GRSS FARS Technical Committee

Annual Meeting

14 July 2009
IGARSS
Cape Town, South Africa

Shannon Brown
Chair, GRSS-FARS

New Chair

Shannon Brown

Affiliation:

Jet Propulsion Laboratory, USA

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818-393-0773

Agenda

- Overview of FARS committee
- Co-chair Nominations (term through Oct 2011)
- Special topics:
  - ⇨ High-power transmitters at 57-64 GHz
  - ⇨ Applications at 275-3000 GHz
- Other related activity updates
  - ⇨ NRC Spectrum Survey Panel
- Old/New Business:
  - ⇨ Support letter for AMS RFI statement
  - ⇨ Position statement on RFI technology development (IFT collaboration)
  - ⇨ Inclusion of filter response in frequency allocations
  - ⇨ Information on RFI observations or future RFI campaigns
  - ⇨ Recommendations for FARS focus
  - ⇨ Possible special section in TGRS on RFI studies/mitigation?
  - ⇨ Other business

FARS website: http://www.ece.osu.edu/~johnson/fars/
Website will be moving to GRSS site soon.

Frequency Allocation for Remote Sensing (FARS) Technical Committee

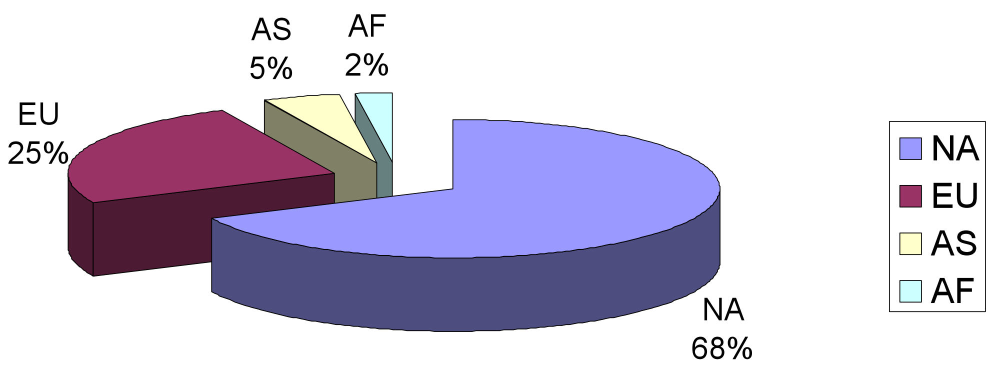
- Objectives
  - ⇨ ***Interface between GRSS and the frequency regulatory process***
    - ❑ Help to educate membership on frequency regulatory process
    - ❑ Gather and distribute information on current frequency management issues to membership
    - ❑ Organize GRSS efforts to impact regulatory process as appropriate
  - ⇨ ***Coordinate and advocate GRSS technical input to regulatory organizations and working parties***
    - ❑ Standardization of methods applied to analyses
    - ❑ ITU-R RS 577, 1166, 1028, 1029
    - ❑ Respond to requests for sensor and user information
    - ❑ Investigation of RF interference and mitigation

Membership

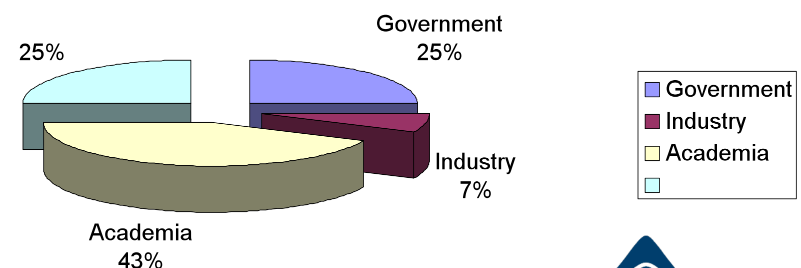
New members are welcome, you are encouraged to recruit/ spread the word! Interested parties (must be GRSS members) contact Shannon.T.Brown@jpl.nasa.gov

- June 2008
  - ⇨ 56 Members; 10 Countries

FARS Membership by Continent



FARS Membership by Organization



Other: Non Profit, FFRDC (LL, JPL, Aero)

