1 Bonus Challenges

1.1 Attempted: Data Downlink

Bonus Challenge B: Data Downlink was attempted for both flights of the competition. For both flights, XBEE downlink data was collected from Arduino activation on the launchpad until landing. This proved to be critical since the onboard SD card malfunctioned during both flights, and orientation data was still able to be analyzed without loss from the XBEE log files.

1.1.1 Data Logging Method

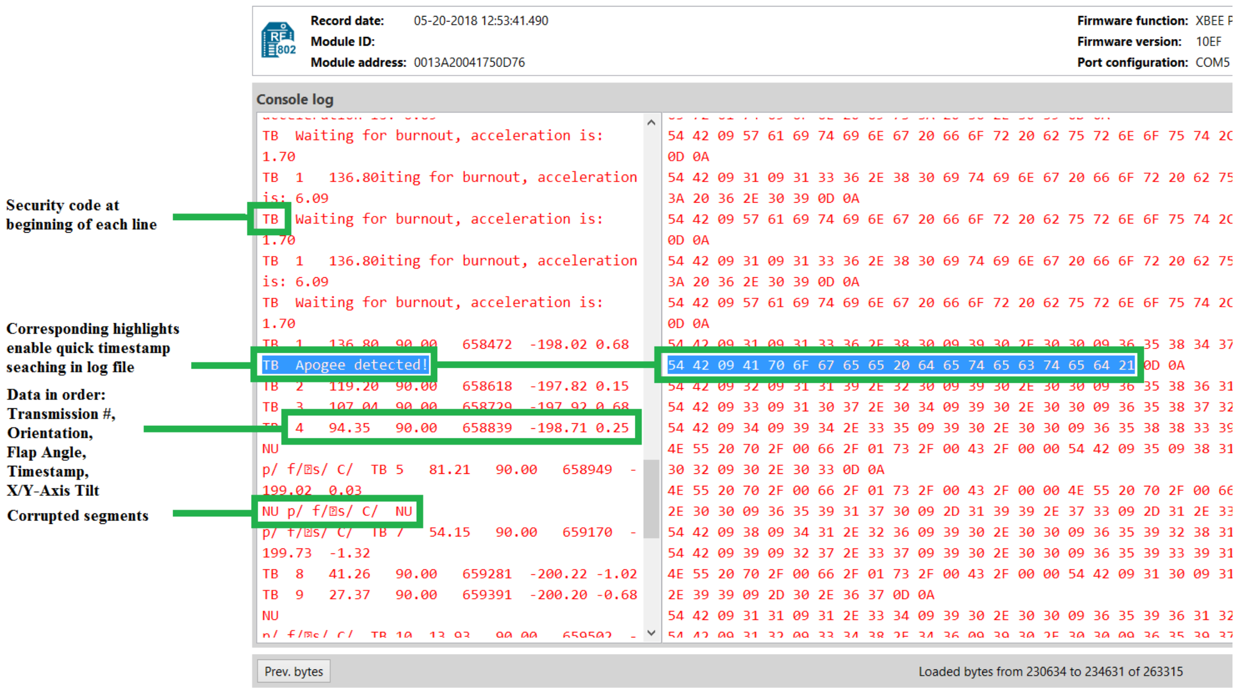
Data downlink was received via the XCTU interface, a software program built by Digi specifically for XBEE communication. Data was logged using a built-in function of the XCTU, and was stored as a .log file able to be read by any text editor program. Normally data throughput would be discarded from the interface after a limited time, but by selecting "Record Session," an entire flight may be logged locally. This also allowed the team to reduce log file size by only beginning to record a session seconds before launch, thereby reducing file size.

1.1.2 Data Reading and Quality

Log files created during flight were read via built-in viewers provided by XCTU. A sample view from Flight 1 is shown below in Figure 1. Each transmission is prefixed with the team's chosen security code "TB," followed by a tab character and transmission data. Shown in the image is a snapshot of data at motor burnout.

The XCTU's built-in ability to match highlighted hexadecimal data with their translated ASCII counterpart was very useful in determining the timing of events, particularly for events prior to burnout, when no timestamp was added to the transmission. By finding the unique sequence of hexadecimal characters, it is possible to open the raw log file using a text editor and look up timestamps automatically prefixed by the XCTU application, as shown in Figure 2.

