SMARTCubeS

System of Magnetically Aligning Reconfigurable Tiny Cube Satellites

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Mission

- Demonstrate functionality of CubeSat swarm that can lock to each other, but also rearrange unrestricted.
- Potential applications include a telescope reflector, antenna, or instrument boom.

Key Functionalities

- ✓ *Three identical, independent SMARTCubeS.*
- ✓ *Cubes freely pivot about each other.*
- ✓ *Swarms held together via **passive locking.***
- ✓ *Wireless cube power and communication.*
- ✓ *Active faces self-align with other active faces.*
- ✓ *Five active faces, one payload enabled face.*

Magnetic System Design

Electromagnets

- Cause actuation via repelling magnetic fields.
- 8 N of force between repelling electromagnets.
- Draw 7A during ½ second actuation period (24V).
- Same magnetic pole always facing outwards.

Permanent Magnets

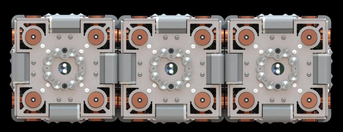
- *Dual Function*: Passive Locking *and* Pivot Point
- 1.5N of attractive magnet-to-magnet force.
- Contained within Edge Assembly.

Passive Locking Mechanism

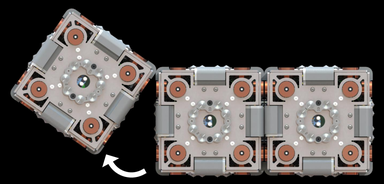
- Universal attraction between cube faces.
- Diametric, permanent magnets rotate when face-to-face to create passive locking force.
- Once electromagnets initiate separation, permanent magnets retract into Edge Assembly.

Actuation

1. *User Generates Command*
2. *Inter-cube Communication*
3. *Signal Processing*
4. *Electromagnet Activation*
5. *Coasting*
6. *Passive Locking*
7. *Positional Verification*



Step 4



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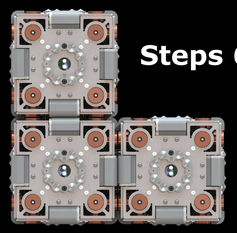
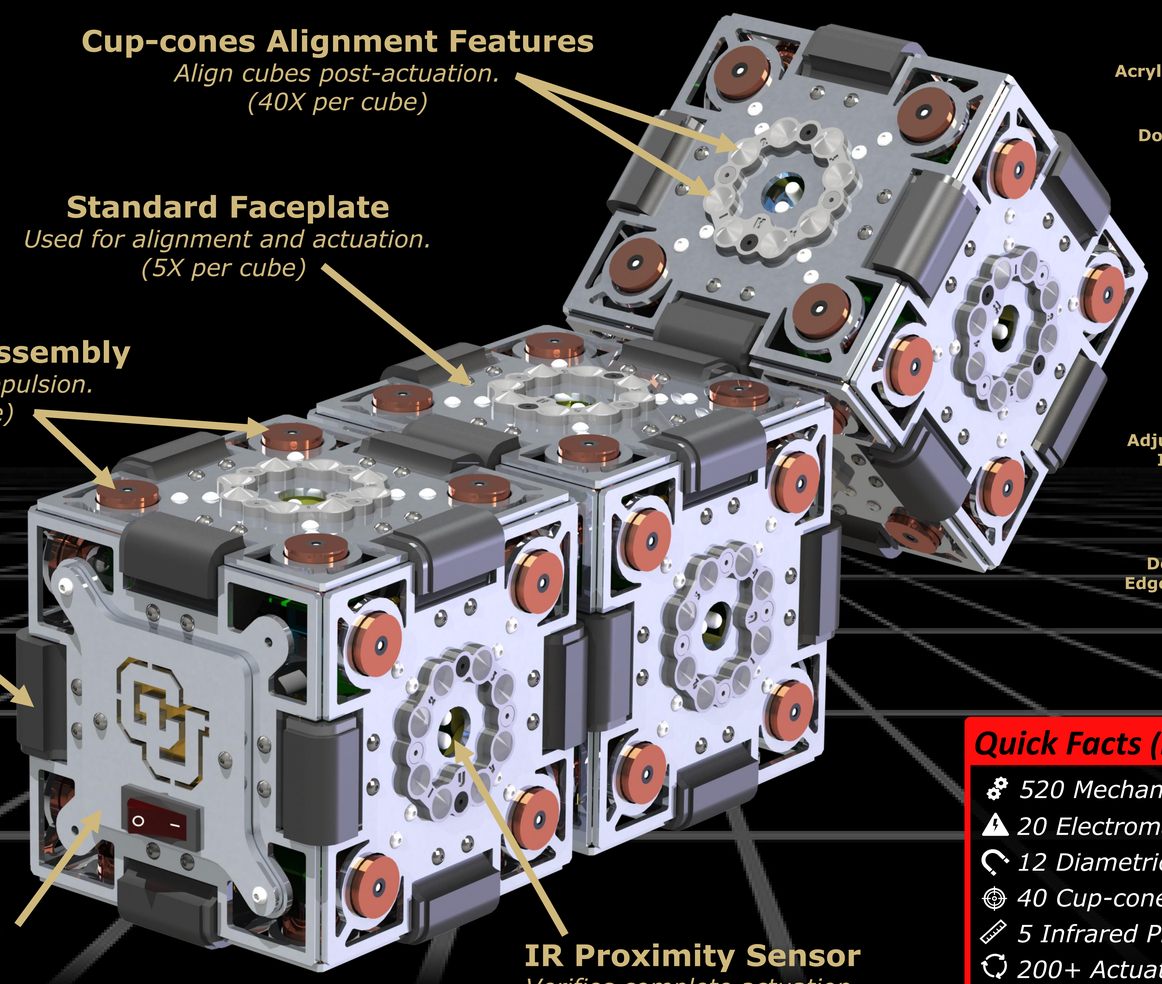
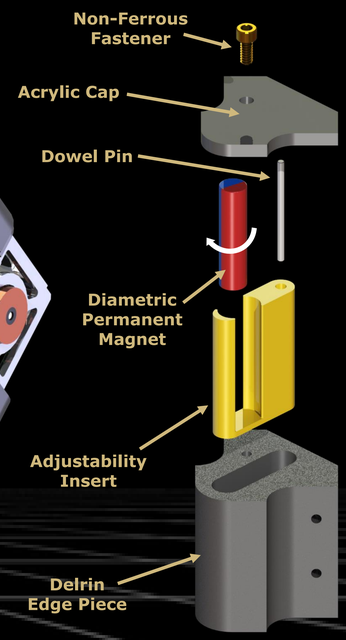


