PAWSS

Delta-ISTR

Penn State University
June 11th, 2018
ISTR Presentation Outline

- Section 1: Integrated Subsystem Testing Results
- Section 2: Subsystem Testing Results
- Section 3: Plan for FMSR
- Section 4: Project Schedule
- Section 5: Launch Procedures
- Appendix
  - Section 6: Mission Overview
  - Section 7: Final Design Description
  - Section 8: Project Management Update
  - Partnerships
Where We Left Off Last Time:

- **PAWSS at ISTR** was only able to deliver testing plans, notional performance expectations, and design progress
- **Outstanding deliverables from ISTR:**
  - Subsystem testing results
  - Integrated system testing results
  - Plan of action for integration and further integrated testing
1.0 Integrated Subsystem Testing

Erica Venkatesulu
Integrated Subsystem Testing Status

Full subsystem functionality outstanding for:
- PLP: debugging ops, probe integration
- LIDAR: heat mgmt, detector functionality
- ADS: system design
- Structures: deployment testing and stress analysis
- Power: heat mgmt
1.1 CDH and Lidar

- CDH and Lidar were tested together on June 9th by having CDH communicate to the portion of the Lidar subsystem that will be communicating to CDH (the Teensy microcontroller).
- Lidar was able to properly receive the appropriate signals from CDH, and send data to CDH at the specified sizes and rates.
- Lidar communication to CDH was tested for an hour continuous, with sporadic breaks in the connection to ensure CDH can withstand a break in the data stream, and all communication was successful.

1.2 CDH and TEC

- CDH and TEC SDR were tested together on June 9th by having the TEC SDR send data to CDH and ensuring CDH could handle all the data.
- CDH was observed to be able to handle all the data TEC SDR will send it with some small modifications to the communication between the two (TEC had to slow its rate of sending large data packets).
- TEC still has some internal refining of their system to do, so CDH and TEC will be tested again to ensure none of their changes hurt the communication to CDH.
1.3 CDH and Langmuir Probe

- PLP has been tested in various operating modes to communicate with CDH system; bitrate out overwhelmed buffer, which is a known problem previously faced and resolved on OSIRIS-3U
- Testing completed on Jun 9
- Debugging of system in progress, but due to known nature of bug should be resolved without further issues

1.4 CDH and Power (Power Data)

- CDH and Power were tested together by having the power subsystem send simulated analog data to CDH to ensure CDH is able to read the analog data power will send.
- CDH was able to read the analog data from Power successfully.
1.3 CDH and All Subsystems

- CDH was tested communicating to multiple subsystems at once on June 9th.
- CDH communicated to TEC SDR and Lidar concurrently, as will be happening on the flight.
- CDH was observed to be able to handle communication to multiple subsystems concurrently very successfully.
- CDH is able to communicate to multiple subsystems concurrently, and communication to one subsystem is not hindered by loss of communication to another.
  - This was tested by manually turning off one subsystem, while observing that communication to the other subsystem was still upheld.
- Communication to multiple subsystems was tested for 20 minutes and no failures occurred.
- Although the PLP was not tested concurrently as well, we expect that adding this will not prove any major challenge, as communicating to three subsystems concurrently in our software is functionally the same as communicating to two.
CDH Integration Testing Pictures

CDH and TEC SDR Testing

CDH and Lidar Testing
CDH Integration Testing Pictures

CDH and PLP Testing

CDH and Lidar Simulation
Integrated Subsystem Testing Status

3.0 Power subsystem and each other subsystem

- This will verify that subsystems operate in the same way when using a benchtop power supply or using the regulators on the power board
- Will conduct basic functionality testing as in CDH testing, using power system as power source, individually per subsystem
- Verify that electrical noise from the power system doesn’t interfere with measurements
  - Compare to the data we get from powering from a low-noise source.
- Test will be completed on Jul 7

4.0 Power and all other subsystems simultaneously

- This will verify that the power board can supply power to all other subsystems simultaneously
- Test will be completed on Jul 7
- Ability to complete test is contingent upon completion of above tests
5.0 Power and CDH with all instruments

- This will verify that all instruments operate and can communicate with the flight computer when being powered by the power board
- Test will be completed on Jun 17
- Ability to complete test is contingent upon completion of tests 2.0 and 4.0

6.0 Ensure boxes are ready for integration

- This will verify that the boxes, lids, and boards have been designed and fabricated to work together and fit on the deck
- Test will be completed on Jun 16
- Ability to complete test is contingent upon sending boxes out to be manufactured and receiving them as well as boards being finished
7.0 Install boards in boxes
- This is a step towards finishing mechanical integration
- Verifying system ground is not connected to chassis is necessary for User’s Guide compliance
- This will be completed on Jul 14
- Ability to complete this is contingent on test 5.0 and 6.0 are completed

