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Small Satellite Research Laboratory

Research and Development of Satellite Software and Electronics

Adam King, Dustin Mizelle, & AJ Banerjee

2017 CURO Symposium

Overview

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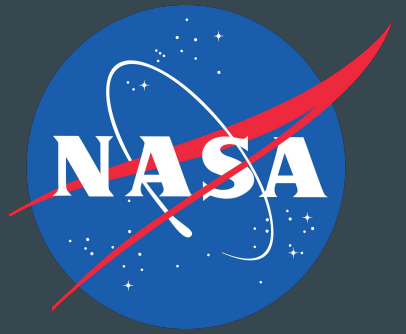
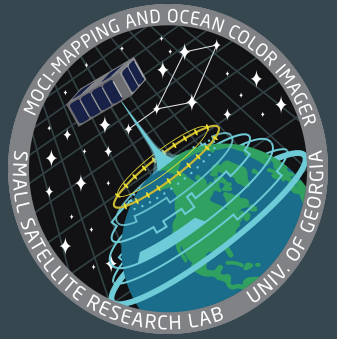
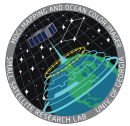
Missions

- NASA Spectral Ocean Color (SPOC) satellite will gather hyperspectral imagery, launch 2018 to 2020
- Air Force Research Laboratory Mapping and Ocean Color Imager (MOCI) satellite will create on-board 3D maps of Earth's surface using 2D images, competitive review January 2018







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Schedule

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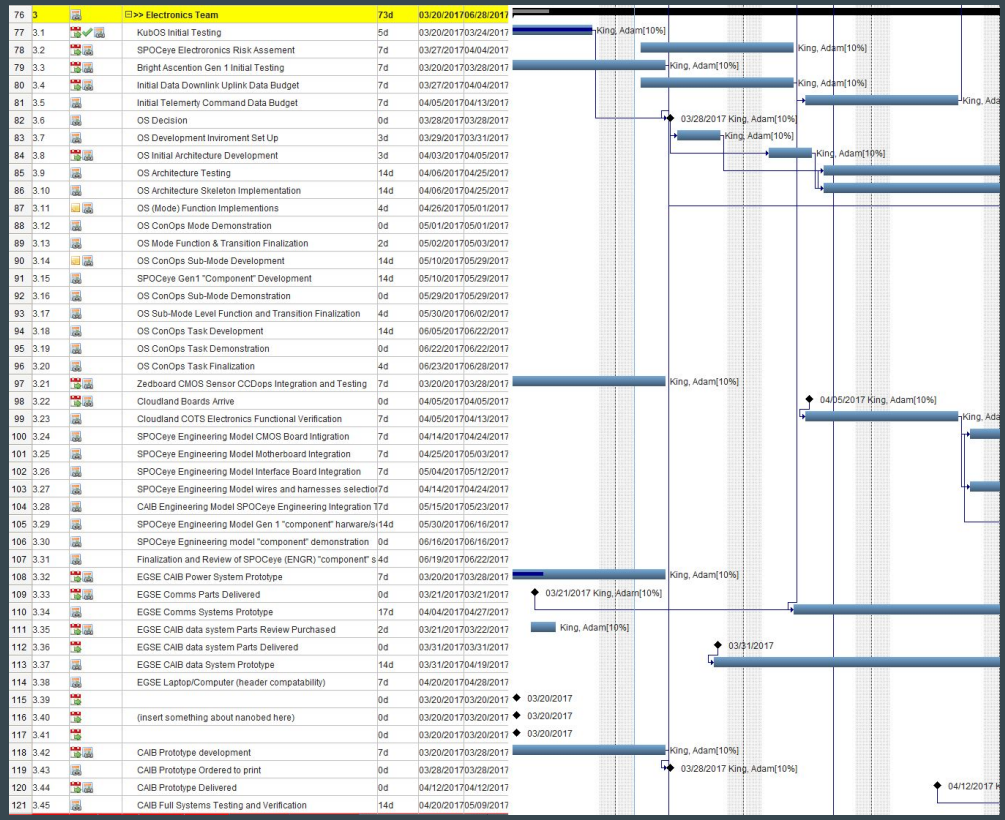
Gantt Chart

- Tasks with dependencies
- Timeline is more realistic, functional, and predictive
- Each tasks maps to 2 - 5 other tasks to be assigned
- As the Electronics Team Leader, it is up to me to determine this mapping from tasks to assignments



76	3	>> Electronics Team	73d	03/20/2017	06/28/2017
77	3.1	KubOS Initial Testing	5d	03/20/2017	03/24/2017
78	3.2	SPOCeye Electrononics Risk Assement	7d	03/27/2017	04/04/2017
79	3.3	Bright Ascention Gen 1 Initial Testing	7d	03/20/2017	03/28/2017
80	3.4	Initial Data Downlink Uplink Data Budget	7d	03/27/2017	04/04/2017
81	3.5	Initial Telemerty Command Data Budget	7d	04/05/2017	04/13/2017
82	3.6	OS Decision	0d	03/28/2017	03/28/2017
83	3.7	OS Development Invironment Set Up	3d	03/29/2017	03/31/2017
84	3.8	OS Initial Architecture Development	3d	04/03/2017	04/05/2017
85	3.9	OS Architecture Testing	14d	04/06/2017	04/25/2017
86	3.10	OS Architecture Skeleton Implementation	14d	04/06/2017	04/25/2017
87	3.11	OS (Mode) Function Implementions	4d	04/26/2017	05/01/2017
88	3.12	OS ConOps Mode Demonstration	0d	05/01/2017	05/01/2017
89	3.13	OS Mode Function & Transition Finalization	2d	05/02/2017	05/03/2017
90	3.14	OS ConOps Sub-Mode Development	14d	05/10/2017	05/29/2017
91	3.15	SPOCeye Gen1 "Component" Development	14d	05/10/2017	05/29/2017
92	3.16	OS ConOps Sub-Mode Demonstration	0d	05/29/2017	05/29/2017
93	3.17	OS Sub-Mode Level Function and Transition Finalization	4d	05/30/2017	06/02/2017
94	3.18	OS ConOps Task Development	14d	06/05/2017	06/22/2017
95	3.19	OS ConOps Task Demonstration	0d	06/22/2017	06/22/2017
96	3.20	OS ConOps Task Finalization	4d	06/23/2017	06/28/2017
97	3.21	Zedboard CMOS Sensor CCDops Integration and Testing	7d	03/20/2017	03/28/2017
98	3.22	Cloudland Boards Arrive	0d	04/05/2017	04/05/2017
99	3.23	Cloudland COTS Electronics Functional Verification	7d	04/05/2017	04/13/2017
100	3.24	SPOCeye Engineering Model CMOS Board Intigration	7d	04/14/2017	04/24/2017
101	3.25	SPOCeye Engineering Model Motherboard Integration	7d	04/25/2017	05/03/2017
102	3.26	SPOCeye Engineering Model Interface Board Integration	7d	05/04/2017	05/12/2017
103	3.27	SPOCeye Engineering Model wires and harnesses selection	7d	04/14/2017	04/24/2017
104	3.28	CAIB Engineering Model SPOCeye Engineering Integration	7d	05/15/2017	05/23/2017
105	3.29	SPOCeye Engineering Model Gen 1 "component" harware/s	14d	05/30/2017	06/16/2017
106	3.30	SPOCeye Egineering model "component" demonstration	0d	06/16/2017	06/16/2017
107	3.31	Finalization and Review of SPOCeye (ENGR) "component" s	4d	06/19/2017	06/22/2017
108	3.32	EGSE CAIB Power System Prototype	7d	03/20/2017	03/28/2017
109	3.33	EGSE Comms Parts Delivered	0d	03/21/2017	03/21/2017
110	3.34	EGSE Comms Systems Prototype	17d	04/04/2017	04/27/2017
111	3.35	EGSE CAIB data system Parts Review Purchased	2d	03/21/2017	03/22/2017
112	3.36	EGSE CAIB data system Parts Delivered	0d	03/31/2017	03/31/2017
113	3.37	EGSE CAIB data System Prototype	14d	03/31/2017	04/19/2017
114	3.38	EGSE Laptop/Computer (header compatability)	7d	04/20/2017	04/28/2017
115	3.39		0d	03/20/2017	03/20/2017
116	3.40	(insert something about nanobed here)	0d	03/20/2017	03/20/2017
117	3.41		0d	03/20/2017	03/20/2017
118	3.42	CAIB Prototype development	7d	03/20/2017	03/28/2017
119	3.43	CAIB Prototype Ordered to print	0d	03/28/2017	03/28/2017
120	3.44	CAIB Prototype Delivered	0d	04/12/2017	04/12/2017
121	3.45	CAIB Full Systems Testing and Verification	14d	04/20/2017	05/09/2017

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Ground Station

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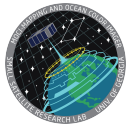

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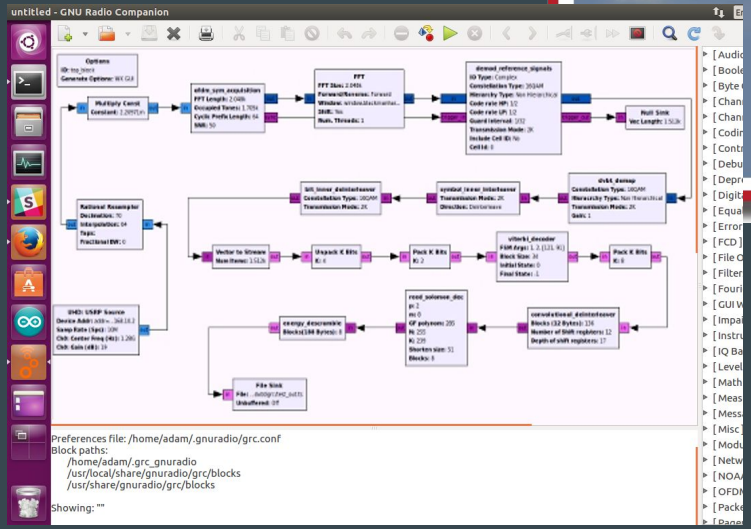
Hardware vs Software

