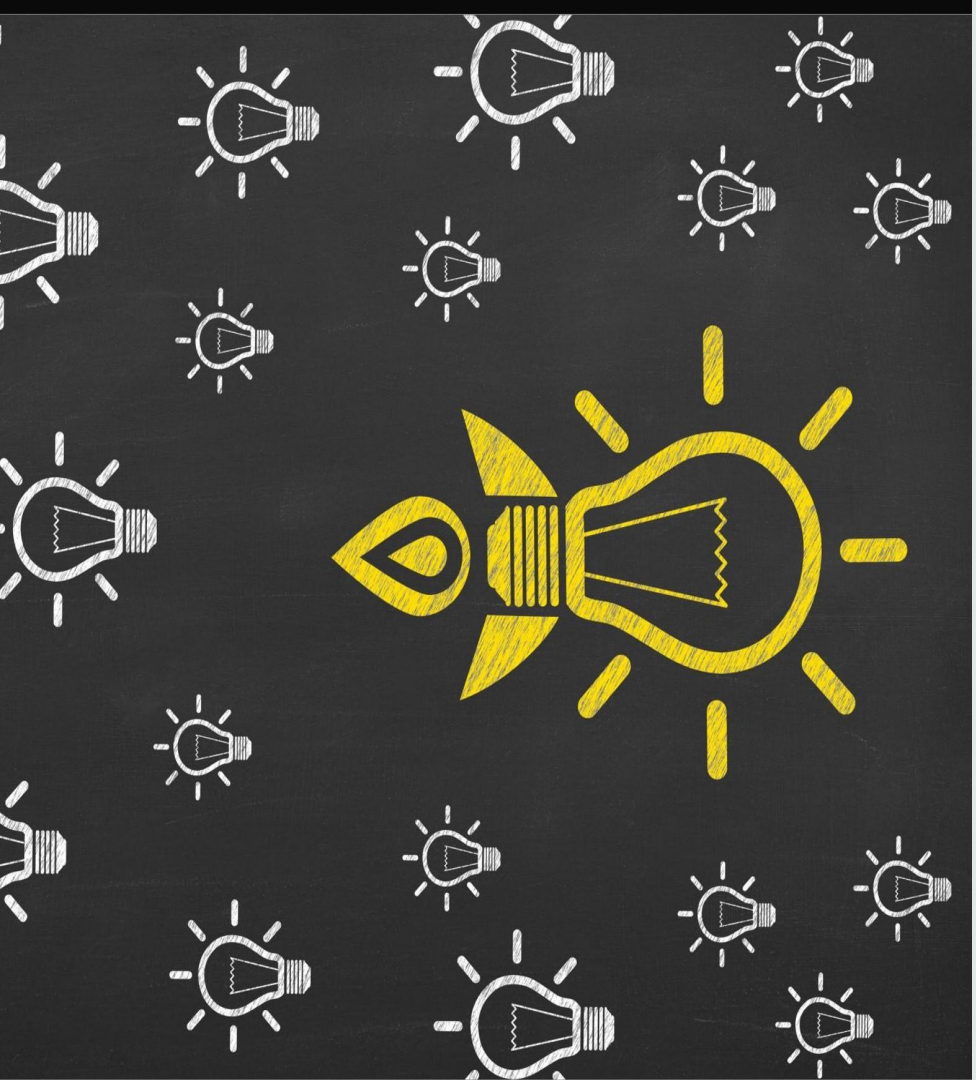


Ideation Derby

Team Seven Subteam:
Kismet Crossdale, Hayden Fuller,
Jameson Giannattasio

Problem Statement + Design Criteria

Problem Statement

Goal: To design a device that reduces time and labor of cleaning solar panel in the absence of rain; through cleaning, will increase the solar panel efficiency

