OIT- Portland Metro
Subsystem Testing Review

Jean-Luce Nabors
Mark Johnston
Caleb Ives
Thomas Pearce
Austin Hinman
Krystal Cruz
Steven Reeves
Jack Thomas

02/13/2018
Presentation Outline

• Section 1: Mission Overview
• Section 2: Final Design Description
• Section 3: Hardware Procurement Status
• Section 4: Subsystem Testing Results
• Section 5: Integrated Subsystem Testing Plan
• Section 6: Project Management Update
• Section 7: User Guide Compliance
1.0 Mission Overview

Austin Hinman
Steven Reeves
Mission Overview

• **Oregon Tech Rocksat-C 2018**
  
  - The primary mission is to design a complex, multi-experiment payload emulating (downscaled) the methodology of a satellite or other space vehicle.
  
  - Four main experiments include radiation shielding testing, laser based gyroscope, unified C³ system, and a plug & play modular system.
  
  - Mission success will be defined as such that all four primary systems must function and collect data, with a secondary goal of 100% functionality of all modular payloads.
  
  - Our results will included the effectiveness of non-standard radiation shielding, performance data on the gyroscope system, performance characteristics of the unified data management system, and discrete data from the five modular payloads. Data will be used to design better systems for space applications.
Concept of Operations

• The main project and subsystems will begin collecting data at launch.
  – Special altitudes of interest include 50 km and above, as this is where radiation will change the most. Subsystems areas of interest will differ.
  – Main project and data management system will run until power loss or retrieval
Concept of Operations Overview:

Launch
- G switch triggered
- Main project on
- Begin data collection/ data management

Launch
- G switch triggered
- Main project on
- Begin data collection/ data management

End of Orion Burn
- Radiation levels change
  t ≈ 0.6 min
  Altitude: 52 km

Apogee
  t ≈ 2.8 min
  - Main project collects radiation data
  Altitude: ≈115 km

High Tumble Rate
  - Main project collects radiation data
  t ≈ 4.0 min
  Altitude: 95 km

Low N2, Low spin
  t ≈ 5.5 min
  Chute Deploys

Splash Down
  t ≈ 15 min
  - Main project stays on

t = 0 min

RockSat-C 2018
STR
2.0 Final Design Description

Name of Presenter(s)
Changes from CDR

• Changes since the CDR include how the radiation shielding will be measured. This coming Tuesday 02/13/18 testing will be done at Reed college on a FPGA, Geiger Counters, and a photo sensor. These tests will give us a better idea of how radiation will affect certain materials.
Changes from CDR

• FPGA: Hardware Coded to turn on an LED for every time radiation hit occurs.
• Geiger Counter: Verify the durability of the counting mechanism used in prior years, incase the FPGA fails.
• Photo sensor: Detecting radiation particles
Functional Block Diagram
Functional Block Diagram
Functional Block Diagram
## EPS Design: Power Budget

<table>
<thead>
<tr>
<th>Power Delivery System</th>
<th>MAX POWER(mA)</th>
<th>Power System Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>OptoRelay</td>
<td>25mA*2</td>
<td>50 3A delivery from single channel</td>
</tr>
<tr>
<td>Indicator lights</td>
<td>20mA*3</td>
<td>60 3.4Ah capacity from single battery pack</td>
</tr>
</tbody>
</table>

### Radiation Payload

- **800**
  - 1 FPGA
  - 8 srRam chips 80mA*8

### Data Collection

- **300**
  - 2 Raspberry Pi zeros 150mAh * 2

### Harvester

- **80**
  - Arduino Mega Equivalent
  - External Sensors

### Additional Modular Payload Power

- **600**
  - Modular power budget 150mA*4

### FOG

- **80**
  - Arduino Mega Equivalent
  - Laser Diode With Regulator
  - External Sensors

<table>
<thead>
<tr>
<th>Total Estimated max current draw (mA)</th>
<th>2790</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current source capability (mA)</td>
<td>3000</td>
</tr>
</tbody>
</table>

