Post-Flight Analysis

Introduction

This telemetry data focuses on a high-altitude balloon flight which took place on 31.03.2024.

General information

The flight aimed to test and validate various systems the new detachment mechanism, the new payload flight computer revisions, initial mission control and the experiment jar in real-world flight conditions. Moreover, we introduced a lot of fixes and improvements to existing systems such as the antenna pointing system (rotators).

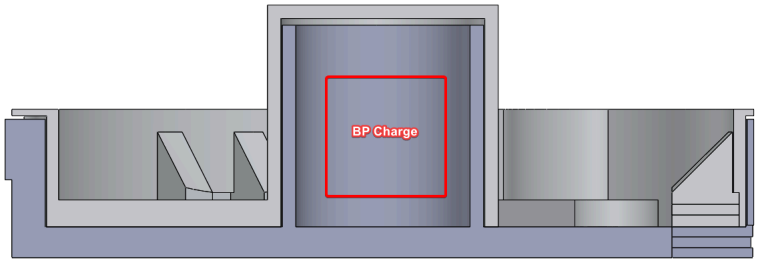
Overall the flight was largely successful

Detachment mechanism

The servo ejection mechanism in its final use case will detach the platform from the balloon. However, if in the final use case configuration the ballon pops before the platform has detached, there is a substantial risk of the ballon string tangling with the parachute. Due to the last test before flight indicating that the 2 way communications might not work we chose to use it in a minimized test configuration. If the minimized version were to fail there would be no additional risk to the parachute tangling.
From the GoPro footage, we identified that the flight config detachment worked as expected, thus the team feels confident in using future flights the final use case configuration.

Payload minimized ejection test

For the minimized ejection test we wanted to see mainly if the BP charge would not be affected too much from the changed environment. In an ideal scenario the ejection test would have popped - separating the assembly in two parts. In the actual flight the BP charge triggered but the two parts were accidentally jammed in the assembly process, thus resulting in the explosion chamber being destroyed.



The good thing is that the ejection charge it self worked but we cannot estimated if mybe it was to powerful or weak so moving on to the payload implementation a few

experiments should be done to make sure there is a healthy safety margin for the ejection chamber and that the working limits of the chamber are tested.

Payload experiment jar
Flight computers
PFC restarted 20 times due to most likely hardware issues. The only way it could have not worked Watchdog triggering posibility was ruled out due to there not being more than 8 seconds between logged messages. There was a 22 min long telemetry communication blackout in which the payload was still logging data during this time even ranging worked. which started a few minutes after a restart and ended right as a restart happened 22mins later.

Mission control
Heltec static IP doesn't work. Possibly a router setup could be done. Otherwise all good

Timing

BFC:

- Turned ON: 11:13:42
- Turned OFF: 14:09:56
- Total time ON: 10533 seconds or 2:55:33 hours

PFC:

- Turned ON: 11:13:31
- Turned OFF: 13:50:42 (Battery voltage too low)
- Total time ON: 9431 seconds or 2:37:11 hours

Flight:

- Launch time: 11:57:35
- Top of ascent time: 13:20:54 or 4999 seconds after lift-off
- Landing time: 13:35:13 or 859 seconds after top of ascent
- Time of flight: 1:37:38 hours or 5858 seconds

Altitude

Max GPS altitude: 32026 meters or 32.026 kilometers
Max barometer altitude: 42810 meters or 42.81 kilometers

Ascent/Descent speed

Average speed from GPS altitude:

- Ascent:
    - 114-5114 meters: 4.66 m/s
    - 5114-10114 meters: 5.82 m/s
    - 10114-15114 meters: 6.1 m/s
    - 15114-20114 meters: 5.69 m/s
    - 20114-25114 meters: 6.16 m/s

    - 25114-30114 meters: 6.04 m/s
    - 30114-32026 meters: 4.9 m/s
- Descent:
    - 32026-27026 meters: -50.43 m/s
    - 27026-22026 meters: -29.88 m/s
    - 22026-17026 meters: -62.4 m/s
    - 17026-12026 meters: -45.7 m/s
    - 12026-7026 meters: -30.92 m/s
    - 7026-2026 meters: -23.72 m/s
    - 1000-800 meters: -18.38 m/s
    - 800-600 meters: -16.68 m/s
    - 600-400 meters: -18.3 m/s
    - **400-217 meters: -19.27 m/s or -69.372 km/h**

