Radio Astronomy in a New Era of Satellite Radar

Harvey Liszt

NRAO Spectrum Manager (www.nrao.edu)

&

Chair, IUCAF (www.iucaf.org)

SCIENTIFIC COMMITTEE ON FREQUENCY ALLOCATIONS FOR RADIO ASTRONOMY AND SPACE SCIENCE

IUCAF

NRAO

AAS 235 Honolulu 8 January 2020 -Updated for Stellenbosch, March 2020

9.2-10.4 GHz Synthetic Aperture Radar

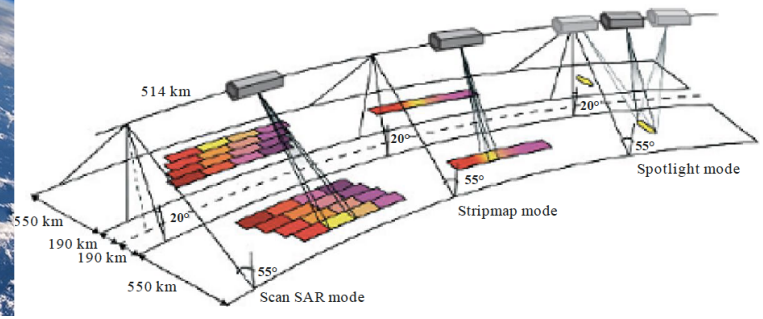
ICEYE
EVERY SQUARE METER,
EVERY HOUR

Commercial startups are launching fleets of dozens Space agencies had 1-2

CAPELLA SPACE CORPORATION
DENALI
VAFB - Falcon 9

SARS don't need operating licenses in the countries they image 5.474A

FIGURE 1
Modes of operations for SAR system in the 9 GHz EESS allocation

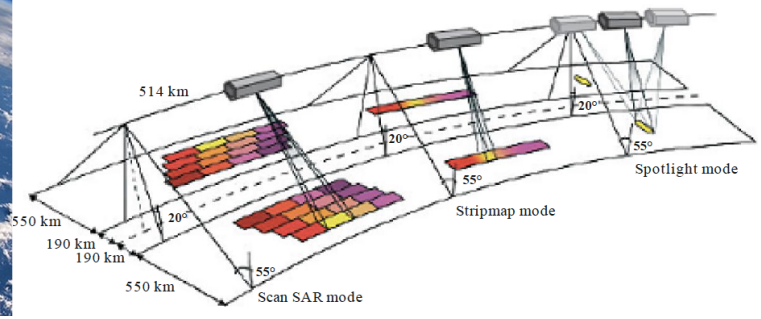


9.2-10.4 GHz Synthetic Aperture Radar

ICEYE
EVERY SQUARE METER,
EVERY HOUR

The most powerful SAR have pfd 17dB above our burnout level, ground albedo is -10 dB