- Power system has been designed with far more capacity than required so payload can be tested without recharging battery, and future OIT teams have extra power budget for future expansion.
- An extra 600mA (Additional Modular Payload Power) is reserved for projects that join later in the year.
- Power draw estimates are max possible current draw each element could require.
EPS Design: PCB

- The power distribution board will control the enabling of power based on the Wallops switch and G Switch. It will also prevent overdischarge of the batteries by using the threshold voltage of the optical relays.
- The board is single sided and entirely populated with through-hole components for ease of repair and reuse in future years.
- The circuit is a modified version of the RockOn circuit that has been duplicated to provide redundancy. Multiple failures have to occur to prevent the payload from being powered.
- G-Switch activation will activate entire board at time of launch. No early activation has been requested.
EPS Design: PCB
A total of 4 Panasonic NCR18650B batteries will be used. The batteries will be purchased with individual protection circuits attached. The batteries will be formed into 2 nickel tab welded packs with a protective shrink wrap shell, each providing 7.4V 3400mAh.
Hazardous Electrical Items

• Batteries
## Mechanical Design

### TOP TRAY

<table>
<thead>
<tr>
<th>Components</th>
<th>Dimensions</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raspberry Pi</td>
<td>3.4&quot; x 2.3&quot; x 0.8&quot;</td>
<td>2</td>
</tr>
<tr>
<td>SRAAM</td>
<td>Unknown</td>
<td>8</td>
</tr>
<tr>
<td>FPGA</td>
<td>0.4&quot; x 0.3&quot; x 0.2&quot;</td>
<td>1</td>
</tr>
</tbody>
</table>

### THIRD TRAY

<table>
<thead>
<tr>
<th>Components</th>
<th>Dimensions</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiber</td>
<td>3.9&quot; x 4.3&quot;</td>
<td>1</td>
</tr>
<tr>
<td>Primitive Laser Black Box</td>
<td>2.2&quot; x 1.8&quot; x 0.5&quot;</td>
<td>1</td>
</tr>
<tr>
<td>Arduino Nano</td>
<td>1.7&quot; x 0.7&quot; x 0.2&quot;</td>
<td>1</td>
</tr>
<tr>
<td>Micro SD Card Reader</td>
<td>1.6&quot; x 0.9&quot; x 0.2&quot;</td>
<td>1</td>
</tr>
</tbody>
</table>

### SECOND TRAY

<table>
<thead>
<tr>
<th>Components</th>
<th>Dimensions</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload Modules</td>
<td>3.5&quot; x 2.3&quot; x 2.3&quot;</td>
<td>3</td>
</tr>
</tbody>
</table>

### FIRST TRAY

<table>
<thead>
<tr>
<th>Components</th>
<th>Dimensions</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery</td>
<td>3.5&quot; x 2&quot; x 1.5&quot;</td>
<td>2</td>
</tr>
<tr>
<td>Payload Modules</td>
<td>3.5&quot; x 2.3&quot; x 2.3&quot;</td>
<td>2</td>
</tr>
</tbody>
</table>
Revised Second Tray
Mechanical Assembly
Polycarbonate Disks

MATERIAL: \( \frac{3}{4} \)" LEXAN

\( \varnothing 9.25 \)

\( \varnothing 7.00 \)

\( \varnothing 2.275 \)

\( \varnothing 1.91 \)

\( R.666 \)

\( 8^\circ \)

\( 45^\circ \)
Aluminum Collars
Central Conduit (Schedule 80 ABS Pipe)
Payload Modules

Dimensions:
- R0.19in
- R14in
- 0.85in
- 0.66in
- 45°
- 3.88in
- Ø0.17in
- 2.35in
- 0.3in
- 3.53in
- Ø0.22in
- 1.26in
- 2.25in
- 2.37in
- 0.14in

RockSat-C 2018
STR
Payload Doors
See Appendix For:

- Bottom Standoff
- Payload Trays 1 & 2 Struts
- Payload Tray 3 Strut
- Top Payload Tray Standoff
Materials Used

