

Team  
TARDIGRADES



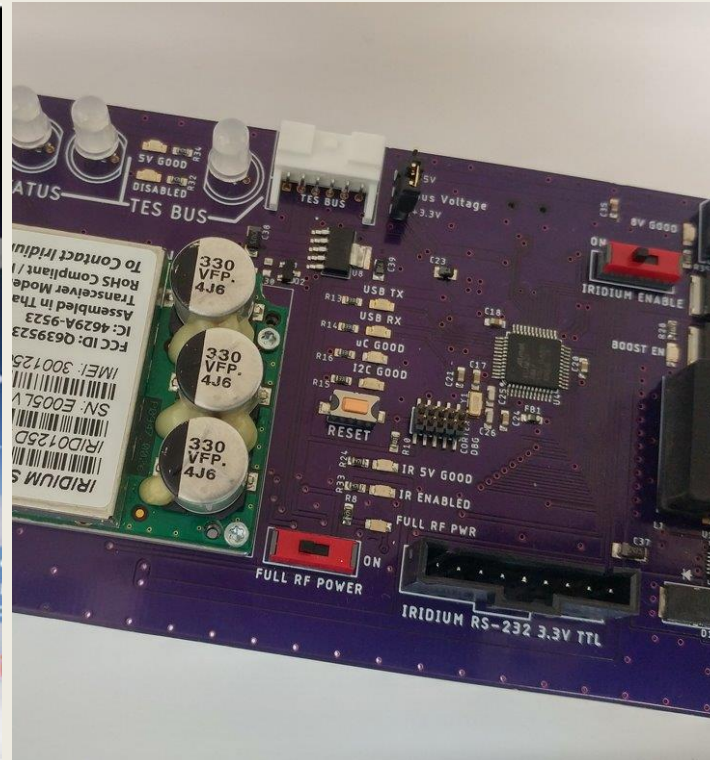
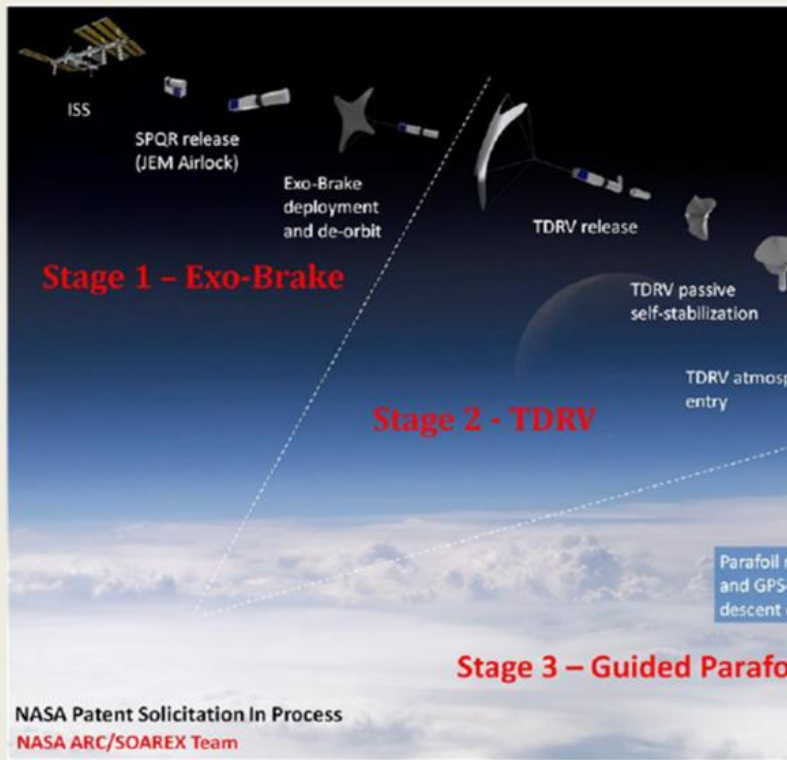
# 9523 Subteam

