

CCP-CNB-00042-PRJ-RP-B--RAC-endorsement-application-form

For revision B, July 13, 2020, updates were on the names and call signs of the radiocommunications team.

Application for RAC endorsement for a satellite using amateur frequencies

The primary purpose of this form is to obtain endorsement from Radio Amateurs of Canada (the Canadian national amateur radio membership organization) to be used in filling out the IARU amateur radio frequency coordination request form (a prerequisite for using amateur radio frequencies for satellite communications). There is more detailed information attached to the end of this form, including links to the IARU coordination request form and related documents.

Rather than make many changes to the format of this document, the only change is to insert two blank lines before each RAC question.

Name, amateur radio call sign and email address of the licensee of the amateur radio station on the satellite (this person must hold an Advanced amateur qualification):

Name: Brent Robert Petersen

Last name: Petersen

Given Names: Brent Robert

Personal Call sign: VE9EX

CubeSat NB's New Brunswick ground station club call sign: VE9CNB

CubeSat VIOLET's club call sign, if allowed: VE9VLT

Email address: b.petersen@ieee.org

If different from the above, name, call sign and email address of the ground station licensee (also holder of an Advanced qualification):

It is the same as above.

Names and call signs (if known) of other members of the radiocommunications team (Amateur radio operator qualification will be required for anyone who operates the ground station; Advanced qualification is not required for operators other than the station licensee):

Bruce Colpitts, VE9ENG

Sarah Siddiqua, VE9SSB

Alex Voisine, VE9REX

Benjamin Wedemire, VA6RAB

Stephen Downward, VE9QLE

Yassine Bouslimani, VE9ING

Will any of these persons receive financial compensation for performing radiocommunications in support of the project? If so, please explain:

No.

Purposes of the project, with estimated relative proportions (amateur, educational including student research, professional research, testing on behalf of commercial or professional interests, ...):

The purposes of the CubeSat NB's CubeSat, named VIOLET, are student education, educational research, radio amateur use, and radio amateur education. Payloads on the satellite will perform the functions described below.

The radio amateur purposes of VIOLET are to allow amateurs to communicate with others around the world in VHF/UHF and S bands and motivate the use of the S band radio amateur frequencies. Two communication systems on VIOLET that enable this are the VUB (VHF/UHF Board) and the SBU (S-Band Unit). These functions are further described in a later section.

There are two main educational research purposes of the project.

One is for a mission payload called GRIPS (GNSS Receiver for Ionospheric and Position Studies) which will record and transmit raw GNSS observations to be used in the study of Earth's upper atmosphere.

The second mission payload, SASI (Spectral Airglow Structure Imager) records images of the middle and upper atmosphere to capture phenomena that occur here that affect the circulation of the atmosphere and the movement of the energy and constituents.

The attitude control system of VIOLET will include a permanent magnet in order that VIOLET predominantly points north and south, much like a compass. This allows SASI mostly to capture images tangential to the surface of the Earth, in order that airglow is imaged, but the surface of the Earth is not imaged.

CubeSat NB is one of fifteen teams selected for the Canadian CubeSat Project (CCP) which gives CubeSat NB additional objectives. These are to train highly qualified personnel, increase student interest in STEM (Science, Technology, Engineering and Math) particularly in the space domain, develop student expertise in space domains, give students hands-on experience and advance space science and technology.

If these purposes include any industrial, business or professional purposes, please explain:

CubeSat NB is primarily focussed on student education. There are no direct industrial and business activities, but the extent that business is involved in CubeSat NB is described below in the context of our funding and support.