8.0 Complete test 5.0 with subsystems mechanically integrated
- This will verify that the mechanical integration has not compromised the operation of any of the subsystems
- Test will be completed on Jul 15
- Ability to complete test is contingent upon step 7.0, upon attaching subsystems to the deck, and upon subsystems having a testing procedure that verifies they are operating
  - The testing procedure each subsystem will develop will be used to verify that the outputs of the system are as expected based on a variety of different inputs
Special Requests

• **Attitude Determination in the rocket**
  – What hardware does it include? Will a gyroscope be flown?
  – Latency and resolution of onboard GPS; what coordinates are received? Altitude, Latitude, Longitude?
  – What is the onboard magnetometer resolution?
    • Can we get more details on the system in place?
  – What accuracy do you think can be achieved in measuring pointing from magnetometer readings?

• **System Start-up power timeline questions**
  – When are the parallel lines turned on?
  – When does telemetry begin?
2.0 Subsystem Testing Results
Structures

Carl Smeltz
System Changes Since STR

- Most important action was defining the deployable systems. The boom designs have been updated to be more reliable. Analytical model for velocity calculations created.
- Systems have been advanced to where their positions on deck are certain. Langmuir booms still use a tape measure. TEC booms are purely a thin metal rod for simplicity.
- These changes do not change any mission objectives or requirements.
Design Overview: Deck
Design Overview: Deck
Design Overview: Deployments

Design Overview: Deployments
Design Overview: Deployments

• TEC Deployment. Metal rod is sturdy, length fits into given volume. Less moving parts.
Design Overview: Deployments
Materials List:

- 6061 Aluminum (system and deployable housing)
- Tape Measure
- (x6) 8” Threaded rods
- (x24) Steel lock nuts
- (x12) Female threaded hex standoffs
- (x12) Long spacers
- (x20) 6-32 .5” Steel socket head screws (TEC)
- (x16) 6-32 1” Steel socket head screws (Deployables)
- (x30) 4-40 Screws
- (x4) Solenoids/Linear Actuators
Functional Block Diagram
• CDH has had no significant changes since ISTR
• Quick Status
  – Almost all of the core CDH software has been written and tested. This includes all of the communication and data handling software.
  – CDH daughter board is getting laid out by a professional and is almost ready to be printed.
  – The BeagleBone Black Industrial was vibration tested successfully.
  – CDH has simulated communication with all the subsystems and the telemetry interface; actual communication between CDH and the subsystems needs to be tested.

• The CDH Subsystem is not final.
  – We still need to integrate the BeagleBone and daughter board into the CDH box, and connect all the D-Sub’s and wires.
CDH Photos from Testing
CDH Testing Results

• The results of all of CDH’s testing have been positive.
  – CDH can reliably communicate simultaneously with all of the simulated subsystems using UART and I2C for an extended period of time.
  – The BeagleBone Black Industrial withstood vibration testing at the levels specified in the User Guide Appendix B. Both a sine test and a random test were completed successfully.
Power

Steven Krupa
Power

● Status:
  ○ Schematics captured and PCB is being routed
  ○ Logic circuitry and measurement scheme successfully tested on breadboard
    ■ Inconsistencies and/or poor performance updated in schematic and PCB before board manufacture
  ○ Step-down converters and regulators tested for voltage output
  ○ Enclosure main components machined
Power

Future tasks:
- Complete construction of enclosure
- Thermal tests on high power components (vacuum chamber with controlled load)
- Manufacture and populate PCB
- Verify full system power delivery functionality
  - Thermal tests while under full load
- Calibrate voltage and current readings
- Construct wiring harness for payload
- Develop troubleshooting procedures
Power - Structural status

Drill 32 in CDH, drill 43 and tap 4-40 Power

Hole depth is ~0.6in
Drill 43 and tap 4-40

From Front panel side

Drill with number 43 and tap 4-40
Power - Structural Status
Power Testing results - clock signal

Clock signal

Clock signal rising edge
Power Testing results - Up counter output

LSB Rising edge
Power Testing results - Multiplexer output

Each ‘stair step’ represents a specific reading from the power system. The number of volts per unit for each reading will be measured during the power system calibration.