Collars, Struts, Standoffs  Aluminum
Payload Disks  Polycarbonate
Payload Modules  PLA/ABS
Heat Sets  Brass
Fasteners  Steel
## Mass Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Weight (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Harvester</td>
<td>0.12</td>
</tr>
<tr>
<td>Fiber Optic Gyroscope</td>
<td>1.00</td>
</tr>
<tr>
<td>Mechanical Structure</td>
<td>12.80</td>
</tr>
<tr>
<td>Power Supply</td>
<td>1.61</td>
</tr>
<tr>
<td>Radiation Sensor</td>
<td>0.04</td>
</tr>
<tr>
<td>Available for Ballast</td>
<td>4.43</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20.000</strong></td>
</tr>
</tbody>
</table>
Software Design

• Data Management System (DMS)
  – This system is designed with two Raspberry Pi Zeros, as to reduce chance of failure
  – The system is to record all the data from each experiment to SD cards, maintain communication between the Pis/experiments, and maintain stability
  – If one experiment is to fail, a reset command will be sent from the pi system.

• Data Interpreter
  – UI to interpret .csv files from SD card (capstone requirement)
Software Flow Diagram

G-Switch Activation → Power-up

Initialization of: Functions, logEntry Arrays, variables → Connection to main and modular experiments

Standby for Data

D1 - Connected?
- yes → 
  - D2 - Message from COM1
    - yes → Read Timestamp
      - Save in logEntry Array
      - Read RAM index
        - Save in logEntry Array
    - yes → Read Data
      - Save in logEntry Array
      - Write logEntry contents to SD card
  - no → D2

D2 - Connected?
- yes → Read Timestamp
  - Save in logEntry Array
  - Read Data
    - Save in logEntry Array
  - Write logEntry contents to SD card
- no → D3

D3 - Message from COM2
- yes → Read Timestamp
  - Save in logEntry Array
  - Read Data
    - Save in logEntry Array
    - Write logEntry contents to SD card
- no → D4

D4 - Message from COM3
- yes → Read Timestamp
  - Save in logEntry Array
  - Read Data
    - Save in logEntry Array
    - Write logEntry contents to SD card
- no → D4
De-Scopes and Off-Ramps

- If budget does not allow for eight shielding samples, we can reduce to four and proceed with the best/cost effective designs.
- Modular system could use a single central data collection to be processed after the flight.
De-Scopes and Off-Ramps (Software)

- Use one Pi
  - Remove redundancy of two and ability to reset one another
- Modular experiment fails (sends no data)
  - Keep COM line open and send reset command
- Pi fails
  - Send restart to failed Pi
De-Scopes and Off-Ramps: (FOG)

- If unable to stabilize laser temperature:
  - Measure laser temperature and record to calculate out errors.
- Could be downgraded to tumbler style sensor for rotational performance tracking
3.0 Hardware Procurement Status

Jean-Luce Nabors
Krystal Cruz
Steven Reeves
Mechanical Elements

Completed:
Support Collars
Fasteners

In Progress:
Payload Disks
Struts
Payload Modules
Central Shaft
Electrical Elements

What has been manufactured/soldered?
No system has been manufactured or soldered at this point.

What still needs to be manufactured/soldered?
- Fiber Optic Gyroscope
- Power Delivery System
- Relay Banks (primary, secondary)
- Modular Ray
- Optical Port and System Activation Read out
- Vibration and Gravitational Force Energy Harvester

PCB revision status?
In development. Power supply system has been designed and will be soon transferred to PCB.