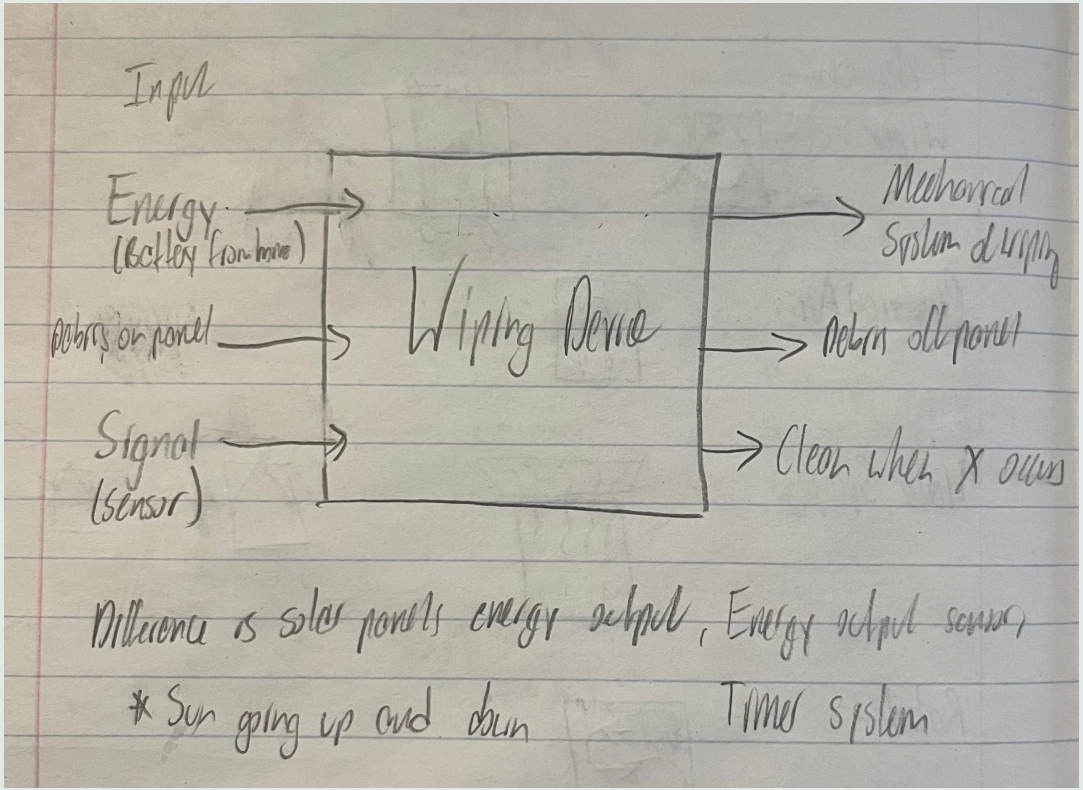
Design Criteria

- Affordability - less than $100 USD
- Easy to Install - can install within 30 minutes
- Energy Output - consistent source of energy
- Longevity - lifetime of solar panel increases by 10 years

Concept Generation Process

Step 1	Step 2	Step 3	Step 4	Step 5
Clarify the Problem	**Search Externally**	**Search Internally**	**Explore Systematically**	**Reflect on Solutions & Processes**

Step 1: Clarify the Problem



Pictured to the left: Black box diagram

Step 2: Search Externally

3 Related Patents:

- Pleco Solar
  - Robot w/ rotating brush
  - Doesn't utilize water
  - Too expensive
- Straight Sweep Windshield Wiper
  - Efficient motor arm
- iRobot Roomba
  - Excellent debris detection

Competitive Product	Patent Number	Title/Description	Relation to the Project
Pleco Solar	Based on Bar-Ilan University Patents Patent Pending?	Robot Solar Panel Cleaner	Concept for brushing debris off Rotating brush (robot does not use water)
Straight Sweep Windshield Wiper	US4245369A	Wiper arms	Concept for the movement of the wiper
iRobot Roomba	US9883783B2	Debris detection	Concept for detection of when to clean the panel.

Pleco Solar (Brushing)

Pros:

- Little to no water use
- Ease of application
- Cleaning efficiency

Cons:

- Expensive (>$100 USD)
- Not simplistic in design

How it influenced the concept selection and generation process:

- Realized importance of device not using any water/cleaning solution to bring down cost

Metric	Importance	Score
No Water Use	4	5
One-Time-Purchase	5	4
Cost	4	1
Easy-to-Use	4	5
Brushing Debris	5	5
Simplicity	5	2
Compatibility with panels	4	4

Straight Sweep Windshield Wiper

Pros:

- Efficient in motion ability
- Length
- Simplicity in design

Cons:

- Blades are not the entire length of wiper arm

How it influenced the concept selection and generation process:

- Length of blade & wiper arm
- Rotational motion

Metric	Importance	Score
Motion efficiency	4	4
Long length	4	3
Blades are whole of wiper arm length	4	1
Motor driven arm	5	4
Simple design	5	4
Low cost	5	3
Durability	5	4

Roomba Dirt Detect

Pros:

- Inability to be impeded by debris
- Durability

Cons:

- Not low cost (>$100 USD)

How it influenced the concept selection and generation process:

- Realized importance of specificity of sensor
- Detection style of sensor

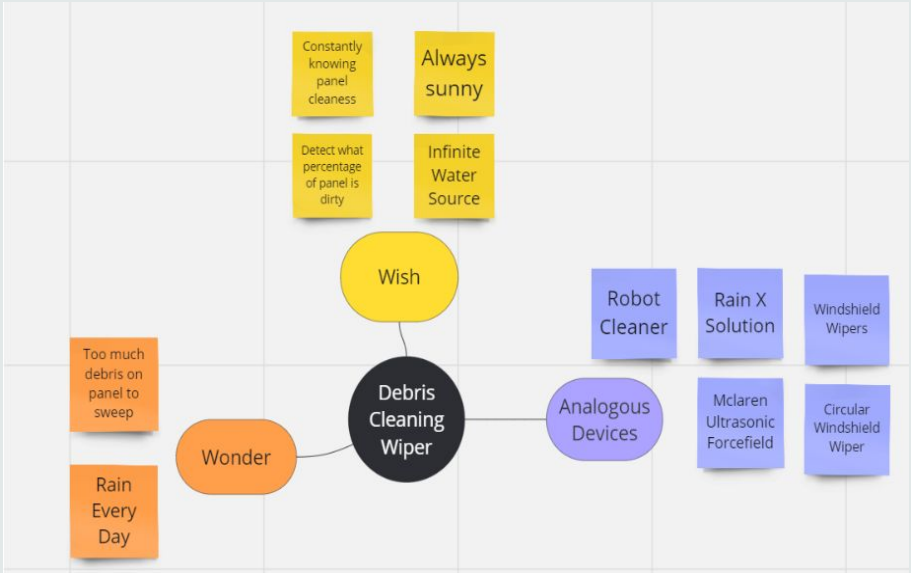
Metric	Importance	Score
Doesn't clog up	5	4
Low cost component	4	3
Piezoelectric sensor	3	5
Durable	5	4
Detects instantaneously rather than build up	3	5

Step 3: Search Internally

- Utilized ideation templates such as Miro
- Generated concepts using personal knowledge/creativity

Brainstorming:

- Wish and Wonder
  - Identify boundaries of problem
- Analogous Devices
  - Recognize similar solutions



Step 4: Explore Systematically

Store/Accept External Energy:

- Battery
- Directly from solar panel
- AC power

Triggering/Sensing Debris:

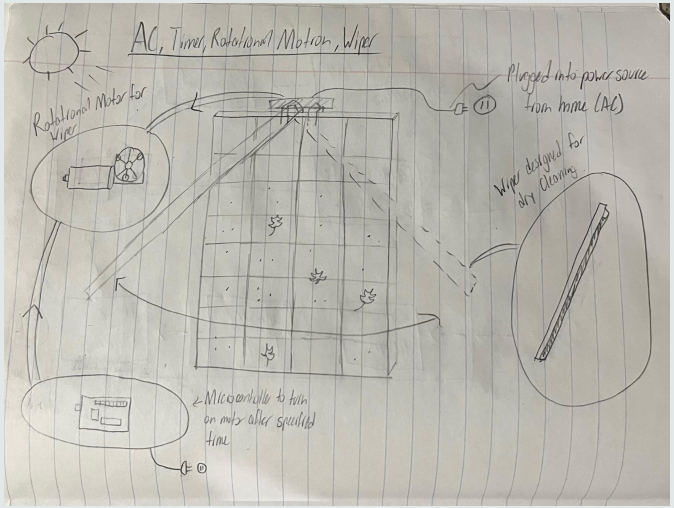
- Light detector
- Solar Efficiency
- Timer
- Manually triggered

Energy to Debris:

- Rotational motor connected directly to blade (Windshield)
- Belt driven pulley system (Horizontal)
- Air/Water/Other liquids

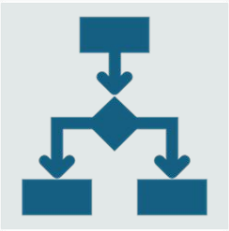
Most Promising Methods:

Store/Accept External Energy	Triggering/sensing debris	Energy to Debris
AC power	Timer	Rotational motion
Battery	Efficiency calculation	Linear motion



Sketch of 1st promising method

Step 5: Reflections on Solution & Process



Fully Explored Solution Space

- Sub functions & systems were entirely fleshed out
  - Black box diagram
  - Energy, Materials, & Signals framework

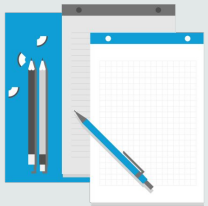
Alternative function diagrams & problem decomposition

- Ex: functional block diagram, circle diagram
- We believe that the diagrams & frameworks we used (named above) were most efficient in decomposing the problem

Step 5 (Cont.)

