The International Amateur Radio Union

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

AMATEUR SATELLITE FREQUENCY COORDINATION REQUEST INSTRUCTIONS AND APPLICATION FORM[1]

1. **Amateur-satellite service.** Amateur stations meet the requirements of the radio regulations[2], RR 1.56. and 1.57.

> **RR 1.56** *amateur service:* A *radiocommunication service* for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized **[licensed]** persons **[individual natural people]** interested in radio technique solely with a personal aim **[for themselves]** and without pecuniary interest **[compensation]**. (NOTE: Explanatory terms in brackets are not part of the treaty text.)
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> **RR 1.57** *amateur-satellite service:* A *radiocommunication service* using *space stations* on earth *satellites* for the same purposes as those of the *amateur service*.

Before asking for help from IARU with frequency coordination in the amateur-satellite service, make sure that your proposed operation meets the treaty requirements. NOTE: “Without pecuniary interest” means that you may accept free will donations of goods and services, that is, with nothing required in return. You may not sell services or data to anyone for any reason.

Ultimately, the decision of whether the proposed operation is appropriate for the amateur-satellite service rests with your country’s administration (your national telecommunication regulator). Therefore, before sending your frequency coordination request to IARU, we suggest that you consult with your administration to determine whether the amateur-satellite service or another radiocommunication service is appropriate for your operation.

2. **Self-coordination.** For over 100 years, amateur radio operators have maintained an effective tradition of self-regulation. Amateurs are expected to coordinate their use of frequencies. (Nobody has any exclusive right to use any particular frequency.) Coordination of many terrestrial stations, repeaters and beacons, for example, usually works well through IARU member national societies and local coordinating committees.

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[1] Terms used here are defined in the radio regulations and repeated in the IARU paper, *Amateur Satellites*. See:. http://www.iaru.org/uploads/1/3/0/7/13073366/iarusatspec_rev15.7.pdf

[2] The radio regulations are annexed to and part of a treaty, the International Telecommunication Convention, to which nearly every country in the world is a signatory party. See: http://www.itu.int/pub/S-CONF-PLEN-2011.

Coordinating satellites. Amateur radio satellites present a special problem because satellites have global effect. Only a global frequency coordination system can work. Uncoordinated satellites will cause harmful interference to stations around the world and receive interference from them — which could result in mission failure.

Coordination serves everyone's best interests!

3. **IARU Coordination procedure.**

a) Frequency coordination for amateur radio satellites is provided by the IARU through its Satellite Advisor, a senior official appointed by the IARU Administrative Council, its top policymaking body. The IARU Satellite Advisor is assisted by an Advisory Panel of qualified amateurs from all three IARU Regions. (Similar to ITU Regions.)

b) It is a mandatory requirement for the IARU coordination that the licensing administration notifies the ITU with the selected frequency assignments/bands for the proposed satellite (ref RR Article 9, sub-section IA[3]). The licensing administration files the Advanced Publication Information (API) with ITU. This should preferably be done prior to the actual frequency coordination by IARU. As a response to this submission, the ITU will assign a special section number (API/A). This API/A special section number must be provided in field 1d of the Frequency Coordination Request form. If this information is not available when the IARU Frequency Coordination Request is filed, please provide the date that you submitted the API information to your administration. Usually an API special section publication appears within two to three months after its submission to ITU. It is important that you encourage your national administration to forward their notice to ITU as early as possible.

Note that for the amateur satellite service, ITU offers this registration without any fee of cost recovery.

c) It is important that all satellites operating in the amateur satellite service are registered with ITU in order to obtain international recognition, something that demonstrates the relevance of the amateur satellite service and protects its frequency allocations. IARU therefore strongly recommends that you work with your national administration and encourage them after the API submission to continue with the submission of the Notification form of notice of the satellite stations when they are brought into use (RR Article 11.2). Assistance with the notification process is provided on the ITU web.

4. **Getting Help.**

a) **Start** by reading *Amateur Radio Satellites*, which is an IARU paper. You will find explanations and interpretations of Treaty provisions. IARU satellite frequency coordination follows these interpretations. Download the latest version from: https://www.iaru.org/wp-content/uploads/2019/12/iarusatspec_rev15.7.pdf

b) **Discuss** your project with the national amateur radio society of your country and your national AMSAT organization, if there is one. They may be able to assist you in a variety of ways.

c) **Use information** available on-line.

i. For a list of national amateur radio societies (Member Societies of IARU), see: http://www.iaru.org/iaru-soc.html.