One sample of power information
Power Testing results - Multiplexer output

Multiplexer edge between input 15 and 0
Total Electron Count (TEC)

- **Quick Status**
  - SDR TEC daughterboard is completed and is being fabricated
  - Analog TEC is operational
  - SDR TEC code is fully operational and is being optimized

- **Subsystem design is final**
  - Code for SDR TEC completed
  - RF splitter network is designed and being fabricated
Total Electron Count (TEC) - Model of subsystem

Analog TEC

SDR TEC
Total Electron Count (TEC) - Power and Data

Power Consumption
- Analog TEC = 28mW (4mA at 7V)
- SDR TEC = 4.54W (915 mA at 5V)
  - Computer = 3.65W (730 mA at 5V)
  - Software Defined Radio = 925mW (185 mA at 5V)

Data Usage
- Analog TEC
  - 4, 10 bit ADC lines at a refresh rate of 250 Hz (2500 baud rate)
- SDR TEC
  - Still being optimized, but at least 400 bytes per collection cycle at 115200 baud
Total Electron Count (TEC) - Mechanical and Electrical Interfaces

**Mechanical Interfaces**
- Will be attached to payload housing using a series of bolts

**Electrical Interfaces**
- **Analog TEC**
  - PWR and to the 4 ADC lines using a single (1) D-SUB connector
  - Connected to matching network via (1) SMA coaxial connection
- **SDR TEC**
  - PWR and CDH via two (2) D-SUB connectors
  - Connected to antenna through matching network via (1) SMA coaxial connection
Total Electron Count (TEC) - Hardware Used

Analog TEC
- Aluminum casing (to be machined)
- Printed circuit boards (on hand)
- Electrical components (on hand)
- D-SUB and Coaxial Connectors (to be ordered)

SDR TEC
- Aluminum casing (to be machined)
- Daughterboard (printing)
- Electrical components (on hand)
- D-SUB and Coaxial Connectors (to be ordered)
Total Electron Count (TEC) - Weight

- **Analog TEC**
  - Casing = 200g
  - Components $\sim$ = 50g
- **SDR TEC**
  - Casing = 200g
  - PCB $\sim$=66 g
  - Raspberry Pi = 42g
- **Total** = 558g
Total Electron Count (TEC) - Analog Test Results/Plans

- Sensitivity found to be -100 dBm
- Width of signal sensitive to is 430 Hz
- Can measure signal strengths up to -40 dBm
Total Electron Count (TEC) - SDR Test
Results/Plans

- Bench tests have been conducted on prototype of the SDR TEC using the new software:
  - Latency has been lowered from above 300ms to about 130ms.
  - Software will continue to be improved on in attempt to bring latency below nominal 70ms.
  - Software was tested running for 90 minutes consistently with a heatsink.
- Once the daughterboard has been assembled the same tests will be conducted on the finished instrument.
Risk Matrix: (TEC)

TEC.RSK.1: Software freezes during data collection
TEC.RSK.2: Interference from other payloads
TEC.RSK.3: Interference from other subsystems
Langmuir Probe

Sebastian Niuman
Langmuir Probe (LP)

● Status:
  ○ Langmuir probe circuit completed and functionality tested
  ○ Low Earth orbit (LEO) chamber ready for probe testing
  ○ Boom deployment length preliminarily defined

● To finalize:
  ○ Define probe sizing with parametric plasma model
  ○ Validation of current reading threshold for probe area
    ■ Theoretically
    ■ Plasma chamber
  ○ Effects of boom length on plasma readings (experimental and modeling, reach goal)
Testing Results

● **Status:**
  ○ Successful Langmuir probe test mode operations with CDH for both simulated fixed constant probe and swept pulsed probe
  ○ Finalizing verification code for plasma probe sizing
  ○ Experiencing packet transmission bugs previously seen on OSIRIS-3U: known factors

● **To finalize:**
  ○ Debug PLP board operations
  ○ Operation testing while connected to Power system

LP test setup for CDH functionality test
Risk Matrix: (LP)

LP.RSK.1: Voltage required for low altitude characterization
LP.RSK.2: Interference from other subsystems
LP.RSK.3: Interference from other subsystems
Lidar

Andrew O’Neill
Lidar

- **Status:**
  - Diodes characterized → finishing optics for collimation
  - Optics design tested
    - Need to vibe and t-vac
  - Detector is being tested and characterized
- **Design is not final**
  - We are finishing collimation optics for diodes and mounting diodes
  - Need to mount everything to the deck
Lidar Structure
Photos from Testing
Lidar Test Results (prior)

- Optics behave as expected
  - we don’t have any formal results, the beam through the lenses is the appropriate shape, size and color
- We can detect pulses from the photodetector
  - need to characterize the recovery time when the detector sees the sun.
    - We can test this by determining the saturation current on the detector, saturating it, and then waiting until it returns to the nominal current draw
    - Without formal testing, it is on the order of ms
    - Past tests weren’t valid. The detector was saturated and we were observing noise. Will be testing in a dark location.
Current Test Results Lidar:

Lidar CDH Test:
- lidar code rewritten, confirmed that lidar teensy can respond to GPIO from BBB
- Tested that the teensy interrupt worked by flipping a switch on the interrupt pin
- Needed to convert the 32 bit int to an unsigned byte array manually in the teensy code to get it so the BBB could receive
- Tested 250 Hz transmission rate for an hour
- Tested starts and stops of transmission by pressing the reset on the Teensy
- Substituted the detector circuit on the interrupt at varying speeds to test limits of what teensy interrupt can detect
  - Detected a minimum of a 20ns pulse
## Risk Matrix: Lidar

<table>
<thead>
<tr>
<th>Possibility</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Transmitted wavelength changes with temperature variation during launch</td>
</tr>
<tr>
<td>Medium</td>
<td>In band interference from auroral, or man-made optical phenomenon</td>
</tr>
<tr>
<td>High</td>
<td>Electrical interference from other payloads</td>
</tr>
<tr>
<td>Very High</td>
<td>Laser diodes are burned out due to an overcurrent event</td>
</tr>
<tr>
<td></td>
<td>Stresses of launch causes misalignment of optics, leading to completely missing the photo detector</td>
</tr>
<tr>
<td></td>
<td>Microcontroller communication to CDH is disrupted due physical disconnection</td>
</tr>
<tr>
<td></td>
<td>Laser diodes are not powered on due to error in triggering timed event; Structural failure of lidar</td>
</tr>
</tbody>
</table>
3.0 Plan for Full Mission Simulation Review (FMSR)

Erica Venkatesulu
Mechanical Testing

• Will complete vibration testing, pre outgassing procedures, and test operations under vacuum with PSU facilities
• Pre outgassing procedures on some lidar components will start in the next week
• Some tests won’t be able to be completed until other steps are completed
• Deployment tests:
  ○ Activate the pin pullers under normal conditions repeatedly to ensure they work as intended
  ○ Vibrate the deployment mechanism and then test again
• Inhibit mechanism is shown in SolidWorks models and will need to be removed with tools
Electrical Testing

- Electrical tests will involve the testing described that will be used while integrating, these tests will be described according to schedule detailed as part of integration plans
- Lidar detector uses high voltage
- **Laser diodes will be on a timed event, and a physical inhibit to block the lasers will be used**
Software Testing

- All code to interface with the other subsystems has been written and unit tested individually. Thus, all software is ready for testing the electrical components of the payload at its various points.
- This testing occurred June 9th with CDH integration with the other subsystems.
- Software inhibits needed will be the ability to run tests without turning on Lidar’s laser diode, and to run any configuration of testing the different instruments.
System Level Testing

- Flow chart at the beginning shows process to work up to system level testing
- Tests that will be conducted at the full system level
  - Sequence-testing: Test of data management, power budgeting, and command of subsystems
  - Environmental testing: Vibration testing at Penn State facilities, thermal testing to fit launch conditions
  - Mission simulations: Performing experimental instrument operations in an integrated system to discover potential interference
- When will these tests be performed?
  - System integration will be completed the 7/15 and system level testing will be performed the week of 8/6
Plan for FMSR

• A schedule for the summer is detailed on future slide
• We think the major hurdles will be getting the instruments done while everyone is gone for the summer, and expect to be able to integrate with the power and CDH systems as planned if the instruments are finished
4.0 Project Schedule

*Erica Venkatesulu*
Project Schedule

• The weekend of July 7th will be used to do integration related to the power subsystem, work on attaching booms to the deck, and complete tests related to any software changes that occur since being previously tested
• The weekend of July 14th will be used to do mechanical integration of instruments
• The week of 8/6 will be used to do any final preparations before going to Wallops, including doing a vibration test of the payload at Penn State
August Operations

- Payload Integration Operations in August:
  - RS-XN GSE: add physical and electrical inhibits to deployables and enable power hook-up with student “power suitcase” or external power supply for preliminary sequence-testing with CDH “umbilical cord” as an output, providing dummy feedback from instruments.
  - Sequence testing with Wallops GSE: use NASA interfaces for all power and telemetry operations, retaining all inhibits, providing dummy feedback from instruments
  - Wallops GPS and RFI testing: RFI not applicable
  - Vibration testing: remove mechanical inhibits sans Lidar optical safety inhibit; retain electrical inhibits on deployable mechanisms
  - Post-vibe sequence testing with Wallops GSE: Replace mechanical inhibits and retain electrical inhibits during sequencing, with dummy feedback for instrument data. Can fully deploy if desired by Wallops team.
5.0 Launch Procedures

