EMC Analysis of MiTEE-1

Summary of MiTEE-1

The MiTEE-1 is a 3U cubesat being launched into orbit at 500-km altitude, and 61 degree inclination. MiTEE-1 is operated from a single ground station location at The University of Michigan, 2455 Hayward Ave, Ann Arbor, MI 48109-2143. The frequency used for space to Earth communication and Earth to space communication is 437.8 MHz. This frequency was selected by the International Amateur Radio Union (IARU). (See first letter in the Appendix.) This report reviews other authorized operators in this frequency range and operating range. It shows that no interference is reasonably expected to occur with the local amateur radio club and no interference with any preexisting operators in our operating range.

Compliance with Local Amateur Radio Operators

Because the operating frequency is in the amateur frequency range, we coordinated with the local amateur radio club in Ann Arbor. The ARROW Communication Association has provided a letter of support, which is the second letter in the Appendix of this report. It states that the University of Michigan ground station will not cause unacceptable interference with local operations.

Compatibility within the Operating Range

ITU radio regulations provide power flux density (PFD) limits, above which coordination with terrestrial and aeronautical mobile systems is required. The PFD thresholds for these terrestrial and aeronautical mobile systems are as follows:

- Terrestrial Services: -125 dBW/m^2/4KHz
- Aeronautical Mobile (R): -125 dBW/m^2/4KHz
- Aeronautical Mobile (OR): -140 dBW/m^2/4KHz

The most critical threshold for the MiTEE-1 satellite is the Aeronautical Mobile (OR) threshold of -140 dBW/m^2/4KHz. For the MiTEE-1 spacecraft in its

nominal orbit, this level may be exceeded on the ground at a distance of less than 1087 km, which can be seen in Figure 1. Also, a calculation was done to analyze the coverage area of the satellite when communicating with the ground as a function of ground antenna elevation angle (see Figure 2). For MiTEE-1, we intend to use a minimum antenna elevation angle of 10^{o}.

The area of coverage is approximately a 2700-km radius of the ground station location. This radius covers the majority of the US, half of Mexico, half of Canada, and all of Cuba and the Bahamas. In addition to this radius for normal communication, there will be a satellite mode for beacon transmission. The beacon PFD will be higher than -140 dBW/m^2/4KHz, so FCC and ITU database searches were conducted across all areas to identify other users near our frequency. Using the Master International Frequency Register (MIFR) and FCC database, one result, California Polytechnic State University, was returned for our frequency range of 437.8 MHz ± 8 KHz. We have communicated with CalPoly, and have determined that there will be no interference between our operations. See Figures 3, 4, and the third letter (email) in the Appendix.

