Application for Conventional Experimental Authority

Produced by Care Weather Technologies, Inc. for the Veery-0G Mission

Narrative Description

CAREWEATHER

Revision History and Signatures

Revision	Notes	Approved By	Date
A	First Version	 Patrick Walton CEO, Care Weather Veery Mission Manager	11/11/2024
B	Updated to include table of required exhibits	 Patrick Walton CEO, Care Weather Veery Mission Manager	12/3/2024

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 conventional experimental authority for a period of two years to operate its Veery-0G low-Earth orbit 1U cubesat with the following spectrum allocations:

- Iridium 9603 modem transmitting and receiving in the 1618.725-1626.5 MHz band,
- Care Weather custom radar transmitting and receiving in the 5255.1-5260.0 MHz band.

Experimental authority will enable Care Weather to make significant progress in its mission to address critical gaps in U.S. weather capabilities by testing the Veery-0G satellite. This experiment will test a prototype of a full wind-vector scatterometer, providing vector data for ocean surface winds. This is a significant advancement over Care Weather's previous satellite experiments and enables the company to support its work with the Space Force with on-orbit testing. To achieve this milestone, Care Weather will perform evaluation and validation of an enhanced ADCS subsystem capable of spinning about the nadir axis, radar calibration and data analysis, and overall software improvements.

Ensuring the reliability and performance of its first prototype scatterometer is crucial before investing in Care Weather's full vision for a weather sensing satellite constellation capable of 10X more frequent mapping of global sea winds. This constellation will significantly improve global weather forecasting, maritime safety, and hurricane monitoring, which will help

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

mitigate the dramatically rising cost of extreme weather to American infrastructure. A timely grant of the requested experimental authority would therefore strongly serve the public interest and contribute to advancements in weather monitoring and prediction in a professional and efficient manner. All required exhibits for the experimental authority application can be found in Table 1 below.

Table 1. Required Exhibits

FCC Requirement	Exhibit	Relevant Section
Antenna Registration Question 4: Directional Antenna Information	Attachment 12 REV B Veery0G Radar Orientation	Section A - Iridium Antenna Orientation
Form 442 Question 4: Government Project Description	Narrative Description REV B Veery0G	Section J - U.S. Space Force Contract
Form 442 Question 6: Description of Research Project	Narrative Description REV B Veery0G	Section E - Experimental Subsystem Descriptions

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.[2] 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. While recent

[2] See "Impact per observation" in Giovanna De Chiarra, et al. "On the impact of scatterometer winds in coupled and uncoupled DAS: preliminary results." International Ocean Vector Winds Science Team Meeting. 2017.

dramatic growth in hurricane damages has underscored the need for improved weather forecasting, the U.S. has fallen behind in scatterometry, decommissioning its last scatterometer in 2016. The United States has become fully reliant on foreign governments for this critical dataset. The development and operation of new 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.

Care Weather's mission is to reinstate U.S. leadership in scatterometry by significantly reducing the cost of scatterometers. Achieving such cost reduction requires substantial volume optimization through tight integration of the satellite bus and sensor, necessitating the development and on-orbit verification of in-house technologies.

To this end, Care Weather is building the Veery-0G satellite to conduct on-orbit testing of a radar system as a precursor to its future small scatterometer, "Veery." The primary objective of this satellite is to demonstrate measurement of ocean surface vector winds using Care Weather's new in-house systems that have not yet been tested on orbit. To achieve this goal, refined software, enhanced radar calibration, and nadir-spinning attitude control will be developed under a U.S. Space Force contract.

The verification of these systems on-orbit equips Care Weather with the technical assurance required to further integrate them with the full Veery scatterometer on later missions. The Veery-0G mission is an essential step towards Care Weather's goal of increasing the rate of

ocean surface vector wind measurement ten-fold, providing earlier warnings for hurricanes and other forms of extreme weather.

II. Discussion

A. Veery-0G Satellite

Veery-0G subsystems include radar, power, command and computing, communications, deployment mechanism, attitude determination, and attitude control. The radar subsystem includes a refined, in-house radar backend system and a patch array antenna. This radar has improved noise performance, enabling successful measurement of ocean surface vector winds. The power subsystem includes solar panels, lithium-ion batteries, and power management circuit boards. The command and computing subsystem consists of enhanced reliability computing hardware, a significant amount of software improvements for increased controllability. The communications subsystem includes an Iridium 9603 satellite modem with a body-mounted patch antenna (not deployed), as well as an amateur radio payload, which will be discussed in more detail below, with deployed dipole antenna.

The Attitude Determination and Control Subsystem has been almost entirely rebuilt, based on limitations and lessons from prior on-orbit tests. This new system gives the satellite a prototype nadir spinning capability using higher-precision sensors and reaction wheels, embedded magnetorquers, improved reaction wheel controllers, and a new end-to-end control software system.