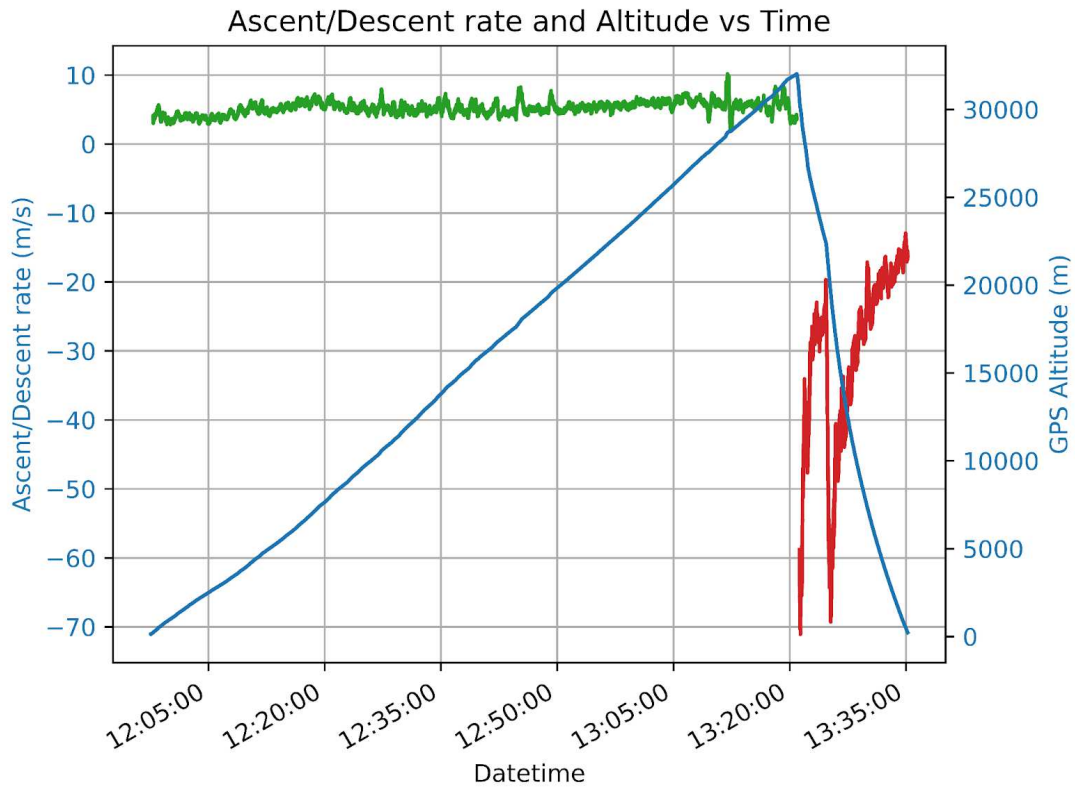
Event timeline

- GoPro 1:
    - 0:00 - 8:51
    - 0:00 (1:17 launch) - 8:51
    - 0:00 - 8:51
    - 0:00 - 8:51
    - 0:00 - 8:08
    - Total time on: 2612 seconds
    - Turned off: 2004 seconds after launch at time 12:39:50 at altitude 15813 meters
- GoPro 2:
    - 0:00 - 8:52
    - 0:00 (0:28 launch) - 8:52
    - 0:00 - 8:52 * 9
    - 0:00 (0:36 landing) - 8:52
    - 0:00 - 8:52
    - 0:00 - 7:08
    - Total time on: 7876 seconds
    - Turned off: 7316 seconds after launch at time 13:59:31 after landing
    - Run out of 64GB storage
- GoPro 3:
    - 0:00 (9:50) - 12:00
    - 0:00 - 12:00
    - 0:00 - 12:00
    - 0:00 - 7:56
    - Total time on: 2636 seconds
    - Turned off: 2046 seconds after launch at time 12:31:41 at altitude 12341 meters

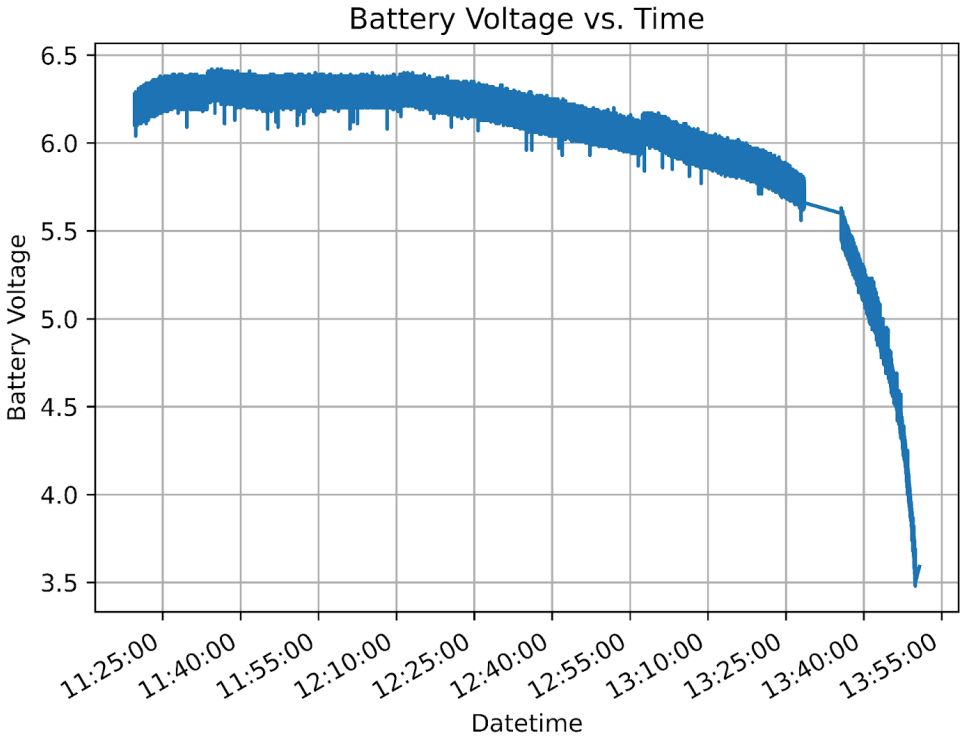
Payload lost comms at 12:35:11 at altitude 13875 meters

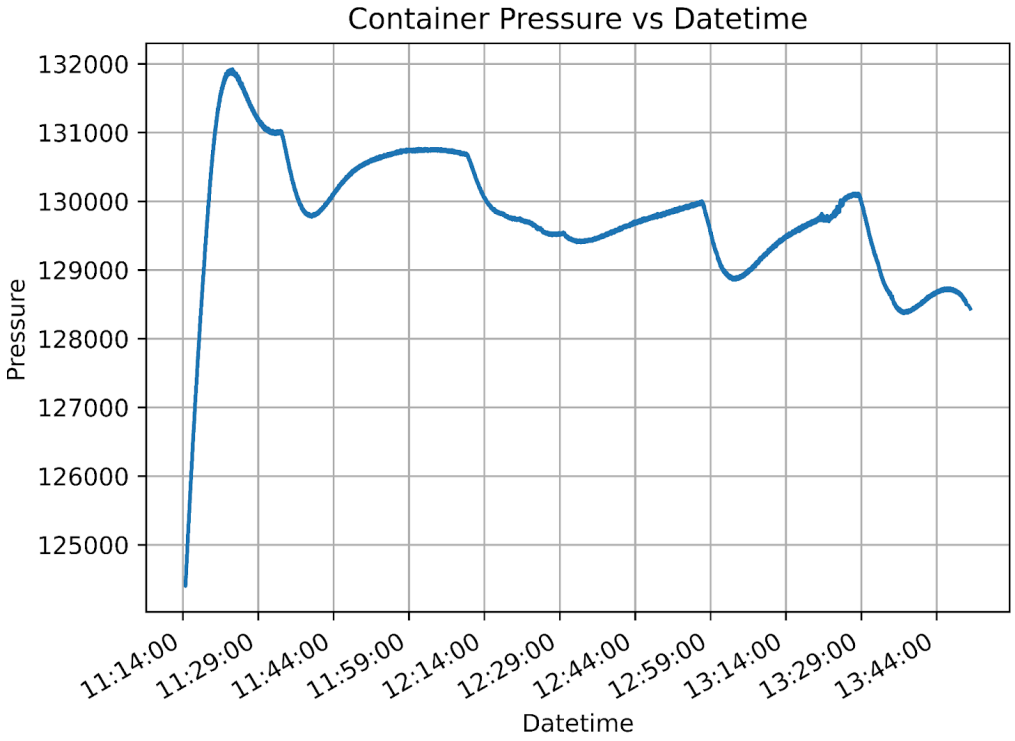
Payload regained comms at 12:57:42 at altitude 22774 meters
Payload comms blackout duration 1351 seconds or 22:31 minutes
Nothing interesting happens/no difference in sound at blackout start time in GoPro videos
Telemetry shows no weird signs at blackout start/end or during it.

