Narrative Statement

A. Introduction and Background

NanoSatisfi Inc. (NanoSatisfi), a Delaware corporation based in San Francisco, California, requests a conventional experimental radio license to conduct a market trial pursuant to 47 C.F.R. §§ 5.3(k), 5.54(a)(1), and 5.602. With this experimental license, NanoSatisfi seeks to research and evaluate the demand in the maritime, meteorological, aeronautical, and education markets for nanosatellite technology.

NanoSatisfi creates tools that make it simple for anyone to interact with space by offering convenient, affordable, and on-demand access to satellites.[1] The enterprise grew out of a volunteer effort by four graduate students at the International Space University who began building a prototype nanosatellite as a platform for making space accessible and affordable to students. Early funding for the concept came from the crowd-funding website Kickstarter, where the original ArduSat (short for Arduino-based satellite) concept raised more than $100,000 from nearly 700 private space enthusiasts.[2]

Pursuant to a grant of special temporary authority awarded earlier this year,[3] two ArduSats are scheduled to be launched this summer.[4] To be clear, these first two satellites will not be a part of the market trial that is the subject of this application. However, these satellites show the great deal of excitement surrounding nanosatellite technology and provide background

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[1] NanoSatisfi, *Homepage* (last accessed July 10, 2013), http://www.nanosatisfi.com/.

[2] *ArduSat – Your Arduino Experiment in Space*, Kickstarter (last accessed July 9, 2013), http://www.kickstarter.com/projects/575960623/ardusat-your-arduino-experiment-in-space.

[3] The Commission granted Special Temporary Authority to ArduSat Inc. for operating these satellites on April 26, 2013 (Call Sign: WG9XFC; File No. 0917-EX-ST-2012). ArduSat Inc. is a non-profit corporation founded solely to launch these two satellites. The applicant here, NanoSatisfi Inc., is a separate, for-profit entity, which was founded by many of the same members of the ArduSat Inc. team.

[4] *ArduSat Has a Launch!*, NanoSatisfi (last accessed July 10, 2013), http://www.nanosatisfi.com/2013/02/ardusat-has-a-launch/.

for the market trial proposed here. After these satellites are launched, Kickstarter funders and others will be able to use these satellites to test experiments, play games, take pictures, and run applications in a manner that will truly allow anyone to access space. For this pioneering work so far, which is helping to democratize access to space, the Obama Administration has recognized NanoSatisfi Co-founder and CEO Peter Platzer as a Champion of Change.[5]

Based on the experience with ArduSat technology and the great deal of interest surrounding it, NanoSatisfi seeks authority to conduct a market trial to determine if somewhat more advanced ArduSats have consumer and commercial applications. NanoSatisfi seeks approval to operate up to fifteen ArduSat-2 and ArduSat-2x nanosatellites – nanosatellites up to 20 centimeters larger than the original 10 centimeter nanosatellite and housing some more advanced equipment – in order to test the educational, meteorological, aeronautical, and maritime markets.

B. Description of Equipment and Theory of Operation

NanoSatisfi seeks to test the educational, meteorological, aeronautical, and maritime markets using two types of ArduSats: the ArduSat-2, which measures 10x10x20 centimeters, and the ArduSat-2X, which measures 10x10x30 centimeters.

1. The ArduSat Concept.

An ArduSat is a nanosatellite built in the CubeSat form factor,[6] a standard that helps reduce the cost of launching small satellites into space by allowing for a common deployment system. The basic unit for the CubeSat form factor is a single 10-centimeter cube, weighing no more than 1.33 kilograms. The CubeSat standard, however, is scalable along one axis, allowing

[5] *Creating Next Generation Innovators Through Space Education*, The White House (June 6, 2013), http://www.whitehouse.gov/blog/2013/06/06/creating-next-generation-innovators-through-space-education.

[6] *See* California Polytechnic State University, *CubeSat Design Specification* (last visited July 10, 2013), http://www.cubesat.org/images/developers/cds_rev12.pdf.

up to three of these 10-centimeter cubes to be joined together (so-called “1U,” “2U,” and “3U” CubeSats). The original ArduSats are constructed according to the 1U form factor, while the AruSat-2 and ArduSat-2X models are designed to the 2U and 3U specifications, respectively.

ArduSats carry a suite of sensors and a payload computer that can be reprogrammed while in space. The user-programmable payload computer is comprised of an array of Arduino processors (AVR processors) and can run code developed on the ubiquitous, open-source Arduino software development platform. ArduSats were invented with the purpose of creating an inexpensive, accessible development platform in space on which students, teachers, hobbyists, and researchers could affordably create and run their own custom-built experiments and applications.

Users can design their own space-based applications, experiments, and even space games using the Arduino open-source prototyping platform. Once a user-designed application has passed testing on an ArduSat clone located on Earth, users can upload their applications to the payload computer of an ArduSat that is orbiting in space, where it is monitored and maintained by the satellite’s main computer. From there, the applications are free to sample data from the payload sensors and bus, take pictures, and return data to the user’s web browser whenever the satellite is in range of a participating ground station. At the end of the user’s experiment period, which can be up to a week in length, any remaining data is downlinked and returned to the user.