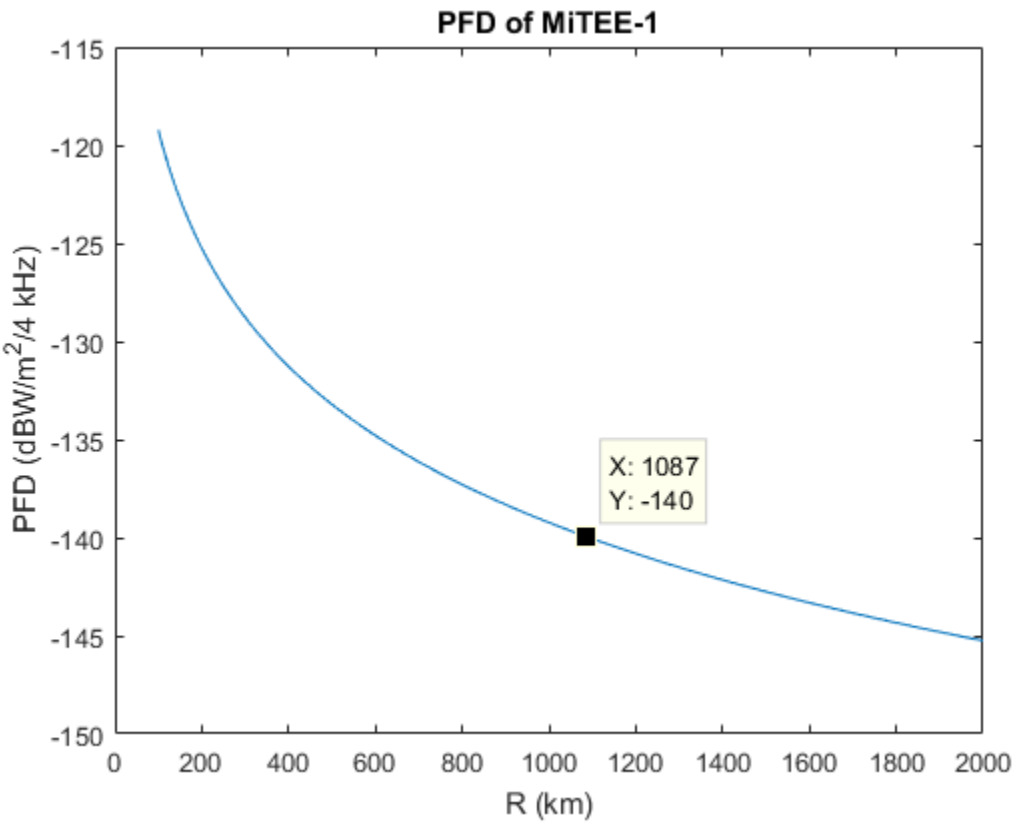

Figure 1: PFD of MITEE-1 over different distances

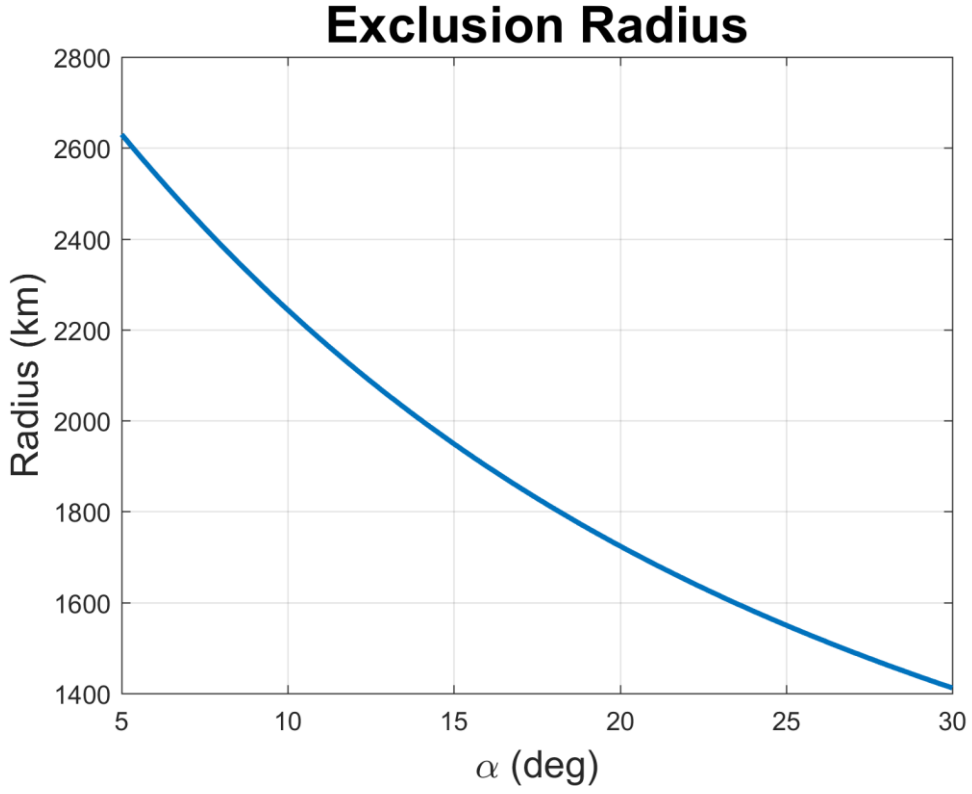

Figure 2: Exclusion radius of MITEE's transmission

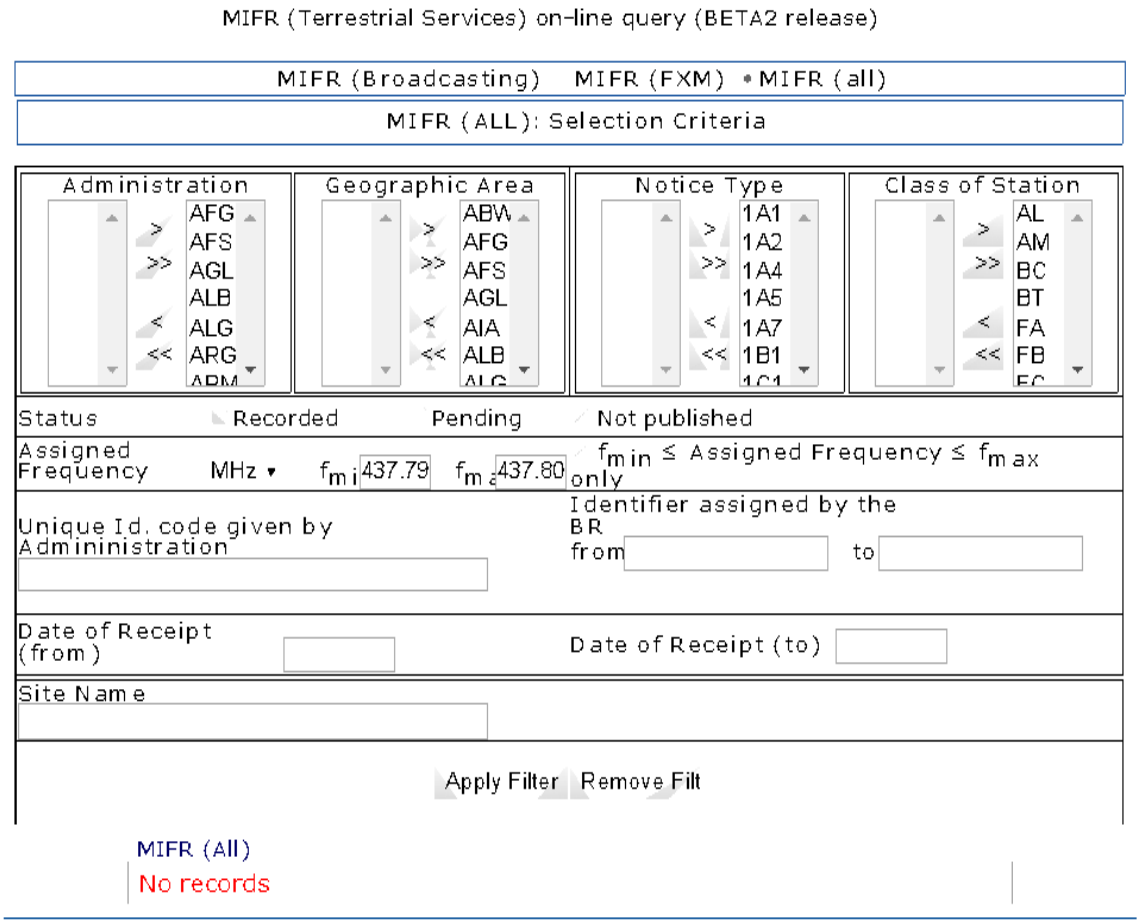

Figure 3: ITU Database Search

Site / Frequency / Market Search Results

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Site / Frequency / Market Search Results

Search Criteria: Frequency Range = 437.792 MHz through 437.808 MHz, Box Search: Start Coordinates = 18° 12' 0" N 66° 39' 52" W End coordinates=71° 28' 0" N 158° 30' 30" W, Currently Licensed and Pending Facilities

OET Experimental Licensing System Database							
Callsign: WI2XPH	File Number: 0042-EX-CN-2016	Licensee: California Polytechnic State University	FRN: 0025303736	Issue Date: 07/13/2017	Expiration: 07/01/2020	Radio Service: XT	Status: Granted
Site Address:	State: CA	County: SAN LUIS OBISPO	Fixed Coordinates: 35° 18' 8" N 120° 39' 55" W		Mobile Coordinates: 35° 18' 8" N, 120° 39' 55" W		
Frequency: 437.80000000 M							

OET Experimental Licensing System Files: 1

Figure 4: FCC Database Search

Appendix

The International Amateur Radio Union

Since 1925, the Federation of National Amateur Radio Societies
Representing the Interests of Two-Way Amateur Radio Communication

Hans P. Blondeel Timmerman, PB2T
Satellite Advisor
Nieuwe weg 21, 4031 MN Ingen, Netherlands
Email: satcoord@iaru.org

Date: 12 December 2016

To Brian Gilchrist

Dear Brian,

This is the IARU frequency coordination for your satellite **MiTEE-1**.

Coordinated frequency for uplink and downlink 437.800 MHz with emission designator 15K3F1D. Note that this frequency is not the requested frequency.
output power 1 Watt.
antenna gain 1 dBi.
Planned launch date: December 2017.
Licensing administration: USA.
Height and Orbit Apogee 500 km, Perigee 500 km, inclination 90 degrees, period 96 min.
Earth Command station location: University of Michigan, Ann Arbor MI, USA.