Officer Status

- According to GRSS rules, technical committee officers serve a two year term (max two terms)
- Basic responsibilities (split among officers) include
  - ⇨ Preparing (and presenting if available) short reports for 3 GRSS Adcom meetings/year
  - ⇨ Attend/present at the IGARSS Technical committees dinner
  - ⇨ Organize annual IGARSS FARS session
  - ⇨ Maintain membership list and website
  - ⇨ Defining and implementing any other agenda for FARS
- Chair elected by membership, co-chair appointed by chair
- Current terms through Oct 11
- No current co-chair (thanks to J. Johnson for assistance)
- Seeking co-chair nominations, self nominations welcome

FARS Officer History

Year	Officers
2000-01	Ram Narayanan
2001-02	Ram Narayanan, Chris Ruf
2002-03	Chris Ruf, Ram Narayanan
2003-04	David Kunkee, David DeBoer
2004-05	David Kunkee,David DeBoer
2005-06	Joel Johnson, David Kunkee
2006-07	Joel Johnson, David Kunkee
2007-08	Joel Johnson,-
2008-09	Joel Johnson, Shannon Brown
2009-10	Shannon Brown, ?
20010-11	Shannon Brown, ?

57-64 GHz Studies

- **Assessing impact of 57-64 GHz plans (IEEE 802.15.3)**
  - ⇨ **No impact from lower power "personal network" devices**
- **Remaining issue: Another standard exists with higher EIRP limits**
  - ⇨ **Not part of 802.15.3 standard but rather under WCAI**
  - ⇨ **Should we continue investigation**

Systems using these bands

- **Advanced Microwave Sounding Unit-A (AMSU-A)**
  - 26 frequency bands from 56.9 to 57.7 GHz, bandwidths 3 to 330 MHz
  - Cross-track scan, scanning ±48.3° from nadir
  - Nadiral spot diameter= 48 km
  - Multiple AMSU’s currently in orbit, more planned for the future
- **SSMI/S**
  - Conical scanning multi-freq radiometer observing at 53.1 deg incidence
  - Channels 57.1-57.5 and 63-63.6 GHz, as well as several near 60 GHz
  - Lower overall attenuation @ 63 GHz could be an issue
  - Main beam attenuation in dB 66.6% larger than nadiral, minimal nadiral sidelobes
- **Future instruments:**
  - ATMS: Similar to AMSU in most aspects
  - MIS

ITU Frequency Allocations 57-64 GHz

- **57.000 - 58.200 EARTH EXPLORATION-SATELLITE (passive)**
  FIXED
  INTER-SATELLITE
  MOBILE
  SPACE RESEARCH (passive) 5.547 5.556A 5.557 5.558
- **58.200 - 59.000 EARTH EXPLORATION-SATELLITE (passive)**
  FIXED
  MOBILE
  SPACE RESEARCH (passive) 5.547 5.556
- **59.000 - 59.300 EARTH EXPLORATION-SATELLITE (passive)**
  FIXED
  INTER-SATELLITE
  MOBILE
  RADIOLOCATION
  SPACE RESEARCH (passive) 5.556A 5.558 5.559
- **59.300 - 64.000 FIXED**
  INTER-SATELLITE
  MOBILE
  RADIOLOCATION 5.138 5.558 5.559▲

- **No relevant footnotes**

Does your application use frequencies > 275 GHz?

- No regulation above 275 GHz, but currently a topic at SFCG
- Input requested from FARS members that use this portion of the spectrum

SFCG-30

- **FARS should provide GRSS representation at Space Frequency Coordinating Group meeting (SFCG-28)**
  - ⇨ July 2010, Austrailia
  - ⇨ Details TBD

  - ⇨ FARS should be represented
    - ❑ travel expenses paid by GRSS
    - ❑ Contact FARS chair if interested

What is the SFCG?

