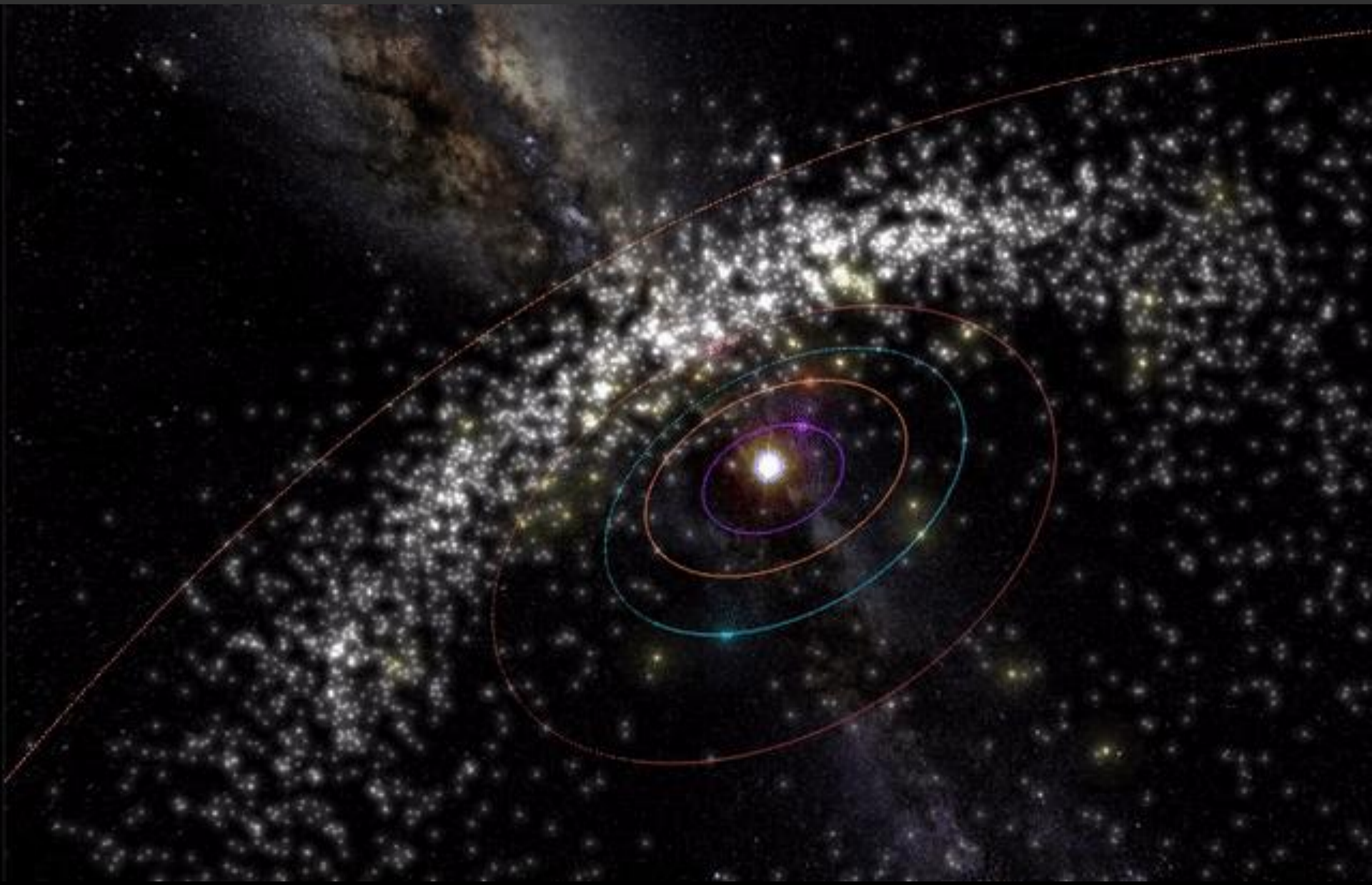


DRAGONFLY

Sensing Your Opportunities in Space

#BringMeARock

ASTEROID MINING

Team Dragonfly
2016 NASA SpaceApps Challenge
Laimis Belzinskas, Miranda Caudill, Daniel Dudley, Muz Hasan, Jessica Ice, Eugene Malinskiy, Andy Mitofsky, Brad Roskoph, Lauren Roskoph, Beck Strauss

Problems

- Need a lot of resources to survive in space
- Very expensive to bring materials from Earth ($770 – $10,000 per POUND to Low Earth Orbit)
- Increasingly expensive to retrieve materials on Earth
- Some asteroids are also potentially headed towards Earth (Angry Asteroids ARE COMING!)

Scenario

- 20-30 years in the future
- Active Moon Colony with manufacturing and refining capacities
- Ongoing mission to Mars

Mission

Hydrogen & Oxygen

Gold

Plutonium

Osmium

Nitrogen

Cobalt

Rhodium

Nickel

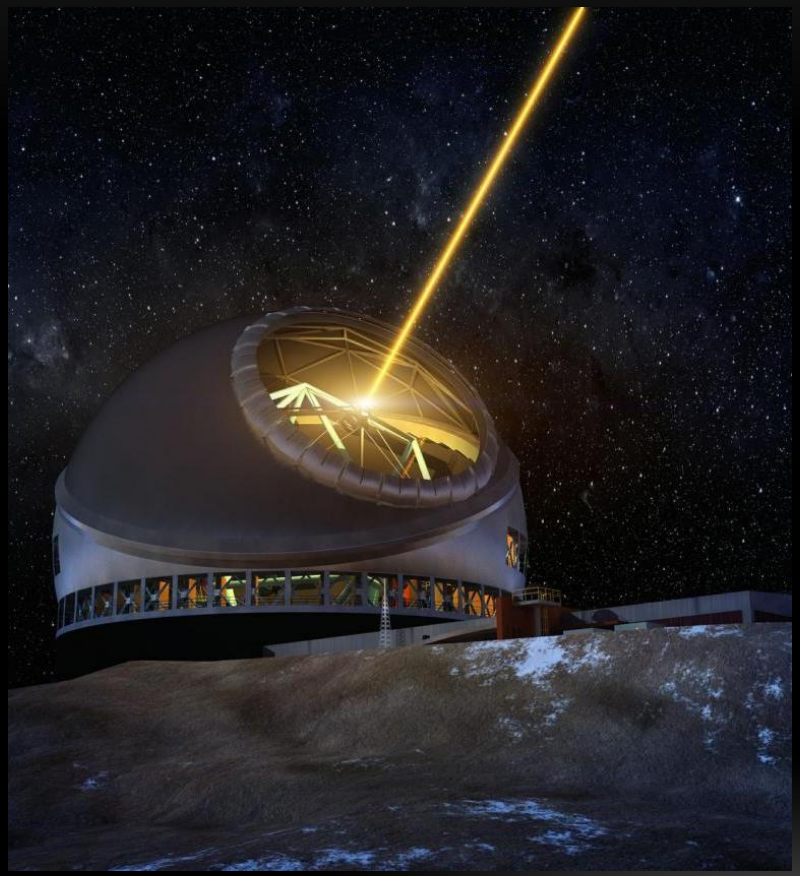
Platinum

Ruthenium

Our Mission:

Identify key resources from near earth/moon objects (NEMOs) to sustain human life and continue exploration by using exploratory cube satellites called *Dragonflies*.

