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Rocket Payload Team
Senior Design EE41440

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Agenda

1. Introduction & Project Description
2. Design Proposal
3. Subsystem Design
4. Board Design
5. Testing and Integration Plans
6. Future Improvements & Conclusion

Project Abstract

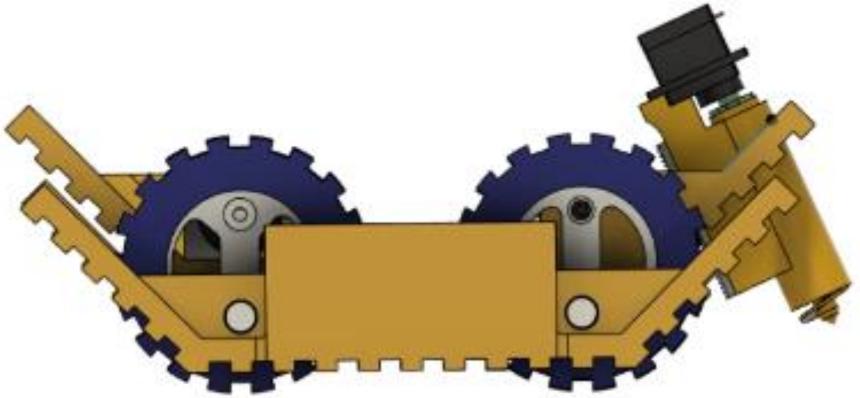
- Work to design electrical systems for a rover payload on the Notre Dame Rocketry Team (NDRT) in the NASA Student Launch competition

NASA Student Launch

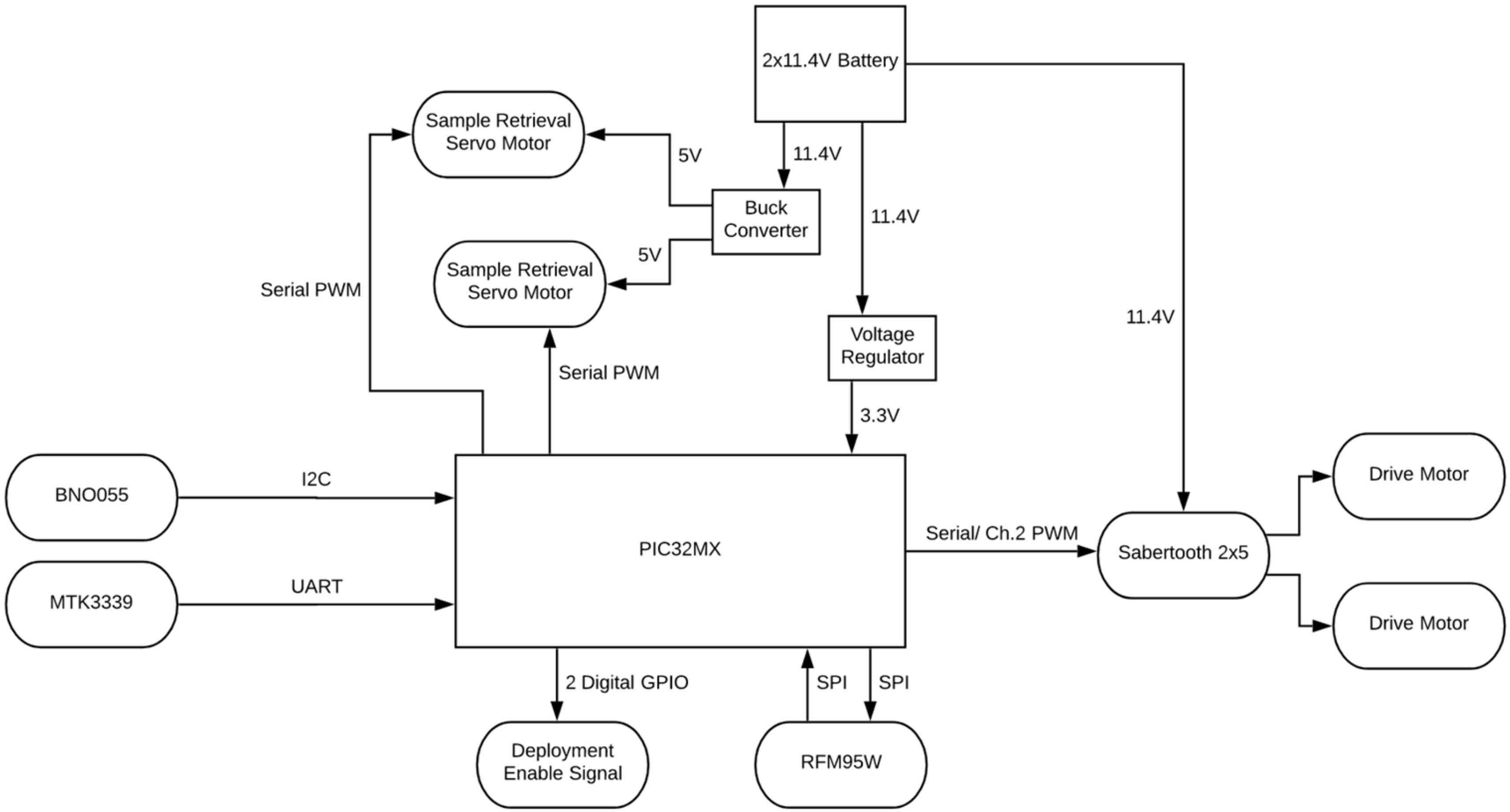
- “The NASA Student Launch (SL) is a research-based, competitive, and experiential learning project that provides relevant and cost-effective research and development.”
- 2020 Payload challenge:
- “Navigate to one of five predetermined sample locations that are each 3 feet in diameter with a colored tarp 10 feet in diameter surrounding the sample area, and collect at least 10 mL of a simulated lunar ice that could be as much as two inches below the ground.”