External sources

- Chose patents most relevant to device due to similarities in subsystems & functions



Collective brainstorm & integrated ideas

- Each member picked a different patent to explore
  - Kismet: **Straight Sweep Windshield Wiper - blade design and motion**
  - Hayden: **iRobot Roomba - sensor and detection abilities**
  - Jameson: **Pleco Solar - waterless solution & solar panel compatibility**
- Aspects welcomed & blended into final design
  - **AC power + Efficiency sensor + Wiper with Rotational Motion**

Concept Screening

Selection Criteria:

- Cleaning Effectiveness
- Detection Efficiency
- Durability
- Low Cost
- Motion Efficiency
- Simplicity

Ranked with +,-,0 system

➢ C had best Detection
  - Combine with highest overall rank (B)

	Concepts				
	A Straight Sweep Windshield Wiper + manual (Reference)	B AC Power + Timer Sensor + Rotational Motion	C Battery + Efficiency Calculation Sensor + Linear Motion	D Ultrasonic Vibration Force Field	E Circular Windshield Wipers
Net Score	0	3	-1	-1	2
Rank	3	1	4	4	2
Continue?	Revise	Yes, Combine	Yes, Combine	No	Yes

Decision Matrix

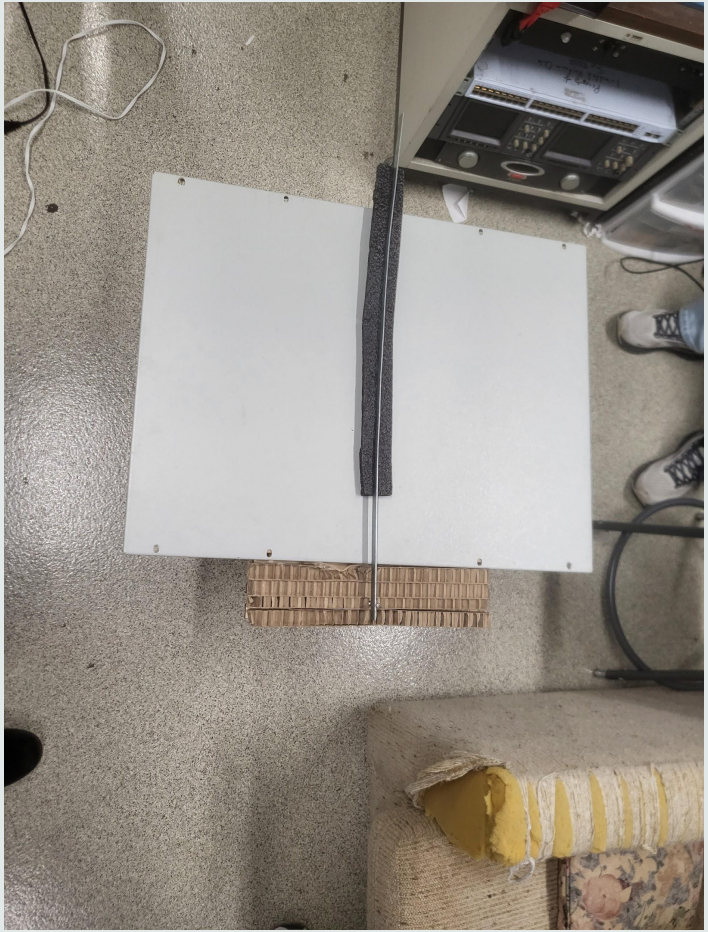
- Combined B and C
  - AC Power, Efficiency Sensor, Rotational Motion
- Weight of selection criteria determined by importance to users and product
- **BC had highest score**

		Concepts					
		A Straight Sweep Windshield Wiper		BC AC Power, Sensor, Rotational Motion		E Circular Windshield Wiper	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Durability	15%	3	.45	4	.6	4	.6
Motion Efficiency	15%	3	.45	4	.6	4	.6
Low cost	20%	3	.6	3	.6	4	.8
Simplicity	15%	3	.45	3	.45	4	.6
Cleaning Effectiveness	20%	3	.6	3	.6	2	.4
Detection Efficiency	15%	3	.45	5	.75	2	.3
Total Score Rank		3 3		3.6 1		3.3 2	
Continue?		No		Develop		No	

Low-Fidelity Prototype

Functions and Materials:

- Solar Panel
  - Metal Sheet
- Wiper
  - Metal Blade
  - Foam
  - Bolt
- Mounting Apparatus
  - Wood
  - Cardboard



Conclusion

Through the ideation process, a solution was collectively devised by our subteam that meets the design criteria:

- Proposed solution concept
  - Rotational wiper powered by AC source with an efficiency sensor
- Benefits of concept
  - Detects debris effectively
  - Efficiently removes all debris to increase energy output
  - Minimal parts to keep simplistic, affordable, and easily installable

Questions?

