

Exhibit C - Interference Analysis

Interference and Electromagnetic Compatibility Study

The experimental Swarm satellite network, which includes 12 satellites and 3 US earth stations,¹ employs the 137-138 MHz band for space-to-earth links and the 148-150.05 MHz band for earth-to-space links, consistent with the US and International Table of Frequency Allocations. To demonstrate compliance with an experimental system's obligation to operate on a non-interference basis with other authorized operators in the bands, this report provides a three-part electromagnetic compatibility study with the existing authorized users. Specifically, the report includes: 1) a study of compatibility with terrestrial services, 2) a study of compatibility with other satellite systems, and 3) a study of compatibility with radio astronomy services.

Statement of Terrestrial Compatibility

ITU Radio Regulations impose power flux density (PFD) limits that trigger coordination for certain terrestrial (fixed and mobile) systems in the 137-138 MHz band.² In summary, the PFD threshold that triggers coordination with terrestrial services is $-125 \text{ dBW/m}^2/4\text{kHz}$. Figure 1 shows a plot of the expected PFD at Earth's surface for all angles of arrival at the operational orbit altitude of 505 km. As shown in Figure 1, the maximum PFD at the Earth's surface produced by a Swarm satellite transmission will not exceed -133 dBW/m^2 in any 4 kHz band at any angle of arrival, which is under the threshold for coordination with terrestrial services and therefore does not trigger a coordination requirement.

¹ The satellites for which an authorization is sought will transmit only when within line of sight of three US earth stations, one in Los Altos, CA, one in Atlanta, GA, and one in Draper, UT. No other earth stations will transmit to the satellite.

² ITU RR Appendix 5, Annex 1, article 1.1.1.