Design Proposal

- Eccentric Crank-Rover
- Payload Electrical
  - Subsystems
  - Considerations & choices
- UAV
- Autonomous navigation/Control systems



System Block Diagram



Subsystem Designs

- Motors
  - 2 drive motors and 2 servo motors
- Power
  - 2 11.4V batteries
- Sensor
  - IMU and GPS
- Communication
  - RF Transceiver
- Microcontroller/Intelligence
  - PIC32

Subsystem 1: Motors

- Used 2x 3.8A drive motors
- 2 servo motors for sample retrieval
- 2x5 Sabertooth motor controller used to control drive motors
- Serial PWM from PIC32 used to control servo motors

Figure X: From Left to Right: 98 RPM Drive Motor, 2x5 Sabertooth Motor Controller

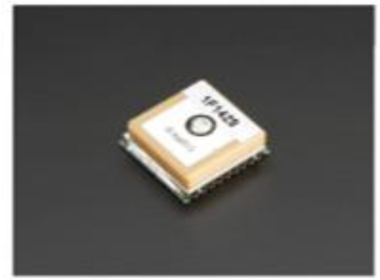
Subsystem 2: Power Management

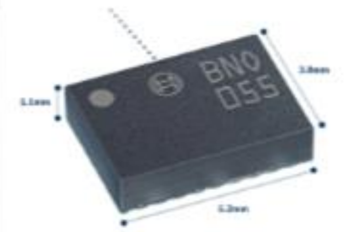
- 2x 11.4V Li-Po batteries provide 3600mAh
- With average power consumption, runtime was estimated at 51 minutes

Device/State	Current Draw (mA)
PIC32MX	120
LM2596-3V	10
LM2596-5V	10
BNO055	12.3
MTK3339	20
RFM95W	12.1
2x Motors: half-stall	4000
Total Current:	**4184.4**

Subsystem 3: Sensor System

- Major systems:
  - IMU
  - GPS
- Applications
  - Motor Control System
  - Autonomous navigation

