Space Frequency

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Report SFCG 39-2

COMPARISON OF MAXIMUM PFD LEVELS AT EARTH'S SURFACE FROM EESS (ACTIVE) SYSTEMS WITH BURNOUT LEVELS OF RAS SYSTEMS

Abstract

This report compares on a system-by-system basis the maximum pfd levels at the Earth's surface produced by EESS (active) systems with RAS burnout levels provided by IUCAF.

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COMPARISON OF MAXIMUM PFD LEVELS AT EARTH'S SURFACE FROM EESS (ACTIVE) SYSTEMS WITH BURNOUT LEVELS OF RAS SYSTEMS

1. Introduction

This document compares on a system-by-system basis the maximum pfd levels at the Earth's surface produced by EESS (active) systems with RAS burnout levels provided by IUCAF in Table 1. For those systems that would potentially exceed the RAS reference level, parameters are defined that could be relevant for facilitating avoidance of mainbeam to mainbeam events in Table 2 below.

2. Calculation of maximum pfd levels produced by EESS (active) systems

The maximum pfd levels produced by EESS (active) systems are calculated in this section. Equation (1) gives the expression for calculation of the power flux density (pfd) level at the Earth's surface.

$$PFD = \frac{P_t G}{4\pi}\left(\frac{1}{\frac{h}{\cos\theta}}\right)^2 \quad \text{W/m}^2 \qquad (1)$$

where:

PFD: power flux density level at the Earth's surface (W/m^2)

P_t: radar transmit power (W)

G: antenna gain (dBi)

h: orbital altitude (m)

θ: incidence angle (deg).

Using equation (1), the pfd of the EESS (active) spaceborne radars as listed in ITU-R Recommendation RS.2017 can be calculated from radar parameters in Tables 5-18 of the Recommendation. The amount that the calculated pfd level is above the RAS burn-out pfd level is shown in Table 1. Values of pfd level that are above the RAS burn-out pfd level have been highlighted in "yellow".

TABLE 1
Comparison of Maximum PFD Levels with RAS Burnout Levels

ITU-R Rec. RS.2105 Name	Actual EESS (active) Name	Center Freq , (MHz)	Transmit Pk Pwr, (W)	Max. Antenna TX Gain, (dBi)	Orbit Altitude, (km)	Min.Look Angle, (deg)	Min. Incidence Angle, (deg)	PFD, dB (W/m^2)	RAS PFD Burn-out Level, dB (W/m^2)	Amount above burn-out level, (dB)
SAR-A1	BIOMASS	435	270	33.3	665	25	27.8	-70.9	-55	-15.9
SAR-B1	NISAR	1257.5	1440	34	757	30	34.0	-64.6	-55	-9.6
SCAT-B1	SMAP	1257.5	200	36	670	34	38.2	-70.6	-55	-15.6
SCAT-B2	Aquarius	1260	200	28.1	657	25.9	28.8	-77.4	-55	-22.4
SAR-B2	ALOS-2	1257.5	6120	34.7	628	7.2	7.9	-54.5	-55	0.5
SAR-C1	HJ-1C	3200	3000	37.6	500	25	27.1	-53.6	-55	1.4
SAR-D1	Sentinel-1 CSAR	5405	4140	44.8	693	20	22.3	-47.5	-55	7.5
SAR-D2	Envisat ASAR	5331	2500	45	764	15	16.8	-50.1	-55	4.9
SAR-D3	RISAT-1	5350	4000	35	536	10	10.9	-54.7	-55	0.3
SAR-D4	Radarsat-2	5405	3700	49	792	9	10.1	-44.4	-55	10.6
SAR-D5	Radarsat-3 RCM	5405	1490	45	586.9	16	17.5	-50.0	-55	5.0
SAR-D6	Radarsat RNG	5405	1990	45	586.9	16	17.5	-48.8	-55	6.2
ALT-D1	JASON-2/3, SSALT	5300	17	32	1336	0	0.0	-89.2	-55	-34.2
ALT-D2	Sentinel-3 SRAL	5410	32	34.5	814	0	0.0	-79.7	-55	-24.7
ALT-D3	HY-2A	5250	20	35	963	0	0.0	-82.7	-55	-27.7
ALT-D4	Sentinel 6 POSEIDON 4	5410	25	33.5	1336	0	0.0	-86.0	-55	-31.0
ALT-D5	ALT-D5	5300	17	32	890	0	0.0	-85.7	-55	-30.7
ALT-D6	ALT-D6	5300	15.8	33.6	1000	0	0.0	-85.4	-55	-30.4
SCAT-D1	Metop-A,B,C, ASCAT	5235	120	32	832	22	25.1	-77.5	-55	-22.5
SCAT-D2	Metop- SGSCA	5355	2512	31	832	17.5	19.9	-64.9	-55	-9.9
SAR-E1	SAR-E1	8600	3500	44	400	20	21.3	-44.2	-55	10.8
SAR-F1	TerraSAR or TandemX	9650	2000	45.5	514	15	16.2	-47.1	-55	7.9
SAR-F2	COSMO-SkyMed	9600	7600	45.5	620	21	23.2	-43.3	-55	11.7