Power Flux Density vs. Elevation angle

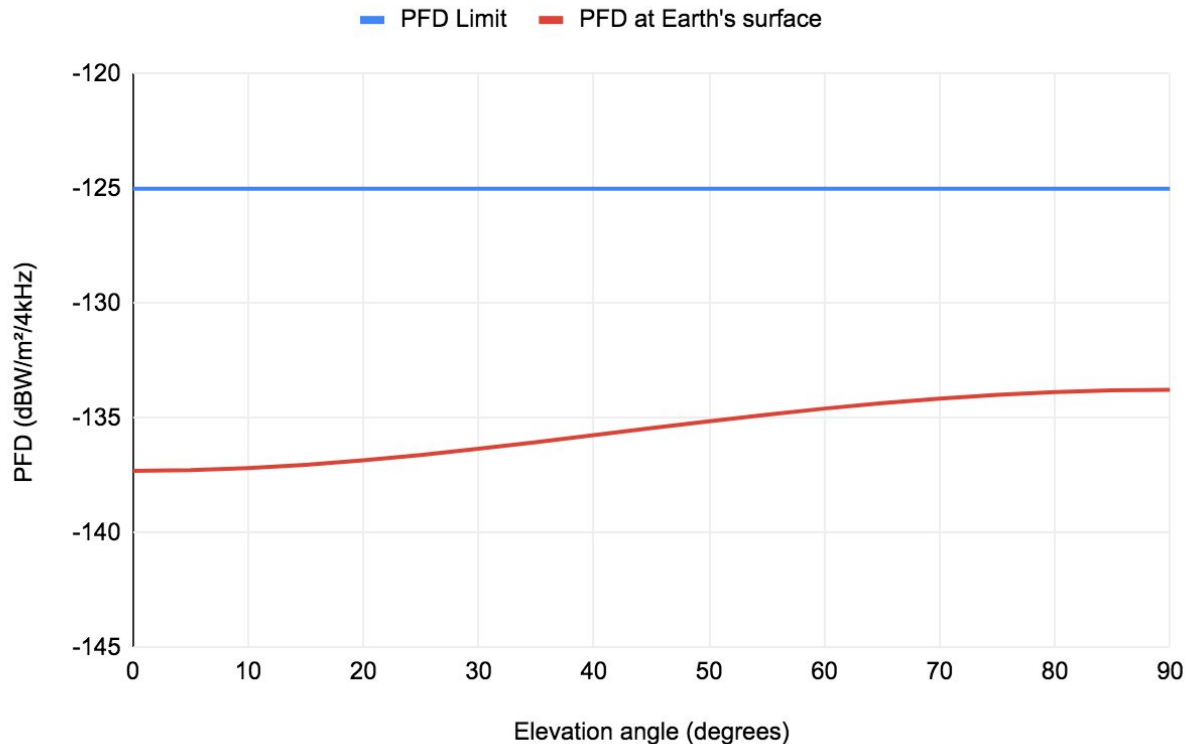


Figure 1. PFD at Earth's surface produced by a satellite transmission.

Statement of Satellite Service System Compatibility

For this experimental deployment, Swarm proposes to operate on the 137.880-138.000 MHz band in the space-to-Earth direction and on the 148.300-148.420 MHz band in the Earth-to-space direction (see accompanying Exhibit A: Narrative for additional details).

From the ITU Space Network Systems Online (SNS), lists of satellite systems using the 137-138 and 148-150.05 MHz bands were collected and shown in Tables 1 and 2. For each satellite system, the table indicates the administrative jurisdiction, service areas, frequency overlaps, and ultimately a disposition for a coordination requirement. Most satellites have either no frequency overlap with Swarm satellites, have no area coverage overlap, or have no apparent earth stations in the USA. In addition, a search of the FCC IBFS for the 137-138 MHz band shows that only Orbcomm is licensed for a space system using these space services links within the United States. In summary, only Orbcomm and NOAA N require some form of coordination for operations in the USA. Swarm will seek consent from Orbcomm regarding its system. As shown below, the experimental Swarm satellite system meets the Interference Protection Criteria (IPC) for the NOAA N satellite, so coordination should not be required.

The Interference Protection Criteria (IPC) for meteorological satellites³ in the 137-138 MHz band is -136 dBW per 150 kHz. This IPC is applicable for the NOAA N and NOAA KLM satellites. There is no frequency overlap with NOAA KLM and therefore no interference is expected. The NOAA N earth stations may have an isotropic gain as high as 10 dBi⁴ and in this case the signal power from a Swarm satellite into a NOAA N ground receiver could reach -128.1 dBW, exceeding the IPC. This however will be a rare situation where a Swarm satellite is transmitting at the same time the NOAA N earth station is pointed in the direction of the Swarm satellite (given a 10 dBi antenna has some directionality).

In fact, potential interference conjunctions above the -136 dBW/150 kHz IPC is estimated to occur less than 0.0062% of the time, which meets the IPC limit of less than 0.0063% of the time (as specified by the previously referenced ITU recommendation). This is estimated as follows:⁵ The Swarm transmissions will occur less than 1.17% of the time daily. The NOAA N satellite may transmit up to 3.3% of the time daily in the same area. A 10 dBi earth station antenna has a 6 dB beamwidth of approximately 72 degrees, which is about 16% sky coverage. This results in a potential interference conjunction exceeding -136 dBW into the earth station receiver no more than 0.0062% of the time. Therefore the experimental Swarm satellite system meets the IPC for NOAA N and coordination should not actually be required. Note that this estimate assumes the worst-case scenario in which the satellites share a similar orbit and equatorial crossing time and anything otherwise would yield a smaller conjunction percentage.

There are several other satellite systems shown in the tables below deserving additional attention: EBSAT-LEO-1, EBSAT-LEO-1B, IMDC, SI-SAT-BILIKIKI, and NSL-1. In each of these cases there is potential frequency overlap and the USA is a designated coverage area in the ITU notices. However, none of these systems have launched yet and no US licenses or applications were submitted by these systems to the FCC as of April 2019. The EBSAT-LEO-1 and -1B systems are planned Mobile Satellite Service constellations by Thales Alenia Space filed through the French administration. The IMDC system is a single satellite by the company Innovative Solutions In Space in the Netherlands. It appears there will only be an earth station in the Netherlands. The SI-SAT-BILIKIKI system is a planned large Mobile Satellite Service constellation by Pangea Networks LLC. Pangea Networks is a U.S.-based company but filed their satellite system notification through the Solomon Islands administration. The NSL-1 system is a planned constellation by NSLComm, filed through Israel. For each of these systems, the status of the launch authorization licensing and construction progress of the systems is unknown by Swarm, and the systems have no space system licensing within the United States. As such, no coordination is required with these systems.