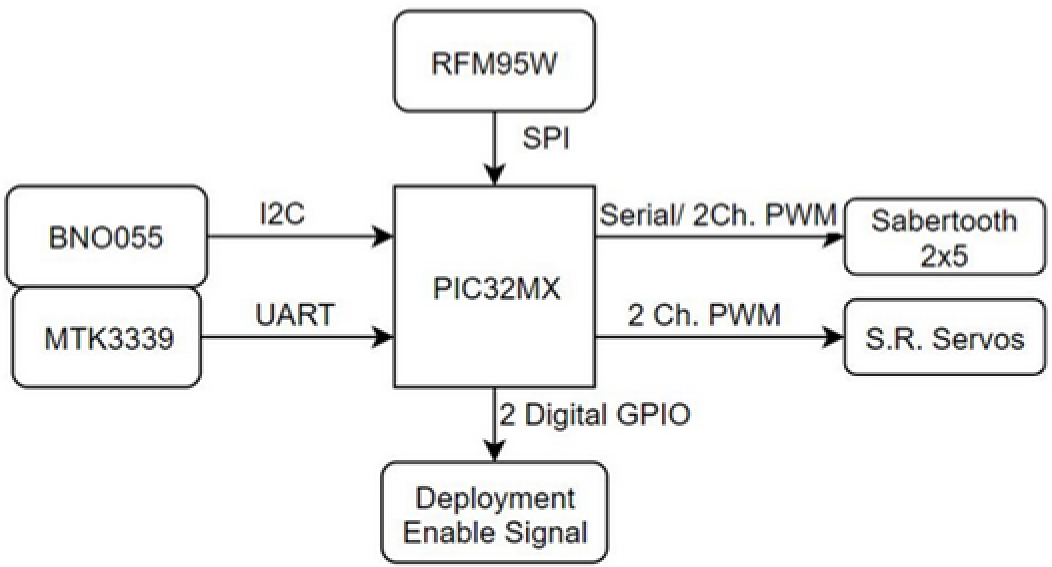




From left to right, MTK3339 GPS Module, BNO055 IMU

Subsystem 4: Communication System

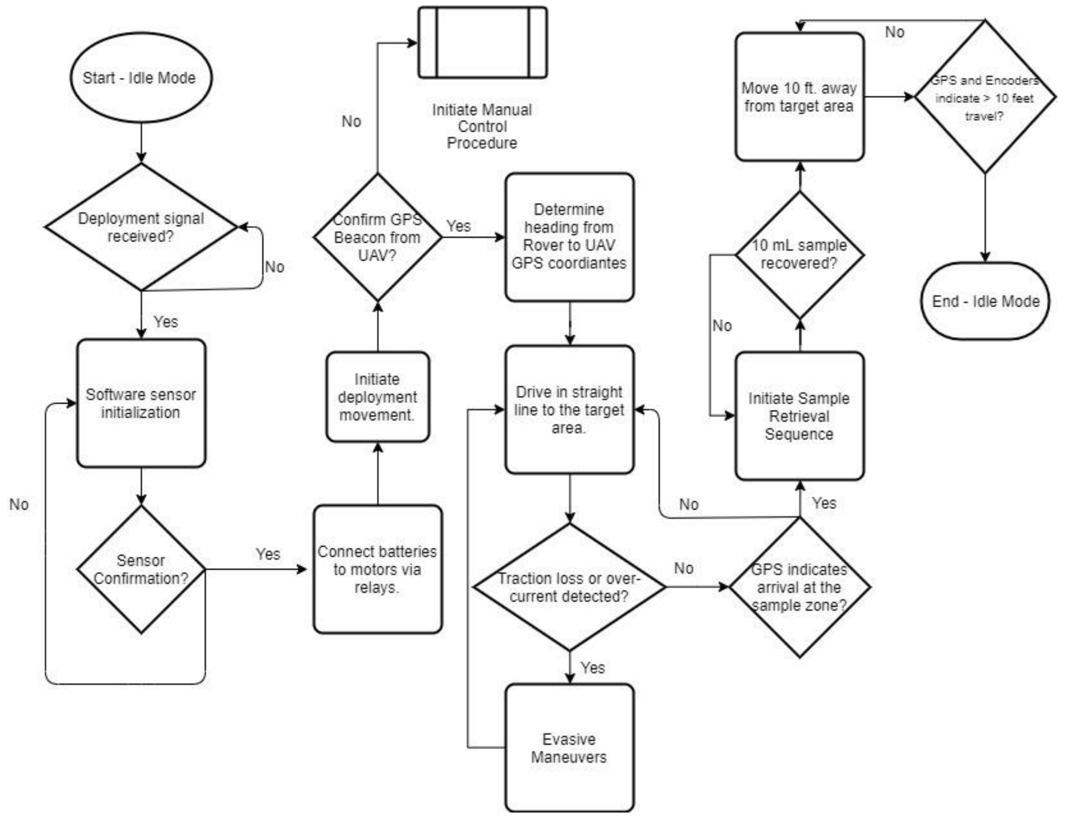
- Hope RF RFM95W radio module
- Manual control
- Sending telemetry data to ground station
- Sending destination coordinates to rover
- Sending deployment signal to release retention on the rover