- Ground station research and development
- Hardware-defined
- Software-defined
- Ongoing development



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Satellite Emulation

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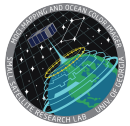

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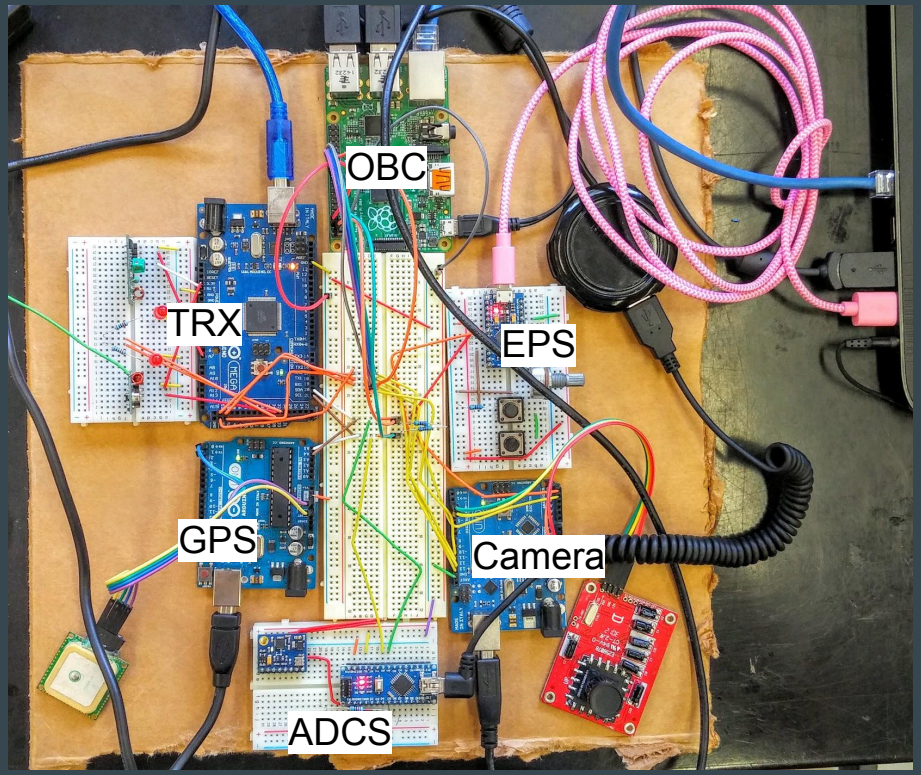
Bread Satellite, v1.0

- Satellite emulation
- Data transmission tests
- Understanding of common communication protocols
- Purchasing engineering model hardware now from Clyde Space



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Power Budget

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Power Consumption by Mode

- Ensure satellite will not die
- Determine how long we can operate in each mode
- Data Gathering for SPOC and Data Processing for MOCI are the most power intensive
- Critical for mission success

Spacecraft Subsystem, Unit, Quantity and Power Consumption						Power Consumption by Spacecraft Mode							
Subsystem	Component	Peak Power(W)	Qty	Comment	Total Power (W)	Deployment		Calibration		Sample, Scan: Data Nadir		Downlink	
						Duty Cycle	Mode Power	Duty Cycle	Mode Power	Duty Cycle	Mode Power	Duty Cycle	Mode Power
Core Avionics													
C&DH	Clyde Space CubeSat OBC Typical	0.350	1		0.350	100.00%	0.35	100.00%	0.35	100.00%	0.35	100.00%	0.35
COMM	CPUT CMC – UHF TX	6.322	1		6.322	10.00%	0.63	10.00%	0.63	10.00%	0.63	10.00%	0.63
	CPUT CMC – VHF RX	0.188	1		0.188	10.00%	0.02	10.00%	0.02	10.00%	0.02	10.00%	0.02
	CPUT S-band TX	5.976	1		5.976	0.00%	0.00	0.00%	0.00	0.00%	0.00	100.00%	5.98
ADCS	erboard Ty	0.500	1		0.500	0.00%	0.00	100.00%	0.50	100.00%	0.50	100.00%	0.50
	Motherboard Detumbling	2.000	1		2.000	100.00%	2.00	0.00%	0.00	0.00%	0.00	0.00%	0.00
	MTQ (x y)		2							0.00%	0.00		
	MTQ (z)		1							0.00%	0.00		
	3 Reaction Wheels	2.500	1		2.500	100.00%	2.50	0.00%	0.00	0.00%	0.00	0.00%	0.00
	GPS	0.726	1		0.726	10.00%	0.07	10.00%	0.07	100.00%	0.73	10.00%	0.07
EPS	EPS Board	0.200	1		0.200	100.00%	0.20	100.00%	0.20	100.00%	0.20	100.00%	0.20
	Battery	0.100	1		0.100	100.00%	0.10	100.00%	0.10	100.00%	0.10	100.00%	0.10
	Heater	0.400	1		0.400	50.00%	0.20	50.00%	0.20	0.00%	0.00	50.00%	0.20
Payloads													
PYLD	SPOCEye CMOS	17.800	1		17.800	0.00%	0.00	100.00%	17.80	100.00%	17.80	0.00%	0.00
	SPOCEye MB		1										
	SPOCEye PicoZED		1										
Total Mode Power (W)						**6.07**		**19.87**		**20.33**		**8.05**	

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Data Budget

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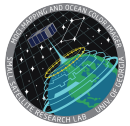

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Data Gathered or Created by the Payload

- Ensure data gathered/created can be downlinked
- Estimated based on information from SSRL Research Team
- Critical for mission success

Source	Sample Size (bytes)	Sample Overhead (bytes)	Sample Frequency (Hz)	Duration (s)	Sample Total (bytes)	Downlink Overhead (bytes)	Total (bytes)	Total (Kbytes)	Total (Mbytes)
GPS	972	68	0.20	3600	748800	74880	823680	823.68	0.82
EPS	96	18	0.02	20736000	39398400	3939840	###	43338.24	43.34
OBC	40	12	0.02	20736000	17971200	1797120	###	19768.32	19.77
COMM (UHF TRX + S-band TX)	32	6	0.03	20736000	26265600	2626560	###	28892.16	28.89
NanoCam C1U (payload)	471,859,200	94,371,840	0.02	1500	1.4156E+10	1415577600	###	15571353.60	15571.35
eSOMTK1 (point cloud generation)	8100000	113,246,208	0.00	108000	3640386240	364038624	###	4004424.86	4004.42

Notes:

The data budget refers to the entirety of an 8 month mission. For sample overhead it was .3 for all subsystems and .2 for the NanoCam.

EPS is singular packet

WIP: eSOMTK1 - duration and sample size

Total generated data (MB)	19669
Total data overhead (MB)	5901
Total data (MB)	25569
Total downlink capability (MB)	8160.4
Final overhead (MB)	-213.33%
Minimum Mission Success Criteria (MB)	456.759706
Full Mission Success Criteria (MB)	1287.2319

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Electrical Ground Support Equipment

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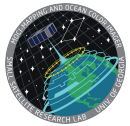

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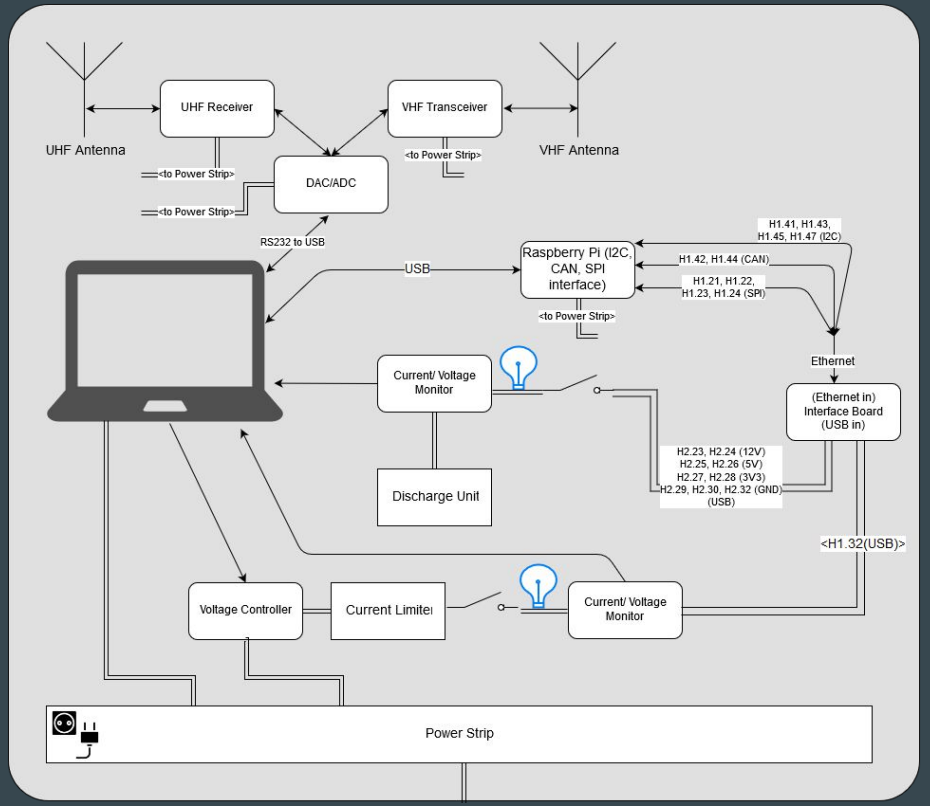
Satellite Testing

