



University of Colorado Earth Escape Explorer

RF Interference Analysis

05/19/2021

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Revision History

Rev	Date	Change Description	Pages Affected
1	05/19/21	Initial Release	All

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1.0 Document Scope

This document serves as the Radio Frequency (RF) interference and Electromagnetic Compatibility (EMC) analysis for the University of Colorado Boulder Earth Escape Explorer (CU-E3) experimental license application (File Number: 0086-EX-CN-2021). The interference analysis is accomplished through both an evaluation of an International Telecommunication Union (ITU) Space Network List (SNL) database search as well as a Federal Communication Commission (FCC) International Bureau Filing System (IBFS) ground station search to identify space systems and ground stations operating in the frequency bands being proposed for use in the CU-E3 experimental license application. As the CU-E3 Space-to-Earth frequency band is approved for use by the Deep Space Network (DSN) (see PL Deep Space Frequency Coordination Letter), no interference analysis is provided for the CU-E3 RF downlink connection.

Additionally, the mitigation measures that CU-E3 will employ to ensure that operations do not cause harmful interference are presented.

2.0 Acronyms

Table 2-1. Acronyms

ACRONYM	DEFINITION
CU-E3	University of Colorado Boulder Earth Escape Explorer
RF	Radio Frequency
EMC	Electromagnetic Compatibility
ITU	International Telecommunication Union
SNL	Space Network List
FCC	Federal Communications Commission
IBFS	International Bureau Filing System
DSN	Deep Space Network

3.0 Documents

3.1 Applicable documents

The documents listed below are applicable to this report to the extent referenced herein. Unless otherwise stipulated, the most recently approved version of a listed document shall be used.

Table 3-1. Applicable Documents

Document Title	Full Document Name
PL Deep Space Frequency Coordination Letter	PL Deep Space Frequency Coordination Letter
CU-E3_C-band_FCC_ground_station_search	CU-E3_C-band_FCC_ground_station_search
5 - NOAA.License.CU-E3_00086-EX-CN-	5 - NOAA.License.CU-E3_00086-EX-CN-

4.0 Ground Station Interference Analysis

4.1 Interference Analysis Methodology

A United States (US) Federal Communication Commission (FCC) International Bureau Filing System (IBFS) search was competed to identify ground stations operating within the CU-E3 ground to space uplink frequency band (5181.5-5182.5 MHz). The primary search settings were a frequency range between 5150 and 5250 MHz and a search radius of 1000 miles around the CU-E3 C-band ground station location. A full description of the search parameters is provided in Table 4-1.

Table 4-1. IFBS Ground Station Search Settings

Parameter	Value
Latitude	48° 8' 45.6" N
Longitude	119° 42' 0.4" W
Radius	1000 km
Lower Frequency Bound	5150 MHz
Upper Frequency Bound	5250 MHz

4.2 Interference Analysis Results

The search identified only a single ground station licensed under Denali LLC and operated by US Electrodynamics Inc (USEI). USEI is supporting CU-E3 with the experimental license uplink operation, and CU-E3 uplink will occur from the USEI teleport in Brewster Washington. The USEI Teleport is licensed for operation in several frequency bands, all of which are outside of the frequency band identified by the CU-E3 experimental license application (5181.5-5182.5 MHz). Specifically, all USEI Teleport antennas have maximum licensed operating frequencies $\leq$ 5181.5 MHz or minimum licensed operating frequencies $>$ 5182 MHz. Additionally, pre-coordination has been completed with USEI teleport's end users through USEI to ensure that there will be no RF interference in the operating frequency bands of satellite systems employing the USEI teleport. A full summary of the USEI licenses as identified by the FCC IBFS search is provided in CU-E3_C-band_FCC_ground_station_search.

As there are no identified ground stations operating between 5181.5 and 5182.5 MHz within 1000 km of the CU-E3 uplink ground station, CU-E3 will not be capable of interfering with any of the space systems with ground-to-space or space-to-ground links identified in the SNL database query discussed in Section 5.