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- Joe Dennison (CompE)
- Robert Goes (Math & CS)
- Cosette King (CS)
- Drew Pilchard (EE)
- Harrison Thomsen (EE)
- Taegan Williams (CS)

Objective: Develop CubeSat Carrier  
Module for the Iridium 9523  
transceiver

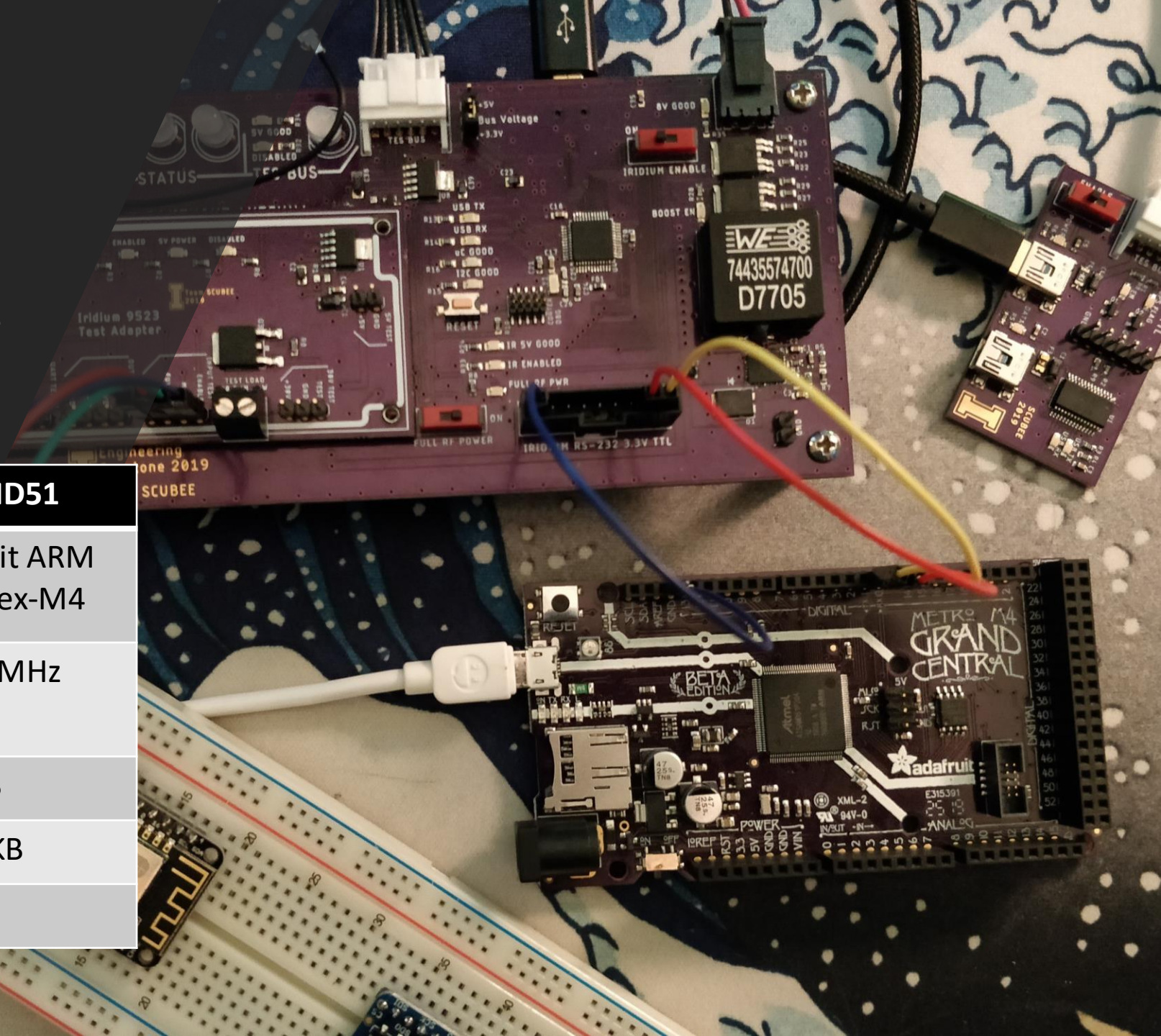
# SCUBEE's Contribution (2018-2019)



- A system to return the payload to a pre-determined GPS location on return
- A carrier module able to control and house the Iridium 9523
- Initial code for communicating with the Iridium satellite via short burst data messages.