TABLE 1 (continued)
Comparison of Maximum PFD Levels with RAS Burnout Levels

ITU-R Rec. RS.2105 Name	Actual EESS (active) Name	Center Freq , (MHz)	Transmit Pk Pwr, (W)	Max. Antenna TX Gain, (dBi)	Orbit Altitude, (km)	Min.Look Angle, (deg)	Min. Incidence Angle, (deg)	PFD, dB (W/m^2)	RAS PFD Burn-out Level, dB (W/m^2)	Amount above burn-out level, (dB)
SAR-F3	SAR SCLP	9600	3000	46	512	30	32.7	-45.9	-55	9.1
SAR-F4	CSG-1/2	9500	7600	46.8	620	37.8	42.3	-43.8	-55	11.2
SAR-F5	Paz SAR-X	9650	2260	43.4	514	15	16.2	-48.6	-55	6.4
SAR-F6	WB SAR (RS.2043)	9800	7000	47	514	18	19.5	-40.3	-55	14.7
ALT-G1	Envisat RA-2	13575	60	41.2	764	0	0.0	-69.7	-55	-14.7
ALT-G3	HY-2A	13580	20	43	963	0	0.0	-74.7	-55	-19.7
ALT-G4	JASON-2/3, SSALT	13575	25	43.2	1336	0	0.0	-76.3	-55	-21.3
ALT-G5	Cryosat-2 SIRAL	13575	25	42	717	0	0.0	-72.1	-55	-17.1
ALT-G6	Sentinel 3 SRAL	13575	7.1	42	814	0	0.0	-78.7	-55	-23.7
ALT-G7	Sentinel 6 POSEIDON 4	13575	8	42.1	1336	0	0.0	-82.4	-55	-27.4
ALT-G8	ALT-G8	13575	5.6	42.2	1000	0	0.0	-81.3	-55	-26.3
SCAT-G1	Quikscat SEAWINDS	13402	100	41	803	40	46.4	-71.3	-55	-16.3
SCAT-G2	HY-2A	13255.5	120	42	963	35	41.3	-70.4	-55	-15.4
SCAT-G3	OCEANSAT-2	13515	100	39.5	720	43.63	50.2	-72.5	-55	-17.5
SCAT-G4	FY-3E	13350	1000	48	836	36	41.7	-54.0	-55	1.0
PR-G1	TRMM PR	13647	1000	47	410	0	0.0	-46.2	-55	8.8
PR-G2	CPM PMR	13597	1000	47.4	407	0	0.0	-45.8	-55	9.2
PR-G3	GPM DPR	13626	2000	55	400	0	0.0	-35.0	-55	20.0
SAR-H1	SAR SCLP	17250	4000	49	512	30	32.7	-41.7	-55	13.3
SCAT-I1	SCAT-I1	24150	100	41	803	40	46.4	-71.3	-57	-14.3
PR-I1	PR-I1	24150	578	47.4	350	0	0.0	-46.9	-57	10.1
ALT-J1	SARAL	35750	2	49.3	800	0	0.0	-76.7	-57	-19.7
ALT-J2	SWOT	35600	1500	61.5	970	0	0.0	-37.5	-57	19.5

TABLE 1 (continued)
Comparison of Maximum PFD Levels with RAS Burnout Levels

ITU-R Rec. RS.2105 Name	Actual EESS (active) Name	Center Freq , (MHz)	Transmit Pk Pwr, (W)	Max. Antenna TX Gain, (dBi)	Orbit Altitude, (km)	Min.Look Angle, (deg)	Min. Incidence Angle, (deg)	PFD, dB (W/m^2)	RAS PFD Burn-out Level, dB (W/m^2)	Amount above burn-out level, (dB)
SAR-J1	SIGNAL	35750	3000	49.5	780	30	34.1	-46.2	-57	10.8
PR-J1	Doppler Radar on ACE	35600	1500	60.4	650	0	0.0	-35.1	-57	21.9
PR-J2	GPM DPR	35547	140	47.4	407	0	0.0	-54.3	-57	2.7
PR-J3	CPM PMR	35547	150	47	410	0	0.0	-54.5	-57	2.5
PR-J4	CPM PMR2	35526	300	55	600	0	0.0	-46.8	-57	10.2
PR-K1	PR-K1	78500	1000	61.7	400	0	0.0	-31.3	-58	26.7
CPR-L1	Cloudsat	94050	1000	65.2	705	0	0.0	-32.8	-58	25.2
CPR-L2	Earthcare CPR	94050	1430	65.2	393	0	0.0	-26.1	-58	31.9
CPR-M1	CPR-M1	133750	300	75	705	0	0.0	-28.2	-58	29.8
CPR-N1	CPR-N1	237950	80	78	705	0	0.0	-30.9	-58	27.1