5.0 Spacecraft Interference Analysis

To determine satellite systems CU-E3 could potentially interfere with, an ITU SNL database query was obtained to identify satellites (both geostationary and non-geostationary) operating between 5181.5 and 5182.5 MHz. A summary of the database query results for all space systems operating between 5162 and 5202 MHz is provided in Appendix A, and includes 42 unique satellites, at least 41 of which are currently active.

5.1 Interference Categories

From the SNL database query, space systems operating in the 5181.5-5182.5 MHz band that CU-E3 plans to operate in for Earth-to-Space link were separated into two separate categories:

1. Category 1: Those systems with which there is no potential for interference
2. Category 2: Those systems with which there is some potential for interference

Appendix A provides information on the sorted category of all space systems identified by the ITU SNL database query as well as the reasoning for the categorization.

5.2 SNL Interference Summary

The vast majority of space systems operating in the proposed CU-E3 Earth-to-Space frequency band have no potential for interference. The primary reason CU-E3 has no ability to interfere with these non-geostationary satellites is the lack of overlapping ground station assets, as shown in the database search from Section 4. However, some satellites, such as JASON-2, employed frequencies between 5181.5 and 5182.5 MHz, but have already been decommissioned and are no longer operating in the proposed CU-E3 ground-to-space uplink frequency band. Additionally, two satellites (PAKSAT-MM1-38.2E-KA) are geostationary with nominal longitudes of 38.2° E and 56.5° E, which are significantly outside of the range of the proposed CU-E3 ground station site at Brewster Washington (119° 42' 0.4" W).

Out of the 42 unique satellites identified in the ITU SNL database query, only one, JASON-3, was determined to have some potential for interference. The ITU SNL database query results for JASON-3 are provided for reference in Table 5-1. JASON-3 is a NOAA/NASA science mission, and the Posiden-3B instrument employs the frequency band between 5140 MHz and 5460 MHz for sea level altimetry. CU-E3 has completed coordination with NOAA and determined that CU-E3 does not need a NOAA operator's license. The CU-E3 – NOAA coordination information is defined in the 5 - NOAA.License.CU-E3_00086-EX-CN-2021 letter. It should be noted that the JASON-3 Posiden-3B instrument conducts science over the oceans thus science is not conducted over land where the CU-E3 ground station is located.

Table 5-1. Satellite Systems with Potential CU-E3 Interference

ntc_id	sat_name	ntc_type	adm	freq_min1 (MHz)	freq_max1 (MHz)	Category	Reasoning
112500130	JASON3	N	F	5140	5460	2	JASON 3 is a joint NOAA/NASA mission. Coordination with NOAA determined that CU-E3 does not need a NOAA operator's license.

6.0 Conclusion

The CU-E3 RF Interference Analysis identified 42 unique satellites and 0 ground stations operating in the proposed CU-E3 Earth-to-Space frequency band of 5181.5 to 5182.5 MHz. Of the 42 identified space systems, only one satellite could potentially be potentially interfered with. JASON3 is a joint NOAA/NASA satellite employing the frequency range of 5140 MHz to 5460 MHz for altimetry measurements and CU-E3 has completed coordination with NOAA for approval to operate in the proposed C-band frequency range. Using the JASON3 ephemeris, CU-E3 operations can be scheduled to avoid times when JASON3 is in the 10dB beamwidth of the antenna. Additionally, nominal CU-E3 uplinks are expected to be short (typically < 5minutes) and occur a few times per week, making scheduling around JASON3 and potentially other satellite overpasses relatively easy. The one exception is immediately post launch and early operations where additional uplink time may be required to locate, acquire and track the CU-E3 satellite after deployment from SLS (Artemis-1).

CU-E3 will continue to monitor satellite systems operating between 5181.5 and 5182.5 MHz and will coordinate with any potentially impacted satellite system to determine and deploy appropriate mitigation methods. These potential methods include transmitting only when affected space systems are out of the CU-E3 ground station beamwidth as well as stopping all Ground-to-Space communication if necessary.