List of organizations and institutions participating in the project, with a description of their roles (cash grants, donations of equipment or facility time, any considerations they expect to receive from the project, financial interests in the data to be obtained from the satellite, ...):

The cash funding of the project comes equally from the Canadian Space Agency (CSA) and the New Brunswick Innovation Foundation (NBIF) from approximately May 2018 until March 2022. It is approximately \$200,000 from each. NBIF funding is intended to be of benefit to the province of New Brunswick. CubeSat NB's primary purpose of student education includes education of students about entrepreneurial activities. In 2014, the University of New Brunswick got an award for the most entrepreneurial university in Canada. A significant contributor to that award was the Master's Degree Program in Technology Management and Entrepreneurship (MTME), in which each student must start a business in order to get their degree. NBIF funding includes partial support of two MTME students who are to take their participation out of the CubeSat NB education and into an innovative and entrepreneurial direction.

CubeSat NB is a first-of-its-kind partnership among the New Brunswick Community College (NBCC), the Université de Moncton (UdeM), and the University of New Brunswick (UNB). Those three institutions have contributed \$375,000 in terms of cash and in-kind contributions. Some of the research grants of participating faculty members are from the Natural Sciences and Engineering Research Council (NSERC) and these grants require that research and results not be directly involved in a for-profit business.

CubeSat NB hosted a Preliminary Design Review (PDR) as shown at

<https://www.unb.ca/initiatives/cubesat/events/pdr.html>

and RAC was involved as shown at:

<https://www.rac.ca/rac-attends-canadian-cubesat-meeting-in-fredericton/>

To reduce the cost of hosting the event and providing food, sponsorships were sought.

Approximately \$5000.00 was obtained from UNB, the New Brunswick Section of the Institute of Electrical and Electronics Engineers (IEEE), the Atlantic Canada - Aerospace & Defence Association (AC-ADA), the company Spirent, and the company Testforce.

Finally, CubeSat NB is in the process of receiving sponsorship, a donation, from Valispace which provides project management software. See

<https://www.valispace.com/>

<https://cubesatnb.valispace.com/login>

Amateur frequency bands proposed to be used by the satellite (144 MHz, 435 MHz, 2.4 GHz, etc.) for telecommand, telemetry, beacons, and communications links (up and down):

VIOLET plans to use these frequencies with the VUB and SBU:

VHF to VIOLET: 145.8 - 146.0 MHz

UHF to Earth: 435 - 438 MHz

S band to VIOLET: 2433 - 2438 MHz

S band to Earth: 2403 - 2408 MHz

The reason for multiple radio interfaces came out of a risk assessment. The hardware for SBU is all custom, higher speed, but has a higher risk of failure. The students will design, build and test the SBU. The hardware for the VUB is planned to be purchased from a bus provider.

Will any of these communications (other than telecommand uplinks) be encrypted? If so, please explain:

Other than telecommand uplinks, communications will not be encrypted; however, the airglow images from SASI require a comment. On December 21, 2019, CubeSat NB submitted a technical questionnaire to CSA regarding VIOLET and the RSSSA. On February 12, 2020, CubeSat NB received a notice from CSA that it may proceed with the RAC Endorsement part of the RF Licencing process.

Will the satellite carry an amateur radio transponder or repeater that can be used by other amateurs for intercommunications? If so, what modes of communication will be supported (FM, SSB, CW, digital voice, AX.25 or other data, ...)?

The communication needs of VIOLET are shared three ways: GRIPS, SASI and amateur radio communication. GRIPS will gather its research data until memory is full and transmit the data to Earth. SASI will gather its research data until memory is full and transmit the data to Earth. The amateur radio communication will be enabled until VIOLET's battery is drained to the point where it must be re-charged. GRIPS and SASI have so much data that the S band link will be used to send the data to Earth. The current plan has GRIPS and SASI gathering and transmitting data for about 14.5 orbits per day and the amateur radio communication being used for one orbit per day.

The amateur radio communication will alternate between S band and the VHF-UHF frequencies, on different days. With the VHF-UHF frequencies, communication will use an FM transponder, which is part of that bus provider's board. Both the VHF receiver and UHF transmitter may operate at the same time. Consequently, it would be easy for amateurs to communicate with amateurs by voice using the popular VHF and UHF frequencies. One of the radio amateurs listed in this document offered to re-write their AX.25-based bulletin board for VIOLET.

