Designing a Reliable Asteroid Sample Retrieval System

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MECHANICAL ENGINEERING

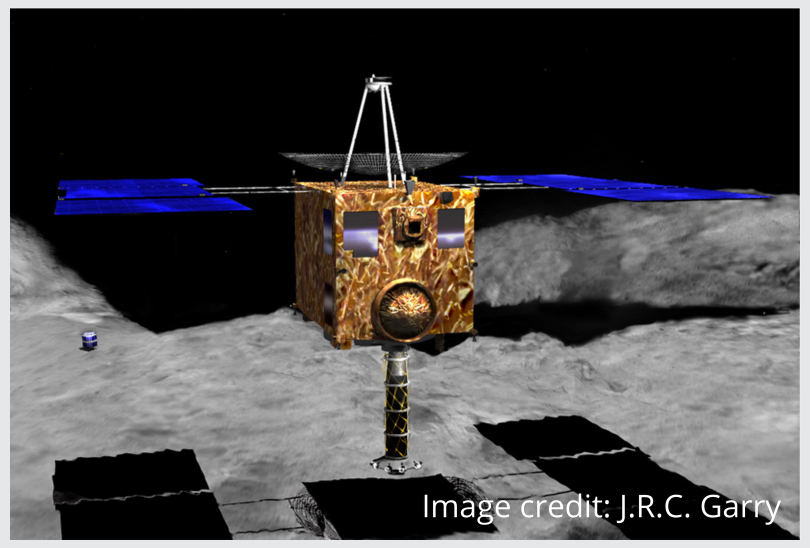
RESEARCH QUESTION

How do we make asteroid sample retrieval cheaper and more reliable?

BACKGROUND

Asteroid sampling is valuable for research and resources

Why do we need a new system?



Hayabusa[1]
- Collected 1500 dust particles
- Cost $100 million

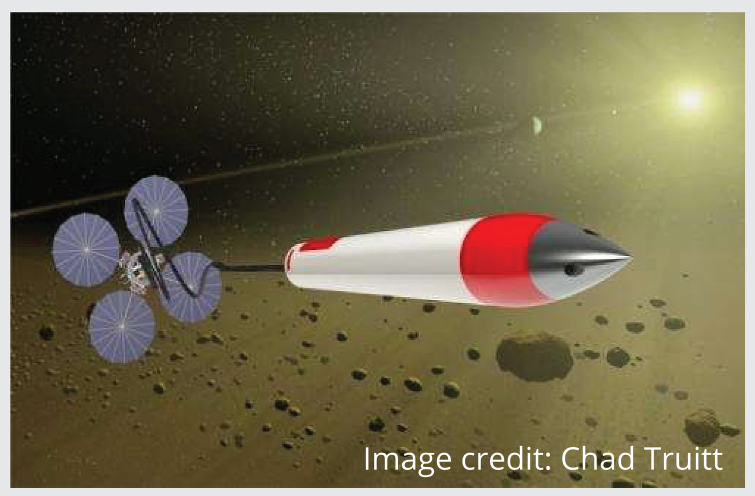
OSIRIS-REx[2]
- Planned to collect >60g of material
- Costs $800 million (~$13 million per gram)

Above: Illustration of Hayabusa descending onto asteroid.
Right: Illustration of OSIRIS-REx. Image credit: NASA

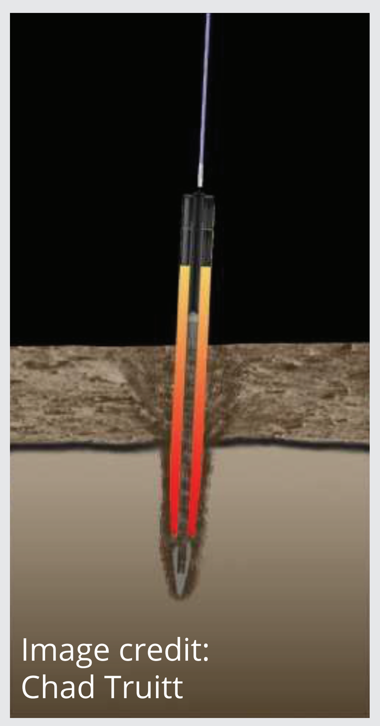
Existing systems are expensive, complicated, and return small samples.

