



Jet Propulsion Laboratory
California Institute of Technology

NASA Hacks

Hackaday Supercon 2016

Charles Dandino, Lucy Du

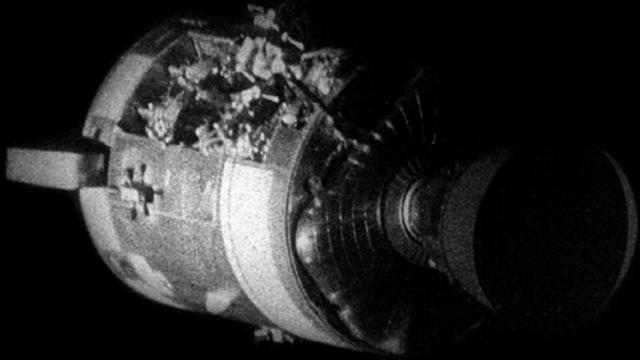
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Government sponsorship acknowledged.



Apollo 13

...your spaceship just exploded



Failure:

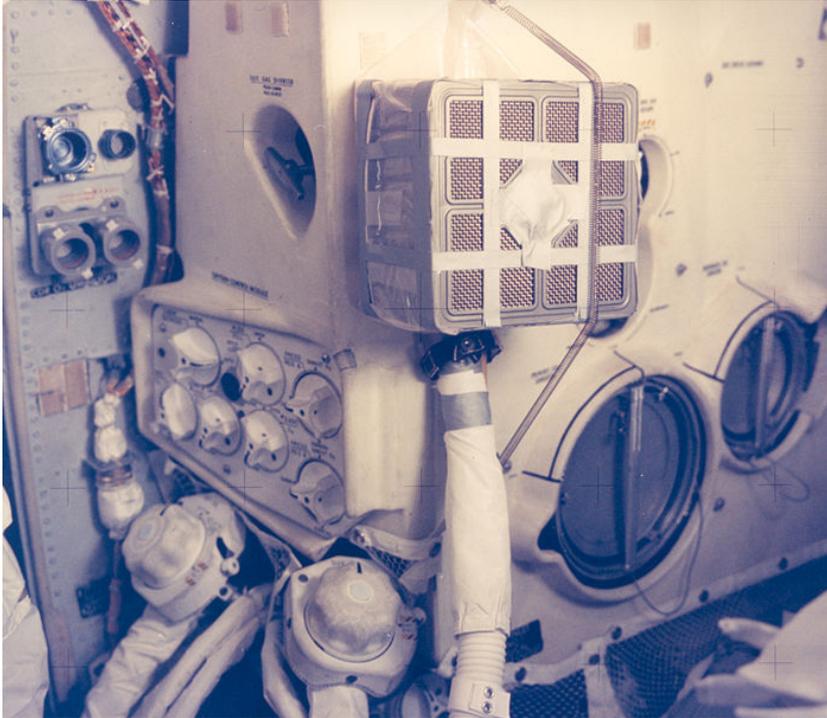
- Service Module oxygen tank exploded
- Lunar landing canceled

Solution:

- Moved to Lunar Module to save energy for return

Apollo 13

...you're 205,000 miles under the ocean with half the oxygen you thought you had.



Problem:

- Lunar Module CO₂ filter designed for 2 men over 2 days, not 3 men for 4 days

Solution:

- Duct tape!
- Square filters from Command Module to mate with round barrel in Lunar Module

Ares 1 Rocket

...shake your phone really hard and try to text

Problem:

- Solid booster rocket causes strong oscillations in crew capsule; astronauts can't read digital display!

Solution:

- Used accelerometers on astronaut seats to measure frequency
- Strobed digital display at same frequency



ISS Solar Arrays

...you can sail in space, trust me



- Not just for solar power!
- That's a BIG sail
- Can be rotated to increase/decrease drag to change altitude

Deployable Antenna

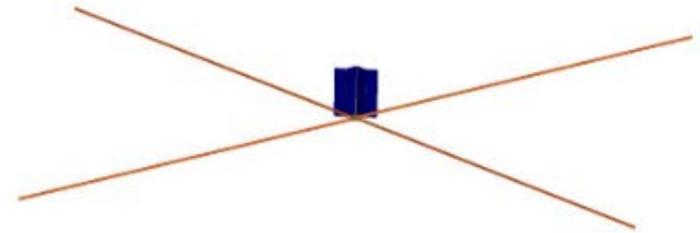
...BIG antenna, small spacecraft

Problem:

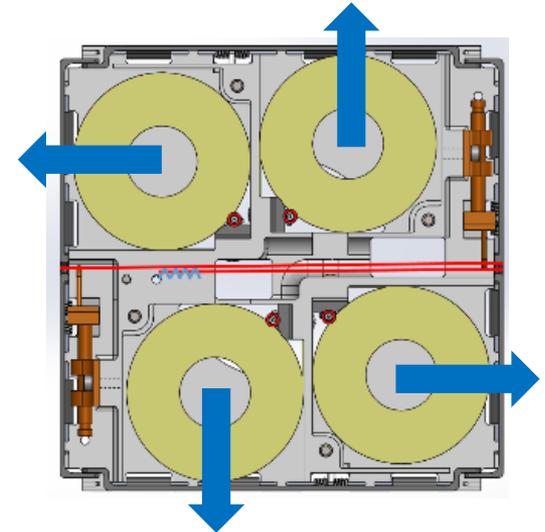
- You need 12m of antenna to fit in <10cm of spacecraft

Solution:

- Crossed 6m long antenna elements
- 4 coiled tape measures
 - Deployed rigidity
 - Small stowage volume



CubeSat and antennae at scale



Antenna mechanism overview

Deployable Antenna

...BIG antenna, small spacecraft



Foamed Concrete Space Simulant

...you need to test a shovel, but have no idea what you're digging

Problem:

- There is a need to sample and anchor into comets and asteroids, but we don't know what they're made of

Solution:

- Start with educated estimates based on little information
- Then make foamy concrete to test your hardware

Soil	Cohesion (kPa)	Compressive Strength (kPa)
Lunar Regolith ¹	0.1-1	1.6-68
Mars Reference Soil ¹	<0.45	0.52
Snow ¹	0.6-6	5.9-86

1. L Richter, priv. comm (2005)

Foamed Concrete Space Simulant

...you need to test a shovel, but have no idea what you're digging

- Now that we have a target, more or less, we try to hit it.
- The Goldilox Paradox: concrete is too hard, powder is too soft
- Solution: Use foamed concrete for a weak, powder-ish simulant!!!



Fish hooks to Snag Asteroids

...fish hooks snag everything. Except fish.

Problem:

- Need a way to grab an asteroid and bring it back to the moon

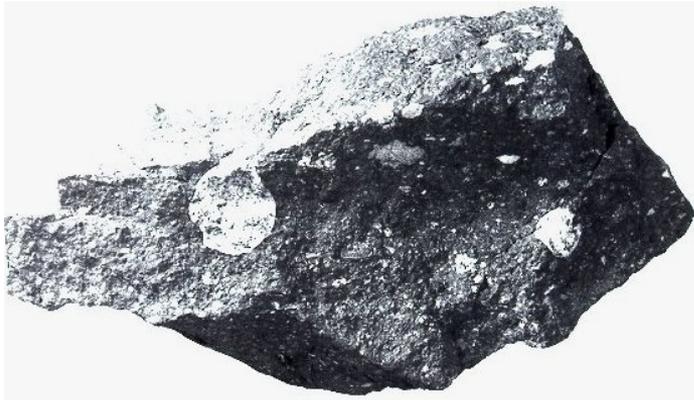


Image credit: <http://pics-about-space.com/asteroid-with-white-background?p=1>

Solution:

- Make a bug a feature
- Multiply it by several hundred
- Get that asteroid!



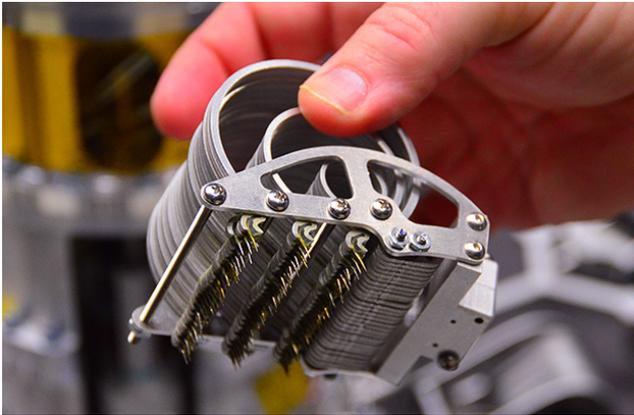
Image Credit: <http://cliparts.co/clipart/3597542>

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Launch Locks as Odometry Features