FIGURE 1
Modes of operations for SAR system in the 9 GHz EESS allocation



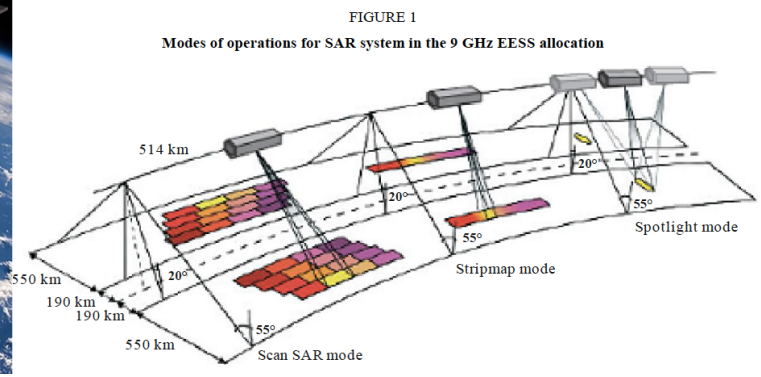
9.2-10.4 GHz Synthetic Aperture Radar

ICEYE
EVERY SQUARE METER,
EVERY HOUR

Info at http://SFCGOnline.org

Active Sensing Information for Radio Astronomers

CAPELLA SPACE CORPORATION
DENALI
VAFB - Falcon 9



9.2-10.4 GHz Synthetic Aperture Radar

ICEYE
EVERY SQUARE METER,
EVERY HOUR

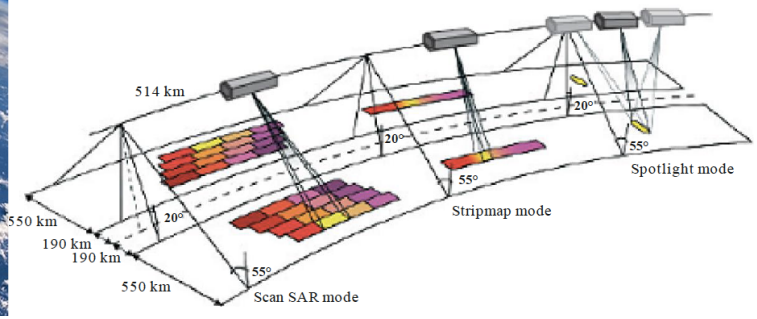
Info at http://SFCGOnline.org

Active Sensing Information for Radio Astronomers

CAPELLA SPACE CORPORATION
DENALI
VAFB - Falcon 9

But Iceye & Capella don't participate at SFCG

FIGURE 1
Modes of operations for SAR system in the 9 GHz EESS allocation



9.2-10.4 GHz Frequency Allocation

5.474B applies at the extremities of the 9.2 - 10.4 GHz EESS (active) allocation made at WRC-15

Allocation to services		
Region 1	**Region 2**	**Region 3**
9 200-9 300	EARTH EXPLORATION-SATELLITE (active) 5.474A 5.474B 5.474C RADIOLOCATION MARITIME RADIONAVIGATION 5.472 5.473 5.474 5.474D	
9 300-9 500	EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION RADIONAVIGATION SPACE RESEARCH (active) 5.427 5.474 5.475 5.475A 5.475B 5.476A	
9 500-9 800	EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION RADIONAVIGATION SPACE RESEARCH (active) 5.476A	
9 800-9 900	RADIOLOCATION Earth exploration-satellite (active) Fixed Space research (active) 5.477 5.478 5.478A 5.478B	
9 900-10 000	EARTH EXPLORATION-SATELLITE (active) 5.474A 5.474B 5.474C RADIOLOCATION Fixed 5.474D 5.477 5.478 5.479	
10-10.4 EARTH EXPLORATION-SATELLITE (active) 5.474A 5.474B 5.474C FIXED MOBILE RADIOLOCATION	**10-10.4** EARTH EXPLORATION-SATELLITE (active) 5.474A 5.474B 5.474C RADIOLOCATION Amateur	**10-10.4** EARTH EXPLORATION-SATELLITE (active) 5.474A 5.474B 5.474C FIXED MOBILE RADIOLOCATION

9.2-10.4 GHz Synthetic Aperture Radar

5.474B Stations operating in the Earth exploration-satellite (active) service shall comply with Recommendation ITU-R RS.2066-0. (WRC-15)

9.2-10.4 GHz Synthetic Aperture Radar

5.474B Stations operating in the Earth exploration-satellite (active) service shall comply with Recommendation ITU-R RS.2066-0. (WRC-15)

Recommendation ITU-R RS.2066-0

(12/2014)

Protection of the radio astronomy service in the frequency band 10.6-10.7 GHz from unwanted emissions of synthetic aperture radars operating in the Earth exploration-satellite service (active) around 9 600 MHz

recommends

1 that, in order to ensure compatibility of EESS SAR with RAS stations, EESS SAR systems operating around 9 600 MHz should avoid, to the maximum possible extent, to illuminate an area around radio astronomy stations. The size of such an area is defined in Annex 1. Annex 2 provides the list of RAS stations capable to operate in the frequency band 10.6-10.7 GHz and which may perform observations during times of illumination;

2 that, in the event that the conditions referred to in *recommends* **1** are not met, the operator of the EESS SAR system should contact the operator of the concerned radio astronomy station at least seven calendar days before an event for EESS SAR routine operations and at least 24 hours for EESS SAR acquisition of images in cases of emergency only such as disaster management in order to coordinate and, if necessary, to agree on mitigation or other preventive measures.

RS. 2066

RS. 2066 describes the viewing geometry to calculate the size of the exclusion zone and has surprisingly long, obsolete lists of RAS sites operating at 10.6 - 10.7 GHz