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3 This applies to non-GSO amateur satellites only. For GSO satellites contact the IARU Satellite Advisor for further guidance.

ii. For a list of amateur satellite organizations, see: https://www.amsat.org/amsats-around-the-world/

iii. A link budget spread sheet is at: http://www.amsatuk.me.uk/iaru/spreadsheet.htm

iv. Check frequencies of currently operating satellites at https://www.amsat.org/status/ Check on coordinated and other planned amateur satellites at: http://www.amsat.org.uk/iaru/.

v. If you need help understanding the requirements or completing the coordination request, ask the Satellite Advisor or a Panel Member.

5. **When to make the frequency coordination request.** Make your frequency coordination request as far in advance as possible. Remember, coordination takes account of your own needs and the needs of others. Receiving coordination early enough makes design and construction easier and less expensive. In any event, be sure to make your request while it is still possible to change operating frequencies in response to the Satellite Advisor's recommendations. A good moment to submit your coordination request would be right after you have done your preliminary Design Review.

6. **Who makes the frequency coordination request?** The prospective space station licensee must make the coordination request, as that person will be responsible for space station transmitter operations.

7. **Where to send your frequency coordination request.** Send frequency coordination requests to the IARU Satellite Advisor by e-mail to satcoord@iaru.org. You should get an acknowledgement that the request has been received within a week.

8. **What will happen?** The IARU Satellite Advisor will make recommendations to the licensee concerning plans based upon all available information and advice from the Satellite Advisory Panel. His goal is to help you and your project to succeed. The current status of your request will be published through the link at http://www.amsat.org.uk/iaru. When the process is complete, the licensee will receive a coordination letter with detailed information. Visit also http://www.iaru.org for information about the IARU and its activities.

VERY IMPORTANT!

CHECKLIST:

1. ☐ **USE THE FREQUENCY COORDINATION REQUEST FORM PROVIDED IN THE PAGES BELOW.**

2. ☐ **NAME THE ELECTRONIC DOCUMENT** you submit with the name of the proposed satellite followed by the submission date. Example: if the name before launch is NewsatA and the document is submitted on 1 August 2017, the document file name should be: “newsata_req 170801.doc.”

3. ☐ **LARGE FILES** should **NOT** be in the request form. **INDICATE** URL’s for pictures, sketches, drawings, and other pertinent information.

4. ☐ **INDICATE** in box number 13 whether or not you feel that the proposed operation in the amateur-satellite service is consistent with the radio regulations as interpreted by the IARU Satellite Advisor. If not, please, explain your interpretation of the radio regulations. Tic only ONE box.

5. ☐ **REMOVE** RED explanatory texts in the form below.

6. ☐ **LICENSEE** must sign and date the form in boxes 3.8, 6.4 and 14.

7. ☐ **SUBMIT THE COMPLETED FORM** as soon as possible, **do NOT submit the request before it is 100% complete and signed**. Incomplete and unsigned requests will NOT be assessed by the IARU frequency coordination panel.

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AMATEUR SATELLITE FREQUENCY COORDINATION REQUEST

(Make a separate request for each space station to be operated in the amateur-satellite service.)

	Administrative information and document control	
1.1	Date of this submission	13-Jul-2020
1.2	Submission revision number	V.0.1

	Spacecraft identification	
2.1	Name	Multiview Onboard Computational Imager (MOCI)
2.2	Notifying administration	FCC
2.3	API/A number	FCC license applied for on June 30, 2020.