Subsystem 5: Microcontroller

- Microchip PIC32MX795F512H
  - 6 UART, 4 SPI, 5 I2C
  - 5 PWM pins
  - 53 GPIO pins max
- Satisfies Rover system requirements
  - 2 UART, 1 SPI, 1 I2C
  - 4 PWM signals
- Had familiarity with this PIC from previous assignments

Subsystem 5: Intelligence

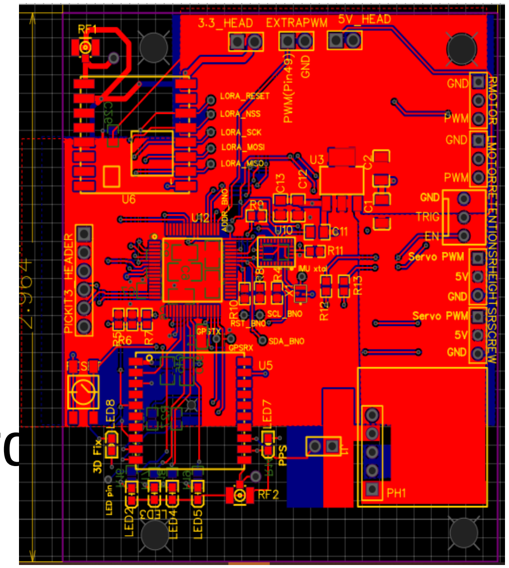


- GPS bearing algorithm:
  - IMU calculates current heading of rover
  - fuse IMU data to provide data for calculating heading

$$\theta = \text{atan2}(\sin(\Delta\lambda) * \cos(\phi_2), \cos(\phi_1) * \sin(\phi_2) - \sin(\phi_1) * \cos(\phi_2) * \cos(\Delta\lambda))$$

Board Design

- Careful use of copper pours
- Followed example circuits for each component
- Every subsystem was tested individually and found to work
- Useful extra pins brought to edge of board
- 5 volt switching regulator to step down 12V in order to save energy
- Linear regulator to step down and clean up 5V to 3.3V MCU and sensor power requirements