The SFCG is an **informal** group comprised of the major civil space agencies and related national and international scientific organizations

Its main objectives are:

- Working level coordination of int'l RF spectrum usage among the science services
- Agreements that optimise the use of the allocated bands
- Identify long-term potential changes to int'l regulations (ITU-R, WRC, other)
  - Remote sensing is only one (important) element of the SFCG activity
  - Remote sensing other than from satellites is not within the SFCG scope

- Group meets ~ annually; each meeting hosted by a member agency
  - Action Items: to be completed for next SFCG meeting
  - Resolutions: express action for SFCG members
  - Recommendations: express action, to be pursued by SFCG members outside the group, e.g. within member agencies and administrations

- SFCG web site: http://sfcgonline.org

SFCG and Remote Sensing

- Previous achievements:
  - World-wide agreement on revision of the EESS (passive) allocations in the 50-60 GHz range (WRC-97)
  - World-wide agreement on revision of passive allocations above 71 GHz (WRC-2000)
  - Global revision of satellite passive sensor protection criteria resulting in revision of corresponding ITU-R Recommendations (2002)
  - Agreement on the mechanisms to coordinate cloud radar missions at 94 GHz with radio astronomy operations
- Current activities:
  - “Standing agenda item” on EESS, MetSat, and disaster management issues
  - Action Item 26/4 to “Update/Revise EESS Passive Band Requirements” contained in Resolution 21-2R2, especially the requirements for 275-3000 GHz
  - Intersessional Working Group on remote sensing for disaster management

Current Remote Sensing Resolutions and Recommendations

- RES 5-9R1 “Protection of Frequency Bands Allocated to Passive Sensing and Radio Astronomy” (2001)
- RES 19-6R1 “EESS Active Sensing Requirements > 100 GHz” (2000)
- RES 21-2R2 “Requirements, Performance, and Protection Criteria for EESS (Passive) Sensors” (2004)
- RES 21-3R2 “Protection of EESS (Passive) Sensors from Ultra Wideband Device Emissions” (2005)
- RES 23-2 “Use of Synthetic Aperture Radars in the Band 5250-5570 MHz” (2003)
- RES 23-3 “Use of the Allocation for EESS (active) in the Band 432-438 MHz” (2003)
- RES 24-2 “Use of the allocation for EESS (active) in the band 94-94.1 GHz” (2004)
- REC 18-1 “Use of the Bands 31.3–31.8 GHz and 36-37 GHz for EESS passive Sensing” (1999)
- REC 24-2 “Frequency assignment guidelines for active remote sensing in the Mars region” (2004)

Other Activities

- **FARS members participating (and co-chairing) in a US National Research Council (NRC) panel on "A survey of scientific uses of the radio spectrum"**
  - ⇨ Goal is to provide a document that will influence US policy makers
  - ⇨ Panel includes both Earth sensing and radio astronomy researchers
  - ⇨ 6/18 panel members are FARS members
  - ⇨ **We should be considering an endorsement of the final report by either IEEE GRSS or IEEE?**

- **Spectrum study expected to have recommendation for technology development**
  - ⇨ **We should develop FARS position statement/white paper on needed technology for RFI mitigation**
  - ⇨ **Coordinate with IFT radiometer working group**

Inclusion of Frequency Response

- Microwave filters are not box-cars like the allocations
- “legal” emissions often observed by radiometers in protected bands
  - ⇨ Example: Advanced Microwave Radiometer
    - ❑ Sees 24 GHz transmission from Micro-Rain Radar
    - ❑ AMR operates in 23.8 GHz protected band
- Should we consider drafting a statement to incorporate emission levels at band edges consistent with typical radiometer filter response?

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AMS Statement

- Should we provide support letter for AMS statement on protecting frequency allocations for passive sensing?
- Do we have any changes to statement?
- Provide feedback prior to July 18th.
- http://www.ametsoc.org/policy/draftstatements/
- Link to the statement itself:
  - http://www.ametsoc.org/policy/draftstatements/radiofreq_allocations_draftstatement.pdf

First Paragraph from AMS statement

"The AMS expresses concern over increasing pressure on weather-related radio frequency bands and stresses the need for adequate protection and mitigation efforts against the loss and shared use of this spectrum. The AMS addresses its concern to policy makers, to national radio-frequency administration agencies, and to the meteorological community. Protection of traditional weather-related radio frequencies is critical to the continued function and improvement of weather sensing, monitoring, forecasting, and warning, and is therefore in the best interests of public safety and security. The meteorological community increasingly relies on remote-sensing technologies for both routine and experimental observations of weather and climate. These activities require global access to radio frequency spectrum by radars, wind profilers, microwave radiometers, and telemetry systems, as well as satellite-based passive and active sensors. The impressive progress in meteorological predictions made in recent years is largely attributable to these technologies…"

