Delaware Atmospheric Plasma Probe Experiment (DAPPEr) – RATS Board

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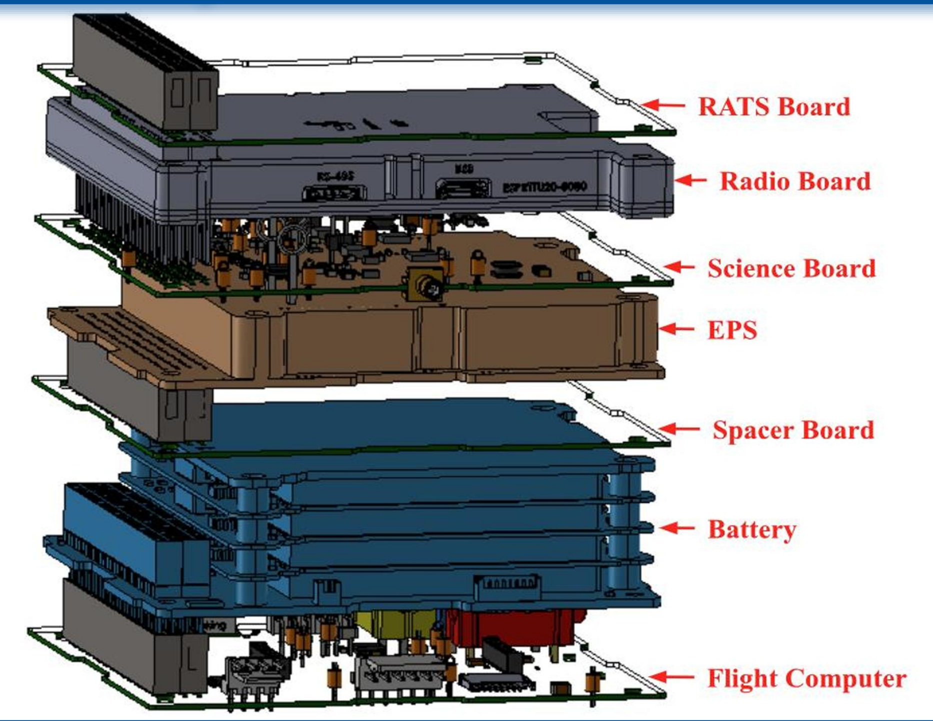
Mission Overview & Need

DAPPEr is a student-led mission following NASA's CubeSat 3U form factor. Approved for launch in NASA's CubeSat Launch Initiative, CLSI, DAPPEr will be the state of Delaware's first orbital spacecraft. DAPPEr will orbit in the F2 layer of the Ionosphere, tracking and mapping out large variations of density based on latitude and mean solar time.

The Relay and Temperature Sensor (RATS) board serves as the "odds and ends" board within the electrical stack. Several isolated, miscellaneous circuits live on RATS, supporting critical functions of the system.

