Industry Day Briefing
Delivered July 24, 2007
Owen C. Brown, Ph. D.
Tactical Technology Office

Industry Day Briefing
System F6

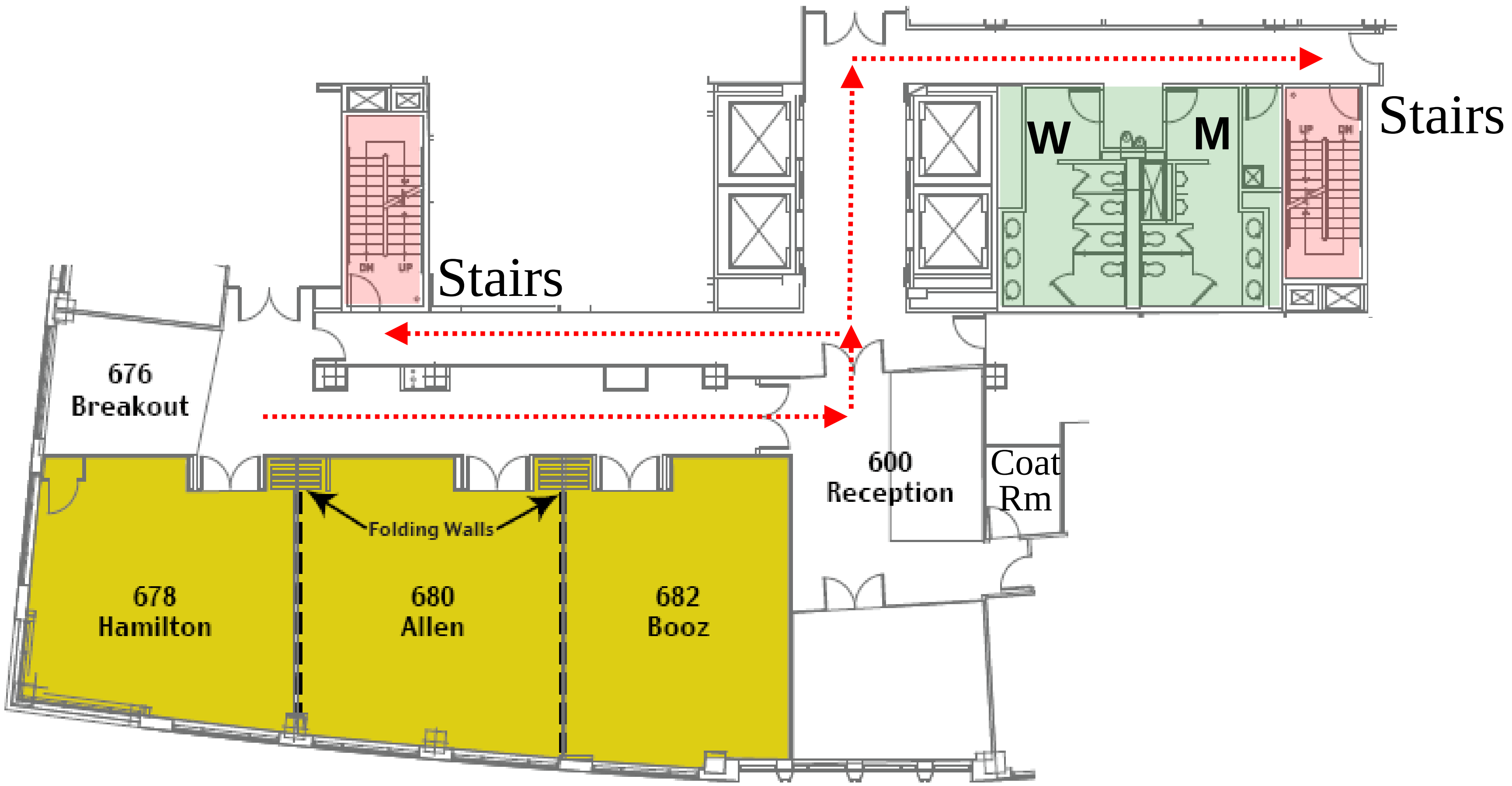
Basic Info

- Classification Level
  - Unclassified today, Classified tomorrow
  - All participants registered and badged
  - Badges worn above waist, visible at all times
- Cell Phones
  - Please turn off your ringers
- Lunch
  - Here, catered
- Starbucks
  - Across the street, to the left, 2 blocks
- Parking
  - Building closes and locks at 6 PM
  - Street parking is free starting at 6 PM

Basic Info

- Internet
  - Small number of Ethernet connections available at end of hall.
  - Please limit usage to 5 minutes to give others access as well.
- Restrooms
  - See receptionist for key to women's lounge
- Red Top Cab
  - 703-522-3333
- BAA Question Cards
  - Available on each table in room
  - Submit by first break at 9 AM
- Please use rear set of doors to enter or leave during proceedings.

