Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
	)	
Theia Holdings A, Inc.	)	SAT-LOA-20161115-00121
	)	
Application for Authority Launch and Operate a Non-Geostationary Satellite Orbit System in the Fixed-Satellite Service, Mobile-Satellite Service, and Earth Exploration Service	)	Call Sign: S2986

PETITION TO DENY OR DEFER

The GPS Innovation Alliance ("GPSIA"), pursuant to Section 25.154(a)[1] of the Commission's Rules, submits this petition ("Petition") requesting that the Commission either deny the above-captioned application ("Application") of Theia Holdings A, Inc. ("Theia" or "Applicant"), or defer action on the Application until Theia amends and removes the proposed space-to-earth use of the 1215-1300 MHz frequency band from its proposed non-geostationary satellite orbit ("NGSO") constellation.[2] As currently formulated, in addition to communications services, Theia plans to offer earth observation payloads and specifically an Earth Exploration Satellite Service ("EESS") active radar (synthetic aperture radar ("SAR")) that will operate with relatively high power on frequencies important to global navigation satellite system ("GNSS")

1 *See* 47 C.F.R. § 25.154(a).

2 *See OneWeb Petition Accepted for Filing*, IBFS File No. SAT-LOI-20160428-00041; *Cut-Off Established for Additional NGSO-Like Satellite Applications or Petitions for Operations in the 10.7-12.7 GHz, 14.0-14.5 GHz, 17.8-18.6 GHz, 18.8-19.3 GHz, 27.5-28.35 GHz, 28.35-29.1 GHz, and 29.5-30.0 GHz Bands*, Public Notice, 31 FCC Rcd 7666 (IB 2016).; *See also* IBFS File No. SAT-LOA-20161115-00121 ("*Application*").

signals, including the Global Positioning System ("GPS") L2 signal (at 1227 MHz).[3] The Theia EESS radar system would gather worldwide soil and vegetation information by radiating the entire planet with high power pulses in the aforementioned frequency bands used for GNSS.

Theia's proposed constellation of 52 spacecraft with active SAR emissions radiating in the 1215-1300 MHz frequency band would create widespread, unacceptable harmful interference for GNSS receivers, including important GPS use cases critical to the United States national defense, aviation, cellular communications base stations, high precision applications in agriculture and construction, and various other irreplaceable components of our contemporary global infrastructure.

Given the severe and unavoidable harmful interference Theia's SAR emission would create, the approval of such a proposal would be inconsistent and irreconcilable with U.S. and International Telecommunications Union allocations for the 1215-1260 MHz band. Theia should be encouraged to pursue alternative spectrum options including those currently in use by other scientific and commercial SAR operations. Prompt denial of the Application, or amendment to remove the proposed SAR emission, will ensure the Commission averts a foreseeable collision with higher priority spectrum uses that cannot be moved or otherwise protected from such harmful interference. The GPSIA does not otherwise object to Theia's application.

[3] In the Application and complementary Schedule-S filing Theia proposes 16 and 32 megahertz SAR emissions centered at 1233 MHz, 1240 MHz, 1250 MHz, 1260 MHz, 1270 MHz and 1280 MHz.

I. GPSIA Background and Interest in the 1215-1300 MHz Band

GPSIA was formed in February 2013 to protect, promote, and enhance use of GPS and GNSS technologies. Members and affiliates of the GPSIA are drawn from a wide variety of fields and businesses reliant on GPS, including transportation, agriculture, construction, surveying, mapping and public safety. GPSIA members also include organizations representing consumers who depend on GPS in a wide variety of applications including boating and other outdoor activities and in their automobiles, smart phones, and tablets.

The Application's request for authority to transmit a space-to-Earth SAR emission in the 1215-1300 MHz band compels GPSIA to object to this portion of Theia's proposal because this band supports GPS and GNSS signals pursuant to a co-primary allocation in the 1215-1240 MHz band and a footnote to the United States Radio Table creating *de facto* co-primary status in the 1240-1260 MHz band.[4] Most significantly, Theia's SAR emissions propose to share the same frequencies already occupied by the higher priority GPS L2 and other GNSS signals. As a result of the proposed co-channel use of the same frequencies, GPS and other affected GNSS systems would experience harmful interference on a global basis if Theia's Application were approved without amendment.[5]

[4] *See* 47 CFR § 2.106, n.US 5.332, which provides that "[i]n the band 1215-1260 MHz, active spaceborne sensors in the Earth exploration-satellite and space research services shall not cause harmful interference to, claim protection from, or otherwise impose constraints on operation or development of the radiolocation service, the radionavigation-satellite service and other services allocated on a primary basis. "

[5] GPSIA notes that the Globalnaya Navigazionnay a Sputnkovaya Sistema ("GLONASS") G2 signal also operates co-channel to Theia's proposed SAR emission. The GPS L2 and GLONASS G2 signals are centered at 1227 MHz and 1246 MHz, respectively.

