(SP)ectral (O)cean (C)olor Satellite

UNIVERSITY OF GEORGIA
Small Satellite Research Laboratory

Caleb Adams, David Cotten, Deepak Mishra, Nicholas Neel, Graham Grable, Khoa Ngo

2017 Cubesat Developers Conference
SPOC – Spectral Ocean Color

- First Mission for UGA
- NASA USIP 2016
- CSLI 8, 2017
- Sparked founding of UGA SSRL
  - Undergraduate Founded
  - Undergraduate Run
  - Faculty Supported
  - Started with 4 undergraduates
  - Now has 54 undergraduates
- Past PDR
- CDR in May
SPOC mission

- 3U Form Factor
- Schedule in CSLI 8, 2018-2020 launch
- Hyperspectral Sensor from 432 nm - 866 nm
- Coastal Analysis and Resources
- Data complements Sapelo Island LTER
Scientific Objectives

- Monitor coastal wetlands status
- Monitor estuarine water quality including
  - Wetland biophysical characteristics
  - Phytoplankton dynamics
- Monitor near-coastal ocean productivity
  - SPOC shall use hyperspectral remote sensing techniques to quantify vegetation health
    - primary productivity
    - ocean productivity
    - suspended sediments
    - organic matter in coastal regions.

NOAA record setting toxic algal blooms
Science Data

- Sapelo Island ~50x50 km area
  - Takes 385 frames to cover the island
  - 506 frames needed due to ADCS pointing inaccuracies

- 4.12 nm (Hyperspectral) Scheme
  - yields 228 MB of data
    - Pro: High Spectral Resolution
    - Con: Low SNR

- 20 nm (Multispectral) Binned Scheme
  - yields 18.22 MB of data
    - Pro: Wide Area Data Acquisition
    - Con: Low Spectral Resolution
Payload Overview

- Pushbroom Scanner
- Diffraction Grating
- Monochrome CMOS
- Data similar to ESA Sentinel 2 and NASA MODIS
- 120m Spatial Resolution
- 4.12nm Spectral Resolution
  ○ Can bin from 4 - 40nm

UGA SSRL design for the SPOC Satellite’s internal optical payload
Payload Optics

- Mirror System
- Single Slit
- Collimating Lense
- Grating spectrometer blazed for 500 nm and has 150 lines per mm
- Focusing Lenses
- 752 x 480 pixel Monochrome CMOS array
- Adjustable Lense System
Payload Sensor

- Monochrome CMOS
  - 752px by 480px active
  - 55.55 fps
  - 17.5 ms readout
- Results in 120 m spatial resolution
- Each pixel is 1.03 nm spectrally
- Onboard FPGA performs binning of 4 pixel to produce 4.12 nm spectrally
- 3 Dimensional Data Cube

UGA SSRL pushbroom method for data acquisition with CMOS
### Binning

- Optimization in progress
- Current Binning Scheme:

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Bandwidth (nm)</th>
<th>QE</th>
<th>SNR (per pixel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>443</td>
<td>20</td>
<td>0.48</td>
<td>181</td>
</tr>
<tr>
<td>490</td>
<td>20</td>
<td>0.53</td>
<td>185</td>
</tr>
<tr>
<td>510</td>
<td>20</td>
<td>0.52</td>
<td>171</td>
</tr>
<tr>
<td>555</td>
<td>20</td>
<td>0.52</td>
<td>157</td>
</tr>
<tr>
<td>670</td>
<td>20</td>
<td>0.55</td>
<td>139</td>
</tr>
<tr>
<td>750.9</td>
<td>20</td>
<td>0.50</td>
<td>83</td>
</tr>
<tr>
<td>865</td>
<td>40</td>
<td>0.33</td>
<td>63</td>
</tr>
</tbody>
</table>

QE of the SPOC CMOS sensor
Payload Mechanics

- 2 piece housing
  - Lens housing
  - Electronics housing and payload structure
- PC104+ Compliant
- Total mass ~0.9 kg
- Designed for a low CTE

<table>
<thead>
<tr>
<th>Material Name</th>
<th>Purpose</th>
<th>CTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum 6061 t6</td>
<td>SpocEye Housing</td>
<td>2.36E-05</td>
</tr>
<tr>
<td>Aluminum 7075</td>
<td>SpocEye Housing</td>
<td>1.31E-05</td>
</tr>
<tr>
<td>Stainless Steel 304</td>
<td>Hardware</td>
<td>6.60E-05</td>
</tr>
<tr>
<td>Ultem 9085</td>
<td>Lens Holder</td>
<td>3.67E-05</td>
</tr>
</tbody>
</table>

UGA SSRL mechanical housing for the SPOC payload
Payload Electronics

- PicoZed Board
- Cloudland Instruments Motherboard
- Cloudland CMOS board
- Cloudland Interface Board
- 17 Watt Total power draw

UGA SSRL internal board layout with serial communications diagram
Satellite Bus Integration

- CubeSat PC104+
- Clyde Space Core Avionic Stack with Custom interface boards

SPOC Clyde core avionic stack with SSRL boards and BUS diagram
# SPOC, MODIS, Sentinel 2 & 3

Comparing 400 - 866 nm

<table>
<thead>
<tr>
<th></th>
<th>SPOC</th>
<th>(Terra) MODIS</th>
<th>Sentinel 2</th>
<th>Sentinel 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor Type</td>
<td>Pushbroom</td>
<td>Cross Track</td>
<td>Pushbroom</td>
<td>Pushbroom</td>
</tr>
<tr>
<td>Bands</td>
<td>20 - 120</td>
<td>13</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>SNR</td>
<td>63 - 185</td>
<td>128 - 1087</td>
<td>72 - 172</td>
<td>232 - 2188</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>4.12 - 20 nm</td>
<td>10 - 50 nm</td>
<td>15 - 115nm</td>
<td>2.5 - 20nm</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>120m</td>
<td>250 - 1000m</td>
<td>10 - 60m</td>
<td>300 - 1200m</td>
</tr>
</tbody>
</table>
Questions?