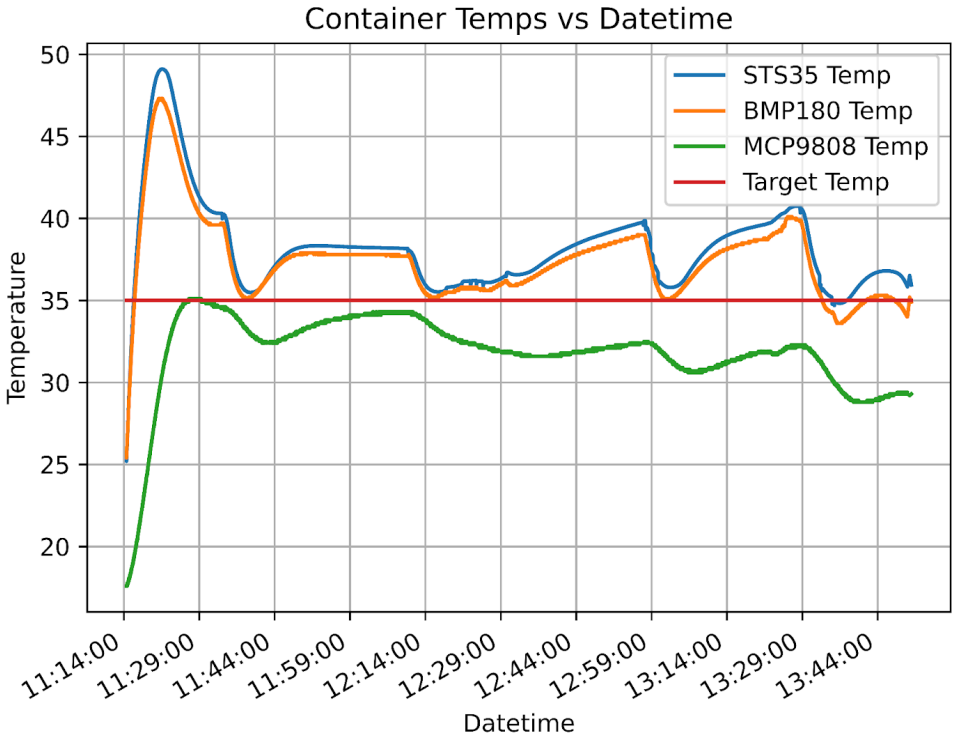
Detach command acknowledgment at 12:57:34 - Detach mechanism activated
Detach command acknowledgment at 12:58:04 - Detach mechanism activated again
Detach command acknowledgment at 12:59:04 - Detach mechanism activated again
Ejection charge acknowledgment at 12:59:34 - Ejection activated
Detach command acknowledgment at 13:00:04 - Nothing happens

