DESCRIPTION OF PROPOSED EXPERIMENTATION

Pursuant to Sections 5.54, 5.61, and 5.64 of the rules of the Federal Communication Commission ("Commission"),[1] Care Weather Technologies ("Care Weather") respectfully requests experimental special temporary authorization ("STA") for a period of six months in order to launch and operate its Veery-RL1 low-Earth orbit 1U cubesat with an Iridium 9603 modem transmitting and receiving in the 1618.725-1626.5 MHz band.

The experimental STA is necessary for on orbit testing and validation of the custom satellite computing, power, and avionics electronics developed by Care Weather. The proposed experimentation constitutes an important milestone towards Care Weather's broader mission to fill critical gaps in U.S. weather remote sensing capabilities by enabling Care Weather to develop satellite bus technologies that can be tightly integrated with its future satellite wind-sensing radar (a "scatterometer") to produce the final, compact instrument system. Timely grant of the requested experimental STA request would therefore strongly serve the public interest.

I. Background

Of all the satellite datasets incorporated into global numerical weather forecasts, ocean surface vector winds measured by scatterometers improve forecast accuracy more than measurements from any other satellite sensor. Unfortunately, these measurements are one of the least available by quantity of measurements.

In the 1980s and 1990s, the United States led the world in satellite scatterometer development and operation with the NSCAT and SeaWinds scatterometers. In recent years, all U.S. scatterometers have reached their end of life and the United States has become fully reliant on foreign governments for this critical dataset. The development and operation of new

[1] *See* 47 C.F.R. §§ 5.54, 5.61, and 5.64.

scatterometer systems is a priority for national security, weather and maritime safety, and for U.S. leadership in space and weather forecasting. Many follow-on missions have been proposed, but all have been too cost prohibitive for limited national Earth science budgets.

Significant cost reduction requires tight integration between sensor and satellite bus to the point of individual components carrying both sensor and satellite functionalities. To this end, Care Weather is building the Veery-RL1 satellite to demonstrate custom satellite computing, power, and avionics systems designed and manufactured by Care Weather.

Verification of these systems on-orbit will provide Care Weather with the technical assurance required to further integrate them with Care Weather's nanosatellite scatterometer on later missions. Such experiments will also further development of Care Weather's integrated solar panel, antenna, and radiator ("SPAR") technology to permit tight integration and miniaturization of satellite subsystems.[2] The Veery-RL1 mission is an important step toward Care Weather's goal of increasing the rate of ocean surface vector wind measurement ten-fold to provide earlier warnings for hurricanes and other forms of extreme weather.

II. Discussion

A. Veery-RL1 Satellite

The Veery-RL1 satellite is a 1U cubesat designed and manufactured by Care Weather. The custom Veery-RL1 satellite is comprised of commercially available cubesat components, complies with the operational requirements of the CubeSat Design Specification Revision 13, and is otherwise consistent with cubesat manufacturing standards.

[2] Care Weather recently proposed an integrated SPAR system to the NASA Earth Science Technology Office, in partnership with NASA Marshall Spaceflight Center and Brigham Young University. When complete, this component will fill solar power, waste heat management, antenna, and radar front end functionalities. However, before developing this integrated system, Care Weather must develop and test individual component technologies such as those included in the Veery-RL1 mission.

Veery-RL1 satellite subsystems include power, command and computing, communications, structures, mechanisms, thermal control, attitude determination and control. The power subsystem includes solar arrays, lithium-polymer batteries, and power management circuit boards. The command and computing subsystem includes a watchdog, a thermal timeout system, microcontroller, and microprocessor.

The mechanisms subsystem includes burn wire deployment subsystems that use nylon wires to restrain the solar panels in their stowed position. Nichrome wires heat and break the nylon wire, releasing these panels. The attitude determination and stabilization subsystem includes an inertial measurement unit and six sun-sensing photodiodes for attitude determination and a set of magnetorquers for attitude control.

The Veery-RL1 satellite will also be equipped with an experimental AIS-gPPT3-1C Series Integrated Pulsed Plasma Propulsion Module which uses Teflon as a fuel source and does not require pressure vessels.[3] Veery-RL1 will test this experimental propulsion module on-orbit for performance, as well as for conjunction avoidance in the unlikely event that maneuvering may be required in the satellite's short orbital lifetime.

