



Morph

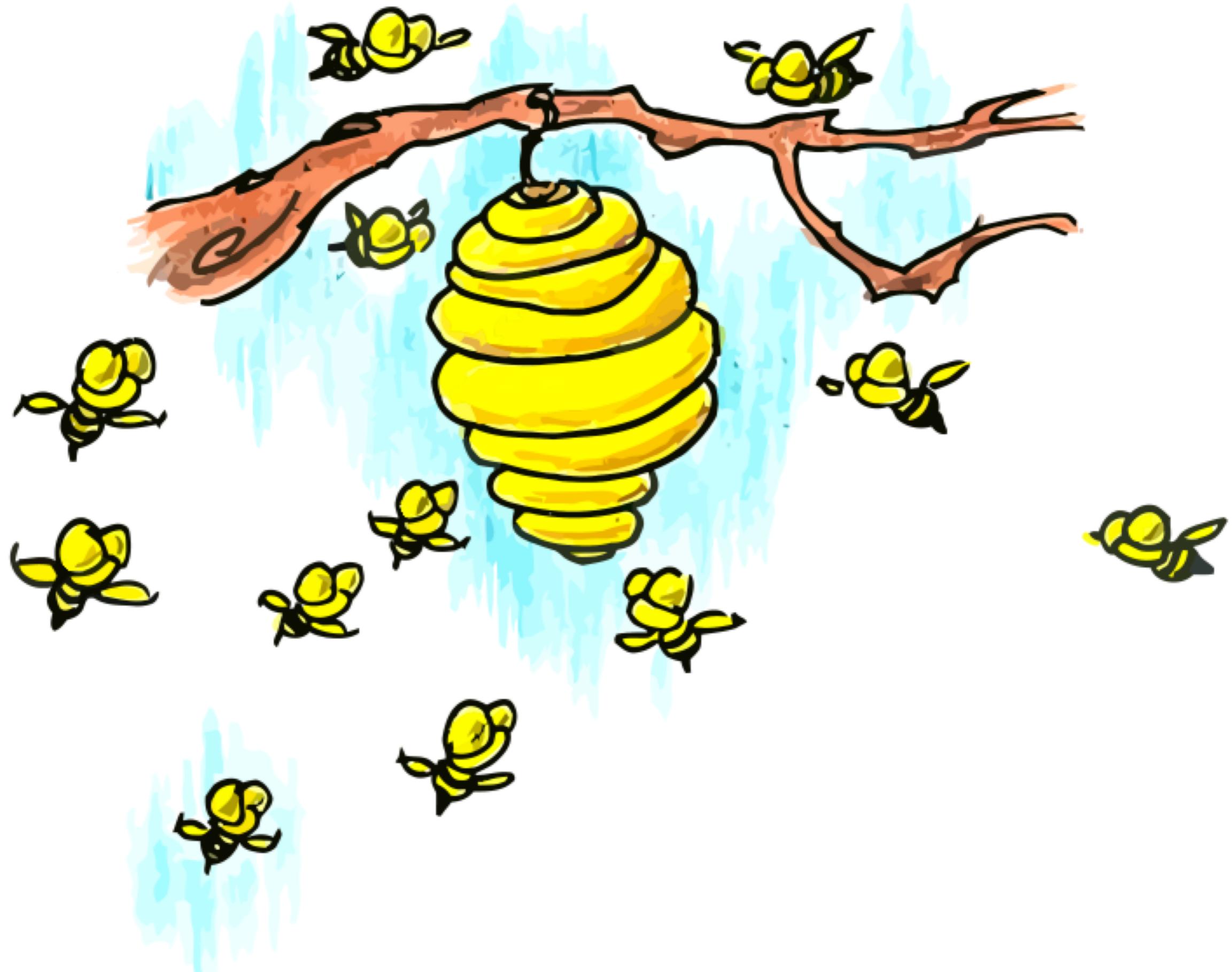
Steve Matousek