Citations (IEEE)

[1] “Product Pleco Solar” Blade Ranger. Accessed February 12, 2024. [Online]. Available: https://bladeranger.com/pleco/
[2] “Straight Sweep Windshield Wiper” Google Patents. Accessed February 12, 2024. [Online]. Available: https://patents.google.com/patent/US4245369A/
[3] “Debris Sensor for Cleaning Apparatus” Google Patents. Accessed February 12, 2024. [Online]. Available: https://patents.google.com/patent/US20170202419A1/
[4] All Images courtesy of Kismet Crossdale, Hayden Fuller, and Jameson Giannattasio or Microsoft Powerpoint Stock Image, Icon, and Illustration Library.

Design Concept Summary - Hayden, Jameson, Kismet

Our problem statement for the Ideation Derby is to design a device that reduces the time and labor of cleaning solar panels in the absence of rain. The proposed device, through cleaning, will increase the solar panel's efficiency.

The design criteria revolve around affordability, ease of installation, energy output, and longevity. We aim to keep the product cost under $100 USD and ensure the installation takes no longer than 30 minutes. The energy output of the solar panel should remain a consistent source of energy, despite the cleaning apparatus. Lastly, we want to elongate the lifetime panel by 10 years.

Nigeria is hot with consistent power outages due to an unreliable power grid. Our team aims to reduce the cost of cleaning solar panels, thereby lowering the overall maintenance expenses, and making it more feasible for families to adopt solar panels. Our target users are lower to middle-class families in Nigeria, for whom affordability is paramount in making solar panels more accessible. An easy install cuts down the amount of time and labor solar panel maintenance takes, especially for working-class families. Cleaning debris will ensure a consistent source of solar energy, which is vital to a region with such an unreliable power grid. Extending the longevity of a solar panel ensures that a family can keep a solar panel for longer, essentially "stretching their dollar" and getting their money's worth out of the solar panels they originally purchased for years to come.

Our solution concept works similarly to a windshield wiper, where a rotating arm will sweep away dirt, dust, and debris. We built a physical prototype out of materials we had free access to, including cardboard, wood, metal, foam, bolts, and hot glue.

A main throughline between the solution concept, physical prototype, and problem statement is the time and labor it takes to clean residential solar panels. In our solution concept and physical prototype, we established a wiper arm that would utilize rotational motion in order to quickly sweep off debris and we entail little to no labor from the users other than the initial install.

For the solution concept developed through the ideation process, a low-fidelity prototype was created to show the connections to our design criteria, and professional, societal, and DEI considerations. To meet the needs of a simplistic product, a minimal amount of parts were used in the construction of the prototype to demonstrate that the design will be simple to install. The low amount of total parts will also help in keeping the total costs down so that our team can offer an affordable solution. The wiper arm and mounting apparatus will be relatively cheap to reproduce, cutting cleaning and maintenance costs. Our prototype is representative of a low-cost solution that would satisfy our professional consideration (financial resources) of our users. With our proposed efficiency sensor, the panel will always be producing the most energy possible since it will be wiped clean frequently, helping to aid users in receiving the full benefits of solar. This satisfies our energy output criteria. The poor infrastructure of the power grid will be compensated by the reliability of the solar panels that we will clean and ensure a consistent source of solar energy.

IED MS2 Peer/Self Feedback (10pts)

Sub-Team Student Names Jameson, Hayden, Kismet **Full Team Name** Team Scott **Section** 8

The following document should be filled out by each reviewing team and by the presenting team as a self-evaluation. Circle YES or NO to score each criterion (YES=1 point). No half points are possible. A "YES" indicates a response was completely clear, on topic and unambiguous otherwise each criterion should be scored as NO.

Intro/Problem Statement

- Presented the problem statement and design criteria in a clear unambiguous manner. YES / NO

Research

- Summarized research findings. YES / NO
- Summarized how research findings influenced concept generation/selection process. YES / NO

Concept Selection

- Reviewed sub-teams 5-step concept generation and ideation process. YES / NO
- Demonstrated Low-fi prototype model YES / NO
- Discussed Societal and DEI Considerations and how these influenced concept selection YES / NO

Conclusion and Q &A

- Conclusion summarized major points YES / NO
- Provided final persuasive argument in favor of their concept idea YES / NO
- Invited questions and responded in a professional manner YES / NO
- Presentation was well paced and used appropriate time YES / NO

Total Points for Sub-Team Presentation 10/10

Narrative Feedback (Keep comments brief)

Two highlights of presentation and two areas to improve or further develop:

Highlights

- Demonstrated prototype with functioning subfunctions
- Explained research findings and how they spurred ideas in design

Improvements

- Type of wiper blade can be improved to a brush or some other material
- develop a better way to place the wiper onto the solar panel with mounting apparatus

Technical questions left unanswered by the presentation:

- How the motor will play a factor
- How big the box that stores the motor/sensor will be

IED MS2 Peer/Self Feedback (10pts)