THE NEW SYSTEM

Must be
- Reliable
- Inexpensive
- High yield



Right: Space Harpoon, the new system.
Below: Impactor colliding with asteroid



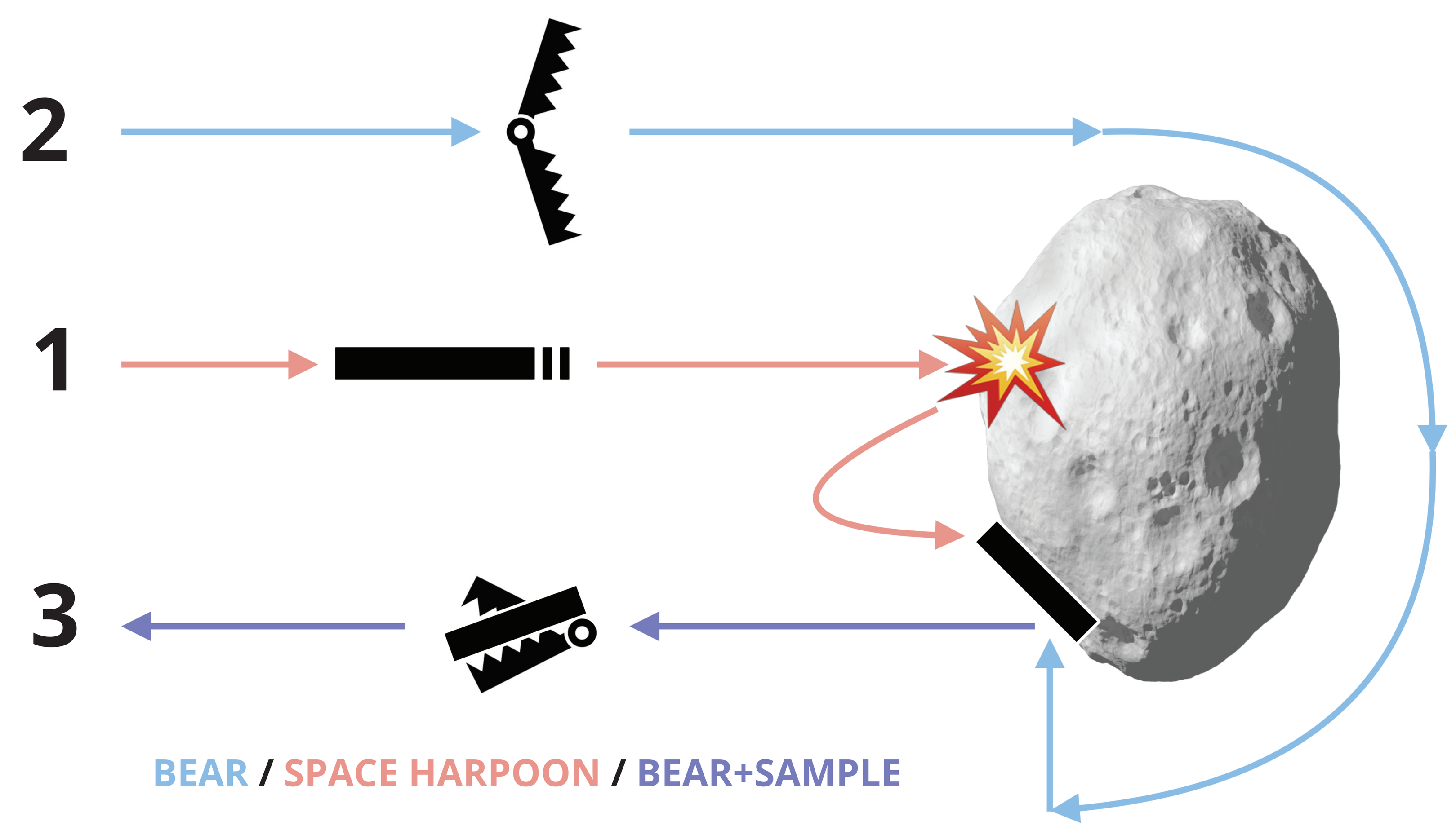
SPACE HARPOON

- Rocket design impactor launched from satellite
- Up to five impactors per system
- Up to kilogram-scale sample retrieval

"It's like drive-by shooting an asteroid"
- Chad Truitt

RETRIEVAL SYSTEM

1) Space Harpoon - cylindrical impactor collides with asteroid and ejects sample
2) BEAR (Bore Excavated Asteroid Retrieval) - sample collector releases from satellite
3) BEAR collects sample and returns to satellite