XBEE downlink data was consistent but contained occasional fragments of corrupted data. This issue was noted during testing, but was ignored due to its sparse occurrence and harmless nature. These corrupted fragments appeared at a slightly higher rate during flight as compared to testing. It should be noted that, curiously, data fragments only appeared in Flight 1, from 0.60 seconds before launch was detected until 76 transmissions after burnout. A possible cause may be the result of buffering issues from writing to the SD card - a corrupted flight log was created in the SD card for Flight 1, while no flight log was created during Flight 2.

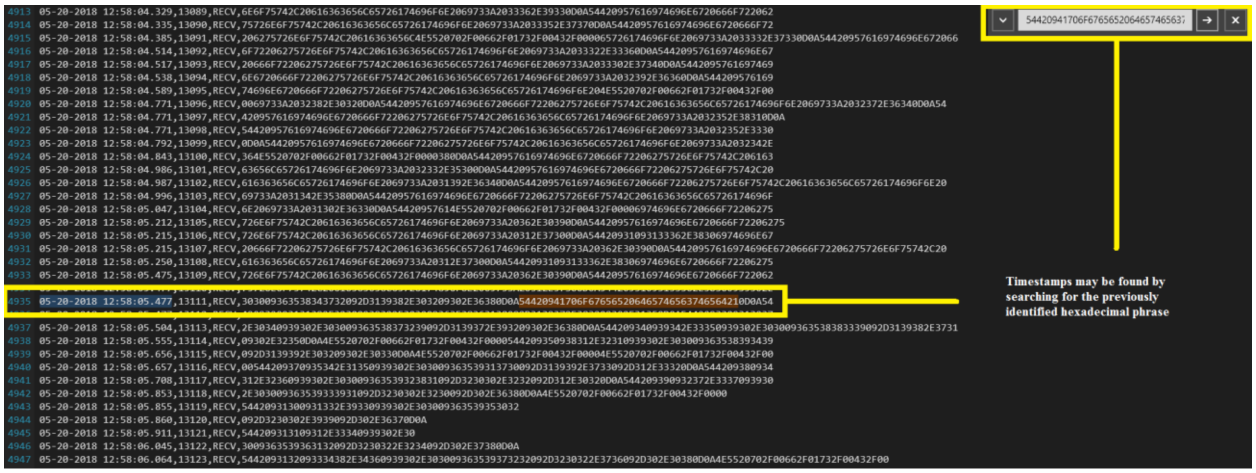

Security code at beginning of each line
Corresponding highlights enable quick timestamp seaching in log file
Data in order: Transmission #, Orientation, Flap Angle, Timestamp, X/Y-Axis Tilt
Corrupted segments
Console log
Prev. bytes

```
Record date:      05-20-2018 12:53:41.490          Firmware function:  XBEE P
Module ID:                                         Firmware version:   10EF
Module address:   0013A20041750D76                 Port configuration: COM5
```

```
TB  Waiting for burnout, acceleration is:      54 42 09 57 61 69 74 69 6E 67 20 66 6F 72 20 62 75 72 6E 6F 75 74 2C
1.70                                           0D 0A
TB  1   136.80iting for burnout, acceleration  54 42 09 31 09 31 33 36 2E 38 30 69 74 69 6E 67 20 66 6F 72 20 62 75
is: 6.09                                       3A 20 36 2E 30 39 0D 0A
TB  Waiting for burnout, acceleration is:      54 42 09 57 61 69 74 69 6E 67 20 66 6F 72 20 62 75 72 6E 6F 75 74 2C
1.70                                           0D 0A
TB  1   136.80iting for burnout, acceleration  54 42 09 31 09 31 33 36 2E 38 30 69 74 69 6E 67 20 66 6F 72 20 62 75
is: 6.09                                       3A 20 36 2E 30 39 0D 0A
TB  Waiting for burnout, acceleration is:      54 42 09 57 61 69 74 69 6E 67 20 66 6F 72 20 62 75 72 6E 6F 75 74 2C
1.70                                           0D 0A
TB  1   136.80  90.00   658472  -198.02 0.68   54 42 09 31 09 31 33 36 2E 38 30 09 39 30 2E 30 30 09 36 35 38 34 37
TB  Apogee detected!                           54 42 09 41 70 6F 67 65 65 20 64 65 74 65 63 74 65 64 21 0D 0A
TB  2   119.20  90.00   658618  -197.82 0.15   54 42 09 32 09 31 31 39 2E 32 30 09 39 30 2E 30 30 09 36 35 38 36 31
TB  3   107.04  90.00   658729  -197.92 0.68   54 42 09 33 09 31 30 37 2E 30 34 09 39 30 2E 30 30 09 36 35 38 37 32
TB  4   94.35   90.00   658839  -198.71 0.25   54 42 09 34 09 39 34 2E 33 35 09 39 30 2E 30 30 09 36 35 38 38 33 39
NU                                             4E 55 20 70 2F 00 66 2F 01 73 2F 00 43 2F 00 00 54 42 09 35 09 38 31
p/ f/s/ C/  TB 5   81.21   90.00   658949  -  30 32 09 30 2E 30 33 0D 0A
199.02  0.03                                   4E 55 20 70 2F 00 66 2F 01 73 2F 00 43 2F 00 00 4E 55 20 70 2F 00 66
NU p/ f/s/ C/  NU                             2E 30 30 09 36 35 39 31 37 30 09 2D 31 39 39 2E 37 33 09 2D 31 2E 33
p/ f/s/ C/  TB 7   54.15   90.00   659170  -  54 42 09 38 09 34 31 2E 32 36 09 39 30 2E 30 30 09 36 35 39 32 38 31
199.73  -1.32                                  54 42 09 39 09 32 37 2E 33 37 09 39 30 2E 30 30 09 36 35 39 33 39 31
TB  8   41.26   90.00   659281  -200.22 -1.02  4E 55 20 70 2F 00 66 2F 01 73 2F 00 43 2F 00 00 54 42 09 31 30 09 31
TB  9   27.37   90.00   659391  -200.20 -0.68  2E 39 39 09 2D 30 2E 36 37 0D 0A
NU                                             54 42 09 31 31 09 31 2E 33 34 09 39 30 2E 30 30 09 36 35 39 36 31 32
```

```
Loaded bytes from 230634 to 234631 of 263315
```

Figure 1: XCTU Log Console


54420941706F67656520646574656374
Timestamps may be found by searching for the previously identified hexadecimal phrase

```
05-20-2018 12:58:04.329,13089,RECV,6E6F75742C20616363656C65726174696F6E2069733A2033362E39330D0A54420957616974696E6720666F722062
05-20-2018 12:58:04.335,13090,RECV,75726E6F75742C20616363656C65726174696F6E2069733A2033352E37370D0A54420957616974696E6720666F72
05-20-2018 12:58:04.385,13091,RECV,206275726E6F75742C20616363656C4E5520702F00662F01732F00432F000065726174696F6E2069733A2033332E37330D0A54420957616974696E672066
05-20-2018 12:58:04.514,13092,RECV,6F72206275726E6F75742C20616363656C65726174696F6E2069733A2033322E33360D0A54420957616974696E67
05-20-2018 12:58:04.517,13093,RECV,20666F72206275726E6F75742C20616363656C65726174696F6E2069733A2033302E37340D0A5442095761697469
05-20-2018 12:58:04.538,13094,RECV,6E6720666F72206275726E6F75742C20616363656C65726174696F6E2069733A2032392E36360D0A544209576169
05-20-2018 12:58:04.589,13095,RECV,74696E6720666F72206275726E6F75742C20616363656C65726174696F6E204E5520702F00662F01732F00432F00
05-20-2018 12:58:04.771,13096,RECV,0069733A2032382E30320D0A54420957616974696E6720666F72206275726E6F75742C20616363656C65726174696F6E2069733A2032372E36340D0A54
05-20-2018 12:58:04.771,13097,RECV,420957616974696E6720666F72206275726E6F75742C20616363656C65726174696F6E2069733A2032352E38310D0A
05-20-2018 12:58:04.771,13098,RECV,54420957616974696E6720666F72206275726E6F75742C20616363656C65726174696F6E2069733A2032352E3330
05-20-2018 12:58:04.792,13099,RECV,0D0A54420957616974696E6720666F72206275726E6F75742C20616363656C65726174696F6E2069733A2032342E
05-20-2018 12:58:04.843,13100,RECV,364E5520702F00662F01732F00432F0000380D0A54420957616974696E6720666F72206275726E6F75742C206163
05-20-2018 12:58:04.986,13101,RECV,63656C65726174696F6E2069733A2032332E35300D0A54420957616974696E6720666F72206275726E6F75742C20
05-20-2018 12:58:04.987,13102,RECV,616363656C65726174696F6E2069733A2031392E36340D0A54420957616974696E6720666F72206275726E6F75742C20616363656C65726174696F6E20
05-20-2018 12:58:04.996,13103,RECV,69733A2031342E35380D0A54420957616974696E6720666F72206275726E6F75742C20616363656C65726174696F
05-20-2018 12:58:05.047,13104,RECV,6E2069733A2031302E36330D0A54420957614E5520702F00662F01732F00432F00006974696E6720666F72206275
05-20-2018 12:58:05.212,13105,RECV,726E6F75742C20616363656C65726174696F6E2069733A20362E30390D0A54420957616974696E6720666F72206275
05-20-2018 12:58:05.215,13106,RECV,726E6F75742C20616363656C65726174696F6E2069733A20312E37300D0A54420931093133362E38306974696E67
05-20-2018 12:58:05.215,13107,RECV,20666F72206275726E6F75742C20616363656C65726174696F6E2069733A20362E30390D0A54420957616974696E6720666F72206275726E6F75742C20
05-20-2018 12:58:05.250,13108,RECV,616363656C65726174696F6E2069733A20312E37300D0A54420931093133362E38306974696E6720666F72206275
05-20-2018 12:58:05.475,13109,RECV,726E6F75742C20616363656C65726174696F6E2069733A20362E30390D0A54420957616974696E6720666F722062
[illegible]
05-20-2018 12:58:05.477,13111,RECV,303009363538343732092D3139382E303209302E36380D0A54420941706F676565206465746563746564210D0A54
[illegible]
05-20-2018 12:58:05.504,13113,RECV,2E30340939302E303009363538373239092D3139372E393209302E36380D0A544209340939342E33350939302E303009363538383339092D3139382E3731
05-20-2018 12:58:05.555,13114,RECV,09302E32350D0A4E5520702F00662F01732F00432F0000544209350938312E32310939302E303009363538393439
