**TO:** NOAA/CRSRA Office

**FROM:** Ricky Prasad, Lead Systems Engineer, Tyvak Nano-Satellite Systems INC

**DATE:** 3/10/2017

**SUBJECT:** NanoACE Public Summary per 15 CFR §960.5

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To NOAA/CRSRA Office,

The following provides the publicly-releasable summary for the licensed system (NanoACE vehicle) in accordance with 15 CFR §960.5 for the grant of license to operate a private, space-based, remote sensing system. Please use the Licensee Information listed below for contacts.

**Licensee Information**:

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## 1.0 NANOACE SUMMARY

The goal of NanoACE is to validate the Endeavor suite technologies that will be used for future missions and is solely for the purpose of internal Tyvak development as an attitude control experiment. The technology demonstration will validate the Command and Data Handling (CDH) system, Guidance Navigation and Control (GNC) software and actuators, as well as test visible & IR cameras. A basic overview of the vehicle is shown below:

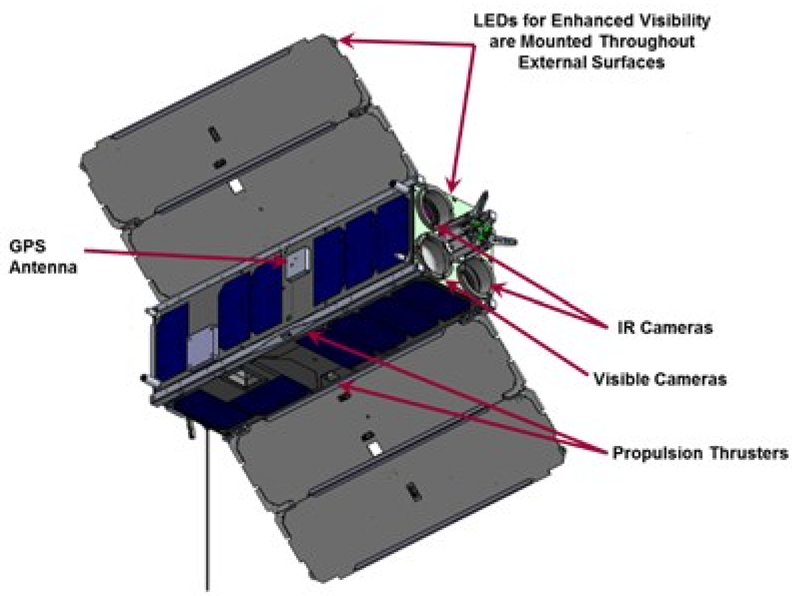


*Figure 1-1: NanoACE Vehicle*

The NanoACE vehicle will begin operations following the release of the vehicle by the deployer. The NanoACE vehicle will perform general commissioning operations to validate vehicle State-Of-Health (SOH). Following successful commissioning, NanoACE will perform operations to demonstrate 3-axis pointing for various targets and perform basic small impulse propulsive maneuvers to verify performance and orientation. The parameters for the candidate launch and insertion are shown below:

| Parameter | Value |
|---|---|
| Launch vehicle and launch site | Soyuz Fregat, Baikonur, Kazakhstan |
| Proposed launch date | Q2 2017 |
| Mission duration | 1+ year |
| Launch and deployment profile | The Soyuz launch vehicle will launch the primary mission satellite. After which, it will deploy the NanoACE satellites into their final mission orbit |

| | |
|---|---|
| | (~610km[1], circular, sun-synchronous orbit ~ 97.8° inclination). There is no parking or transfer orbit.<br>The NanoACE satellite will decay naturally for debris mitigation and will re-enter in 10.3 years, within the 25 year window following completion of mission. |

***Table 1: Summary of Mission Parameters***

## 1.1 Physical Description of Spacecraft

The NanoACE vehicle has been designed to support a 1+ year mission in LEO, and it is compatible with the P-POD launch environments and designed to the requirements in the CubeSat Design Specification (CDS). The NanoACE vehicle is a 3U CubeSat with the core of the vehicle being 30cm x 10cm x 10cm with a mass of roughly 5.2 kg. The vehicle uses a total of four deployable solar panels, with each roughly 30cm x 10cm in size.

The NanoACE vehicle design uses subsystem modules built from printed circuit boards (PCB) or miniature enclosures mounted to the open frame primary structure. The open structure permits the vehicle to be built incrementally with open access for securing interconnects. The subsystems are placed within the vehicle to optimize mass properties, radiation protection, thermal heat rejection, power handling, vehicle orientation, and cabling length. The body mounted side panels attach directly to the primary structure and are used for thermal management and can be easily removed to get access to the interior of the vehicle. The vehicle is primarily constructed out of aluminum and PCB materials. The only imagers that are incorporated into the vehicle bus are two star tracker cameras for attitude estimates. The NanoACE payload houses two IR, two visible cameras, and electronics for image processing.

| Parameter | Value |
|---|---|
| Total satellite mass at launch, including all propellants and fluids | ~5.2 kg |
| Dry Mass of satellite at launch, excluding solid rocket motor propellants | ~4.7 kg |
| Identification, including mass and pressure, of all fluids | R236fa (common refrigerant), 420 grams, 67 psig at room temp. |
| Fluids in Pressurized batteries | NONE. NanoACE uses unpressurized standard COTS Li-ion battery cells |

***Table 2: Summary of Spacecraft Parameters***

### 1.1.1 Description of Propulsion Systems

The NanoACE cold gas propulsion system utilizes a mature design that was developed by VACCO Industries and tested extensively (70,000+ firings) in a vacuum by the US Air Force Research Lab and traces heritage to DARPA and Aerospace Corp programs. The highly integrated unit utilizes R236fa as a propellant that is stored as liquid for volume efficiency. All sensor and control electronics are contained inside the unit and only requires power and serial data connections. Extensive materials compatibility testing and analyses have demonstrated that the propellant is compatible being immersed around the electronics. The NanoACE propulsion

[1] Soyuz Fregat insertion orbit is 600 km +/- 10 km. Worst case of 610 km used for all analysis

module is made out of aluminum and has eight thrusters located at the corners of the unit. The unit can hold roughly 420 grams of propellant.

### 1.1.2 Description of attitude control system

The NanoACE attitude determination and control system consists of a processor, Inertial Reference Module (IRM), nano-Reaction Wheel Array (nRWA), GPS receiver, Sun sensors, magnetometers, and integrated torque coils. Primary attitude knowledge is provided by the IRM which hosts two star sensors and the inertial measurement unit (IMU). Primary attitude control is provided by the nRWA which consists of an orthogonal set of three wheels. Momentum management and vehicle detumble are provided by a set of three torque coils.

### 1.1.3 Description of normal attitude of the spacecraft with respect to the velocity vector

The nominal attitude of the NanoACE vehicle has the long axis (z-axis) of the vehicle pointed along the velocity vector. The vehicle is rotated about the long axis to point the deployable panels in a zenith direction for energy collection. The NanoACE vehicle will spend a majority of its time in this attitude.

### 1.1.4 Description of the electrical generation and storage system

Energy generation is accomplished using four deployable solar panels and additional solar cells that are mounted on the core of the vehicle. Energy storage is accomplished using standard COTS Li-ion battery cells in a 3S2P (3 in series, 2 parallel) configuration. The cells are recharged by the solar cells mounted on the deployable and body panels. The power management and distribution is provided by the electrical power system and battery protection circuitry.