How will we find our target?



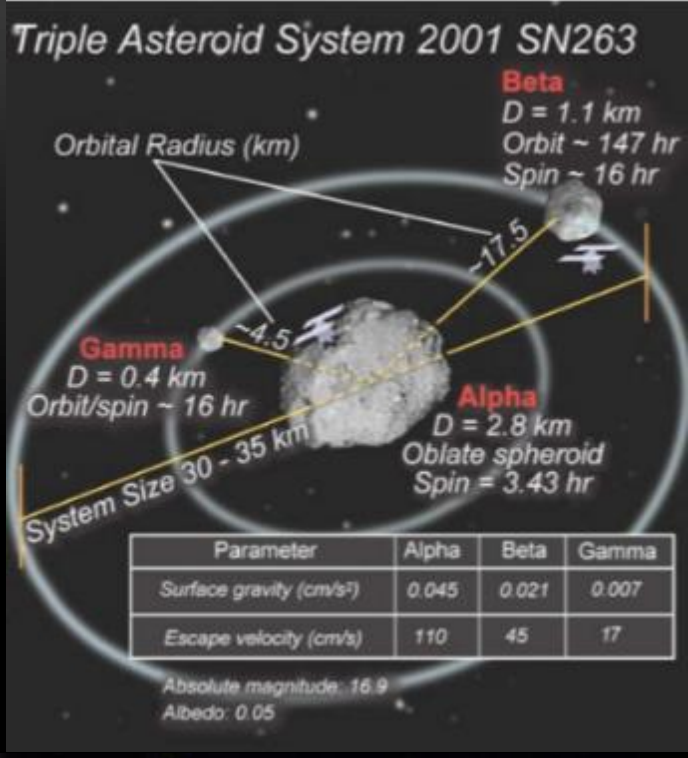
- Use infrared and optical telescopes with radar, Doppler, and infrared spectroscopy capabilities
- Located on the dark side of the moon to avoid glare
- Combine data to identify size, location, speed, rotation, and composition of NEMOs

Which NEMOs will we target?

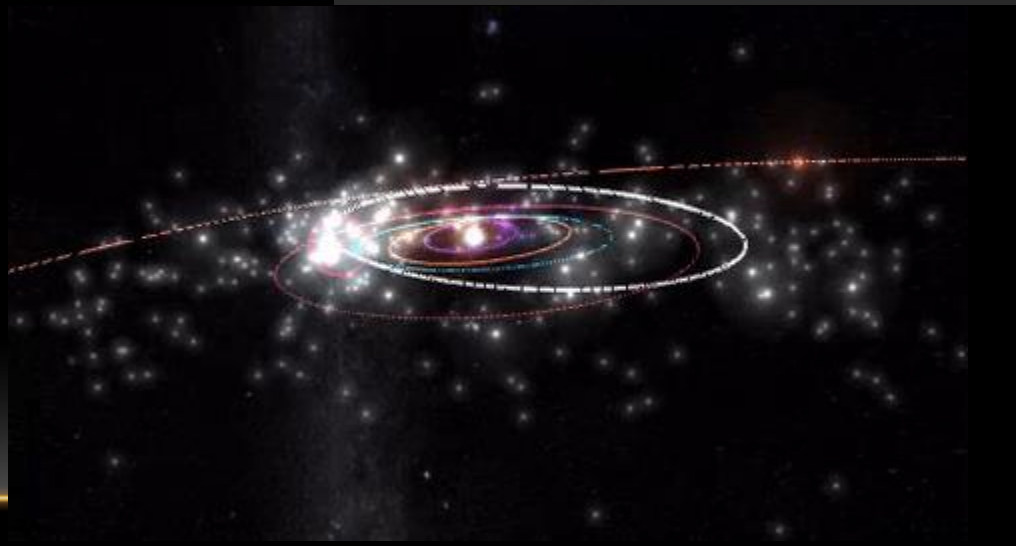
- Composition: Carbonaceous (C-type) asteroids
  - Have many of the important minerals, require least energy to mine, and are the most abundant in space
- Speed: Slow
  - Ideally 5 to 10k per hour
- Rotation: Slow
  - Much easier to land on
- Size: Large or multiple clustered together
  - Most cost effective
- Location: Near to the moons orbit
  - More frequent mission potential

Sample Target– 2001 SN_{263}

- Composition – C-type
- Size: One of only two known NEMOs that are a **triple asteroid cluster**
  - Alpha - diameter of 2.8km
  - Beta - 1.1 km in diameter
  - Gamma - 0.4 km in diameter
- Orbit near Earth and Moon
- Low Delta V and Spin



Parameter	Alpha	Beta	Gamma
Surface gravity (cm/s²)	0.045	0.021	0.007
Escape velocity (cm/s)	110	45	17



How we get there

- Launcher system
  - Modular
  - Easy Construction
  - 4 Dragonflies
  - Core Javelin Miniature satellite
- Dragonflies are let loose in cluster formation
- As the rocket separates the Javelin telescopes
- Remaining launcher assembly is retrieved for re-use


