Background

- **Kessler Syndrome**
  - Decommission satellites can collide creating a cascading effect of increasing space debris.

- **Debris**
  - There are approximately 500,000 pieces of tracked debris, millions of pieces of the debris are too small to track.
  - Traveling at high velocities any size debris can become a hazard to satellites and space vehicles.

- **Why is this a problem?**
  - Without intervention the problem will continue to worsen and could eventually inhibit future space travel and communications.
Background: Current Solutions

- **Current Solutions**
  - Debris shields that can resist damage from debris particles < 1cm
  - We are able to track debris > 5cm
- **Problems with these Solutions**
  - The problem area is the debris larger than 1 cm and smaller than 5 cm
- **Project O.S.C.A.R’s Solution**
  - To develop a cost effective method to alter the trajectory of space debris during suborbital flight utilizing electrostatic fields to induce a dipole attraction in the debris.
  - The experiment is going to be launched on two stage sounding rocket RockSat-X from Wallops Flight Facility in August 2018.
Our Solution: Design

**Electrostatically Charged Collector Box**
Box is lined with Rabbit Fur and swiffer To be rolled out of box at apogee.

**Debris Launcher**
Projects aluminium debris toward extended collector.

**Electronics Box**
Enclosing all vital electronics needed to survive reentry.

**Small Debris Experiment**
Separate small experiment to test the use of electronically induced electric fields to collect small debris.
Our Solution: Mechanical

● **Extend Boom Arm**
  ○ Design a custom 3D printed arm to extend the experimental area of the payload for the launch of debris.

● **Mechanical Movement to Create a Static Charge**
  ○ Utilize the extension of the collector material to induce a static charge.

● **Optimize Power Usage**
  ○ Ensure payload does not exceed current draw allowed
    ■ Staggered component activation to limit current draw at any single time.
Our Solution: Materials

- Using polyester and rabbit fur to create a charge on the Swiffer
- Charged swiffer will induce a dipole-dipole attraction to alter the trajectory of the debris
Our Solution: Software

- Tasked with taking object and gather data from it.
- Objects will be identified with Open Source Computer Vision (OpenCV) installed on a raspberry pi.
- OpenCV is library of programming functions for real-time computer vision, developed by intel.
- The software will gather the size of the objects in the frame of the camera.
- The data of the objects’ sizes will be telemetered down to the ground.
  - From the data, the speed and the relative distance can be calculated.
Our Solution: Small Debris Experiment

- Testing the potential of using static electricity to influence the path of small space debris.
- This tech could dissuade small debris from vulnerable areas of a spacecraft.
- Custom cut copper capacitor plates will be charged with 12V.
- Positively charged resin beads (from a prior student project) simulates space debris.
- Debris will be contained and electrostatically charged by rotating the cylinder with a small DC motor.
- Field between capacitor plates will influence the path of the debris, attracting it toward the negative plate. Field should be particularly strong because it is in vacuum.
Development: Design

- **Material Selection for Collection**
  - Adhesives → Inducing a dipole-dipole attraction through static charge.

- **Modeling in CAD**

- **Rapid Prototyping**
  - 3D Printing
  - Laser Cutting
  - Quick design reviews

- **Testing**
  - Subsystem verification
  - Integrated verification
  - Environmental testing
Development: Mechanical

● **Physical**
  ○ Solidworks motion analysis.
  ○ Payload weight and CM established in Solidworks.

● **PCB**
  ○ Iterations of boards designed in Eagle Cad
  ○ Atmega328 based control boards
    ■ Scrapped for Nano due to size

● **Power**
  ○ Distribution boards
  ○ Buck converters
Development: Materials

- **Infrared spectroscopy confirmed the polyester composition of the Swiffer**
  - Electronegative ester group
- **Resonance within the molecule to create isolated charge**
  - Electrons are delocalized
  - Creating a negative charge on the oxygens
- **Dipole-Induced Dipole Attraction**
  - Negative charge will induce a dipole in the debris and the positive end will form an attraction with the negative charge
Development: Materials

- **Testing drop test**
  - Drop hole at origin
  - Control group (blue plot)
    - No Swiffer
  - Experimental Group (orange plot)
    - Charged Swiffer at the top of the Y-Axis

- **Results**
  - The graph shows a noticeable change in the trajectory of the debris with the Swiffer present
Development: Software

- **The coding was developed in the python 3 environment of the raspberry pi.**
  - When the timer event is triggered.
    - First the raspberry will loop in capturing images
    - The program for the getting the object sizes will loop at each picture and telemetry it in ASCII.
    - It will also save the data in a text file during the loop.
- **The data of the objects are gathered through OpenCV with the help of other installed programs.**
  - OpenCV python, Numpy, Serial, Matplotlib.
    - OpenCV python converts image into arrays that can be converted into Numpy array.
    - Numpy converts image into array list of numbers that identify color or intensity of a pixel.
      - Makes OpenCV python image array easier to read with other raspberry programs like Matplotlib
    - Matplotlib converts Numpy arrays into a readable grid structure to be analysed later.
    - Serial gives the raspberry the power to utilize its’ telemetry and convert each data into ASCII characters to be sent out.
- **Made custom heatsinks and conformal coated all of the devices.**
  - Calculated the required heatsink for the raspberry pi and tested it.
  - Conformal coating to keep components from arcing.
Development: Small Debris Experiment

- **Capacitor Plates**
  - Copper plates custom cut in the jewelry lab

- **Enclosure Box for Capacitor Plates**
  - 3D printed prototype out of PLA.
  - Final print in ABS to endure the extreme temperatures.

- **Cylindrical Spinning Chamber**
  - Powered by a DC motor with time event run on an Arduino Nano
  - Translucent disposable Winchel's straw, cut to a 2 cm length.

- **LED** will turn on \( t = 0 \) and backlight the chamber for visibility

- **Raspberry Pi** camera will record the attraction event to Pi Zero

- **Arduino Nano** will run 12V through a MOSFET Logic gate

- We will recover the video and compare debris movement vectors with Earthbound testing results

Magnitude of the electric field in terms of voltage:

\[
E = \frac{d}{V_0^2 A^2}
\]

Using this formula, we could reliably scale our model up or down as needed and as what deemed necessary based on the amount of voltage we would be provided.
Metrics of Success: Subsystems

- **Mechanical**
  - Extension of boom arm & polyester collector.
  - Launch of debris.

- **Software**
  - Successfully getting object data and telemetering.

- **Materials**
  - Effectively creating a charge and creating a dipole-dipole attraction with the simulated debris.

- **Small Debris Experiment**
  - To measurably influence the path of small charged debris in a controlled chamber and record these results as a retrievable video file.
Metrics of Success: Payload

- **Minimum Success Criteria**
  - Metadata confirmation of a change in velocity of the debris as a result of interaction with the charged material.
  - May include:
    - Debris changing velocity after impact with the charged debris collector.
  - Failure would be the metadata showing no change in the movement of the debris.

- **Comprehensive Success Criteria**
  - Visual and metadata confirmation of debris (Aluminum) adhering to the capture device.
  - Secondary experiment (Small Debris Experiment) returns video data, confirming experiment hypothesis.
  - All video and video metadata recovered for additional on-the-ground analysis.
Conclusion

We are excited for data collection from our upcoming launch in August.

We believe project O.S.C.A.R. is a promising solution to a problem that is not yet being addressed at the scale needed.