

Sapling

*NOAA Remote Sensing License Application*

# Part A: Description of Applicant (Operator)

## 1. General Applicant Information

1.a. **Name of Applicant (entity or individual):**

Associated Students of Stanford University in care of the Stanford Student Space

Initiative

1.b. **Location and address of Applicant:**

491 South Service Road

Stanford, CA 94305

1.c. **Applicant contact information (for example, general corporate or university contact**

**information):**

**Email Address:**

[space.initiative@stanford.edu](mailto:space.initiative@stanford.edu)

**Mailing Address:**

HEPL Receiving

c/o Stanford SSI M300

452 Lomita Mall, Room 109

1.d. **Contact information for a specific individual to serve as the point of contact with**

**Commerce:**

Simone D’Amico

Associate Professor of Aeronautics and Astronautics, Stanford University

**Mailing Address:**

Aero Astro - SLAB

496 Lomita Mall #006

Stanford, CA 94305

**Email Address:**

[damicos@stanford.edu](mailto:damicos@stanford.edu)

**Phone Number:**

650-272-9968

1.e. **Contact information for a specific individual to serve as the point of contact with**

**Commerce for limited-operations directives, if different than main point of contact,**

**in the event that the applicant will receive a license in Tier 2 or Tier 3:**

N/A

1.f. **Place of incorporation and, if incorporated outside the United States, an**

**acknowledgement that you will operate your system within the United States and are therefore subject to the Secretary’s jurisdiction under 15 CFR Part 960:**

520 Lasuen Mall

Old Union 103

Stanford, CA 94305

## 2. Ownership interests in the Applicant

2.a. **If there is majority U.S. ownership: report any domestic entity or individual with an**

**ownership interest in the Applicant totaling at least 50 percent:**

Associated Students of Stanford University in care of the Stanford Student Space

Initiative, 100% ownership

2.b. **If there is not majority U.S. ownership: report all foreign entities or individuals**

**whose ownership interest in the Applicant is at least 10 percent:**

N/A

2.c. **Report any ownership interest in the Applicant by any foreign entity or individual**

**on the Department of Commerce’s Bureau of Industry and Security’s Denied**

**Persons List or Entity List or on the Department of the Treasury’s Office of Foreign**

**Asset Control’s Specially Designated Nationals and Blocked Person List:**

N/A

## 3. Identity of any subsidiaries and affiliates playing a role in the operation of the System, including a brief description of that role:

## N/A

Part B: Description of System

## 1. General System Information

1.a.  **Name of system:**

**Mission Name:** Sapling

**Spacecraft Names:** Sapling Sempervirens (referred to as “Sapling”)

1.b. **Brief mission description:**

The Sapling spacecraft will be launched from a Quad Pack CubeSat Deployer aboard Launcher Inc.’s Orbiter SN1. Sapling will attempt to take pictures of the Earth and downlink them, and will not attempt to take pictures of non-Earth objects. The spacecraft will be equipped with coarse attitude control (magnetorquers), and images will be processed to determine whether the Earth is in view before downlinking. This approach will mitigate the probability of accidental imaging of a non-Earth target.

All code, designs, and data obtained through the launch of this mission will be published in the public domain.

As a secondary mission goal, the Sapling spacecraft will attempt to demonstrate satellite-to-satellite and satellite-to-satellite-to-ground data relays with another spacecraft, Yearling, owned and operated by California Polytechnic State University, Pomona, in care of Bronco Space, deployed from the same deployer on the same launch vehicle.