Floorplan



Stairs
W
M
Stairs
676
Breakout
600
Reception
Coat
Rm
Folding Walls
678
Hamilton
680
Allen
682
Booz

System F6 Industry Day

06:00	Registration / Continental Breakfast
07:30	F6 Video
07:35	Opening Remarks, Dr. Anthony Tether
07:50	Agenda and Administrative Remarks, Dr. Brook Sullivan
07:55	System F6 Overview, Dr. Owen Brown
08:55	Review of FAQ's
09:00	Break
09:45	Open Forum for Q&A
	Government Presentations
10:10	BAA Procedure, Mr. Chris Glista, DARPA CMO
10:30	AFRL/VSSE Presentations
11:00	Break
11:15	F6 Life Cycle Cost Study Results, Dr. Owen Brown
11:45	Lunch / Catered

July 24 2007

7:30 am – 4:30 PM

System F6 Industry Day

13:00	Instructions for next day, Mr. Paul McLean, TTO PSO
	Performers Only – Networking / Teaming Opportunity
13:30	Dr. Dave Finkleman – Center for Space Standards and Innovation
13:45	Mr. Richard Zimmerman – Lockheed Martin Information Systems & Global Solutions
14:00	Dr. Young Bae – Bae Institute
14:15	Dr. Marin Soljacic – Massachusetts Institute of Technology
14:30	Break
14:45	Mr. Travis Langster – Analytical Graphics, Inc.
15:00	Mr. Vincent Tate – Design Net Engineering
15:15	Dr. Andrew Turner – Space Systems Loral
15:45	Closing Remarks, Dr. Owen Brown

July 24 2007

7:30 am – 4:30 PM

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System F6

F6: What's up with all the F's?

- **Future**: Possibly the architecture of the future.
- **Flexible**: Providing the ability to modify the system at *anytime* during the lifecycle.
- **Fast:** Smaller, leaner, production line mentality.
- **Fractionated:** Decomposing a monolith into elements.
- **Free-Flying:** Those elements are launched separately and then dock or virtually dock.
- **Spacecraft united by Information eXchange:** Wireless data connectivity creates a virtual spacecraft.

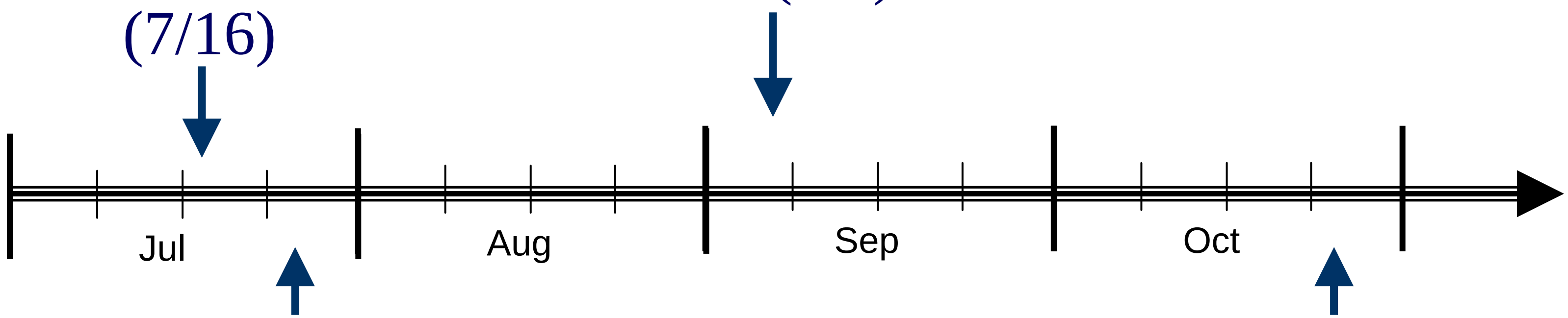
Program Concept

- Fractionate a monolithic satellite into microsat-like modules
- Intra-module connectivity
  - Wireless data
  - Wireless power transfer
- Inter-module connectivity
  - Wireless data
- Robust, secure, self-forming wireless network
- Resource sharing across modules
  - Computation, etc.
- Cluster Orbits
  - Docking allowable, but no physical power or data connection

BAA Schedule

BAA release (7/16)

BAA Responses Due (9/7)



Industry Day (7/24), Classified Session (7/25)

Projected Award Announcements

F6 BAA Overview

Broad Agency Announcement (BAA07-31)

System F6

For

Defense Advanced Research Projects Agency (DARPA)