DRAGONFLY

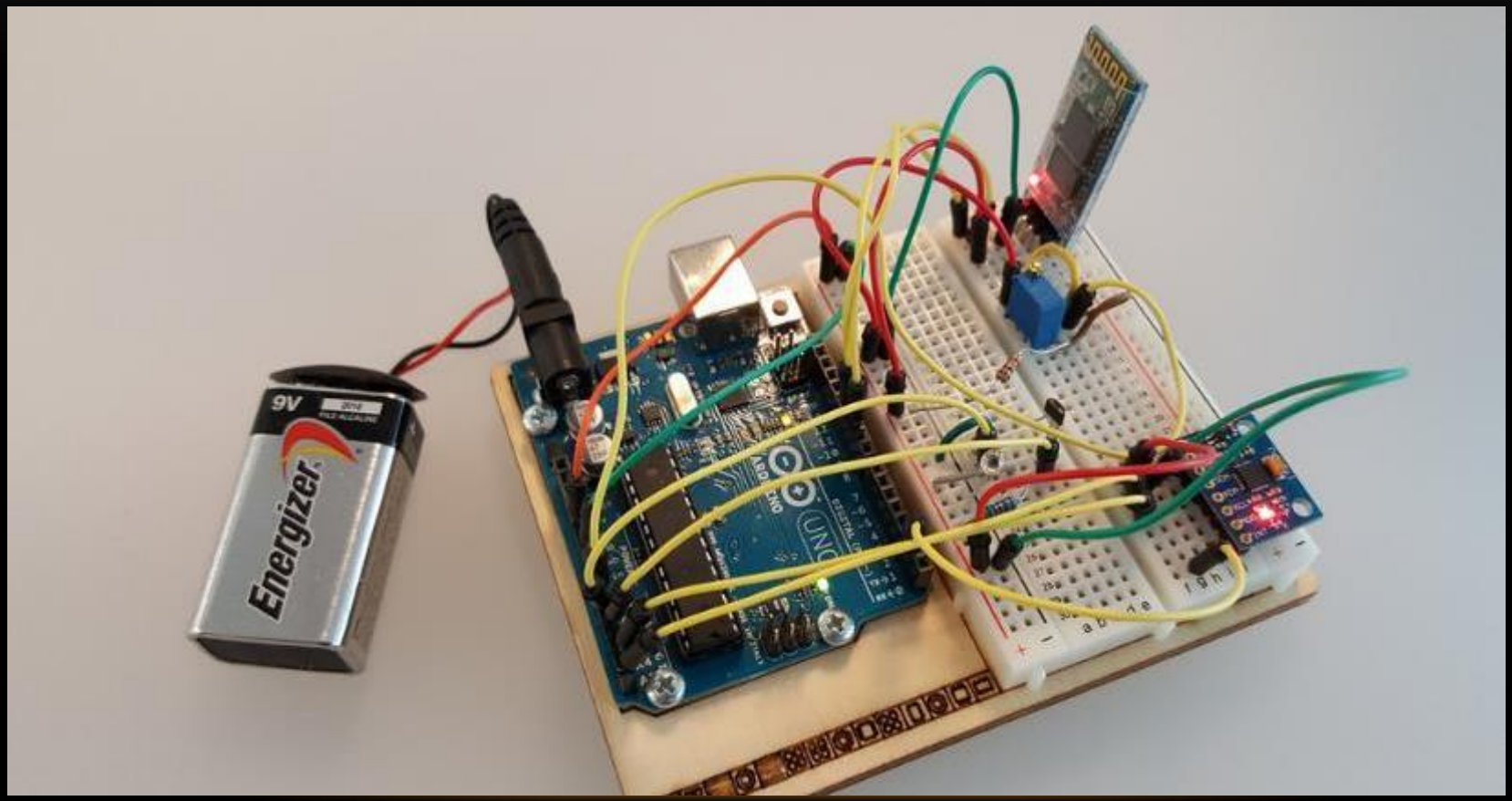
Dragonfly

- **Dragonfly Cluster** – send out set of modular, medium-production satellites
- Each dragonfly contains a **modular sensor package** to analyze a potential mining target
- **Communication** possible between satellites using a built in mesh-net with interferometry, location, and navigational aspects

Dragonfly – Sensor Package

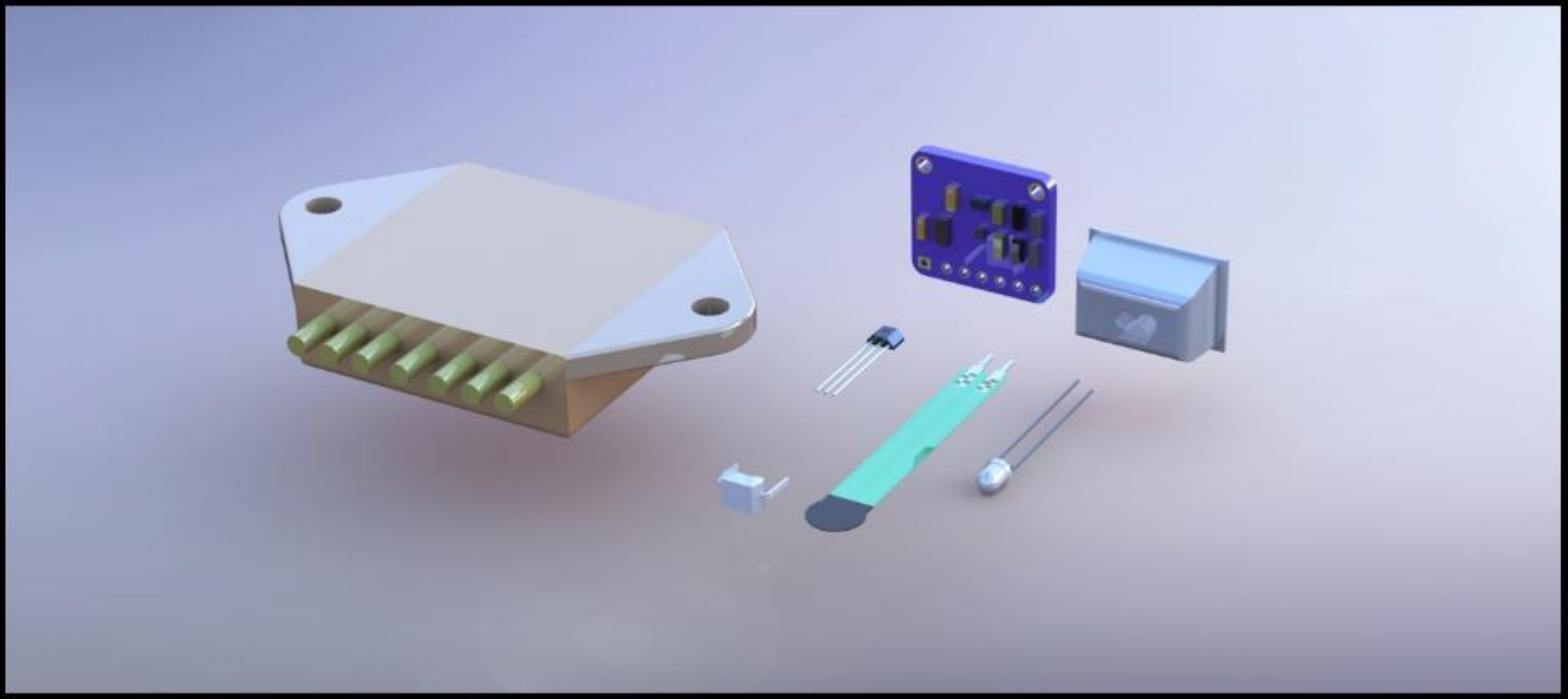
- Dragonfly Telescopic Imaging System (DT-IS)
- Dragonfly 3D Imaging System (D3D-IS)
- Dragonfly IR/Thermal/UV System (DIRecT-US)
- Dragonfly Gamma+Neutron+X-Ray Spectrometer Complex (DGNX-SC)
- Dragonfly Laser Spectrometer (DLS)
- Dragonfly High+Low Frequency Radar Multi-Sat System (DHLR-MSS)