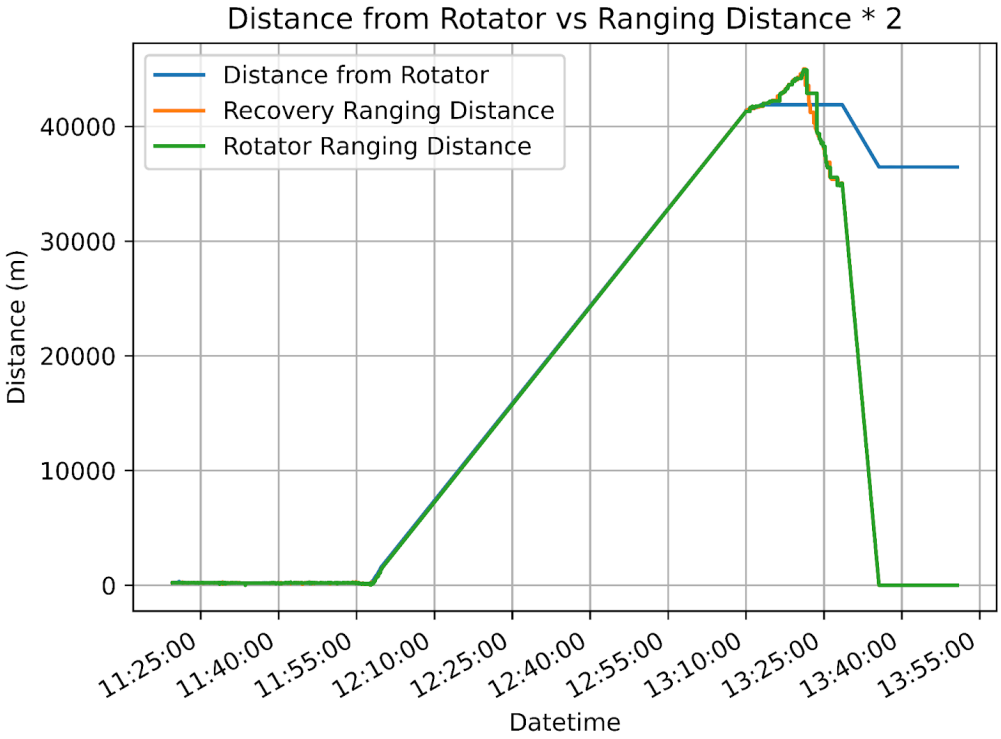


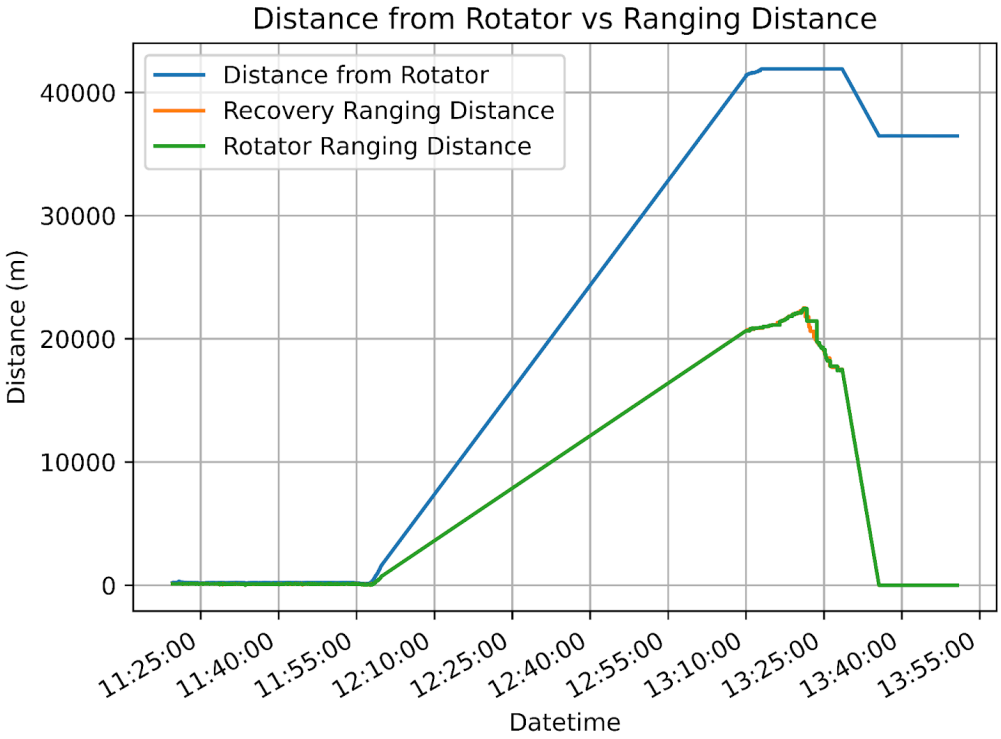
PFC Plots

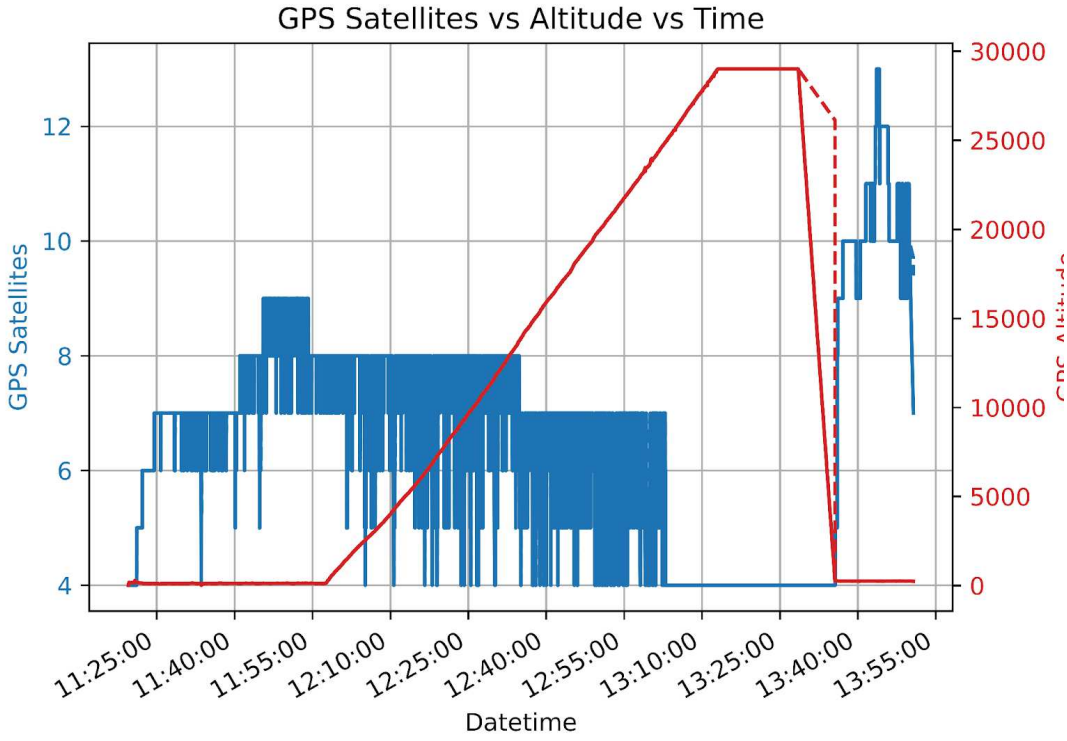

Battery Voltage vs. Time
Battery Voltage
6.5
6.0
5.5
5.0
4.5
4.0
3.5
11:25:00
11:40:00
11:55:00
12:10:00
12:25:00
12:40:00
12:55:00
13:10:00
13:25:00
13:40:00
13:55:00
Datetime

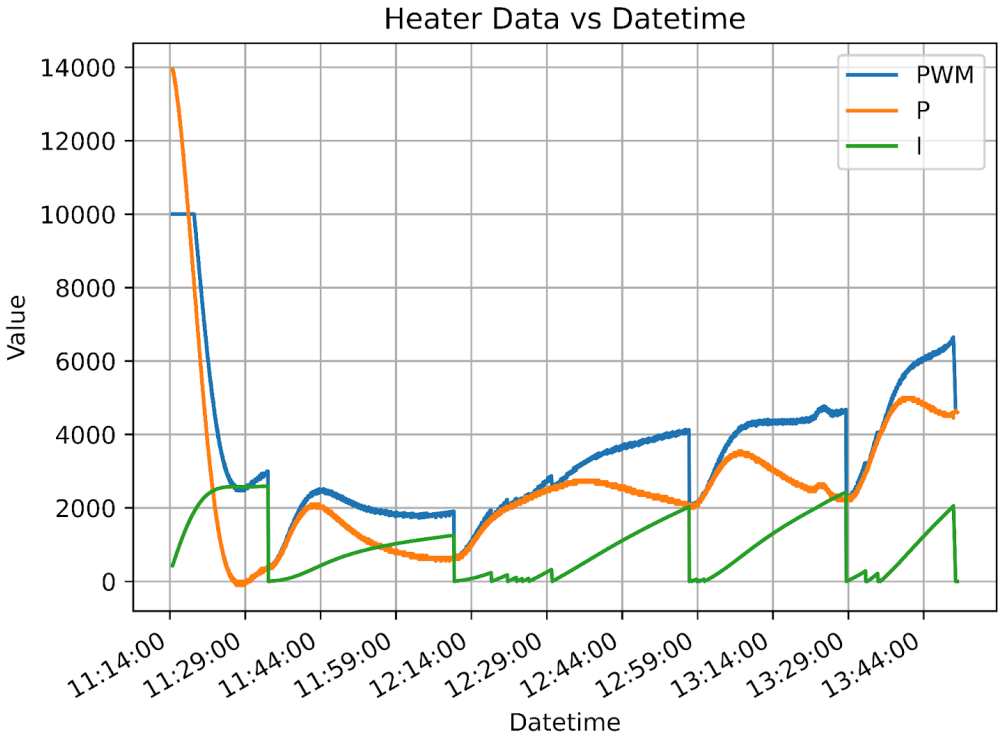

Container Pressure vs Datetime
Pressure
132000
131000
130000
129000
128000
127000
126000
125000
11:14:00
11:29:00
11:44:00
11:59:00
12:14:00
12:29:00
12:44:00
12:59:00
13:14:00
13:29:00
13:44:00
Datetime

