

Small Satellite Research Laboratory

Franklin College of Arts and Sciences

UNIVERSITY OF GEORGIA

 $\bullet \bullet \bullet$

Mission Overview and Concept of Operations

Nicholas Neel, Sydney Whilden 2018 SPOC CDR

Mission Overview

 $\bullet \bullet \bullet$

Spectral Ocean Color (SPOC) Satellite

The SPectral and Ocean Color (SPOC) Satellite shall acquire moderate resolution imagery across a wide range of spectral bands to monitor coastal ecosystems and ocean color. SPOC will acquire image data between 433 and 866 nm to monitor 1) coastal wetlands status, 2) estuarine water quality including wetland biophysical characteristics and phytoplankton dynamics, and 3) near-coastal ocean productivity. SPOC shall use multispectral remote sensing techniques to quantify vegetation health, primary productivity, ocean productivity, suspended sediments, and organic matter in coastal regions.







Small Satellite Research Laboratory

Mission Objectives

- Acquire moderate resolution imagery of coastal ecosystems, ocean color
- Acquire image data between 433 and 866 nm
- Use multispectral image products to monitor status of coastal wetlands, including estuarine water quality and ocean productivity



- Train STEM students
 - Data transmission techniques
 - Georeference mapping
 - Photogrammetric processing
- Community outreach
- Aerospace design, testing, and manufacturing





Small Satellite Research Laboratory

Franklin College of Arts and Sciences

Success Criteria

Minimum	Full
Image one coastal target with spatial resolution 240m	Image the same coastal target 5 times with spatial resolution 150m
Acquire images with band spectral resolution of 50nm	Acquire images with band spectral resolution of 10nm
30 students involved for at least 2 semesters each over project lifetime	75 students involved for at least 2 semesters each over project lifetime
Give 5 community outreach presentations, mentor 2 local high school students, produce 5 space news/educational podcasts	Give 20 community outreach presentations, mentor 5 local high school students, produce 20 space news/educational podcasts, plus 10 instructional YouTube videos





Small Satellite Research Laboratory Franklin College of Arts and Sciences

Payload

Structure is based on Cloudland-designed HawkEye sensor, onboard SeaHawk mission (UNC Wilmington)

SPOCeye

- Pushbroom multispectral primary payload
- 16 adjustable bands
- 130 m GSD

Finderscope

- Small 1km GSD imager
- Aid post data processing and acquire oblique satellite imagery







Small Satellite Research Laboratory Franklin College of Arts and Sciences UNIVERSITY OF GEORGIA

Requirements

- Flow down from the mission statement
- Break into requirements for each subsystem
- Traced and must be verified prior to launch
- Under the Science Traceability Matrix