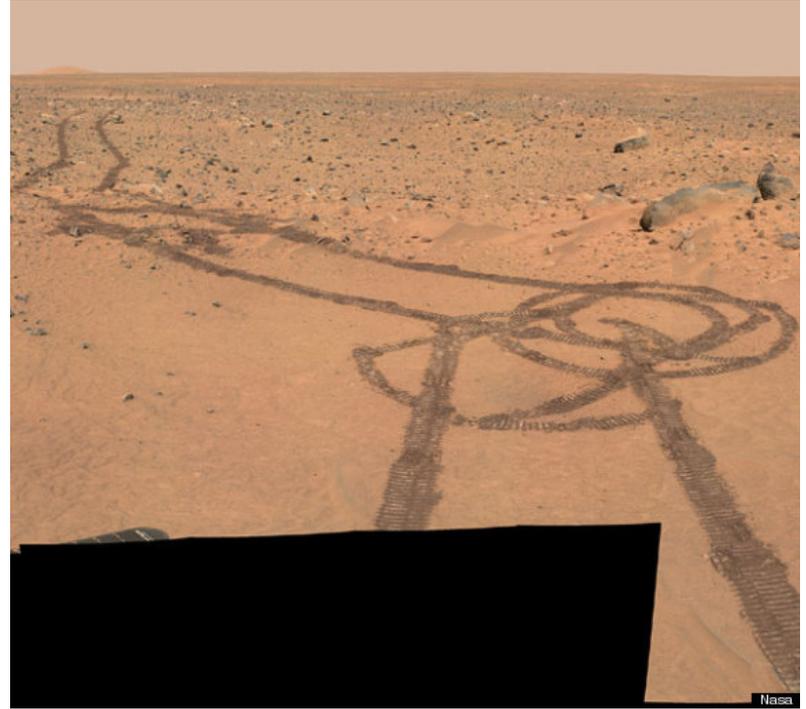
...are we there yet? Are we even moving?

Problem:

- Need a way to grab an asteroid and bring it back to the moon

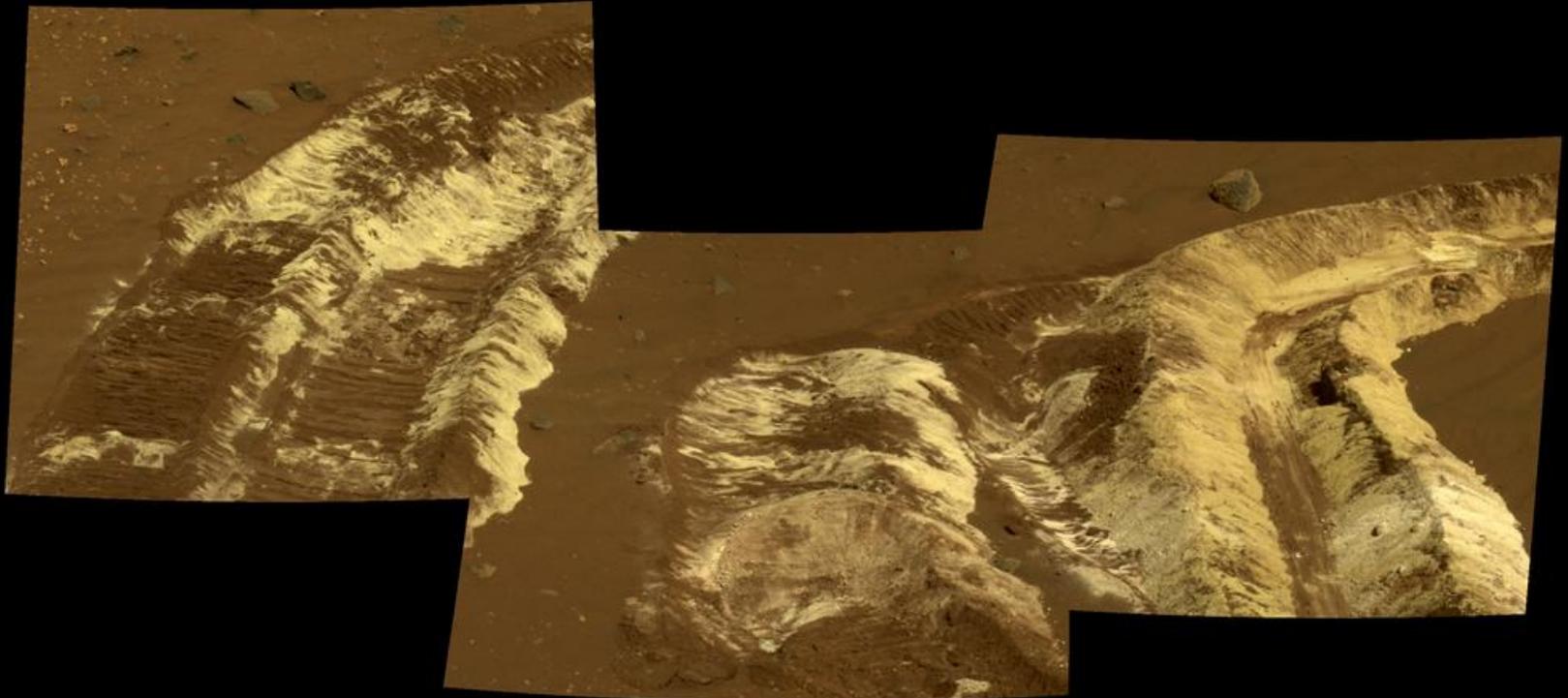
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Launch Locks as Odometry Features

...are we there yet? Are we even moving?