Erica Venkatesulu
Please answer and provide details for the following items:

1. What will need to be done with your experiment hardware prior to sequence testing in Norway in January 2019?
   – Enable check out operations
     • Remove inhibits except on deployables
2. How much time will these operations take?
   – Enable check out operations - less than 10 minutes
3. What type of access will you need to your experiment?
   – Inhibits are under the skin and need to be removed with tools
   – Cable must be connected to flight computer to enable check out operations
4. How many people do you expect to send to Norway to support launch?
   – Less than 15
6.0 Mission Overview

Erica Venkatesulu
Mission Overview: Action Items from STR/ISTR

• Develop details on the deployment mechanism further
  – This will be covered in Structures section
Mission Overview: Mission Statement

• The Polar Atmospheric Winter Student Sounding rocket (PAWSS) mission will provide \textit{in situ} atmospheric measurements to be integrated with ground-based measurements to support the investigation of polar mesospheric and lower ionospheric phenomena.
Mission Overview: Success Criteria

Minimum Success Criteria:
– Collect valid data from at least one instrument system.
  – Will prove lidar as viable rocket-borne instrument
  – Confirm SDR TEC is comparable to analog version
  – Langmuir probe data can be correlated with 4D data
  – Data may have scientific utility besides PMWEs

Comprehensive Success Criteria:
– Collect data that furthers understanding of PMWEs.
## Mission Overview: Concept of Operations

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Phase</th>
<th>Description</th>
<th>Challenges</th>
<th>Comments</th>
</tr>
</thead>
</table>
| t-10<--3 mins | Payload initialization | - Ground Support Equipment (GSE) activated power lines become active at PAWSS-specified time  
- Power on flight computer  
- Pause a discrete amount of time in order for power fluctuations stop  
- Primary electronics power on  
- Telemetry is established, system data begins to transmit  
- Initialize basic systems (power, Guidance Navigation and Control (GNC), data handling)  
- Establish available power  
- Establish current and expected power consumption  
- Establish spatial orientation  
- Boot individual sensor systems (Langmuir, TEC, Lidar)  
- Transmit initialization data |  |  |
| t-0 | Launch |  | Vibrations during launch, sudden acceleration |  |
| t+31.7 | End of Maismute Burn |  | Exposure to environment |  |
| t+74 | Aft skirt separation |  |  |  |
| t+80 | Activation of Langmuir Probe | - Timed event 1 activates pin puller to deploy fixed bias Langmuir probe boom  
- Timed event 2 activates pin puller to deploy swept bias Langmuir probe boom  
- Data is transmitted at specified rate to flight computer via UART  
- Data collection and transmission continues until power shut off |  |  |
| t+80 | Activation of TEC system | - Timed event 3 activates pin pullers to deploy TEC antenna  
- Search for ground station transmission  
- SSDR TEC collects data at 100 Hz and data is transmitted to flight computer via UART  
- Analog TEC data is transmitted to analog lines on telemetry connector  
- Data collection and transmission continues until power shut off |  |  |
| t+84 | Activation of lidar laser diodes | - Redundant timed event gives power to lidar laser diodes  
- Beagle bone gives signal to lidar microcontroller to enable laser diodes  
- Data is collected at 250 Hz  
- Data is transmitted to flight computer via UART  
- Data collection and transmission continues until power shut off | Applies to all three instruments:  
If instrument appears to not be collecting data properly, there can be different consequences decided on based on how tight the power budget it. The duty cycle can be decreased different amounts for the remainder of the duration of the flight, decreased only outside of the region of interest, or no changes can be implemented at all.  
The nature of how each of the instruments operates is cyclic, which is not fully conveyed in the bulleted format. When the con ops is converted to a flow chart format, this cyclical nature should be made apparent. | Systems may become confused by sudden changes in force and orientation |
| t+217.9 | Apogee |  |  |  |
| t+43 | Power Shutoff | - Power to payload is cut off |  |  |
| t+457.2 | Splashdown |  |  |  |
### RS-XN 2019 Mission Timeline (1st Draft)