List of radio astronomy stations operating in the band 10.6-10.7 GHz
Region 1

Country	Name	N Latitude	E Longitude	Antenna size (m)
Belgium	Humain	50° 11' 30"	05° 15' 27"	4
Finland	Metsahövi	60° 13' 04"	24° 23' 37"	13.7
Germany	Effelsberg	50° 31' 29"	06° 53' 03"	100
	Stockert	50° 34' 10"	06° 43′ 19 "	10
	Wettzell	49° 08' 41"	12° 52′ 40"	20, 13.2
Italy	Medicina	44° 31' 14"	11° 38' 49"	32
	Noto	36° 52' 33"	14° 59' 20"	32
	Sardinia	39° 29' 34"	09° 14' 42"	64
Latvia	Ventspils	57° 33' 12"	21° 51' 17"	32
Norway	Ny Ålesund	78° 55' 45"	11° 52' 15"	
Portugal	Flores	38° 31' 12"	-31° 07' 48"	
	Santa Maria	36° 58' 12"	-25° 10' 12"	
Russia	Badari	51° 45' 27"	102° 13' 16"	
	Kaliazyn	57° 13' 29"	37° 54' 01"	
	Pushchino	54° 49' 20"	37° 37' 53"	
	Svetloe	61° 05' 00"	29° 46' 54"	
	Zelenchukskaya	43° 49' 34"	41° 35' 12"	
South Africa	Hartebeesthoek	–25° 52′ 48"	–27° 40′ 48"	
	MeerKAT	–30° 43′ 16"	21° 24′ 40"	64
Spain	Robledo	40° 25' 38"	–04° 14' 57"	
	Tenerife	28° 30' 00"	-16° 30' 00"	
	Yebes	40° 31' 27"	–03° 05′ 22"	
Sweden	Onsala	57° 23' 45"	11° 55' 35"	
	Onsala	57° 23' 35"	11° 55' 04"	
Switzerland	Bleien	47° 20' 26"	08° 06' 44"	
Turkey	Kayseri	38° 59' 45"	36° 17' 58"	
UK	Merlin Cambridge (mean)	52° 10' 01"	00° 03' 08"	
	Merlin Knockin	52° 47' 25"	–02° 59' 50"	
	Merlin Darnhall	53° 09' 23"	–02° 32' 09"	
	Merlin Jodrell Bank (mean)	53° 14' 07"	–02° 18' 23"	64
	Merlin Pickmere	53° 17' 19"	–02° 26' 44"	25

List of radio astronomy stations operating in the band 10.6-10.7 GHz
Region 2

Country	Name	N Latitude	E Longitude	Antenna size (
Brasil	Itapetinga	–23° 11' 05"	–46° 33' 28"	14
Canada	Algonquin Radio Obsy	45° 57' 19"	–78° 04' 23"	3.7 and 9.1
USA	Arecibo	18° 20' 39"	–66° 45' 10"	305
	GGAO Greenbelt	39° 06' 00"	–76° 29' 24"	12
	Green Bank Telescope	38° 25' 59"	–79° 50' 23"	100
	Haystack	42° 36' 36"	–71° 28' 12"	18
	Kokee Park	22° 07' 34"	–159° 39' 54"	20
	Jansky VLA	33° 58' 22" to 34° 14' 56"	–107° 24' 40" to –107° 48' 22"	27 antennas of
	VLBA Brewster, WA	48° 07' 52"	–119° 41' 00"	25
	VLBA Fort Davis, TX	30° 38' 06"	–103° 56' 41"	25
	VLBA Hancock, NH	42° 56' 01"	–71° 59' 12"	25
	VLBA Kitt Peak, AZ	31° 57' 23"	–111° 36' 45"	25
	VLBA Los Alamos, NM	35° 46' 30"	–106° 14' 44"	25
	VLBA Mauna Kea, HI	19° 48' 05"	–155° 27' 20"	25
	VLBA North Liberty, IA	41° 46' 17"	–91° 34' 27"	25
	VLBA Owens Valley, CA	37° 13' 54"	–118° 16' 37"	40
	VLBA Pie Town, NM	34° 18' 04"	–108° 07' 09"	25
	VLBA St. Croix, VI	17° 45' 24"	–64° 35' 01"	25
	Allen Telescope Array	40° 10' 44"	–119° 31' 53"	42 antennas o
	Goldstone	35° 25' 33"	–116° 53' 22"	70.3