What electrical components are in house?
- Rectifier diode (low current)
- Relay SSR
- Diode Shottky
- Switch Snap Action
- Conn. Header
- Conn Term Female
- Switch Push Dpdt.
- Topled
- Photodiodes for gamma testing
- Conn. Rcpt. Housing

What electrical components still need to be procured?
None
Software Elements

• Initialization

```python
#libraries
import time
import csv
from datetime import datetime
import serial
import RPi.GPIO as GPIO
```

• Connection

```python
#serial connection initialization
ser = serial.Serial("/dev/ttyAMA0", 9600)  #change ACM number as found from ls /dev/tty/ACM*
ser.baudrate=9600
```

• Writing to .csv

```python
myData = [['Time', 'Count', 'Col 3', 'Col 4']]

#Data written to 2 dimentional array

with open("data.csv", "w") as d:
    writer = csv.writer(d)
    writer.writerow(myData)
```
Software Elements : Data Management

**Initialization:**
- Factory
- Communicator “COM”
- Data structure “DS”
  - writeTo()
  - readFrom()
  - addTime()
  - addData()
  - checkStatus()
  - reset()
  - Connect()
  - receivedMessage()
  - ...

---

[Diagram of software elements and data management processes]

**D1:** Com.Connect()
**D2:** Com.receivedMessage()
**D3:** Com.checkStatus()

- **D1** - Connect to experiments/other Pi
- **D2** - Loop for receivedMessage/checkStatus
- **D3** - com.reset()
4.0 Subsystem Testing Results

Krystal Cruz
Jack Thomas
Austin Hinman
Caleb Ives
Steven Reeves
System Definitions

- UMS: Universal Mounting System (Jack)
- RDS: Radiation detection System (Austin, Caleb)
- REH: Rocket energy Harvester (Caleb)
- FOG: Fiber Optic Gyroscope (Austin)
- DMS: Data Management System (Steven)
Subsystem Testing
Universal Mounting System (UMS)

Jack Thomas
Stress Analysis (Simulated Load 30G)

Max Strain: Shear force between bottom standoff and strut within Polycarbonate Disk.

Max Stress: 41 MPa
Yield Strength Polycarbonate: 70MPa
Displacement

Max Displacement ≈ .005"

RockSat-C 2018
Center of Gravity

Center of Gravity about 3.25 inches from bottom.
Subsystem Testing:
Radiation Detection System (RDS)

Austin Hinman
Caleb Ives
Radiation Detection System

Progress: 40%

- Radiation detection for shielding is not complete
- Initial testing into sensing systems to be completed Tuesday, February 13th at Reed College in Portland, Oregon
- Basic proof in concept for optical based detection system performed by Austin and Thomas with inconclusive results
Radiation Detection System

- Neutron and Alpha particle testing used to test new optical based system
Radiation Detection System

• Inconclusive data for optical based system, further testing will be done at Reed College and as new components arrive
Radiation Detection System Testing (FPGA)

- FPGA has been programmed and is ready for testing on 2/13 at Reed nuclear reactor.
  - A series of counters values compared to each other, then OR’d to a 4-bit counter with LEDs. LED’s will indicate how many times radiation affected the counters.
Subsystem Testing:
Rocket Energy Harvester

Caleb Ives
Rocket Energy Harvester

• **Status**
  
  – Each sensor has been individually tested
    • (RTC, GYRO, ACCEL, MICROSD)
  – Tested Piezo charging theory

  – Yet to be tested:
    • Mechanical designs of harvesters (gravitational & vibrational)
    • PCB (not printed)
Rocket Energy Harvester

- Each sensor tested using an Arduino MEGA:
  - RTC
  - Gyroscope
  - MicroSD breakout
  - Accelerometer

- Piezo-energy harvesting theory tested using a single transducer and mechanical pressure to charge a capacitor.
  - Bridge rectifier circuit
  - Several sizes of capacitors
  - Piezo transducers
Rocket Energy Harvester

- **Results**
  - All sensors passed and work well.
    - Currently working on integrating sensors and capacitor monitoring into one program.
  - **Piezo-energy**
    - Tested first without bridge rectifier (fig. 1), then with (fig. 2)
    - Bridge rectifier circuit capture much more energy.

![Fig. 1](image1.png)  
![Fig. 2](image2.png)

- Calculation for harvested energy per piezo activation:
  - 9.52µJ per activation
  - Much lower than expected – Currently trying to find higher quality Piezo transducers.
HS Vibration Detector/Energy Harvester

• Status
  – This subsystem is new, but is adapted from a previous concept that was going to be incorporated with the energy harvester.
  – Uses an Arduino UNO to monitor vibration and a charging capacitor fed by a Piezoelectric strip.

