CoDR Presentation Content

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  – Concept of Operations  
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• Section 2: Design Overview  
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CoDR Presentation Contents

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• Section 4: Conclusion
Mission Overview: Mission Statement

TRAPSat aims to capture and parameterize micro-debris in Low Earth Orbit (LEO) using aerogel as a capture medium, and image the aerogel over time to quantify how much debris is encountered in each orbit.

The ROCKSAT mission will provide verification of our subsystems.

- aerogel container
- nichrome-released lid
- aerogel blanketing insulation
- flight computer
Mission Overview: Mission Statement

● The aerogel support container
  ○ Will protect the aerogel from both the stresses of launch and exposure to the space environment, such that it can still function as a capture medium.

● The lid
  ○ Will successfully protect the aerogel until it is released, and then will properly open.

● The aerogel blanketing
  ○ Will provide adequate insulation and shielding in a space environment.

● The flight computer
  ○ Will be capable of activating the lid release and collecting data while in a space environment.
Mission Overview: Mission Statement

ROCKSAT data will benefit the design of the next iteration of TRAPSat which will be the primary scientific payload that will be launched into LEO as part of NASA’s CubeSat Launch Initiative in 2018, on the CACTUS 1 mission.

This payload will benefit NASA

- Data about micro-debris that is currently too small to be tracked from the ground
- Proof-of-concept of the use of aerogel to remove debris
Mission Overview: Mission Statement

• This mission is an important step in the path from concept to final deployment of TRAPSat, which could prove to be a viable solution to the orbital debris problem.

• Subsystems contained within this mission have already been flown aboard multiple HABs.

• The next step in preparing TRAPSat for the CACTUS-1 launch is to test the TRAPSat design on a suborbital flight.

• The members of the team have multiple semesters of experience working together on this project.
Mission Overview: Mission Objectives

Mission Objectives
• To take images of aerogel
• To collect data from camera and sensors
• To protect aerogel during launch, then expose the substrate to space the environment.

Minimum Success Criteria
• Lid release mechanism exposes aerogel
• Aerogel remains secure and intact until reentry
• At least one stored image from camera
• At least one stored temperature data point
Aerogel for capture

- extremely low-density
- nearly transparent material with unique properties that make it ideal for micro-debris capture

Aerogel “is a silicon-based solid with a porous, sponge-like structure in which 99.8 percent of the volume is empty space... When a particle hits the aerogel, it buries itself in the material, creating a carrot-shaped track up to 200 times its own length. This slows it down and brings the sample to a relatively gradual stop. Since aerogel is mostly transparent - with a distinctive smoky blue cast - scientists will use these tracks to find the tiny particles.”

Mission Overview: Theory and Concepts

- NASA has used aerogel successfully to capture comet debris and micrometeorites on space missions, one of which was the Stardust mission.

- TRAPSat has flown aerogel and confirmed capture in the past on various balloon payload missions.

- Spectral analysis and micro-photography were used for proof of capture. Six micro debris were analyzed.
Mission Overview: Theory and Concepts

Above: Image of impact streaks in aerogel during testing for project Stardust out of JPL. Image courtesy of NASA JPL. http://stardust.jpl.nasa.gov/photo/aerogel.html

Photo bottom left: Captured debris particles in aerogel using onboard cubesat camera during the Fall 2015 HAB launch

Photo Right: Carrot style streaks in aerogel after a TRAPSat HAB launch using a DSLR.
Aerogel Blanketing:
- TRAPSat has used aerogel blanketing in previous balloon payload missions.
- The temperature curve provided from Fall 2015 HAB launch data proves that the blanketing is a viable insulation solution.
- Addition of a kevlar and lead layer, aerogel blanketing is less expensive, more robust, lightweight and low profile compared to traditional MLI.
Internal vs External temperature graph during the spring 2015 HAB launch. This data proves that aerogel insulation can be a viable option for space insulation.
ConOps