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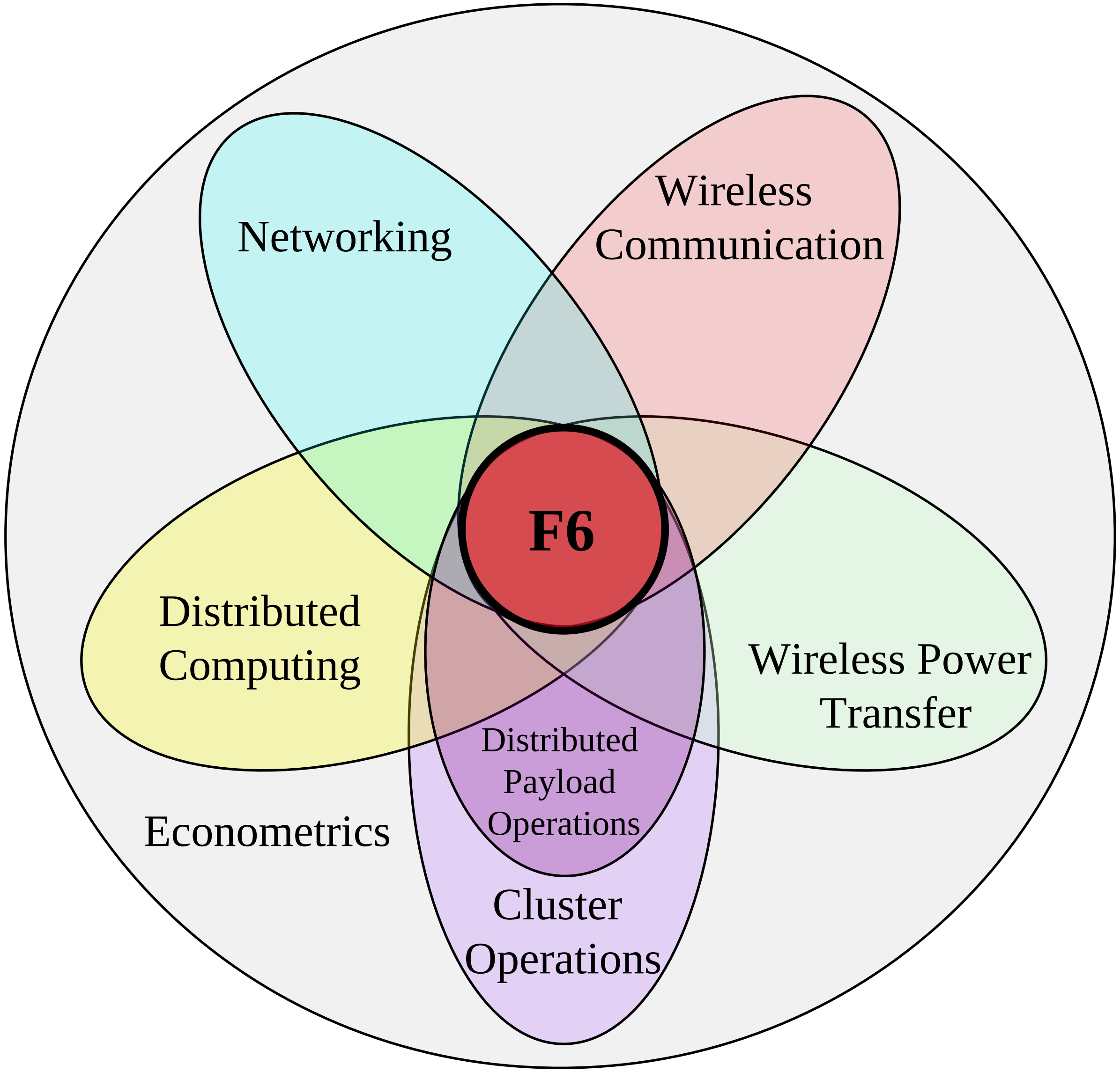
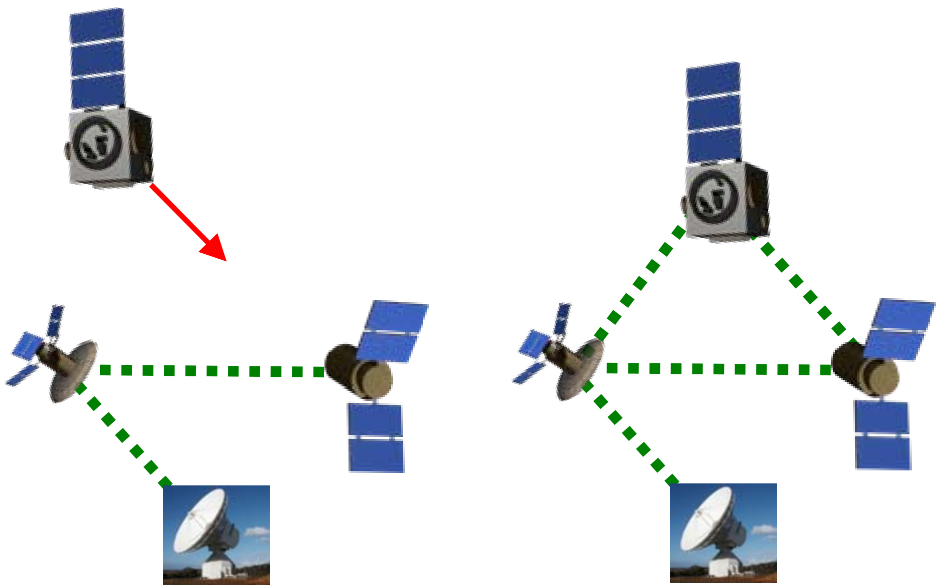
System F6 Technology Pillars