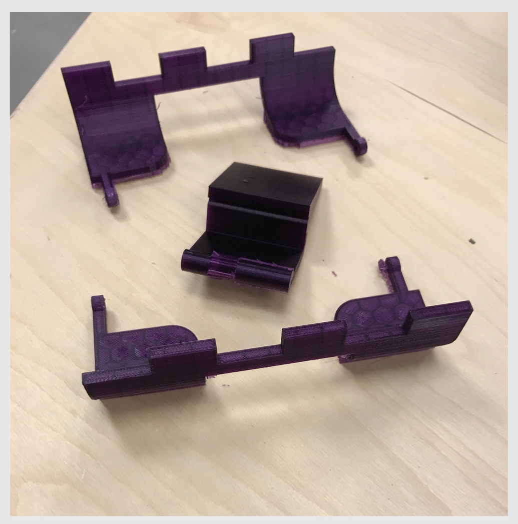


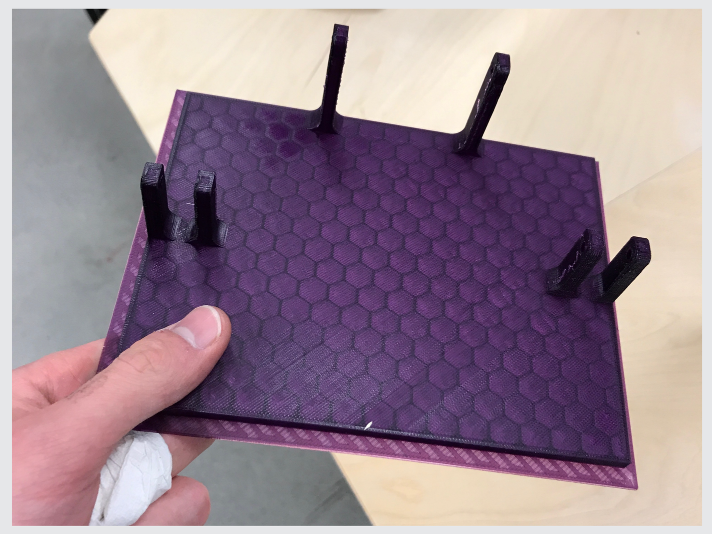
DESIGN PROCESS

- We built an resettable system with a sturdy design that could withstand some impact force.

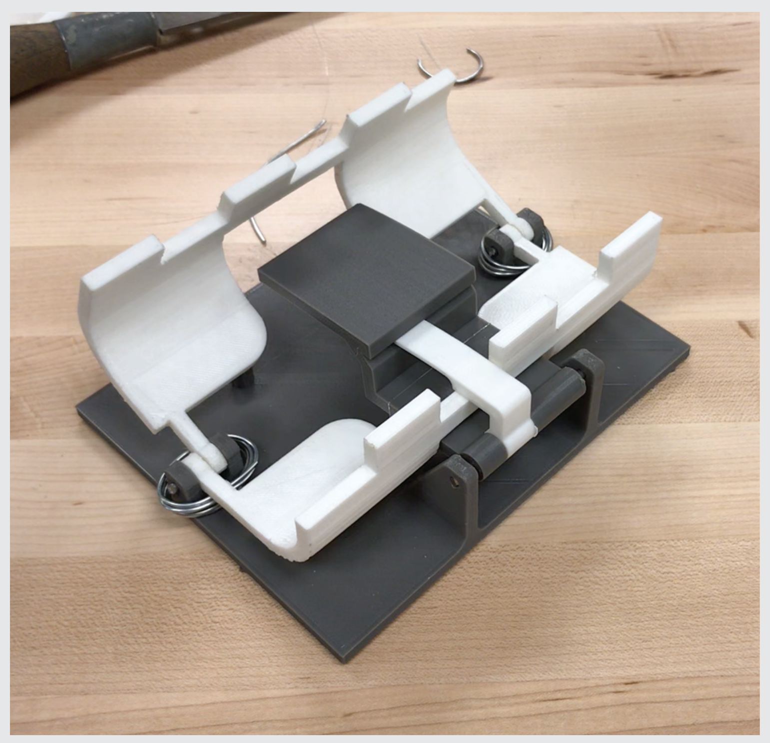
- We used SolidWorks to model a majority of the components.

