Fractionated Spacecraft Workshop

Vision & Objectives

Owen C. Brown, Ph.D.
Tactical Technology Office
Defense Advanced Research Projects Agency

August 3 & 4, 2006
Colorado Springs, Colorado
Disclaimers

• This is NOT industry day; it is an open technology and concept discussion forum.
• The DARPA PM does not have authority to bind the government; anything I say is advisory in nature.
• Views expressed in individual presentations are those of the presenters and perhaps their organizations, but not those of the U.S. Government, DARPA, or Booz Allen Hamilton.
• Presentation copies may or may not be available directly from presenters or their organizations; this presentation is available.
• All briefings and discussions in this forum must be unclassified, non-proprietary, and not subject to ITAR.
Genesis of Fractionation

- Wireless bus
- Reducing launch risk
- Pixie dust
Vision for Fractionated Systems

• This is not TechSat-21
  - Aperture synthesis may be enabled, but not raison d'être
• DARPA demo may not be the “optimal” fractionated spacecraft
  - LEO vs. GEO
  - Fully heterogeneous vs. mixed
  - Single payload vs. multiple payloads
• Objective is instead to develop hard technologies and processes
Fractionation - A Panacea?

• Per Pete Rustan (AW&ST op-ed, 9/5/2005), biggest problems facing space industry:
  – Overly detailed and inflexible requirements
  – Inflexible budgets
  – Requirements creep
  – Poor management of subcontractors
  – Uncertainty about new electronic components
  – New spacecraft for each set of requirements
  – Forgetting about ground services

• Fractionated systems are an architectural response to each of these!
Logic of Fractionation

- Space systems are developed and operate under uncertainty:
  - Technical uncertainty
  - Environmental uncertainty
  - Launch risk
  - Demand uncertainty
  - Requirements uncertainty
  - Funding risk
- Traditional approach to coping with uncertainty:
  - Margins
  - Redundancy
- Fractionated systems offer architectural approach to uncertainty:
  - Flexibility
  - Diversification of risk
  - Spatial distribution
Net Value Proposition

**VALUE**
- Capability
  - Incremental Deployment
  - Graceful Deterioration
- Flexibility
- Diversification
- Distribution

**COST**
- Baseline Mass
- Fractionation Overhead
- Learning Curve
- Payload Isolation
- Industry Process Changes

**NEW PARADIGMS**
- Very Large Spacecraft
- Enabling Small Launch Vehicles
- Payload Security
- Industry Competition
Value Sources

• **Capability:** Similar to that of monolithic spacecraft with analogous payload, except:
  - Incremental Deployment
  - Graceful Deterioration

• **Flexibility:** Options to add modules, remove modules, replace modules, or reconfigure spacecraft architecture throughout development and operational life.

• **Diversification:** Decorrelation of failure probabilities across components leads to lower variance of lifecycle cost and value streams; target spreading.

• **Distribution:** Spatial distribution of spacecraft modules reduces undesirable interactions and leads to reduced system fragility.
Cost Sources

- **Baseline Mass**: Comparable to monolithic spacecraft for given capability level.
- **Fractionation Overhead**: Fractionated spacecraft incurs mass penalties due to overhead of replicating some structural and thermal control elements, plus addition of transceivers and inter-module interfaces.
- **Learning Curve**: Production learning effects from duplication of infrastructure modules either in a given spacecraft or across multiple spacecraft.
- **Payload Isolation**: Pointing accuracy and resultant ADCS requirement isolated to payload module only yielding to mass saving.
- **Industry Process Changes**: Commoditization, non-traditional participants, rapid design-build-fly, systems engineering processes.
New Paradigms

- **Very Large Spacecraft:** Enabling “virtual spacecraft” in excess of current launch vehicle capacity without on-orbit construction.
- **Enabling Small Launch Vehicles:** Provide small payloads in volume (economies of scale) for tactical responsive launch vehicles.
- **Payload Security:** Physical separation of payload allows separation of classified from unclassified spacecraft development efforts.
- **Industry Competition:** Structural changes to the space industry permitting participation by smaller players and competition on value.
Lifecycle Cost-Benefit (Monolithic)

- Cumulative Cost Incurred or Cumulative Value Delivered

- Module Type 1

- Time (weeks)

- Cumulative Cost Incurred (in PV)
- Cumulative Value Delivered (in PV)
- Module Type 1
Value-Centric Acquisition

VALUE-CENTRIC

User Requirements → Capabilities → Uncertainties → System → Value

Operator Desirables → Attributes → System → Cost

Cost-Centric

User Requirements → Capabilities → System → Cost
Workshop Structure & Objectives

- Does the concept make sense?
- Is it technologically feasible?
- What process/industry changes are needed?
- Overview of tradespace for each of the technology "pillars" – i.e., the major enablers.
- Feedback from industry to DARPA on what technologies make sense.
- Feedback from industry to DARPA on demo mission concepts and scope.
- Opportunity for industry to air ideas and form symbiotic relationships.