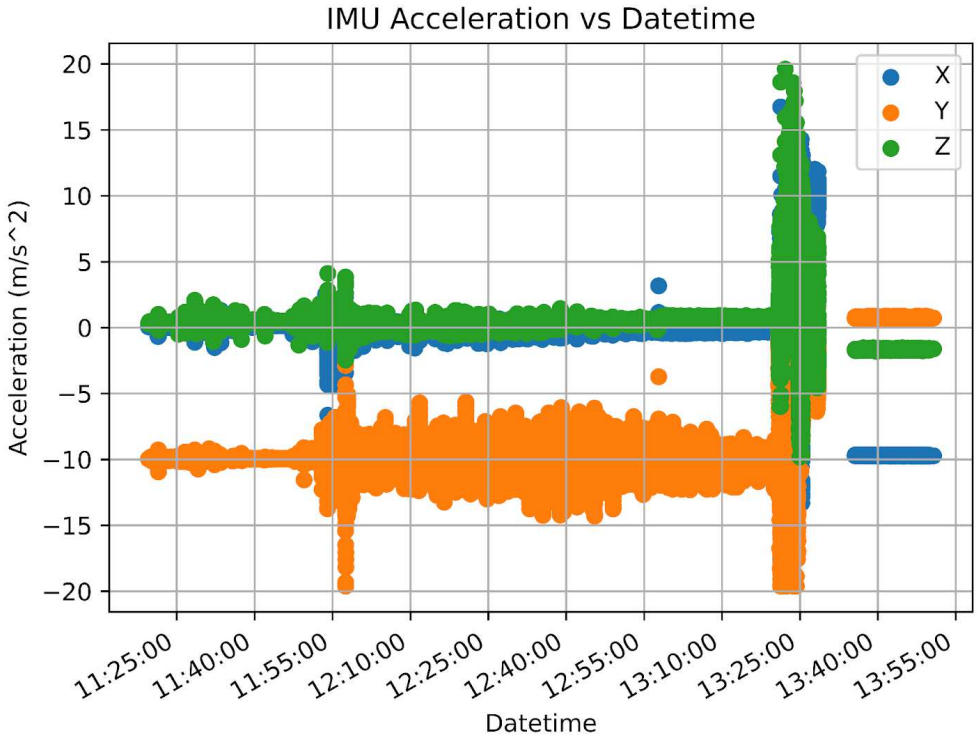

Container Temps vs Datetime
STS35 Temp
BMP180 Temp
MCP9808 Temp
Target Temp
Temperature
50
45
40
35
30
25
20
11:14:00
11:29:00
11:44:00
11:59:00
12:14:00
12:29:00
12:44:00
12:59:00
13:14:00
13:29:00
13:44:00
Datetime

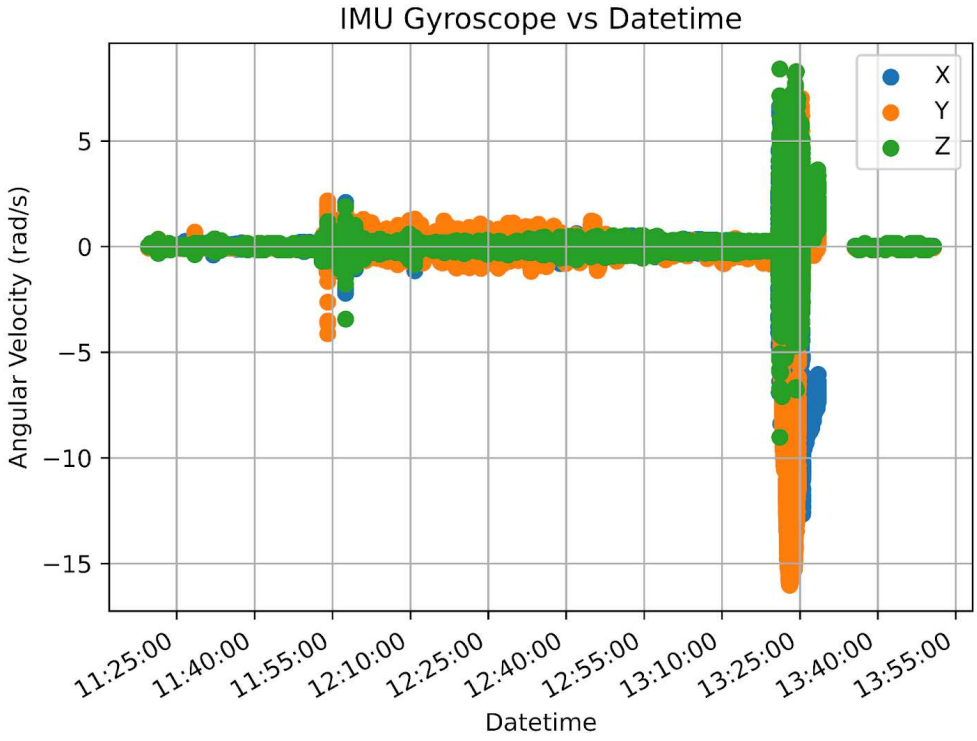

Distance from Rotator vs Ranging Distance * 2
Distance from Rotator
Recovery Ranging Distance
Rotator Ranging Distance
Distance (m)
40000
30000
20000
10000
0
11:25:00
11:40:00
11:55:00
12:10:00
12:25:00
12:40:00
12:55:00
13:10:00
13:25:00
13:40:00
13:55:00
Datetime

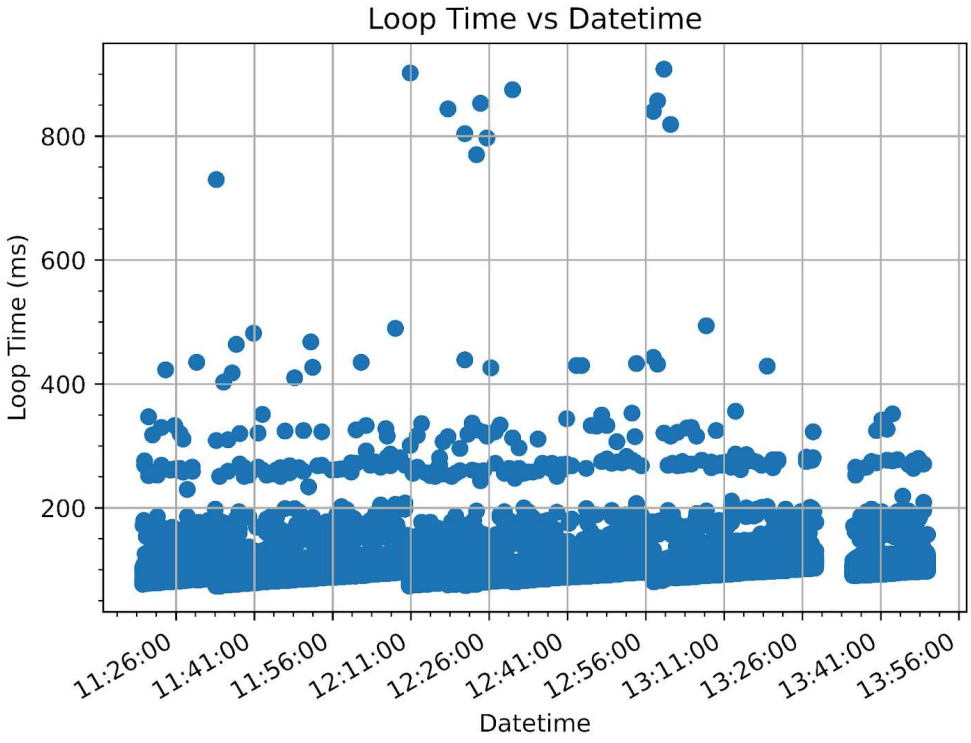

Distance from Rotator vs Ranging Distance
Distance from Rotator
Recovery Ranging Distance
Rotator Ranging Distance
Distance (m)
40000
30000
20000
10000
0
11:25:00
11:40:00
11:55:00
12:10:00
12:25:00
12:40:00
12:55:00
13:10:00
13:25:00
13:40:00
13:55:00
Datetime