	Licensee of the space station or responsible amateur in case of educational mission	
3.1	First (given) name?	Claire
3.2	Last (family) name?	Venenga
3.3	Amature Radio Call Sign	KN4PMV
3.4	Licensed since?	10/11/2018
3.5	Postal address?	210 Field St #204, Athens, GA 30602
3.6	Telephone number (including country code)?	(678) 907-7857
3.7	E-mail address?	cvenenga@uga.edu
3.8	By signing here, the licensee accepts that, except for the telecommand information, the	Signature: Claire Venenga

	IARU may publish all the information contained in this application.	Date: 07/21/2020

	Organizations — complete this section for EACH participating organization	
4.1	Name of organization and/or educational institution?	The University of Georgia Small Satellite Research Laboratory
4.2	Licensee's position in any organization referenced in item 4.1?	Mission Operations Lead
4.3	Postal address?	Geography Department c/o David Cotten 210 Field Street Athens, GA 30602 U.S.A.
4.4	Telephone number? (including country code)	+1 (706) 542-2485 (building management), +1 (706) 542-2374 (PI-David Cotten work phone)
4.5	E-mail address?	dcotte1@uga.edu
4.6	Web site URL?	http://www.smallsat.uga.edu/
4.7	National Amateur Radio Society (including contact information)?	**National** – None from national society **Local** – Athens Radio Club (Affiliate of ARL) Jess Hickey (N4JAH) N4JAHradio@gmail.com (706) 353-2127 See link "ARC Letter of Support (UGA Small Sat).pdf" for a letter of support
4.8	Does your National Amateur Satellite organization and/or National Amateur Radio Society endorse this request?	National AMSAT Organization ☐yes ■no National Amateur Radio Society ■yes ☐no
4.9	Name and email address(es) of the person(s) you've contacted in the National AMSAT Organization or National Amateur Radio Society?	Name:Jess Hickey (N4JAH) Email:N4JAHradio@gmail.com Name: Andrew Glasbrenner Email: glasbrenner@mindspring.com See link "ARC Letter of Support (UGA Small Sat).pdf" for a letter of support

4.10	Will any person or organization involved with the project be, directly or indirectly, financially compensated for operating the satellite and ground station(s)?	☐yes, see 4.11 ■no
4.11	If you've answered yes in 4.10, please explain:	N/A

	Space station mission and frequencies	
5.1	Type of mission? Tick applicable box(es):	☐Amateur ■Amateur combined with Educational ☐Amateur combined with other mission(s)
5.2	If mission type in given in 5.1 is Amateur combined with other missions, will the transmitters or receivers operating in the amateur radio frequencies be used to control, or retrieve data (telemetry, payload, etc.) from, the non-amateur mission sub-systems?	☐yes, see 5.3 ■no
5.3	If you've answered yes in 5.2, please explain:	N/A
5.4	List and describe the project mission(s):	MOCI (Multi-view Onboard Computational Imager) is a 6U satellite designed to create 3D models of structures using SfM calculations. The satellite is built and operated by undergraduate students at the University of Georgia (UGA) who are directly involved in K-12 outreach within the community and work with the Athens Radio Club which is why the satellite will also serve as a store-and-forward satellite for amateur radio enthusiasts. The stack contains The Ruda Cardinal Optical Train with Imperx and Blackfly. The rest of the stack consists of Clyde Space (OBC, EPS), ISISpace (UHF antennas), COTS (GPU), F'Sati (Sband Transmitter, and

		UHF Transceiver), and custom parts (three interface boards). The solar panels are constructed in-house with solar cells from CESI. The MOCI mission will acquire imagery of the Earth's surface from(Low Earth Orbit (LEO) and perform near real time Structure from Motion (SfM) at a landscape scale using custom algorithms and off the shelf, high performance computational units. The MOCI mission will also identify and map or image surface objects, including but not limited to coastal environment phenomena, while training students in STEM-related fields. Efficient data compression, feature detection, feature matching, and SfM processing techniques of space-based imagery will be performed on board the spacecraft as a proof-of-concept of high performance, on board processing capabilities. 3D models produced by the MOCI satellite will take the form of Digital Surface Models (DSM) as their end product for quick data downlink. The secondary goals of the project will be to lay the foundations for a self-sustaining Small Satellite Research Laboratory (SSRL) at UGA involving numerous students at the University and creating a free repository of imagery. In addition, the SSRL will engage with the public through guest lectures and the development of outreach programs such as workshops, instructional YouTube videos, educational podcasts, and performing guest lectures at local schools and events. For the current mission MOCI shall: 1. Run on-board Structure from Motion (SfM) of target areas and transmit the processed data using customized compression techniques; 2. Identify algal blooms and sediment plumes in order to track their growth, size, and location;