Launch Locks as Odometry Features

...are we there yet? Are we even moving?



Trash to Interstellar Treasure

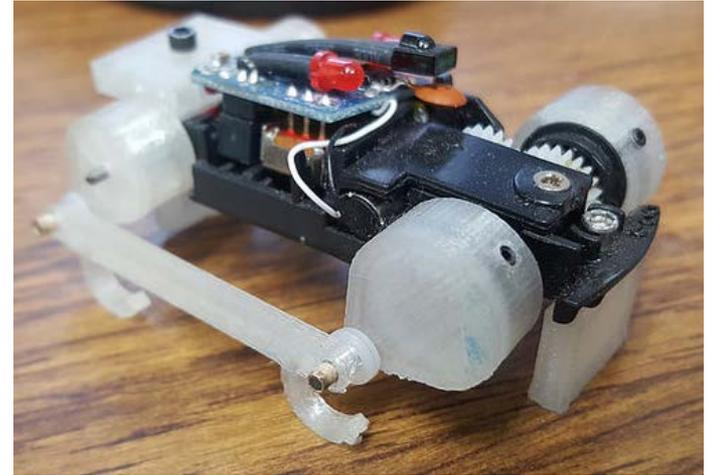
...do you think these are toys?

Problem:

- You have an idea, but not enough millions to build it for space... yet.

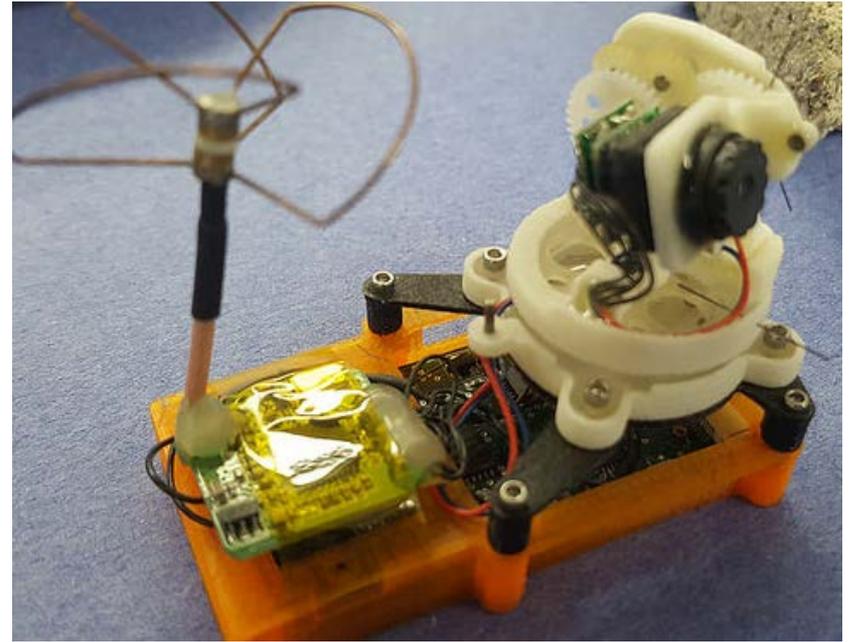
Solution:

- Repurpose cheap toys for early tests
- Pull out sensor and rechargeable batteries
- Reuse motors and gears



Trash to Interstellar Treasure

...do you think these are toys?



Galileo

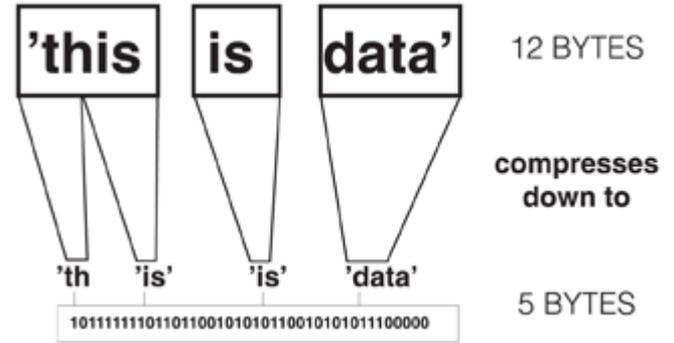
...can you hear me now? - Eh, kinda?

Problem:

- Primary high gain antenna failed to deploy fully

Solution:

- Write new data compression code and (slowly) uplink it
- Same information with less bandwidth



Galileo

...can you hear me now? - Eh, kinda?



References

...sometimes you make a presentation containing none of your own work

- <http://www.universetoday.com/62339/13-things-that-saved-apollo-13/>
- <http://sploid.gizmodo.com/this-is-the-actual-hack-that-saved-the-astronauts-of-th-1598385593>
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- DHFR Peer Review



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