Acquisition Strategy and Source Selection for Co-designing a New-development Spacecraft

by Randall L. Taylor
NASA/Jet Propulsion Laboratory

2006 IEEE Aerospace Conference
Big Sky, Montana
March 4-11, 2006

Discussion Topics

- Prometheus Project Acquisition Objectives
- The Problem: A Single Design Agent was Not Available
- The Solution: Co-design
  - Co-design Definition
  - RFP/contract implementation
- Co-design Techniques
- Advantages and Disadvantages of Co-design
- Results and Recommendation

  - NOTE: time does not permit discussion of acquisition strategy process, benchmarking, and streamlined procurement source selection (please read the paper!)

Acquisition Objectives

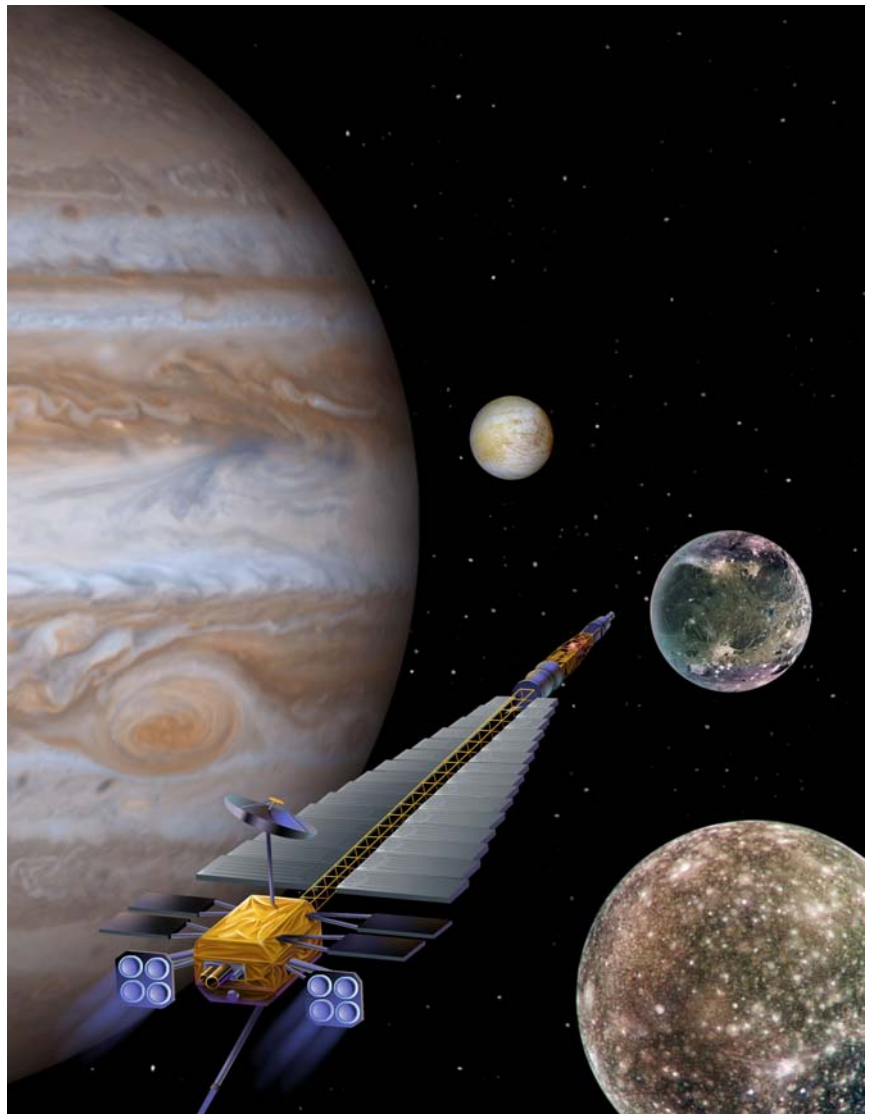
- The Prometheus Project, in support of the Vision for Space Exploration, was intended to produce a revolutionary capability for space exploration
  - Tasked with both technology and scientific objectives (highlighted on slide 4)

- The acquisition objectives, designed to support the Project objectives, were:
  - Establish the Prometheus team
  - Co-design the conceptual Spaceship
  - Estimate its costs in time to support the FY 06 NASA budget submission