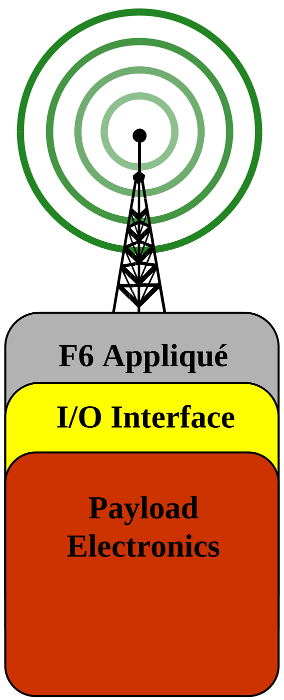
Enabling Technology: Networking

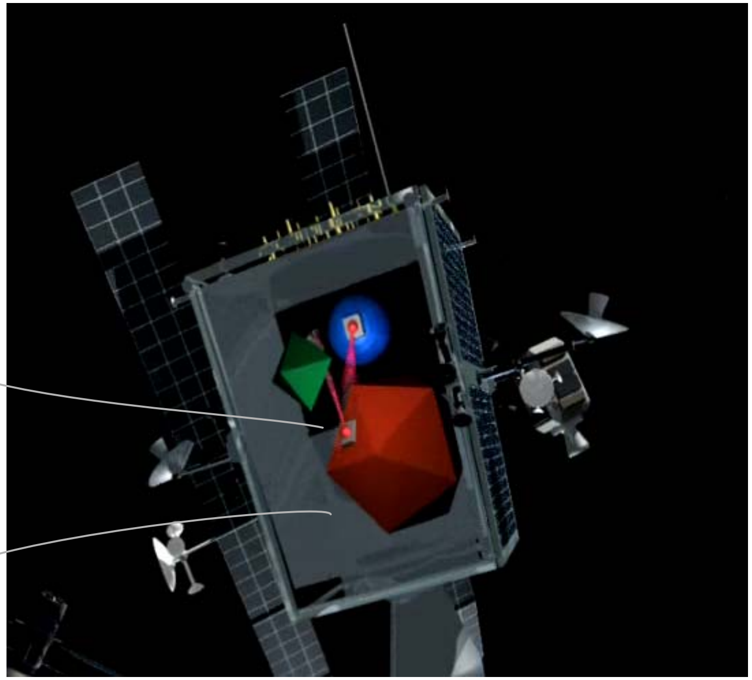
- Demonstrate autonomous, self-forming network of nodes
- Ground element treated as another network node.
  - Transfer a spacecraft function to ground and then back
  - Maintain 24/7 TT&C
- Demonstrate ground node flexibility
  - Re-locate within CONUS in 24 hours



Enabling Technology: Networking

- Develop a standard hardware and software appliqué that enables the “packaging” and insertion of spacecraft components as uniquely addressable network devices.

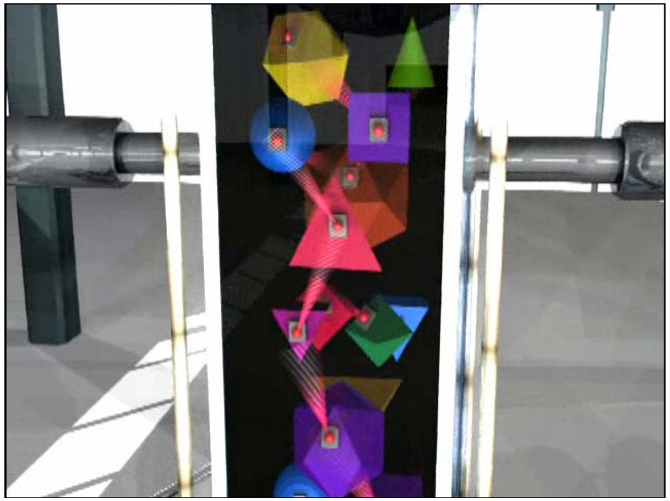




Networked internal sub-systems

Enabling Technology: Wireless Communications

- Aggressive full duplex data rate via wireless communications
- Enables Spacecraft Black Box
  - Component maintains data connectivity wirelessly to host node and to network
- Wireless networking data protocol between each node
  - Continues operation in the presence of interference