In conformance with the Process for Limiting Orbital Debris, NASA-STD-8719.14A, the Veery-0G 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 low-Earth orbit below 590 km. Veery-0G passively drag-stabilizes in its high-drag orientation, passively disposing of Veery within 5 years.

As described in more detail in the attached Orbital Debris Assessment Report[3] and for the avoidance of doubt, Care Weather has (i) 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) 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 of 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-0G Satellite Launch and Operations

Veery-0G is flying in the Exolaunch Exopod dispenser on a SpaceX Falcon 9 launch. This launch will take place in the United States. The mission authorization and operation timeframes are included in Table 2 below.

Table 2. Mission Authorization and Operation Timeframe

[3] *See* Attachment 1 Veery0G Orbital Debris Assessment Report.

Launch Mission	Transporter-14
Authorization grant-by date (integration):	April 1, 2025
Launch date (no earlier than):	June 1, 2025
Date for initiation of on-orbit operations:	0-3 days after launch
Expected mission duration:	2 years

Upon release, Veery-0G's power system will be reconnected to its batteries by its separation switches. This will power the microcontroller system, which will initiate timers that ensure deployables are released and radio transmissions begin at a safe separation distance from the upper stage. When the deployment timer is completed, the microcontroller will initiate deployment of the dipole antenna. When the radio timer is completed, the radios will begin communications with the Iridium satellite network. After commissioning of the Iridium communications system and the attitude determination and control system, Care Weather will initiate testing of the radar.

C. Weather Radar Pathfinder

The Veery-0G satellite is equipped with a C-band weather radar system operating in the 5.255.1-5.260.0 GHz band, which has been granted previously.[4] The radar is a scatterometer, a coarse imaging radar system that utilizes Linear Frequency Modulated Interrupted Continuous Wave (LFM-ICW) range-doppler processing to segment Veery-0G's footprint into long, thin slices for coarse wind measurement. When passing over Care Weather's receiver in Utah, the

[4] *See, e.g.*, Care Weather Technologies, Inc., ELS File No. 0675-EX-CN-2023.

radar transmits an FSK radar calibration signal with integrated data. The radar system uses a body-mounted, 10 cm by 10 cm, non-deployable patch array antenna. The antenna has a peak gain of 11 dBi.

D. Iridium Satellite Relay

The Veery-0G satellite uses an Iridium satellite relay to communicate with Care Weather mission control. The Iridium satellite relay system uses an Iridium 9603 satellite modem, which has been routinely granted in other circumstances,[5] and body-mounted 25mm Iridium single-feed, non-deployable ceramic patch antenna manufactured by Taoglas, Model CGIP.25.4.A.02.[6] 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-0G satellite.

D. Deferred Radio Payload

The Veery-0G satellite will include a radio system capable of communication in the VHF or UHF bands, but this radio will be switched off unless Care Weather obtains authorization for its use. An arrangement for deferral of use until authorization of this nature has been granted to

[5] *See, e.g.*, Care Weather Technologies, Inc., ELS File Nos. 1840-EX-ST-2020, 1838-EX-ST-2021, and 0675-EX-CN-2023 (authorizing communication with the Iridium 9603 modem); *see also* 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).

[6] See Attachment 2 Antenna Beam Patterns. Note that the Taoglas antenna beam pattern information 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. There are no Earth stations in this filing, so no Earth station antenna diagrams are included.

Care Weather by the FCC previously.[7] That satellite (Veery-FS1) deorbited while coordination efforts were ongoing. Including this radio on Veery-0G provides a renewed opportunity for Care Weather to test that radio if the company is able to coordinate it and receive authorization for its use. This radio communications system includes a Care Weather Trill radio and tape-spring dipole antenna, both manufactured by Care Weather.

E. Experimental Subsystem Descriptions

Care Weather's custom satellite bus and radar support technologies on Veery-0G require in-flight testing to advance their readiness for integration with the full satellite scatterometer. We plan to carry out critical on-orbit testing of the following new subsystems:

1. *Attitude determination and control system for nadir spinning:* Care Weather's plans to revitalize American weather monitoring rely on a novel body-spun scanning technique in which the entire spacecraft is spun to provide the measurement geometry required, but with less bulk and cost. The Veery-0G test is required not only to demonstrate the functionality of Care Weather's attitude control systems in meeting these requirements, but to demonstrate the feasibility of this unproven measurement approach generally. Veery-0G builds on Care Weather's previous nadir-pointing control experiments with enhanced algorithms, higher precision attitude determination sensors, and higher-stability reaction wheels that enable the system to perform steady spinning about the nadir vector.
2. *Scatterometer ocean surface wind sensor*: Veery-0G builds on lessons of Care Weather's previous satellite to detect not just wind speeds of the ocean surface,

[7] See Care Weather Technologies, Inc., ELS File No. 1371-EX-ST-2021.

but also wind vectors. This new sensor builds on lessons from Care Weather's previous radars and updated models. This new sensor relies on the attitude control approach mentioned above and a number of modifications are required to operate the sensor and the above control system in tandem. This new radar will be capable of measuring wind speed and direction, providing Ocean Surface Vector Winds. The radar's performance will be assessed by comparing on-orbit measurements of ocean wind vectors to ground-truth data.