## 2. Remote Sensing Instrument

2.a. **Sensor type (Electro Optical, Multi-Spectral (MSI), Hyperspectral (HSI), Synthetic**

**Aperture Radar (SAR), Light Detection and Ranging (LIDAR), Thermal Infrared**

**(TIR), etc.):**

1 Electro Optical RGB Sensor (MSI) - OmniVision OV5645

2.b. **Imaging/frame rate in Hertz; pulse repetition frequency for SAR or LIDAR:**

**Peak frame rate at maximum resolution:** 15 Hz at 2592 x 1944 resolution

**Peak frame rate:** 60 Hz at 720 x 540 resolution

2.c. **Spatial resolution in meters (show calculation for the anticipated finest ground**

**spatial distance (GSD), impulse response (IPR), or other relevant appropriate unit**

**of resolution):**

140 meters (using 250 km altitude EOL)

*Based on 1.4 um \* 250 km / 2.5 mm = 140*

2.d. **Spectral range in nanometers:**

400-700nm

2.e. **Collection volume in area per unit time per spacecraft: provide an estimate of the**

**maximum number of square kilometers of which the system can provide**

**data/imagery per hour or per minute. If this is a fast-framing system, consider each recorded frame as a separate image collected:**

150,000 km^2/hour

*Based on 1 image ≃ 225,000 km^2, and downlink data rate limiting the spacecraft to 1 image downlinked per orbit (period ≃ 1.5 hours).*

2.f. **Ability of the remote sensing instrument to slew, point, or digitally look off-axis from the x, y, and z axes of travel:**

N/A. The OmniVision OV5645 sensor is fixed to the body frame of Sapling and is incapable of imaging off-axis.

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## 3. If any entity or individual other than the Applicant will own, control, or manage any *remote sensing instrument* in the System:

3.a. **Identity and contact information of that entity or individual:**

N/A

3.b. **Relationship to Applicant (i.e., operating under Applicant’s instructions under a**

**contract):**

N/A

## 4. Spacecraft Upon Which the Remote Sensing Instruments are Carried

4.a. **Description:**

Sapling is a 1U CubeSat, with overall sizes of 10 cm x 10 cm x 11 cm. It will fly the PyCubed flight computer and battery pack with minimal modifications, and body mounted silicon cell solar arrays. The primary structure is made of 6061 aluminum, with bronze steel composite (with a melting point similar to that of bronze) additively manufactured secondary support structures. The communications system consists of commercial, off the shelf LoRa radios with both command, telemetry, and data downlink on 437.4 MHz.

4.b. **Estimated launch date(s) in calendar quarter:**

November 7th, 2022.

4.c. **Number of spacecraft (system total and maximum in-orbit at one time):**

**System total:** 1

**Maximum on orbit:** 1

4.d. **For each spacecraft, provide the following (or if an entire constellation will have**

**substantially the same orbital characteristics, provide these values for the entire**

**constellation and note whether or not all spacecraft will be evenly spaced)**

4.d.i. **Altitude range in kilometers:**

**Lowest operational altitude (EOL):** 250 km (used for GSD calculations)

**Highest operational altitude (BOL):** 525 km

4.d.ii. **Inclination range in degrees:**

95.68° (Sun Synchronous)

4.d.iii. **Period (time of a single orbit):**

94.63 minutes (BOL).

4.d.iv. **Longitude of the ascending node:**

20:00

4.d.v. **Eccentricity:**

0.0

4.d.vi. **Argument of perigee:**

N/A (circular orbit).

4.d.vii. **Propulsion (yes/no). (If “yes,” you must complete question #2, the affirmation, in**

**the beginning of this application):**

No.

4.d.viii. **Ability of the spacecraft to slew, point, or digitally look off-axis from the x, y, and z**

**axes of travel:**

Sapling will use air-core PCB magnetorquers for coarse attitude control. Navigation will be performed using ambient light sensors and a 3-axis magnetometer, with an expected attitude knowledge error of ~5°. Underactuated attitude control will be used primarily to detumble the spacecraft, and will achieve ~20° pointing accuracy at peak performance for nadir pointing.