II. Theia's Active Space-to-Earth EESS SAR Emission Proposed for the 1215-1300 MHz Band Would Cause Harmful and Unavoidable Co-Channel Interference to GPS and other GNSS Signals on a Global Scale

Theia's proposed space-to-earth EESS SAR emission in the 1215-1300 MHz band will reach the Earth's surface with a staggering 100,000,000x power advantage over GPS and other co-channel GNSS signals in the band. As discussed in greater detail below, even with Theia's relatively low duty cycle, this power discrepancy and the aggregate effect created by multiple Theia satellites passing overhead and simultaneously radiating targets on the ground will cause the EESS radar signals to dominate GPS and GNSS receivers, thereby inhibiting or even precluding any GNSS signal reception and processing. GPSIA expects that, at a minimum, GPS and GNSS receivers will experience degradation in Carrier to Noise Ratio ("C/N_0") well above the established threshold for harmful interference to GPS service.[6] This harmful interference will be experienced over wide swaths of the Earth's surface and occur multiple times every day. Further, in situations with impaired GNSS reception, SAR emissions from Theia's constellation will result in the complete loss of all GNSS navigation solutions and greatly increased time to reacquire the signal after an interruption. Given that this powerful and ubiquitous interference will occur in frequencies inside the GNSS band, no effective mitigation options exist. Besides sharing the limited interference budget with other EESS SAR's, Theia will be sharing with various aeronautical sources such as DME/TACAN.

The power discrepancy between GPS signals and Theia's proposed SAR emission is substantial. With transmit effective isotropic radiated power ("EIRP") of 72.13 dBW (~16

---

[6] *See, e.g., Memorandum from National Space-Based PNT Executive Group to Administrator*, NTIA, June 14, 2011, at 4, available at http://www.gps.gov/spectrum/lightsquared/docs/2011-06-NPEFlightsquared-report.pdf (last visited June 20, 2017), explaining that degradation may actually occur before the point at which there has been a 1 dB reduction in C/N_0, at which the noise due to interference has increased by 25 percent.

megawatts), Theia's SAR emissions in the 1215-1300 MHz band will reach the Earth's surface with approximately -80.5 dBW of signal strength.[7] In contrast, GPS signals have approximately -160 dBW of signal strength at the Earth's surface. The resulting 80 dB discrepancy between the two signals (weighted heavily in Theia's favor) corresponds to meaningful levels of harmful interference even with Theia's approximate 6.5% pulse duty cycle ("PDC").[8] Specifically, a single Theia satellite with a 6.5% PDC will generate approximately 0.5 dB of C/N_0 degradation in a typical high-precision GPS receiver.[9] However, in the case of multiple interference sources incident upon a GPS receiver, a near-certainty given Theia's plan to operate the active radar feature on 52 satellites on a "nearly continuous" basis,[10] their effect is cumulative, and will result in degradation of C/N_0 far greater than that of a single radar transmitter.

While Theia's application includes a brief, perfunctory assertion that it will not interfere with higher priority services, including GNSS, the Application is devoid of any substantive technical analysis to support this assertion.[11] Nor did Theia avail itself to well-known interference studies developed by the International Telecommunications Union Radiocommunications Sector ("ITU-R") to evaluate the preliminary effect of pulsed interference by non-GNSS sources on GNSS service systems and networks operating in the 1164-1215 MHz, 1215-1300 MHz. Specifically, the ITU-R has developed and published an analytic method for the preliminary evaluation of a single satellite transmitter source of non-GNSS pulsed

---

7 *See Application*, Schedule-S.

8 PDC represents the product of SAR pulse width and repetition rate. Theia's proposed pulse length is 16 µsec and pulse repetition is 3710 Hz, which yields a PDC of 0.0638.

9 Various receiver parameters, including filter bandwidth, may create some variation in the level of signal loss experienced by GPS/GNSS receivers.

10 *Application*, Narrative Exhibit at 3.

11 *See Id.*, Technical Exhibit at. 37.

interference,[12] and an analytic method for preliminary evaluation of the aggregate interference effects of pulsed RF systems on ground-based GNSS receivers in the 1164-1215 and 1215-1300 MHz bands requires further analysis due to the potential for overlapping RF power from multiple sources[13]. Application of these methods for calculating aggregate interference have been performed for existing and proposed EEES (active) sensors[14]. A sincere effort to demonstrate compatibility with higher priority services would have begun with an application of the ITU-R methods. Theia made no such effort.

III. The *De Minimis* EESS Satellite Missions in the 1215-1300 MHz Do Not Support Theia's Sweeping and Unprecedented Proposal to Use the Band for SAR

Theia cannot credibly argue that the *de minimis* SAR operations in the 1215-1300 MHz band serve as a basis for finding its "continuously" transmitting 52 satellite network compatible with higher priority incumbents. Specifically, the Application makes reference to the presence of a discrete Japanese research satellite, the Japan Aerospace Exploration Agency (JAXA) PALSAR-2 payload on the ALOS-2 spacecraft operating at 1215-1300 MHz. As highlighted in **Exhibit A** to this pleading, the PALSAR-2 SAR payload has emission characteristics that loosely approximate those of Theia's SAR payload. While the PALSAR-2 payload does pose an in-band interference threat for GPS and GNSS signals, and GPSIA and U.S. federal interests

---

[12] *See* ITU-R M.2030 (12/2012), available at https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2030-2003-PDF-E.pdf (last visited June 25, 2017). "Evaluation method for pulsed interference from relevant radio sources other than in the radionavigation-satellite service to the radionavigation-satellite service systems and networks operating in the 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz frequency bands."