- Test the satellite once it is constructed
- Command with the satellite over radio communications
- Ensure data integrity on data interface
- Power satellite without operating the battery
- Charge the battery without operating the satellite
- Ongoing development



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MOCI Payload

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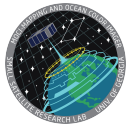

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GOMSpace NC1U

- Capture images using traditional RGB camera
- Provides 2048x1536 resolution
- Researching higher resolution options

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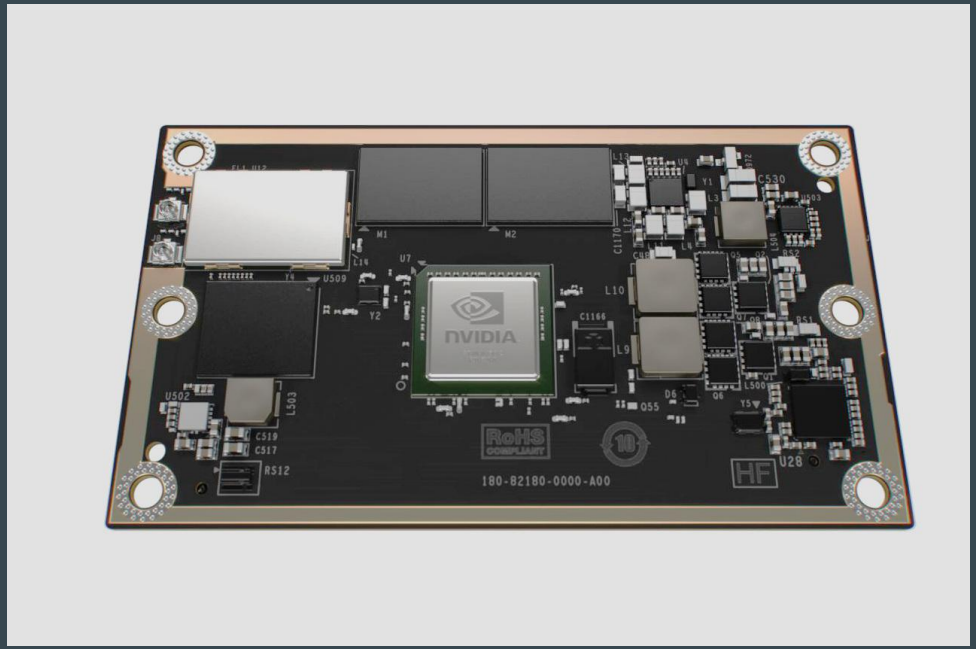
NVIDIA Jetson TX1

- Original research began into the NVIDIA TK1 from eCON Systems
- Contact with NVIDIA pointed us towards the TX1
- Coincidentally, the same GPU in the Nintendo Switch
- TX1 will created 3D representation of Earth's surface using Structure from Motion with 2D images



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SPOC Payload

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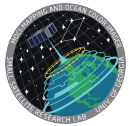

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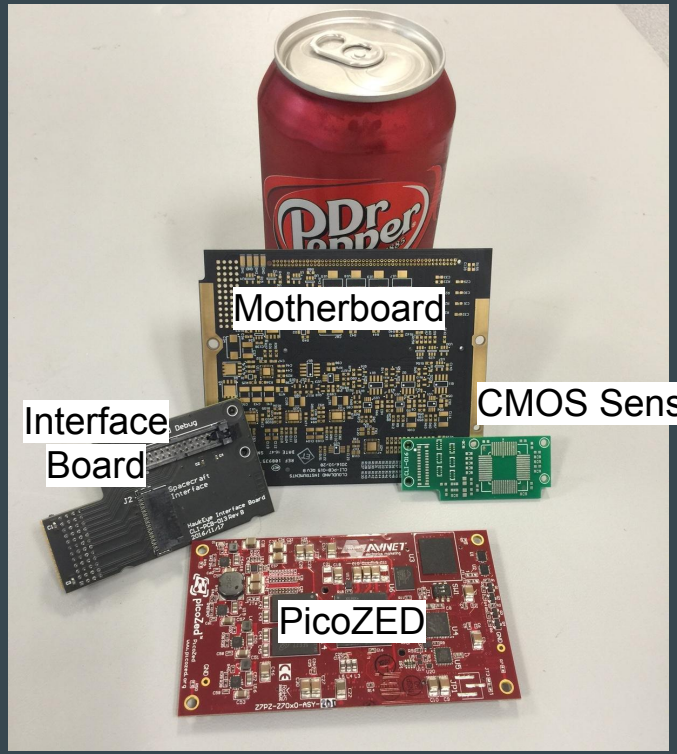
"SPOCeye"

- From Cloudland, similar to the SeaHawk mission's Hawkeye payload
- After light goes through processing, images are captured with CMOS board, routed through PicoZED, then motherboard, then Interface Board
- Ongoing development with how this will integrate with mission software



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Radiation Mitigation Design

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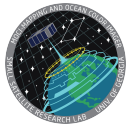

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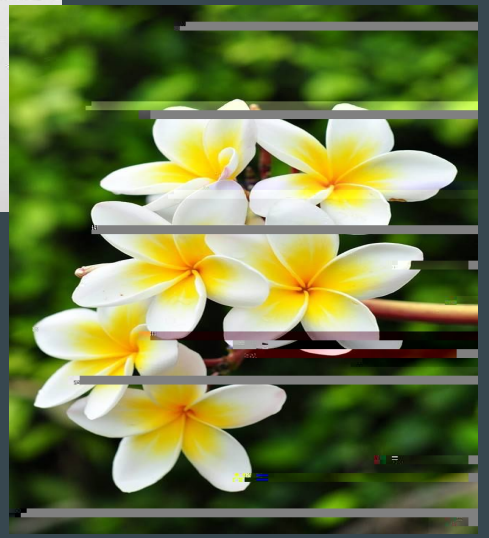
Error-Correcting Code

- Radiation can cause electronics to malfunction
- Bit-flips are hazardous to all types of data, including image data (as seen here, thanks to Kayla Gilbert)
- Extended Hamming Code and Golay Code
- Ongoing development into how this can be detected and corrected



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GPU Simulation

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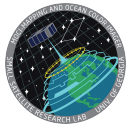

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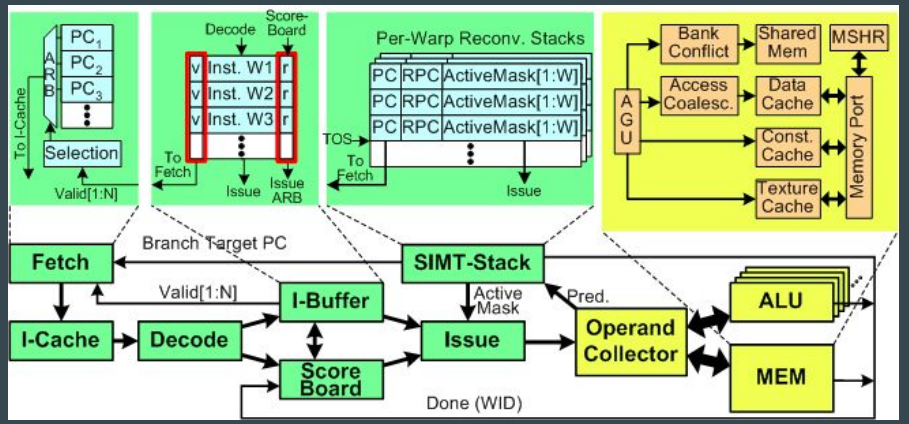
GPGPU-Sim

- Compares GPUs with CUDA cores
- Allows development of Structure from Motion on GPUs without having real GPUs
- Ongoing development



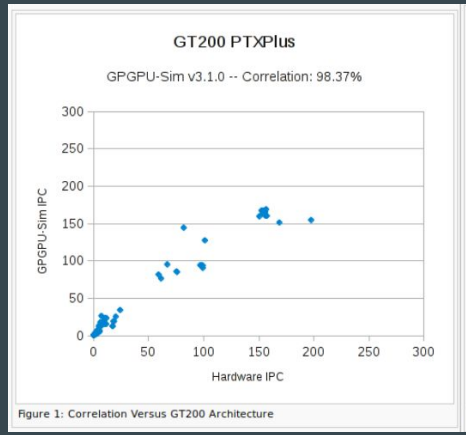


Figure 1: Correlation Versus GT200 Architecture

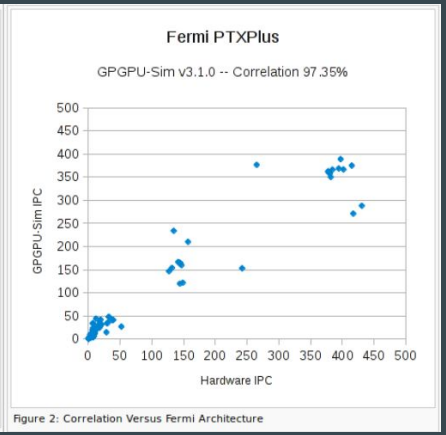


Figure 2: Correlation Versus Fermi Architecture

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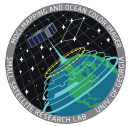
Software Systems