Amateur communication with the SBU would be in one orbit due to VIOLET being energy limited; discharging VIOLET's 40 Watt-hour (W-hr) battery to its recommended limit of 30 W-hr, gives 10 W-hr to the SBU which consumes 20 W and thus can transmit only for 0.5 hr, but one orbit is 1.5 hr. The SBU is half duplex, meaning only one of the transmitter and receiver may be on at a given time. The amateur mode of the SBU could beacon its call sign, record the band 2433-2438 MHz for ten seconds, then transmit that recording on 2403-2408 MHz, then pause for 40 seconds to cover more of one orbit. A time of ten seconds allows a call sign and a Maidenhead grid square to be spoken. Both FM and packet signals could be sent, because it is just a recording and playback. The mode would motivate amateurs to use S band; presently there

are relatively few S band amateur transceiver options and interest, compared with other frequency bands.

URL of web site where information about the satellite will be posted (frequencies of beacons, telemetry downlinks and amateur communications uplinks/downlinks, information on demodulation and interpretation of telemetry data, planned mission and operating schedules, etc.):

The permanent URL is

<https://www.unb.ca/cubesat-radio-info>

which currently re-directs to:

<https://www.unb.ca/initiatives/cubesat/radio.html>

Please fill out as completely as possible and submit the completed form by email to RAC at <regulatory@rac.ca>.

Organizations and Resources

Among the radio services regulated by Innovation, Science and Economic Development Canada (ISED) are the Amateur Radio Service and the Amateur Satellite Service. Radio amateurs in Canada have established a national membership organization, Radio Amateurs of/du Canada Inc. (RAC - < <https://wp.rac.ca/> >), to represent their interests. RAC provides information, analysis and how-to- do-it instructions for radio amateurs of all interests and levels of experience thorough its magazine and website. Many of its affiliated clubs across Canada provide courses for those interested in becoming radio amateurs. RAC works with governments at all levels to promote the growth of amateur radio and facilitate its use in serving communities across the country. RAC is a non-profit volunteer organization whose funding comes from membership fees. Membership is not obligatory, i.e. we act on behalf of all amateurs, members and non-members alike, but of course we encourage Canadian amateurs to join RAC and participate in the organization's activities.

National amateur radio organizations in many countries have joined together to form the International Amateur Radio Union (IARU - < <http://www.iaru.org/> >), which is a union of national societies. RAC is the Canadian national society member of IARU. The IARU plays a central role in the coordination of frequency usage by satellites using amateur radio frequencies. One other organization you may also see mentioned is the Radio Amateur Satellite Corporation (AMSAT - < <https://www.amsat.org/> >. AMSAT is a non-profit volunteer organization whose focus is mainly on satellites carrying amateur radio transponders or repeaters that can be used by amateur radio operators around the world to communicate with one another. There are a number of CubeSats carrying such transponders and repeaters currently in orbit.

The IARU web page at < <http://www.iaru.org/satellite.html> >, together with the links on that page, form an important information resource on this subject. In particular, we would recommend to you the following documents:

< http://www.iaru.org/uploads/1/3/0/7/13073366/short_info_paper.pdf > - a short information paper on the Amateur Satellite Service, and

< http://www.iaru.org/uploads/1/3/0/7/13073366/iarusatspec_rev15.7.pdf > - more detailed information and instructions for Amateur Satellite Service frequency coordination.

The IARU requests proponents of satellites in the Amateur Radio Satellite Service to submit a frequency coordination request on form <

http://www.iaru.org/uploads/1/3/0/7/13073366/iaru_amateur_satellite_coordination_request_v39.doc > . Detailed instructions on filling out this form are at <

http://www.iaru.org/uploads/1/3/0/7/13073366/iaru_amateur_satellite_coordination_request_instructions_01aug17.docx > .