[13] *See* ITU-R M.2220 (10/2011). available at http://www.itu.int/pub/R-REP-M.2220 (last visited June 25, 2017). "Calculation method to determine aggregate interference parameters of pulsed RF systems operating in and near the bands 1 164-1 215 MHz and 1 215-1 300 MHz that may impact radionavigation-satellite service airborne and ground-based receivers operating in those frequency bands."

[14] *See* WP7C, Document 7C/TEMP/152-E 22 May 2015, available at https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-WP4C-C&question=217-2/4 (last visited June 25, 2017).

have undertaken a painstaking effort to facilitate manual coordination between the PALSAR-2 payload and discrete National Aeronautics and Space Administration ("NASA") missions enabled with SAR payloads. This coordination process ensures that the PALSAR-2 and NASA missions avoid beam overlap and the attendant cumulative harmful interference.

Whereas JAXA and NASA have been able to carefully coordinate the current 2-3 scientific SAR missions that operate in the 1215-1300 MHz band, the introduction of an additional 52 SAR-enabled satellites would dramatically increase the noise-floor in the band. Theia's proposal does not present any plan to coordinate with the GPS and GNSS stakeholders, nor does it deal with the practical impossibility of coordinating Theia's proposed extensive and continuous SAR emissions with existing and planned systems. While U.S. and Japanese agencies have been able to devote the resources and systems required for careful, meticulous coordination of the limited operations in the 1215-1300 MHz band, it is unreasonable to assume that this process can accommodate a super-constellation of spacecraft with SAR payloads that are continuously or nearly continuously transmitting.

IV. Other Radiofrequency Bands Potentially Offer Theia a More Viable Home for the Proposed Synthetic Aperture Radar Payload

The Theia application offers no meaningful explanation for the Applicant's choice of the 1215-1300 MHz band as a potential home for the active, SAR payload. No administration has previously attempted to coordinate and launch a commercial active EESS satellite in the 1215-1300 MHz band, and given the lack of a primary allocation for non-federal use, Theia's proposed SAR emission would always operate on a sufferance basis, with the possibility of a higher-priority service forcing the company to disrupt its operations in the event of an interference

event. GPSIA wishes to make both Theia and the Commission aware of the inevitability of interference in order to avoid such a disruption and loss of revenue.

Other radiofrequency bands may be more accommodating for an NGSO constellation with an active SAR feature. For example, TerreSAR-X (a joint venture between the German Aerospace Center and Airbus) presently operates an imaging satellite enabled with an active SAR payload in the 9.3-9.9 GHz band, along with a handful of other commercial or quasi-commercial spacecraft operators. This band, which does not involve sensitive incumbents such as GPS/GNSS, or another alternative band, may prove to be more apt home(s) for Theia's proposed SAR payload. The Commission should encourage Theia to explore such alternative options for its SAR proposal and unambiguously clarify that no further consideration will be given to its current unsafe and technically unsound proposal to use the 1215-1300 MHz frequency range.

V. Conclusion

Based on the foregoing, the Commission should either deny Theia's Application or defer action until Theia amends the Application and removes the proposals for SAR emissions in the 1215-1300 MHz band.

Respectfully submitted,

/s/

Mark N. Lewellen
GPS INNOVATION ALLIANCE

Dated: June 26, 2017

EXHIBIT A - PALSAR-2/THEIA PAYLOAD COMPARISON

	PALSAR-2	Theia
Transmit EIRP, dBWi	74.5	72.13
Altitude, km	628	800
Transmit frequency, MHz	1236.5, 1257.5, 1278.5	1233, 1240, 1250, 1260, 1270, 1280
Chirp width, MHz	28	16, 32
Pulse length, µsec	37	16
Pulse Repetition Rate, Hz	1860	3710
Pulse Duty Cycle	.069	.0638
Path Loss, dB	150.5	152.6
Receive Power, dBW	-76.0	-80.5

DECLARATION

The foregoing Petition to Deny or Defer action on Theia Holdings A, Inc. non-geostationary satellite system application has been prepared using facts of which I have personal knowledge or upon information provided to me. I declare under penalty of perjury that the foregoing is true and correct to the best of my information, knowledge and belief.

Executed June 26, 2017

Mark N. Lewellen
Secretary of Executive Committee
GPS INNOVATION ALLIANCE

CERTIFICATE OF SERVICE

I, M. Renee Britt, hereby certify that on this 26th day of June 2017, I caused a true and correct copy of the foregoing GPS Innovation Alliance Petition to Deny or Defer to be served via electronic mail and U.S. First Class mail, to the following:

Tom W. Davidson
Jennifer L. Richter
Steven A. Rowings
Akin Gump Strauss Hauer & Feld LLP
1333 New Hampshire Avenue, NW
Washington, D.C. 20036
Counsel for Theia Holdings A, Inc.

/s/ M. Renee Britt

M. Renee Britt, Senior Paralegal