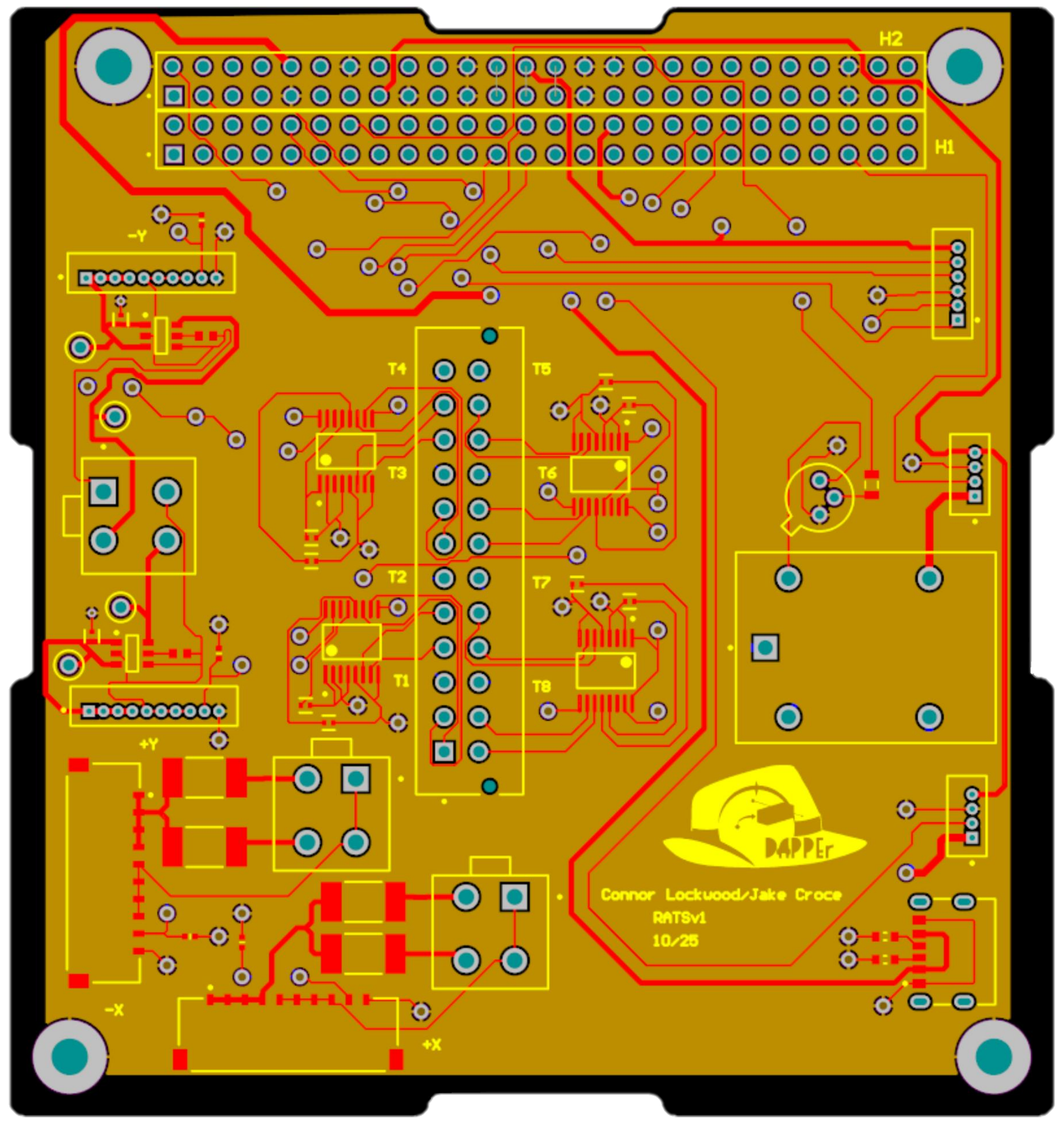
System Architecture

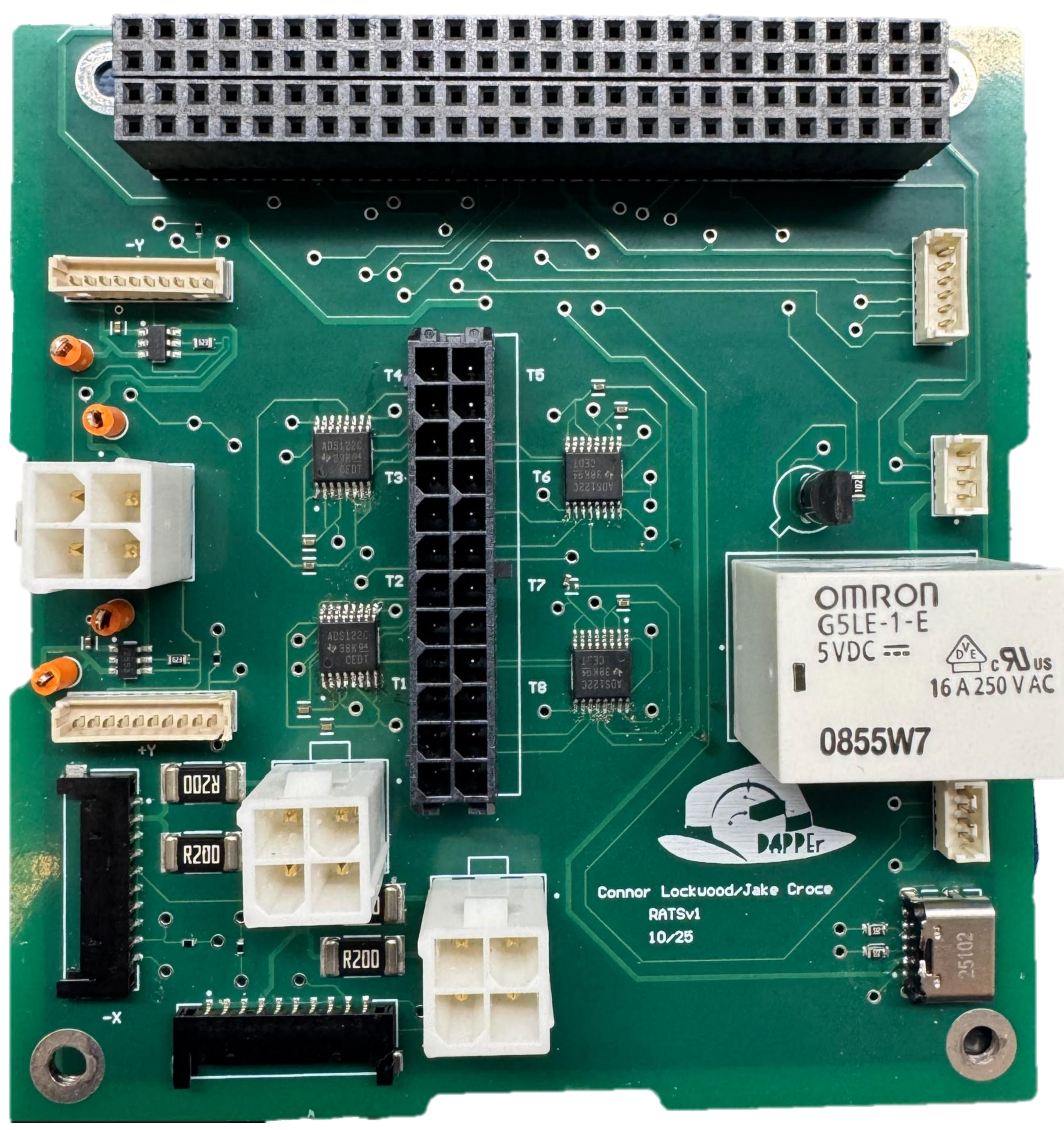


RATS Requirements

- Solar panel current management
  - Current splitting for 3U panels
  - Current limiting for 1.5U panels
- Solar panel photodiode sun sensor interfacing
- Temperature sensor measurements
  - Monitor chassis, solar panels, cameras, and electrical stack temperature
- Boom deployment board burn-wire activation and confirmation
- Antenna system connectivity
- USB-C charging for DAPPEr's battery

RATS Board Design





Subsystem Implementation

- **Solar Panel Interfacing:**
  - Current Management:
    - Clyde Space EPS provides 3 BCRs for 4 EnduroSat solar panels, need to regulate current to handle offset
    - 1.5U panels feed current into TPS2553DBVR Current-Limiting IC with a 62k ohm resistor to limit current going from each panel to port of Sepic BCR to ~480 mA, within maximum of 520 mA
    - 3U panels evenly split current their current into the two ports of their corresponding Buck BCR
  - Photodiode Sun Sensors:
    - Integrated solar panel photodiodes routed to ADC inputs to read sun sensing data used for spacecraft orientation
- **Temperature Sensing:**
  - Implemented 4 ADS122C04 RTD ICs supporting for 12 three-wire PT100 RTD sensors
- **Deployment Board Interaction:**
  - GPIO controlled mechanical relay activates burn wire mechanism on each deployment board using 12V PDM power
  - Provides connectivity for a Hall sensor read through ADC values to confirm deployment of Langmuir probes
- **Antenna Interfacing:**
  - Provides connectivity to EnduroSat UHF Antenna enabling omni-directional transmission over I2C lines and maintaining spacecraft link during non-nominal altitudes
- **Battery Charging:**
  - Implements USB-C charging for the Clyde Space battery routed through a dedicated PC104 header pin, providing external battery charging at an always accessible port

Results & Future Plans

Test Results

- Solar panel current was successfully limited and split through onboard circuitry
- Photodiode sun sensors produced varying ADC values relative to simulated light intensity (2 500W halogen lamps)
- PT100 temperature sensors produced accurate ADC values that were converted to temperature measurements
- Mechanical relay showed inconsistent switching and did not reliably alternate power between deployment board connectors
- Successful I2C read/write communication was established with the antenna system
- USB-C charging circuitry successfully provided accessible external battery charging

Plans for the Future:

- Develop RATSv2 to improve subsystem reliability and flight re
  - Utilize smaller LM19 temperature sensors with wider operating range
  - Replace mechanical relay with a smaller, more reliable alternative
  - Optimize photodiode load resistor to improve range
- Retest functionality for each subsystem
- Continue integrated full stack testing

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