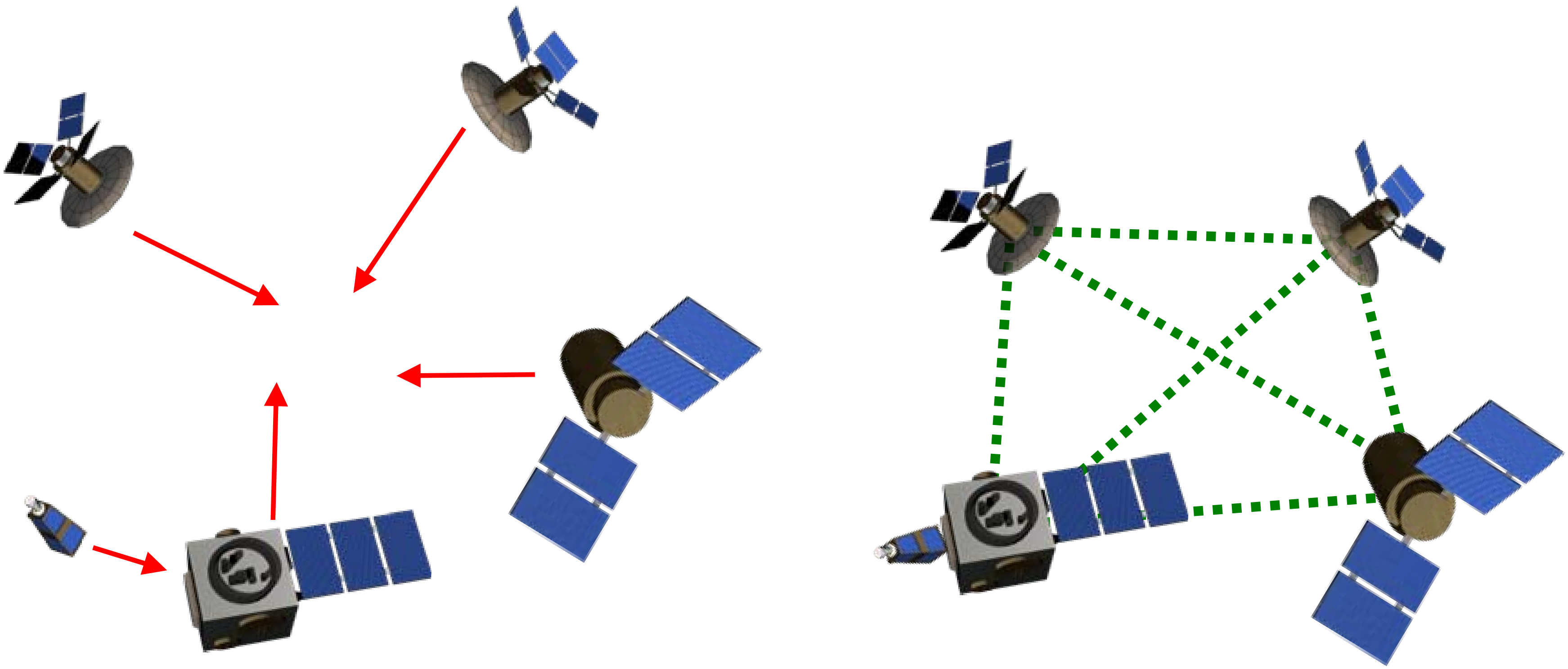


Intra-Satellite Communication

Inter-Satellite Communication

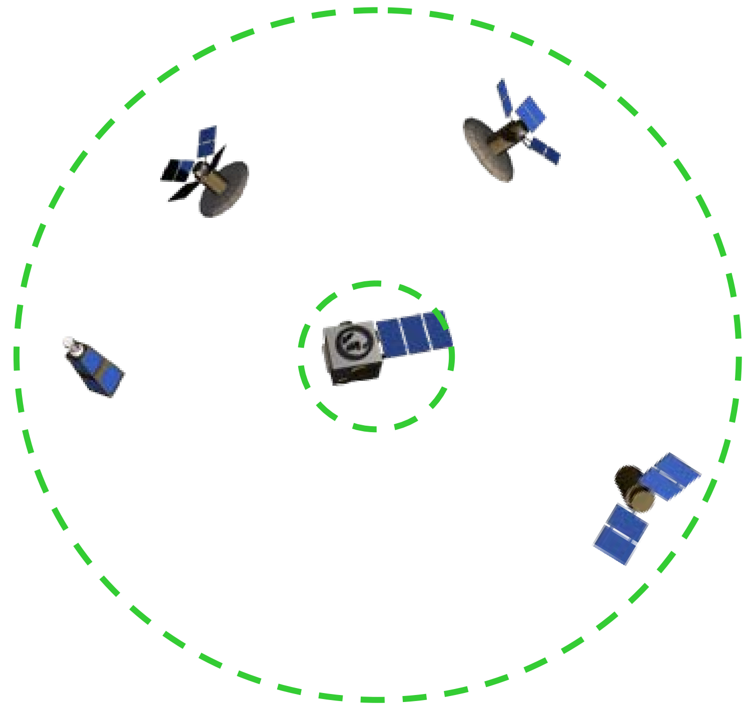
Enabling Technology: Cluster Flight

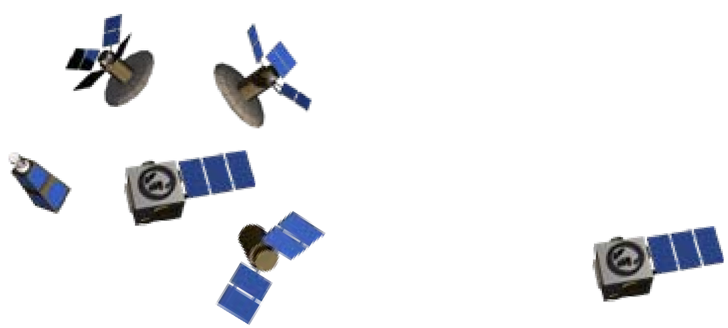
- Autonomous gathering and virtual "docking"
- Mechanical docking allowed, but no physical power or data connections