		3. Map the coastal regions of the Eastern United States for marsh phenology, land use, and off coast water quality; 4. Train students in STEM related fields by having them investigate optimal data transmission techniques, georeference imagery for mapping, conduct photogrammetric processing of images acquired from the satellite, develop community outreach programs, and learn general aerospace manufacturing/testing/designing skills. 5. Host a UHF repeater on board to benefit the greater amature radio community. The UGA SSRL is a student-run research lab, with oversight from a faculty support group. Apart from requirements, which are formulated in collaboration with faculty, the undergraduate team conducts all design decisions, reviews, and also, in the case of the author of this document, handles the licensing process. Members are taught the full engineering process, from requirements development to the delivery of a final design and launch-ready satellite. Once the satellite is in orbit, the UGA SSRL Mission Operations team members, all undergraduates and all amature radio operators, will command and control the satellite. A full, current list of operators can be found within this document. Currently, the mission plan dictates that only telecommands shall be encrypted. All science data and beacon telemetry will be unencrypted. This is in order to contribute something of experiential or educational value to our local amateur (ham) radio community. The science data collected by the mission operators will undergo processing, and then be stored for use by anyone who requests

		access. The UGA Geography Department will analyze it and use it in the classroom and for local outreach events. In addition to the space-oriented portion of the mission, the UGA undergraduate team has also built the Center for Orbital Satellite Mission Operations (COSMO), to communicate with space stations. This endeavor was funded by the Center for Teaching and Learning at UGA and the Parents and Families Outreach Program at UGA, with the intention to provide licensed students access to high quality radio equipment. These students will be rigorously trained to operate spacecraft. In addition to the student contribution to COSMO, we have also received a significant amount of help from the Athens Radio Club (ARC). Once fully operational, the SSRL will collaborate with the ARC to plan outreach events to demonstrate COSMO's abilities, and to inspire future radio enthusiasts. In summary, this project is an educational and scientific mission to allow students hands-on experience with the breadth of satellite development. This includes the training of students to 1) design and build spacecraft, 2) operate spacecraft, and 3) to interact with the local community as they fulfil the mission success criteria. To the community at large, we will offer a platform to listen to spacecraft, process specialized imaging products, hold outreach events, and use the satellite as a repeater. The telecommand and telemetry beacon will operate on the UHF band, while science data will downlink on the S band. Specifically, the frequencies are as follows: ● 437.35 MHz (UHF) ● 2.4105 GHz (S-band)

5.5	Explain in plain text how your mission(s) complies with provisions no. **1.56**, **1.57** and **25** (see Annex 1); how will your mission contribute to the advancement of the amateur satellite service; and how will amateur operators around the globe be able to participate in your mission, besides just receiving the satellite telemetry?	Since our lab's founding in 2015, one of our main goals was to benefit and involve both the education and amateur community through all aspects of the mission from development to downlink. We plan to operate under the amateur + educational coordination category for the reasons listed below. • We currently have a Small Satellite course at the University which, as a part of its curriculum, covers satellite communication and frequency allocations. This course is for both undergraduate and graduate students and typically has students from engineering, physics, mathematics, geography, business, and law. • Within the Small Satellite Research Laboratory have individual research courses where undergraduate student are learning about radio wave propagation, RF communication, and writing packet protocols for data uplink and downlink. • We also work closely with the amateur radio community by attending monthly meetings, participating in their field days, and recently leading the February 2020 meeting. We always want to do more to improve our knowledge of the amateur radio community and to expand its reach. • To that point MOCI will also have the ability to act as a store-and-forward satellite for amateur radio enthusiasts. This gives the global community the ability to send data up to our satellite where it will be stored and re-transmitted at a user specified time. This has the current and past lab students the most excited because it allows everyone to interact with the satellite even after they have left the university. • Furthermore we host numerous elementary/middle/high school outreach events where we share our