Sample Dragonfly Sensor Board

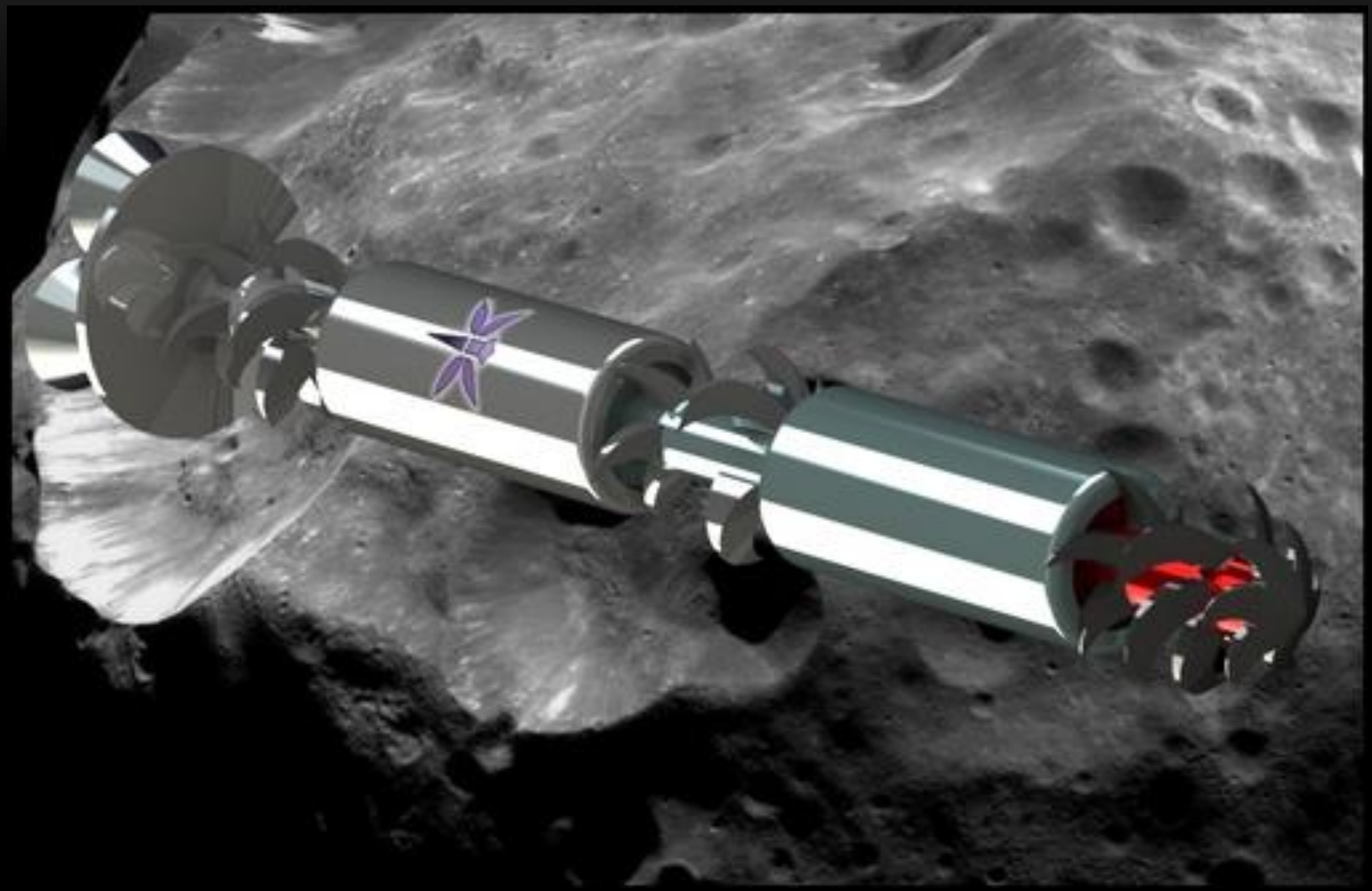


Gyroscope, Accelerometer, Light Sensor, Hall Effect, Force Sensor

Dragonfly – Sensor System (modularized)

