CubeSat Constellation Release/Reassembly

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Abstract

CubeSat constellation flight will facilitate many astrophysical missions, such as inter-satellite quantum link experiments, and multi-view asteroid observations. CubeSats can be deployed as an assembly into the targe space region, then be released into a constellation. CubeSats can be reassembled again into one module after completing inter-CubeSats experiments or distributed observation, and then be redeployed for next experimental and observational tasks.

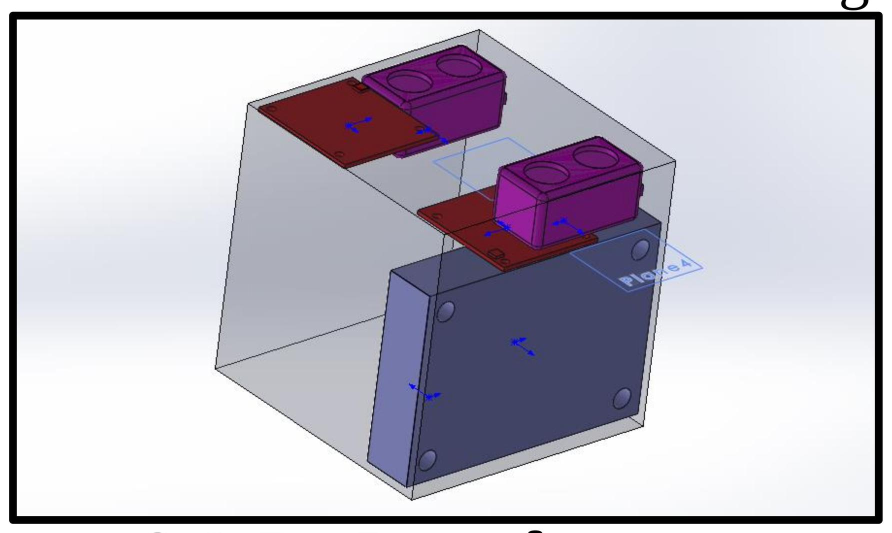
We are developing CubeSat release / reassembly mechanisms for this exciting goal. Two designs have been investigated as to make CubeSat constellation deployment possible. The first design is a vertical mechanism while the second design is a horizontal mechanism. These configurations will accommodate various payload configurations, and leave room for optical sensing instruments.

Design Goals

- Meet 1U CubeSAT Requirements
  - Must fit within 10cm x 10cm x 10cm Envelope
- Lock two 1U units together w/o power consumption
  - Incorporate Dual Gender/Genderless system to enable versatile CubeSAT
- Provide error compensation in the event of misalignment during docking sequence
  - Develop self-alignment design permitting up to 0.25” misalignment
- Withstand Anticipated Loads in Practical Application
  - Anticipated load is 10 kgf in tension pulling two units apart
  - Design to FOS 2.0 on loaded parts
- Fit Around Necessary Electronic Sensors and Cameras
  - Packaging study completed using geometry data from electronics/optics team
  - Design leaves maximum space in center of unit for payload