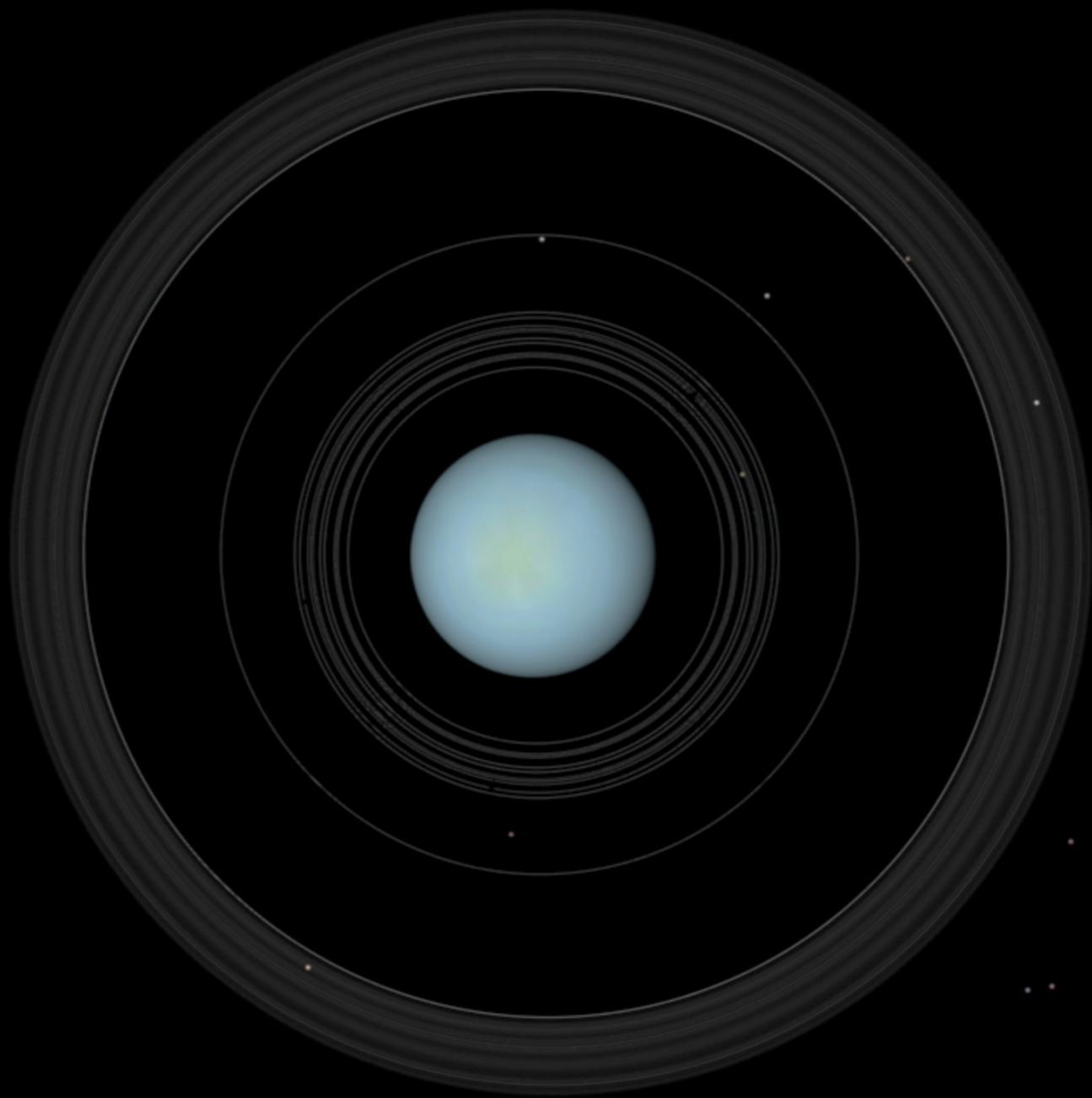
Jet Propulsion Laboratory, California Institute of Technology