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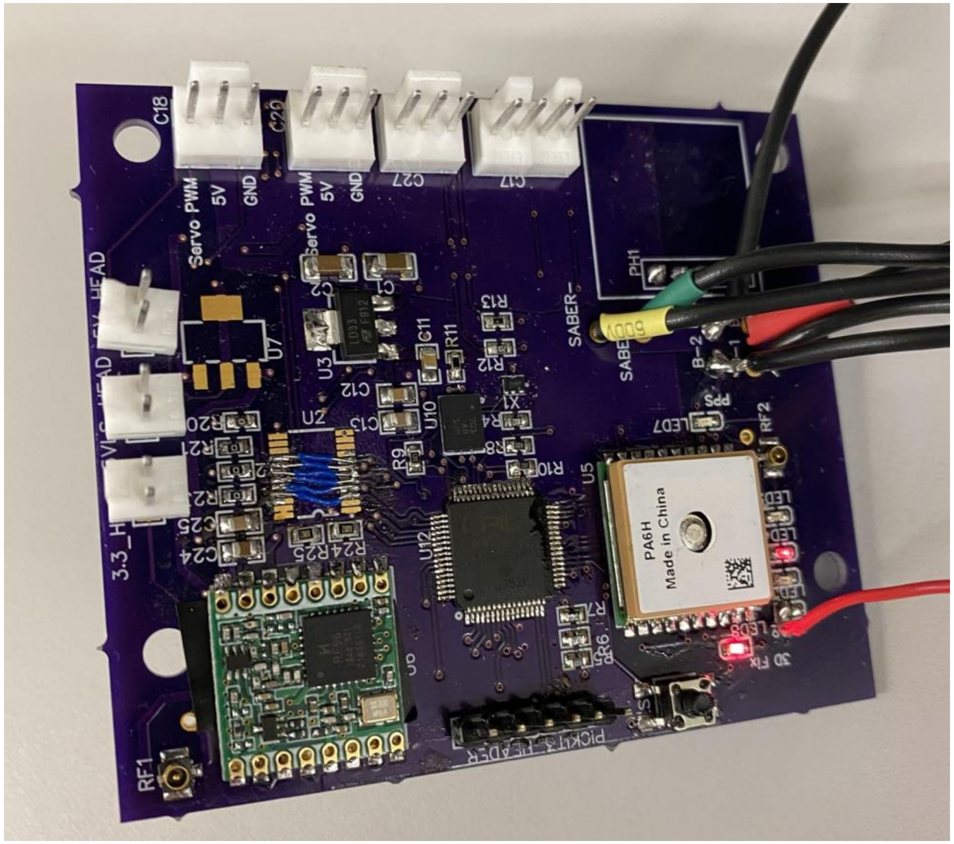
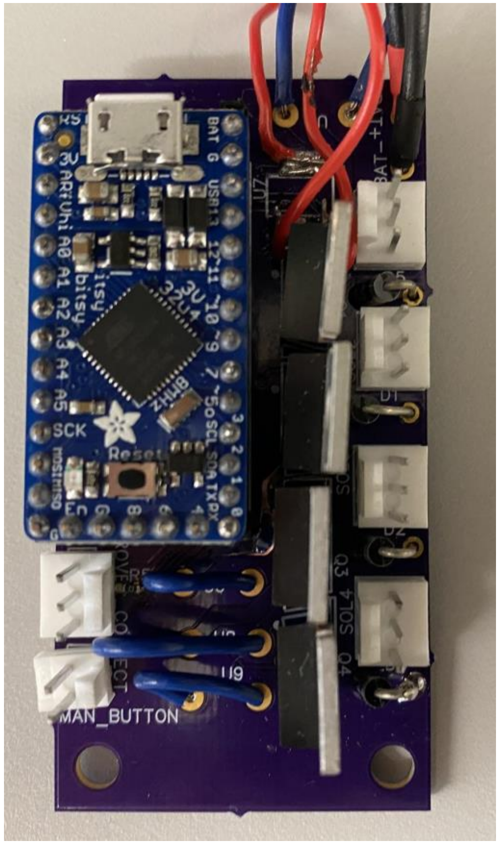
Board Assembly



-Rover Main Board
Revision 1 Assembly



Retention Board
Revision 1 Assembly

Testing and Integration Plans

- Were only able to conduct subsystem testing
- Demonstrated successful functionality for the following systems:
  - Sensors
  - RF Transceiver
  - Motor Control
  - Retention Board

Retention Board

Future Improvements

- Finish completing subsystem testing, system integration, and software improvements originally planned for after spring break
- Improve user control and data interfaces for better decision making by manual or autonomous control
- Future project spin-off: design a system to actually analyze and report wirelessly the status of the sample collected (amount, what material etc.)

Conclusion

- Successfully designed a robust electrical system and conducted assembly and subsystem testing
- Gained professional skills through working with NDRT and handling scheduling and supply chain changes due to COVID-19