SHARD

Structural Health and Rupture Detection

CSE Team Members:

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Aero/Mechanical Team Members:

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CSE Faculty Advisor:

Dr. Silaghi, msilaghi@fit.edu

Advisor Meeting Dates:

04/13/2023

Client:

Dr. Willard, FIT Aeronautics Professor and NASA Engineer

Client Meeting Dates:

03/10/2023

03/24/2023

03/31/2023

04/10/2023

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1 Current Milestone Progress

Task	Completion %	Julian	Matthew	To do
Finish webpage/website	100%	0%	100%	N/A
Demo video for showcase	100%	100%	0%	N/A
Poster and e-book page with group	100%	0%	100%	N/A
Finish simulation mode	0%	0%	0%	Create Simulation/Animation before showcase
Finish sensors and software interface if applicable	100%	100%	0%	N/A

2 Discussion - Tasks

2.1 Task 1: Finish webpage/website

The purpose of this task was to review the webpage with the other group members and perform various updates/revisions to improve both the functionality and the overall visual appeal.

2.2 Task 2: Demo video for showcase

Created the demo video for the showcase and for the milestone presentation. The demo video contains a demonstration of the model creation portion. The demo also shows the sensor data and lighting up of the tiles when hitting the tiles aggressively.

2.3 Task 3: Poster and e-book page with group

The purpose of this task was to finish the poster and e-book page. This task was attempted last milestone but was pushed back to include the entire group’s feedback and input.

2.4 Task 4: Finish simulation mode

Simulation mode was not completed during this milestone. Some type of simulation/animation will be attempted before the final showcase.

2.5 Task 5: Finish sensors and software interface if applicable

Programmed in the application an user interface for the user to to click on the tile and view the data of the sensors in real time. This only works if the sensors are connected to the application via the arduino.

2.6 Other miscellaneous tasks accomplished:

Worked with the other group members to test the sensors, attach the sensors, create the 3D models, and cut aluminum in the workshop.

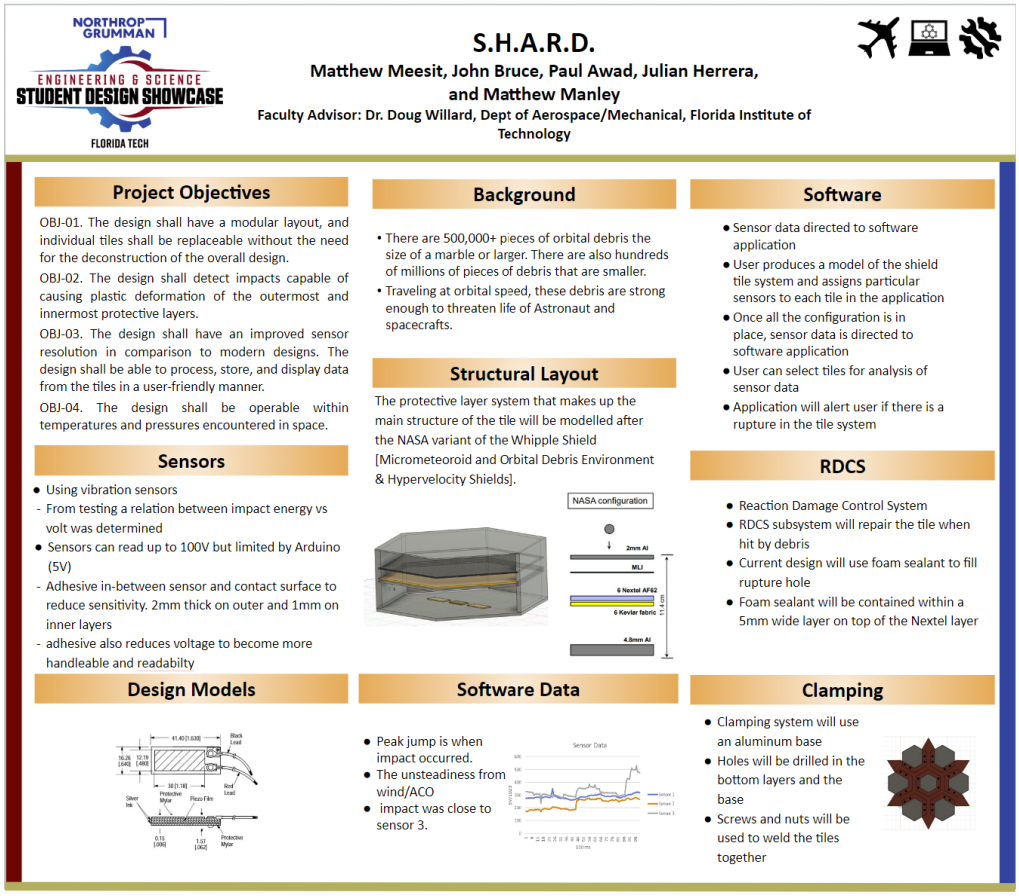
3 Discussion - Contributions

3.1 Julian Herrera

Integrated the interface between the software application and the sensors. Helped non cs major group members with various menial tasks that need to be done to finish a singular tile (e.g. stripping of wires and soldering). Created the demo video for the showcase and for presentation in the milestone.

3.2 Matthew Manley

Completed the poster and e-book page for the Senior Project Design Showcase and completed the webpage/website. Also, helped the team construct the tile by cutting metal in the machine shop and attaching piezoelectric sensors to the outer layers.



NORTHROP GRUMMAN
ENGINEERING & SCIENCE
STUDENT DESIGN SHOWCASE
FLORIDA TECH

S.H.A.R.D.