<table>
<thead>
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<th>Event</th>
<th>Time (sec)</th>
<th>2 sigma Low Altitude (km)</th>
<th>Nominal Altitude (km)</th>
<th>2 sigma High Altitude (km)</th>
<th>Nominal Range (km)</th>
<th>Velocity (m/s)</th>
<th>Nominal Q (psf)</th>
<th>Mach NO.</th>
<th>Flight Elevation (deg)</th>
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<td>0.1</td>
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<td>1.7</td>
<td>1.7</td>
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<td>588.7</td>
<td>3763.1</td>
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<td>Imp. Malemute Ignition</td>
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<td>UNH: TE-3 Launch Trigger</td>
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<td>UNH: TE-R Redundant Launch Trigger</td>
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<td>15.9</td>
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<td>Imp. Malemute Burnout</td>
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<td>JAXA: TE-2 MED HVPS Ramp Up</td>
<td>55.0</td>
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<td>Apogee, Nominal</td>
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<td>181.2</td>
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<td>Apogee, 2s High</td>
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<td>-</td>
<td>165.4</td>
<td>177.0</td>
<td>401.4</td>
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<td>-87.6</td>
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Payload Location

- Confirmed (these are revised mounting locations shared previously)
## Mission Overview: Timed Events

<table>
<thead>
<tr>
<th>Event</th>
<th>Time On</th>
<th>Dwell</th>
<th>Event Description</th>
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</thead>
<tbody>
<tr>
<td>GSE 1</td>
<td>T-300 sec</td>
<td>660 sec</td>
<td>Supply power subsystem for distribution to other subsystems.</td>
</tr>
<tr>
<td>GSE 2</td>
<td>T-300 sec</td>
<td>660 sec</td>
<td>Redundant. See above.</td>
</tr>
<tr>
<td>TE-1</td>
<td>T+84 sec</td>
<td>246 sec</td>
<td>Both lines will supply the Lidar System's laser diodes</td>
</tr>
<tr>
<td>TE-2</td>
<td>T+80 sec</td>
<td>3 sec</td>
<td>Activate Langmuir Probe boom #1 deployment pin puller</td>
</tr>
<tr>
<td>TE-3</td>
<td>T+80 sec</td>
<td>3 sec</td>
<td>Activate Langmuir Probe boom #2 deployment pin puller</td>
</tr>
<tr>
<td>TE-R</td>
<td>T+80 sec</td>
<td>3 sec</td>
<td>Activate TEC System antenna #1 and #2 deployment pin puller</td>
</tr>
</tbody>
</table>
7.0 Final Design Description

Erica Venkatesulu, Carl Smeltz, Matthew Miller
System Changes Since STR

• Lidar changed from parabolic mirrors to telescope and lidar system moved to bottom side of deck
  – Moved to bottom for space accommodation
## Detailed Weight Budget

<table>
<thead>
<tr>
<th>Component</th>
<th>Tolerance (%)</th>
<th>Mass w/ tolerance (lb)</th>
<th>Percentage of Mass (%)</th>
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</thead>
<tbody>
<tr>
<td>CDH &amp; Power</td>
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<td>3.34</td>
<td>10.8</td>
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<td>Lidar</td>
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<td>1.12</td>
<td>3.62</td>
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<td>Deployments (Langmuir/TEC/ pin pullers)</td>
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<td>0.904</td>
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<td>Lead</td>
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<td>Copper</td>
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<td>5</td>
<td>16.2</td>
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<td>Deck</td>
<td>--</td>
<td>6061 Aluminum</td>
<td>3.29</td>
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<td><strong>Total Mass</strong></td>
<td></td>
<td><strong>Over</strong></td>
<td><strong>30.91 lb</strong></td>
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<td></td>
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<td><strong>0.91 lb</strong></td>
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</table>
Hazardous Mechanical Items:

- **Structures**
  - Deployment mechanisms
    - Energy stored in folded metal booms (tape measure-esque)
    - Contained within closed boxes (1 for each of Langmuir booms)
    - Rapid deployment
    - Boxes each have a single spring-loaded door
    - Effect on CG and MOI negligible
# Subsystem Design: Detailed Power Budget

## Penn State University - Power Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage (V)</th>
<th>Max Subsystem Current (A)</th>
<th>Max Battery Current (A)</th>
<th>Start Time (min)</th>
<th>Time On (min)</th>
<th>Watts</th>
<th>Ah</th>
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<tr>
<td>Lidar</td>
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<td>0</td>
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<td>1.25</td>
<td>0.004</td>
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<td>Detector bias</td>
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<td>0.09</td>
<td>0</td>
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## Total

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| GSE Current Max (A):     | 0.832357143 | TE Current Max (Burn Wires and Lidar Diodes) (A): | 3 | # of Flights Margin | 6.0 |
## Pin Assignments: Power