3. Facilitating avoidance of mainbeam to mainbeam events for different types of EESS (active) systems

The EESS (active) has five key types of sensors: SARs, scatterometers, precipitation radars, altimeters and cloud profile radars. The SARs and scatterometers typically point to the side at incidence angles from 7 deg to 60 deg. The precipitation radars, altimeters, and cloud profile radars typically point toward nadir at zero incidence angle. The EESS (active) SAR systems which have calculated pfd levels above the RAS burn-out pfd level are the following: SAR-B2, SAR-C1, SAR-D1 to D6, SAR-E1, SAR-F1 to F6, SAR-H1, SAR-J1, ranging from L-band to Ka-band. The amount that calculated pfd level is above the RAS burn-out pfd level for these SARs range from 0.3 dB to 14.7 dB. The minimum incidence angles for these SARs range from 7.2 deg to 42.3 deg, such that if the RAS were pointed to the zenith, the antenna gain reduction would put the calculated pfd level below the RAS burn-out pfd level. Only one scatterometer SCAT-G4 at Ku-band has a calculated pfd level that is above the RAS burn-out pfd level, and it has a minimum incidence angle of 41.7 deg such that if the RAS were pointed to the zenith, the antenna gain reduction would put the calculated pfd level below the RAS burn-out pfd level. Precipitation radars PR-G1 to G3, PR-I1, PR-J1 to J4, PR-K1 at Ku-band to W-band have calculated pfd level that are above the RAS burn-out pfd level from 8.8 dB to 26.7 dB. All these PRs are nadir looking with zero degree incidence angles, so that if the RAS systems were turned away from zenith, the antenna gain reduction would put the calculated pfd level above the RAS burn-out pfd level. The altimeters ALT- J2 at Ka-band has a calculated pfd level above the RAS burn-out pfd level of 19.5 dB. The altimeter is nadir looking with a zero degree incidence angle so that if the RAS systems were turned away from zenith, the antenna gain reduction would put the calculated pfd level below the RAS burn-out pfd level. The cloud profile radars CPR-L1 and L2, CPR-M1 and CPR-N1 at W-band and millimetre wave-bands have calculated pfd levels above the RAS burn-out pfd level from 25.2 dB to 31.9 dB. The CPRs are nadir looking with a zero degree incidence angle so that if the RAS systems were turned away from zenith, the CPR antenna gain reduction would put the calculated pfd level below the RAS burn-out pfd level.

4. Parameters relevant for facilitating avoidance of mainbeam to mainbeam events

For those systems that would potentially exceed the RAS reference level, parameters are defined that could be relevant for facilitating avoidance of mainbeam to mainbeam events in Table 2 below. For those EESS (active) systems such as SARs and scatterometers which typically point to the side, if the RAS were pointed to the zenith, the antenna gain reduction would put the margins into the negative. For those EESS (active) systems such as precipitation radars, altimeters, and cloud profile radars which typically point at nadir, if the RAS were pointed away from the zenith, the antenna gain reduction would put the margins into the negative.

The “Active Sensors Look-Up Table” has been revised to list the following parameters in seven columns: Mission, Agency, ITU Name, Frequency, Bandwidth, Radiated Power and NORAD catalog number. Using the above parameters in the table, along with the calculated pfd, RAS burn-out pfd, and margin, by knowing the minimum look angle, systems with positive margins could avoid mainbeam to mainbeam events by either looking away from zenith or looking at zenith, depending on whether the EESS (active) system is nadir looking or non-nadir looking,

respectively. The 2-line NORAD orbit elements are given on the SFCG site for the EESS (active) systems.

TABLE 2

Parameters to Avoid M/L to M/L Events to RAS

EESS (active) systems Parameters	
Transmit Peak Power	Watts
Maximum Antenna TX Gain	dBi
Orbit Altitude	km
Minimum Look/Incidence Angle	deg
Power Flux Density	dB (W/m^2)
RAS PFD Burn-out Level	dB (W/m^2)
Margin	dB

5. Conclusion

This report presents a comparison on a system-by-system basis of the maximum power flux density (pfd) levels at the Earth's surface produced by EESS (active) systems with RAS burnout levels provided by IUCAF. For those systems that would potentially exceed the RAS reference level, the parameters are defined that could be relevant for facilitating avoidance of mainbeam to mainbeam events. Table 1 of the report lists the calculated pfd for all the EESS (active) systems as shown in ITU-R Recommendation RS.2017.