Three additional satellite systems listed in the tables below deserving additional discussion are KELYPSIS, HOL-MG-A006, and MNSAT. The KELYPSIS system is a planned constellation by Kepler Communications with an ITU filing through Canada. Kepler filed for US market access (IBFS File No.

³ ITU R-REC-SA.1027-5, Table 1, Sharing Criteria at 137-138 MHz. Interfering signal power (dBW) should not exceed -136 dBW per 150 kHz more than 0.0063% of the time.

⁴ The ITU SNS for NOAA N shows receive antenna type ND with up to 10 dBi isotropic gain.

⁵ Swarm transmissions: 2 second duration * 42 contacts * 12 satellites / 86,400 seconds/day = 1.17%,
NOAA transmissions: 12 minute duration * 4 contacts * 1 satellite / 1440 minutes/day = 3.3%,
NOAA earth station antenna sky coverage: $\text{PI} \cdot (72 \text{ deg beamwidth} / 2)^2 / \text{PI} \cdot (90 \text{ deg})^2 = 16\%$

SAT-PDR-20161115-00114), but only requested access to the 10.7-12.7 GHz and 14-14.5 GHz frequency bands in the United States. No request was made to the Commission for access to frequencies in the 148-150.05 MHz band, so coordination with Kepler will not be required. The HOL-MG-A006 system is a planned constellation by Hiber (formerly Magnitude Space), licensed by the Netherlands. Hiber filed for U.S. market access,⁶ but only requested access to the 399.9-401 MHz bands. No request was made to the Commission for access to frequencies in the 148-149.9 MHz band, so coordination with Hiber will not be required. The MNSAT system is a planned constellation by Myriota, licensed in the Netherlands. The MNSAT system is a planned Mobile Satellite Service constellation filed by Myriota through the Australian administration. Myriota recently applied for U.S. market access,⁷ but only requested authority to operate on UHF bands, meaning that there is no overlap with Swarm's requested frequencies and coordination will not be required.

In these tables, red-colored boxes indicate frequency overlap between the respective system in the row and the Swarm satellite. Green rows indicate some level of coordination or additional consideration is required for the system.

Table 1: List of Satellite Systems in the ITU SNS, transmitting 137-138 MHz

| Satellite | Country | Service Area | Maximum Frequency | Coordination requirement | Notes |
|------------------|-----------------|--------------------------|-----------------------|--------------------------|--|
| AGILE | Italy | XVE Kenya ES | 138 | None | Equatorial NGSO, no orbital access to USA. |
| ATS-5 | USA | GEO NC ES | 137.365 | None | GEO, no frequency overlap |
| EBSAT-LEO-1 | France | XAA (world) | 138 | None | Not launched yet No US license/stations |
| EBSAT-LEO-1 B | France | XAA | 138 | None | Not launched yet No US license/stations |
| EUTELSAT-48 E | France | GEO Belgium ES | 137.230 | None | GEO, no frequency overlap |
| IMDC | Nether lands | XAA, Netherland ES | 137.9-138 E-S, S-E | None | Not launched yet? No US license/stations Innovative Solutions In Space |
| IMP-J | USA | AK, NC ES | 137.995 | None | Inactive, 1970's |
| LEOTELCOM-1 | USA | XAX (world) | 137.325 | Orbcomm Consent | No frequency overlap |
| LEOTELCOM-2 | USA | XAX | 137.928 | Orbcomm Consent | To be coordinated with Orbcomm |
| LEOTELCOM-5 | USA | XAA | 137.655 | Orbcomm Consent | No frequency overlap |
| MCSCS | China | XAA | 137.525 | None | No frequency overlap |
| METEOR-3M | Russia | XAA | 137.975 | None | Deactivated March 2006 |
| METOP | France | XAA | 137.1 | None | No frequency overlap |
| MNSAT | Australia | AUS, NZ, CAN, USA | 138 | None | Not launched yet No US license/stations |
| NOAA N | USA | XAA | 137.932 | NTIA consent | To be coordinated w/ NTIA |

⁶ See SAT-PDR-20180910-00069, filed September 10, 2018.