Sub-Team Student Names Hayden, Kismet, Jameson **Full Team Name** Team Seven **Section** 8

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- Provided final persuasive argument in favor of their concept idea — YES / NO
- Invited questions and responded in a professional manner — YES / NO
- Presentation was well paced and used appropriate time — YES / NO

Total Points for Sub-Team Presentation 10/10

Narrative Feedback (Keep comments brief)

Two highlights of presentation and two areas to improve or further develop:

good prototype
well organized presentation
what type of cleaning surface
find energy consumption

Technical questions left unanswered by the presentation:

wiper material
motor type/control

IED MS2 Peer/Self Feedback (10pts)

Sub-Team Student Names Kismet, Jameson, Hayden **Full Team Name** Team Seven **Section** 8

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- Invited questions and responded in a professional manner — YES / NO
- Presentation was well paced and used appropriate time — YES / NO

Total Points for Sub-Team Presentation 10/10

Narrative Feedback (Keep comments brief)

Two highlights of presentation and two areas to improve or further develop:

2 Highlights
→ our description of the 5 step process
→ our ~~concise and well prep~~

2 Areas to improve/develop
→ what ~~title~~ type of appartus that would be added to arm/blade (i.e. rotating brush)
→ how much energy that would take

Technical questions left unanswered by the presentation:

IED MS2 Peer/Self Feedback (10pts)

Sub-Team Student Names Kismet, Jameson, Hayden **Full Team Name** Team 7 **Section** 8

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Research

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- Summarized how research findings influenced concept generation/selection process. (YES) / NO

Concept Selection

- Reviewed sub-teams 5-step concept generation and ideation process. (YES) / NO
- Demonstrated Low-fi prototype model (YES) / NO
- Discussed Societal and DEI Considerations and how these influenced concept selection (YES) / NO

Conclusion and Q &A

- Conclusion summarized major points (YES) / NO
- Provided final persuasive argument in favor of their concept idea (YES) / NO
- Invited questions and responded in a professional manner (YES) / NO
- Presentation was well paced and used appropriate time (YES) / NO

Total Points for Sub-Team Presentation 10/10

Narrative Feedback (Keep comments brief)

Two highlights of presentation and two areas to improve or further develop:

*goal is to be low cost

*Overall presentation → very organized

↳ spend less time

↳ weight of wiper itself (not too heavy not too light)

↳ speed unkown, power unkown → will be decided later

Technical questions left unanswered by the presentation:

IED MS2 Peer/Self Feedback (10pts)

Sub-Team Student Names Kismet, Hayden, Jameson **Full Team Name** Team 7 **Section** 8

The following document should be filled out by each reviewing team and by the presenting team as a self-evaluation. Circle YES or NO to score each criterion (YES=1 point). No half points are possible. A "YES" indicates a response was completely clear, on topic and unambiguous otherwise each criterion should be scored as NO.

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Conclusion and Q &A

- Conclusion summarized major points — YES / NO
- Provided final persuasive argument in favor of their concept idea — YES / NO
- Invited questions and responded in a professional manner — YES / NO
- Presentation was well paced and used appropriate time — YES / NO

Total Points for Sub-Team Presentation 9/10

Narrative Feedback (Keep comments brief)

Two highlights of presentation and two areas to improve or further develop:

→ Concept Selection
→ Solar panel cleaner prototype → very organized

louder voices

Technical questions left unanswered by the presentation:

where debris will be moved to

IED MS2 Peer/Self Feedback (10pts)

Sub-Team Student Names hayden fuller, jameson grimtkssin kismet crossdale **Full Team Name** Team Seven **Section** 08

The following document should be filled out by each reviewing team and by the presenting team as a self-evaluation. Circle YES or NO to score each criterion (YES=1 point). No half points are possible. A "YES" indicates a response was completely clear, on topic and unambiguous otherwise each criterion should be scored as NO.

Intro/Problem Statement

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Research

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- Reviewed sub-teams 5-step concept generation and ideation process. (YES) / NO
- Demonstrated Low-fi prototype model (YES) / NO
- Discussed Societal and DEI Considerations and how these influenced concept selection (YES) / NO

Conclusion and Q &A

- Conclusion summarized major points (YES) / NO
- Provided final persuasive argument in favor of their concept idea (YES) / NO
- Invited questions and responded in a professional manner (YES) / NO
- Presentation was well paced and used appropriate time (YES) / NO

Total Points for Sub-Team Presentation 10

Narrative Feedback (Keep comments brief)

Two highlights of presentation and two areas to improve or further develop:

- very Professional - slides look great
- very fluid & well spoken

- better hot glue
-

Technical questions left unanswered by the presentation:

how to get brush not to scratch solar cell?
what kind of brush?
how heavy should brush be?