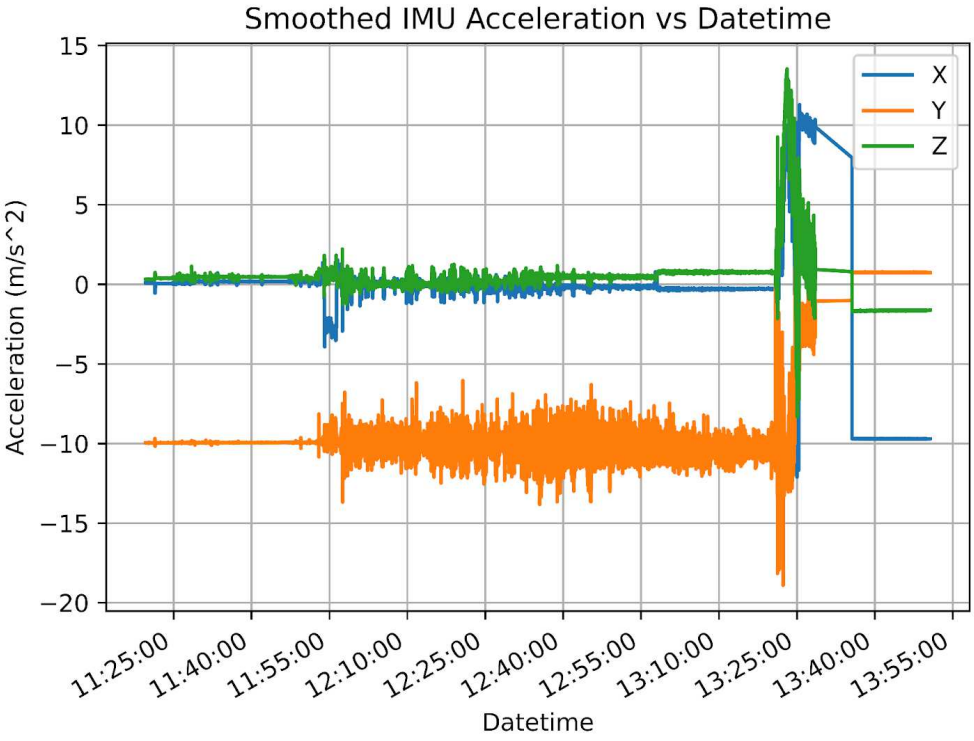

GPS Satellites vs Altitude vs Time
GPS Satellites
12
10
8
6
4
30000
25000
20000
15000
10000
5000
0
11:25:00
11:40:00
11:55:00
12:10:00
12:25:00
12:40:00
12:55:00
13:10:00
13:25:00
13:40:00
13:55:00
Datetime

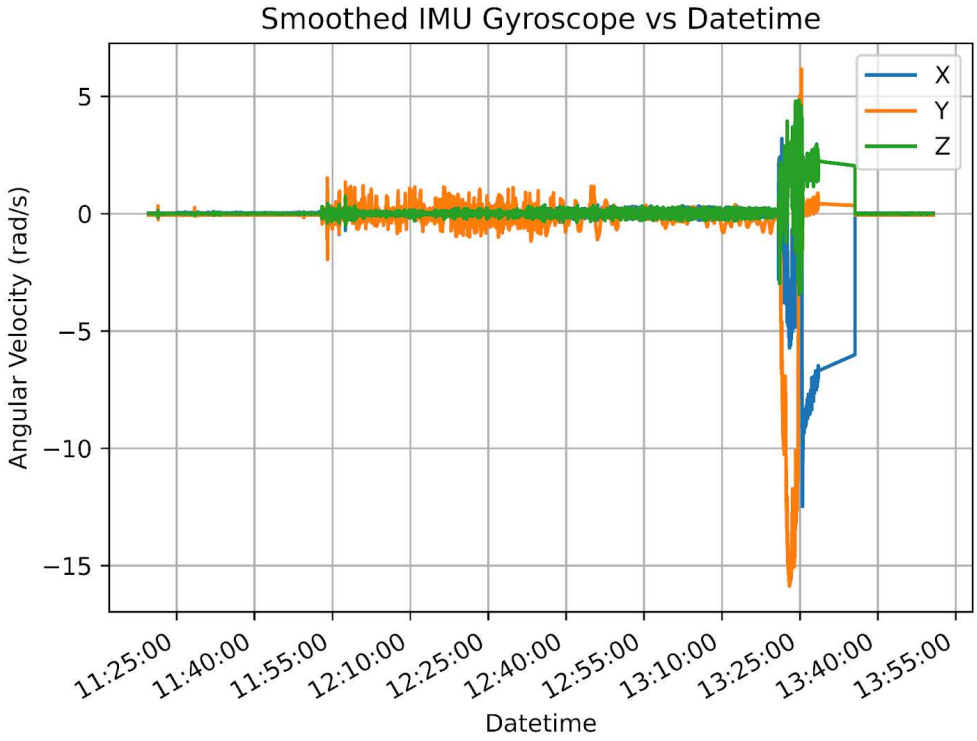

Heater Data vs Datetime
PWM
P
I
Value
14000
12000
10000
8000
6000
4000
2000
0
11:14:00
11:29:00
11:44:00
11:59:00
12:14:00
12:29:00
12:44:00
12:59:00
13:14:00
13:29:00
13:44:00
Datetime