These tests, conducted during the Veery-0G mission, will together demonstrate the first subscale prototype of Care Weather's weather full sensing technology, ultimately contributing to the company's goal of improving global weather forecasting, maritime safety, and hurricane monitoring.

F. Points of Contact

Care Weather remains the primary point of contact that can terminate *all* satellite transmissions, including those from the amateur radio payload, via the Iridium radio. In the unlikely event of an Iridium anomaly, Care Weather will coordinate with Dr. David Long of BYU to terminate transmissions of the amateur radio payload. The radar only operates upon command via the Iridium link, so if Iridium contact is lost, then all radar transmissions will be terminated by default.

Primary contact who can terminate ALL satellite transmissions.

Point of Contact Name: Patrick Walton

Organization Name: Care Weather Technologies
Role: CEO, Mission Manager
Address: 144 W 400 N, Provo, UT 84601
Email: patrick@careweather.com
Telephone Number: (801) 227-4740

Secondary contact who can terminate ALL satellite transmissions.

Point of Contact Name: Alex Laraway
Organization Name: Care Weather Technologies
Role: CTO, System Engineer
Email: alex@careweather.com
Telephone Number: (801) 636-3388

Tertiary contact who can terminate ALL satellite transmissions.

Point of Contact Name: Dr. David G. Long
Organization Name: Brigham Young University
Role: Professor
Email: long@ee.byu.edu
Telephone Number: (801) 422-4383

G. 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 application.[8] Care Weather has also prepared the ITU Advance

[8] *See* Attachment 3 ITU Cost Recovery Letter.

Publication Information ("API") submission along with the applicable Space Capture V.9.1 information for the Veery-0G satellite.[9,10]

H. NOAA Commercial Remote Sensing Regulatory Compliance

NOAA has granted an Earth remote sensing license for three satellites in the Fledgling Veery series, of which Veery-0G is the third.[11]

I. Electromagnetic Compatibility

Care Weather recognizes its limited experimental operations cannot create interference into, and must accept interference from, authorized systems (including satellite systems) in the band. Care Weather will seek to coordinate its proposed operations with co-frequency operators to the extent required. To facilitate NTIA coordination, Care Weather has attached a completed NTIA space record data form.[12]

J. U.S. Space Force Contract

Care Weather is working with the U.S. Space Force (USSF) to advance space-based environmental monitoring (SBEM) capabilities. Scatterometers are key to filling five of the nine highest-priority SBEM capability gaps identified by the Department of Defense Joint Requirements Oversight Council, yet the U.S. still lacks a

[9] *See* Attachment 4 API Cover Letter; see also Attachment 5 Veery0G SpaceCap; see also Attachment 6 Veery0G SpaceVal; see also Attachment 7 Veery0G SpacePub; see also Attachment 11 Veery0G GIMS; see also Attachment 12 Veery0G Radar Orientation, which should be included as the first attachment to the ITU API.

[10] The SpaceVal form shows a warning for the radar pulse length exceeding 2 ms. This warning can be ignored. The pulse length for Veery-0G is 3.5 ms, which is consistent with previous scatterometers, such as the ASCAT scatterometers on Europe's MetOp satellites, which use a 10 ms pulse length.

[11] *See* Attachment 8 Fledgling Veery Tier 1 NOAA CRSRA License Part A

[12] *See* Attachment 9 NTIA Space Record Data

domestic scatterometry capability. The Veery-0G mission enables Care Weather to test the prototypes developed with USSF support on orbit, a major stepping stone toward meeting USSF demand for a rapidly-developed, cost-effective scatterometer.

K. Broader Government Interest

The Veery-0G mission is the first subscale scatterometer prototype to be implemented in Care Weather's fleet to pursue its ultimate goal of developing and operating low-cost, miniaturized, satellite-based scatterometers that increase ocean surface vector wind measurements exponentially to enhance weather forecasting for the protection of lives and livelihoods. Care Weather has partnered with and has received support from a range of U.S. government agencies and affiliated academic institutions, including the National Science Foundation,[13] NASA, NOAA, the Air Force, the Space Force, the U.S. Forest Service, and the University of Utah, as well as U.S. international partners, including the U.K. Meteorological Office.[14] Thus, there is an even broader government interest in conducting the Veery-0G mission.

III. Conclusion

In light of the important role of Veery-0G in revitalizing American weather monitoring, and the critical need for on-orbit testing of new technologies, Care Weather respectfully requests a conventional experimental license to operate the Veery-0G satellite for a period of two years, in accordance with the specifications outlined herein.

[13] *See* NSF Award Number 2304609.
[14] *See* Attachment 10 Letters of Support.