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Interplanetary Small Satellite Conference, San Jose, California

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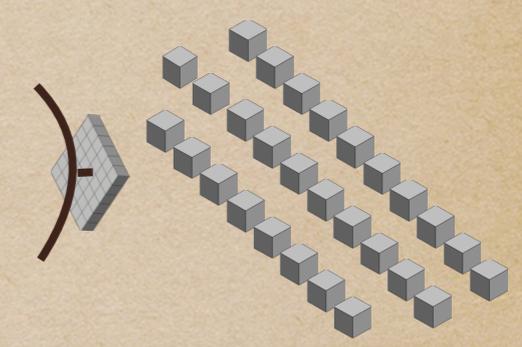
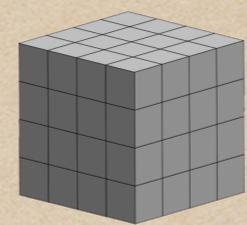
What is Morph?

Smallsat/CubeSat



+

Reconfigurable spacecraft



+

Mother/daughter for Earth
and deep space exploration

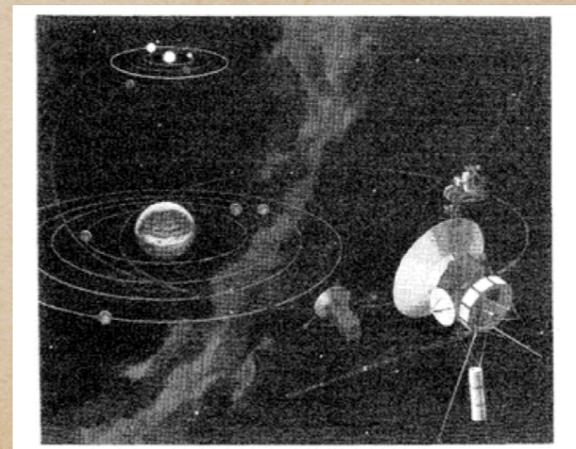


Fig. 1 Concept of Jupiter orbiter mother /daughter spacecraft pair, showing the daughter spacecraft before and after deployment.

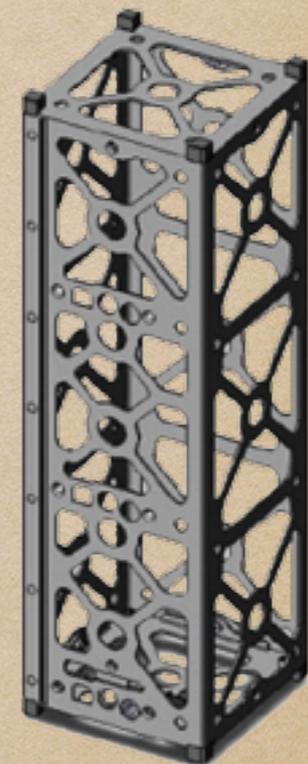
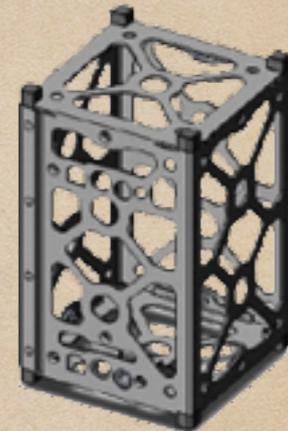


Advantages

- ◆ Each unit optimized for the required function
- ◆ No compromise in configuration throughout mission
- ◆ If one functional unit fails, discard, and replace with next redundant functional piece