Steps 6, 7





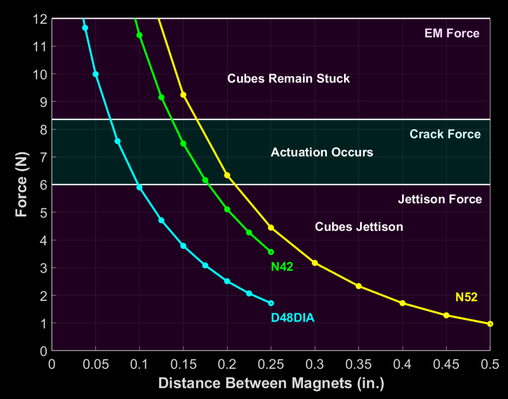
Exploded View of Edge Assembly

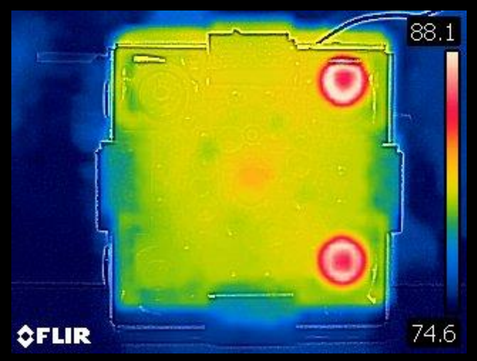
Quick Facts (Per Cube)

- *520 Mechanical Components*
- *20 Electromagnets*
- *12 Diametric Magnets*
- *40 Cup-cone Alignment Features*
- *5 Infrared Proximity Sensors*
- *200+ Actuations Per Charge*

Testing & Results

- Permanent magnets selected to balance cube rotation with jettison/locking forces.
- Magnet force curves used to set edge contact thickness.
- Electromagnets selected using force and voltage relationships collected on UTM/Instron.
- Thermal testing used to determine cube actuation frequency limits.





Thermal testing of an actuation.

Impact

- Magnetic subsystem unprecedented in research and industry.
- Enables creation of larger deployable space-structures than ever before.

Future Work

- Write technical paper and publication to AIAA SciTech 2023.
- Advanced microgravity testing.
- Potential JPL future mission.

"This technology could be used for adjustable deployable booms, large aperture reflectors and more complex structures down the road such as a fleet of space assembled and reconfigurable interplanetary vessels."

-Tom DiSarro, JPL Mechanical Engineer

A Special Thanks To: *Mieszko Salamon (JPL) • Tom DiSarro (JPL) • Daria Kotys-Schwartz • Julie Steinbrenner • Shirley Chessman • Dr. Jianliang Xiao • Greg Potts • Chase Logsdon • Victoria Lanaghan • Lauren McComb • Patrick Maguire*