		passions with local students and bring them into the lab to track and communicate with amateur satellites.In the past 4 years we reached over 1800 K-12 students. • Additionally, 15 of our 40 current lab members have their ham radio licenses, along with 19 previous members who have graduated. Due to these programs, we hope that our satellite will be able to operate under amateur radio bands because we want to be a direct link to the greater amature radio community.
5.6	Amateur satellite bands used:	☐144-146 MHz X 435-438 MHz ☐1260-1270 MHz ☐2400-2450 MHz ☐3400-3410 MHz ☐5650-5670 MHz and/or 5830-5850 MHz ☐10.450-10.500 GHz ☐24.000-24.050 GHz ☐Other (please list)
5.7	Planned duration of each part of the mission?	5/1/2021-10/31/2023
	Proposed space station transmitting (space-to-Earth and/or space-to-space) frequency plan. Provide the following information for each frequency or frequency range:	
5.8	List all the frequencies (or frequency bands) requested and describe the function of each:	437.35 MHz (UHF) – Beacon and downlink of telemetry. 2.4105 GHz (S-band) – Downlink of critical mission data.
5.9	Frequency tuning range (in MHz) of transmitter and tuning step increment (in Hz or kHz)?	UHF: 430-440 MHz adjustable in 25 kHz steps S-band: 2.4-2.45 GHz adjustable in 500 kHz steps
5.10	E.I.R.P (in dBm) of each transmitter?	UHF: -3.5 – 3.0 dBW S-band: 1.5 – 7.5 dBW
5.11	List all ITU emission designator for each	UHF: F1DB 4k80 S-band: G1DB 2M70

	transmitter:	
5.12	Common description of the emissions including modulation type AND data rate?	UHF: 9600 baud, GMSK, AX.25 S-band: 2 Mbaud, QPSK, IESS-308
5.13	Type of antenna, antenna gain and radiation pattern?	UHF: ISIS Turnstile antenna with 0dBi gain S-band: F'Sati SANT patch antenna with 8dBi gain
	Proposed space station receiving (Earth-to-space and/or space-to-space) frequency plan. Provide the following information for each frequency or frequency range:	
5.14	Requested receive frequency and function?	437.35 MHz for receiving commands from the ground
5.15	Frequency tuning range (in MHz) of receiver and tuning step increment (in Hz or kHz)?	437.35 MHz range at 12.5 kHz steps
5.16	ITU emission designator for each transmitter and emission type?	F1DB 4k80
5.17	Common description of the emission including modulation type AND data rate for each transmitter and emission type?	Data rate of 9600 bps, GMSK
5.18	Noise temperature for each receiver onboard the satellite?	41.9K
5.19	Associated antenna gain and radiation pattern for each receiver onboard the satellite?	0dBi turnstile antenna
	Other information	
5.22	Physical structure of the space station, including dimensions and mass?	**UHF Turnstile Antenna** ● 102 x 228 x 6.6 mm undeployed ● 442 x 568 x 6.6 mm deployed ● 115 grams

		- Placed on the zenith 2U end of 6U Cube Satellite **S-band Patch Antenna** 89 x 81.5 x 4.1 mm 50 grams - Placed on Nadir facing 2U face of 6U Cube Satellite
5.23	Functional Description of each satellite sub-system, including non-amateur payloads?	**Payload:** The MOCI payload sub-system gathers images of targets on Earth and runs a series of computations on said images in order to generate 3D surface models of the targets. The payload is comprised of several components: **Core GPU Interface (CORGI):** A student-made board that allows the onboard NVIDIA Jetson TX2i GPU, which runs the image processing algorithms on gathered data, to interface with the main PC104+ bus of the CubeSat. The CORGI communicates with both the cameras and onboard computer (OBC) to handle image/DSM requests. **Optical Train:** Consists of a B&W camera (Imperx Cheetah) and a color camera (FLIR Blackfly) within a lens housing that is manufactured by Ruda Cardinal. Interfaces with the rest of the CubeSat via the camera interface board. **Camera Interface Board:** A custom board with USB and SPI interfaces that allow the cameras to communicate with both the TX2i and the OBC, in case of TX2i failure. **CD&H:** The MOCI CD&H sub-system is the command and data handling subsystem. This subsystem handles the flow of information and handles the spacecraft communications