1. Power on Computer
   1.1. Start up Imaging Sequence
   1.2. Start up Temperature Sensing
   1.3. Start up Data Storage
2. Continue Imaging and Sensing
3. After Rocket sheds the skin, deploy the lid with Nichrome
4. Continue Imaging, Sensing Temperatures, and Storage Data
5. Continue Imaging, Sensing Temperatures, and Storage Data
6. Splash down in Atlantic Ocean
   6.1. Be recovered by Navy/RockSat X
   6.2. Delivered to the team (TRAPsat)
ConOps

- Aerogel/internal Camera
- Flight Computer
- External Camera

Dimensions:
- 4.000" (4 inches)
- 1'-0.000" (1 foot)
- 1.0000"
- 1.2598" (1.2598 inches)
- 1.7720" (1.7720 inches)
- 0.8498" (0.8498 inches)
- 0.1968" (0.1968 inches)
ConOps

Aerogel/internal camera bay

Dimensions:
- 4.0000"
- 2.5000"
- 2.0000"

CoDR
Mission Overview: Expected Results

- How aerogel reacts to space environment and launch conditions in our container through imaging the aerogel block.

- Although not mission success criteria, if an impact with micro debris occurs, the internal camera’s images of the aerogel will have “carrot streaks”. This, however, would be an unlikely event. Our objective with the internal camera will be met if the images are clear.

- The external camera will take images of the outside of the aerogel container to verify the lid’s operation.

- The “health” of the external camera will be recorded through the quality of the images it produces.

- The temperature sensors’ values will be recorded to get a resultant temperature curve that measures the effectiveness of the custom insulation.
Design Overview: Science Design

Instruments to be used in this mission:

- Temperature Sensors
- Internal Camera facing Aerogel
- External Camera facing lid
- Lid opening mechanism
- Lid State sensor

How the instruments will be used:

- The internal camera will be scheduled through software to take images of the aerogel.
- The external camera will be scheduled to take images of the outside of the aerogel container.
- The temperature sensors’ values will be recorded and sent to RockSat-X external storage.
- The lid mechanism will open the lid to expose the aerogel.
Design Overview: Engineering Design

- Structures
  - Lid/Internal Camera/Aerogel Structure
  - Flight Computer Structure
  - External Camera

- Power
  - Voltage regulator to provide 5V to flight computer from GSE Controlled Power.
  - Higher amperage will be needed for the Lid Release Mechanism; this will get power from one of the Timer Controlled Events to make use of higher current limits.

- Command and Data Handling
  - Store photos and environment data locally and using telemetry system provided by RockSat-X.

- Software
  - Core Flight System (cFS)
  - TRAPSat cFS applications
Design Overview: RockSat-X User’s Guide Compliance I

- Rough Order of Magnitude (ROM) weight estimate
  - Flight Computer - 70g
  - Flight Computer Case -
  - Internal Camera - ~< 6g
  - Internal Camera Case -
  - External Camera - ~< 10g
  - External Camera mount - 5g
  - Box/cases or housings TBD

- Estimate on payload dimensions
  - Two 4in (~10cm) box’s center of platform, one lightweight camera unshielded, facing capture portion of payload.
Design Overview: RockSat-X User’s Guide Compliance I

- Deployables/booms
  - Lid
- ADC use
  - Data transfer for sensor data
    - Optional
    - This data could be transferred over the asynchronous/parallel lines after processing
- Asynchronous/Parallel use
  - Data transfer for image storage
Design Overview: RockSat-X User’s Guide Compliance II

- Power lines and timer events
  - GSE-1 power used for flight computer
  - TE-1 power used for Lid Release Mechanism
- CG requirement
  - Center of mass within 1” of payload center
- High Voltage
  - A 28V line will be needed, regulated 5V required
- Hazardous Procedures
  - Lid Release Mechanism (springs and nichrome)
• Radio Frequencies
  – No Radio Frequencies used.
• Bolt heads on bottom of deck flush mount?
  – For stand offs used where applicable
• US Persons compliance
  – All US except, one Latvian international student on A2 visa currently filing for permanent residence.
• ITAR compliance
  – TBD
Team Organization Chart