Science, Mission, and Spin-dual Color Disease Physical Disease Disease Physical Disease Diseas	Requirement Traceasti et al. (1997) and experimentary and the second sec	By Matrix Versi Construction Constructi			
Spectral Operations Colored Operations Disager Operations Spectral Processing Pleaser Processing Pleaser Processing Operations Pleaser Processing Pleaser	The Alexan control of				
Masten 3-1 Subern til 3-1 Masten Scott Sacens Pick Pickers Pick	Manual and Same Sole (2005) Sectors and Same Sole (2005)	The first of all and a constraints with an other definition of the second seco	In a sequence service statics are good and y exclusion given a solar service good of event states of T22 One and present to a solar service and present to a solar solar service and present to a solar solar service and present to a solar solar solar solar and present to a solar solar solar solar and present to a solar solar solar and present to a solar and pres	eponent source (C. Davie on Millioner), an oracle method out of photophotoco, space out one of the source of the source of the source of the source of the filter of the source of the source of source of photoco of the source of the source of	n senid song som and n
Access Saccess Criteria Acc Picc	 Henrichige over week dag Seld have do some roaded Seld have do some roaded Seld have do some roaded Seld have do some roaded have Henrichie Seld Seld have Henrichie Seld Seld have Henrichie Seld Seld have Henrichie Seld Seld have have have some roads have have some roads have some have have some roads have some roads have some roads have have some roads have some roads have some roads have have some roads have some ro	and Tartes upon that I am emotioners are particulars a "Borning in adultion of and quarter and emotion of 100 er- and quarter and emotion of 100 er- tends, are done in 10000 from the atom in dy are related in 10000 from the atom is go a finance community in adultion of a go a finance community in adultion of the goar finance community in adultion of the goar finance community in adultion of the goar finance community in adultion of the goar finance community in adultion of the goar finance community in adultion of the goar finance community in adultion of the goar finance community in adultion of the goar fi	galid real age of 120% reals aroughd a school of 197 digreen/finite barries served ar hyperen/finite barries served	er, senar for lifetyne of the proposi er soner for lifetyne of Horpsyn er al soneren, wel her synar er an beine disert	
THE PERSON NAMED IN CONTRACTOR OF	Measurement Objectives	Manuarret Basiarret	n, reeks for head high selection	in transition and a post of the second s	Data Brockets
SU BLE CONCINE	Personal Collection	Print Centers in apprenties	interantina	In Carolina Magaremena	LORA PTORACIO
	are 19 setting Costs, Petersony Prost out only a 1 Constability of areas	1 Municeph in the area of 800 800mm 2 Novice could area seen a reach 30 novice could area seen a reach 31 novice could be a first the first firs	Onderstinder one "IFOX Byr"	1 Speciel & Rowaldow 10 Sect of 1 NR 100 2 Painting units says of 100 degrees	Carlos - Sergen Antino Par
~	nan linndoni Silmena la piata e Jake	1 Bool 3000 - 7000 re(and of sound (700 - RCOse) barrish 2 Barrish consult area server a reads	Couline Index and "IFCC Bys"	Effective of the solution 20xm1 all 198300 2) Painting area may of 100 degrees	Uptile Holk
Andered Station	Coastal Propping	1 Fresh san abil and a phone work	les 82H G.NJ Testenreps"	3.0/D laster i than 30 wet maps right 2 Painting scan ray of 100 argum	Coastal Imageny
	aine on Plan and April Barry Taking	1) Books was word & some larget some a mariti	fex 83H 0.00 "Testencope"	1.02D tasks ritise 300mm unper pixel 31 Painting area ang of 1.00 degrees	Instea of Parm and April Rat
	Manuar (Inda yiyi)) hij Belinsterne	17hr or kanisher an e d'Nued 190nes. It des al Oscand on: NOCher '2	Ossilard induces he 'BOC lipe'	Highers of the solution 20 mm Facil 108 XXG 21 Painting across range of FGD Argumen	Phylopheliter Gauss
Person Examine Personal Aster Catalog Story Borghound	lamat Reparative FC Network	11 Banda and read on 629 nm 639 nm, and 754 nm (~) Sam for each least 23 Am of Chamatan (1020 Jan 3	Coulord Index and "IFOC Bys"	1 Specified for solution 20 mm fract 108 XX0. 2) Pointing series may of 1 GD degrees.	C parentinal orde Game
digit opticable and generation) () (a	en in Geboord Disactional Digers Material EXEM Wolfsmanne	1 Fan december it en Aller er and 100 en: Skew of Obsimulation (1000 km² 2	Conduct Induct and "IFC Byr"	1 Speciela Revalution 20vert al 198300 2) Pointing scale and of 1000 degrees	Winter Gaultin
	naar bail haperied Soderen (201 Milot e w	1 Far Acceleration (1990) Silves of Occuments of SOCIAN' 2	Coulord Industry, "With Dy-	1 Speciel 4 Re-solution 20ver/14(118700) 2 Painting area say of 100 degrees	Louisson Plan a Lopa
Atlantic Ocean				6	1
	Measur Dura Calo Brib Kann	1 Maslergh to its sage of 8D-8Dee- Skew of Okonstan (1900ker' 2	Condent Index and "BOX Spr"	Elipson d Re window 30xw1 a(\$38500 3) Paining som sog of 100 degrees	O k optyd Baie Ann Almonghain Gaar da
l Paritor Grant	Henniet Galer physioni Bellenieren	175e on bandshart one is 25Court 10Court 2 Ben of Observation, 10Color, 12	Condend Instanton, "IPOX Bys"	13pres 4 Re salatare 20ver5.s338900 2) Painting area tau of 100 degrees	Phyliphetics Game
Austination and Antipation dynamics	Annual Physics parts F.C. Millio Serve	234 and 1-2" from the match and 1 (block of Observation 1/0000 et " 2	Oculies Industries "IFOX Bys"	Class is 4 for solution 20xec1 w2.NRXXX 2) Proving some mag of 1000 degreen 2) Second (for solution 20xec1 w2.NRXXXX)	C paradiant rota Gauge I
	CIEM Ballestern	Splace of Obstream of SODLer' 2	Goaland Insteam and "IPOC Bys"	2 Pointing som sog of 1000 degrees	Mater Goality