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<th>Power Pin</th>
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<th>Intended Use</th>
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<td>1</td>
<td>GSE 1</td>
<td>Connect to power subsystem to supply all subsystems with operating power.</td>
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<tr>
<td>2</td>
<td>Timer Event Redundant (TE-RA)</td>
<td>Operation of Lidar laser diodes</td>
</tr>
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<td>Timer Event Redundant (TE-RB)</td>
<td>See above</td>
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<td>GSE 2</td>
<td>Redundant subsystem supply line</td>
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<td>Timer Event 2 (TE-2)</td>
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<td>13</td>
<td>GND</td>
<td>Payload power common ground</td>
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Pin Assignments: Telemetry

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<td>Parallel Bit 16 (LSB)</td>
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<td>32</td>
<td>RS-232 Data (TP1)</td>
<td>Lidar, Langmuir #1, Langmuir #2, TEC SDR, and Attitude Data</td>
</tr>
<tr>
<td>33</td>
<td>RS-232 GND (TP2)</td>
<td>RS-232 Circuit Ground</td>
</tr>
<tr>
<td>34</td>
<td>N/C</td>
<td>N/C</td>
</tr>
<tr>
<td>35</td>
<td>N/C</td>
<td>N/C</td>
</tr>
<tr>
<td>36</td>
<td>Ground</td>
<td>Payload signal common ground</td>
</tr>
<tr>
<td>37</td>
<td>Ground</td>
<td>Payload signal common ground</td>
</tr>
</tbody>
</table>
Hazardous Electrical Items:

- Lidar will use 4 1.6W lasers
- TEC will receive a radio signal from the ground
CDH Software Design:

- CDH software will be written in C++ using C++ 11 standards. The software shall use some object-oriented design, as well as multiple threads to facilitate in concurrent data collection and transmission, as well as to maximize efficiency.
- The high level design of CDH software is as follows:
CDH Software Design:

- The CDH software flow diagram is as follows:
8.0 Project Management Update
Erica Venkatesulu
## User Guide Compliance: Summary

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center of gravity in 1&quot; plane of plate?</td>
<td>YES (CAD model)</td>
</tr>
<tr>
<td>Weight 30.0+/ - 1.0 (15.0 +/- 0.5) lbs.?</td>
<td>YES (Mass budget)</td>
</tr>
<tr>
<td>Max Height &lt; 10.75&quot; (5.13&quot;)</td>
<td>YES</td>
</tr>
<tr>
<td>Bottom of deck has flush mount hardware?</td>
<td>N/A, Bottom-mid mount used</td>
</tr>
<tr>
<td>Within Keep-Out Zone</td>
<td>YES (SolidWorks model)</td>
</tr>
<tr>
<td>Using &lt; 10 A/D Lines</td>
<td>YES, using 4</td>
</tr>
<tr>
<td>Using/Understand Parallel Line</td>
<td>YES</td>
</tr>
<tr>
<td>Using/Understand Asynchronous Line</td>
<td>YES, at 76800 baud</td>
</tr>
<tr>
<td>Using X GSE Line(s)</td>
<td>YES, GSE-1, GSE-2</td>
</tr>
<tr>
<td>Using X Non-Redundant PWR Lines (TE-1, TE-2, TE-3)</td>
<td>YES, TE-1, TE-2, TE-3</td>
</tr>
<tr>
<td>Using X Redundant Power Lines (TE-R)</td>
<td>YES</td>
</tr>
<tr>
<td>Using &lt; 1 Ah</td>
<td>YES (Power budget)</td>
</tr>
<tr>
<td>Using &lt;= 28 V</td>
<td>YES</td>
</tr>
<tr>
<td>Using RF (If yes, list frequency and TX Power)</td>
<td>NO, but receiving signal from ground of 1.3 MHz, 2.2 MHz, 3.883 MHz, 7.835 MHz (is it more apt to say measure signal strength of...?)</td>
</tr>
<tr>
<td>Using deployable?</td>
<td>YES</td>
</tr>
<tr>
<td>Whole team consists of US Persons</td>
<td>NO</td>
</tr>
<tr>
<td>Using ITAR and/or Export Controlled hardware</td>
<td>NO</td>
</tr>
</tbody>
</table>
PMP: Organizational Chart
PMP: Team Picture
PMP: Management

• Monetary budget
  – Launch fee: N/A
  – Travel: Domestic - $12k
  – Travel: International - $20k
  – Hardware: $10k
  – Deposit status: N/A
# PMP: Latest Contact Matrix