05-20-2018 12:58:05.656,13115,RECV,092D3139392E303209302E30330D0A4E5520702F00662F01732F00432F00004E5520702F00662F01732F00432F00
05-20-2018 12:58:05.657,13116,RECV,00544209370935342E31350939302E303009363539313730092D3139392E3733092D312E33320D0A544209380934
05-20-2018 12:58:05.708,13117,RECV,312E32360939302E303009363539323831092D3230302E3232092D312E30320D0A544209390932372E3337093930
05-20-2018 12:58:05.853,13118,RECV,2E303009363539333931092D3230302E3230092D302E36380D0A4E5520702F00662F01732F00432F0000
05-20-2018 12:58:05.855,13119,RECV,54420931300931332E39330939302E303009363539353032
05-20-2018 12:58:05.860,13120,RECV,092D3230302E3939092D302E36370D0A
05-20-2018 12:58:05.911,13121,RECV,544209313109312E33340939302E30
05-20-2018 12:58:06.045,13122,RECV,3009363539363132092D3230322E3234092D302E37380D0A
05-20-2018 12:58:06.064,13123,RECV,5442093132093334382E34360939302E303009363539373232092D3230322E3736092D302E30380D0A4E5520702F00662F01732F00432F00
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Figure 2: Identifying the timestamp of a hexadecimal phrase using search functions

1.1.3 Data Analysis

Only data that was critical to the performance of the vehicle was chosen for transmission to avoid overflowing the buffer (unlikely) and for easy debugging.

Prior to motor burnout, the vehicle would report its current status (on pad or thrusting) and acceleration in the z-axis (vertical). After motor burnout, the vehicle would coast for 2 or 3 seconds depending on the flight, without reporting data. When control is enabled after the idle coast time, data would be reported in the order of transmission number, orientation, flap angle, timestamp (milliseconds), x-axis tilt, and y-axis tilt.

Flap angle data was selected to analyze the performance of the PID controller used to roll the rocket. A timestamp was included to check the execution speed of the controller and to quickly determine the timing of flight events. Tilt in the x and y axis were selected because the team used tilt for apogee detection, and had issues with integration over time during prior testing.

This proved to be highly valuable because apogee detection malfunctioned during the first flight, causing the controlled to believe the rocket had reached apogee immediately after burnout. Controls were then disabled and no control was provided. The team was able to quickly deduct the source of error from the XBEE data readings and update the controller code before the second flight.

1.2 Not Attempted: Command Uplink, Crosstalk

Bonus Challenge A and C were not attempted. While the team independently verified code that succeeded in both challenge goals, integration with the main controller code caused unforeseen issues. Furthermore, the addition of SD card data logging code heavily reduced available storage space and RAM in the Arduino Uno used by the team.

Even after significant efforts to reduce memory usage by modifying libraries and improving data storage methods, the team still approached limits for storage and RAM with less than 10 bytes to spare for both. With insufficient time remaining to modify the avionics bay and accommodate the larger Arduino Mega, coupled with the inconsistent performance of bonus challenge code, it was decided that bonus challenges A and C would not be attempted.