In conformance with the Process for Limiting Orbital Debris, NASA-STD-8719.14A, the Veery-RL1 satellite does not generate debris as part of normal operations, there is no material probability for on-orbit breakup, no debris will survive re-entry, and there is very low probability for an on-orbit conjunction and human casualty risk. The satellite will be launched into a 500-550 km circular orbit with an inclination of 45°. Assuming launch into the highest altitude, the orbital lifetime of the spacecraft is estimated to be approximately 3.7 years until full demise,

[3] An overview of the propulsion module is available of Applied Ion Systems' website. *See* AIS-gPPT3-1C Series Integrated Pulsed Plasma Propulsion Module, *available at* https://appliedionsystems.com/portfolio/ais-gppt3-1c-series-integrated-propulsion-module/ (accessed on Dec. 6, 2020).

which includes the drag effects of its deployed solar panels (well within the current 25-year benchmark).

As described in more detail in the attached Orbital Debris Assessment Report[4] and for the avoidance of doubt, Care Weather (i) has assessed and limited the amount of debris released in a planned manner during normal operations, and has assessed and limited the probability of the space station becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal; (ii) has assessed and limited the probability of accidental explosions during and after completion of mission operations; (iii) limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations; and (iv) detailed the post-mission disposal plans for the space station at end of life, including an assessment the probability of human casualty as a result. Thus, this application conforms to the requirements of Section 5.64(b) of the Commission's rules, 47 C.F.R. § 5.64(b).

B. Veery-RL1 Satellite Launch and Operations

Veery-RL1 is flying in the Maxwell dispenser on Rocket Lab's Electron launch vehicle. This launch will take place at Rocket Lab's Mahia, New Zealand launch site and Care Weather has already submitted a space payload application in accordance with New Zealand regulations. The mission authorization and operation timeframes are included in the table below.

Mission Authorization and Operation Timeframe	
Authorization grant-by date:	March 8, 2021[5]
LV integration date:	February 16, 2021[6]
Launch date:	March 17, 2021
Date for initiation of on-orbit operations:	0-3 days after launch
Expected mission duration:	6 months

[4] *See* Attachment 1 (Orbital Debris Assessment Report).

[5] Rocket Lab requires either an authorization or a confirmation that authorization will be granted more than two days before launch by February 16, 2021.

[6] The launch dispenser will be integrated with the launch vehicle around January 31, 2020.

Upon release, Veery-RL1's power system will be reconnected to its batteries by its separation switches. This will power the microcontroller system, which will initiate 30 and 45-minute timers. When the 30-minute timer is completed, the microcontroller will deploy solar panels. When the 45-minute timer is completed, the radio will begin communications with the Iridium satellite network.

C. Iridium Satellite Relay

The Veery-RL1 satellite will utilize an Iridium satellite relay to communicate with Care Weather mission control. The communications subsystem includes an Iridium 9603 satellite modem and body-mounted 25mm Iridium single-feed, non-deployable ceramic patch antenna manufactured by Taoglas, Model: CGIP.25.4.A.02.[7] The antenna has a peak gain of 5 dBi and operates with a bandwidth of 7.275 MHz (the 1618.725 – 1626.5 MHz band). A companion application for experimental authority will be filed by Iridium authorizing the communications from the Iridium satellite system to the Veery-RL1 satellite.

D. Experimental Subsystem Descriptions

To achieve the Veery-RL1 cubesat system integration and low-cost objectives, the Veery-RL1 satellite features subsystems and software of Care Weather's own design and manufacture which must be spaceflight tested, including:

- *Care Weather solar panels*: The solar charge current and voltage will be measured over time. The effect of thermal cycling and UV degradation of the cells over time on the solar panels will be evaluated.
- *Care Weather solar charge controller*: Measurement of solar charge current and voltage confirm the combined effect of varying solar conditions, battery charge states, and thermal cycling on the solar charge controller's performance.

[7] *See* Attachment 2 (Antenna Beam Pattern). Note that the beam pattern information is pulled directly from the Taoglas data sheet, which includes antenna performance at 1575.42 MHz for GPS/Galileo reception. However, only the radiation pattern at 1621 MHz for communication with the Iridium system is relevant to this application.

- *Care Weather battery charge/discharge controller*: Measurement of the battery voltage, charge current, and discharge current will confirm the combined effect of varying input solar power, system power draw, and thermal cycling on the performance of the controller in regulating charge and discharge.

- *Care Weather electrical power manager*: Measurement of solar charge current, solar voltage, battery state, battery voltage, battery charge current, battery discharge current, and software state will confirm the effect of various combinations of system conditions (solar illumination, thermal cycling, UV, charge currents and voltages, discharge currents and voltages) on the success of the electrical power manager in maintaining appropriate power characteristics and ensuring the satellite is only operated under the appropriate thermal and power conditions.

- *Care Weather coarse sun-sensors*: Measurement of tumble by the inertial measurement units ("IMU") along with solar charge currents and system temperatures will be used to verify the performance of the coarse sun sensors over various combinations of solar illumination, rotation rates, and thermal cycling.