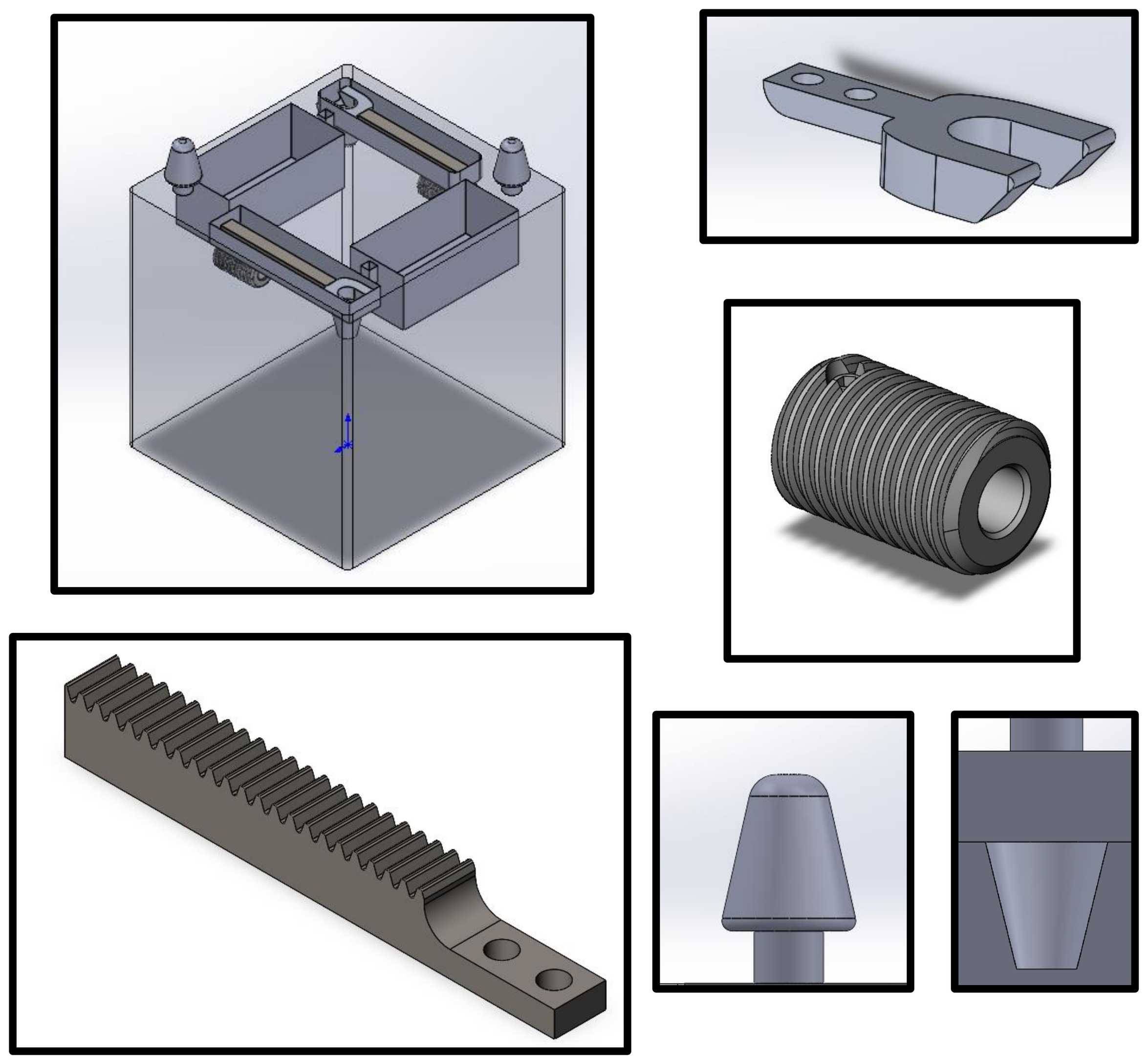
Initial Packaging Analysis

Initial packaging analysis revealed the amount of volume optic and electronic components occupied and helped set a constraint on available volume for the release/reassembly mechanism. After performing packaging analysis, the space available for docking was determined to be 2cm away from the edge of the CubeSat face with depth to be determined by mechanical mechanism chosen for the design