AJ Banerjee



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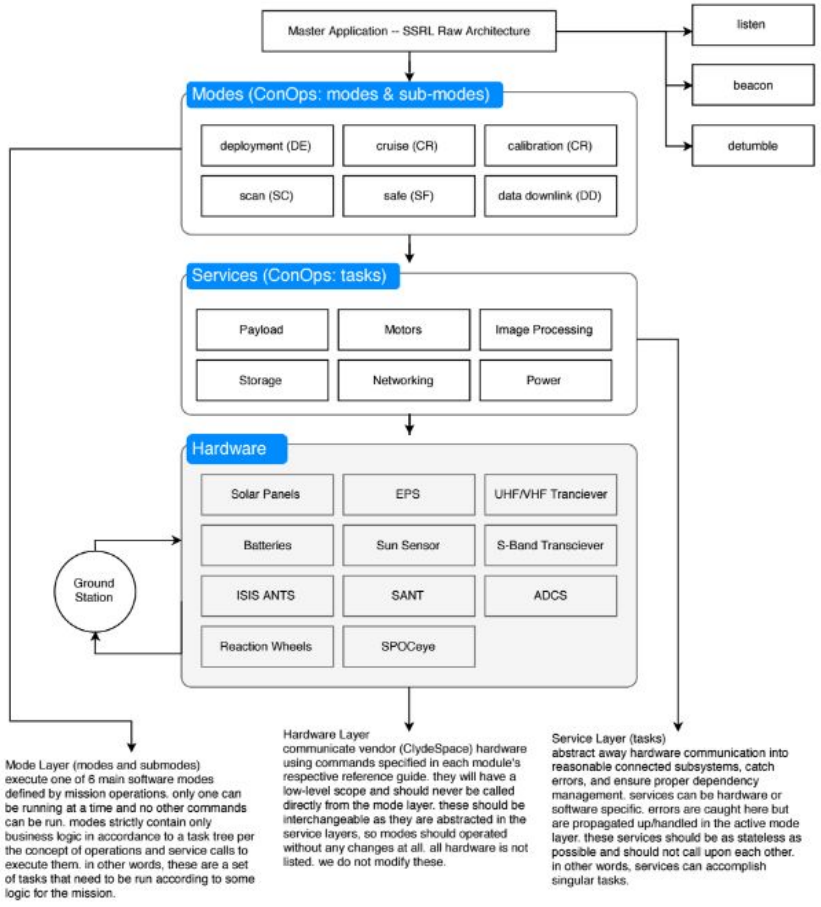
Software Architecture

- Service oriented architecture
  - Modes
  - Services
  - Hardware
- Refined and tweaked as Concept of Operations evolved
- Forms the basis of evaluating possible implementation routes we can take



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Implementation

- Cubesat operations are time-sensitive and OBC only supports RTOS
  - Cannot proceed with Linux
- Difficult to implement everything by hand in allotted time period
- Researched many vendors with a common criteria (OS Trade Study):
  - Performance
  - Cost
  - Reliability
  - Logistics
  - Impact on Timeline
  - Flexibility
- Currently conducting trade studies on
  - compression algorithms
  - space networking protocols (CSP, CCSDS, CFDP, etc.)

Development Manual

- Coordinate using the SCRUM framework (stand-ups, sprints, etc)
- Use Git as a VCS
  - Feature Branching + PR
  - Template for filing issues
  - Template for pull requests
- Code/deliverable acceptance criteria
  - Fully written and passing unit tests
  - Fully documented on usage and reference material
  - Java-doc-style and inline-style comments throughout new code
  - Adhere to Google Style Guides for C++ and Python
- Test often
  - Google Test to test C++
  - Continuous integration system like Jenkins

Satellite Hardware

Dustin Mizelle

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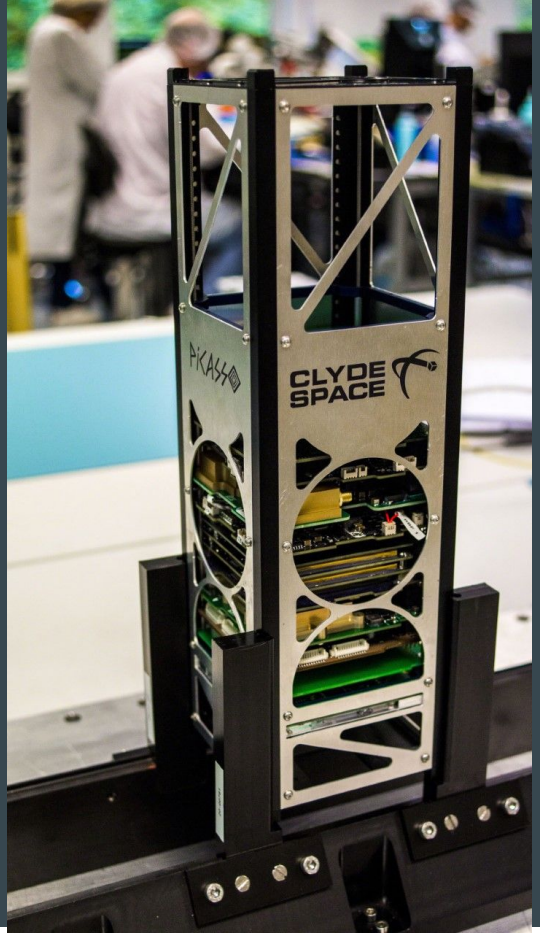
Hardware Interfacing

- Work to ensure compatibility between all subsystems of satellite
- Know the connections and how parts interface with others
- Interface Control Document



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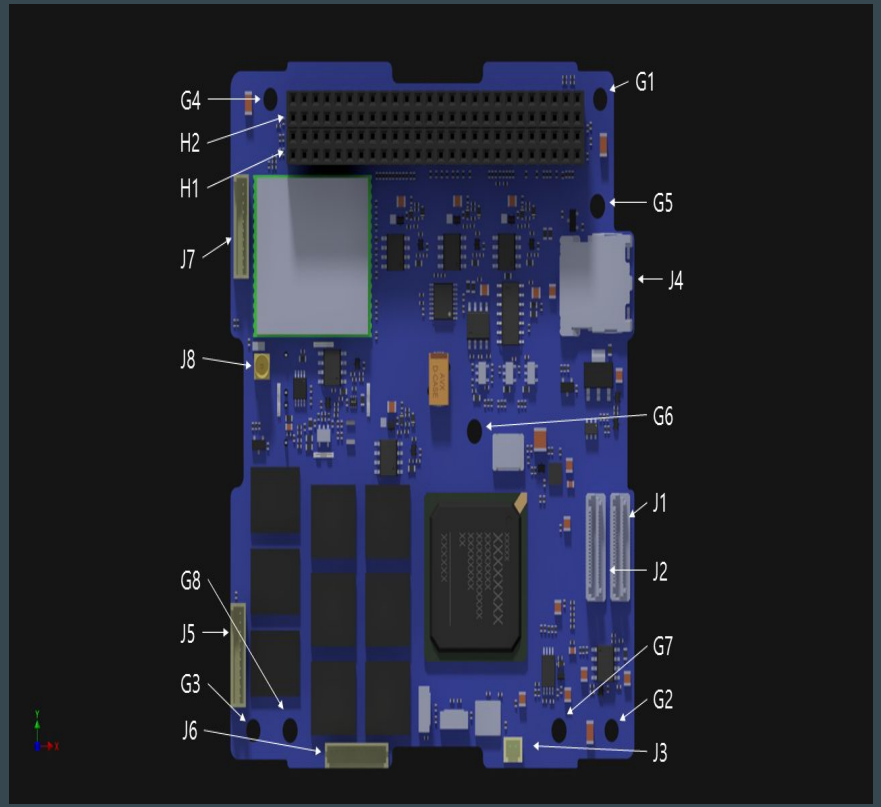
Onboard Computer

- Brains behind the whole satellite
- Determines what actions satellite is to do
- Controls all subsystems



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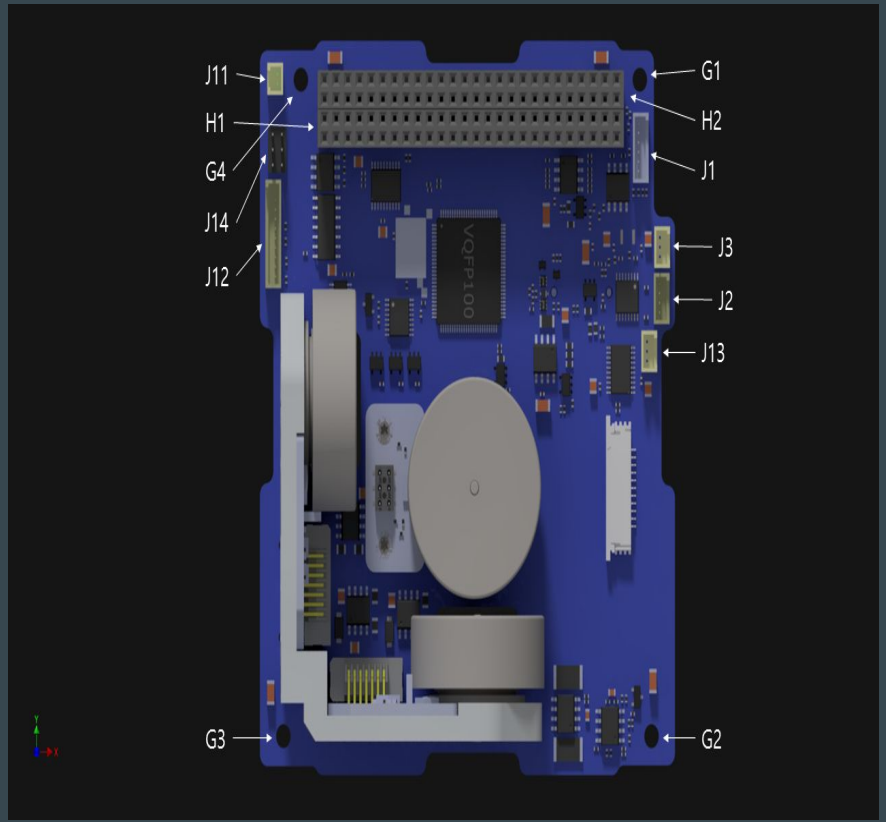
3 Axis Reaction Wheels

- Allows for rotation control while in orbit
- Connects to the Attitude Determination and Control System Motherboard



