Carbon Fiber-Integrated Antennas for GPS & Telemetry

Onboard GPS & LoRa Handling w/ 4-way RF Switches in the Active Drag System

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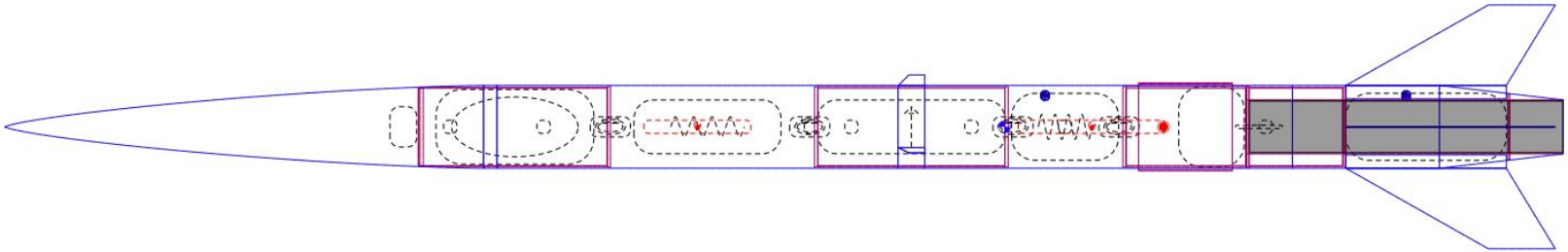
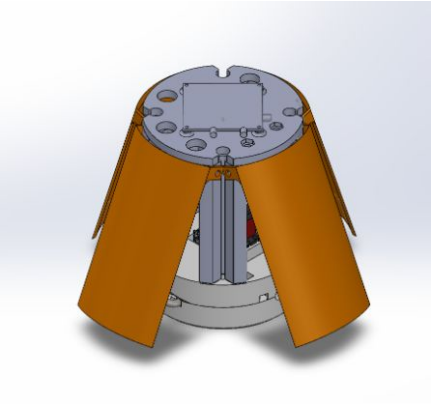
Carbon Fiber Composite Architecture

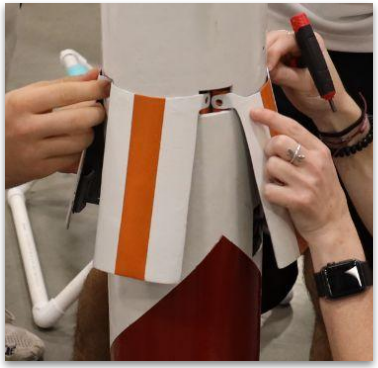
- Goal of maximizing in-house manufacturing capabilities of carbon fiber composites
- Current SRAD composite components include:
  - 2 carbon fiber airframes
  - Fully carbon fiber thrust structure
- Limited by telemetry restrictions imposed by conductivity of carbon fiber



Active Drag System (ADS) Overview

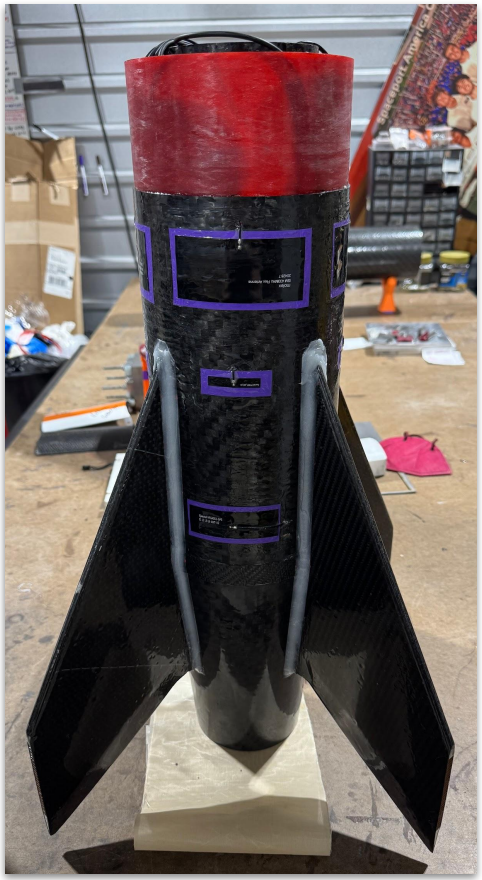
- The Active Drag System (ADS) is our team's solution to the IREC Altitude Accuracy Challenge given the often-varying conditions during launch
- For stability, it is mounted as low as possible in the rocket - directly on top of the forward motor bulkhead
- As the only electronics package in the booster, we would like it to transmit telemetry back to us for redundancy
- Carbon-fiber body tubes in booster are conductive, meaning **RF cannot be transmitted through them**