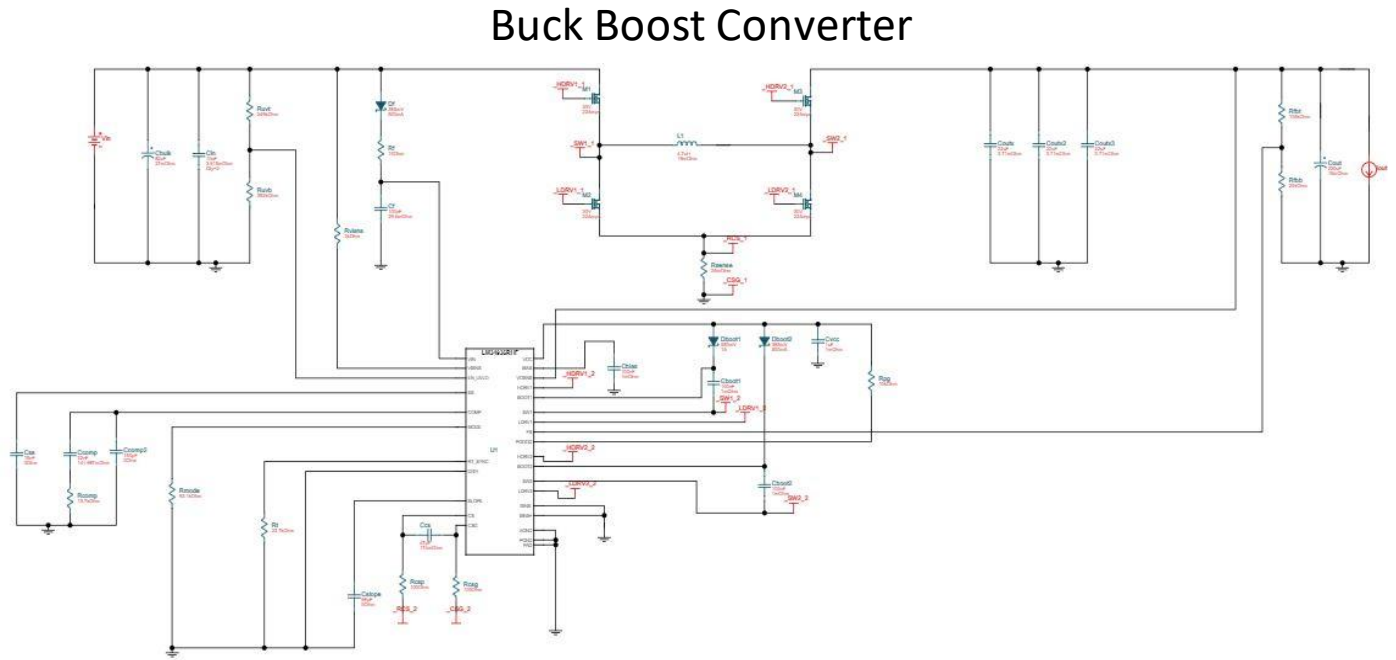
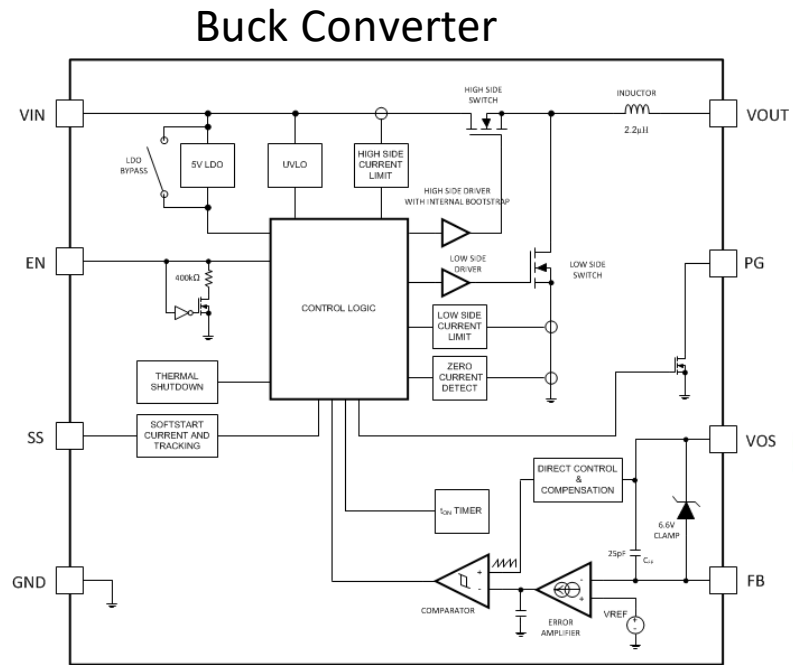
# Upgrading the Microcontroller