- *Care Weather watchdog*: The performance of the watchdog in resetting the system over time in the event of solar energetic particles or state errors will be observed by saving a log of software states and bootup operation.

- *Care Weather magnetorquers*: measurements from the magnetometer on the IMU will be used to measure the magnetic field and magnetorquer output. These measurements will be compared with attitude measurements and drag estimations to evaluate the performance of the magnetorquers.

- *Care Weather flight software*: software state will be logged over time to confirm software performance under various combinations of the measured system and environmental conditions measured above.

These systems continue to be extensively tested on the ground and require spaceflight testing to further evaluate performance and achieve final design parameters.

As discussed above, Care Weather is also carrying an experimental propulsion module for performance, as well as for conjunction avoidance in the unlikely event that maneuvering may be necessary during the satellite's brief orbital lifetime. Measurement of discharge current and acceleration, combined with tracking of the satellite from the ground, will confirm the capabilities and power consumption of this experimental first-generation nanosatellite thruster developed and manufactured by Applied Ion Systems.

E. Points of Contact

Primary contact who can terminate ALL satellite transmissions.

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Secondary contact who can terminate ALL satellite transmissions.

Point of Contact Name:	Alex Laraway
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F. International Telecommunications Union ("ITU") Compliance

It is understood that the commission will submit filings to the ITU on behalf of the applicant pursuant to international obligations for the coordination and registration of space network systems. Care Weather is aware that processing fees will now be charged by the ITU for satellite network filings and has attached a letter accepting responsibility to pay any cost recovery fees associated with this this application.[8] Care Weather has also prepared the ITU Advance Publication Information ("API") submission along with the applicable Space Capture V.9 information for the Veery-RL1 satellite.[9]

G. Public Interest Considerations

The Veery-RL1 mission is an integral part of Care Weather's technology development plan and ultimate goal of developing and operating low-cost, miniaturized, satellite-based

[8] *See* Attachment 3 (Cost Recovery Letter).

[9] *See* Attachment 4 (API Cover Letter); *see also* Attachment 5 (Veery-RL1 Space Cap).

scatterometers to increase ocean surface vector wind measurements exponentially in order to enhance weather forecasting for safety of life and other purposes. Care Weather is partnering with and has received support from a range of U.S. government agencies and affiliated academic institutions, including NASA, the Air Force, the U.S. Forest Service and the University of Utah.[10] Thus, there is a strong government interest in conducting the Veery-RL1 mission.

Care Weather has separately applied for another experimental STA (the "Canary pocketqube" mission)[11] that would test and demonstrate some of Care Weather's other proprietary satellite systems and subsystems in an even smaller form factor (a pocketqube is one-quarter the size of a 1U cubesat). This application remains pending, however, and Care Weather was recently informed that this launch will be delayed to no earlier than a June-August 2021 window.

Care Weather became aware of the early 2021 launch opportunity on a Rocket Lab launch vehicle that will preserve its technology development schedule to reduce technical risk by performing testing on the larger 1U cubesat, enable additional experimentation in a single spaceflight. Care Weather is still pursuing the Canary pocketqube mission, particularly given the miniaturization requirements and the potential to incorporate data from the Veery-RL1 satellite experimentations in second-generation systems, so the proposed Veery-RL1 experimental satellite mission is an important replacement that will enhance Care Weather's follow-on pocketqube mission.

Care Weather recognizes the processing issues associated with the experimental STA request, and has streamlined this application for simpler approval: compliance with the 1U

[10] *See* Attachment 6 (Letters of Interest).

[11] Care Weather Technologies, Application for Experimental STA, ELS File No. 0997-EX-ST-2020 (filed June 26, 2020).

cubesat standards and use of the previously authorized Iridium relay to facilitate TT&C and data communications with the spacecraft. As noted above, the Veery-RL1 satellite will communicate with mission operations via the Iridium constellation, which has routinely been granted in other circumstances, including the use of the same Iridium 9603 modem.[12] There are no other communications payloads on the Veery-RL1 satellite. Accordingly, Care Weather has sought to minimize any concern regarding spectrum compatibility in order to permit timely authorization for integration on the Rocket Lab launch vehicle.

III. Conclusion

In view of the foregoing, Care Weather respectfully requests a six-month experimental STA to operate the Veery-RL1 satellite in accordance with the specifications, launch, and integration schedule described herein.

[12] *See, e.g.*, Capitol Technology University, ELS File No. 0033-EX-CN-2017 (authorizing communication with the Iridium 9603 modem); *see also* Thomas Jefferson High School Partnership Fund Inc., ELS File No. 0950-EX-CN-2018) (authorizing communication with the Iridium 9602 modem).