NASA Advisors:
Allison Evans
Cinnamon Wright

Ryan Schrenk
Principal Investigator / Lead Engineer

Alumni Advisors:
Tye Dillard

Michael Strittmatter
Lead Business Analyst

Zach Richard
Lead Computer Engineer

Nathan Weideman
Co Lead Engineer

Keegan Moore
Lead Software Engineer

Team TRAPSat
# Preliminary Schedule

<table>
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<tr>
<th>Task Mode</th>
<th>Task Name</th>
<th>Duration</th>
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<td>138 days</td>
<td>Wed 10/14/15</td>
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Team Mentors

Faculty Advisors:
  Prof. Angela Walters chair dept
  Dr. Alex “Sandy” Antunes head dept

NASA Advisors:
  Allison Evans
  Cinnamon Wright

Alumni/ industry Advisors:
  Tye Dillard
  CJ Giovingo
# Contact Matrix

## TRAPSat / Capitol Technology University

### Fall 2016 RS-X 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>OK to Add to Mailing List?</th>
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<tr>
<td>Principal Investigator / Lead Engineer</td>
<td>Ryan Schrenk</td>
<td>443-829-8228</td>
<td>443-829-8228</td>
<td>Yes</td>
<td><a href="mailto:rmschrenk@captechu.edu">rmschrenk@captechu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td>Lead Software Engineer</td>
<td>Keegan Moore</td>
<td>302-542-2293</td>
<td>302-542-2293</td>
<td>Yes</td>
<td><a href="mailto:keeganmoore.km@gmail.com">keeganmoore.km@gmail.com</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Engineer</td>
<td>Dan Whiteside</td>
<td>703-309-3416</td>
<td>703-309-3416</td>
<td>Yes</td>
<td><a href="mailto:danwhiteside1@gmail.com">danwhiteside1@gmail.com</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Engineer</td>
<td>Mikus Bormanis</td>
<td>202-375-0335</td>
<td>202-375-0335</td>
<td>Yes</td>
<td><a href="mailto:mikalandzelo@gmail.com">mikalandzelo@gmail.com</a></td>
<td>Latvian</td>
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<tr>
<td>Co-Lead Engineer</td>
<td>Nathan Weideman</td>
<td>240-538-1870</td>
<td></td>
<td>Yes</td>
<td><a href="mailto:nathan_weideman@yahoo.com">nathan_weideman@yahoo.com</a></td>
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<tr>
<td>Lead Computer Engineering</td>
<td>Zach Richard</td>
<td>302-245-6170</td>
<td>302-245-6170</td>
<td>Yes</td>
<td><a href="mailto:zach.richard94@gmail.com">zach.richard94@gmail.com</a></td>
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## Team Availability Matrix

### TRAPSat / Capitol Technology University

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Please Place priority levels for times you are available. This is done by simply typing a 1, 2, 3, or 4 in each clear box. Hashed boxes are not available.

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<td>Highest Priority</td>
<td>Lowest Priority</td>
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Risks/Worries:

• Keeping the aerogel safe is a high priority.

• If the aerogel is not perfectly square, the aerogel will vibrate into the wall of the container during launch and then disintegrate on exposure to the space environment.

• Another major risk for aerogel is air getting under the top or somehow get around the side of the aerogel. Aerogel will likely shatter and then blow out in small pieces.
Risk/Worries

• Both of the aerogel problems can be overcome by having the container be pre-made by CnC mill and then drying the aerogel inside of that mold. This would ensure a perfect fit, not allowing air flow or vibration.

• Another risk involved in this mission is that the lid could have insufficient spring force to overcome the drag force in LEO to open and remain stable open for the duration of the flight.

• With a lack of proper insulation and or shielding, the sensitive equipment on board maybe dosed by radiation causing single event failures or upsets. This can also lead to completely destroying the equipment.
Risks to be Mitigated Through Design Effort

- Aerogel break due to launch vibrations
  - Make aerogel form in its flight container so there are no gaps between the aerogel block and the walls.
  - Hot glue the gaps on sides of aerogel. Need to test off-gassing issues on camera.