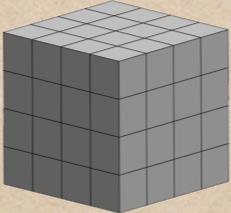
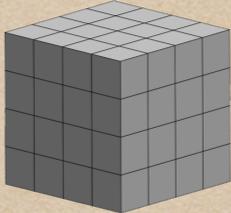
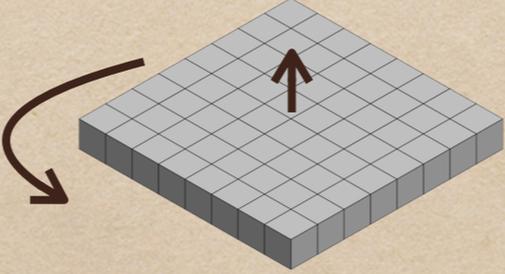
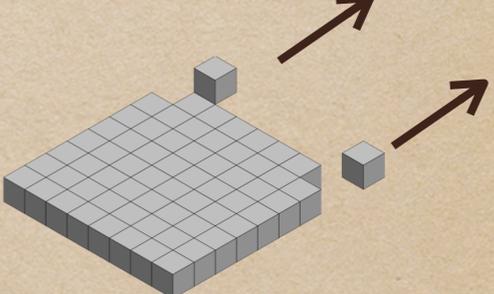
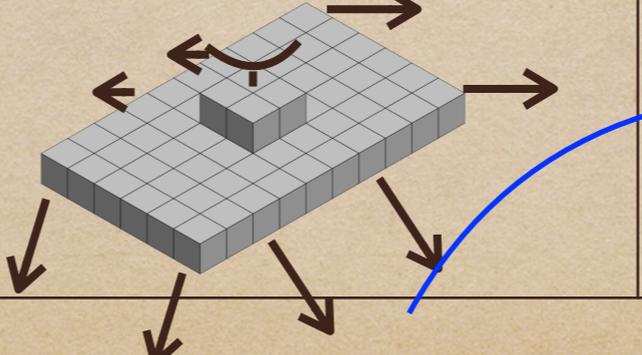
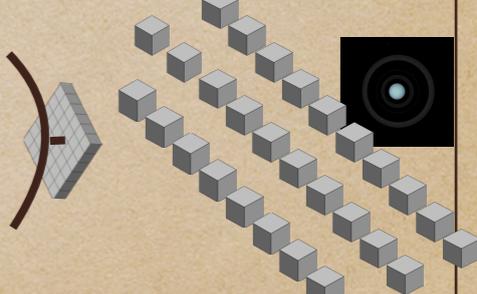
Multiple Size Units



- ◆ Different size and shape units combine
- ◆ Standard interface allows reconfiguration in-flight
- ◆ CubeSat standard drives small functional units
- ◆ Wifi inter-unit communication



Vignettes

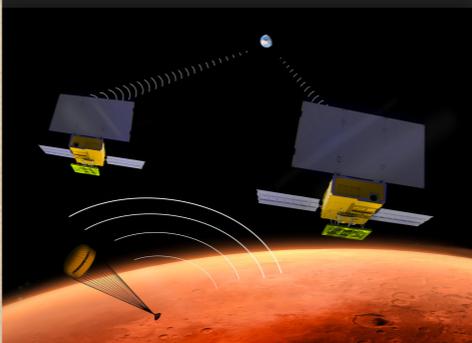
Mission/Phase	LEO Earth Observing	Ice Giant
Launch		
Maneuver/Deploy Probes		
Science		