Enabling Technology: Cluster Flight

- Operator definable min and max spread radius and cluster geometries
- Demonstrate defensive rapid cluster geometry change
- Autonomous collision avoidance

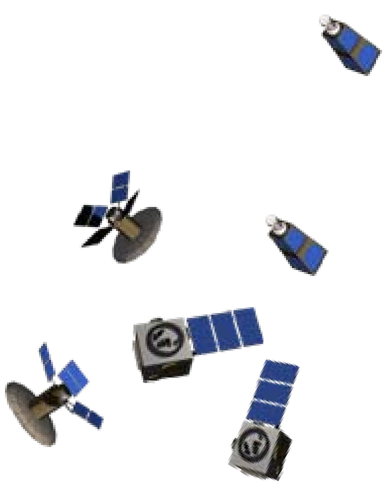




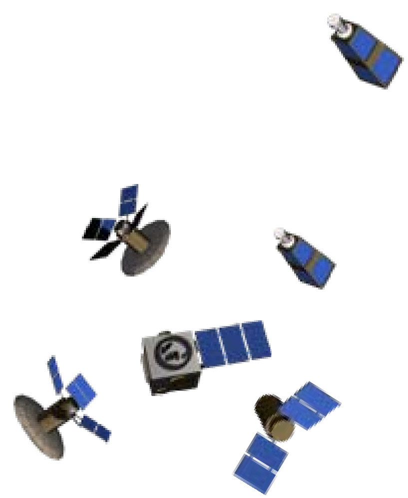
Enabling Technology: Distributed Computing

- Demonstrate basic “keep alive” functionality of the system with the failure of any node.

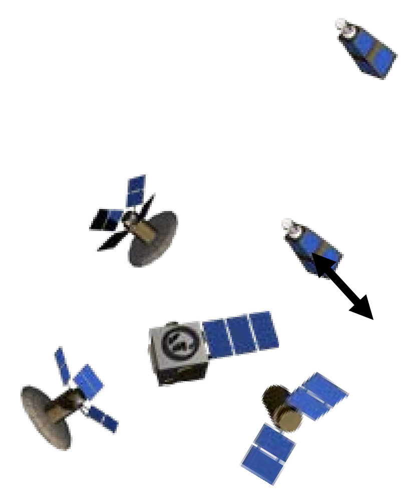
- Demonstrate the insertion of a new mission data processor into the cluster for processor node failure, upgrade, and parallel operation.



Processor Node Failure/Replacement



Processor Node Upgrade



Processor Node Parallel Operation

Enabling Technology: Wireless Power Transfer

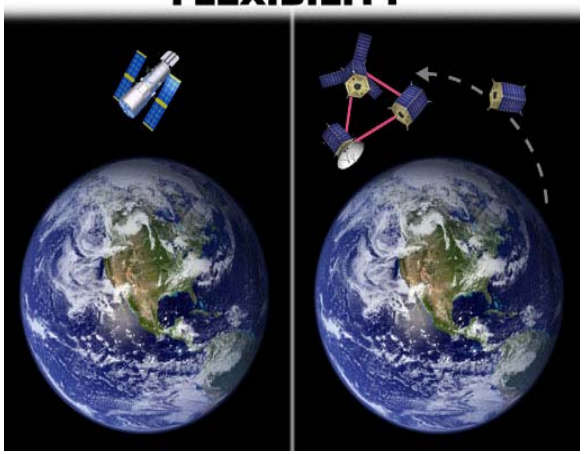
- Demonstrate wireless power transfer at minimum within a single spacecraft node.
- Acceptable methods of wireless power transfer include RF, optical, inductive, and WiTricity techniques.

Enabled Technology: The Spacecraft Black Box

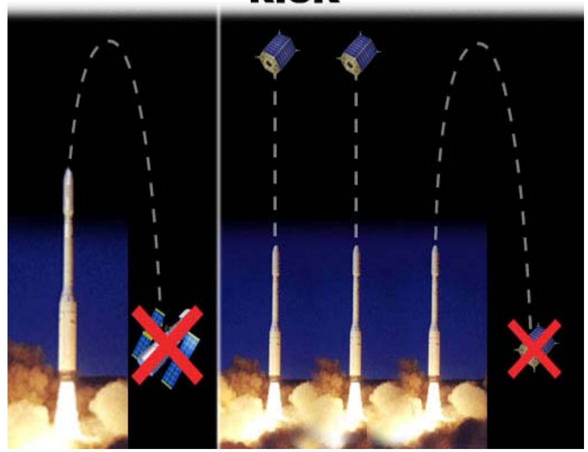
- New class of spacecraft component, enabled by Wireless Power Transfer and Wireless intra/inter spacecraft comm
- Capabilities
  - Flight Data Recorder (Black Box) for failure diagnosis
  - Back-door Spacecraft Recovery Option
- Demonstrates
  - Intra and Inter module communication
  - Wireless power transfer
- Characteristics
  - Capable of being powered externally
  - Maintain 90 minutes of spacecraft health and status information
  - "Bluetooth-like" communications with intra-module components
    - Can provide commands directly to SC components
  - TBD communications with inter-module components