FARS Focus

- What direction should we take FARS?
- If the status-quo working?
- Input requested from members

Spectrum Study Membership

Members

- Marshall Cohen, co-chair, Caltech
- Albin Gasiewki, co-chair, U. Colorado
- Donald Backer, UC-Berkeley
- Roberta Balstad, Columbia
- Steven Ellingson, Virginia Tech
- Darrel Emerson, NRAO
- Aaron Evans, Stonybrook University
- Joel Johnson, Ohio State
- Paul Kolodzy, Kolodzy Consulting
- David Kunkee, Aerospace Corp.
- Molly Macauley, Resources for the Future
- James Moran, Harvard-Smithsonian CfA
- Lee Mundy, U. Maryland
- Timothy Pearson, Caltech
- Christopher Ruf, U. Michigan
- Alan Tanner, JPL
- Frederick Solheim, Radiometrics Corp.
- David Staelin, MIT

● = remote sensing
● = radio astronomy
● = policy

Staff: Brian Dewhurst and David Lang, BPA

Backup

57-64 GHz Studies

- **Assessing impact of 57-64 GHz plans (IEEE 802.15.3)**
  - **There is an IEEE standards committee (802.15.3) currently developing wideband (i.e. ~2 GHz) comm links with 57-64 GHz one targeted band**
  - **Numerous articles have been written on this (Spectrum, Feb 08 for example), but no mention is ever made of passive sensing**
  - **Letter to the editor in IEEE Spectrum (April 08) published on this issue**
  - **Report on this issue published in GRSS Newsletter (June 08)**
- **Assessment activities**
  - **Contacts with 802 committee identified "coexistence" group 802.19 as appropriate forum for discussion**
  - **Three telecons held with 802.19 committee to discuss, also reported by 802.15.3 officers at their recent meeting in Orlando**
  - **Analysis led by FARS chair incorporating information from 802.15.3 suggests that remote sensing impact is negligible even with a high density of sources**
    - Primary potential impact was on AMSU-A instrument, nadiral observations
    - High atmospheric attenuation coupled with likely low antenna gain of sources in zenith direction shows that interference >0.01 K for AMSU is unlikely
- **Remaining issue: Another standard exists with higher EIRP limits**
  - **Not part of 802.15.3 standard but rather under WCAI**
  - **Currently investigating**