		● **Clyde Space OBC**: This component handles the flight software and acts as the "brain" of the satellite. It communicates with all other components and stores necessary data. ● **F'Sati UTRX**: This component is the UHF transceiver and nominally handles just the telemetry and telecommands. The transceiver will receive and transmit all data from and to the ground. Ham licensed undergraduate and graduate students will generate operational schedules and uplink them to the satellite and process all downlinked telemetry. ● **F'Sati STX**: This component is the S-band transmitter. The transmitter will nominally transmit payload data to the ground. **EPS:** The Electrical Power System provides power for the entire satellite. In addition, the EPS is responsible for generate and store power through solar panels in batteries. ● **Clyde Space EPS 3G (XUA)**: This is the EPS motherboard. Equipped with power regulators and switches, this connects with solar panels to generate and condition incoming power. In addition, it works with the battery to provide a constant energy source for the rest of the satellite. ● **Clyde Space 80Whr Battery**: This component stores energy generated by the solar cells and provides power to the motherboard so it can properly generate the necessary voltages on the spacecraft bus. In addition, all spacecraft inhibits interact with the batteries directly to ensure that the satellite does not power up prematurely. ● **Custom Solar Panels**: The cells are purchased from CESI and made into

		panels at UGA. These components simply generate power from the sun. **ADCS:** The Attitude Determination and Control System is responsible for the accurate pointing and positioning of the spacecraft. CubeSpace provides a complete ADCS solution: ● **CubeSpace CubeComputer:** Onboard computer dedicated to ADCS control and communication with the stack. ● **CubeSpace CubeSense:** Consists of nadir and sun sensors for attitude determination. ● **CubeSpace CubeControl:** Encompasses the rate sensors and magnetic torquers, which help determine and control spacecraft attitude, respectively. ● **CubeSpace CubeStar:** Module for the star tracker, another attitude determination sensor. ● **CubeSpace CubeConnect:** Interfaces the rest of the solution with the reaction wheels (which help control attitude), the CubeSense module, and the CubeStar.
5.24	Electrical Power budget. (average power consumption and power generation in Watts)?	Average Power Consumption: 3.2 W Average Power Generation: 6.72 W
5.25	Method of attitude stabilization (if used)?	Attitude stabilization via reaction wheels and magnetorquers
5.26	Service area?	Worldwide

	Encryption of downlink?	
6.1	Will all transmissions from the satellite have published and	■yes ☐no, see 6.2

	publicly available details on the project web site? (Note: The signal **must not** be effectively encrypted by not providing the necessary information. See No. **25.2A** in Annex 1)	**Lab Website:** www.smallsat.uga.edu/ We *will* publish all transmission formats at the URL www.smallsat.uga.edu/moci
6.2	If you've answered no in 6.1, please explain:	N/A
6.3	Contact details of the person responsible for publishing the descriptions of modulation, protocol, format, etc.?	Dr. David L Cotten dcotte1@uga.edu 706-542-2374
6.4	By signing here, the responsible person listed in 6.3, agrees that the details required in 6.1 will be made publicly and freely available.	Signature: Date: 07/13/2020

	Telecommand Information (NOT published)	
7.1	Telecommand station amateur radio callsign?	**Student License Callsigns:** (Default) Claire Venenga - KN4PMV Alexandria Lin - KM4MJP Jack McDaniels - KO4BVU Conor McFerren - KN4SIT Andrew Decker - KO4ALM Sean Krautheim - KO4BVW Cole Hooper - KO4ANL Sydney Whilden - KM4YHF
7.2	Physical location of station antennas, including latitude and longitude?	33°56'55.2"N 83°22'31.8"W
7.3	Proposed space station telecommand frequencies?	437.35 (UHF)
7.4	List all ITU emission designators for each transmitter:	F1DB 4K80

7.5	Common description of the emission including modulation type AND data rate?	430-440 MHz adjustable in 12.5 kHz steps with a data rate of 9600 bps GMSK
7.6	Radio Link budget(s):	See attached links to “MOCI Link Budget - UHF”, “Link Budget - S”, and “Link Budget Overview”
7.7	A general description of any telecommand encryption:	We will use AES 256 to ensure telecommands to the satellite are from approved ground stations.
7.8	Explain how telecommand stations will turn off the space station transmitter(s) immediately, even in the presence of user traffic and/or space station computer system failure. See No. **22.1** in Annex 1.	The SSRL will control the transmit capability using three levels of redundancy. First, the SSRL will attempt to power down the transmitter via a telecommand. The next level of redundancy is in order to mitigate user traffic or congested airways. The SSRL will coordinate with the Athens Radio club to send telecommands to the MOCI satellite from varying locations. The third level of redundancy is in case the on-board computer fails. The EPS of the satellite will power cycle the entire system. If the onboard computer powers on then operations will proceed as in the first two cases. Otherwise the system will remain in an attempted boot mode and will not be able to transmit.
7.9	Explain the mechanism to ensure the space station is turned off in the event communications is lost with the command station.	A software task is run onboard the spacecraft that times out if no communication (i.e. commands) are sent to the spacecraft after a predefined period of time. In the case that the ground station is no longer able to communicate with the spacecraft through any means, when this task timeouts, the spacecraft is placed in a safe mode. In safe mode, without further ground intervention to place the spacecraft in a more operational state, the spacecraft will slowly approach an end-of-life stage as battery voltage is unable to be recovered efficiently over a longer period of time.