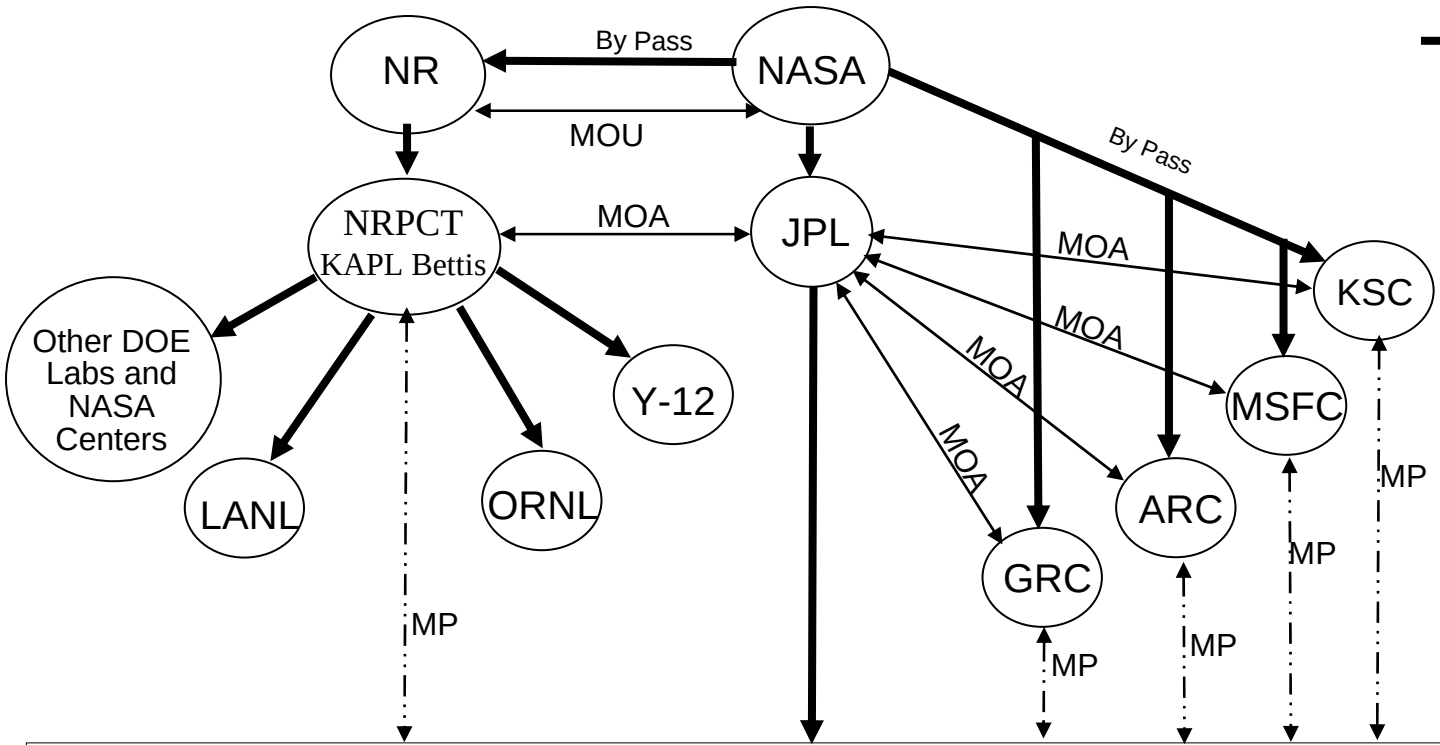
- The most important guiding principles were:
  - Obtain and effectively utilize the best national resources as an integrated team (see Government team members on slide 5)
  - Retain Total System Performance Responsibility (TSPR) in the Government team

Project Overview

- Salient Features
  - Nuclear fission-powered electric propulsion systems would enable a new era of exploration across the solar system
  - There would be unprecedented science data return through high power science instruments and advanced communications technology
- Science
  - The Europa orbiter mission is the highest priority for a flagship mission in this decade (Academy Decadal Report)
  - Search for evidence of global subsurface oceans on Jupiter's three icy Galilean moons that may harbor organic material



Government Team



Funds Flow

Funds from NASA to participating organizations will be provided as authorized by the project manager.