An ArduSat’s payload consists of a suite of sensors, including an optical spectrometer, a Geiger counter, an atmospheric sensor, an infrared sensor, an accelerometer, a gyroscope, a magnetometer, a sun sensor, an electromagnetic wave sensor, a dual-frequency GPS receiver (for ionospheric studies), a megapixel camera, and more. The sensors (and other telemetry values) are sampled by the user-generated programs running on the payload computer. The first two

ArduSats are scheduled for launch this summer pursuant to a grant of special temporary authority.

2. ArduSat-2.

The ArduSat-2 fits the 2U CubeSat form factor, with a total mass of 2.66 kg and an outer envelope of 10x10x20 centimeters (excluding the deployable dipole antenna). With this additional capacity, the ArduSat-2 follows the same basic ArduSat concept but has increased room onboard for hosting experiments, improved data downlink capability, and new payload sensors.

The ArduSat-2 will be used to test the maritime, meteorological, and educational markets. The ArduSat-2 will not, however, have the necessary equipment to test the aeronautical market.

3. ArduSat-2X.

The ArduSat-2X adds an additional 10 centimeter cube to the ArduSat-2, for a total mass of approximately 4 kilograms and an outer envelope of 10x10x30 centimeters (excluding the deployable dipole antenna). This additional capacity will house another receiver allowing for monitoring of aeronautical traffic, as well as supplemental gyroscopic equipment for steering the satellite more precisely. With the addition of the receiver for monitoring aeronautical traffic, the ArduSat-2X will be employed for testing each one of the markets that are the subject of this application – the maritime, meteorological, educational, and aeronautical markets.

C. Purpose, Scope, and Objective of Market Trial

NanoSatisfi Inc. seeks authority to conduct a market trial for the meteorological, maritime, aeronautical, and educational markets. NanoSatisfi will launch up to fifteen satellites for these market trials over the course of the authorized period. Each individual satellite will

remain in orbit for a limited lifespan of between approximately ten and eighteen months, after which time it will re-enter the atmosphere and completely burn up before reaching the ground.

1. *Maritime Monitoring*.

NanoSatisfi requests authority to test the market for using its nanosatellite technology to track ships. Current maritime monitoring systems are generally land-based and do not offer the ability to track ships when they are outside of a 50-mile zone. NanoSatisfi plans to test a satellite-based system relying on a small constellation of up to fifteen satellites, including both the ArduSat-2 and ArduSat-2X models. These satellites will provide reasonable re-visit times of less than six hours. For purposes of this trial, no equipment will be required onboard subject vessels as vessels with gross tonnage of 300 tons or greater are required by international law to carry a functional Automatic Identification System (AIS) beacon transmitter on-board.[7]

NanoSatisfi believes that such data is of interest to shipping companies, harbor operators, governments, Vessel Traffic Service (VTS) data providers, and financial services companies. Additionally, NanoSatisfi hopes to fuse optical data with communication data to help detect pirate ship activity. However, these uses have to be verified, which is the purpose of this experimental period.

During this experimental period, NanoSatisfi expects to have a small number of pilot customers (less than 100) to help refine the service and quantify the market need for this data, which it predicts could be tens of thousands of customers across the globe.

2. Aeronautical Monitoring

Similar to the limitations of existing maritime monitoring systems, current land-based aeronautical monitoring systems lose contact with airplanes once they are over the ocean.

[7] *See* The International Convention for the Safety of Life at Sea, Dec. 2002 Amendments (Dec. 2002), *available at* http://bit.ly/15vyqx5.

Among other drawbacks, this loss of contact renders optimal route planning very difficult, if not impossible. NanoSatisfi would like to test a satellite-based system relying on a small constellation of up to fifteen ArduSat-2X satellites in low earth orbit (the ArduSat-2 will not have the capability to monitor aircraft). This system will be used to monitor aircraft and provide routing data, and the constellation of satellites could revisit individual locations approximately every two hours. For purposes of this trial, no equipment will be required onboard aircraft as the nanosatellite will merely monitor a signal that the aircraft is already required to emit.

NanoSatisfi believes that such data is of interest to air traffic control agencies, airline operators, financial services companies, search and rescue missions, and governments, as well as other entities. The experimental license will allow NanoSatisfi to verify the market for these services.

During this experimental period NanoSatisfi expects to have a small number of pilot customers (less than 50) to help refine the service and qualify the market need for this data. NanoSatisfi estimates the total market for this product to be thousands of customers across the globe.

3. Meteorological Monitoring.

NanoSatisfi requests authority to test the market for using its nanosatellite technology to conduct atmospheric studies. Current satellite-based systems rely on large, expensive satellites and suffer from extensive delays and long revisit times. NanoSatisfi plans to test a satellite-based system relying on a small constellation of up to fifteen satellites, including both the ArduSat-2 and ArduSat-2X models. These satellites will provide reasonable re-visit times of less than six hours.