ITU RS.1029-2

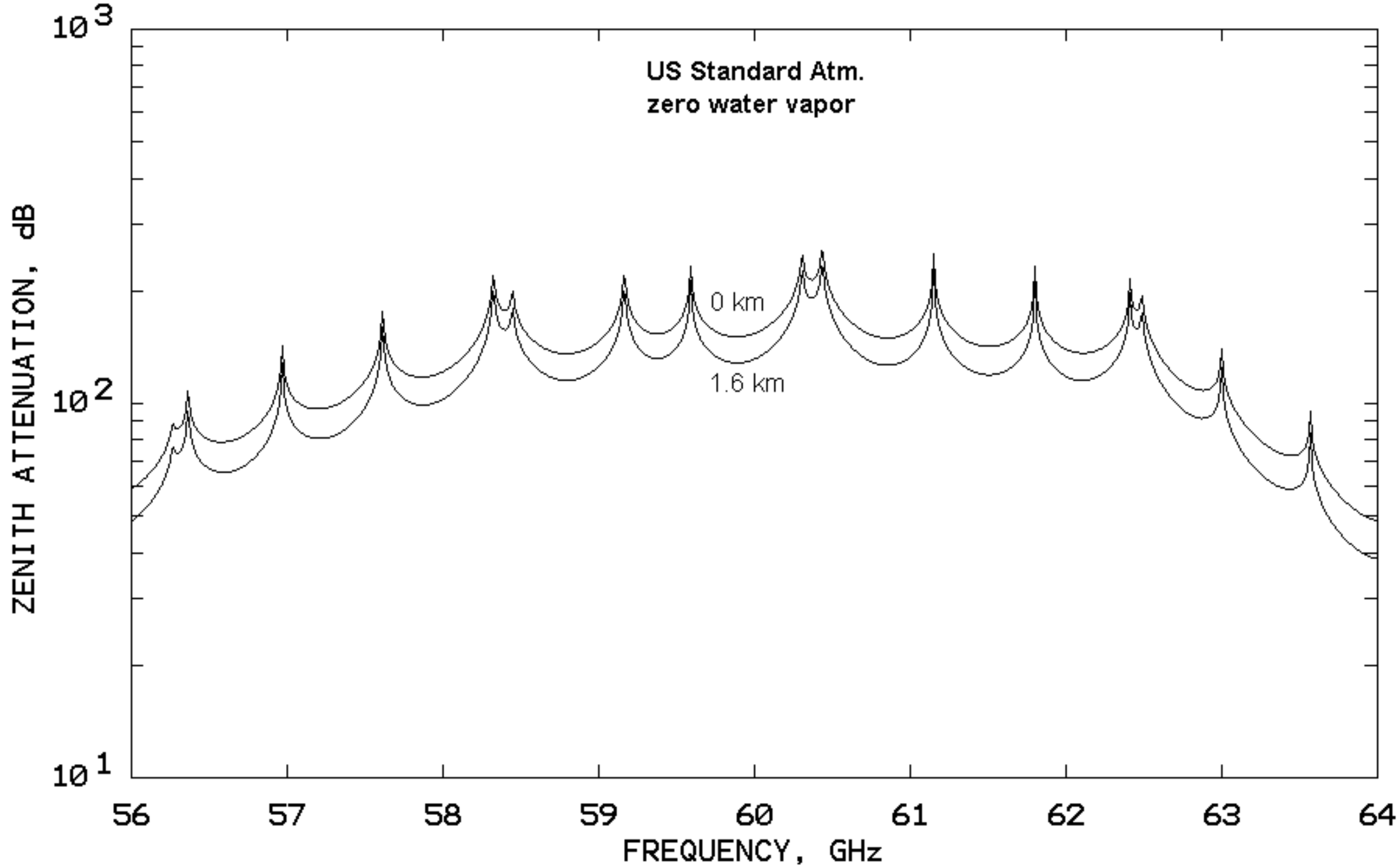
- ITU recommendation RS.1029-2 also addresses the EESS service from 57-59.3 GHz
  - Sets a received power limit of -169 dBw not to be exceeded either 0.01% of the time or area
  - this is 0.01K in a 100 MHz radiometer bandwidth

Frequency band(s)[1] (GHz)	Total bandwidth required (MHz)	Reference bandwidth (MHz)	Maximum interference level (dBW)	Percentage of area or time permissible interference level may be exceeded[2] (%)	Scan mode (N, L)[3]
52.6-54.25P, 54.25-59.3p	6 700[5]	100	–161/–169[4]	0.01	N

- Scan mode: N=Nadiral, L=Limb

Zenith Atmospheric Attenuation

- Compute using ITU P676-7 algorithms:



Comments on Zenith Attenuation

- For sea level transmitters, minimum is around 95 dB @ 57.3 GHz (even lower at 64 GHz)
- Transmitters at higher elevations (e.g. Denver) have minimum around 80 dB
- No accounting here for through wall attenuation etc.
- Is there any possibility of transmitters at higher altitudes (i.e. airborne?)
- Results also depend weakly on atmospheric conditions, ITU separates into different climate regions

Co-Existence Analysis

- Used Friis formula as starting point for received power Pr:

$$P_R = \frac{P_T G_T}{4\pi R^2} A_{eff} e^{-\tau} \qquad A_{eff} = \frac{\lambda^2 G_R}{4\pi} \approx \frac{\lambda^2}{4\pi}\left(\frac{\pi}{\Delta\theta}\right)^2 \qquad A \approx \pi/_4 (R\Delta\theta)^2$$

- Requires knowledge of:
  - transmitted power (Pt), antenna gain of transmitter in direction of radiometer (Gt), [radiometer antenna effective area (Aeff) in direction of transmitter, Range to radiometer (R)], atmospheric attenuation (exp(-tau))
- Recast for brightness perturbation given transmit/radiometer bandwidth BT/BR and number of sources N in footprint of area A; k is Boltzmann's constant

$$EIRP \frac{N}{A}\left(\frac{B_R}{B_T}\right)\frac{G_T(0^0)}{G_T} = \frac{kB_R \delta T e^{\tau}}{\lambda^2}\left(\frac{64}{\pi}\right)$$