- OBC 01
 - OBC shall log extracted telemetry from each subsystem via the satellite bus.





Small Satellite Research Laboratory

Franklin College of Arts and Sciences

Target List

- Primary Targets:
 - \circ Total Area ~606.7 km²
 - Sites that have been preselected in order to fulfil the success criteria of the mission
- Secondary Targets:
 - Total Area ~1,004,494.782 km²
 - Extended targets to image/scan should SPOC complete all success criteria for each primary target
- Tertiary Targets:
 - Experimental images/scans gathered for educational purposes, but does not have scientific merit
- Total Scan Area: ~5,253,788.03 km²
- Will have margin to take multiple scans of primary targets to add temporal resolution





Small Satellite Research Laboratory

Experiments

- Obtain radiance values of all surface targets
- Calculate Remote Sensing Reflectance (Rrs)
 - over targets with in-situ downwelling radiation measurements
 - Estimated over other targets
- Near Coastal Ocean Productivity
 - Total Suspended Sediment (TSS)
 - Chlorophyll
 - Particulate Organic Carbon (POC)
- Wetland Biophysical Charactaristics
 - Normalized Difference Vegetation Index (NDVI)
 - \circ Enhanced Vegetation Index (EVI)

- Other
 - Phycocyanin
 - Leaf Area Index (LAI)



Franklin College of Arts and Sciences UNIVERSITY OF GEORGIA

Small Satellite Research Laboratory





Concept of Operations

 $\bullet \bullet \bullet$

(CONOPS)

Overview

2 core principles:

- 1. Safe satellite operation
- 2. Acquisition of telemetry, payload, and end-product data to meet mission requirements







Small Satellite Research Laboratory

Automation

- Prolong operational lifetime
- Reduce number of required ground staff
- Acquisition of multispectral image data (payload boot, data acquisition, data handling, payload shutdown)
- Command/data handling (logger, monitor, scheduling, facilitation modules)
- Onboard error detection/correction; hardware watchdogs

- Uplink of operational schedules allows pseudo-autonomy
- Failsafe state: Ground intervention unavoidable. Automated processes cease, besides command/data handling





Small Satellite Research Laboratory Franklin College of Arts and Sciences

Flight Rules

A flight rule is a constraint that the mission operators place on the satellite or on operational procedures..

SFR-1: Spacecraft cannot downlink data while in eclipse.

- SFR-2: Payload cannot look directly at sun
- SFR-3 : Permission from Mission Director is required to manually transition into Safe Mode.
- SFR-4: Software updates may only occur if another pass occurs within 100 minutes.
- SFR-5: Weekly housekeeping "outage" passes must be open-ended and controlled by ground operations.
- SFR-6: Batteries shall not exceed 20% depth of discharge during operations





Small Satellite Research Laboratory



Transitions

Soft transition

- Central command passed to core logic of current operational state
- No new tasks issued for current mode
- Wait for completion of in-progress tasks
- All nominal transitions are soft.

Hard transition

- Immediately end all processes and go to Safe Mode
- Do not wait for completion of any task





Small Satellite Research Laboratory

Safe Mode

Off-nominal, unique, or hazardous situations.









Small Satellite Research Laboratory

Franklin College of Arts and Sciences

Scan Mode

Primary science mode; can run continuously for 30 minutes max.