MS2 Totals Form

Sub-team A
Sub-Team team members: Kismet, Hayden, Jameson

	Total Points for Sub-Team Presentation (IED MS2 Peer/Self Feedback)
Sub-team A (self-score)	10 /10
Sub-team B	9.67 /10
Sub-team C	/10
AVERAGE:	9.83 /10

Sub-team B
Sub-Team team members: Fanta, Hamsi, Nate

	Total Points for Sub-Team Presentation (IED MS2 Peer/Self Feedback)
Sub-team A	7.2 /10
Sub-team B (self-score)	8.67 /10
Sub-team C	/10
AVERAGE:	7.93 /10

Sub-team C
Sub-Team team members: _____

	Total Points for Sub-Team Presentation (IED MS2 Peer/Self Feedback)
Sub-team A	/10
Sub-team B	/10
Sub-team C (self-score)	/10
AVERAGE:	/10

Prototype Documentation

Describe how the prototype was proficiently used to evaluate broad concept ideas or different solutions options.

- In the prototype, we explored the broad concepts of mounting apparatuses to the solar panel and rotational motion of the wiper
- For rotational motion, we chose to have our wiper operate 180 degrees, from the center of the panel's long edge, so that it can clean the entire panel.
- For the mounting apparatus, we needed to show how we intended to hold and support the wiper on the panel, implementing a device that allows for the wiper to move

Describe how the prototype was proficiently used to understand form and physical relationships between elements of the concept solution.

- Foam was put onto the wiper to show a softer brushing material so as to not scratch the panel and remove debris.
- We realized that our mounting apparatus needed to be at a greater height to the side of the panel instead of just being below the panel. With the extra height of our mounting piece, the wiper was attached to the piece with less egregious effort, allowing for an easier install.

Describe how the concept solution proposal includes improvements found through engagement with one or more important functional features.

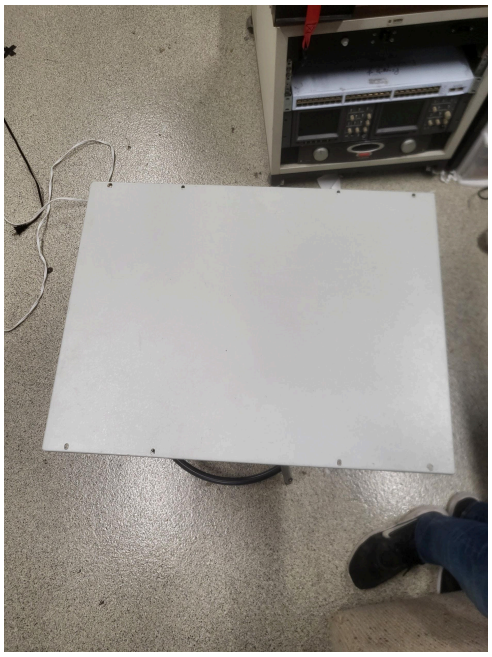
- We discovered that the mounting system we will likely have plenty of space to house the electronics as well
- We also decided on the position of the wiper. It would be placed in the center and be a shorter wiper than we originally conceptualized. This means that the wiper will have less mass and use less energy.

Describe how the prototype actively follows through on modelling new and potentially risky concepts.

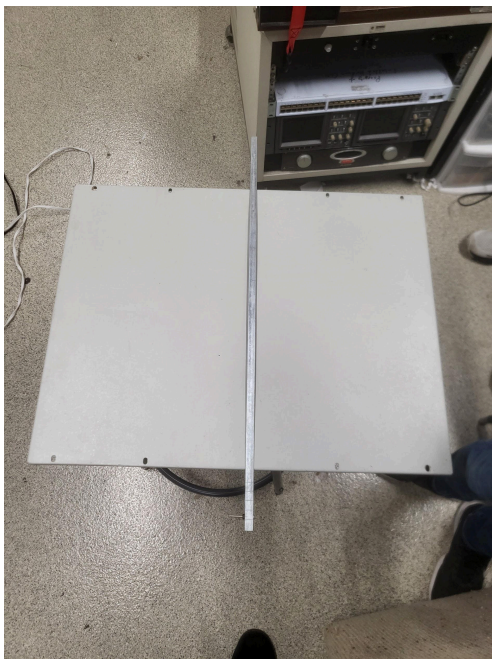
- The geometry of both the mounting system and the wiper was something that could only be considered with a physical prototype. We needed to create a wiper that could reach the entirety of the panel and also not egregiously interrupt the cleaning process of other panels. We needed to create a mounting system that had a universal compatibility with solar panels. We needed to make sure that it's not a mounting system that we attached to the roof. Through prototyping, we created a device that fit all these specifications.