	Telemetry frequencies	
8.1	All amateur telemetry	437.35 MHz (UHF)

	frequencies or frequency bands used in the mission?	
8.2	ITU emission designators:	F1DB 4K80
8.3	Common description of the emission including modulation type AND data rate?	430-440 MHz adjustable in 12.5 kHz steps with a data rate of 9600 bps GMSK.
8.4	Radio Link budgets:	See attached links to “MOCI Link Budget - UHF”, “Link Budget - S”, and “Link Budget Overview”
8.5	Transmission formats e.g. AX25 etc.? Provide any other details required to understand the telemetry transmission:	UHF - AX.25 Sband - Intelsat IESS-308 For in-depth instructions of how to use MOCI data, see “Transmission Formats” for the latest information.

	Launch plans	
9.1	Launch agency?	Name of launch agency
9.2	Launch location?	Name and location of spaceport
9.3	Expected launch date?	dd-MMM-yyyy, or estimate in case exact date is not yet known.
9.4	Planned orbit apogee?	400 +100/-150 km
9.5	Planned orbit perigee	400 +100/-150 km
9.6	Planned orbit inclination	50 +/- 15 deg
9.7	Planned orbit period	Planned orbit parameters
9.8	List other amateur satellites expected to share the same	List all other amateur satellites that you know about may be sharing the same launch. (This is important for

	launch (if known):	frequency coordination to avoid problems between satellites when they are physically close together.)

	Typical Earth station — transmitting	
10.1	Describe the hardware and software of a typical Earth station to transmit signals to the planned satellite:	The Earth station with the capabilities to transmit a signal to the MOCI satellite must have a UHF transmitter with an EIRP of 1000 W. The Earth Station must then transmit a GMSK signal at 9600 baud utilizing the AX.25 packetization format. The data encapsulated in the AX.25 is encrypted so the Earth Station would encrypt the telecommand with the Advanced Encryption Standard (AES) 256 with key-hashed message authentication code (hmac). This is to restrict tasking of the MOCI satellite to the University of Georgia Small Satellite Research Laboratory students.
10.2	Radio Link budget. Show complete link budgets for all Earth station transmitting frequencies, except telecommand.	See attached link to “MOCI Link Budget - UHF”

	Typical Earth station — receiving	
11.1	Describe the hardware and software of a typical Earth station to receive signals from the planned satellite.	The Earth Station to receive comes in two categories. The first is to receive the satellite beacon, and the second is to receive image data. To obtain beacon data, the receive station must be able to receive a 2W EIRP signal from at most a 500 km orbit. This signal is a 9600 baud AX.25 packet with no encryption. Once the signal is demodulated, the desired data will be available. For receiving image data, the Imagery will be the same format as the beacon. The Small Satellite Research Laboratory will the use acquired data to share, teach, and process for maximal educational use.
11.2	Radio Link budget. Show complete link budgets for all Earth station receiving frequencies.	See attached links to “MOCI Link Budget - UHF”, “Link Budget - S”, and “Link Budget Overview”

	Additional information: Do not attach large files. Indicate the URL where the information is available.
12	The Small Satellite Research Laboratory at the University of Georgia is a student operated lab satellite lab. Operations of the satellite will be conducted by amateur licensed individuals for the primary purpose of their education. Data from the satellite will be unencrypted and easy to receive from ham enthusiasts. In addition, we have the support of the Athens Ham Radio Club and work directly with them frequently. All licensed lab members are also members of this club. Faculty and Staff of the SSRL will not operate the ground station and will serve only as advisers to educate students in satellite mission control. Faculty will also use the satellite as a teaching tool for current and future coursework. Through these courses' students will learn about satellite operations and the specifics involving data collection and communication from a space-based imager. This will aid in teaching students the proper ways to calibrate image data, geolocate imagery, and also teaching them about photogrammetric techniques and multispectral image processing. At a broader scale our satellite will be a central part of the UGA Physics and Astronomy Open House, and other outreach events hosted by the SSRL where people from the community will come to the lab to learn about satellite tracking, telemetry data, and how we downlink data. More information about the SSRL can be found at http://smallsat.uga.edu.

