Analysis of AeroCube Non-Interference with 902-928 MHz Band

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Scope
Through analysis, show that the AeroCube space service at 914.7 MHz does not interfere with protected land base station services in the 902-928 MHz band.

Protection Criteria for the IMT Systems
For non-interference, space services require field strength below the following values in Table 1:

Table 1 Field Strength to be Protected for Land Mobile Service Systems (from Appendix)

System to be protected	Class of station	Frequency (MHz)	Noise Figure (dB)	Feeder Loss (dB)	Receiving antenna gain (dBi) at 90^0	Field strength to be protected (dBμV/m)			Receiving antenna height (m)
						200 kHz GSM-R	200 kHz GSM	5 MHz LTE	
GSM or LTE system	Receiving base station	880-915	5	3	-1.5* (G_{max}= 15)	16	19	33	30
	Receiving mobile station	925-960	9	0	0 (GSM-R and GSM) -3 (LTE)	15	18	35	1.5

* -1.5 dB of omnidirectional vertical antenna gain at the elevation angle of 90 degree as the worst case is used for calculation. (See *recommends* 2.2 of Recommendation ITU-R F.1336-4).

Per table 1, the maximum field strength allowed for the GMS-R receiving base station is 16 dBμV/m. Note that only an interference with the "Receiving Base Stations" is considered because the "Receiving Mobile Stations" are outside the frequency band of the AeroCube transmitter.

Analysis
The AeroCube has two TT&C radios: the ADV radio and ASDR radio. Each operates at a fixed frequency of 914.7 MHz. Both satellite radios have the same output power of 1.3 W and 0 dBi maximum antenna gain. The resulting EIRP (Pt) is 1.14 dBW.

From Recommendation ITU-R P.525-4 "Calculation of free-space propagation" equation 7, the field strength at a point at distance d from an isotropic emitter is

$$E = Pt - 20 \log d + 74.8$$

where:
Pt: isotropically transmitted power (dB(W))
E: electric field strength (dB(μV/m))
d: radio path length (km).

Table 2 Computation of AeroCube 914.7 MHz field strength at 420 km range

Parameter	Value	Units	Comment
Pt	1.14	dBW	AeroCube EIRP
20LOGd	52.5	dB	d set to 420 km
Factor	74.8	dB	V/M to dBµV/m conversion constant
AeroCube bandwidth	1.1	MHz	AeroCube necessary bandwidth
Victim bandwidth	0.2	MHz	Victim bandwidth for GSM and GSM-R
BW adjust	-7.4	dB	Adjustment to determine the portion of the interfering power that gets into the victim bandwidth
E	**16.1**	dBµW/m	E = field strength on the surface of the earth
Protection Criterion	16	dBµW/m	Source: Interference Protection Guiden 902-928 MHz
Margin	**-0.07**	**dB**	

Conclusion

The AeroCube 914.7 MHz TT&C transmitter will interfere with "Receiving Base Stations" in the 902-928 MHz band because calculated field strength is above the allowable limits in Table 1.

The AeroCube 914.7 MHz TT&C transmitter will not interfere with the "Receiving Mobile Stations" because 914.7 MHz is not within the 925 – 960 MHz band.

APPENDIX

Potential interference to the land mobile service from the NGSO networks (CubSat) in the band 902-928MHz

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1 Introduction

Recently the Radiocommunication Bureau (BR) has received several NGSO filings for the space operation or space research services in the frequency band 902-928 MHz under No. **4.4** of the Radio Regulations (RR) since this frequency band has no allocation to any space service.

On the terrestrial part, 20 467 frequency assignments of the land mobile service in the band 902-928 MHz are currently recorded in the MIFR. This document contains the result of assessment of the interference from some US space stations notified to the BR.