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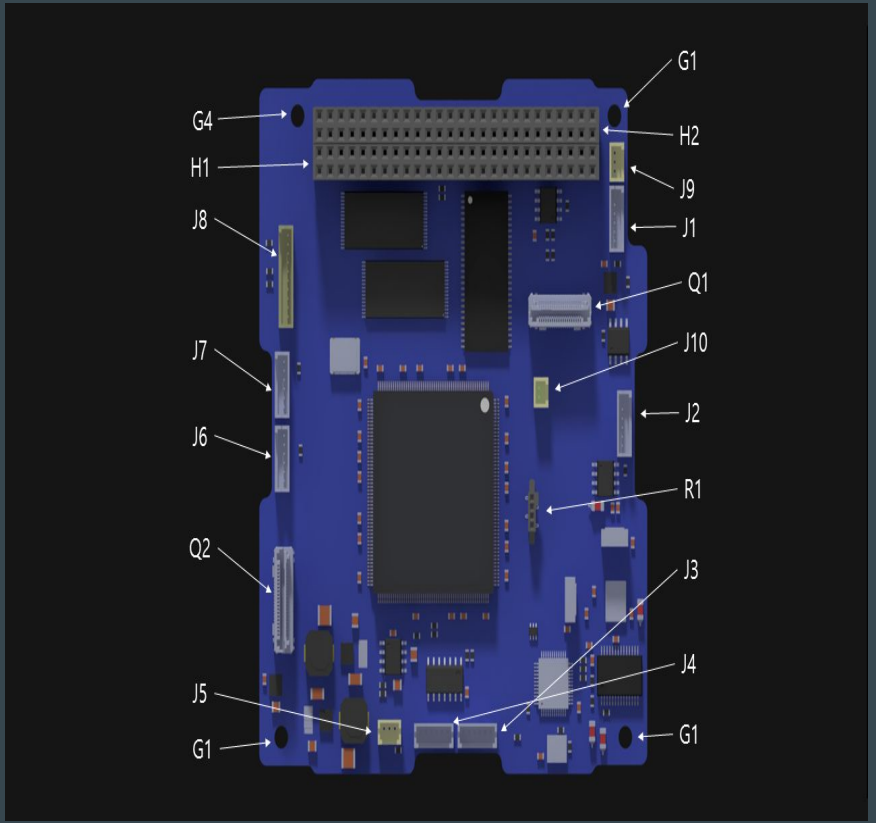
ADCS Motherboard

- Interfaces with our reaction wheels and sun sensors to determine and mandate satellite orientation



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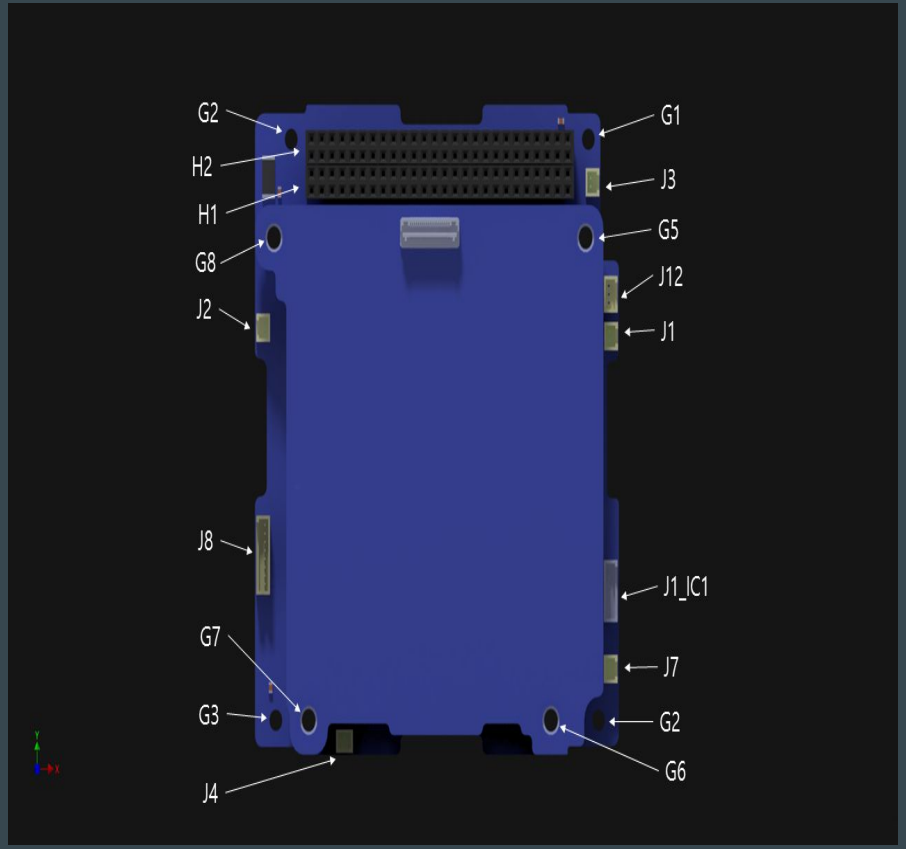
40 Watt-Hour Battery

- Stores power that satellite receives from solar panels
- Allows for operation when not in direct sunlight



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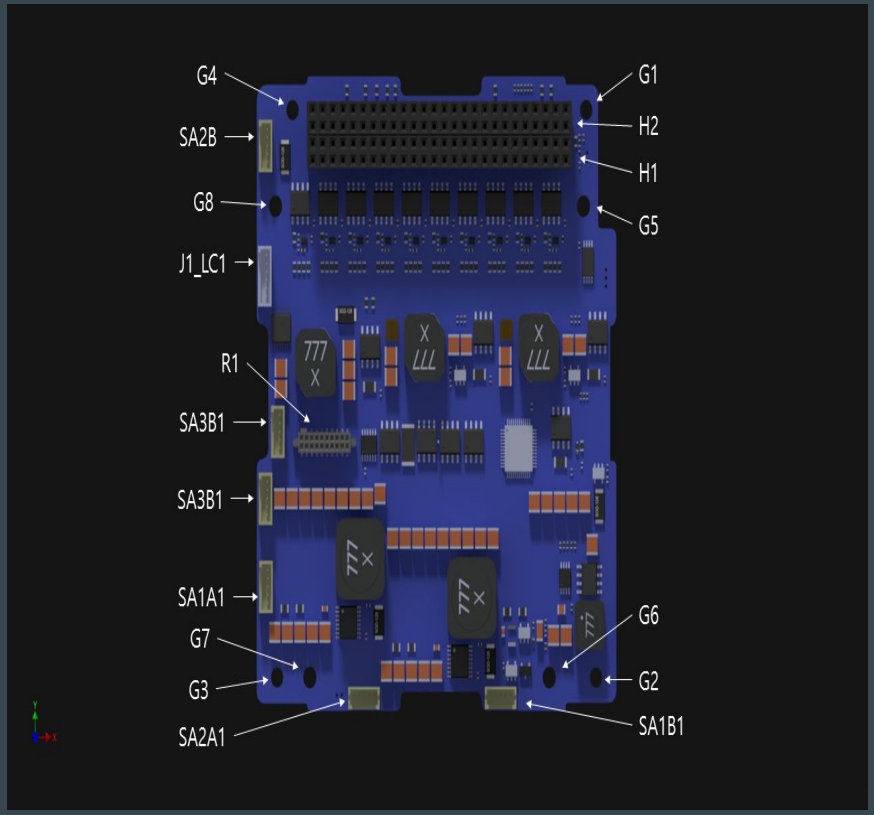
Electrical Power System

- “Brains” behind the power
- Receives and distributes power across the whole satellite



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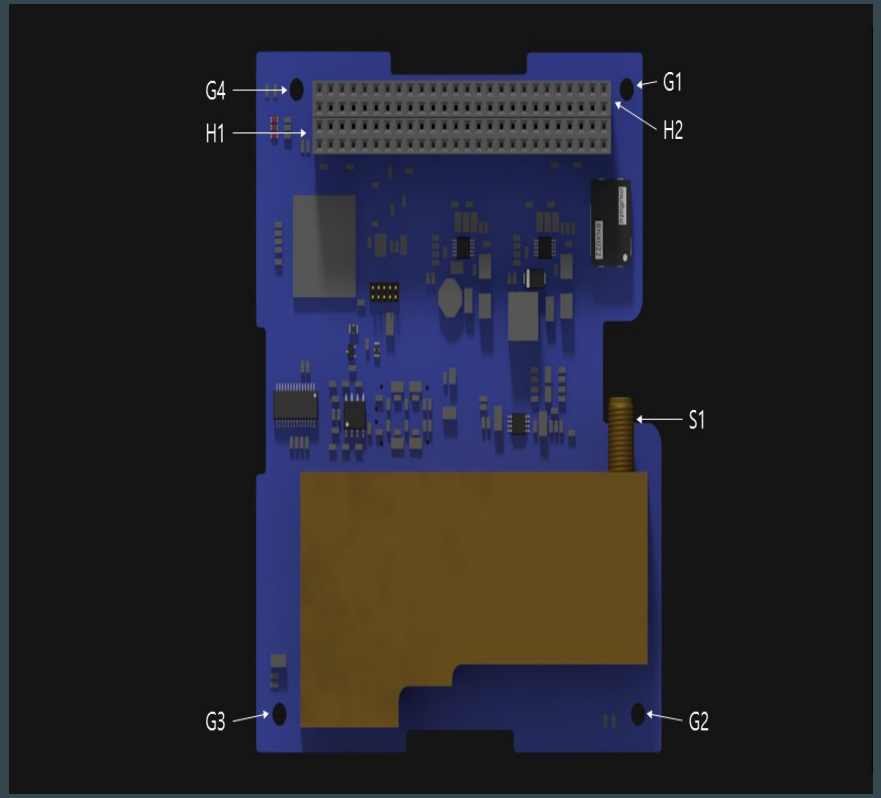
S-Band Transmitter

- Sends data back to ground station
- Highest speed transmission our cubesats will feature