Challenges

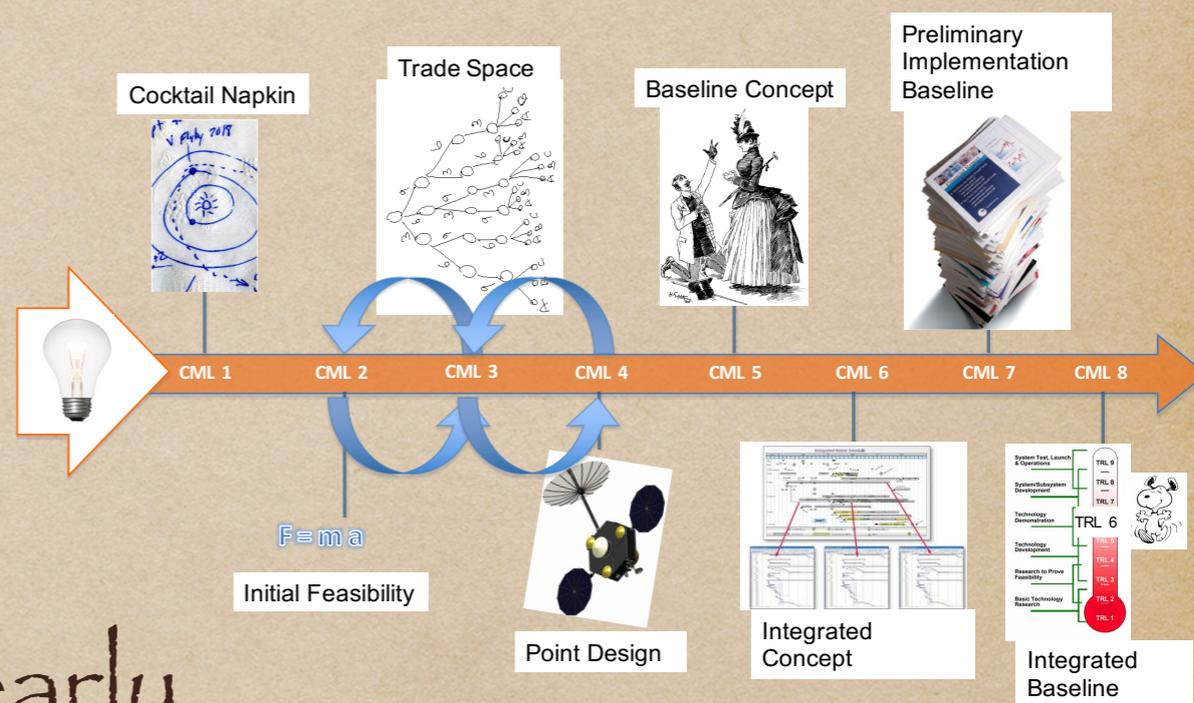
- ◆ Consistent mechanical (and electrical?) interface between units
- ◆ Robust interface that withstands accelerations
- ◆ Functional units within a reasonable size (1 U?)
- ◆ Software to control configuration and cooperation



Challenge	Possibilities
Interface between units	 <p>Electromagnetic docking port concept for ARReST, courtesy Prof Craig I. Underwood © Surrey Space Centre – University of Surrey, Guildford, UK</p> or  <p>Hybrid electrostatic, gecko gripper Courtesy of Aaron Parness, JPL</p>
Communication between units	802.11s based multi-radio multi-channel mesh networking for fractionated spacecraft
Communication back to Earth	 <p>Deployable Antennas, Iris (and other) deep space radio</p>
Cooperative Software	Control algorithms and software derived from fast-evolving and maturing drone swarms

Next Steps

- ◆ JPL Innovation Foundry A-Team feasibility study
- ◆ University design project(s)
- ◆ JPL Atelier for rapid early prototype design





References

- ◆ Small cubes that self assemble: <https://www.youtube.com/watch?v=6aZbJS6LZbs>
- ◆ In 2014 DARPA prepares to launch “satlets”: <http://spectrum.ieee.org/tech-talk/aerospace/satellites/darpas-satellite-revival-program-gears-up-for-first-launch>
- ◆ Reconfigurable robots: <http://www.isi.edu/robots/>
- ◆ Hybrid electrostatic gecko gripper: <https://www.youtube.com/watch?v=hJjHzXlKCpQ&t=3s>
- ◆ 802.11s based multi-radio multi-channel mesh networking for fractionated spacecraft: <http://ieeexplore.ieee.org/document/6497331/>
- ◆ MIT creates a control algorithm for drone swarms: <https://techcrunch.com/2016/04/22/mit-creates-a-control-algorithm-for-drone-swarms/>
- ◆ “Jupiter Orbiter Mother/Daughter Spacecraft Concept, John H. Duxbury, Journal of Spacecraft and Rockets, May, 1976, Vol. 13, No. 5 : pp. 259-260