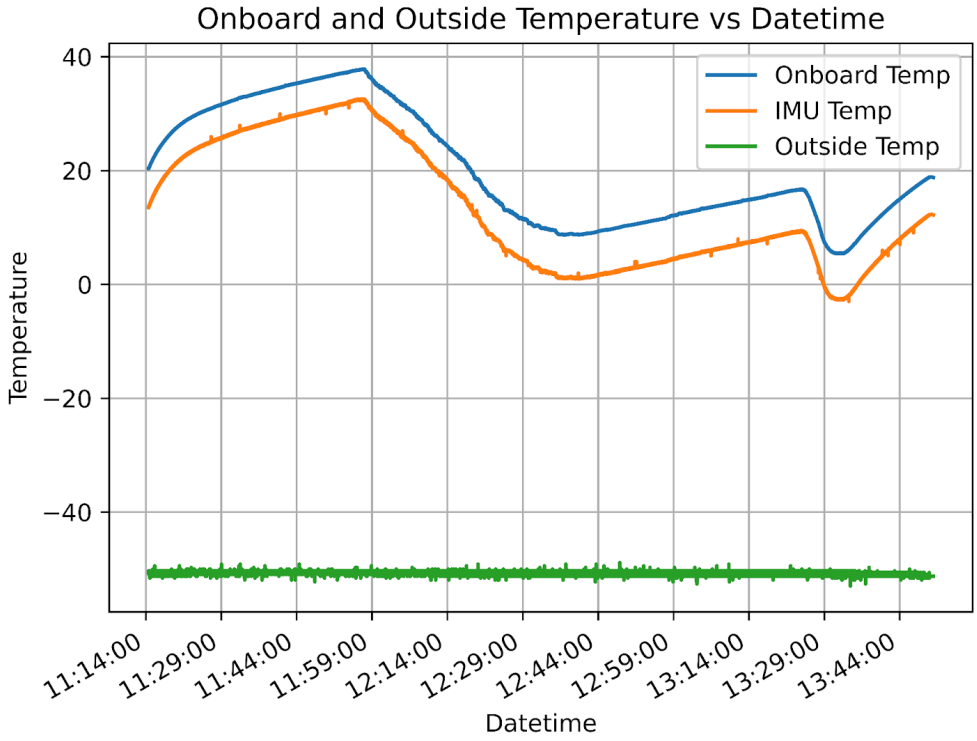

IMU Acceleration vs Datetime
Acceleration (m/s^2)
20
15
10
5
0
−5
−10
−15
−20
11:25:00
11:40:00
11:55:00
12:10:00
12:25:00
12:40:00
12:55:00
13:10:00
13:25:00
13:40:00
13:55:00
Datetime
X
Y
Z


IMU Gyroscope vs Datetime
X
Y
Z
Angular Velocity (rad/s)
5
0
−5
−10
−15
11:25:00
11:40:00
11:55:00
12:10:00
12:25:00
12:40:00
12:55:00
13:10:00
13:25:00
13:40:00
13:55:00
Datetime

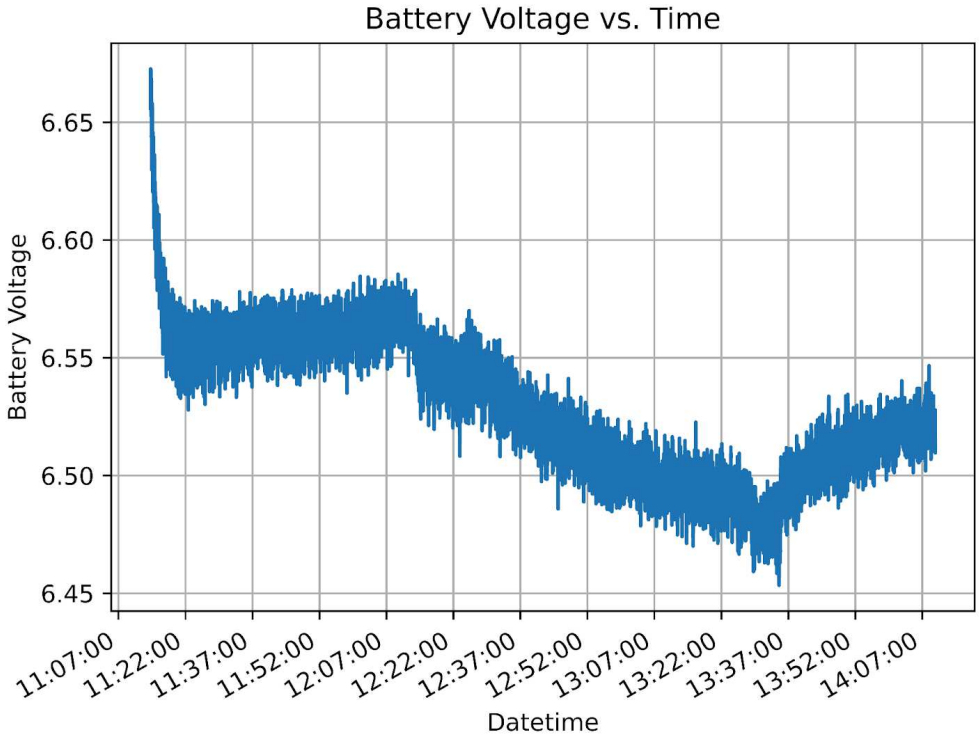

Loop Time vs Datetime
Loop Time (ms)
800
600
400
200
11:26:00
11:41:00
11:56:00
12:11:00
12:26:00
12:41:00
12:56:00
13:11:00
13:26:00
13:41:00
13:56:00
Datetime

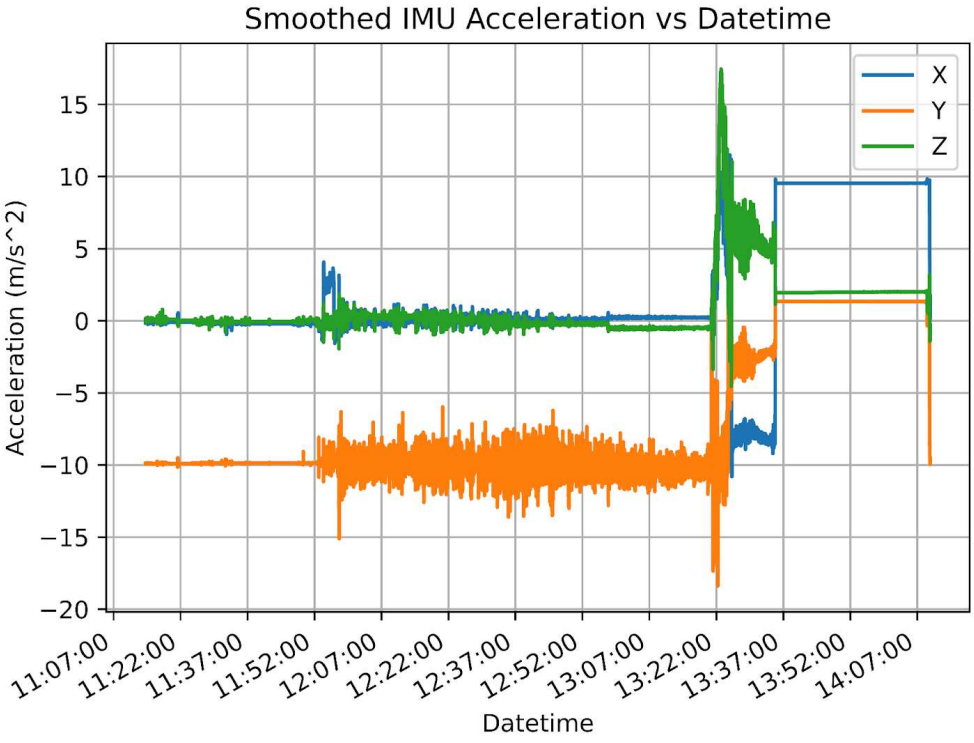

Smoothed IMU Acceleration vs Datetime
Acceleration (m/s^2)
15
10
5
0
−5
−10
−15
−20
11:25:00
11:40:00
11:55:00
12:10:00
12:25:00
12:40:00
12:55:00
13:10:00
13:25:00
13:40:00
13:55:00
Datetime
X
Y
Z