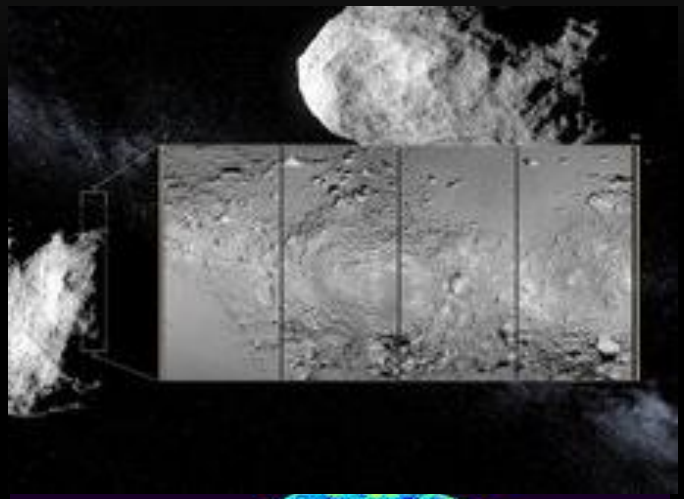


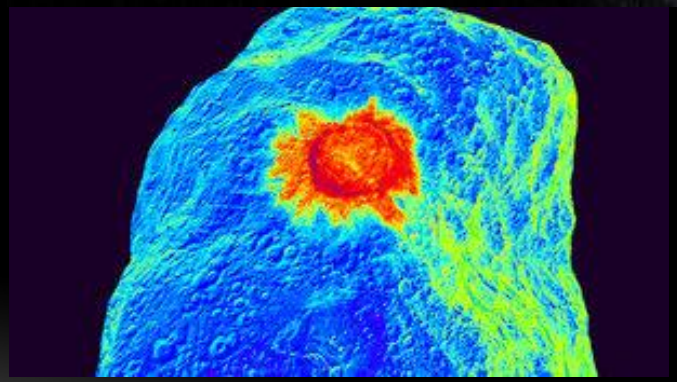
Dragonfly - Javelin



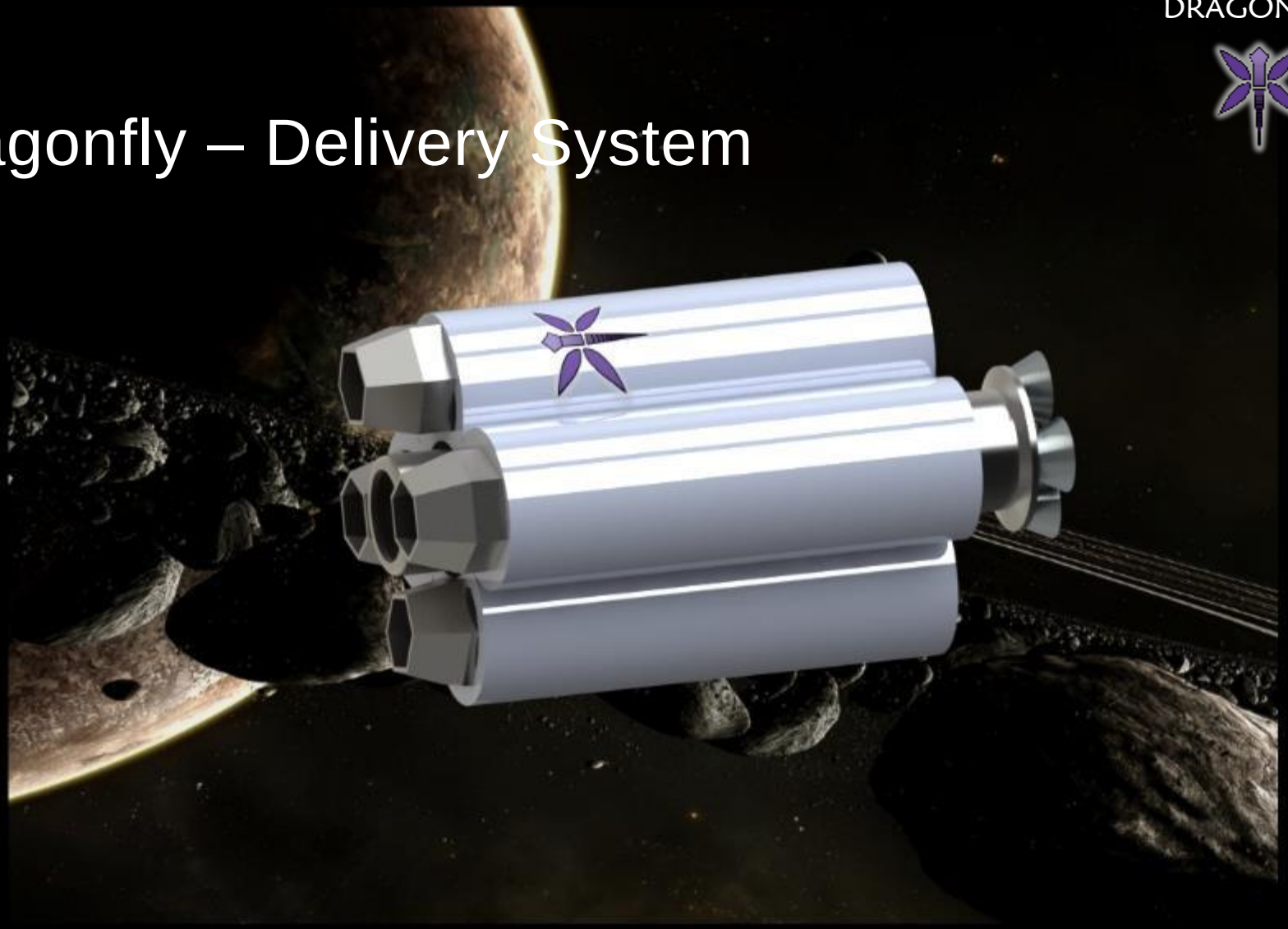
Dragonfly – Javelin Specification

- Javelin Magnetometer System (JMS)
- Javelin GC/MS System (J-GCMS)
- Javelin IR/UV/Vis (J-Spectrum)
- Javelin Ground Penetrating Radar (JGPR)





Dragonfly – Delivery System



Mining and Refining

- Once a key target has been identified a **drilling rig will be sent to the asteroid** to **secure, drill, and potentially refine the materials**
- One option for mining and drilling was proposed in the **Star-Whals Project**
- It is also possible to **attach multiple Javelins to solar sails in order to manipulate orbit of the asteroid** or relocate it to near moon location

Economic Impact

Opportunity to turn threats into profit centers.

1) Preventing disaster to Earth

- Mining Asteroids can prevent future asteroid collisions with Earth

2) Dramatically reduce the cost of space mining

- Weight of mining rig expected to be around 9000kg, weight of the Dragonfly 15kg
- Able to accurately predict composition 90 percent of the time – huge cost savings to deploy mining rigs to only most valuable sites.

Economic Impact

Opportunity to turn threats into profit centers.

3) Dramatically Reduce the Cost of Living In Space

- Cost of transporting *one pound* of cargo into low earth orbit ranges from $770 to $10,000
- One 75 meter diameter C-type asteroid potentially has enough water to run all of the Space Missions to date.
- Resources in two similar sized C-type asteroids were valued by Asterank at **2.62 trillion** and **168.20 billion**

Thank you!

Find ***extensive*** information on asteroid mining, and our solution to it + Renders + Circuit Diagrams on our page Project and GitHub page

- https://2016.spaceappschallenge.org/challenges/solar-system/asteroid-mining/projects/the-dragonfly-sensing-your-opportunities-in-space
- https://github.com/DragonID/NASAAsteroidMiningChallenge2016

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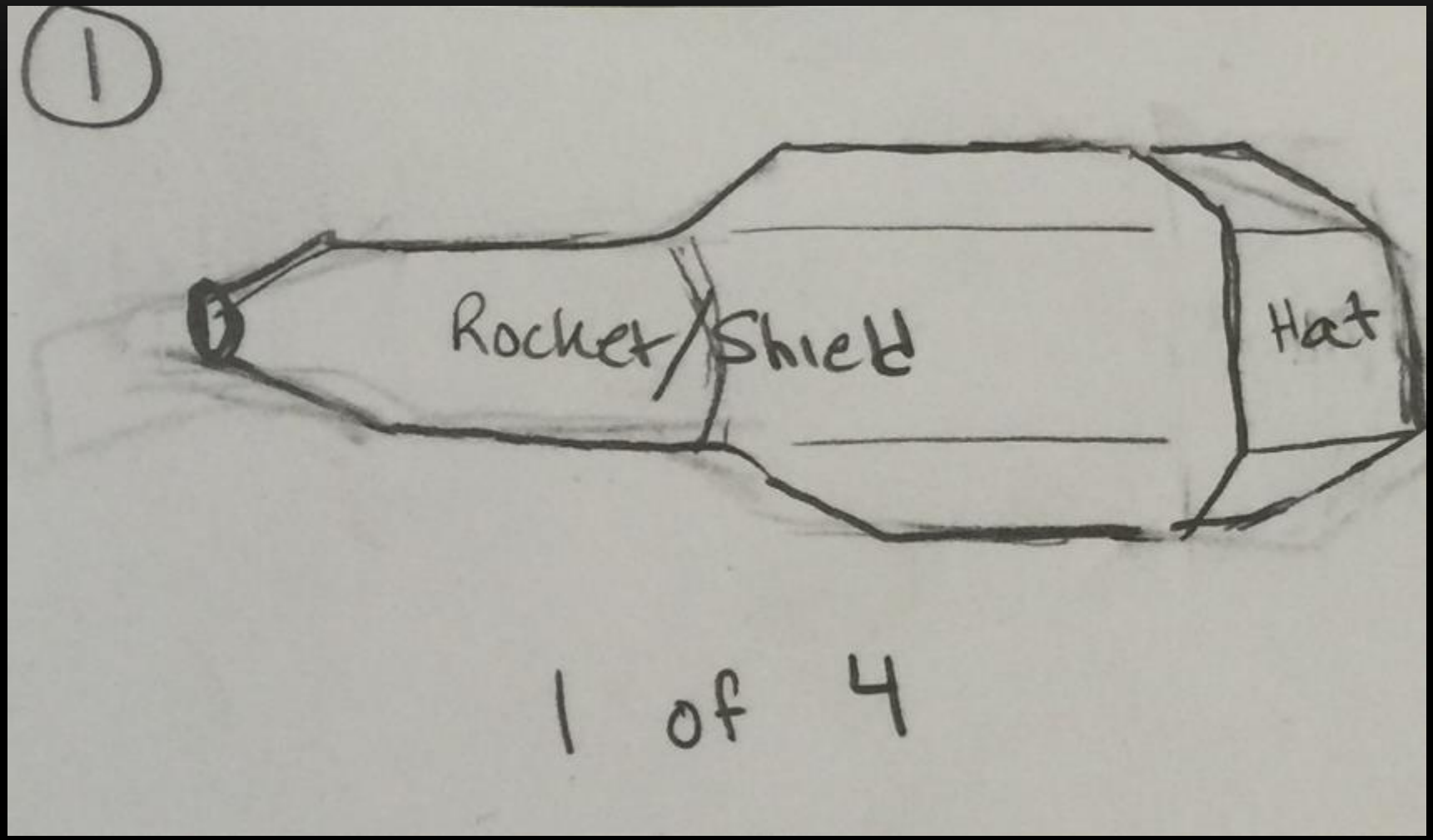
- Info on 2001 SN263: http://www.lpi.usra.edu/meetings/lpsc2011/pdf/2695.pdf
- Moon Telescope - http://cdn.phys.org/newman/gfx/news/hires/2014/3-construction.jpg

Concept Drawings



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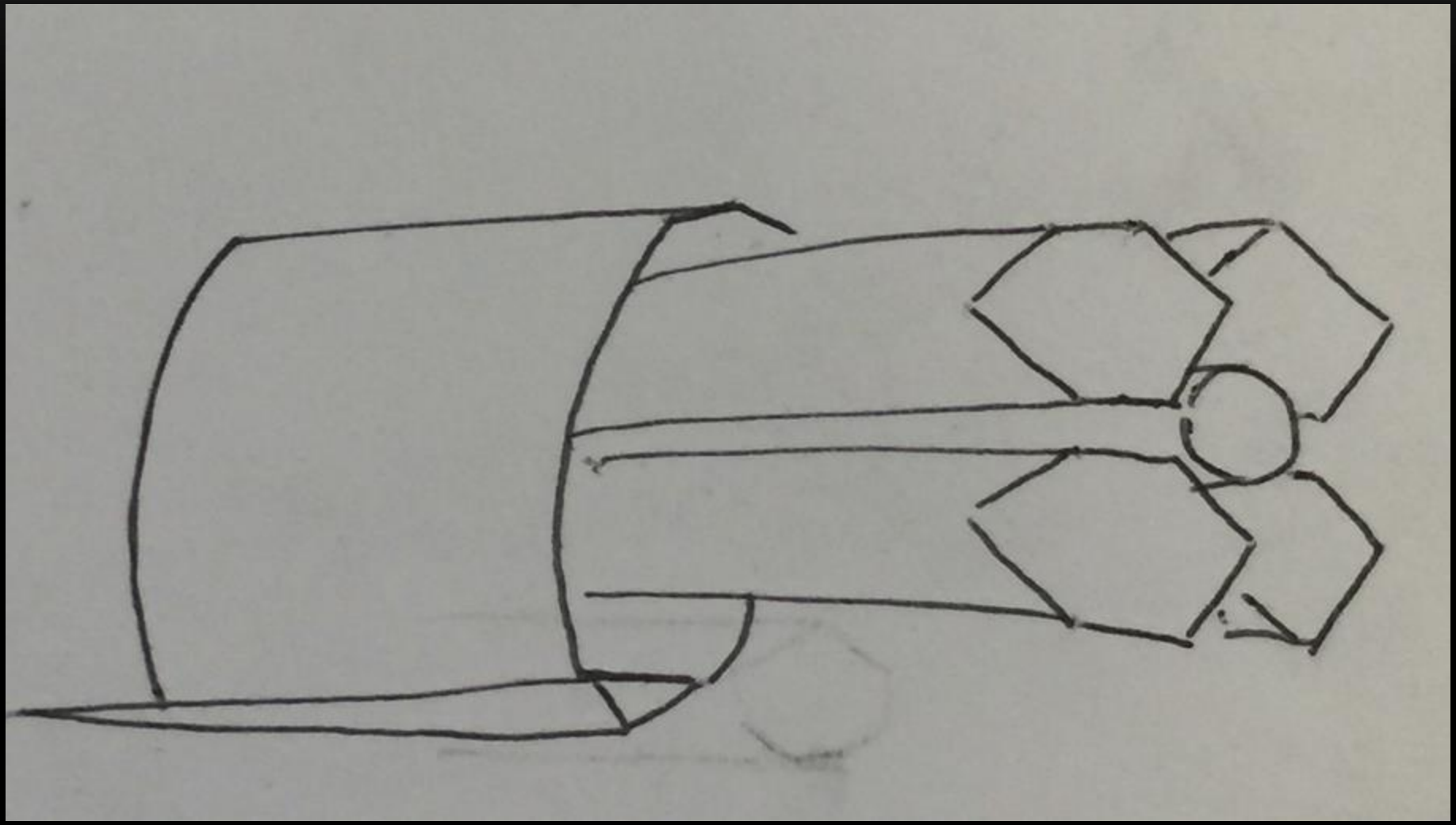