MOU	Broad statement of scope and Agency commitment
MOA	Statement of agreement on areas of project participation
MP	Definition of management responsibilities, tasks and support
Bypass	Bypass Funding and Work Scope Determined by JIMO Project Office

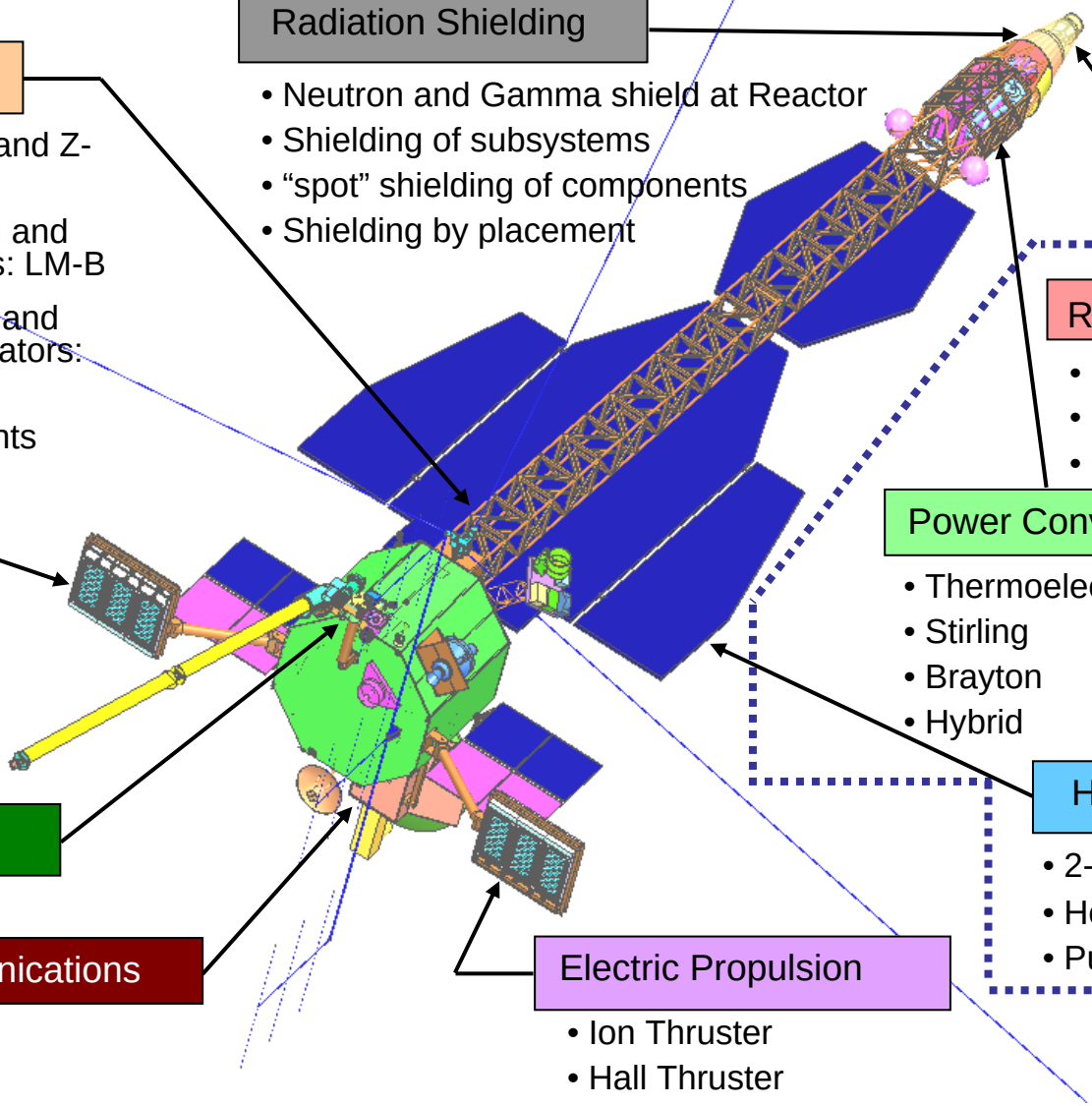
The Problem: No Design Agent

- Every aspect of the Spaceship involved challenging new technology (major challenges are shown in slide 7)