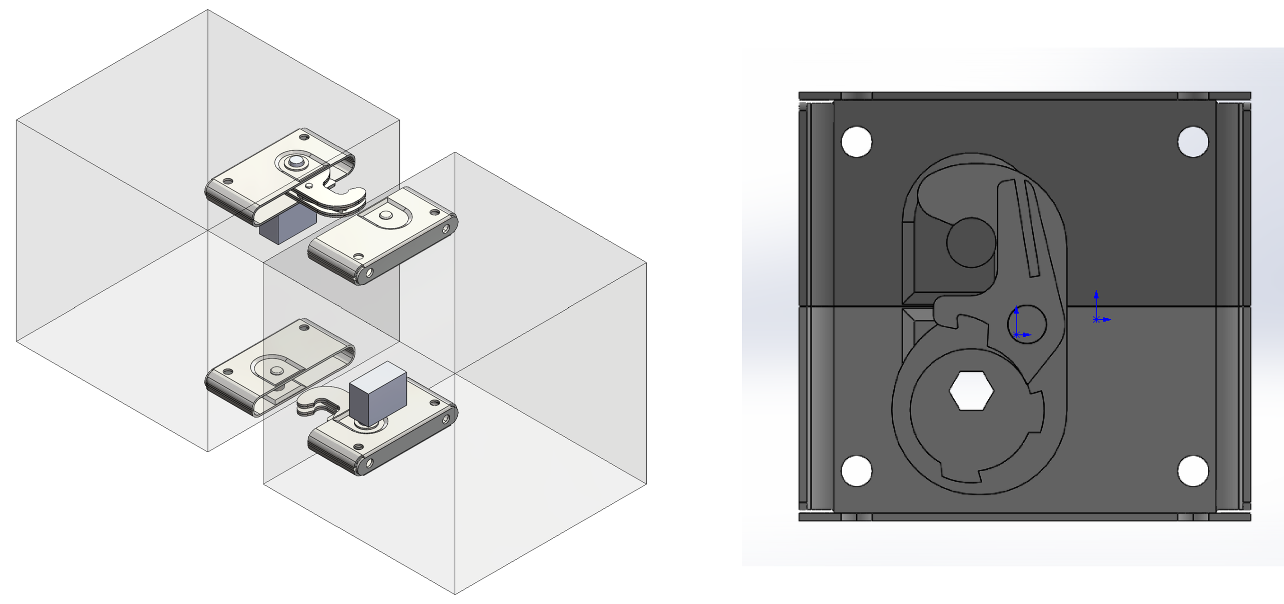
CAD Designs

Horizontal Clamping Design



Design Feature	Benefit of Design
Worm Gear	• Transforms Rotational Motion to Linear Motion in Rack • Can’t drive rack while locking servomotor in case rack pushes back • Utilizes common profiles easily available off the shelf
Rack	• Receives input from worm gear to actuate U-Clamp • Can’t drive servomotor as worm gear acts as lock • Utilizes common geometry available off the shelf
Male Pin/Female Receptacle	• Compensates for error in alignment during docking sequence • Receives U-Clamp to lock CubeSat units together
U-Clamp	• Clamps on to base of Male Pin to Lock Cube Sat units together • Ramped Tips allow for successful docking despite pins not being fully seated • Simple mechanism easily fabricated

Vertical Sliding Hook Design



Design Feature	Benefit of Design/Feature
Hook	• Locks two CubeSats together • Driven by Riding Pin • Easily fabricated simple design • Self-aligning along one axis
Cam	• Shaft w/ eccentric cutout for servomotor enables custom designed motion • Protruding profiles allows for Rotational and Linear motion in riding pin which is mounted to hook
Riding Pin	• Converts rotation of cam to linear and rotational motion of hook • Not available off the shelf, but easily fabricated

Future Work

The designs shown above are in the midst of fabrication via 3d printing. Once designs have been printed, they will be mounted in a CubeSat alongside electrical and optical equipment for live testing of the docking procedure. This testing will involve the use of the lab’s internally developed microgravity test bench For testing, both designs will be 3d printed and tested on the team’s microgravity test bench. On this test bench is where the limits of the error correcting features of both designs will be fully evaluated.

Conclusion

The horizontal clamp design and vertical sliding hook design are promising mechanisms that will enable new developments in miniaturized space experimentation. Both designs successfully meet goals of fitting in a 1U unit and fit in the space available when packaged with electronic sensors and cameras. Both designs also feature genderless components so that any two 1U units can reassemble to each other. Design goals of permitted error compensation and reliability in surviving loading scenario will be verified in the testing phase.