Images Here w/ Captions:

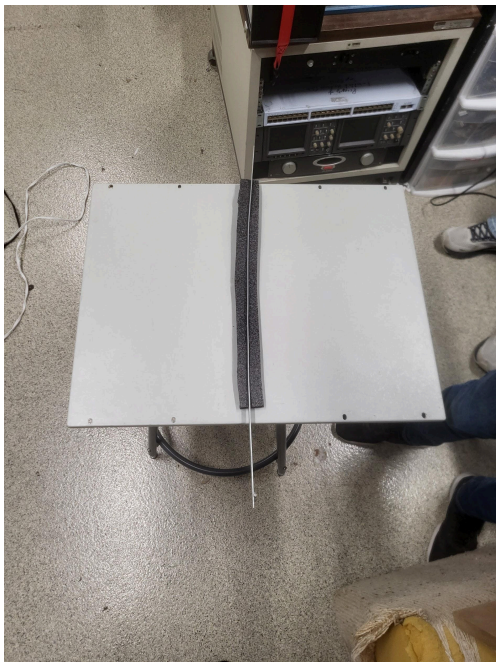
Solar panel:



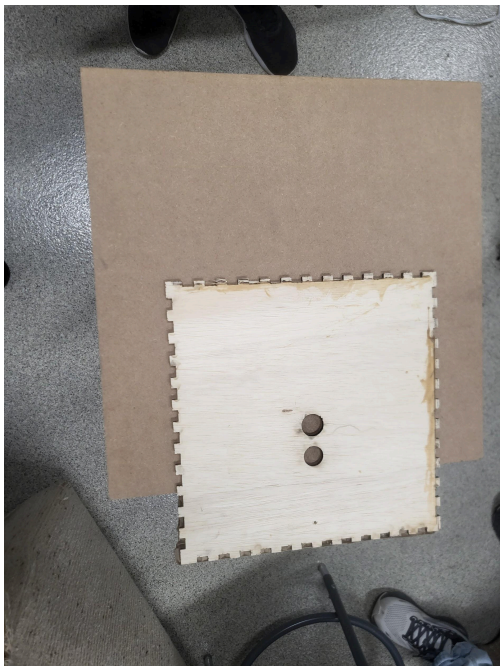
Solar panel with wiper:



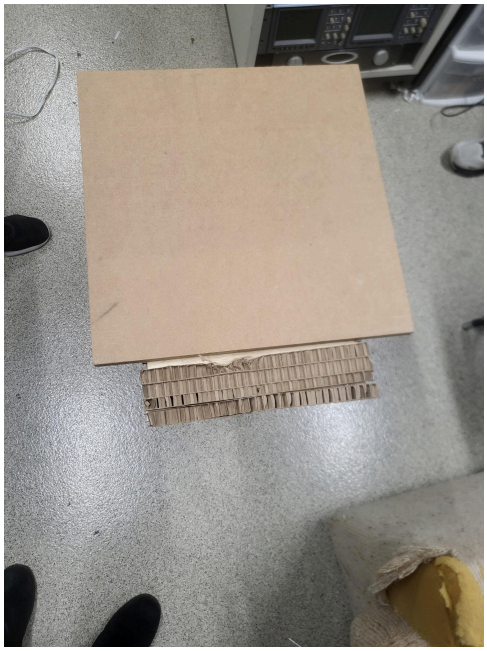
Foam attached to wiper:



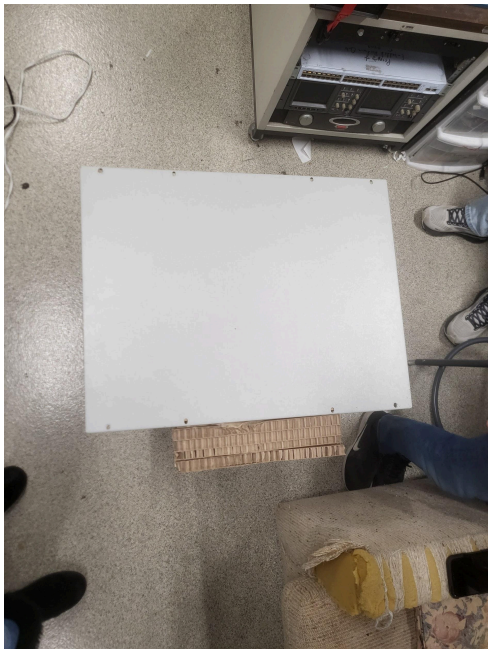
Mounting apparatus:



Existing solar panel mounting system with cleaning mounting system added:



Solar panel mounted with it’s mounting systems and cleaning mounting system attached:



Rotational wiper full lo-fi prototype: