**Question 6 Exhibit: Nature and Necessity of Research**

*Description*

Our research is in support of sensor development with the National Aeronautics and Space Administration's Johnson Space Center (NASA JSC).

Specifically, we are applying for Form 442 to for transmitting data from our orbiting microsatellite to our university ground station. This satellite is designed to fly a prototype GPS receiver, developed by NASA JSC, and take navigation data to determine the usefulness of using such a receiver for navigating with orbital spacecraft. Results of this project and further development have a direct impact on NASA's planned navigational aids for the Space Station operations, the Multi-Purpose Crew Vehicle (MPCV), and other commercial spacecraft in development.

NASA approached Texas A&M University to find a student group to develop this payload. The goals of this project are to provide useful engineering data to NASA JSC concerning this GPS receiver and educate university students in the design and operation of satellites.

*Necessity of Research and Inadequacy of Current Facilities*

This project requires navigation data to be taken in the space environment to characterize the ability of GPS to perform at speeds and altitudes orders of magnitude greater than typical Earth based applications. This requirement facilitates the need for a satellite platform and a satellite platform requires facilities capable of proper distance communications for operation.

The choice to use the bands requested in form 442 in the 400 MHz and 2.4 GHz bands was driven by design constraints on the spacecraft and the need for high data rates.

Our spacecraft for this flight is a 24x24x11 inch box, ~ 110 lbs in weight. We also have to deal with transmitting commands, updating software, and receiving useful amounts of GPS data during short ground station passes (typically 4 minutes or less). In order to accomplish this, high data rates are necessary. Unfortunately, commercial options that can meet the data rates often do not have the power necessary for space communications. To fill this need, a graduate student working under the lab designed and developed radios capable of both as a masters thesis project. In this Exhibit, these experimental radios will be referred to as RFIC units.

In this application, the primary desire is to be licensed to use the frequency in the 400 MHz band. Since the use of a different model Texas Instruments radio chip allows the radio to operate in the 2.4 GHz band, this second frequency has been added to the application in the event that an allocation in the 400 MHz range is not available. However, only one of the two frequencies is absolutely necessary to accomplish our mission, of which we would prefer the 400 MHz range. This is because ground station

hardware is more readily obtained, more robust, and better understood by our personnel. Additionally, the frequency range for the radio capable of 2.4 GHz transmission only encompasses the amateur portion of that band, while the 400 MHz unit can operate well outside (as well as inside) of the amateur UHF frequencies allowing more flexible options for frequency allocation.

The spacecraft communications system will consist of two Kenwood TH-D72A radios operating on VHF and UHF amateur frequencies, a Digi XTend radio operating on the 900 MHz band, and an RFIC unit, operating on either the 400 MHz or 2.4 GHz band.

The VHF amateur radio onboard will be used for the spacecraft command uplink, and the UHF amateur radio will be used as the spacecraft identification beacon and emergency downlink unit. Having this unit operate on an amateur frequency allows amateurs to track the satellite worldwide and increase our awareness of the spacecraft health status. These transmissions are governed by the rules and regulations of the Amateur Radio Service, and are being approached accordingly. The Digi XTend in the 900 MHz band operates on Frequency Hopping Spread Spectrum protocol, and will be used exclusively for spacecraft crosslink communication with our partner satellite from the University of Texas. The RFIC unit will be used solely as high data rate downlinking transmitter, and will transmit one way from the spacecraft to our College Station, Texas ground station.

In addition to our research for NASA, a lower priority scientific experiment will be flown onboard. It is not yet finalized what group this experiment will come from, but several parties are in discussion with management. Because of the proprietary nature of this experimental data, amateur frequencies can not be used. For this reason, amateur frequencies will only be used for spacecraft control purposes, and scientific experiment data will be transmitted on frequencies under form 442.

Our first course of action was to ask for usage of NASA's extensive array of existing communications links. We were denied permission to use these links as they are needed to support high priority national programs and are also directly linked to the safety of manned spaceflight operations.

Our lab currently has a ground station capable of spacecraft tracking and amateur UHF/VHF communication. Plans have been made to upgrade this site in order to be able to receive the data from the high data rate transmitter. Transmissions under form 442 would only originate from the spacecraft, with the ground station having only receive capabilities on these frequencies.

As mentioned above, the need of experimental licensing is due to the nature of the payload data conflicting with the rules governing the use of amateur frequencies.