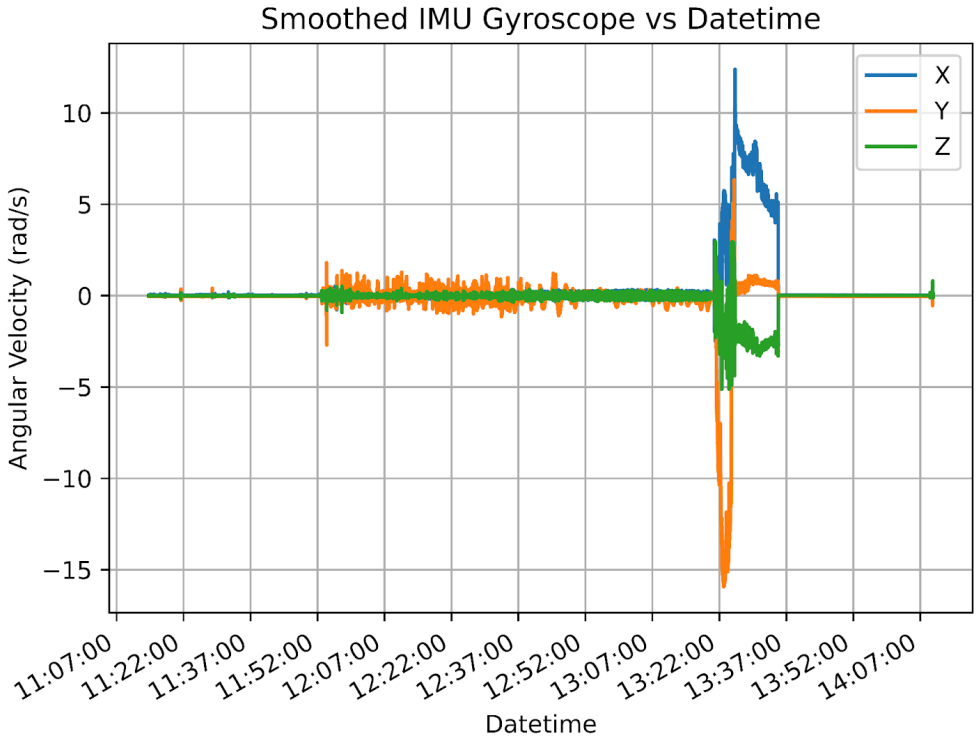

Smoothed IMU Gyroscope vs Datetime
X
Y
Z
5
0
−5
−10
−15
Angular Velocity (rad/s)
11:25:00
11:40:00
11:55:00
12:10:00
12:25:00
12:40:00
12:55:00
13:10:00
13:25:00
13:40:00
13:55:00
Datetime

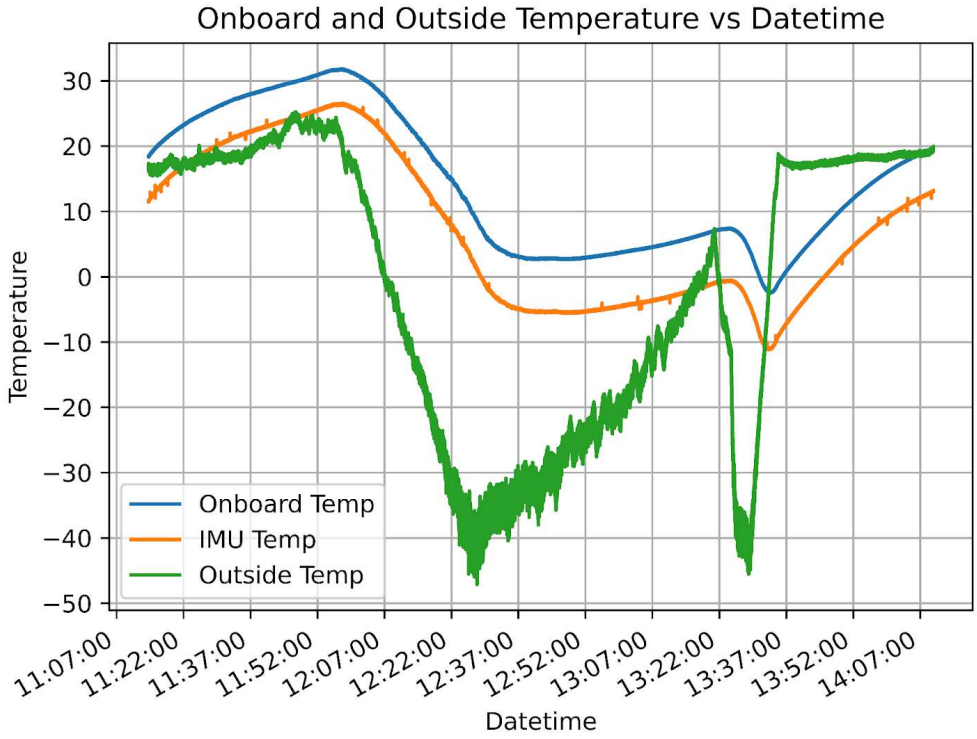

Onboard and Outside Temperature vs Datetime
Onboard Temp
IMU Temp
Outside Temp
Temperature
40
20
0
−20
−40
11:14:00
11:29:00
11:44:00
11:59:00
12:14:00
12:29:00
12:44:00
12:59:00
13:14:00
13:29:00
13:44:00
Datetime

BFC Plots


Battery Voltage vs. Time
Battery Voltage
6.65
6.60
6.55
6.50
6.45
11:07:00
11:22:00
11:37:00
11:52:00
12:07:00
12:22:00
12:37:00
12:52:00
13:07:00
13:22:00
13:37:00
13:52:00
14:07:00
Datetime


Smoothed IMU Acceleration vs Datetime
X
Y
Z
15
10
5
0
−5
−10
−15
−20
Acceleration (m/s^2)
11:07:00
11:22:00
11:37:00
11:52:00
12:07:00
12:22:00
12:37:00
12:52:00
13:07:00
13:22:00
13:37:00
13:52:00
14:07:00
Datetime


Smoothed IMU Gyroscope vs Datetime
X
Y
Z
Angular Velocity (rad/s)
10
5
0
−5
−10
−15
11:07:00
11:22:00
11:37:00
11:52:00
12:07:00
12:22:00
12:37:00
12:52:00
13:07:00
13:22:00
13:37:00
13:52:00
14:07:00
Datetime


Onboard and Outside Temperature vs Datetime
Temperature
30
20
10
0
−10
−20
−30
−40
−50
Onboard Temp
IMU Temp
Outside Temp
11:07:00
11:22:00
11:37:00
11:52:00
12:07:00
12:22:00
12:37:00
12:52:00
13:07:00
13:22:00
13:37:00
13:52:00
14:07:00
Datetime