Motivation: Mission Benefits

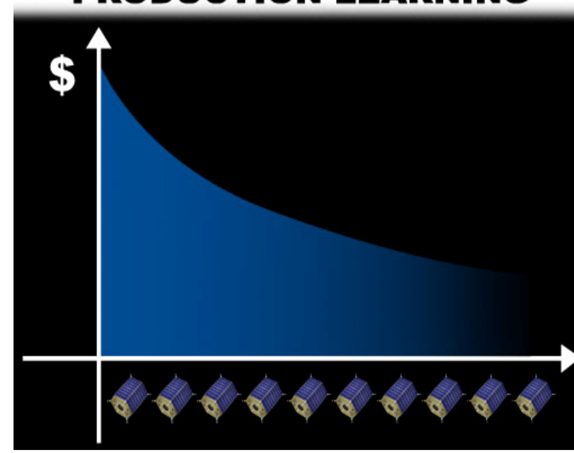
FLEXIBILITY



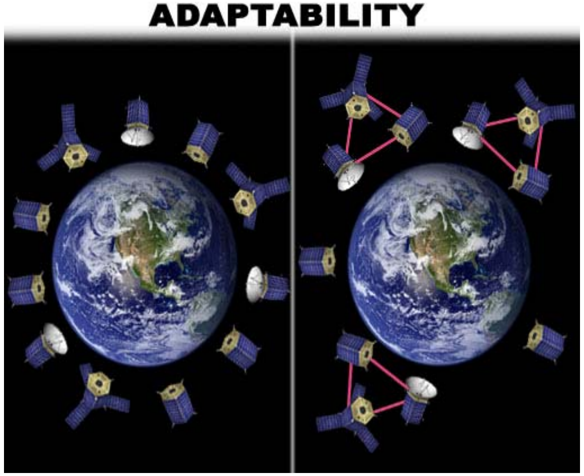
RISK



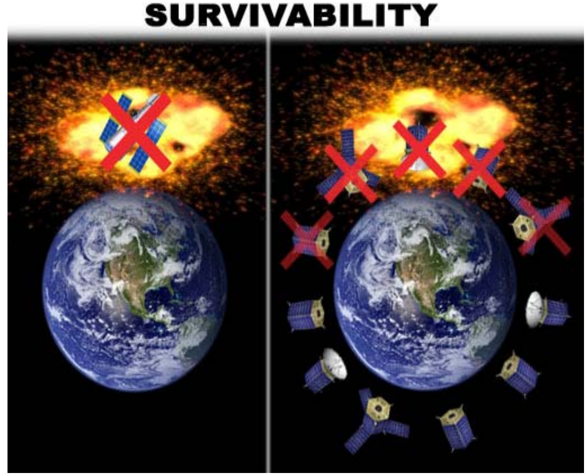
PRODUCTION LEARNING



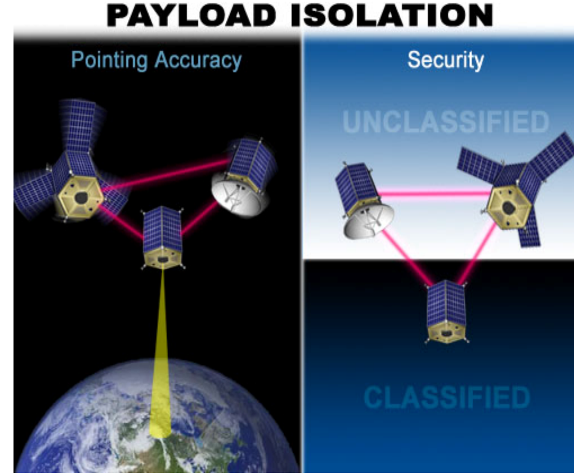
ADAPTABILITY



SURVIVABILITY



PAYLOAD ISOLATION



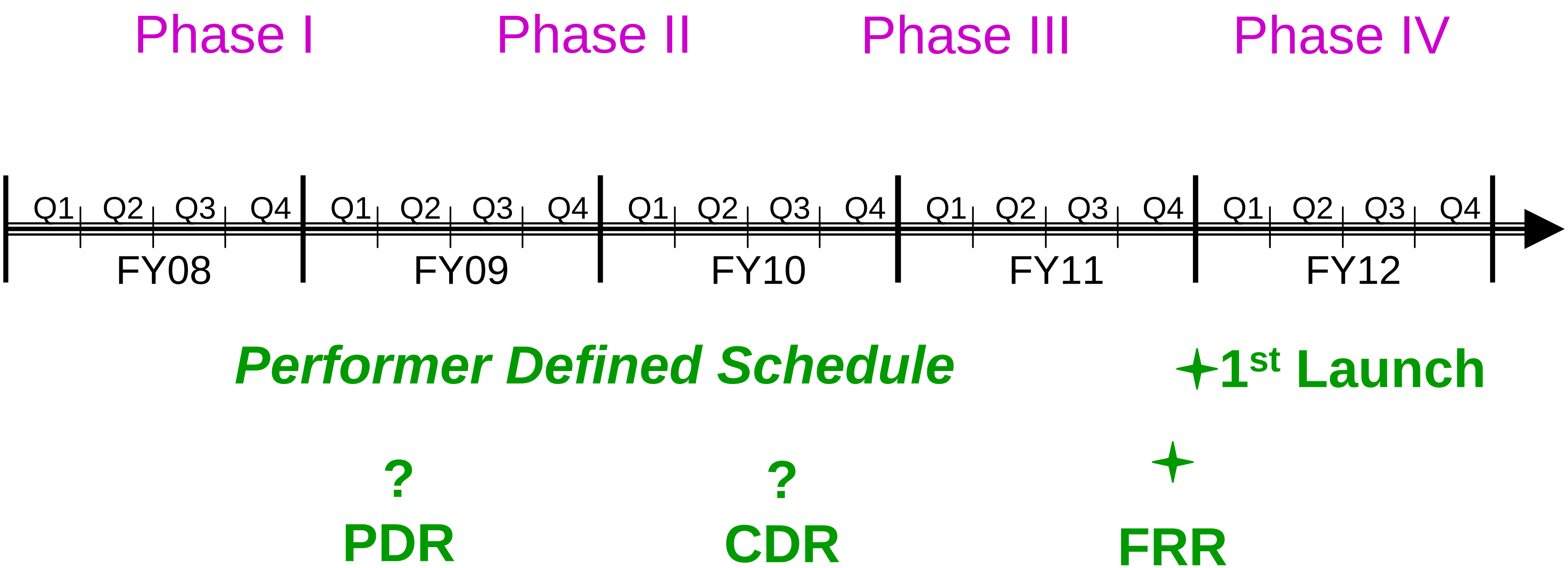
Program Objectives: Top Level

- Decompose a monolithic spacecraft system into a distinct set of two or more modules.
- Demonstrate both pre- and post-launch system functionality
- Demonstrate 99% mission availability over one month.
- Develop an exhaustive hardware and software interface specification
- Demonstrate ability to incorporate mass production schemes.
- Develop a risk-adjusted value centric methodology which quantifies the net value of flexibility
- Conduct a Multi-attribute Utility Analysis for the fractionated system.

Program Constraints

- Each spacecraft module will be on a smallsat/microsat scale (<300 kg wet mass).
- First launch will occur within 4 years of program start.
- Modules will be distributed across multiple launches.
- The launch vehicle(s) will be commercially available, manufactured in the US, and have demonstrated at least one successful previous launch.
- The on-orbit lifetime of the system will be at least one year after the launch of the final spacecraft.

Top Level Program Plan



Key Go-No-Go's By Phase: Phase I (PDR)

- Demonstrate the Top Level program objectives are met at the PDR.
- Develop a hardware in the loop (HIL) test bed which replicates the fractionated spacecraft mission in real time and fast time.
  - Fully networked computers representing nodes.
  - Middleware enabling distributed computing and network management.
  - GPS emulation.
  - RF path emulation of link disturbances.
  - Orbital dynamics simulation.
- Identify possible launch vehicles using design mass and size .
- Perform conceptual design and trade space analysis of spacecraft power transfer options.

Phase I Reviews/Inchstones

System Value Modeling Methodology Design Review