There is also information from the ITU on their application process at <

<https://www.itu.int/en/ITU-R/space/AmateurDoc/ARS-tutorial.pdf> > . You might also find the ITU's Handbook on the Amateur and Amateur Satellite Services (<

https://www.itu.int/dms_pub/itu-r/opb/hdb/R-HDB-52-2014-OAS-PDF-E.pdf >) helpful.

Expected Conditions for the use of the Amateur Radio Service

With the above as background, here is a discussion of the features RAC would look for in a proposal to use amateur radio frequencies for satellite communications as the basis for its recommendations to ISED and IARU:

RAC wishes to encourage the incorporation of amateur radio into educational projects as a means of increasing awareness of amateur radio and promoting self-training in radio techniques by students. This should not be done, however, at the expense of condoning encroachment into amateur radio by commercial or professional interests that are not compatible with the aims of the Amateur Service as defined in both national and international regulations.

One of the uses of the Amateur Satellite Service is to provide communication resources to the amateur community. Alternatively, if the purposes of a project do not include providing such a resource, one of the aims of the project should include teaching and training students in satellite communication and building and launching satellites, including in some cases technical investigations into radio communications. If the sole reason for using amateur radio frequencies is to avoid the expense of licensing on non-amateur frequencies, that would appear to us to represent a misuse of the Amateur Service, whose purposes do not include the provision to non-amateurs of communications that should be carried out by commercial services – see *Radiocommunication Regulations* subparagraph 47(c)(iv).

If there are government, business, industry or professional sponsors of the project, we would suggest that their support should be in the form of unconditional grants or contributions in support of the project, not in the form of contractual arrangements (e.g. paying for the information to be obtained from the project). The results of any investigations should be published in the open literature and not managed as proprietary information.

The telemetry data sent from the satellite should not be encrypted (see *Radiocommunication Regulations* paragraph 47(b)). Information that would allow other persons listening in to convert the telemetry data to meaningful information (e.g. engineering units) should be publicly available (e.g. on a web site). The one exception to this is telecommand communications for controlling the satellite, which may and indeed should be encrypted (see ITU *Radio Regulations* article 25.2A).

A particular concern with satellites is the ability to terminate transmissions quickly by remote control to prevent interference. There is a discussion of this in some detail in an IARU document at < http://www.iaru.org/uploads/1/3/0/7/13073366/controllingsatellites_v27.pdf >. This document suggests having more than one ground station capable of telecommand, preferably in widely separated locations. One way to achieve this might be through co-operative arrangements with other universities undertaking similar projects.

All operation of transmitting equipment in the Amateur or Amateur Satellite Services should be performed by or under the control of “licensed amateurs” (in Canada, this means individuals who have been issued an Amateur Radio Operators Certificate or equivalent by ISED or its predecessor organizations). Non-amateurs should only operate transmitting equipment in the presence and under the direct supervision of a qualified amateur (see *Radiocommunication Regulations* section 46).

Regardless of who is operating the equipment, they should not be paid for doing so (see *Radiocommunication Regulations* section 49). If the operator of the equipment is paid by the University (for example, as a Teaching Assistant), the job description and/or the job tasks for which they are paid should not include operating the radio equipment.

Amateur radio operator certificates and station call signs are issued to individuals, not to corporations. In the case of an organization, the station call sign is issued in the form of an amateur radio club station certificate. This certificate is issued to an individual as “sponsor” or “trustee” of the club station. According to subparagraph 44(b)(ii) of the *Radiocommunication Regulations*, that individual must hold an Advanced qualification in addition to the Basic Amateur Radio Operator Certificate. In order to meet this requirement the team should have available to it, either as a team member or as an advisor, at least one Advanced Amateur who is willing and able to act as the sponsor for the station(s), including the ground station(s) as well as the satellite station.