⁷ See SAT-LOI-20190328-00020, filed March 28, 2019.

| | | | | IPC met | IPC met |
|-----------------------------------|----------------|--------------------|-----------------|---------|---|
| NOAA-KLM | USA | XAA | 137.793 | None | No frequency overlap |
| RS-D2 | India | IND (India) | 137.550 | None | No area or frequency overlap |
| SAUDISAT-1C | Saudi Arabia | ARS (Saudi Arabia) | 137.525 | None | No area or frequency overlap |
| SAUDISAT-2 | Saudi Arabia | ARS | 137.513 | None | No area or frequency overlap |
| SEO BHASKARA-1 | India | IND | 137.990 | None | No area overlap, 1980's |
| SEO BHASKARA-2 | India | IND | 137.990 | None | No area overlap, 1980's |
| SI-SAT-BILIKIK I (300 satellites) | Solomon Island | XAA | 137-138 (1 MHz) | None | Not launched yet No US license/stations Pangea Networks |
| SROSS-1 | India | IND | 137.690 | None | No area or frequency overlap, 1990's |

Table 2: List of Satellite Systems in the ITU SNS, transmitting 148-150.05 MHz

| Satellite | Country | Service Area | Freq. Overlap (closest freq. shown) | Coordination requirement | Notes |
|--------------|-------------|-------------------------|-------------------------------------|--------------------------|--|
| AGILE | Italy | XVE space-to-space link | 149.0 (2 MHz) | None | Equatorial NGSO, no orbital access to USA |
| ATS-5 | USA | GEO NC ES | 148.26 (30 kHz) | None | No frequency overlap |
| CASSIOPE-1A | Canada | XAA | 150.005 | None | No frequency overlap |
| EBSAT-LEO-1 | France | XAA | 148-150.05 | None | Not launched yet? No US license/stations |
| EBSAT-LEO-1B | France | XAA | 148.150.05 | None | Not launched yet? No US license/stations |
| GOES West | USA | GEO Wallops VA | 148.545 | None | No frequency overlap |
| HOL-MG-A006 | Netherlands | XAA | 148-149.9 | None | Not launched yet? Magnitude Space (Hiber). Filed for US market access (IBFS File No. SAT-PDR-20180910-00069), but only requested access to 399.9-401 MHz bands. No area overlap for 148-149.9 MHz band. |
| IMP-J | USA | AK, NC ES | 148.98 (30 kHz) | None | No frequency overlap Inactive, 1970's |
| IPS | Netherlands | HOL | 148.118 | None | No area or frequency overlap |
| IRS-1B, 1E | India | India | 149.522 (12 kHz) | None | No area or frequency overlap |
| KELYPSIS | Canada | XAA | 148-150.05 | None | Kepler Communications, filed |