Matthew Meesit, John Bruce, Paul Awad, Julian Herrera, and Matthew Manley

Faculty Advisor: Dr. Doug Willard, Dept of Aerospace/Mechanical, Florida Institute of Technology

Project Objectives

OBJ-01. The design shall have a modular layout, and individual tiles shall be replaceable without the need for the deconstruction of the overall design.

OBJ-02. The design shall detect impacts capable of causing plastic deformation of the outermost and innermost protective layers.

OBJ-03. The design shall have an improved sensor resolution in comparison to modern designs. The design shall be able to process, store, and display data from the tiles in a user-friendly manner.

OBJ-04. The design shall be operable within temperatures and pressures encountered in space.

Sensors

- Using vibration sensors
  - From testing a relation between impact energy vs volt was determined
- Sensors can read up to 100V but limited by Arduino (5V)
  - Adhesive in-between sensor and contact surface to reduce sensitivity. 2mm thick on outer and 1mm on inner layers
  - adhesive also reduces voltage to become more handleable and readabilty

Background

- There are 500,000+ pieces of orbital debris the size of a marble or larger. There are also hundreds of millions of pieces of debris that are smaller.
- Traveling at orbital speed, these debris are strong enough to threaten life of Astronaut and spacecrafts.

Structural Layout

The protective layer system that makes up the main structure of the tile will be modelled after the NASA variant of the Whipple Shield [Micrometeoroid and Orbital Debris Environment & Hypervelocity Shields].

Software

- Sensor data directed to software application
- User produces a model of the shield tile system and assigns particular sensors to each tile in the application
- Once all the configuration is in place, sensor data is directed to software application
- User can select tiles for analysis of sensor data
- Application will alert user if there is a rupture in the tile system

RDCS

- Reaction Damage Control System
- RDCS subsystem will repair the tile when hit by debris
- Current design will use foam sealant to fill rupture hole
- Foam sealant will be contained within a 5mm wide layer on top of the Nextel layer

Design Models

Software Data

- Peak jump is when impact occurred.
- The unsteadiness from wind/ACO
- impact was close to sensor 3.

Clamping

- Clamping system will use an aluminum base
- Holes will be drilled in the bottom layers and the base
- Screws and nuts will be used to weld the tiles together

Project Name	**Structural Health And Rupture Detection**
Team Lead:	Matthew Meesit, Project Manager, John Bruce, System Engineer
Team Member(s):	Matthew Manley, Julian Herrera, Paul Awad
Faculty Advisor(s):	Dr. Doug Willard, Dept of Engineering and Science, Florida Institute of Technology

Although there are sensors and satellites that collect and record the location of space debris, these instruments are expensive and not feasible for small debris. A need exists for ways to stop micrometeoroids and micro-debris impact. The device shall be economical, stop impacts of a certain size at orbital speeds, be simple to use and maintain, and demonstrate long-term reusability.

To reach these requirements the project is to create a type of hull shielding that will consist of a frame, into which a series of individual tiles, each with its own set of sensors capable of detecting impacts and breaches, will be installed. The end goal of this is to have cost-effective tiles that can automatically react to and inform astronauts of dangerous impacts, as well as be able to easily replace any damaged tiles, to lower the maintenance costs and increase the lifespans of future long-term and reusable spacecraft.

To reach this goal, the project has 4 main objectives:
OBJ-01. The design shall have a modular layout, and individual tiles shall be replaceable without the need for the deconstruction of the overall design.
OBJ-02. The design shall detect impacts capable of causing plastic deformation of the outermost and innermost protective layers.
OBJ-03. The design shall have an improved sensor resolution in comparison to modern designs. The design shall be able to process, store, and display data from the tiles in a user-friendly manner.
OBJ-04. The design shall be operable within temperatures and pressures encountered in space.

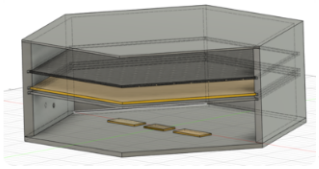


figure 1

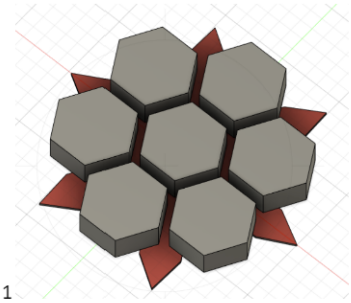


Figure 2

The above images show what has been developed to reach these goals. Challenges overcome to achieve this involves dealing with using the large gap of possible impact energies. These large gaps mean the sensors would need to be able to detect small low energy impacts as well as large powerful impacts. To solve this problem we use piezoelectric vibration sensors that would produce a voltage whenever it vibrates from anything. This provided a way to measure impacts and categories them by voltage. Another issue was dealing with a way to connect each tile to the others. Using magnetic locks, electric locks and push pop locks (similar to a pen) were all possible ideas but all had the same issue. The issue is the chances of an impact that could damage the locking mechanism forcing the tiles to not be able to be removed without a person. Or the tile could potentially pop off from the impact and leave the spacecraft leaving the spacecraft with no protection. To solve this problem we had the tiles be connected with one another to use an aluminum base (Red in Figure 3). Holes will be drilled in the bottom layers and the base where screws would be put to connect them(the black holes). In

4 Client Meetings

- March 10, 2023 - discussed with the GSA our current progress and any updates
- March 24, 2023 - discussed with the GSA our current progress and any updates
- March 31, 2023 - discussed with the GSA our current progress and any updates
- April 10, 2023 - discussed with the GSA our current progress and any updates

5 Client Feedback

- N/A

6 Faculty Meetings

- March 9, 2023 - discussed with Dr. Silaghi our progress so far

7 Faculty Feedback

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