- Neither industry nor Government possessed the full range of capabilities necessary to perform this effort
  - Nuclear systems: Naval Reactors expertise
  - Deep space telecommunications, radiation-hardened electronics, science payload accommodation: Government expertise
  - Spacecraft multiple-unit production: Industry expertise

- Consequently a single Design Agent was not available
  - The traditional model of contractor design/build with Government surveillance did not fit the situation

Key Space System Trades



Boom Structure

- Telescoping Boom and Z-fold Radiators
- Single Hinge, Boom and Deployable Radiators: LM-B
- Single Hinge Boom and Non-deployable Radiators: LM-TE
- Fixed-no deployments

Radiation Shielding

- Neutron and Gamma shield at Reactor
- Shielding of subsystems
- "spot" shielding of components
- Shielding by placement

Reactor

- Heat pipe cooled
- Liquid metal cooled
- Gas cooled

ACS-RCS

- Hydrazine
- Xenon cold gas
- EP
- Forward-Aft

Power Conversion

- Thermoelectric
- Stirling
- Brayton
- Hybrid

Power Generation

P/L Accommodation

Heat Rejection

- 2-Phase Loops
- Heat Pipes
- Pumped loops

Telecommunications

- Klystron
- TWT

Electric Propulsion

- Ion Thruster
- Hall Thruster

The Solution: Co-design

- New paradigm: co-design
  - Government and industry would co-design the spacecraft through Preliminary Design Review in July 2008
  - Industry would subsequently execute the design (critical design, procurement/fabrication, assembly, and test) with Government surveillance

- Definition of co-design:
  - Contractor and Government team personnel jointly:
    - create the system requirements and specifications
    - perform trade studies and design analyses
    - peer review the work
    - prepare and present the Spaceship preliminary design for approval

