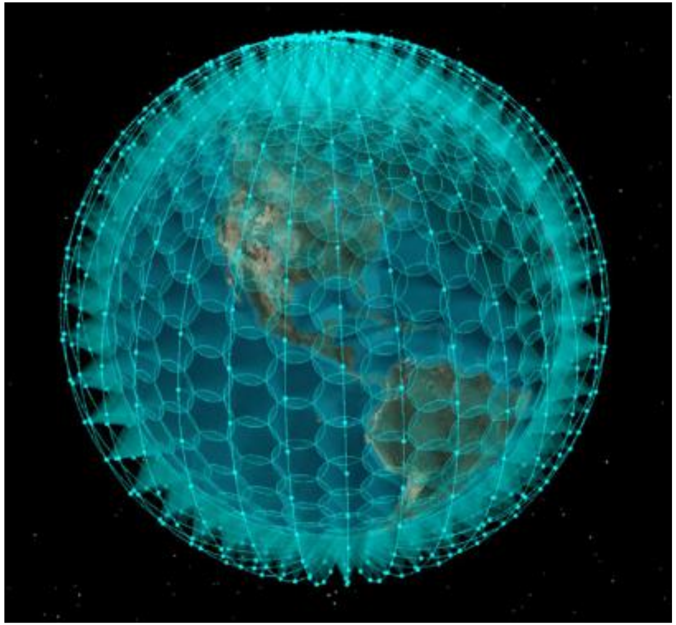


CEPT ECC
Electronic Communications Committee

ECC Report 271

Compatibility and sharing studies related to NGSO satellite systems operating in the FSS bands 10.7-12.75 GHz (space-to-Earth) and 14-14.5 GHz (Earth-to-space)

approved 26 January 2018



Solutions

- Sophisticated quantitative discussion of problems, impacts.
- Policy strength: domestic & international planning & accountability – ITU, FCC
- Place high priority on the critical needs of scientific spectrum passive users – astronomy, weather, Earth observation, etc. Reinforce roles of NSF, CORF, Congress in this situation.
- We must consider new paradigms –
  - Dynamic spectrum allocation
  - Spectrum sharing
  - Zone/regional exclusions e.g. NSF/DoD National Radio Dynamic zone proposal
- Needed: investment in new tech at all levels (companies thru Congress).

ngVLA

- Interferometers – natural fringe rate assistance, separate environments.
- Hardware & algorithmic approaches to mitigating RFI – modest attention over two decades.
- ngVLA – receivers (saturation), # bits, correlator blanking, imaging algorithms – active areas of consideration.
- SpaceX – NRAO Fellow – investigate SpaceX impacts on NRAO/ngVLA, identify promising research areas.
- NGSOs – negotiation & Congressional action – restrict ngVLA core, other keys sites ↔ remove restrictions in urban areas.
- 5G – more directional, less critical in rural regions? 4G max.

- NRAO-led inter-Observatory telecon last summer – US, SKA
- NRAO – Advanced Spectrum Research Division /CDL
- NSF – proposing Dynamic Radio Quiet Zone – NM

- This is a special moment in history… need to find a mutual win.
- Significant opportunities and threats visible.

ngvla

Next Generation Very Large Array