  – No testing has yet been done on this subsystem
Subsystem Testing:
Fiber Optic Gyroscope (FOG)

Austin Hinman (On behalf of Thomas Pearce)
Fiber Optic Gyroscope

• Quick Status

  – Replacement laser diode tested. It works!
  – Designed and printed laser diode driver board, currently assembling.
  – Reference gyro, data storage, and other sensors are working.
  – Still have to design microcontroller board and opamp circuit for FOG output. Characterizing more of the optical system first.

Progress: 50%
Fiber Optic Gyroscope

- Characterized laser diode. Targeted power output currently 3.5mW.
- Tested code for peripheral IC’s
- Building laser controller, will be done by the time you see this.
Subsystem Testing:
Data Management System (DMS)

Steven Reeves
DMS: Status

- Status
  - Tested
    - Log files, Pi/Arduino environments, connectivity
  - Not tested
    - Multiple experiments, real time data ingestion, failure scenarios, watchdog system

```python
log.write("***************Initializing log**************\n")
log.write(str(datetime.now())+ "\n")
log.write("Looping to create data in two dimensional array\n")
myData = [['Time', 'Count', 'Col 3', 'Col 4']

for x in range(1,10):
    myData.append([str(datetime.now()),x,"filler","example"])
log.write("Data Written!\n")
time.sleep(1)
```
DMS: Completed Tests

- Completed Tests
  - Environment setup
  - Pi script on startup
  - Log file written with no I/O
  - `.csv` creation from data structure
  - Physical connection Arduino to Pi
  - Initial serial communication
DMS: Results

• Results
  – Environments, log files, .csv, data structure pass
  – Connectivity fail (serial connection)
Software Testing

• Prototyping materials purchased early to reduce dependency on electrical builds
• Electrical dependencies on Software development
  – Physical mediums, controlling experiments, communication protocol
• Data Management System/ Redundancy prototyping
  – Current – March 1
• Data Management System integration
  – March 1 – April 1
• Refinement and margin for debugging
  – April 1– May 1
• No Wallops concerns
5.0 Plan for Integrated Subsystem Testing

Austin Hinman
Plan for Subsystem Integration

- Subsystem Integration will use a tiered approach, starting with power and power control, moving into data collection, with final stage integration taking place with payloads.
- Maintaining systems integrity and assuring no downstream component damage takes place as new subsystems are connected (copious amounts of temporary fuses will be used).
Plan for Subsystem Integration

Activation systems → Power subsystems → Data collection and control → Modular bay system

Radiation shielding system → Laser Gyroscope system → Unified final system
6.0 Project Management Update

Mark Johnston
Program Management and Team Updates

• Did anyone switch roles?
  - Francis Bartholomew has left the team.
  - Caleb Ives has taken over his spot.
- Due to issues funding for mechanical and electrical has been shifted.
- We eaten into our built in time frame at the end of the term but will keep working the build and integration.
## Budget

<table>
<thead>
<tr>
<th>Category</th>
<th>Estimated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canister</td>
<td>$12,000.00</td>
</tr>
<tr>
<td>Total</td>
<td>$12,000.00</td>
</tr>
<tr>
<td>Engineering</td>
<td></td>
</tr>
<tr>
<td>Parts and Supplies</td>
<td>$3,000.00</td>
</tr>
<tr>
<td>Total</td>
<td>$3,000.00</td>
</tr>
<tr>
<td>Travel</td>
<td></td>
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<tr>
<td>Flight</td>
<td>$4,900.00</td>
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<td>Hotel</td>
<td>$3,240.00</td>
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<tr>
<td>Car Rental</td>
<td>$1,700.00</td>
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<tr>
<td>Gas</td>
<td>$200.00</td>
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<tr>
<td>Food</td>
<td>$3,465.00</td>
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<td>Total</td>
<td>$13,505.00</td>
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<tr>
<td>Contingencies</td>
<td>$2,000.00</td>
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<tr>
<td>Total</td>
<td>$2,000.00</td>
</tr>
<tr>
<td><strong>Total Expenses</strong></td>
<td><strong>$30,505.00</strong></td>
</tr>
</tbody>
</table>