- Aerogel break due to pressure differences
  - Make it in its container
  - Hot glue the gaps on sides of the aerogel. Need to test off-gassing issues on camera.

- Radiation cause single event failure
  - Lead paint /shielding or insulations with radiation barriers built in.
TRAPSat’s Benefit:

- The payload will be one of the few science payloads performed on cubesats aimed at micro space debris.
- TRAPSat will perform a debris study of sub 10 cm debris in the orbit that it is placed.
- The satellite will send down an image, time stamped and dated along with other tracking data so scientists can create a catalog of impacts.
- This will provide valuable data for other satellite operators such as: locations of high density, location of impact, and possibly how hard of an impact.
- These impacts leave streaks or carrot like craters in the aerogel often with a tiny piece of the material left at the bottom.
- Scientists will be able to compare this image of the streak/crater and debris to Stardust data.
- This will hopefully lead to later missions where the TRAPSat payload can be repurposed for atmospheric debris and composition analysis such as Lunar dust profiling or martian atmospheric studies.
- The custom insulation that will be tested is expected to perform better than MLI thermally and to have lower cost.
End of presentation

Thank you!
Second Trapsat is just a prototype, a learning tool, with the knowledge gained from the TRAPsat project. We hope to create the ultimate micro debris removal method or system. If this system works well maybe simply making it larger with many small cells of aerogel or making a constellation of maybe 25-50 trapsats flying millimeters apart in unison removing passive and active debris at each chance encounter. Over time this would greatly reduce the amount of micro-debris making for a safer space environment. On the other hand we may find this is just not a practical idea and it should not be pursued. Either way enough knowledge should be gained through this mission that a better method or mitigation technique may be discovered during the mission. But currently after spending two years studying space debris, especially micro debris, I can tell you why almost every other idea proposed will not work, this is the only viable idea I have come up with or across in studying this heavily. I believe now is the time to prove this is a solution or take it back off the table. Something must be done to stop or mitigate this problem before kessler syndrome or maybe a less dramatic problem but GPS goes down or soldiers on the battlefield loose comms because of unforeseen debris impact. No one can foresee the losses that could occur from doing nothing, it may not be now but it will be a problem in our lifetime.
Third this is an all-volunteer student led multidisciplinary satellite project from start to finish. This project has provided up and coming engineers who could not necessarily get the internship they desired for whatever reason a place to learn grow and shine. Not many internships give you an opportunity to work on what makes you happy or interests you, this one gives students from all backgrounds a taste of engineering toward a space environment. This has truly brought the best out of Capitols students, especially the non-engineering background students. Our camera subsystem lead is a business major with a passion for photography, space and building things, it just works out.

These students are the future engineers and managers of tomorrow, and they are coming quick. We need the hands on experience as well as the opportunity to work with people with so much experience we can learn from and hopefully make future contacts and relationships. These students can bring this knowledge back and teach other students and improve the overall quality of our builds, the longevity and performance of our satellite missions. At Captiol Technology University, we want to do things the correct way, so they last and perform as designed.
1) Need to determine how to get rasc solid and made space grade (aluminum) I guess CnC mill
2) Need to find space grade gasket to seal lid to CnC RASC and aluminum lid
3) Need space grade aluminum lid milled idk maybey press
4) Watch dog /power management?????? was not sure if two separate or one???????
5) Power management board
6) How to get aerogel made in containor ?? can we fill any gaps around the side with thick hot glue I think its to thick to penetrate and it dries clear it will glue it in as well as fill gaps from shaking and air movement (let me know what u think) (mayne we can get a sample and test it cheaper than making aerogel in container)??????????
7) Lighting may need internal no time for best lighting on sensors should have on-board LED primary maybe low light but need something ?????????????
8) Should have cadense rate high as possible to get rapid fire photo we are only up there seconds????????