	Certification: **Please tick ONE appropriate box.**
13	■The licensee of the planned space station has reviewed all relevant laws, rules, and regulations, and certifies that this request complies with all requirements as understood by IARU to the best of his/her knowledge and confirms to meet the requirements of RR 1.56 and RR 1.57 in that the proposed satellite will operate without pecuniary interest. **Please list any commercial interests. If none, please state none.**
	☐The licensee of the planned space station has reviewed all relevant laws,

	rules, and regulations and disagrees with IARU interpretations of Treaty requirements. The IARU Satellite Advisor is asked to consider the following interpretation. Explanation follows.

	Signature	
14	Signature of space station licensee Claire Vuuya	Date 07/21/2020

Document History
29/4/2020: Revision of V39

Annex 1: Extracts from the ITU Radio Regulations

1.56 *amateur service:* A *radiocommunication service* for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest.

1.57 *amateur-satellite service:* A *radiocommunication service* using *space stations* on earth *satellites* for the same purposes as those of the *amateur service*.

ARTICLE 25

Amateur services

Section I − Amateur service

25.1 § 1 Radiocommunication between amateur stations of different countries shall be permitted unless the administration of one of the countries concerned has notified that it objects to such radiocommunications. (WRC03)

25.2 § 2 1) Transmissions between amateur stations of different countries shall be limited to communications incidental to the purposes of the amateur service, as defined in No. **1.56** and to remarks of a personal character. (WRC03)

25.2A 1A) Transmissions between amateur stations of different countries shall not be encoded for the purpose of obscuring their meaning, except for control signals exchanged between earth command stations and space stations in the amateur-satellite service. (WRC03)

25.3 2) Amateur stations may be used for transmitting international communications on behalf of third parties only in case of emergencies or disaster relief. An administration may determine the applicability of this provision to amateur stations under its jurisdiction. (WRC03)

25.4 (SUP - WRC03)

25.5 § 3 1) Administrations shall determine whether or not a person seeking a licence to operate an amateur station shall demonstrate the ability to send and receive texts in Morse code signals. (WRC03)

25.6 2) Administrations shall verify the operational and technical qualifications of any person wishing to operate an amateur station. Guidance for standards of competence may be found in the most recent version of Recommendation ITUR M.1544. (WRC03)

25.7 § 4 The maximum power of amateur stations shall be fixed by the administrations concerned. (WRC03)

25.8 § 5 1) All pertinent Articles and provisions of the Constitution, the Convention and of these Regulations shall apply to amateur stations. (WRC03)

25.9 2) During the course of their transmissions, amateur stations shall transmit their call sign at short intervals.

25.9A § 5A Administrations are encouraged to take the necessary steps to allow amateur stations to prepare for and meet communication needs in support of disaster relief. (WRC03)

25.9B § 5B An administration may determine whether or not to permit a person who has been granted a licence to operate an amateur station by another administration to operate an amateur station while that person is temporarily in its territory, subject to such conditions or restrictions it may impose. (WRC03)

Section II − Amateur-satellite service

25.10 § 6 The provisions of Section I of this Article shall apply equally, as appropriate, to the amateur-satellite service.

25.11 § 7 Administrations authorizing space stations in the amateur-satellite service shall ensure that sufficient earth command stations are established before launch to ensure that any harmful interference caused by emissions from a station in the amateur-satellite service can be terminated immediately (see No. **22.1**). (WRC03)

ARTICLE 22

Space services[3]1

Section I − Cessation of emissions

22.1 § 1 Space stations shall be fitted with devices to ensure immediate cessation of their radio emissions by telecommand, whenever such cessation is required under the provisions of these Regulations.

[3]1 **A.22.1** In applying the provisions of this Article, the level of accepted interference (see No. **1.168**) shall be fixed by agreement between the administrations concerned, using the relevant ITUR Recommendations as a guide.