2 Formulas and assumptions

- a mobile service station is located at nadir of a CubSat at 450 – 550 km;
- parameters of a CubSat space station are taken from the US filings;
- protection requirements of IMT are calculated using the relevant ITU-R deliverables, as below;
- free space propagation model is used for the interference assessment;
- interference are estimated by comparing the field strength produced by CubSat at the IMT antenna with the values of the field strength to be protected for IMT stations;
- single source interference impact is assessed;
- IMT antenna pattern and the difference in the bandwidths are taken into account.

3 Protection criteria for the IMT systems

The protection criteria of I/N = -6 is recommended for GSM and LTE systems and I/N=-9dB for GSM-R system. TABLE 1 shows the field strength to be protected in the frequency band 880-960 MHz, which are calculated using the system characteristics given in Report ITU-R M.2039 and ECC Reports 082 and 096.

TABLE 1

Field strength to be protected for land mobile service systems

System to be protected	Class of station	Frequency (MHz)	Noise Figure (dB)	Feeder Loss (dB)	Receiving antenna gain (dBi) at 90^0	Field strength to be protected (dBμV/m)			Receiving antenna height (m)
						200 kHz GSM-R	200 kHz GSM	5 MHz LTE	
GSM or LTE system	Receiving base station	880-915	5	3	-1.5* (G_{max}= 15)	16	19	33	30
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* -1.5 dB of omnidirectional vertical antenna gain at the elevation angle of 90 degree as the worst case is used for calculation. (See *recommends* 2.2 of Recommendation ITU-R F.1336-4).

The field strengths (E) to be protected are calculated using the following equation:

$$E = -37 + F - G_r(\theta) + L_F + 10 \log (B_r) + 20 \log (f) + I/N$$ (Recommendation ITU-R M.1767)

where:

F : receiving station noise figure (dB)
$G_r(\theta)$: receiver antenna gain (dBi) at the elevation angle of θ
L_F : receiving station antenna cable feeder loss (dB)
B_r : receiving bandwidth (MHz)
f : center frequency of the receiving station (MHz)
I/N : interference to noise ratio (dB)

4 Field strength produced by the space stations

Based on the parameters notified to the BR, the calculations are made to determine the field strength produced at the surface of the Earth from the satellites for every notice. The results are listed in TABLE 2 with potential interference possibility. For the calculation of the field strength produced by the space stations in question, free space propagation model is used (see Recommendation ITU-R P.525-3).

TABLE 2

Field strength produced by the space stations and potential interference possibility

Parameters of NGSO space station notified to the BR						Field Strength on earth surface (dBuV/m)		Excess of Interference, dB 'N': no interference '-' : no frequency overlap				
BR ID	freq_min (MHz)	freq_max (MHz)	Min_dist (km)	Bandwidth (MHz)	EIRP (dBW)	200 kHz*	5 MHz*	GSM-R MS	GSM BS	GSM MS	LTE BS	LTE MS
114540757	914.085	915.315	450	1.1	3	17	25	-	N	-	N	-
114540757	914.085	915.315	450	1.23	3	17	25	-	N	-	N	-
115545029	902	928	500	0.15	-7.2	14	14	N	N	N	N	N
115545029	902	928	500	0.25	2.8	23	24	8	4	5	N	N
115545029	902	928	500	0.35	2.8	21	24	6	2	3	N	N
115545029	902	928	500	0.5	2.8	20	24	5	1	2	N	N
115545029	902	928	500	0.05	-12	9	9	N	N	N	N	N
116545202	914.085	915.315	550	1.09	10	14	30	-	N	-	N	-
116545202	914.085	915.315	550	1.09	10	14	30	-	N	-	N	-
116545207	923.4	923.6	550	0.164	-10.5	9	9	N	-	-	-	-

* The field strength produced by the space station has been normalized to meet the bandwidth of the victim receiver.

5 Conclusion

If the notified NGSO satellites are brought into use without mitigation measures, some transmissions from the space stations of one among the four assessed satellite networks could cause interference to GSM systems with the excess of interference above the permissible level by 8 dB maximum. No interference to LTE is expected