	<b>SAMD21</b>	<b>SAMD51</b>
Chipset	32-bit ARM Cortex-M0	32-bit ARM Cortex-M4
Max Operating Speed	48 MHz	120 MHz
Flash memory	256KB	1MB
RAM	32KB	256KB
GPIO pins	30	70



# Our version of the RF power Converters

- 3 Power Converters
  - Buck Converter (5V to 3.3V Low current <100mA)
  - Buck Boost Converter (2.5-9V to 5V 1.5A)
  - Flyback Converter (2.5-9V to 30V 1A)



# Iridium Firmware and Encryption

# FIRE's Contribution (2019-2020)

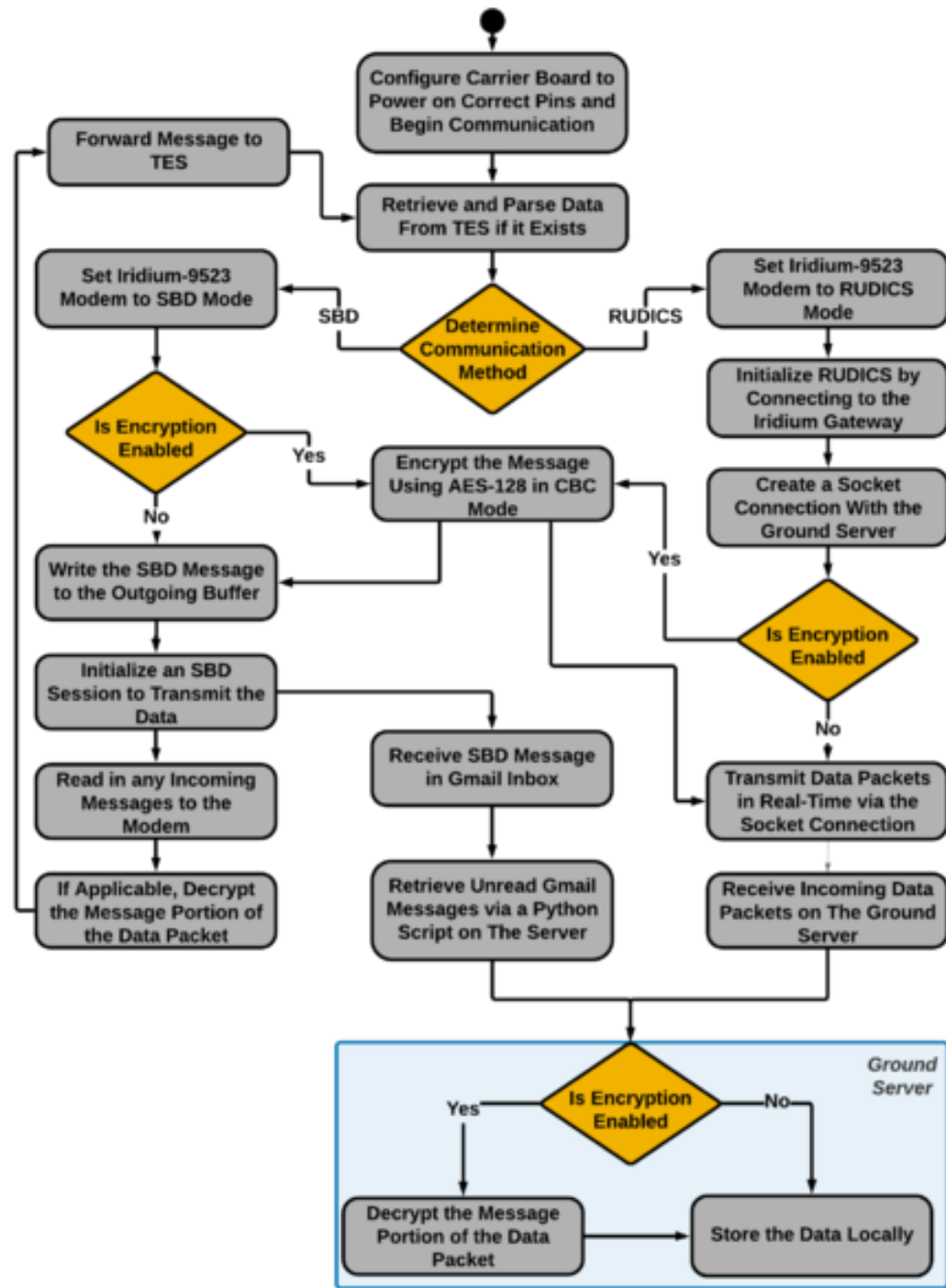
- Built a fireproof containment unit for the power source
- Designed the carrier module for the Iridium 9523
- SBD Communication to a NASA ARC through Gmail (without encryption) using python w/raspberry pie.

```
2 state switched from IDLE to WRITING
3 iridium said: AT+SBDWB=11
4 READY
5 writing sbd:hello world
6 converting to byte array
7 calculating checksum: 4 5C
8 sending bytes:
9 68 65 6C 6C 6F 20 77 6F 72 6C 64 4 5C
10 0
11 OK
12 initiating session
13 state switched from WRITING to INITIATING
14 AT+SBDI
15 +SBDI: 1, 22, 0, 0, 0, 0
16 mo: 1
17 mt: 0
18 SBDI successful
```

Image shows the process of sending an SBD packet



# Firmware: Team Fire Flow Chart



# Firmware: Encryption

- We need to encrypt command/data link
- Choose to use AES-256 to encrypt
- Required to meet or exceed federal standards (FIPS 140-2)
- WolfCrypt's AES module meets standards



# Libraries: WolfCrypt

**What is it:** a C-language-based embedded cryptography engine, offering low memory usage, optimized speed, high portability, and strong feature set that has FIPS 140-2 certified algorithms,

**How are we using it:** We are using it's AES module to encrypt 9523's communication in complice with protection standards.

**Who:** wolfSSL, Provides commercial support and licenses.

**License:** GPL-2



# Libraries: IridiumSBD

**What is it:** Provides functions for SBD comms in a non-blocking fashion with error checking.

**How are we using it:** Replacing and extending team FIRE's SBD code in order to have error checking functionality and stability.

**Who:** Mikal Hart with support from Rock 7 Mobile

**License:** LGPL-2.1



# Tools: Virtual Iridium

**What is it:** A python simulator of Iridium 9602 (Same AT commands) that mimics the SBD functionality.

**How are we using it:** Connecting it to an Arduino so we can test our SBD communication without running up data charges.