Appendix A: SNL Query Results

ntc_id	sat_name	ntc_type	adm	long_nom	freq_min1 (MHz)	freq_max1 (MHz)	Category	Reasoning
109520092	ADS	N	CAN		5180	5186	1	No ground station area overlap.
115520048	AST-NG-C-1	N	F		5091	5250	1	No ground station area overlap.
115520171	AST-NG-C-2	N	F		5091	5250	1	No ground station area overlap.
116520228	AST-NG-C-3	N	F		5150	5216	1	No ground station area overlap.
116520228	AST-NG-C-3	N	F		5091	5250	1	No ground station area overlap.
117520372	AST-NG-C-4	N	F		5150	5216	1	No ground station area overlap.
120520100	AST-NG-C-AD	N	F		5150	5216	1	No ground station area overlap.
116520069	CLEOSAT	N	LUX		5150	5250	1	No ground station area overlap.
112520031	COMPASS-IGSO	N	CHN		5150	5216	1	No ground station area overlap. COMPASS C-Band link used only for telemetry and command, not positioning.
120520072	D-MEG1-1	N	D		5150	5250	1	No ground station area overlap.
117520183	DES-LEO	N	CHN		5150	5250	1	No ground station area overlap.
117520487	EB-SAT-LEO-1	N	F		5091	5241	1	No ground station area overlap.
117520492	EB-SAT-LEO-1B	N	F		5091	5241	1	No ground station area overlap.
115520085	ES-SAT-2	N	F		5091	5250	1	No ground station area overlap.
119520140	EV10	N	CAN		5152	5214	1	No ground station area overlap.
119520266	GEESAT-1	N	CHN		5185	5215	1	No ground station area overlap.
94500133	GEO-IK-2	N	RUS		5140	5460	1	No ground station area overlap.
119520212	GONETS-M1	N	RUS		5150	5250	1	No ground station area overlap.
119520389	GW-S	N	CHN		5091	5250	1	No ground station area overlap.
110520102	HIBLEO-X	N	F		5097.2	5248.92	1	No ground station area overlap.
119520285	HISPASAT-LEO-NB	N	E		5091	5241	1	No ground station area overlap.
119545047	HTV/JEM-MISSION	N	J		5150	5350	1	No ground station area overlap.
107500097	ICO-P	N	G		5100	5250	1	No ground station area overlap.
116520419	IK-NGSO-A10K-1	N	RUS		5150	5250	1	No ground station area overlap.

117520071	IK-NGSO-A10K-2	N	RUS		5150	5250	1	No ground station area overlap.
109500002	JASON2	N	F		5140	5250	1	JASON-2 was decommissioned in 2019.
109500002	JASON2	N	F		5125	5250	1	JASON-2 was decommissioned in 2019.
112500130	JASON3	N	F		5140	5460	2	JASON 3 is a joint NOAA/NASA mission. Coordination with NOAA determined that CU-E3 does not need a NOAA operator's license.
119520356	LEOBIT-V	N	CHN		5150	5250	1	No ground station area overlap.
112520404	M3MSAT	N	CAN		5169.5	5196.5	1	No ground station area overlap.
119520086	M5L2SAT	N	PNG		5150	5250	1	No ground station area overlap.
115520227	MCSCS	N	CHN		5091	5250	1	No ground station area overlap.
117520098	PAKSAT-MM1-38.2E-KA	G	PAK	38.2	5150	5216	1	Geosynchronous and out of beamwidth of CU-E3 ground station.
120520076	PAKSAT-MM1-56.5E	G	PAK	56.5	5150	5216	1	Geosynchronous and out of beamwidth of CU-E3 ground station.
113520278	PAZ	N	E		5167.5	5198.5	1	No ground station area overlap.
116520442	SI-SAT-BILIKIKI	N	SLM		5150	5250	1	No ground station area overlap.
113520061	SIRION-1	N	AUS		5150	5250	1	No ground station area overlap.
116545236	SWOT	N	F		5140	5460	1	No ground station area overlap.
115520228	TXIN	N	CHN		5150	5250	1	No ground station area overlap.
119500195	USOCEAN	N	USA		5140	5460	1	No ground station area overlap.
116520105	XINGYUN	N	CHN		5150	5216	1	No ground station area overlap.
118520216	XINGYUN-2	N	CHN		5150	5250	1	No ground station area overlap.