| | | | | | |
|-----------------------|-------------------|--------------------------|---|--------------------|---|
| | | | | | for US market access (IBFS File No. SAT-PDR-20161115-00114), but only requested access to 10.7-12.7 GHz and 14-14.5 GHz frequency bands. No area overlap for 148-150.05 MHz band. |
| KITSAT-3 | Korea | Korea | 148.025,148.9 (20 kHz) | None | No area or frequency overlap |
| LEOTELCOM-1 | USA | XAX | 148-150.05 | Orbcomm Consent | To be coordinated with Orbcomm |
| LEOTELCOM-2 | USA | XAX | 148-148.905 | Orbcomm Consent | To be coordinated with Orbcomm |
| LEOTELCOM-3 | USA | XAX | 149.81-149.9 | None | No frequency overlap |
| LEOTELCOM-5 | USA | XAA | 148-150.05 | Orbcomm Consent | To be coordinated with Orbcomm |
| LUOJIA-1A | China | CHN | 148.35-148.4 | None | No area overlap |
| LUX-NGSO -1/2/3 | Luxemb ourg | XAA | 149.0-151.0 | None | No frequency overlap |
| MCSCS | China | XAA | 149.025 (44 kHz) | None | No frequency overlap No US stations |
| MNSAT | Australia | XAA | 148-150.05 | None | Not launched yet No US license/stations |
| NSL-1 | Israel | XAA | 148-149.9 | None | Not launched yet No US license/stations |
| QS-1 | China | CHN | ...148.025 | None | No area or frequency overlap |
| RS-D2 | India | IND (India) | ...148.265 | None | No area or frequency overlap Inactive, 1980's |
| SAMSON-2 | Israel | ISR | 148.8... | None | No area or frequency overlap |
| S4P | Swiss | HOL, SUI | 148.2635 -148.5865 | None | No area overlap |
| SAUDISAT-1C | Saudi Arabia | ARS (Saudi Arabia) | 149.025 (44 kHz) | None | No area or frequency overlap |
| SAUDISAT-4, -5, -6 | Saudi Arabia | ARS | 148.035, 148.085, 149.035 (30 kHz) | None | No area or frequency overlap |
| SEO BHASKARA-1 | India | IND | ...148.265, 148.595... | None | No area or frequency overlap Inactive, 1980's |
| SEO BHASKARA-2 | India | IND | ...148.265, 148.595... | None | No area or frequency overlap Inactive, 1980's |
| SIMBA | Belgium | HOL | ...148.118 | None | No area or frequency overlap |
| SI-SAT-BILIKIK I | Solomon Island | XAA | 149.025 (100 kHz) | None | No frequency overlap No US license/stations |
| SROSS-1,-3 | India | IND | 149.272... | None | No area or frequency overlap |

| | | | | | |
|----------|--------|-----|-------------|------|------------------------------|
| TELEOS-1 | SNG | SNG | 148.6875... | None | No area or frequency overlap |
| TSYKADA | Russia | XAA | 149.903... | None | No frequency overlap |
| YOUTHSAT | India | XAX | 149.995... | None | No frequency overlap |

Radio Astronomy Service Protection

Pursuant to the ITU Radio Regulations 5.208A, Swarm's satellites meet the ITU recommendations⁸ to avoid interference with the nearby Radio Astronomy Service (RAS) band (150.05-153 MHz). The satellites transmit only in the 137-138 MHz band and out of band emissions are minimized by digital modulation techniques and filtering with at least 100 dB spectral roll-off at 150 MHz resulting in a power flux density (PFD) at Earth's surface not exceeding -269 dB(W/(m² · Hz)), thereby meeting the RAS protection criteria of -259 dB(W/(m² · Hz)).⁹ The experimental ground stations share the same frequency and out of band suppression characteristics. Ground stations will be positioned at a distance or otherwise obstructed such to prevent line-of-sight observations by a Radio Astronomy site using the 150.05-153 MHz band¹⁰ and resulting in a signal attenuation that meets the RAS interference protection criteria. In addition, the frequency of transmissions from the Swarm earth stations will be less than 2% of the time, which also meets the RAS protection criteria.¹¹

Conclusion

The experimental satellites and US earth stations pose no risk of creating harmful interference with any known system with the exception of Orbcomm. As represented above, Swarm satellite transmissions are compliant with the frequency allocation tables and meet PFD-based protection criteria for terrestrial systems and RAS as well as meteorological satellite systems. Swarm will seek specific consent from Orbcomm to mitigate any potential for interference with their system.

⁸ ITU Radio Regulations, Resolution 739 (Rev. WRC-15) and Recommendation ITU-R M.1583.

⁹ As specified in ITU-R M.1583, the protection criteria is -238 dB(W/m²) in a 2.95 MHz reference bandwidth and as recommended in ITU-R RA.769-2 Table 1, the threshold for harmful interference is -259 dB(W/(m² · Hz)) at a center frequency of 151.525 MHz.

¹⁰ Recommendation ITU-R RA.769-1 specifies "above about 40 MHz sharing may be practicable with services in which the transmitters are not in direct line-of-sight of the observatories".

¹¹ ITU RR 2016, Resolution 739, article g, and ITU-R RA.1513-2, article 2.