**Who:** Private individuals.

**License:** Undetermined, Forked many times on Github

# Firmware: Future Tasks

Getting the WolfCrypt and IridiumSBD libraries to work together and working with Rudics

Have the code work with the iridium 9523 board

Implement error handling

Rudics server implementation

Testing implementation

# ADCS Subteam

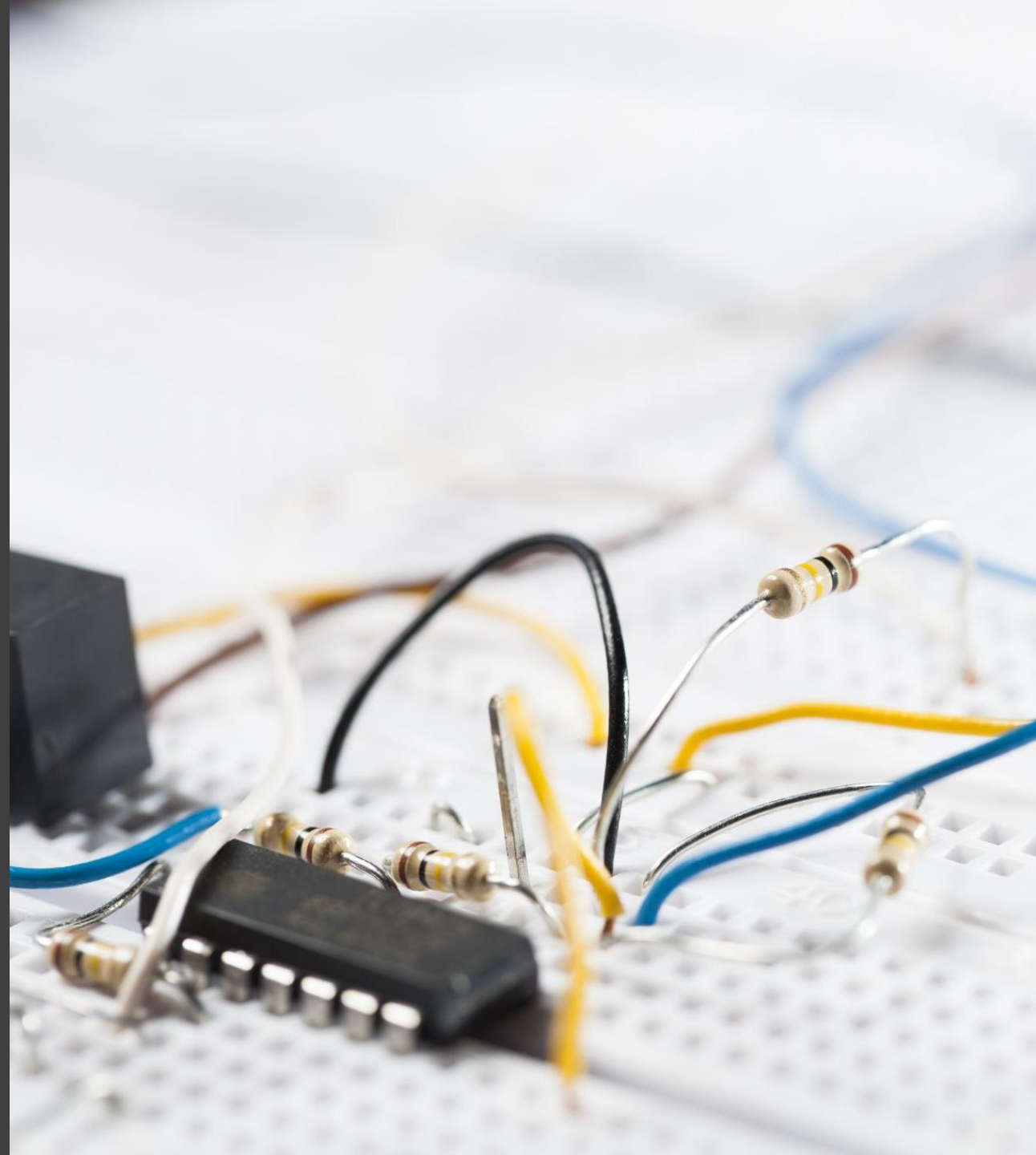
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- Finan Bryan (ME)
- Lily Mortensen (MSE)
- Grace Rosenvall (ME)