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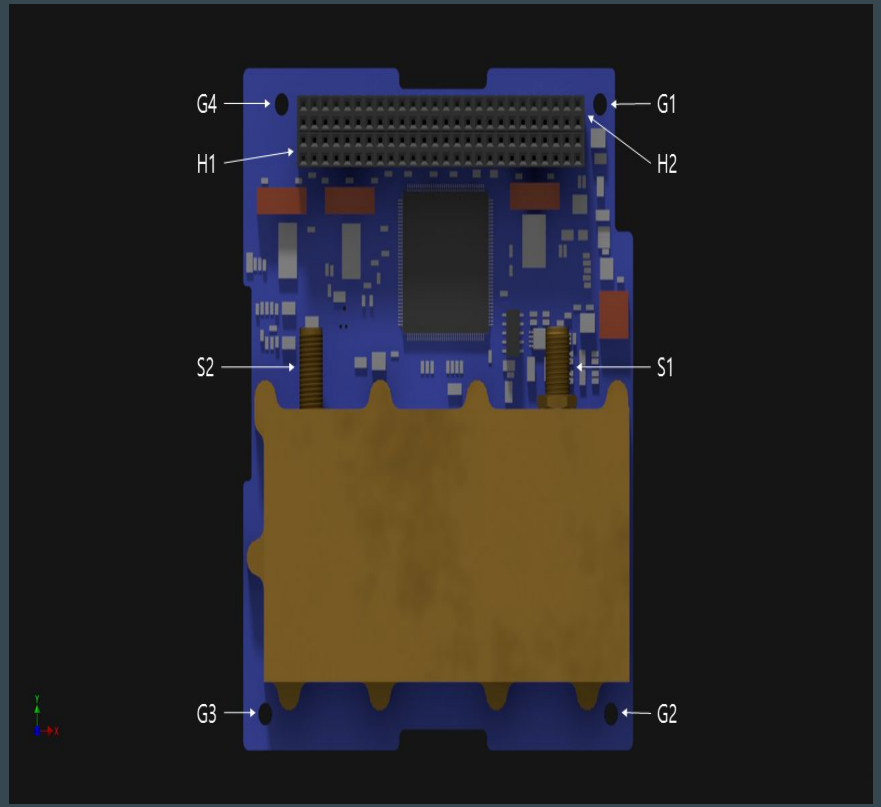
VHF/UHF Transceiver

- Capable of both transmission to and reception from ground stations
- Receives Very High Frequency commands
- Transmits Ultra High Frequency status updates about satellite during orbit



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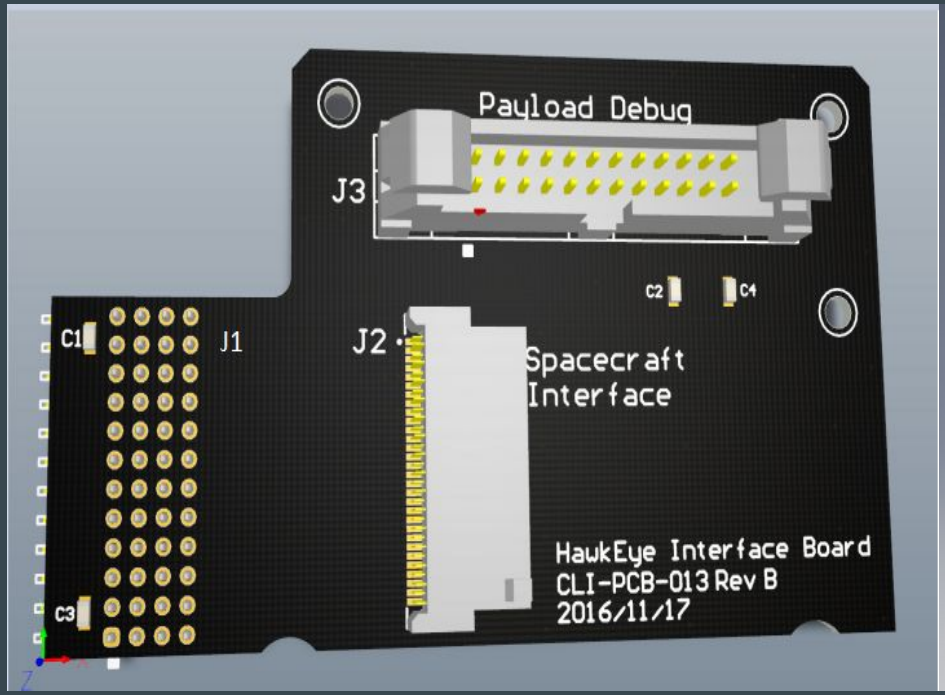
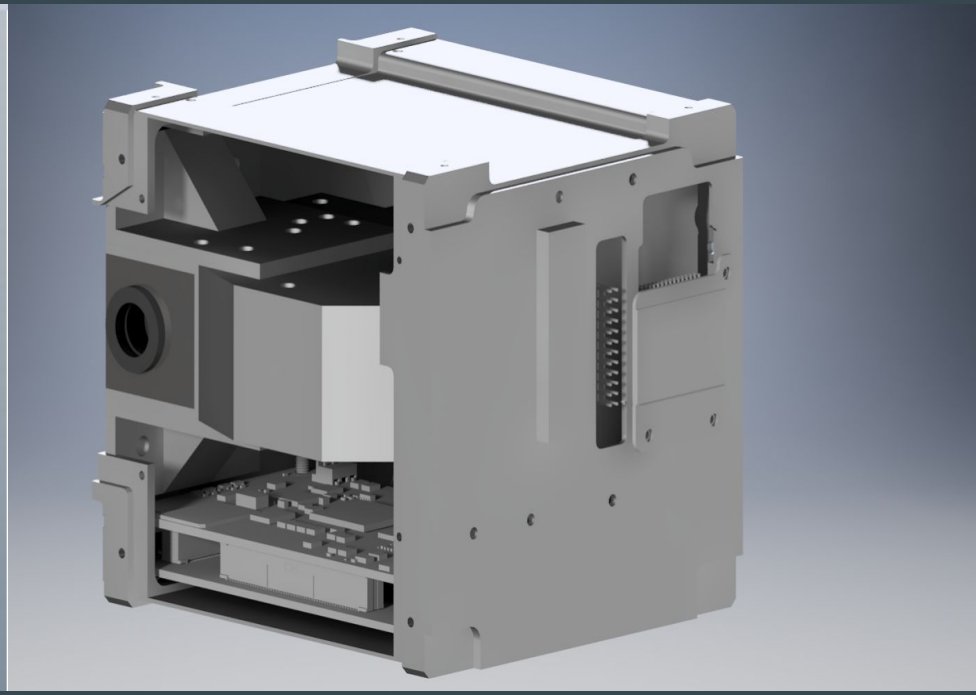
SPOCeye





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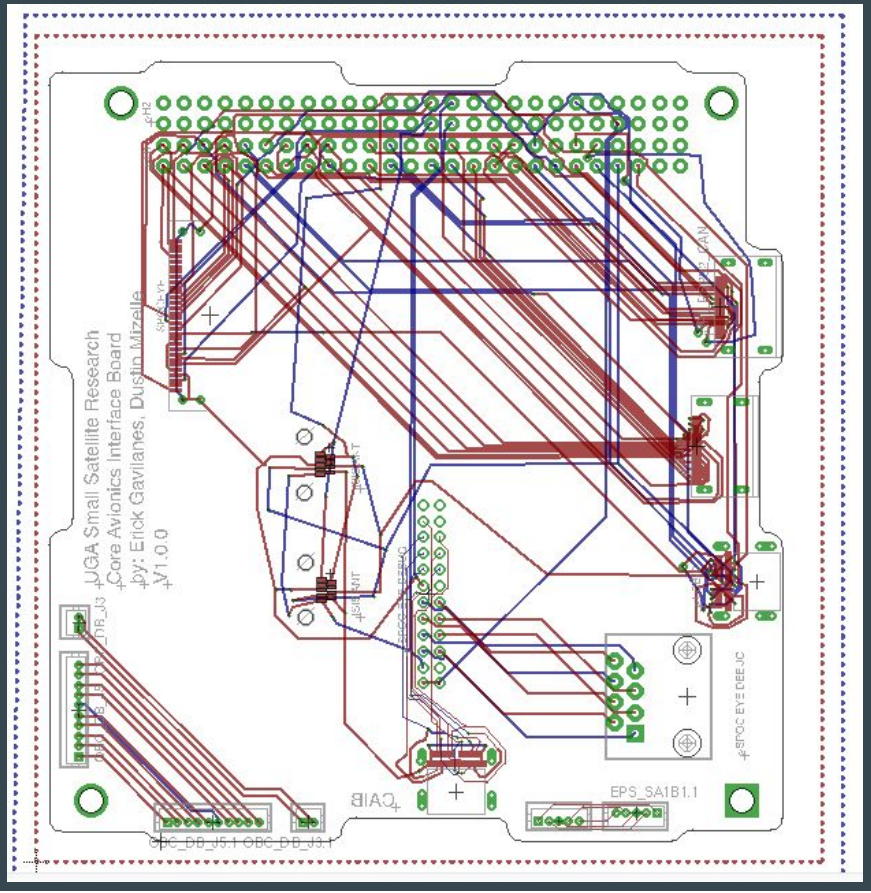
CAIB

- Core Avionics Interface Board
- Interfaces payload, antennas, and electrical ground support connections



