Command Module

Design Review

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BPP

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Outline

Section 1 - Overview
- History
- Requirements

Section 2 - Electronics
- LiteAPRS Specs
- LVC
- Iridium
- Cell Tracker
- Block Diagrams

Section 3 - Mechanical
- Box Design
- Command Purse

Outline (cont'd)

Section 4 - Next Steps
- Schedule
- Open Issues

Overview

Cooper's Box

Components

- 2 HABduino APRS transmitters
- 2G Cell Tracker
- Space for Link/Iridium

Structure

- 3D printed plastic
- Dimensions 9" x 9" x 8"
- Box alone weighs ∼1.7 pounds
- Fully assembled weighs ∼3.8 pounds

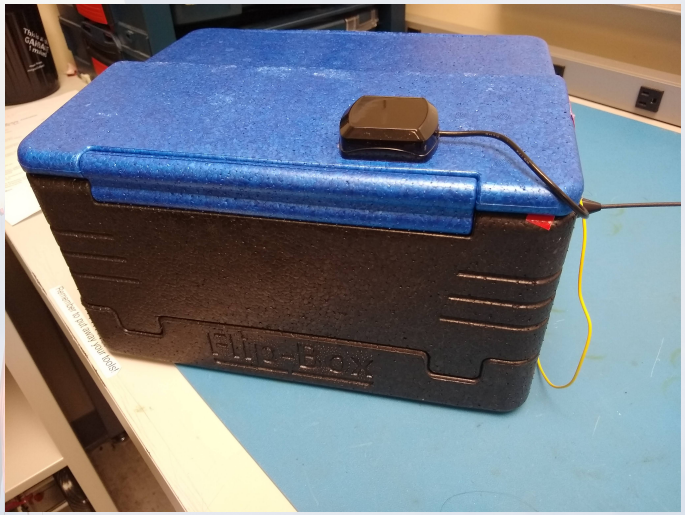
Interim Box

Components

- 2 HABduino APRS transmitters
- 4G Cell Tracker
- Iridium
- Space for new APRS transmitter

Structure

- Expanded Polypropylene
- Dimensions 9.5" x 11" x 6"
- Box alone weighs ∼0.7 pounds
- Fully assembled weighs ∼2.5 pounds



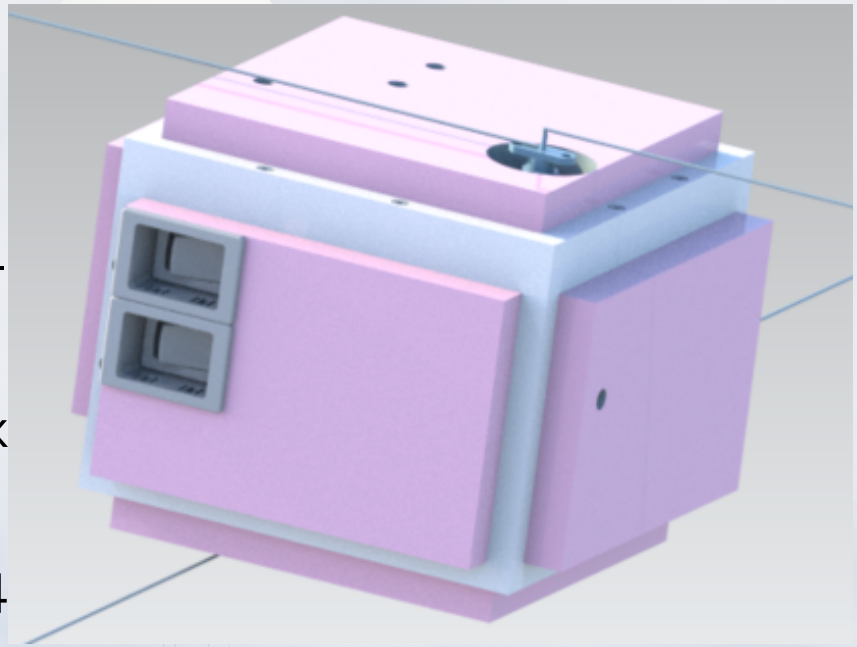
New Box

Components

- 2 liteAPRS transmitters
- 4G Cell Tracker
- Iridium

Structure

- ABS with Expanded Polypropelyne inserts
- Dimensions: 4.25" x 4.25" x 3"
- Box alone weighs ∼0.4 pounds
- Fully assembled weighs ∼1.25 pounds



Mission Statement

To create a small, lightweight, reliable tracking module for use with the Balloon Payload Program.