IARU has coordinated frequencies in a bands allocated to the amateur satellite service. All frequencies in the amateur satellite service are shared frequencies.
Please inform me about the final launch date and the API/A number as soon as that information becomes available.

Best wishes for a successful project.

Hans Blondeel Timmerman
IARU Satellite Advisor

ARROW Communication Association
2545 S. Lima Center Rd
Chelsea, MI 48118

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Dinesh Cyanam, AB3DC
president@w8rp.org

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Secretary
Donald Winsor, AC8TO
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Technical Coordinator
Steve Gladden, N8LBV
tech-coordinator@w8rp.org

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WA8TON/VO1TON
activities@w8rp.org

Public Service Coordinator
Dan Romanchik, KB6NU
public-service@w8rp.org

Trustee Delegate
Thomas Martin, W8TAM
trustee-delegate@w8rp.org

I, Donald C. Winsor, AC8TO, am currently serving as Secretary of the ARROW Communication Association. The ARROW Communication Association is the amateur radio organization representing amateur radio operators in Michigan in Washtenaw and western Wayne counties.

In my role as ARROW Secretary, with the approval of the ARROW board of directors, I hereby recognize and have no objections to the University of Michigan's MiTEE team operating an uplink/downlink satellite ground station at a frequency of 437.800 MHz +/- 8 KHz under an experimental license on the University of Michigan campus. This ground station will not result in unacceptable interference to local amateur operators.

Name: Donald C. Winsor AC8TO

Signature: Donald C. Winsor

Date: 4/13/2018

From: **Justin Nguyen** justinnuwin@gmail.com
Subject: Re: Cal Poly Groundstation Lead
Date: May 4, 2018 at 3:24 PM
To: Brian Gilchrist gilchrst@umich.edu
Cc: Aaron Fielden aaronfielden@sonic.net, Ryan Barnhart ryanbarn@umich.edu, Calvin Shih cshihcal@umich.edu, ICE - Brian brian.gilchrist@umich.edu, Mike Miller mlmiller@sterksolutions.com, John Michael Bellardo bellardo@calpoly.edu

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Hello Brian,

I have consulted with our faculty adviser Dr. Bellardo, also CC'ed to this email, and we agreed that there should not be any interference issues between MiTEE and DAVE.

Best Regards,

Justin

On Apr 26, 2018, at 11:13 AM, Brian Gilchrist <gilchrst@umich.edu> wrote:

> Aaron (and Justin),
>
> Thanks for connecting me with Justin who is your ground station lead. Could I ask one of you to also connect me with the CalPoly CubeSat staff person who likely will need to sign a letter.
>
> So here is the situation…
>
> - To get our license for the MiTEE-1 mission, just a couple of weeks ago or so the FCC asked for an EMC analysis to evaluate for possible interference issues.
>
> - The frequency we were assigned is 437.8 MHz which a search reveals has also been assigned to the CalPoly DAVE mission. Aaron you mentioned that the launch for DAVE is later this fall which is the same time as ELaNA-XX.
>
> - It seems that if our two missions can convince ourselves that interference will not be a big issue and that any interference issues can be managed, then a letter to each other noting this will satisfy the FCC.
>
> As Aaron knows, ELaNA-XX is a 500km circular, polar orbit. MiTEE-1 is using a Li-2 radio with a max power setting of 1W.
>
> Can we coordinate on this soon?
>
> Regards,
> Brian Gilchrist…
> ————————————————————————————————
> Brian E. Gilchrist
> Director, Space Physics Research Laboratory/XTRM Labs, College of Engineering
> Professor, Electrical Engineering and Computer Science Dept
> Professor, Climate and Space Sciences and Engineering Dept
> University of Michigan
> (Work) 734-763-6230, brian.gilchrist@umich.edu
> ————————————————————————————————
>
>> On Apr 26, 2018, at 1:37 PM, Aaron Fielden <aaronfielden@sonic.net> wrote:
>>
>> Hi Brain,
>>
>> This is the email of our ground station lead: Justin Nguyen
>> justinnuwin@gmail.com
>>
>> Hope he can help out more than I can
>>
>> Best,
>> Aaron F.
>> ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
>> Aaron Fielden
>> *Cal Poly SLO Mechanical Engineering Undergrad*
>> (510)-725-0107
>> aaronfielden@sonic.net