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SPOCEye	J2	Samtec SFM-115-02-S-DH		OBC>>>		H1	Samtec ESQ-126-39-G-D			H2	Samtec EQA-126-39-G-D			SPOCEye	J3	EHT-112-01-S-D		OBC	JTAG SELECT - J3	Hirose DF13-	These 2 only	JTAG SELECT - J3	Hirose DF13-
1	VBatt+	CiSpiDataValid_N	2		1	GPIO_A	GPIO_B	2	1			2		1	VBatt+	VBatt+	2		1	3.3V		1	3.3V
3	VBatt-	CiSpiDataValid_P	4		3	GPIO_C	GPIO_D	4	3			4		3	GND	GND	4		2	JTAG_SEL		2	JTAG_SEL
5	VBatt+	VBatt+	6		5	GPIO_E	GPIO_F	6	5			6		5	DbEthMx1_P	DbEthMx1_N	6		Connect 1 + 2 =	If 2 unconnected = M3			
7	VBatt-	VBatt-	8		7	GPIO_G	GPIO_H	8	7			8		7	DbEthMx2_P	DbEthMx2_N	8						
9	VBatt+	CiSpiD2out_N	10		9	SPI_CS_A	SPI_CS_B	10	9			10		9	DbEthMx3_P	DbEthMx3_N	10		JTAG	Hirose DF13-	These 2 only	JTAG	Hirose DF13-
11	VBatt-	CiSpiD2out_P	12		11	SPI_CS_C	SPI_CS_D	12	11			12		11	DbEthMx4_P	DbEthMx4_N	12		1	TCK		1	TCK
13	CcRxD_N	GND	14		13	SPI_CS_E	SPI_CS_F	14	13			14		13	GND	GND	14		2	GND		2	GND
15	CcRxD_P	CiSpiD1out_N	16		15	GPIO_J	GPIO_K	16	15			16		15	DbJtagTdo	DbJtagTdi	16		3	TDO		3	TDO
17	CcTxD_N	CiSpiD1out_P	18		17	GPIO_L	GPIO_M	18	17			18		17	DbEthPhyLed0	DbJtagTms	18		4	GND		4	GND
19	CcTxD_P	GND	20		19			20	19			20		19	DbEthPhyLed1	DbJtagTck	20		5	TMS		5	TMS
21	GND	CiSpiD0out_N	22		21	SPI_CLK	SPI_MISO	22	21			22		21	DbJtagInit	GND	22		6	3.3V		6	3.3V
23	CiSpiD3out_N	CiSpiD0out_P	24		23	SPI_MOSI	SPI_CS	24	23			24		23	VBatt-	VBatt-	24		7	3.3V		7	3.3V
25	CiSpiD3out_P	GND	26		25			26	25	5V_PLAT	5V_PLAT	26							8	TRST		8	TRST
27	GND	CiSpiClk_N	28		27	GPIO_R	GPIO_S	28	27	3V3_PLAT	3V3_PLAT	28							9	TDI		9	TDI
29	Pps	CiSpiClk_P	30		29	GPIO_T	GPIO_U	30	29	GND3	GND2	30							10	GND		10	GND
					31	GPIO_V		32	31		GND1	32											
ISIS	J1	9-Pin Omnetics Bi-Lobe A29100-009			33	RS232_RXA	RS232_RXB	34	33			34											
Pin	Name				35	RS232_TXA	RS232_TXB	36	35			36		EGSE>>>	Ethernet - RJ45	Color of ethernet wire		USB-C 1	SPOCeye Debug	USB-C 2		Mini HDMI 1	Mini HDMI 2
1	VCC				37	RS422_RXC+	RS422_TXC+	38	37			38		1	RX_1_P	orange	1- GND	EGSE GND to EPS	1	EGSE GND to EPS	1	GPIO_A	SPI_CLK
2					39	RS422_RXC-	RS422_TXC-	40	39			40		2	RX_1_N	white/orange	2	RS422_TX+	2	DbJtagTdo	2	GPIO_B	SPI_MISO
3	GND				41	SDA_A	CANH	42	41			42		3	TX_2_N	Green/white	3	RS422_TX-	3	DbJtagTdi	3	GPIO_C	SPI_MOSI
4	I2C_Data_B				43	SCL_A	CANL	44	43			44		4	Bi_3_P	blue	4 - Vbus	EGSE V to EPS	4		4	GPIO_D	SPI_CS
5	GND				45	SDA_B		46	45	VBAT_PLAT	VBAT_PLA	46		5	Bi_3_N	blue/white	5	I2C_Data_B	5	DbJtagTms	5	GPIO_E	SPI_CS_A
6	VCC				47	SCL_B		48	47			48		6	Tx_2_P	Green	6	I2C Data A	6	DbJtagTck	6	GPIO_F	SPI_CS_B
7					49			50	49	DTMF1	DTMF2	50		7	BI_4_P	brown	7	I2C Clock A	7	DbJtagInit	7	GPIO_G	SPI_CS_C
8	I2C_CLK_B				51			52	51	DTMF3	DTMF4	52		8	BI_4_N	white/brown	8	I2C_CLK_B	8		8	GPIO_H	SPI_CS_D
9	GND														https://www.sparkfun.com/products/643		9	RS422_RX-	9	DbEthPhyLed0	9	GPIO_J	SPI_CS_E
																	10	RS422_RX+	10	DbEthPhyLed1	10	GPIO_K	SPI_CS_F
																	http://www.digikey.com/product-detail/en/WM12856TR-ND/WM				11	GPIO_L	RS232_RXA
																					12	GPIO_M	RS232_TXA
																					13	GPIO_R	RS232_RXB
																					14	GPIO_S	RS232_TXB
																					15	GPIO_T	CANH
																					16	GPIO_U	CANL
																					17	GPIO_V	
																					18		
VBatt	6.1-12 V, 7.6 Typic	2.1-2.9 A, 3.2 A max	LCL Trip @ 4.7 A																				
3V3_PLAT	3.15-3.45 V, 3.3 Typ		LCL Trip @ 4.5 A																				
I2C	3.3 V	60 mA min, 100 mA typ																					
CAN	unspecified																						
SPI	3.3 V																						
GPIO	3.3 V																						
UART	3.3 V																						
	2 V differential																						
	mode or 0-3 V	120 ohm resistance --> 3v/120																					
RS422	common mode	= 25mA max																					
	1.25 V +/- .175 V																						
	differential																						
	mode or 0-2.5V																						
If QSPI = LVDS	common mode																						
Ethernet	Cannot find, need to ask																						

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S-Band Patch to STX-B	Manufacturer	Quantity	Info	Purchase Link
1 pin SMA Male Jack: ***	Amphenol ***REVIEW***	2	Options	http://www.amphenolrf.com/connectors/sma.html?gender=7
GPS to OBC				
1 pin MMCX Male Connector: ***	Molex ***REVIEW***	1	Options	https://www.digikey.com/products/en?FV=ffec4c05
Fine Sun Sensor to 3-Axis Reaction Wheels				
10 pin Female Housing: DF13-10DS-1.25C	Hirose ***REVIEW HEADERS***	1	ICD update required (inconsistencies)	http://www.digikey.com/product-detail/en/hirose-electric-co-ltd/DF13-10DS-1.25C/H2231-ND/241805
6 pin Female Housing: DF13-6S-1.25C	Hirose	1		http://www.digikey.com/product-detail/en/hirose-electric-co-ltd/DF13-6S-1.25C/H2183-ND/241753
1 pin Crips for Housing: DF13-2630SCFA	Hirose	8	4 Active Pins on 2 Connectors	http://www.digikey.com/product-detail/en/hirose-electric-co-ltd/DF13-2630SCFA/H9991CT-ND/241818
Solar Panel to EPS				
5 pin Female Housing: DF13-5S-1.25C	Hirose	6	2 per F-F Connector	http://www.digikey.com/product-detail/en/hirose-electric-co-ltd/DF13-5S-1.25C/H2182-ND/241752
1 pin Crimp for Housing: DF13-2630SCFA	Hirose	30	5 per Housing	http://www.digikey.com/product-detail/en/hirose-electric-co-ltd/DF13-2630SCFA/H9991CT-ND/241818
Solar Panel to ADCS				
6 pin Female Housing: DF13-6S-1.25C	Hirose	6	2 per F-F Connector	http://www.digikey.com/product-detail/en/hirose-electric-co-ltd/DF13-6S-1.25C/H2183-ND/241753
1 pin Crips for Housing: DF13-2630SCFA	Hirose	36	6 per Housing	http://www.digikey.com/product-detail/en/hirose-electric-co-ltd/DF13-2630SCFA/H9991CT-ND/241818
ISIS COMM Antennas to T/Rx				
1 pin MMCX Right Angle Jack: ***	Amphenol ***REVIEW***	2	Options	http://www.amphenolrf.com/connectors/mmcx.html?gender=7
1 pin SMC Right Angle Jack: J01171A0181	Telegartner	1		http://www.telegartner.de/en/telegartner-smc-angle-jack-crimp-g07
1 pin SSMC Right Angle Jack: 7105-1521-002	Applied Engineering Products (AEP)	1		http://www.mouser.com/ProductDetail/Radiall/7105-1521-002/?qs=RNP7zUKkPyLPOkqQVDTkZw%3D%3D
ISIS COMM Antenna to CAIB Connectors				
9 pin Male Bi-Lobe Connector: A28000-009	Omnetics	4	2 per M-M Connector	http://www.digipart.com/part/A28000-009
SPOCeye PYLD to CAIB Wires				
30 pin Interface Connector: SFSD-15-28-H-10.00-SR	Samtec	1		http://www.digikey.com/product-detail/en/samtec-inc/SFSD-15-28-H-10.00-SR/SAM8670-ND/1785921
24 pin Debug Connector: TCSD-12-D-05.00-01-S	Samtec ***REVIEW SPECS***	1	Options	http://www.digikey.com/product-detail/en/samtec-inc/TCSD-08-D-02.00-01-N-R/SAM8872-ND/1580910
CAIB Headers		**Quantity = 2x CAIB**		
52 pin Cubesat Header: ESQ-126-39-G-D	Samtec	4		https://products.avnet.com/shop/en/ema/esq-126-39-g-d-30744573456271287 17
30 pin SPOCeye Interface: SFM-115-02-S-DH	Samtec	2		https://www.arrow.com/en/products/sfm-115-02-s-dh-tr/samtec
24 pin SPOCeye Debug: EHT-112-01-S-D	Samtec	2		https://products.avnet.com/webapp/wcs/stores/servlet/ProductDisplay?CMP=NA-US-NEWARK-PDP-CROSS-SELL&langId=-1&productId=3074457345627620796&catalogId=10001&c
9 pin ISIS Antenna Interface: A29100-009	Omnetics	4		http://www.omnetics.com/products/bilobe-cots-dualrow
EGSE Interface USB - C: 1054500101	Molex	2		http://www.digikey.com/product-detail/en/molex-llc/1054500101/WM12856CT-ND/5843891
EGSE Interface RJ45: ***	Undecided ***REVIEW***	2	Options	http://www.digikey.com/products/en?FV=fff40016,fff803b4&k=RJ45
Mini HDMI SMT Horizontal WR-COM	Wurth Elektronik	4		http://katalog.we-online.de/en/em/COM_MINI_SMT_HORIZONTAL