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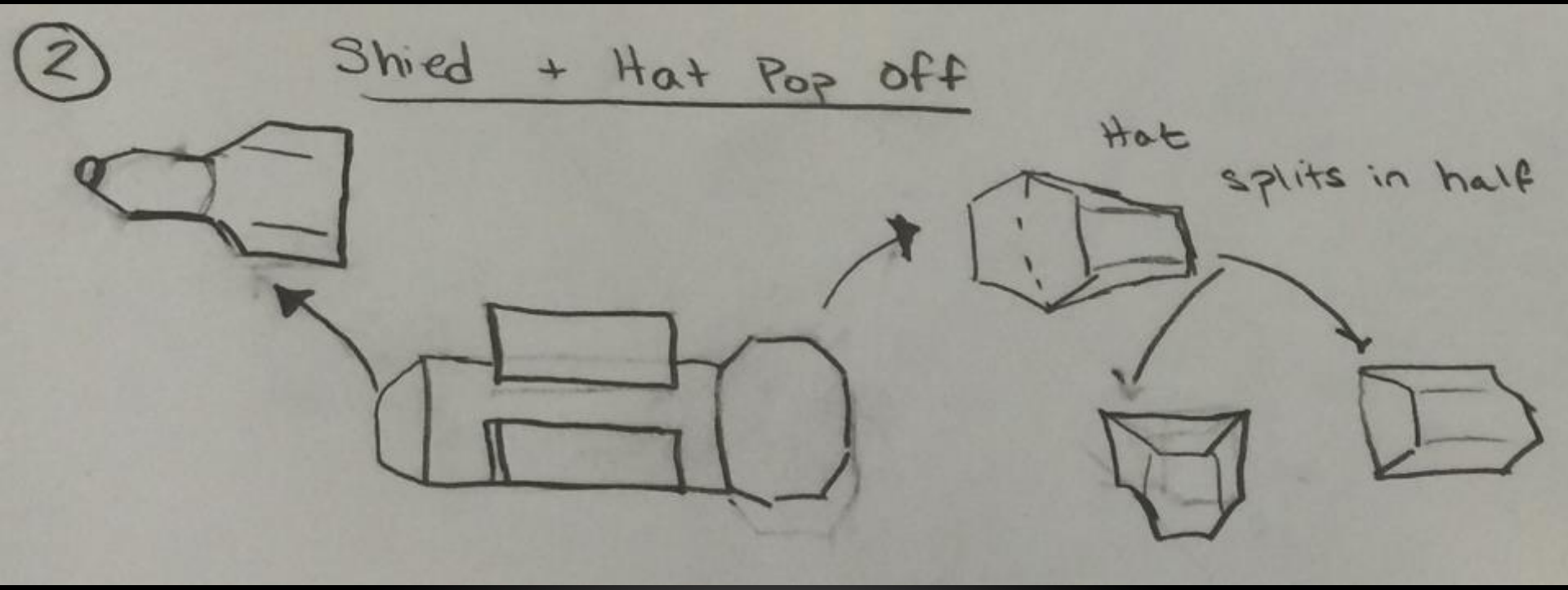

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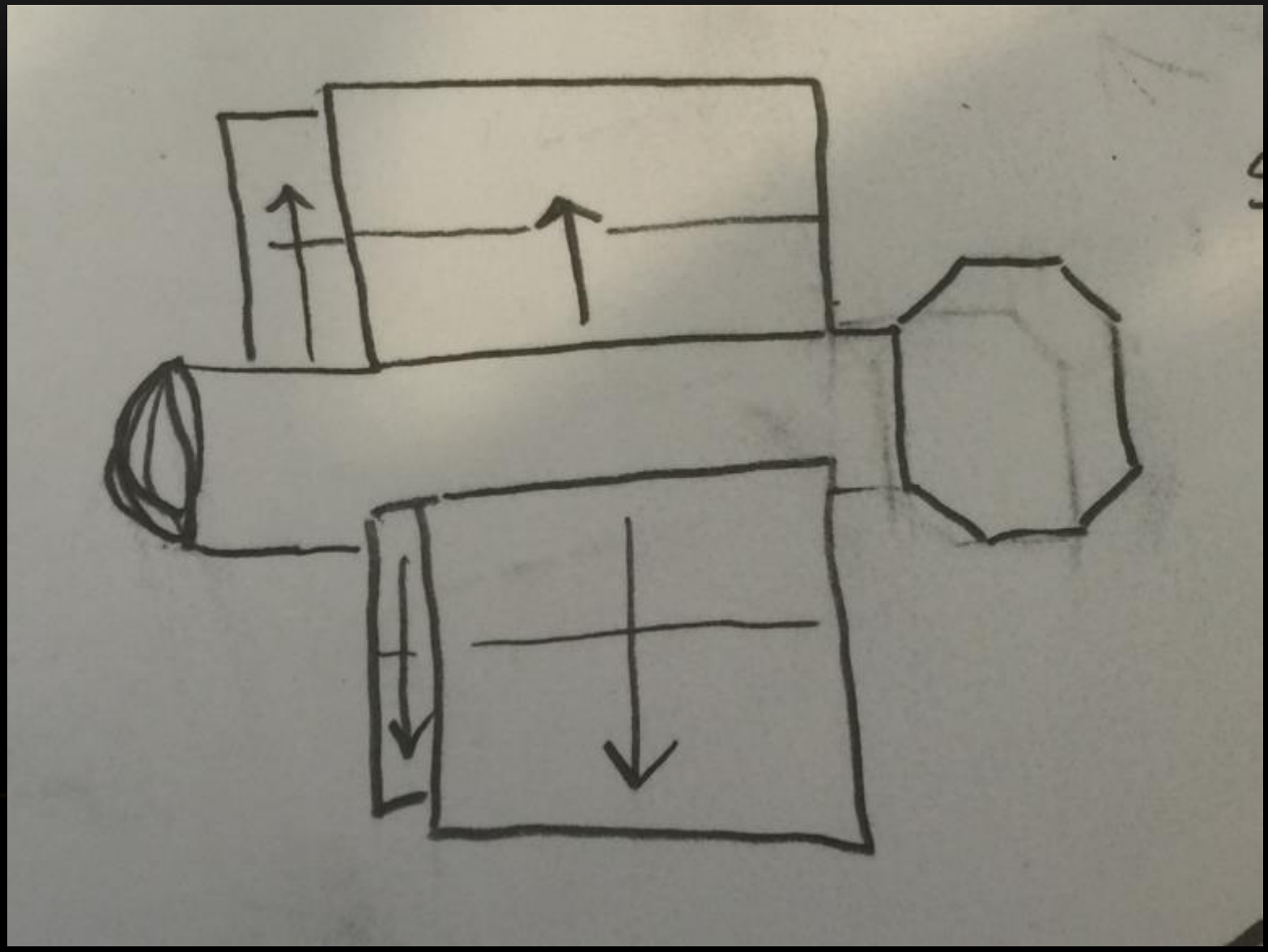