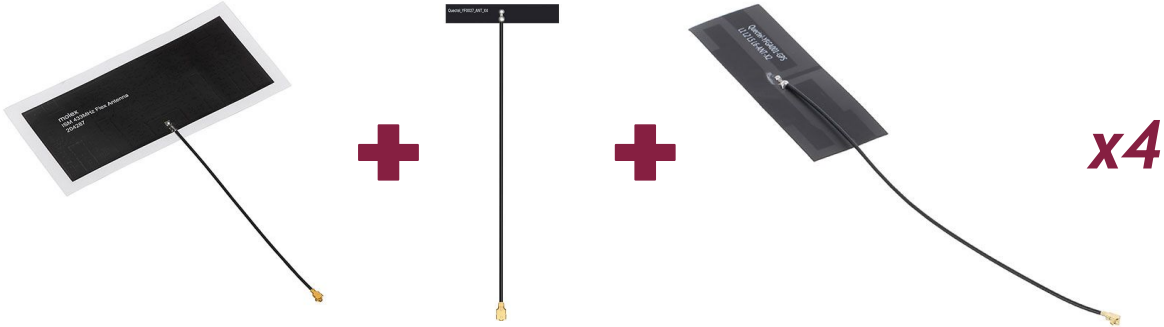


Rocketry at Virginia Tech

Embedded Antenna Architecture



- Rather than using small antennas or adding bulky shrouds to the outside of the airframe, patch antennas are mounted flush around the thrust structure
- Multiple “rings” of 4 antennas each added for several RF bands
  a. 433MHz LoRa (HAM-Band)
  b. 2.4GHz Backup (ISM-band)
  c. Multi-band GPS (~1.1 - 1.7GHz)
- Need best view of the sky for both GPS lock and optimal telemetry reception; having multiple antennas to choose from lets us pick the best ones once the rocket has landed

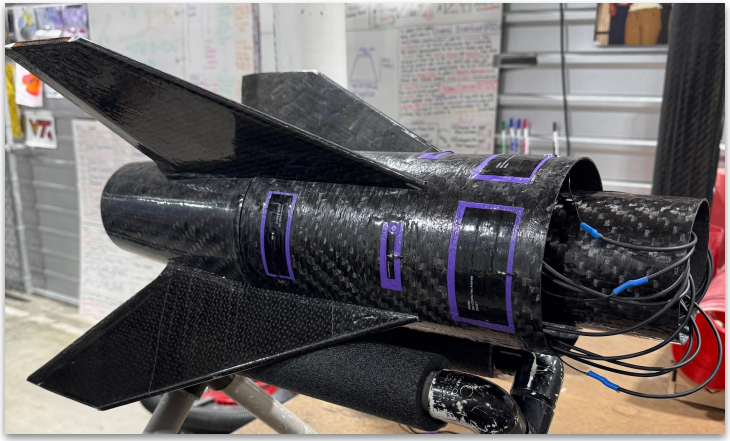


Composite Manufacturing

- Airframe tubes are wrapped around a 6” diameter aluminum mandrel
- Tubes are 3 wraps thick
- Carbon Fiber sheet is wetted with epoxy throughout the wrap
- Tube layup is rotated over a space heater to aid in curing
- The cured tube is sanded and recoated with epoxy to improve surface finish (Post-processing)

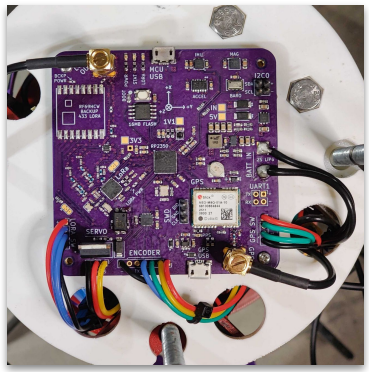
Antenna Integration

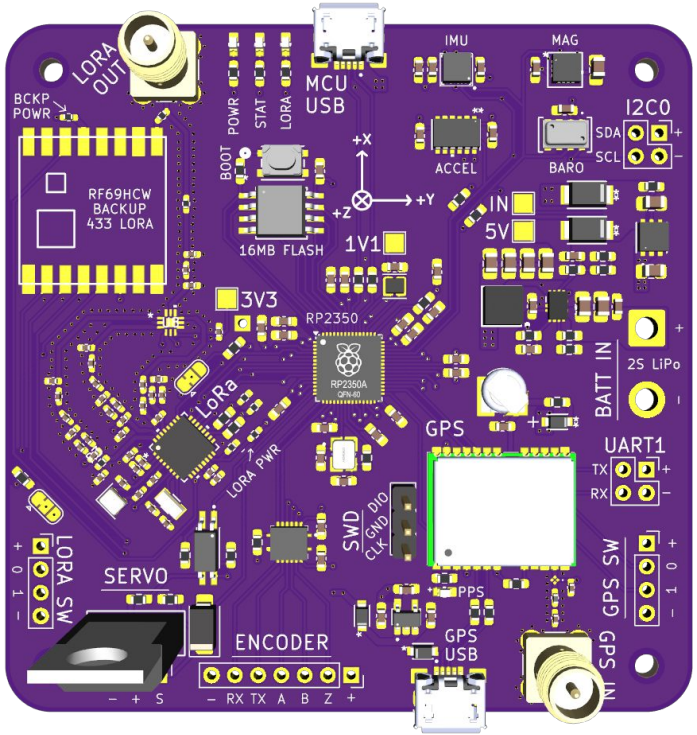
- Patch antennas applied before final layer of epoxy
- Electrical tape base to prevent interference with conductive carbon fiber
- Antenna leads are threaded into through-holes
- Leads are extended using LMR-200 uFL-uFL extensions
- Antenna leads are wired through the thrust structure duing remaining assembly



ADS Control PCB Overview

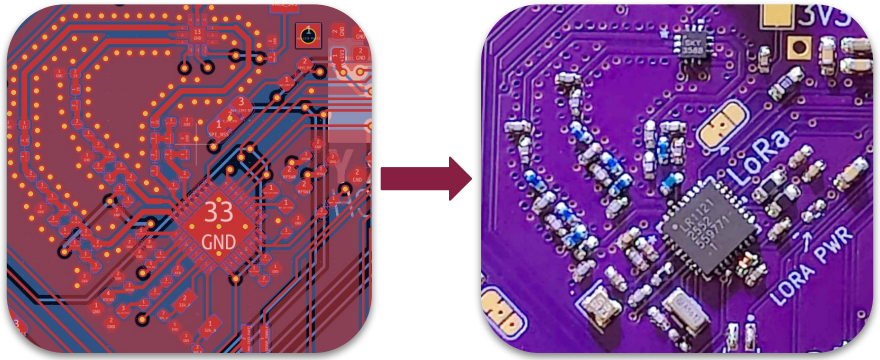
- Based on the RP2350 microcontroller, runs using FreeRTOS utilizing both processor cores
- 16MB of flash memory for flight data logging
- Onboard Barometric Altimeter, Mid-G IMU, High-G Accelerometer, and Magnetometer
- Power/signal isolation and level shifting circuitry for actuator servo and feedback encoder
- **Integrated GPS and LoRa modules** connected to onboard RP-SMA ports

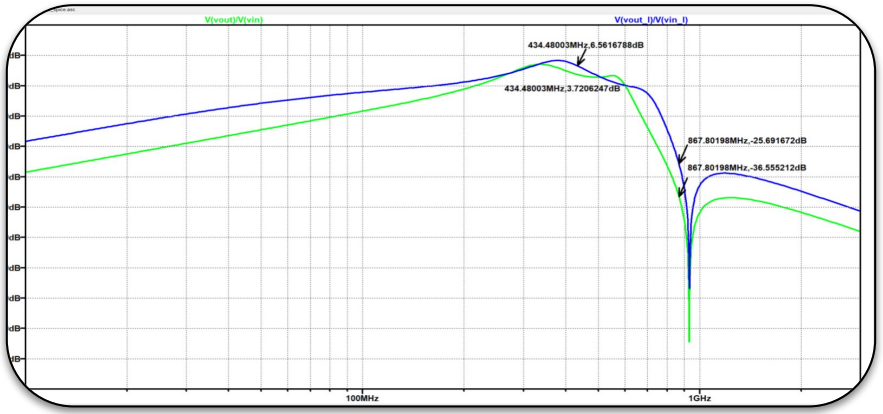




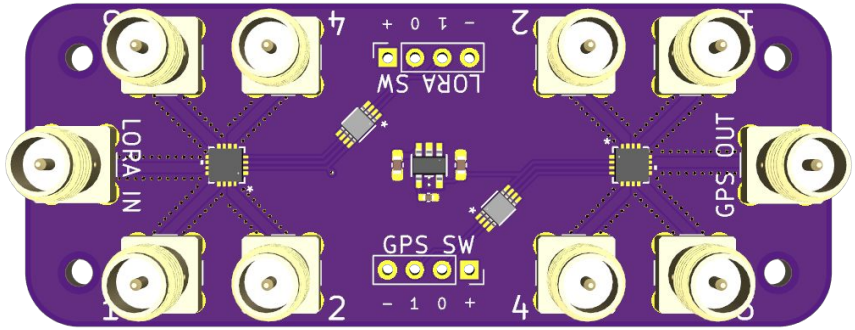
ADS LoRa Design

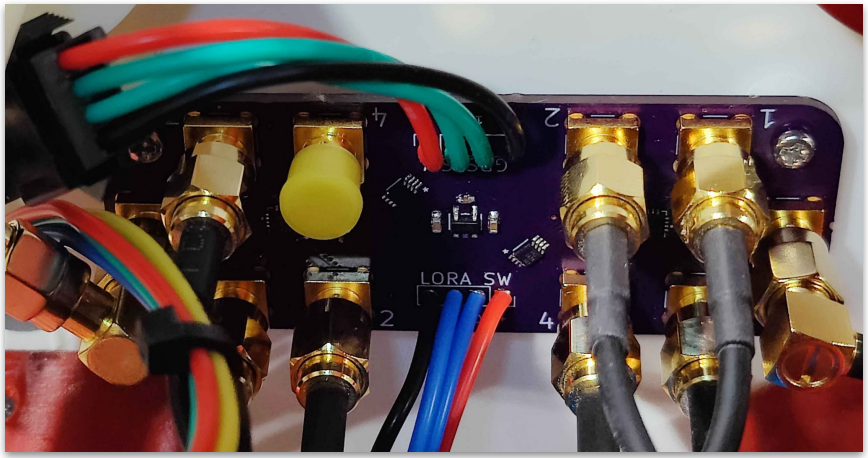
- 915MHz is an unregulated, popular ISM band in North America (congested)
- 433MHz requires a HAM license (less users)
- Frequency has an direct relationship to RF path loss (halving frequency = double transmit distance)
- Onboard transceiver is based on Semtech's LR1121, which supports a sub-GHz band from 150-960MHz at 22dBm (158mW) transmit power
- Requires custom impedance matching and filtering networks to allow maximum output power at 433MHz, while abiding by FCC regulations
- Backup 433MHz LoRa RF transceiver module footprint for redundancy