List of radio astronomy stations operating in the band 10.6-10.7 GHz
Region 3

Country	Name	N Latitude	E Longitude	Antenna size (m)
Australia	Parkes	–33° 00' 00"	148° 15' 44"	64
	Katherine	–14° 22' 32"	132° 09' 09"	12
	Mopra	–31° 16' 04"	149° 05' 58"	22
	ATCA (Narrabri)	–30° 59' 52"	149° 32' 56"	6 antennas of 22
	Tidbinbilla	–35° 24' 18"	148° 58' 59"	70, 34
	Hobart (Mt. Pleasant)	–42° 48' 18"	147° 26' 21"	26
	Ceduna	–31° 52' 05"	133° 48' 37"	30
	Yarragadee	–29° 02' 47"	115° 20' 48"	12
China	Miyun	40° 33' 29"	116° 58' 37"	50
	Sheshan	31° 05' 58"	121° 11' 59"	25
	Nanshan	43° 28' 16"	87° 10' 40"	25
	Tianma	31° 05' 13"	121° 09' 48"	65
	CSRH	42° 12' 31"	115° 14' 45"	60 antennas of 2
	QTT	43° 36' 04"	89° 40' 57"	110
Japan	Nobeyama	35° 56' 40"	138° 28' 21"	45
	VERA-Mizusawa	39° 08' 01"	141° 07' 57"	20, 10
	VERA-Iriki	31° 44' 52"	130° 26' 24"	20
	VERA-Ogasawara	27° 05' 31"	142° 13' 00"	20
	VERA-Ishigakijima	24° 24' 44"	124° 10' 16"	20
	Ishioka	36° 12' 31"	140° 13' 36"	13.2
	Kashima	35° 57' 21"	140° 39' 36"	34
	Usuda	36° 07' 57"	138° 21' 46"	64
	Nishi-Waseda	35° 42' 25"	139° 43' 20"	2.4 antennas of 64
	Tomakomai	42° 40' 25"	141° 35' 48"	11
	Gifu	35° 28' 03"	136° 44' 14"	11
	Yamaguchi	34° 12' 58"	131° 33' 26"	32
	Tsukuba	36° 06' 11"	140° 05' 19"	32
Korea	KSWC (Jeju)	33° 42' 36"	126° 29' 26"	3
	SGOC (Sejong)	36° 31' 12"	127° 18' 00"	22
	K-SRBL	36° 24' 00"	127° 22' 12"	2 antennas of 2
	KVN-Yonsei	37° 33' 55"	126° 56' 27"	21
	KVN-Ulsan	35° 32' 33"	129° 15' 04"	21
	KVN-Tamna	33° 17' 21"	126° 27' 37"	21
New Zealand	Warkworth	–36° 25' 59"	174° 39' 52"	30, 12

9.2-10.4 GHz Synthetic Aperture Radar

5.474B Stations operating in the Earth exploration-satellite (active) service shall comply with Recommendation ITU-R RS.2066-0. (WRC-15)

RS. 2066 is mandatory for EESS (active) use of the ends of the band but is in fact recommended for radar operating “around 9.6 GHz”

Iceye and Capella Space are aware of RS. 2066 and are “considering” whether to follow it. Neither company was willing to share detailed information about their operations or what frequency band they use.

9.2-10.4 GHz Synthetic Aperture Radar

5.474B Stations operating in the Earth exploration-satellite (active) service shall comply with Recommendation ITU-R RS.2066-0. (WRC-15)

RS. 2066 is mandatory for EESS (active) use of the ends of the band but is in fact recommended for radar operating “around 9.6 GHz”

Iceye and Capella Space are aware of RS. 2066 and are “considering” whether to follow it. Neither company was willing to share detailed information about their operations or what frequency band they use.

https://www.bbc.com/news/science-environment-51296585

BBC NEWS

At the recent American Astronomical Society meeting in Hawaii, Dr Harvey Liszt from the US National Radio Astronomy Observatory raised the concern that powerful radar pulses from orbit **could damage the radio receivers** that scientists employ in their ground observatories.

Payam Banazadeh told me Capella was taking this matter very seriously and was keen to co-ordinate his company's activities with the AAS.

"We have also been in contact with Dr Liszt and are actively working to safeguard their mission when operating our SAR constellation.

"Whether it is observing Earth or deep space, Capella believes in exploration and scientific discovery. We also believe in and support protecting the mission of the radio astronomy community."

SFCG

- IUCAF has observer status at SFCG (space frequency coordination group)
- Attended SFCG 6-7 times 2004 - 2017
  - 2004 mutual planning for 94 GHz radar (see next talk)
  - 2010 first comprehensive info on X-band SAR
    - Thanks to John Zuzek and JPL
  - 2016 active sensor info revision started
    - IUCAF asked SFCG to consider avoiding RAS sites without advance notice at other frequencies also
  - 2017 definitive refusal of 2016 IUCAF's request

Thank you

SCIENTIFIC COMMITTEE ON FREQUENCY ALLOCATIONS FOR RADIO ASTRONOMY AND SPACE SCIENCE

IUCAF

5th International IUCAF Spectrum Management School for Radio Astronomy
Stellenbosch, South Africa 2 – 6 March 2020
www.iucaf.org