Requirement Designations

- MS: Mission Statement
- M: Mechanical
- E: Electrical
- P: Programmatic
- T: Testing

Level 1 Requirements

ID	Requirement	Source
P1	The command module shall be attachable to the balloon train	MS
P2	The command module shall comply with all BPP payload regulations	MS
P3	The command module shall provide reliable independent tracking over APRS, iridium and cell networks	MS
M1	The command module shall have a mass less than 0.9 kg	MS

Level 2 Requirements

ID	Requirement	Source
M1	A purse shall attach the command module to the flight train	P1, P2, BPP-Req-130
T1	The command module shall be tested to ensure survival during launch and flight conditions	P2, BPP-Req-110, BPP-Req-101
M2	The command module contents shall be mechanically and non-adhesively constrained to the box	P2, BPP-Req-105
E1	The command module shall provide at least two independent telemetry modes during all flight regimes	P2, P3, BPP-Flight-120

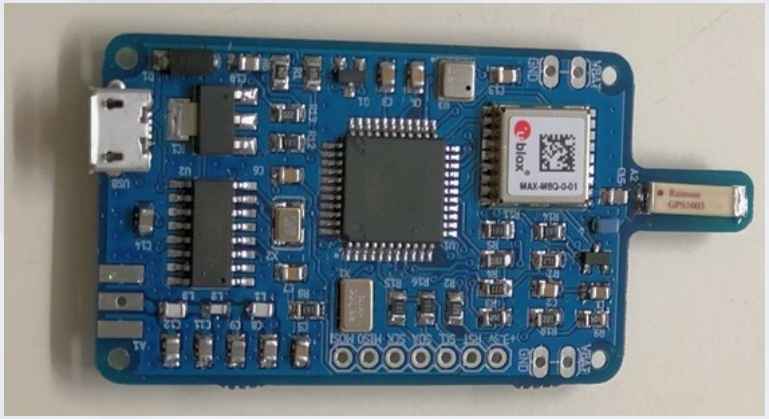
Level 3 Requirements

ID	Requirement	Source
M3	The command purse shall be capable of integration with the payload string when fully sealed and powered on	M1
E2	The command module shall not use HABduino APRS transmitters	P3, E1
E3	The command module shall have external switches to allow for power cycling at any point while fully assembled	E1

Electronics

liteAPRS Boards

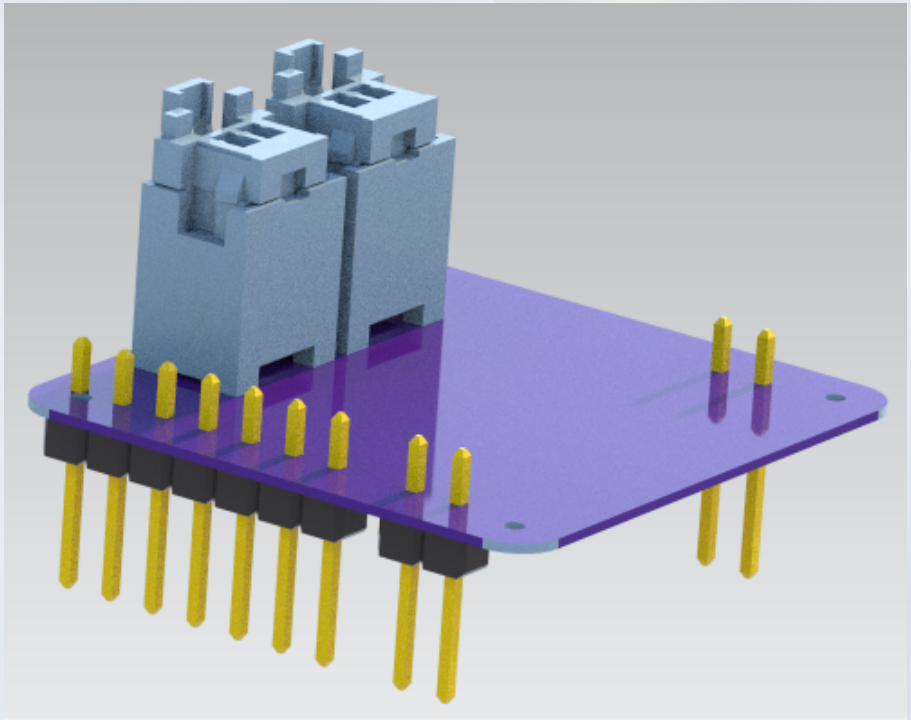
- COTS APRS transmitters
- Come in two variants: with and without the WISPR module
- Onboard power regulator with 15 V max input
- Breakout I2C and SPI pins for additional sensor capabilities
- Open source code