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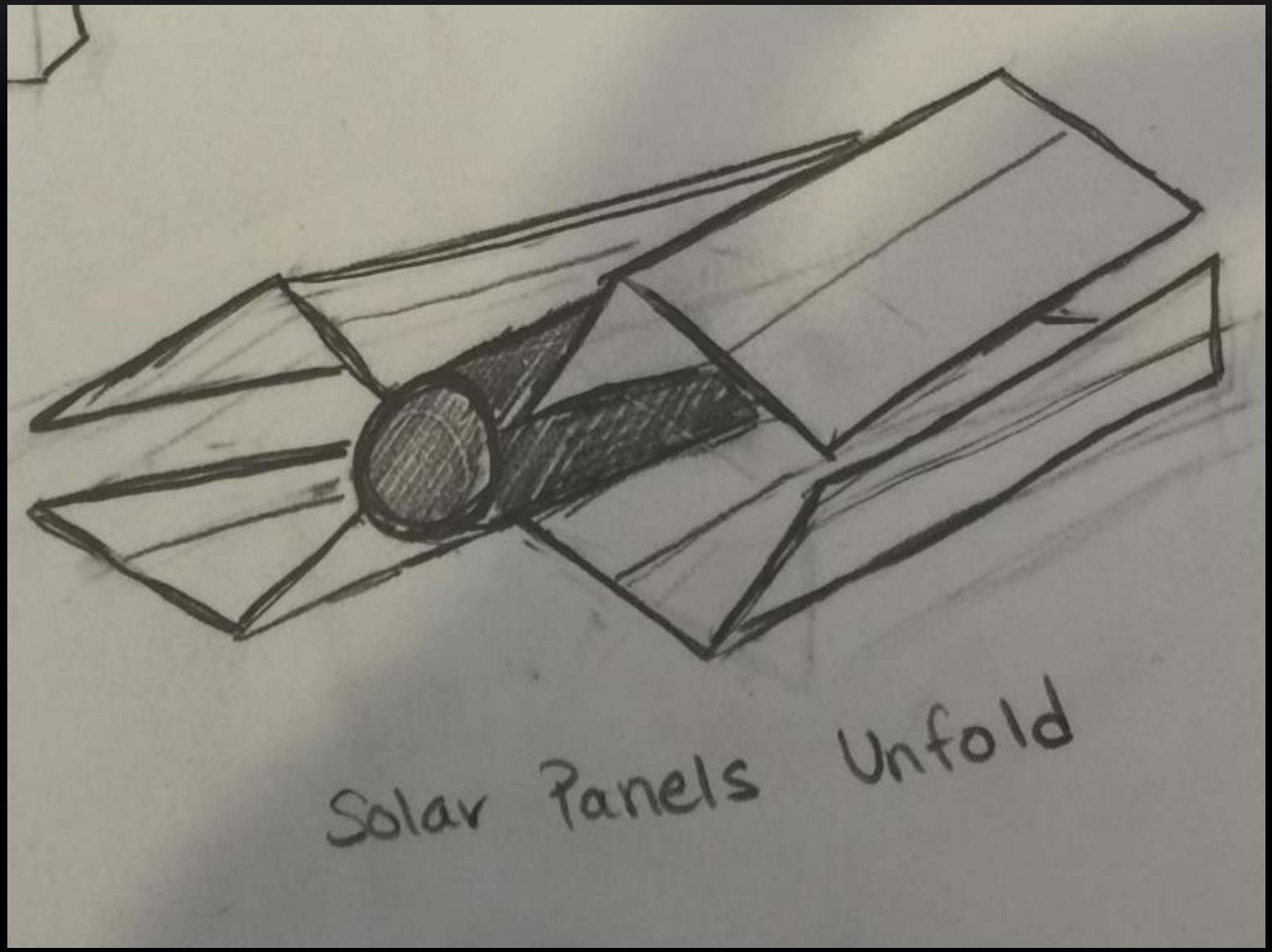

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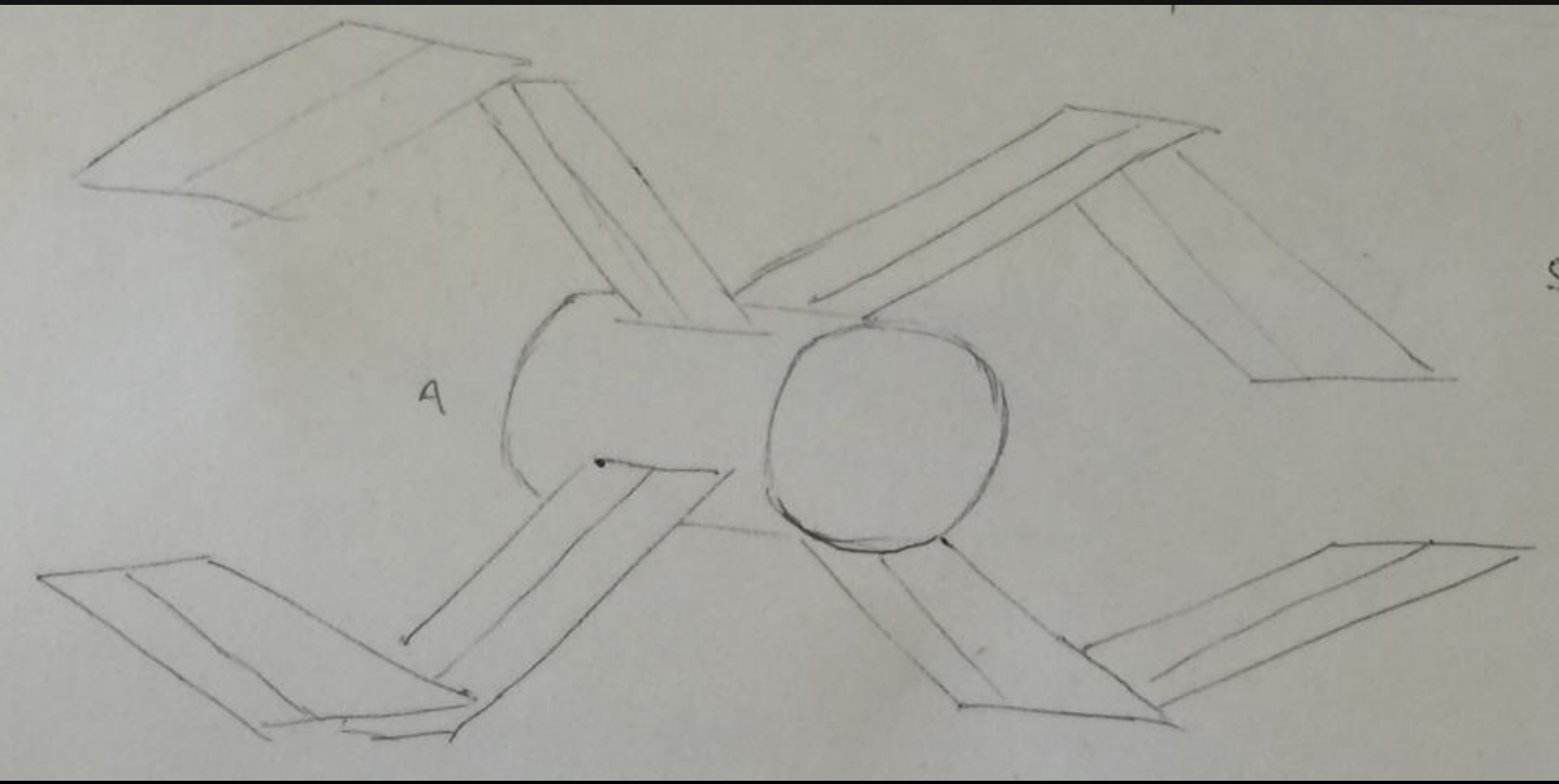

Concept Drawings