

Purpose of Experiment and Description of Experimental Program

Bigelow Development Aerospace Division, LLC (“Bigelow Aerospace” or “BA”) requests authority through this application to establish a two-year program of research and experimentation that utilizes a Global Positioning System (“GPS”) re-radiation device to boost the signal available from the GPS satellite network within the confines of its indoor assembly facility in North Las Vegas, Nevada. The proposed device is to be used to test GPS receivers and equipment used in BA’s ongoing experimental program involving the manufacture and deployment of expandable space habitats (“SpaceHabs”).

Bigelow Aerospace is an entrepreneurial space development company founded in 1999 by Robert T. Bigelow with the purpose of opening the frontier of space to all by dramatically reducing the costs and enhancing the utility of space-based activities. The company’s primary focus is the development of robust expandable SpaceHabs.

Originally pioneered by the National Aeronautical and Space Administration (“NASA”) for use in the space station program, the development of lightweight expandable SpaceHabs had advanced considerably by 1999 when, largely due to budgetary constraints, NASA was forced to shelve the project. At that point, Bigelow Aerospace took up the endeavor, and has been pursuing and advancing this technology as a better and more cost effective method of establishing a long-term human presence in space for scientific and industrial development purposes. In pursuit of its primary goal of developing and deploying an expandable SpaceHab that can safely and affordably support a human presence, BA embarked upon a program of launching subscale technology demonstrators to validate its ideas and engineering concepts. The first of its subscale orbital modules, dubbed, Genesis-1, was successfully launched on July 12, 2006 and has been providing a wealth of valuable data since that time. BA is currently preparing to launch its next generation subscale test vehicle, Genesis 2.

On-board GPS systems will be required for attitude and position determination. Proper validation of GPS systems during assembly integration and testing will be crucial to the mission success of BA’s demonstrators. Use of a fixed, indoor GPS re-radiator within BA’s assembly facility will be the only practical method for validation of on-board systems during the build and test phase.

Bigelow Aerospace maintains facilities in both Houston, Texas and North Las Vegas, Nevada, with the latter location serving as its primary assembly and testing facility. BA has determined that it must boost the GPS signal available at the exterior of this building in order to allow testing of GPS receiving equipment located indoors that is

part of its subscale SpaceHab demonstrators. Since 2005, use of this type of GPS re-radiation device has been permitted under specific criteria established by the National Telecommunications and Information Administration (“NTIA”), which adopted a revision to its Manual of Regulations and Procedures for Federal Radio Frequency Management (“NTIA Manual”) that enumerates ten conditions for approval of such devices. See Memorandum from Fredrick R. Wentland, Associate Administrator, NTIA Office of Spectrum Management, Doc. 34350/1 (May 3, 2005) (Adding Section 8.3.28 to NTIA Manual). NTIA indicated then that it recognized the need for both federal and non-federal users to operate GPS signal re-radiation devices in order to test GPS receivers, and stated that it is “prepared to support requests from [the] FCC that meet these criteria.” *Id.* As described above, Bigelow Aerospace is among the non-federal users that require the ability to augment the strength of the available GPS signal to permit testing of equipment used in its expandable SpaceHab modules, part of its broader program of in-orbit testing of these vehicles.

As Bigelow Aerospace explains below, it meets or exceeds the NTIA criteria for GPS re-radiation devices in Section 8.3.28 of the NTIA Manual;

NTIA Criterion No. 1: *Individual authorization is necessary for each device at a site-specific location:*

Bigelow Aerospace, Inc. proposes to install one fixed indoor location experimental (“XT”) GPS signal re-radiation device in a controlled access clean room in a building located on the premises of its facility in North Las Vegas, Nevada. The building in question is used exclusively for Bigelow Aerospace operations, including space vehicle development, assembly, integration, and testing. This building is under the exclusive control of Bigelow Aerospace, Inc. The zone of potential interference from the proposed fixed indoor location GPS re-radiation devices is limited to an immediate area within the clean room in which the device will be located. The boundaries of the building are located more than 100 feet within a 57 acre property exclusively for the use of Bigelow Aerospace. The location of the device is as follows:

XT Station Location	User	Latitude	Longitude
1899 W. Brooks Ave	Bigelow Aerospace	36° 12’ 43.5” N	115° 9’ 58” W

Datum NAD 1983

NTIA Criterion No. 2: *Application for frequency assignment should be applied for as an XT station with a note indicating that the device is to be used as an "Experimental RNSS Test Device for the purpose of testing stand-alone GPS receivers or GPS receivers that are an integral component of an equipment under test".*

Bigelow will strictly limit the use of the fixed indoor location GPS re-radiation device it proposes here to activities in direct furtherance of its business of developing and

manufacturing expandable space habitats that incorporate GPS receivers and systems that use GPS signals and augmentations. Accordingly, the experimental RNSS test device will be used for the purpose of testing GPS receivers that are an integral component of the equipment under test.

NTIA Criterion No. 3: *Approved applications for frequency assignment will be entered in the GMF.*

The frequency assignment for the proposed indoor fixed location GPS re-radiation device is at the GPS L1-band center frequency of 1575.42 MHz.

NTIA Criterion No. 4: *The maximum length of the assignment will be two years, with possible renewal.*

Bigelow Aerospace requests authorizations with a license term of two years, with the possibility of renewal.

NTIA Criterion No. 5: *The operation must be at a specified fixed location and mobile operation is not authorized.*

The location of the GPS re-radiation device proposed by Bigelow Aerospace will be fixed at the specific indoor location specified in No. 1 above.

NTIA Criterion No. 6: *The area of potential interference to GPS reception (e.g. military or contractor facility) has to be under the control of the user.*

The location of the GPS re-radiation device will be limited within a controlled access room in a secure building on Bigelow Aerospace property. This area is used exclusively for the assembly and testing of Bigelow Aerospace space vehicles. The zone of potential interference from the proposed re-radiating device is limited to the immediate area located within this building. The GPS reradiating device will be mounted on the inside ceiling of this room approximately 20 feet from the floor, and a minimum of 20 feet from the nearest outside wall. This building has concrete walls and ceiling.

NTIA Criterion No. 7: *The maximum equivalent isotropically radiated power must be such that the calculated emissions are no greater than -140 dBm/24 MHz as received by an isotropic antenna at a distance of 100 feet (30 meters) from the building where the test is being conducted. The calculations showing compliance with this requirement must be provided with the application for frequency assignment and should be based on free space propagation with no allowance for building attenuation.*

The GPS re-radiator will consist of a roof top antenna, a low-noise amplifier, a distribution system, and a passive re-radiating antenna. This antenna will be pointed downward from the roof of the facility. The system gains are listed below.

Received Power	-128.5 dBm
Roof Antenna Gain	35 dB
LNA Gain	20 dB
Distribution network, minimum loss	-5 dB
Net radiated power	-78.5 dBm

NTIA Criterion No. 8: *GPS users in the area of potential interference to GPS reception must be notified that GPS information may be impacted for periods of time.*

Bigelow Aerospace will post signs both within and at all entrances to the building where the GPS reradiator will be located, which covers the entire zone where there is the potential of interference to GPS reception from the GPS re-radiation device proposed. GPS users external to this facility will not be affected since the zone of potential influence is located entirely within this facility.

NTIA Criterion No. 9: *The use is limited to activity for the purpose of testing RNSS equipment/systems.*

Bigelow Aerospace will strictly limit the use of the GPS re-radiation device proposed here to activities associated with assembly and testing of GPS systems for use on-board Bigelow space vehicles.

NTIA Criterion No. 10: *A "Stop Buzzer" point of contact for the authorized device must be identified and available at all times during GPS re-radiation operation of the device under any condition.*

The GPS re-radiation device will have a "Stop Buzzer" device installed in the immediate area of the device. It will be clearly labeled and accessible to all personnel working in the vicinity of the device. The contact person at Bigelow's North Las Vegas facility is Eric Haakonstad, who can be reached at (702) 639-4440 and ehaakonstad@bigelow-aerospace.com.

Calculation for compliance with NTIA EIRP limit

Based upon the equation:

$$P_d = P_r - 20 \log \left(\frac{d * 4\pi}{\lambda} \right)$$

Where P_d is the power of the signal at the distance d , and λ is the wavelength of the signal.

λ is given as 0.1904 meters for L1

Received Power	-128.5 dBm
Roof Antenna Gain	35 dB
LNA Gain	20 dB
Distribution network, minimum loss	-5 dB
Net radiated power	-78.5 dBm

Therefore, the power at 30 meters will be

$$P_{30m} = 78.5 - 20 \log \left(\frac{30m * 4\pi}{.1904m} \right) = -144.46 \text{ dBm}$$

From this it can be seen that the proposed re-radiation network meets the NTIA standard of 140 dBm at 30 meters. This calculation is made based upon free space propagation. No allowance is made for the walls of the building.