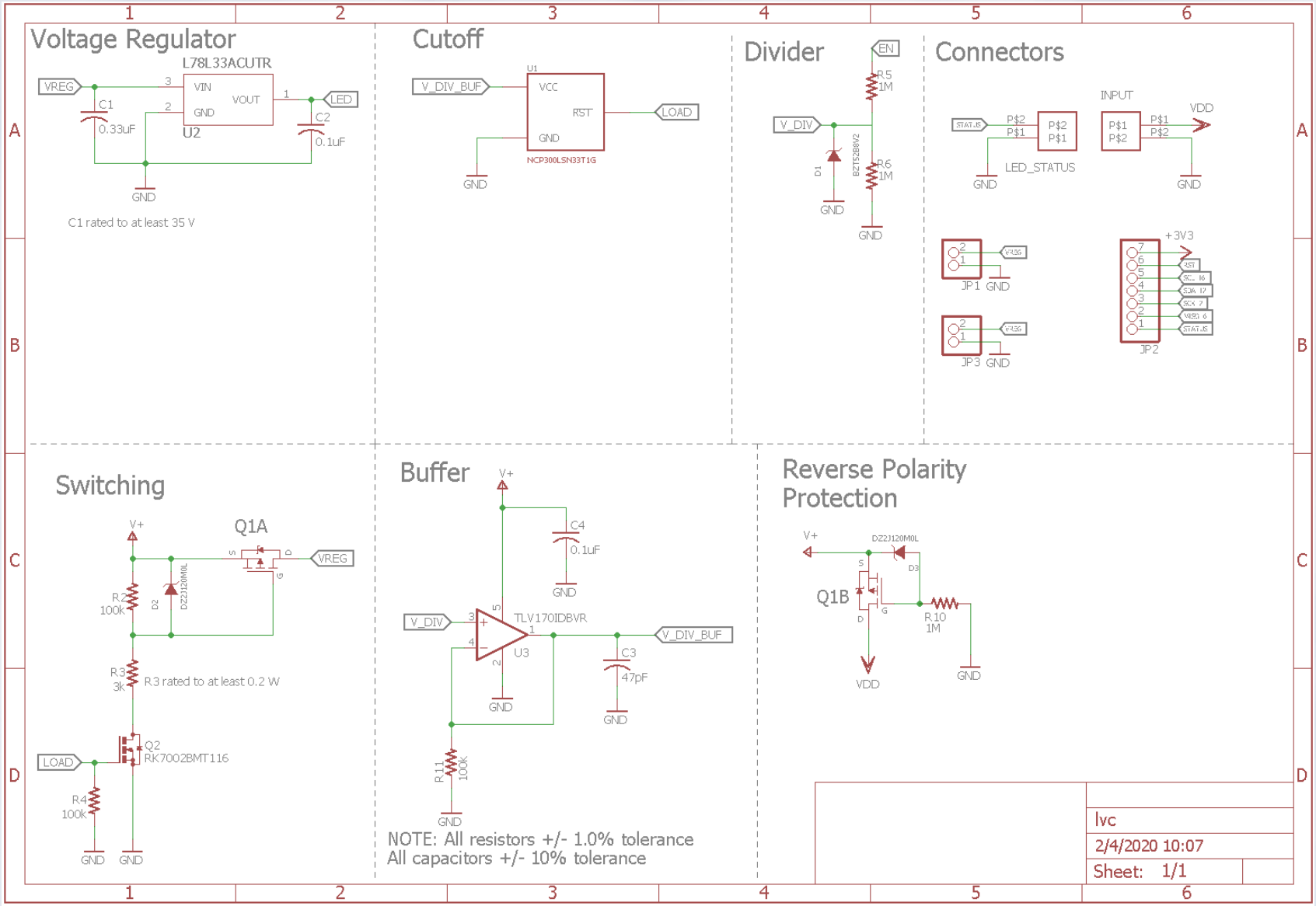
	liteAPRS	**liteAPRS-w**
Weight	8 g	9 g
Dimensions	3.5 cm x 5 cm	3.5 cm x 6 cm
Cost	$100	$115
Owned	3	3

Low Voltage Cutoff (LVC)

- Same components as the standard program LVCs
- Only meant for 2 cell batteries
- Screw terminals replaced with on-board connectors
- In-line with the liteAPRS boards

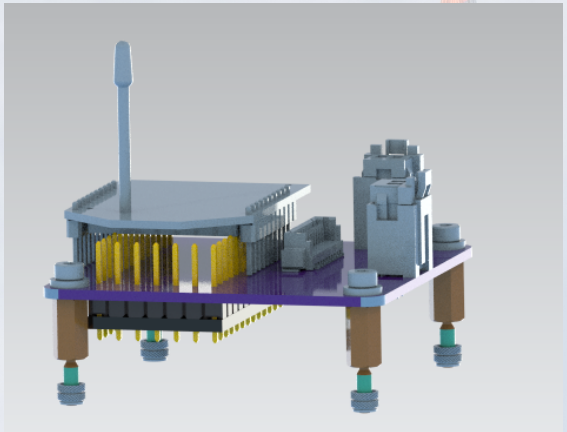


LVC Schematic

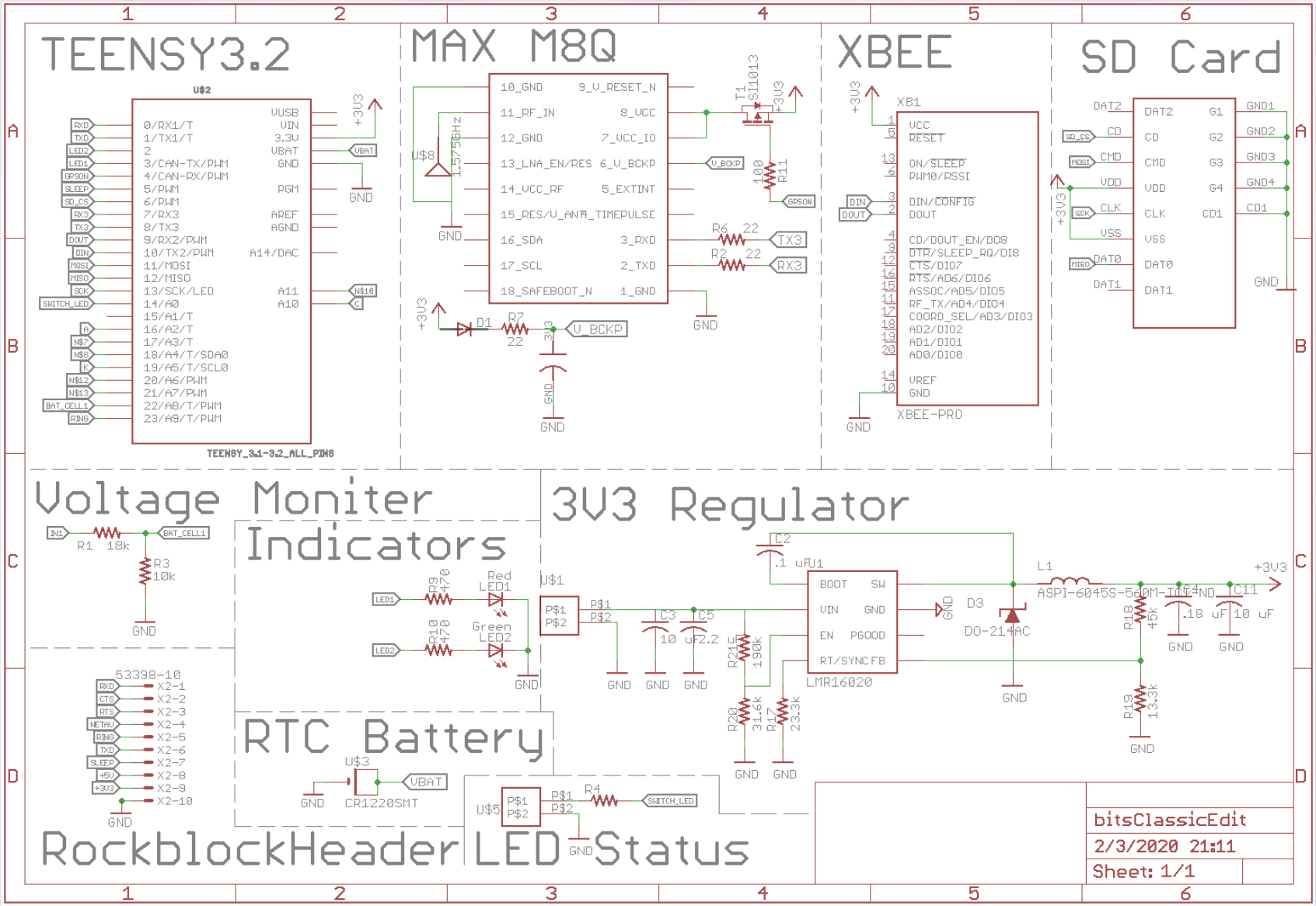


Balloon Iridium Telemetry System (BITS)

- Interfaces with RockBLOCK 9603 Iridium modem for payload-to-ground communications
- 900Mhz XBee for payload-to-payload communications
- Developing XBee payload-to-ground communications
- MAX-M8Q GPS with chip antenna for location tracking
- Increased GPS logging to 5Hz to support HAPL science
- Includes Ring Alert to more quickly process incoming commands
- Outputs directly to a map on the new server

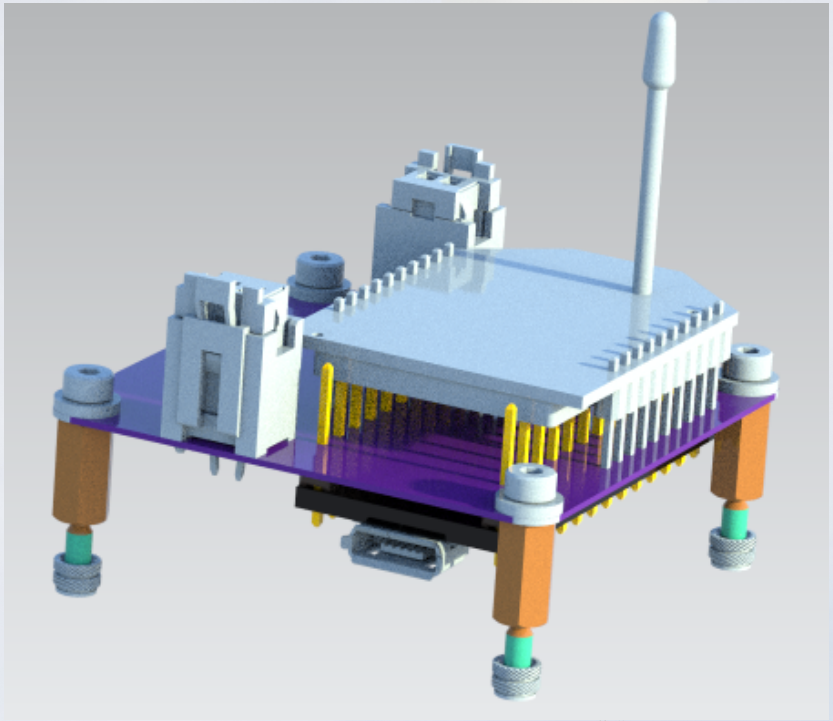


BITS Schematic

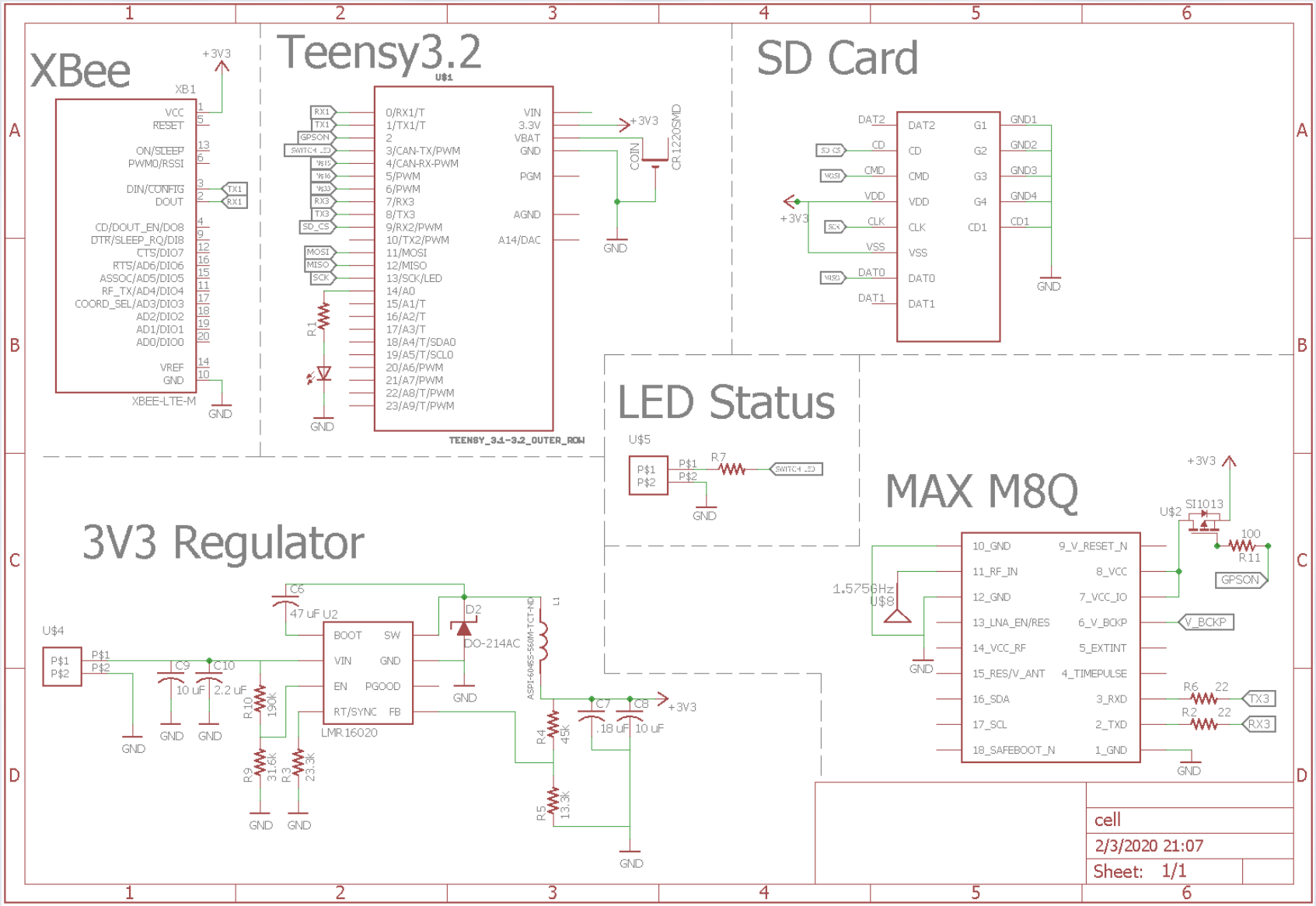


Cell Tracker

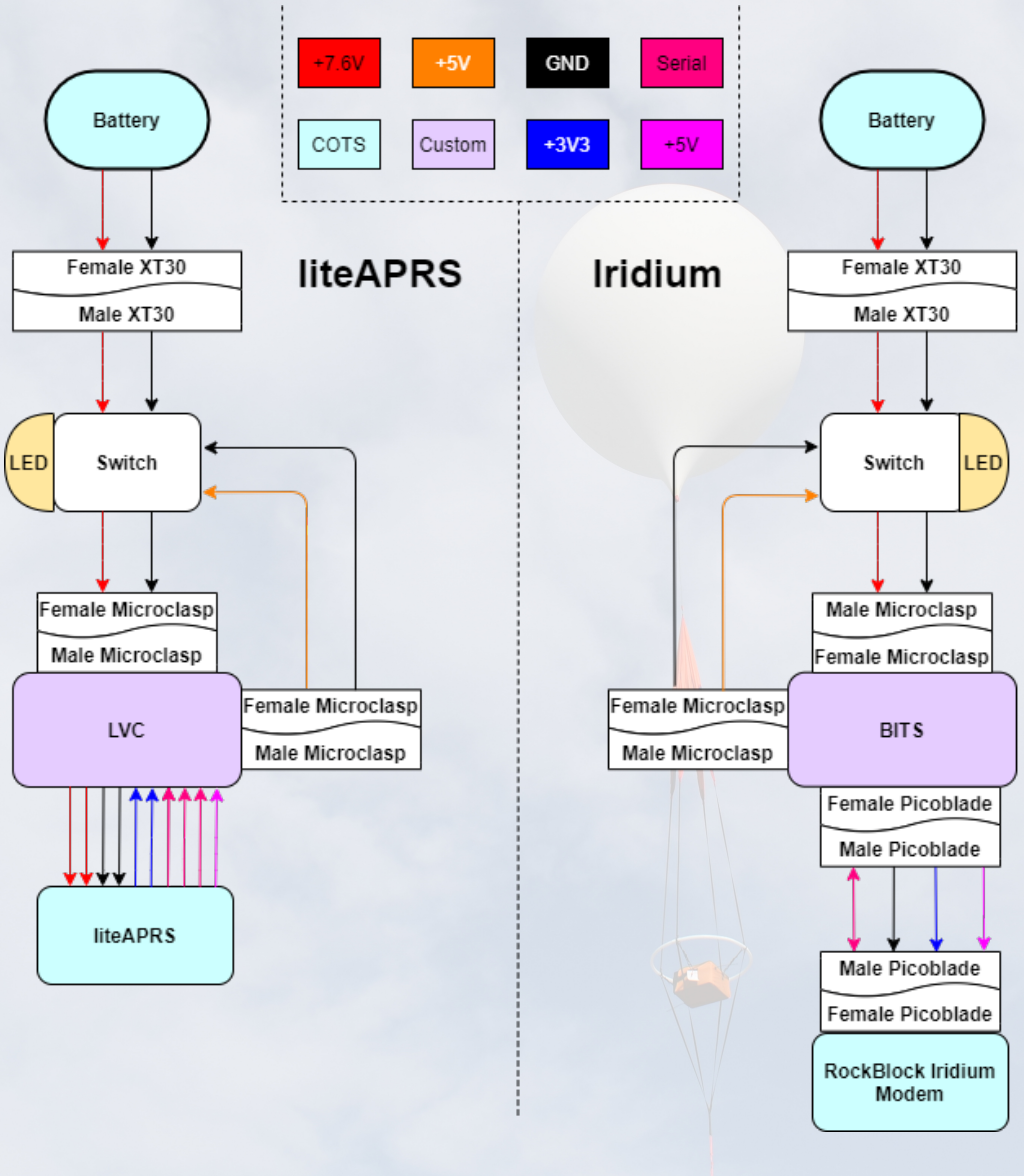
- Xbee 3 Cellular LTE-M for sending SMS messages (texts)
- Sends messages below a preset altitude (currently 5000 feet)
- GPS logging at 1Hz



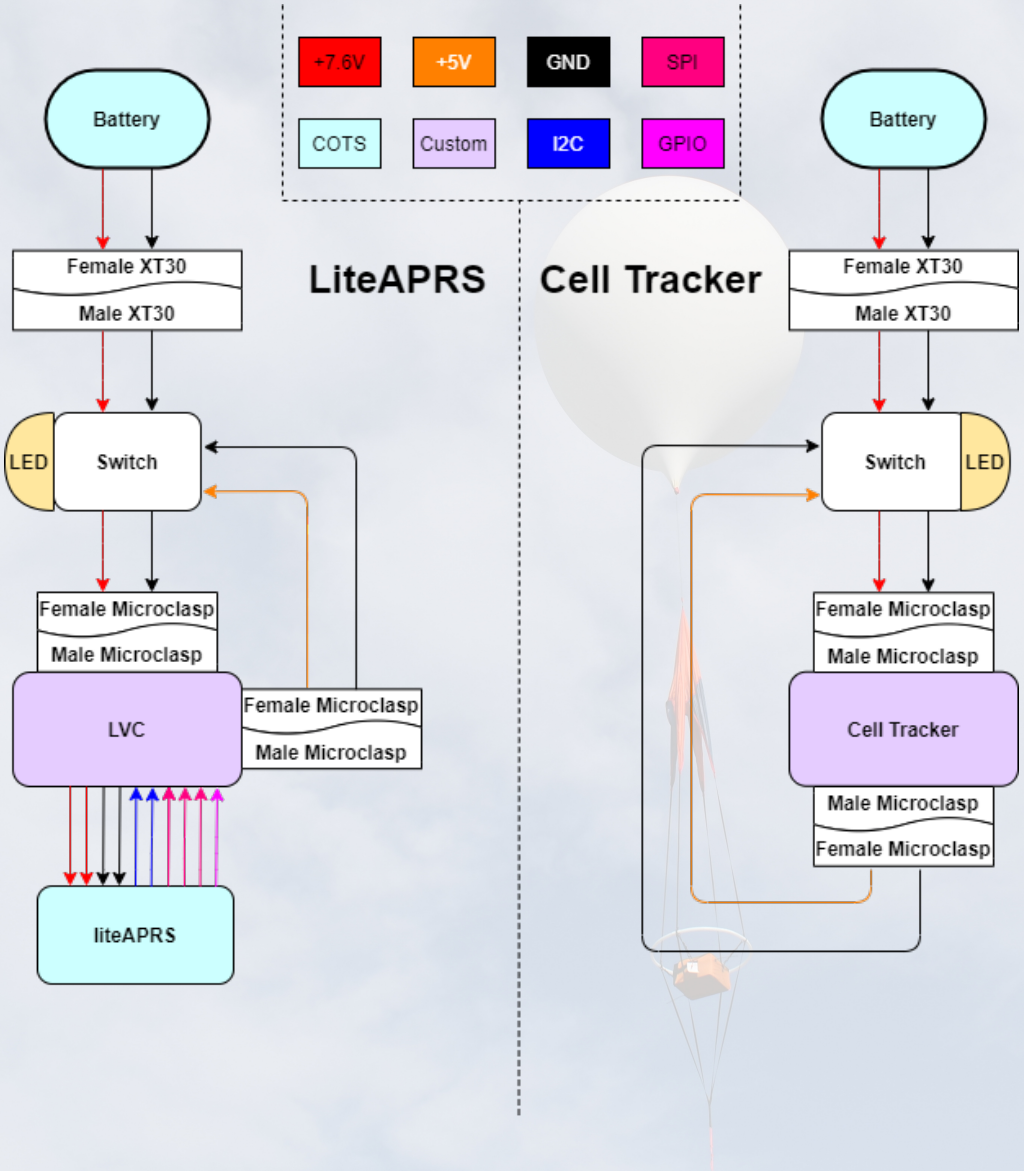
Cell Tracker Schematic



Iridium Box Block Diagram



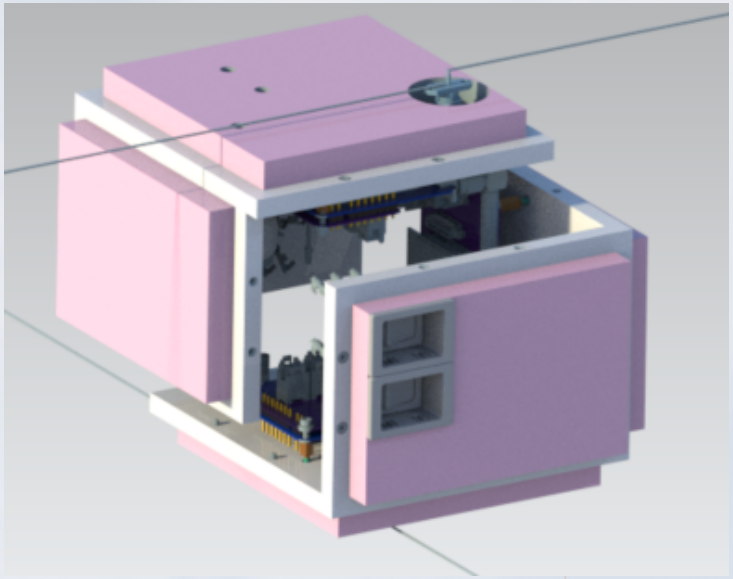
Cell Box Block Diagram



Mechanical

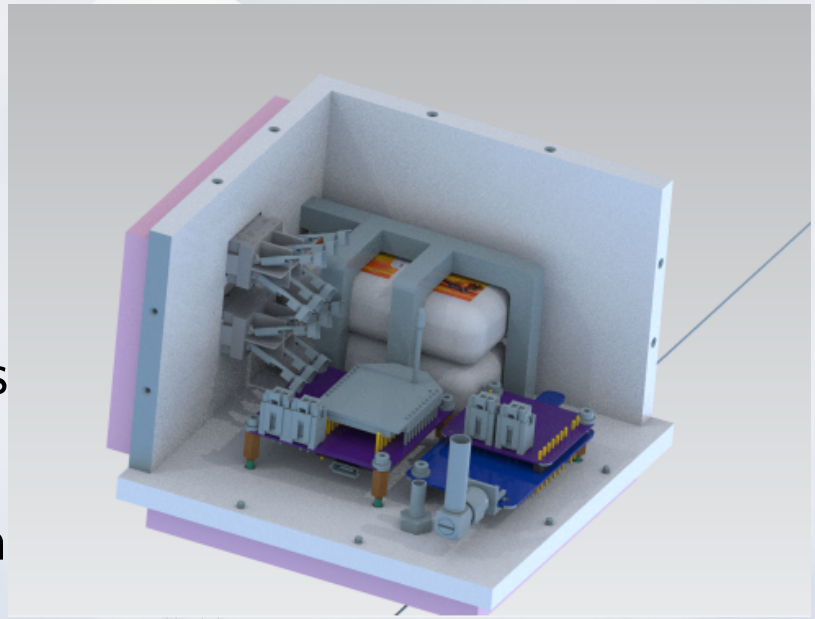
Mechanical Overview

- The command module will be made of two independent, separable halves
  - One half will contain a liteAPRS transmitter and the cell tracker
  - The other half will contain a liteAPRS transmitter and BITS
- Each transmitter will be independently powered