Plugging in numbers for low-power system

- Rewrite in terms of the number of sources per square kilometer N’ and get rid of constants:

$$B_{T,MHz}\delta T_{mK} = N'(EIRP)_W \left(\frac{G_T(0^0)}{G_T}\right)(10^8 e^{-\tau})$$

- Conservative estimate of rightmost factor is unity
- Left-hand side conservative estimate is 2000 MHz * 10 mK=20000
- EIRP for 802.15.3 systems is 42 dBm=16 W
- We’re left with

$$N'\left(\frac{G_T(0^0)}{G_T}\right) > 1250$$

being a problem, or for an AMSU sized footprint (~1810 sq-km) we have

$$N\left(\frac{G_T(0^0)}{G_T}\right) > 2{,}260{,}000$$

Low power system interpretation

- High spatial densities are envisioned for these systems:
  - Wireless link betwn DVD player and TV screen, “personal network”, etc.
  - N’ may be large, esp. in urban areas (but at high elevations in analysis)
- Directive antennas are planned, incl phased arrays
  - Cheap consumer devices so antenna quality not completely known
  - 802.15.3 mostly envisioned as operating inside of buildings, standard has a 42 dBm EIRP limit
    - Attenuation through walls also a factor, estimated at > 10 dB
  - Antennas mostly horizontally directed
    - May orient pattern in some cases to “bounce” signals off ceiling of a room
    - However unlikely to have all antennas in a large spot all directed

Plugging in numbers for high power system

- Rewrite in terms of the number of sources per square kilometer N' and get rid of constants:

$$B_{T,MHz}\delta T_{mK} = N'(EIRP)_W \left(\frac{G_T(0^0)}{G_T} \right)(10^8 e^{-\tau})$$

- Conservative estimate of rightmost factor is unity
- Left-hand side conservative estimate is 2000 MHz?? * 10 mK=20000
- EIRP for WCAI systems is 82 dBm=158 kW
- We're left with

$$N' \left(\frac{G_T(0^0)}{G_T} \right) > 0.125$$

being a problem, or for an AMSU sized footprint (~1810 sq-km) we have

$$N \left(\frac{G_T(0^0)}{G_T} \right) > 226$$

High power system interpretation

- Spatial densities envisioned for these systems unclear
  - Maximum of 1000 in a large city?
    - Source: Doug Lockie of WCAI MMwave committee
- Information on power spectral density (i.e. bandwidth) of source transmissions also important
- Directive antennas are planned
  - Consumer devices so antenna quality not completely known
  - Seems that these systems are mostly planned for outdoor links
  - Antennas mostly horizontally directed

Final Summary

- It appears that AMSU impact is unlikely by indoor "personal network" systems planned under 802.15.3
  - Due to 42 dBm EIRP limit, expected directed antennas, primary indoor operation
  - No further telecons planned with 802.15.3 group
- Need more information to assess plans by WCAI for systems using EIRP=82dBm
  - Maybe more of an issue here, although antennas will be more directive, but planned for outdoor use
  - Currently pursuing this issue
- Your participation welcomed!

FARS and SFCG-28

- Chair examined SFCG Resolutions, mostly on very specific items and generally consistent with protection of remote sensing
- Discussion: focus on 21-2R2 as it is up for discussion at SFCG-28
  - ⇨ Basically a table similar to those of the ITU RS.1029
  - ⇨ Specify dT in a given "reference bandwidth"
  - ⇨ Also a "data availability" threshold
  - ⇨ Our chance to provide input into future changes in RS 1029?
  - ⇨ Is your favorite frequency band included appropriately?