- Our first Earnest deposit of $1,000.00 was made on October 13, 2017.
- We have received a $7040.00 grant from Oregon Tech RBC.
- We are currently working with purchasing to submit the $5,500.00 payment.
- ASOIT-W has currently donated $1000.00.
- Student donations for the project currently stand at $350.00.
- We are working at submitting two corporate sponsorships at the present time to help with our expenses.
Worries and Concerns

• Potential points of failure:
  - Power failure.
  - Cascade failure.
  - Debris damage.

• Mitigation:
  - Will have 2 power supplies, individual relay, armored common power rail.
  - Each system individual.
  - Each modular experiment will be contained within a housing unit.
7.0 User Guide Compliance

Jean-Luce Nabors
## User Guide Compliance

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center of gravity in 1&quot; mid-can?</td>
<td>Yes</td>
</tr>
<tr>
<td>Contained in can</td>
<td>Yes</td>
</tr>
<tr>
<td>Connected to can by 4/5 bulkheads on top and bottom only</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Mass at 20±0.2lbs</strong></td>
<td><strong>4.43 lbs available for ballast</strong></td>
</tr>
<tr>
<td>Shared canister clearance</td>
<td>Whole can requested</td>
</tr>
<tr>
<td>No voltage on the can</td>
<td>Needs to be tested during integration</td>
</tr>
<tr>
<td>Activation wires at least 4 ft</td>
<td>Yes</td>
</tr>
<tr>
<td>Activation wire at least 24 gauge</td>
<td>Yes</td>
</tr>
<tr>
<td>Early Activation: current &lt; 1 A</td>
<td>Yes</td>
</tr>
<tr>
<td>T-0 Activation: current &lt; .1 A</td>
<td>yes</td>
</tr>
<tr>
<td>Battery Type</td>
<td>Lithium Polymer</td>
</tr>
</tbody>
</table>
Conclusion

- Next Steps: 1\textsuperscript{st} Payment, ISTR
- Questions
Additional data not immediately relevant to the presentation

APPENDIX
Appendix: Software Development Plan

• Schedule for completion includes the following stages
  – UI design, prototype, implementation, and testing
    • Currently in implementation phase
  – Data Management System/ Redundancy design
    • Current – Dec 15
  – Data Management System/ Redundancy prototyping
    • Dec 15 – Jan 15
  – Data Management System integration
    • Jan 15 – April 1
  – Refinement and margin for debugging
    • April 1– May 1
  – Test driven development and Unit testing will be performed throughout
Appendix: Fiber Optic Gyrooscope

- Boring data. You could read if you want:

<table>
<thead>
<tr>
<th>Optic Coupler Ratio</th>
<th>Side A: 50.2% Side B: 49.8%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser Power @40mA</td>
<td>3.86mW</td>
</tr>
<tr>
<td>Laser Power @35mA</td>
<td>2.91mW</td>
</tr>
<tr>
<td>Laser Power @30mA</td>
<td>1.93mW</td>
</tr>
<tr>
<td>Laser Thermistor @20°C</td>
<td>10.028kΩ</td>
</tr>
<tr>
<td>TEC Cooler ESR</td>
<td>1.7Ω</td>
</tr>
<tr>
<td>Optical Fiber Attenuation</td>
<td>Tried to measure, so low it was in the noise.</td>
</tr>
</tbody>
</table>
Appendix: Bottom Standoff

$\varnothing.5$

DRILL #29 TAP 8-32 UNC
Appendix: Payload Trays 1 & 2 Struts

8-32 UNC BOTH SIDES

.164
.25
2.5
.5
.164
.5
Appendix: Payload Tray 3 Strut

8-32 UNC BOTH SIDES
Appendix: Top Payload Tray Standoff

- DRILL #29 TAP 8-32

[Diagram showing dimensions and markings related to top payload tray standoff]