Objective: To evaluate and combine  
COTS components to create a more  
cost-effective ADCS unit prototype

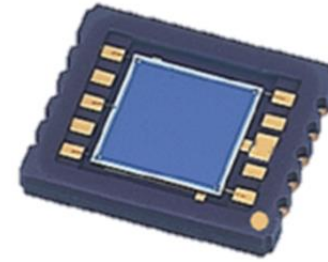


# Components

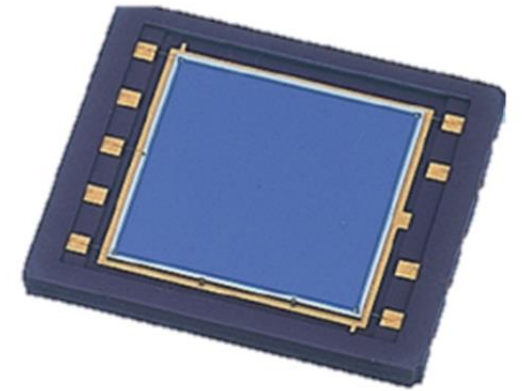


# Sun Sensor

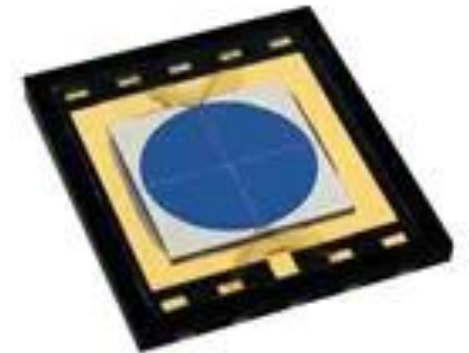
- Main Choice is Hamamatsu s5990
- Relatively cheap through Digikey



Hamamatsu s5990



Hamamatsu s5991



QP50-6-SM

Components	Weights:	Cost	Accuracy	SUM	
Mouser QP50-6-SM			5	2	
Hamamatsu s5990			6	5	40
Hamamatsu s5991			10	6	62
			7	4	43

Image Sources:

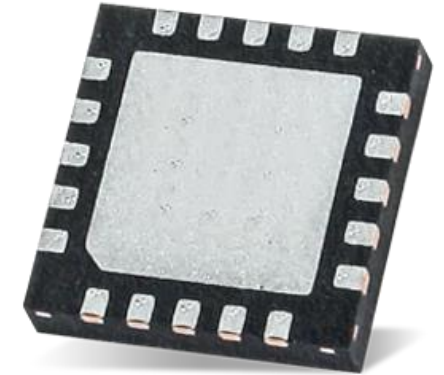
<https://www.hamamatsu.com/us/en/product/type/S5990-01/index.html>

<https://www.mouser.com/ProductDetail/First-Sensor/QP50-6-SM?qs=IxDs%252B9hDEuAb8b22U398Aw%3D%3D>

<https://www.hamamatsu.com/us/en/product/type/S5991-01/index.html>

# Magnetometer

- Evaluated cost (5), accuracy (2), efficiency(3), and flight history (4)
- Highest ranked: DRV425-Q1 by Texas Instruments
  - Is intended for automotive use
  - Would like to investigate further if this could be used



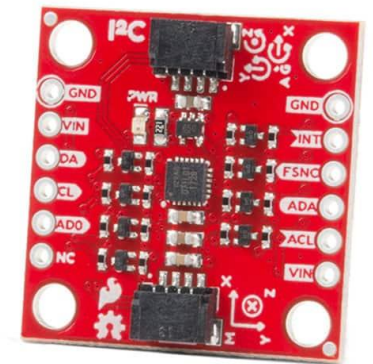
			Cost	Accuracy	Efficiency	Flight History	SUM
			Weights:	5	2	3	4
Magnetometers	PNI RM3100		10	8	5	0	81
	DRV425-Q1	possibly only automotive applications	10	9	5	0	83
	NSS Magnetometer		0	10	5	5	55