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
<th>Day Phone</th>
<th>Cell Phone</th>
<th>Receive Texts</th>
<th>Email</th>
<th>Citizenship</th>
<th>Add to mailing list?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Manager</td>
<td>Stephen Porter</td>
<td>412-226-1656</td>
<td></td>
<td>Yes</td>
<td><a href="mailto:sjp5556@psu.edu">sjp5556@psu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Manager</td>
<td>Erica Venkatesulu</td>
<td>215-808-5008</td>
<td></td>
<td>Yes</td>
<td><a href="mailto:evv5064@psu.edu">evv5064@psu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Principal Investigator</td>
<td>Prof. Tim Wheeler</td>
<td>814-863-5403</td>
<td></td>
<td></td>
<td><a href="mailto:G-Chaser@psu.edu">G-Chaser@psu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Principal Investigator</td>
<td>Dr. Sven Bilien</td>
<td>814-863-1526</td>
<td></td>
<td></td>
<td><a href="mailto:SBilen@engr.psu.edu">SBilen@engr.psu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Principal Investigator</td>
<td>Dr. Tim Kane</td>
<td>814-863-8727</td>
<td></td>
<td></td>
<td><a href="mailto:tjk7@psu.edu">tjk7@psu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Systems Engineer</td>
<td>Sean Hixon</td>
<td>412-315-7236</td>
<td></td>
<td>Yes</td>
<td><a href="mailto:swh5534@psu.edu">swh5534@psu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Science - Lead</td>
<td>Al Guerra</td>
<td>954-592-3432</td>
<td></td>
<td>Yes</td>
<td><a href="mailto:alvaro@psu.edu">alvaro@psu.edu</a></td>
<td>US</td>
<td>Yes</td>
</tr>
<tr>
<td>Lidar - Lead</td>
<td>Andrew O’Neill</td>
<td>610-880-1070</td>
<td></td>
<td>Yes</td>
<td><a href="mailto:ajo5182@psu.edu">ajo5182@psu.edu</a></td>
<td>US</td>
<td>Yes</td>
</tr>
<tr>
<td>TEC - Lead</td>
<td>Scott Foley</td>
<td>570-688-7011</td>
<td></td>
<td>Yes</td>
<td><a href="mailto:sfa5411@psu.edu">sfa5411@psu.edu</a></td>
<td>U.S.</td>
<td>yYes</td>
</tr>
<tr>
<td>TEC - Lead</td>
<td>Rob Martin</td>
<td>570-690-4475</td>
<td>570-690-475</td>
<td>Yes</td>
<td><a href="mailto:rfm5313@psu.edu">rfm5313@psu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Langmuir - Lead</td>
<td>Sebastian Numan</td>
<td>786-208-2160</td>
<td></td>
<td>Yes</td>
<td><a href="mailto:sjn5202@psu.edu">sjn5202@psu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>4D - Lead</td>
<td>Jeremy Mysliwiec</td>
<td>610-858-3512</td>
<td></td>
<td>Yes</td>
<td><a href="mailto:jnmysliwiec@gmail.com">jnmysliwiec@gmail.com</a></td>
<td>US</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Emma Koller</td>
<td>484-252-6300</td>
<td></td>
<td>Yes</td>
<td><a href="mailto:ejk5348@psu.edu">ejk5348@psu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Power - Lead</td>
<td>Steven Krupa</td>
<td></td>
<td></td>
<td></td>
<td><a href="mailto:svk58866@psu.edu">svk58866@psu.edu</a></td>
<td>US</td>
<td></td>
</tr>
<tr>
<td>Command and Data Handling - Lead</td>
<td>Matt Miller</td>
<td>315-414-7719</td>
<td></td>
<td>Yes</td>
<td><a href="mailto:mdm5857@psu.edu">mdm5857@psu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Attitude Determination - Lead</td>
<td>Nick Smith</td>
<td>610-733-6953</td>
<td></td>
<td>Yes</td>
<td><a href="mailto:njs5393@psu.edu">njs5393@psu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Structures - Lead</td>
<td>Carl Smeltz</td>
<td></td>
<td></td>
<td></td>
<td><a href="mailto:csmeltz@gmail.com">csmeltz@gmail.com</a></td>
<td>US</td>
<td></td>
</tr>
</tbody>
</table>
Worries and Concerns

• Conducting sufficient testing of the deployment system to be confident in its operation.
  – Prototyping is ongoing and testing is of primary concern.

• Collecting useful attitude data.

• Members of the team being scattered throughout the summer will make progress more difficult
Conclusion

• Significant tangible progress made in all areas. We are still behind, but will be ready to fly.
System Overview: Description of Partnerships

• University of Oslo
  • Constructing 4D “hockey puck” system.
  • PAWSS will assist with antenna analysis
• Dr. Martin Friedrich – University of Graz
  – Original developer of TEC System
  – Wants analog technology to be updated
• Doug Rowland – NASA
  – Team visited NASA in early November
  – Dr. Rowland visited PSU in February
  – Team is visited VISIONS-2 integration to prepare for our own