ADS Switchboard PCB Overview

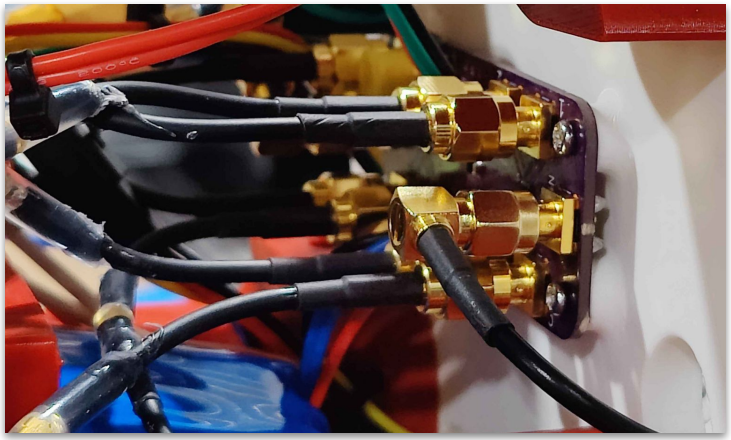


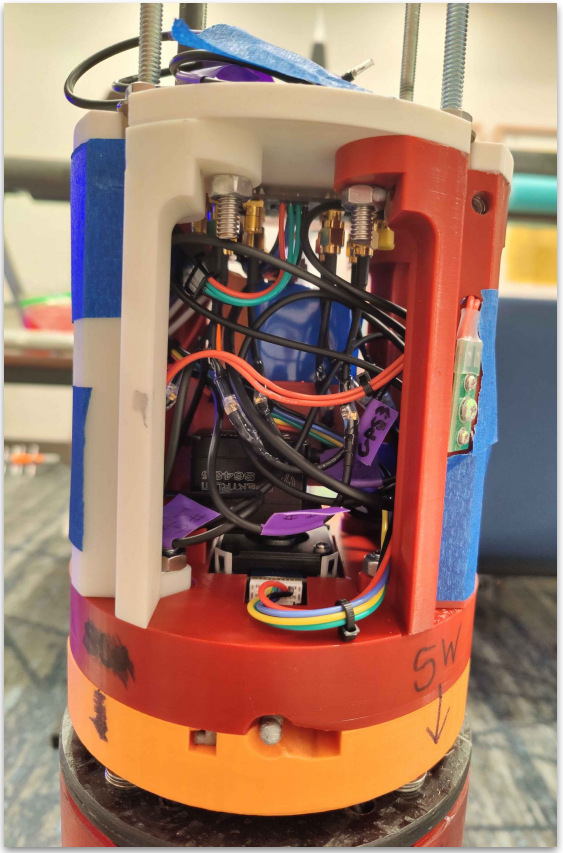


- 2 used bands → 8 total antennas to choose from
- The ADS must be able to actively select its preferred antennas based on orientation
- This was implemented as a separate PCB for ease of testing and reduced form factor
- Control/Switch PCB connection is made by 2 wired tethers between the top/bottom

ADS Integration

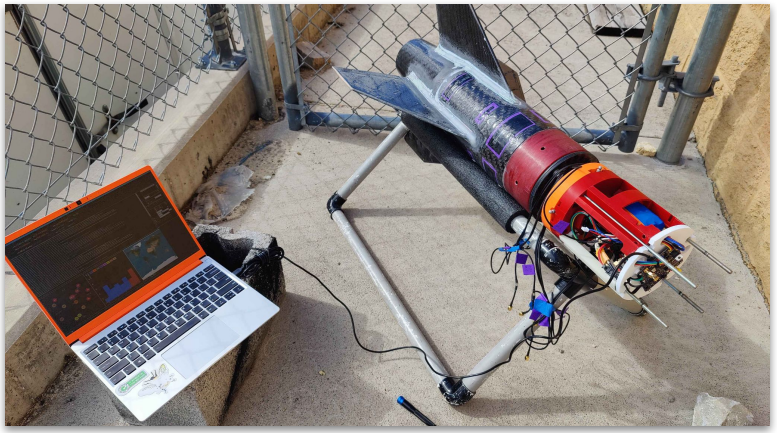
- Once installed, Control and Switchboard PCBs can permanently remain a part of the ADS
- All wiring harnesses can remain installed (i.e. Switchboard harnesses & servo/encoder lines)
- ADS is slid onto threaded rods, and antenna extensions are slid through holes in the bottom of the bracket for installation
- Antenna extensions are labeled by type/number, and are screwed onto corresponding switchboard ports





Antenna/Switchboard Testing

- All antennas were verified with a Vector Network Analyzer (VNA) to ensure proper functionality before final assembly
- VNA was connected *through* switchboard to test RF switch functionality for GPS and LoRa before actual system tests
- GPS was found to have no noticeable performance impact compared to direct connection of antenna to onboard module
- Switchboard was also tested with live switching of antennas during GPS receive/LoRa transmit, no performance impact noted



Questions?