# IMU

- Optional to use
- Opting to use a cheaper one for demonstration
- Best option: ICM-20948



LN-200S



ICM-20948

	Cost	Accuracy	Flight History	SUM	
	Weights:	5	2	2	
SEN-15335 ICM-20948		9	5	0	55
LN-200S		0	10	10	40
STIM277H		0	10	0	20
VUPN6602		5	5	0	35
Adafruit TDK InvenSense ICM-20948		10	5	0	60

Image Sources:

<https://satcatalog.com/component/ln-200s/#1595033511418-8b255408-bebbcbd4-9b78d9d4-03ad>

<https://www.sparkfun.com/products/15335>

# Torque Rods

- Tend to be expensive
- No clear path for proof of concept use

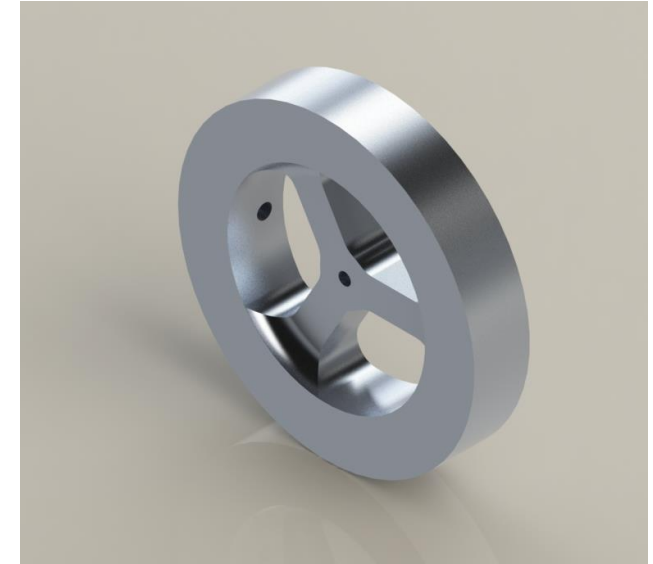


	Cost	Moment Created	Efficiency	Flight History	Mass	SUM	
Weights:	5	3	3	4	4		
SatBus MTQ M6P	9	9	7	6	4	133	
CubeSpace Cube Torquer (Small)	7	9	8	8	5	138	
MTQ200	3	9	9	7	3	109	

Image Sources:  
<https://satsearch.co/products/cubespace-cube-torquer-small>

# Reaction Wheels

- Design Considerations:
  - Maxon 351006 motor
  - 6U Max weight: 7.98 kg
  - 25cm x 10cm x 50 cm (~6U)
- Machined from aluminum- CNC & Mill
  - 48mm diameter, 9mm thick
- Goal is to manufacture and test
  - Use as launch point for future teams



Render of Proposed  
Reaction Wheel Design

	X	Y	Z	
I_wheel	11037.5	11037.5	11037.5	g*mm <sup>2</sup>
omega_wheel	3000	3000	3000	rev/min
I_satellite	1.73E+08	4.82E+07	2.08E+08	g*mm <sup>2</sup>
omega_satellite	0.19	0.69	0.16	rev/min

# Design Validation & Future Work

- Create a physical model
  - Simplified control system (Arduino)
  - Components interchangeable

# AI in the Sky Subteam

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- Robert Goes (Math & CS)
- Lily Mortensen (MSE)



# Radiation Shielding

- Shielding from cosmic rays & solar radiation
  - High-energy protons & neutrons
- Decision matrix considering neutron and gamma attenuation per thickness, cost, and ease of machinability
- Top suggestions are boron-carbide filament & borated polyethylene for Galactic Cosmic Ray (GCR) & Solar Energetic Particles (SEP) shielding
- High density tungsten-copper alloy for gamma and X-ray

Questions?

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