## 5. If any entity or individual other than the Applicant will own, control, or manage any *spacecraft* in the System

5.a. **Identity and contact information of that entity or individual:**

N/A

5.b. **Whether that entity or individual is a U.S. person:**

N/A

5.c. **Relationship to Applicant (i.e., operating under Applicant’s instructions under a**

**contract):**

N/A

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## 6. Ground Components

6.a. **Location of Mission Control Center(s) with the ability to operate the system,**

**including where commands are generated:**

Durand Building

496 Lomita Mall

Stanford, CA 94305

37.4269° N, 122.1733° W

6.b. **Location of other Ground Station components of the system, meaning facilities that**

**communicate commands to the instrument or receive unenhanced data from it, and**

**facilities that conduct data preprocessing:**

| **Type** | **Operator Name and Address** | **Coordinates** |
| --- | --- | --- |
| MCC | Flynn Dreilinger (KN6HCC); 496 Lomita Mall; Stanford, CA 94305 | 37.4269° N, 122.1733° W |

6.c. **If any entity or individual other than the Applicant will own, control, or manage**

**any *mission control center(s)* with the ability to operate the System**

N/A

## 7. Information Applicable to Multi-Spectral Imaging (MSI) and/or Hyper-Spectral Imaging (HSI). Applicants must complete this section only if the response in Part B section 2.a. is “MSI” and/or “HSI.”

7.a **Number of spectral bands:**

3 MSI Bands

7.b. **Individual spectral bandwidths (to include range of the upper and lower ends of**

**each spectral band in nanometers):**

400-510nm

480-580nm

570-700nm

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## 8. Noise Equivalent Target (NET). Applicants must complete this section only if the response in Part B 2.c. is 5 meters or less, and the answer in Part B section 2.a. is neither “SAR” nor “LIDAR.” NET is the primary parameter used by the U.S. Government to describe an Electro Optical sensor’s light sensitivity performance for a target at the same distance from the sensor as is specified as the minimum operating altitude in Part B section 4.d.i. If NET cannot be calculated, simply report the expected minimum detectable ground target radiance in watts:

## N/A

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## 9. Information Applicable to Light Detection and Ranging (LIDAR) if used for remote sensing. Responses should include the calculations used to derive the reported parameters. Applicants must complete this section only if the response in Part B section 2.a. is “LIDAR.”

9.a. **Type (linear scanning or flash LIDAR (Geiger)):**

N/A

9.b. **Laser wavelength and pulse frequency:**

N/A

9.c. **Laser pulse width:**

N/A

9.d. **Spectral linewidth:**

N/A

9.e. **Z/Elevation accuracy in meters:**

N/A

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## 10. Information Applicable to Synthetic Aperture Radar (SAR). Applicants must complete this section only if the response in Part B section 2.a. is “SAR.”

10.a. **Azimuth resolution (ground plane):**

N/A

10.b. **Range resolution (ground plane):**

N/A

10.c. **SAR Signal-To-Noise Ratio (SNR):**

N/A

10.d. **Polarization Capability (i.e. dual polarization, quad polarization):**

N/A

10.e. **Complex data: Preservation of phase history data in standard format? (yes/no):**

N/A

10.f. **Center frequency: MHz or GHz**

N/A

10.g. **Squint and Graze angles (include maximum and minimum), or other parameters**

**that determine the size and shape of the area of regard of the sensor collection**

**footprint at the ground:**

N/A

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## 11. Information Applicable to Thermal Infrared (TIR). TIR is defined as collecting in the spectral range of 3.0–5.0 and/or 8.0-12.0-micrometers. Applicants must complete this section only if the response in Part B section 2.a. is “TIR.”

11.a. **Estimated relative thermometric accuracy in degrees Kelvin (+/- x degrees of**

**actual):**

N/A

11.b. **Noise Equivalent Differential Temperature (NEDT), or if NEDT cannot be**

**calculated, simply provide the expected temperature sensitivity in terms of**

**minimum resolvable temperature difference in degrees:**

N/A

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# Part C: Requests for Standard License Condition Waivers or Adjustments

# N/A