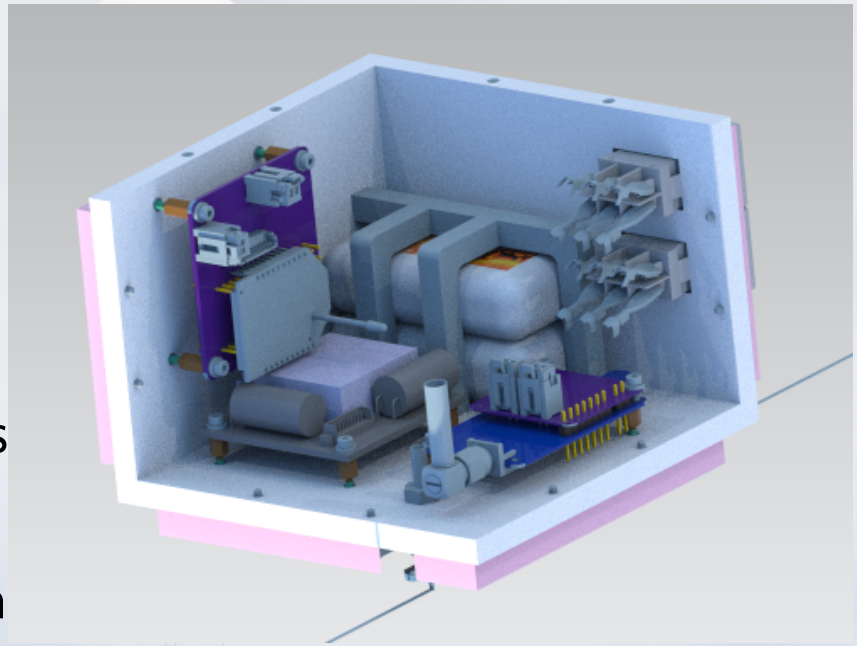
Cell Tracker Box

- One liteAPRS transmitter
- One 4G cell tracker module
- Two 2-Cell batteries
- One battery retainer
- Two external DPST switches with external lights
- One external VHF antenna for liteAPRS



Iridium Box

- One liteAPRS transmitter
- One Iridium module
- One BITS board
- Two 2-Cell batteries
- One battery retainer
- Two external DPST switches with external lights
- One external VHF antenna for liteAPRS



Assembly

- All standoffs are screwed into heat set inserts placed in the box
- All electronics are screwed into brass standoffs
- Where possible, screws are offset from electronics with electrically insulating washers
- Holes cut in the EPS are used to screw in external connectors
  - SMA antenna connector
  - Battery retaining screws
- Connectors are used to provide electrical routing throughout the box
- Switches can be snapped into their holes
- Two box halves mate together and are secured with 12 screws

Command Envelope

- Waterproof ripstop nylon fabric
- Waterproof zipper for assembly
- Grommets for the antenna opening
- Two panels assembled similar to the boxes
- Slipped over the box before putting the antenna on
- One zipper to mate the two after box closeup
- Leaves only a small hole where the zipper ends and the grommets open to the elements
- Cloth hooks for attaching the purse to the parachute

Next Steps

Infill Testing

To determine the infill required for the box:

- The box is least stable against point forces impacting the thin plastic cutouts on the walls
- Print multiple blanks of the correct dimensions with varying infills
- Drop 30-40 pounds from a designated height to simulate a 30-40g landing impact
- Infill to use will be the second infill percentage to not break under load

Environmental Tests

To verify that the electronics can survive at altitude, continuous logging shall be recorded for the duration of the following:

- Run a hot thermal test dwelling at -30°C for an hour
- Run a cold thermal test dwelling at -60°C for an hour

To verify that the box will adequately vent during ascent, no structural damage shall be observed after depressurization in the SSL glovebox.

Box Load Testing

To verify that the box will survive upon landing, no structural damage shall be observed after the following:

- Will be conducted after the thermal test to ensure box has at least one thermal cycle
- Weight box similar to it being fully assembled (to not break electronics if test fails)
- Drop box from arm's height
- Drop box from top floor of manufacturing
- Drop box from parking garage while in command purse attached to parachute

Flight Testing

To flight qualify Command, it should fly in the nominal configuration (attached to the parachute) with HABduinos in a box below for redundant tracking. Flight qualification is all systems functioning and tracking for the duration of flight.

Electronics Timeline

- First rev assembled and tested by 14 Feb
- Second rev ordered by 21 Feb
- Second rev assembled and tested by 6 Mar
- Third rev ordered by 13 Mar
- Third rev assembled and tested by 27 Mar
- Thermal test by 3 Apr
- Goal is to only need two or three revs, to have electronics ready for first flight

Mechanical Timeline

- Infill test pieces printed by 7 Feb
- Infill test conducted by 14 Feb
- Parts ordered by 14 Feb
- Preliminary fit check by 6 Mar with rev 2 boards
- Final fit check by 27 Mar with rev 3 boards
- Drop test conducted by 7 Apr post thermal test
- Pressure test conducted by 7 Apr post thermal test
- This schedule is linked with the electrical timeline - any slip in electronics testing will slip the schedule for mechanical

Open Issues

- Command purse design - anything better?
- Battery Retaining mechanism - anything better?
- Any useful sensors that can be added to the LVC Carrier board?