- BEAR was designed to be printed in PLA, with supplementary use of cardboard and wood.





Top left: Prototype pressure plate and claws
Top right: Prototype base
Lower left: Completed BEAR prototype



CONSTRUCTION

- Simple and more reliable mechanisms were utilized.

- Custom made springs and pins resulted in a more lightweight and robust design.

- The jaws were modeled similarly to a hairpin, and were built to secure but not crush the sample container.

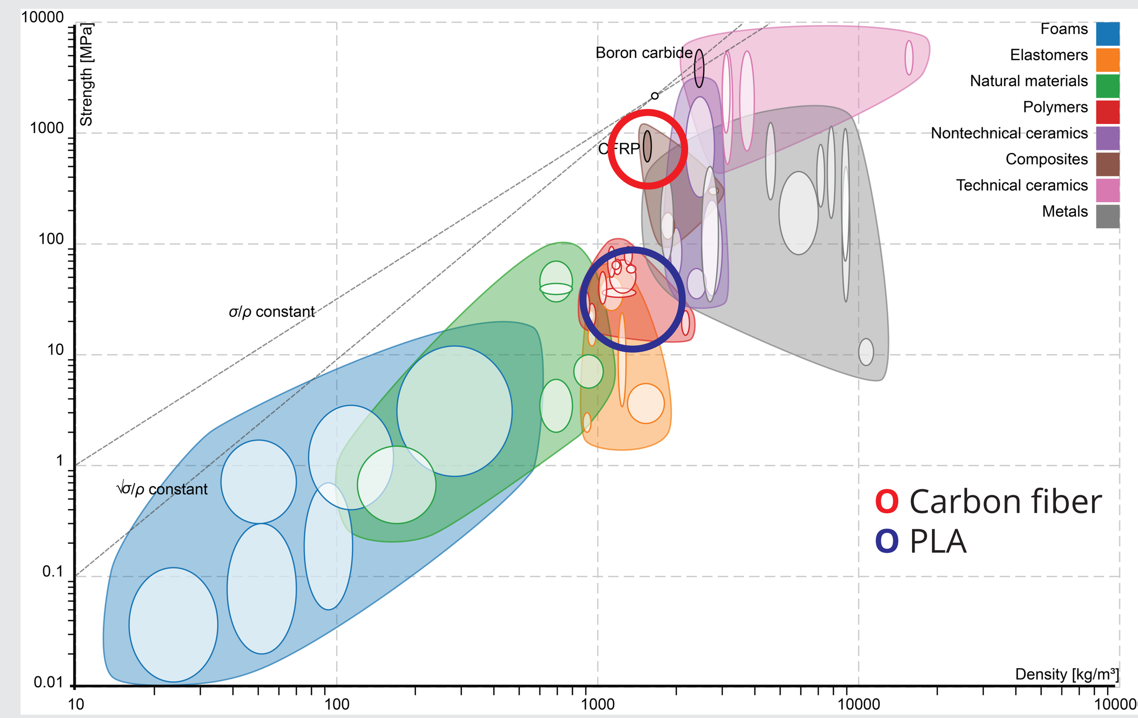
- The current design is not automatically resettable.

- A secondary shield was built around the sample container to reduce the risk of contamination.

FUTURE WORK

Build a more robust prototype

Current material: polylactic acid (PLA)	New material: Carbon fiber
- Inexpensive, easy to use	- Expensive, difficult to use
- Common	- Can use less material
- Not strong	- Strong



Above: Ashby plot for common materials with relevant materials highlighted.

Below: Exhaust trail after impact of penetrator test rocket during previous field test

Below left: Dogless bear trap: trigger pin combined with pressure plate.

Test in the field

- Launch large impactor rocket at site in Eastern Washington
- Use BEAR to pick up ejected sample container after impact

Simplify and make resettable

- Combine trigger pin ("dog") and pressure plate for simplicity
- Add an electronic system to reset in case of failed first attempt

Image credit: Murray's Lures & Trapping Supplies.

REFERENCES

1. Wade, Mark. "Hayabusa." Astronautix, www.astronautix.com/h/hayabusa.html.
2. "OSIRIS-REx Frequently Asked Questions." University of Arizona, bit.ly/2-TO4c5N.
3. Chad Truitt. "Planetary Penetrators for Sample Return Missions", Masters Thesis, 2016.