The satellites will rely on a relatively new technique for performing atmospheric measurement called GPS-Radio Occultation.[8] Because GPS signals refract differently as they pass through the atmosphere depending on temperature and the concentration of water vapor, it is possible to measure weather patterns using this technology, and there is a great deal of interest both commercially and in government to explore this technology further. For example, the Weather Forecasting Improvement Act of 2013 (H.R. 2413) specifically includes provisions for the National Oceanic and Atmospheric Administration to examine this technology.[9] Weather monitoring technologies such as GPS-Radio Occultation and others are currently receiving particularly extensive attention because of a looming gap in the US government's ability to monitor the weather with one of its satellites scheduled to reach the end of its useful life in the near future and without a replacement scheduled for some time.[10]

NanoSatisfi believes that such data is of interest to governments, consumers and the financial services community. Additionally, NanoSatisfi hopes to fuse optical data with atmospheric properties to provide an enhanced value added product. However, these uses have to be verified, which is the purpose of this experimental period.

During this experimental period, NanoSatisfi expects to have a small number of pilot customers (less than 100) to help refine the service and quantify the market need for this data, which it predicts could be tens of thousands of customers across the globe.

[8] *See, e.g.*, NASA, *Generating Climate Benchmark Atmospheric Surroundings Using GPS Radio Occultations* (July 2007), 1.usa.gov/1bOUxEI.

[9] *See, e.g.*, Dan Leone, *Commercial Weather Provisions in NOAA Bill Survive First Vote in House*, SpaceNews (Jul. 9, 2013), http://bit.ly/16bpmwo.

[10] *See* U.S. Government Accountability Office, *Polar-Orbiting Environmental Satellites* 25 (June 2012), *available at* http://www.gao.gov/assets/600/591643.pdf.

4. *STEM Education*

Especially in the United States, but also in Europe and elsewhere throughout the world, economies are suffering from a lack of graduates in the crucial fields of science, technology, engineering, and math (STEM). While these fields are generally accepted to be at the very core of our ability to innovate, generate jobs and stimulate economic growth, budget cuts in our education system have increasingly endangered these fields and created a problematic dearth of graduates.

NanoSatisfi is testing a novel approach to inspire students to pursue careers in these fields by giving them access to control the sensors and cameras of a nanosatellite. Students will engage in an online curriculum similar in format to those offered by Udacity or Coursera. At the end of this online curriculum, students will have access to the satellite's microprocessor to upload their own experiment and control the sensors and cameras. Using a simple online satellite control interface, users can program and control the satellite, provide instructions on sensor activation, track satellite orbit, implement experiments and download data and pictures from space. Users will have access to both the ArduSat-2 and ArduSat-2X models for purposes of testing their experiments and running their applications. Hiding the complexities of space, this simple, integrated environment democratizes space for schoolchildren everywhere so that it is no longer only the province of rocket-scientists.

During this experimental period, NanoSatisfi plans to work with a select number of pilot organizations (less than 200) to help refine the service and curriculum and qualify the market for this kind of educational tool. Nanosatisfi estimates that the total market for this tool could be in the hundreds of thousands of customers across the globe.

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This proposed market trial will help NanoSatisfi better evaluate the demand for its technology in each of these various sectors. Consistent with 47 C.F.R. § 5.602, NanoSatisfi will own all transmitting and receiving equipment in the study, and it will ensure that all trial devices are rendered inoperable at the conclusion of the trial.

D. Contribution of the Proposed Market Trial to the Radio Art

NanoSatisfi's innovative ArduSat-2 and ArduSat-2X, together with its proposed market trial, promises to significantly contribute to the development, extension, expansion and utilization of the radio art. As described above, NanoSatisfi's proposed market trial will explore four areas to determine the market demand for innovative nanosatellite technologies. The ArduSat-2 and the ArduSat-2X will be the first nanosatellites employed for monitoring meteorological and maritime activities, and the ArduSat-2X will be the first nanosatellite employed for aeronautical monitoring. The ArduSat-2 and the ArduSat-2X will also be two of the first devices enabling the general public to access space in a meaningful way. If these market trials are successful, NanoSatisfi plans to widely deploy its technology, promising to offer extensive consumer and educational benefits.

E. Orbital Debris Mitigation Statement

Consistent with 47 C.F.R. § 5.64, NanoSatisfi has included an Orbital Debris Assessment Report for the ArduSat-2 and an Orbital Debris Assessment Report for the ArduSat-2X as exhibits to this application.

F. Conclusion

By granting this application, the Commission can help NanoSatisfi make space accessible to anyone and to unleash the valuable commercial applications made possible with innovative nanosatellite technology.

The “stop buzzer” point of contact for the market trial is Joel Spark, Lead Engineer Satellite Bus (415-947-9865; joel@nanosatisfi.com).