Orbital Mechanics / Trajectory Design Review

Preliminary Design Review (PDR)

Performer Defined Schedule

Program Kickoff

System Conceptual Design Review

Block I Hardware In the Loop (HIL) Test Bed Demo

Power Transfer Trade Space Analysis

Block II HIL Demo

Block III HIL Demo

Plus additional, frequent, detailed program progress reporting
AKA "Inchstones"

Key Go-No-Go's By Phase: Phase II (CDR)

- Demonstrate the Top Level program objectives are met at the CDR.
- At a minimum, add to the HIL:
  - Breadboard wireless data communication modules for node-to-node data transfer.
  - Prototype mission processors.
  - Prototype or flight equivalent GPS receivers.
  - Ground command, control, and mission support suite.
- Demonstrate compatibility of spacecraft design and launch vehicle.
- Execute breadboard level test of selected wireless data communication hardware and software.
- Execute breadboard-level test of selected power transfer hardware and software.

Key Go-No-Go's By Phase: Phase III (FRR)

- Show that FRR system elements meet all program objectives.
- Conduct a successful ground demonstration of end-to-end capability:
- Network demonstration of all flight nodes.
  - Wireless communication demonstration with simulated RFI environment.
  - Power transfer subsystem demonstration in a relevant environment.
  - Ground C2 and mission support suite
  - Inclusion of fractionation-related variables, including data latency, link degradation, and GPS error.
- Completion of individual spacecraft and cross-network integration.
- Completion of all space and launch environmental testing.
- Demonstrate ability to meet all launch integration timelines for launch of each system element.
- Assembly, training, and preparation for ground operations center.

F6 Econometrics Overview

- Value Centric
  - Not cost, but value driven
  - Including real options valuation
- Risk Adjusted
  - Address probabilities of failure: launch vehicle, spacecraft components, etc.
- Stochastic Life Cycle Cost presentation to follow