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Frequency Band[6] (GHz)	Total BW required (MHz)	Reference BW (MHz)		Required ΔT_e (K)	Data availability (%)[3]	Scan Mode N, L[4]
1.370-1.400s, 1.400-1.427P	100	27		0.05	99.9	N
2.640-2.655s, 2.655-2.690s, 2.690-2.700P	45	10		0.1	99.9	N
4.200-4.400s, 4.950-4.990s	200	200		0.3/0.05*	99.9	N
6.425-7.250	200	200		0.3/0.05*	99.9	N
10.60-10.68p, 10.68-10.70P	100	100		1.0/0.1*	99.9	N
15.200-15.350s, 15.350-15.400P	200	50		0.1	99.9	N
18.600-18.800p	200	200		1.0/0.1*	95/99.9*	N
21.200-21.400p	200	100		0.2/0.05*	99/99.9*	N
22.210-22.500p	300	100		0.4/0.05*	99/99.9*	N

Frequency Band[6] (GHz)	Total BW required (MHz)	Reference BW (MHz)		Required ΔT_e (K)	Data availability (%)[3]	Scan Mode N, L[4]
23.600-24.000P	400	200		0.05	99.99	N
31.30-31.50P, 31.50-31.80p	500	200		0.2/0.05*	99.99	N
36.000-37.000p	1 000	100		1.0/0.1*	99.9	N
50.200-50.400P	200	200		0.05	99.99	N
52.60-54.25P, 54.25-59.30p	6 700[1]	100		0.3/0.05*	99.99	N
86.00-92.00P	6 000	100		0.05	99.99	N
100.0-102.0P	2 000	10		0.005	99	L
109.5-111.8P	2 000	10		0.005	99	L
114.25-116.00P	1 750	10		0.005	99	L
115.25-116.00P 116.00-122.25p	7000[1]	200/10[5]		0.05/0.005[5]	99.99/99[5]	N, L

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Frequency Band[6] (GHz)	Total BW required (MHz)	Reference BW (MHz)		Required ΔT_e (K)	Data availability (%)[3]	Scan Mode N, L[4]
148.5-151.5P	3 000	500/10[5] 200		0.1/0.005[5]	99.99/99[5]	N, L
155.5-158.5p[2]	3 000	200		0.1	99.99	N
164.0-167.0P	3 000[1]	200/10[5]		0.1/0.005[5]	99.99/99[5]	N, L
174.8-182.0p, 182.0-185.0P, 185.0-190.0p, 190.0-191.8P	17 000[1]	200/10[5]		0.1/0.005[5]	99.99/99[5]	N, L
200.0-209.0P	9 000[1]	3		0.005	99	L
226.0-231.5P	5 500	200/3[5]		0. 2/0.005[5]	99.99/99[5]	N, L
235.0-238.0p	3 000	3		0.005	99	L
250.0-252.0P	2 000	3		0.005	99	L
275.0-277.0	2 000[1]	3		0.005	99	L

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Frequency Band[6] (GHz)	Total BW require d (MHz)	Refere nce BW (MHz)		Required ΔT_e (K)	Data availability (%)[3]	Scan Mode N, L[4]
294.0-306.0	12 000[1]	200/3[5]		0.2/0.005[5]	99.99/99[5]	N, L
316.0-334.0	18 000[1]	200/3[5]		0.3/0.005[5]	99.99/99[5]	N, L
342.0-349.0	7 000[1]	200/3[5]		0.3/0.005[5]	99.99/99[5]	N, L
363.0-365.0	2 000	3		0.005	99	L
371.0-389.0	18 000[1]	200		0.3	99.99	N
416.0-434.0	18 000[1]	200		0.4	99.99	N
442.0-444.0	2 000[1]	200/3[5]		0.4/0.005[5]	99.99/99[5]	N, L
496.0-506.0	10 000[1]	200/3[5]		0.5/0.005[5]	99.99/99[5]	N, L
546.0-568.0	22 000[1]	200/3[5]		0.5/0.005[5]	99.99/99[5]	N, L

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Frequency Band(6) (GHz)	Total BW required (MHz)	Reference BW (MHz)		Required ΔT_e (K)	Data availability (%)3	Scan Mode N, L(4)
624.0-629.0	5 000(1)	3		0.005	99	L
634.0-654.0	20 000(1)	200/3(5)		0.5/0.005(5)	99.99/99(5)	N, L
659.0-661.0	2 000	3		0.005	99	L
684.0-692.0	8 000(1)	3		0.005	99	L
730.0-732.0	2 000(1)	3		0.005	99	L
851.0-853.0	2 000	3		0.005	99	L
951.0-956.0	5 000(1)	3		0.005	99	L