		Prep Cinter
Prep	Turn on all imagers and set configurations	Scan Mode Sub-Mode Flow
Spectra Gathering	 SPOCeye scans target; finderscope takes 3 images: T_Area_Enter +5 seconds, T_Nadir (or [T_Area_End - T_Area_Enter]/2, T_Area_End -5 seconds 	Prep Spectra Gathering To Safe
Data Finalization:	Move data to non-volatile onboard storage and post-process into bands	Data Finalization To Cruise





Small Satellite Research Laboratory

Data Finalization

Exit

Franklin College of Arts and Sciences UNIVERSITY OF GEORGIA

Spectra Gathering

Image Mode

Optional mode for educational data. Allows the satellite to adjust to a commanded attitude.

Prep	Makes attitude adjustment; checks that finderscope is on and operational
Image Gathering	Tracks point and takes images
Data Finalization	Satellite returns to nadir; finderscope powers off









Small Satellite Research Laboratory

Data Downlink Mode

S-band downlink mode; entered via telecommand from the ground. Ground operators uplink next schedule.

Prep	Powers on transmitters and synchronizes with ground station
Data Transmission	Transfers RF packets
Transmission Exit	Powers down transmitters and deletes downlinked data







To

Small Satellite Research Laboratory Franklin College of Arts and Sciences

Cruise Mode

Nominal mode. Keeps satellite nadir-oriented.



Idle	Default. Satellite beacons unencrypted AX.25	Cruise Mode Sub-Mode Flow
	ground control.	Image Mode Idle
Power Generation Idle	Idle, but with special considerations to maximize power generation.	Scan Mode ↔
Heat Protection Idle	Idle, but with special considerations to maintain operational safety during prolonged Sun exposure.	Data Downlink Mode \leftrightarrow Power Generation Idle Safe Mode \leftrightarrow Heat Protection Idle





Small Satellite Research Laboratory Franklin College of Arts and Sciences

Mission Operations

Commanding

- Operational schedules verified in spacecraft simulator; require approval of Mission Director
- Uplink schedule following predefined time sequence; allows automatic transitions between operations
- Critical command sets may require special approval before uplink
- Document both successful and failed command execution
- Encrypted uplink/downlink





Small Satellite Research Laboratory

Telemetry Monitoring

- Telemetry and event messages will be graphically and textually displayed
- Real-time monitoring with ground system display
- Analysis system provides quick access to historical and near-real-time telemetry
- Data can be retrieved from web interface





Small Satellite Research Laboratory

Routine Operations

"Routine": Performed continuously at consoles by mission operators

- Confirm successful command execution
- Monitor telemetry for precursors to anomalous behavior
- In case of behavioral anomaly, act to maintain operational safety
- Monitor ground system performance
- Create/test schedules





Small Satellite Research Laboratory

Housekeeping Operations

"Housekeeping": Performed regularly to maintain basic functionality

- Manage attitude, clock, and OBC
- Reconfigure subsystems outside of normal scheduled mode transitions
- Periodic payload calibration/maintenance
- Performed approximately weekly, during periodic "outage" times, probably within line of sight





Small Satellite Research Laboratory

Special Operations

- Extreme beta angle:
 - High: Orient Z+ face sunward to minimize heat risk during prolonged Sun exposure. (beta angle > 71 deg or < -71 deg)
 - Low: Orient X+ and Y+ panels toward Sun to maximize power generation during maximum eclipse.
 (beta angle between -5 and +5 deg)
- Fine sun sensor visibility:
 - 2 orthogonal sensors; which Z face sees prograde depends on the sign of the beta angle
 - Beta angle > 0: Z- face toward prograde
 - Beta angle < 0: Z+ face toward prograde
- Weekly OBC reboot





Small Satellite Research Laboratory

Anomaly Operations

In case of failure or degradation of system performance/nominal operations.

Level 0: No attention needed. Bright Ascension detects, logs, does not correct.

Level 1: Bright Ascension automatically detects, logs, corrects.

Level 2: Requires ground intervention. Safe Mode + Primary Boot Image

Level 3: Critical, rapid error resulting in OBC reboot. Safe Mode + Failsafe Image





Small Satellite Research Laboratory

Questions?