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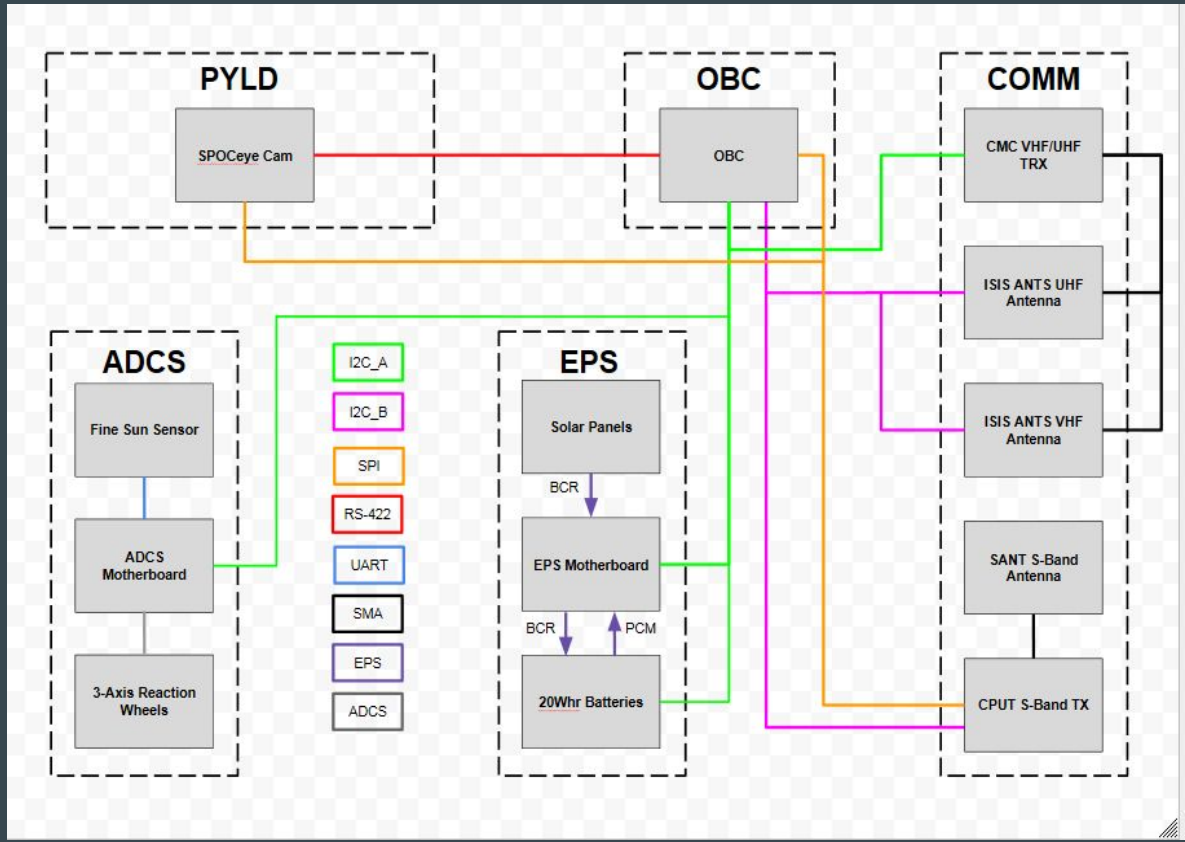
Data

- Ensure communication protocols are distributed evenly



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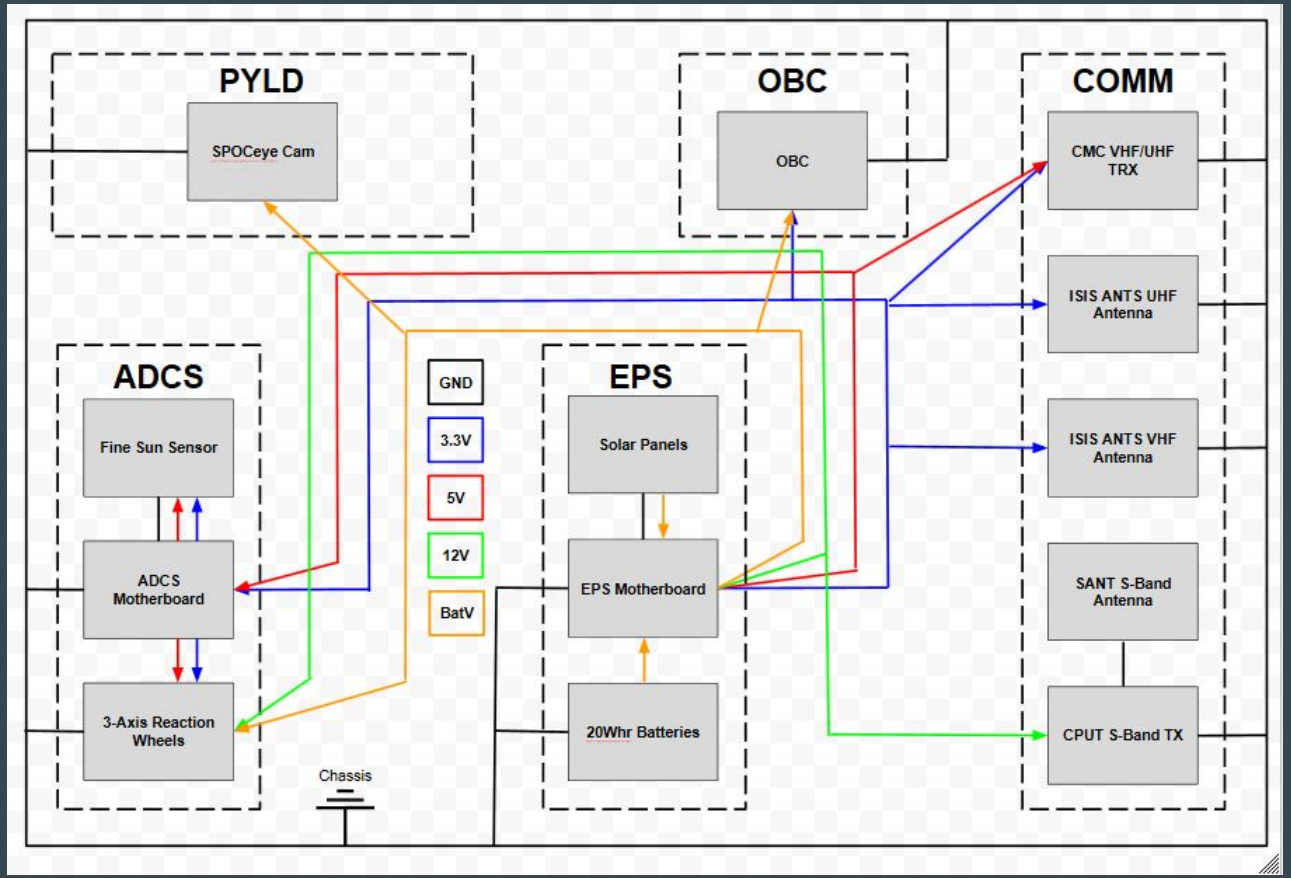
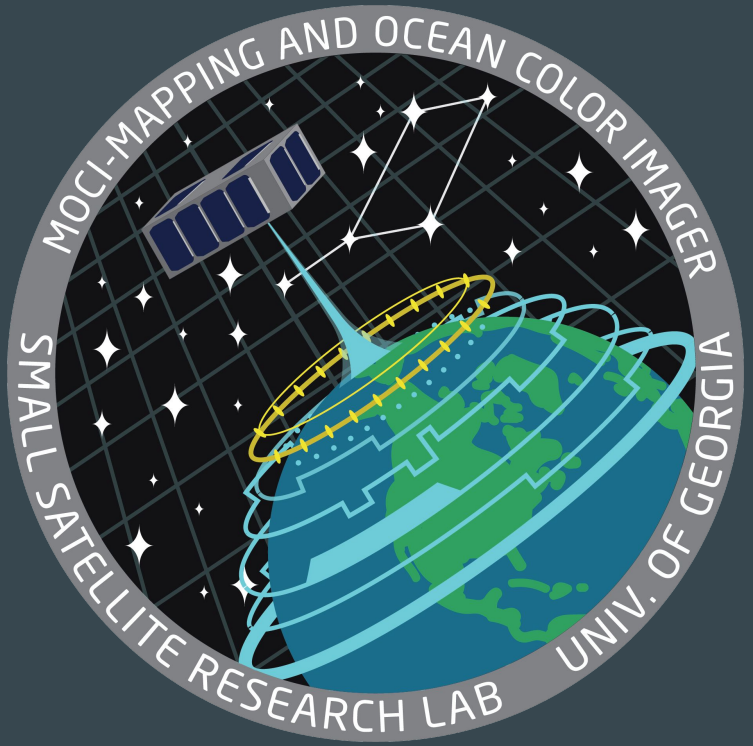
Power

- Ensure necessary voltages are supplied to each subsystem



Questions?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