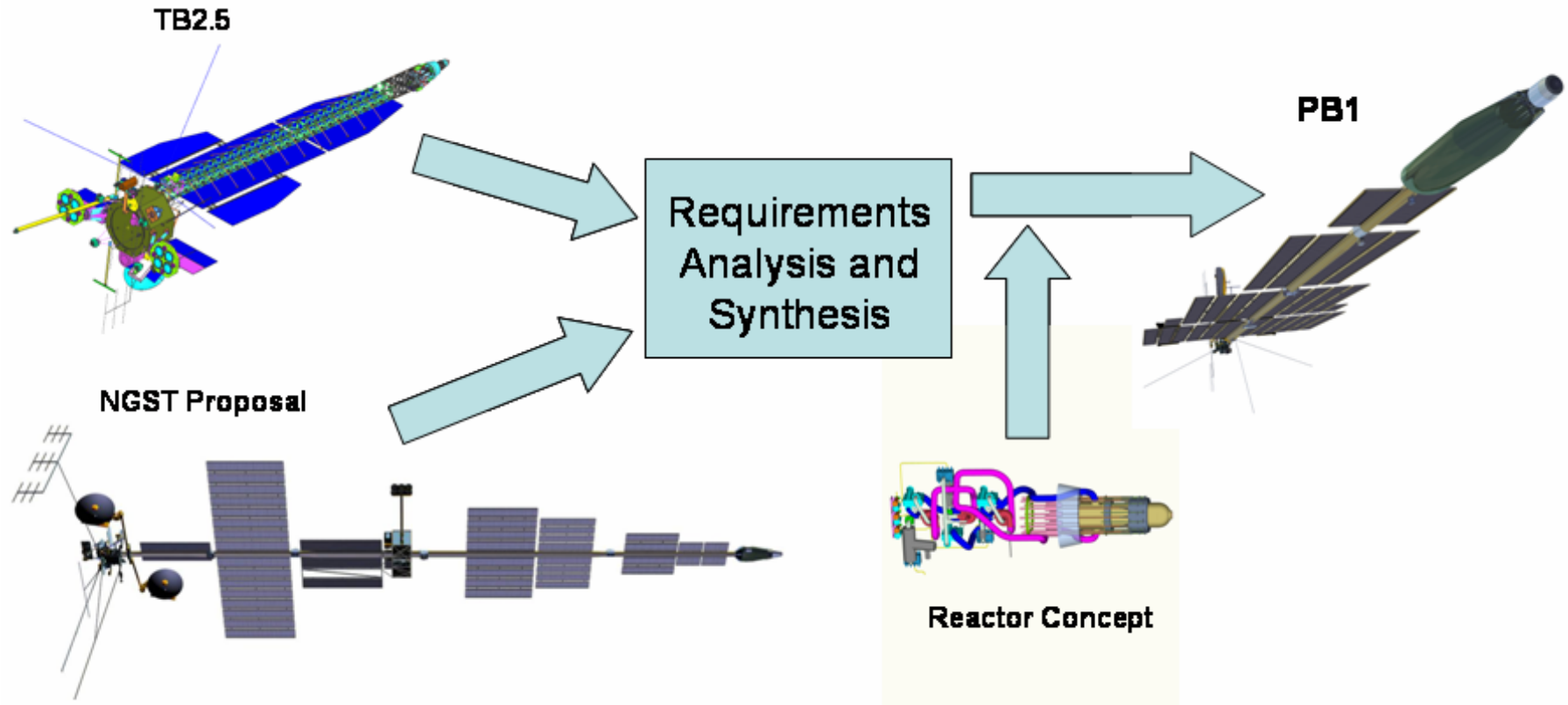
RFP and Contract Implementation

- The RFP for Phase A/B contained a unique Statement of Work and requirements (the job):
  - Co-design tasks
  - No spacecraft specification; instead, Space System Requirements (based on NASA Exploration Systems requirements)
  - Tailored Applicable Documents List and CDRL/DRDs
  - Special Roles and Responsibilities and Guiding Principles
    - Including a Responsibility Assignment Matrix (RAM) that identified the roles for each work element (the RAM is included in the paper)
      - Requirements agent, design agent, design approval authority, design concurrence authority, integration agent, collocation site
- The RFP also contained unique proposal instructions (the basis for source selection):
  - No submission and pricing of a to-be-executed spacecraft; instead, submission of a Design Approach (representative design) as a demonstration of capabilities
    - Supported by representative System Implementation and Verification approach
  - Equally weighted was the submission of the Management and the Technical Team Approach for co-design
- Northrop Grumman was selected as the co-design partner and the resulting contract included Government co-design requirements and contractor-proposed co-design implementation approaches

Co-design Techniques

- Co-design techniques emerged in 3 ways:
  - Government concept (limited in RFP, detailed in support of negotiations)
  - Industry proposed concepts (Northrop Grumman's selected)
  - Collaborative ideas during the course of the job (good ideas, responses to problems, etc.)
- Specific co-design techniques employed were:
  - "Day One Event" kickoff (and subsequent events) for teambuilding
  - Industry and Government personnel collocated (working shoulder-to-shoulder 3 days a week)
  - Shared information systems
  - Work elements assigned to Design Agents, with deputy lead from counterpart organization
    - Lead and deputy jointly responsible for staffing, tasking, performance, reporting
  - Work element Work Implementation Plans
    - Included staffing, budget, roles, team processes and tools
  - Co-chaired Change Control Boards
  - Collaborative engineering using JPL's Team X advanced development process in Northrop Grumman's Integrated Concept Development Facility
  - Joint cost estimation, with review by industry line management and by Government
  - Process owner (Northrop Grumman) for co-design (including health checks)

Spaceship Design Convergence



Advantages and Disadvantages

- Benefits of co-design for Prometheus included:
  - Comprehensive planning, technical, and costing products
    - "The Project is to be commended for the completeness and thoroughness of the gate products produced…" (from review board report)
  - Schedule acceleration (essential to meet the NASA budget cycle)
    - Trade studies and analyses, Spaceship conceptual design, cost estimate, implementation plans, and technical products completed in only 9 months!
  - Mutual learning and team integration
    - "… successful integration of many institutions and organizations into one seamless organization." (from review board report)
    - Board could not tell which project team presenters were from what organizations!
- Detriments of co-design included:
  - Greater up-front (Phase A/B) cost
    - However, this investment was expected to be fully recovered for a positive return on investment during Phase C/D
  - Hard work and attitude adjustment required

Results and Recommendation

- The application of co-design produced a substantial benefit for the Prometheus Project
- The Prometheus experience demonstrated that co-design can be a powerful tool for project managers in appropriate settings
- Co-design is recommended where the following factors are present:
  - A major new-development project, with a defined capability to be delivered
  - The Government needs to retain TSPR
  - No single organization possesses all of the competencies and resources to create the design
  - Sufficient Government resources are available to fully participate in co-design
  - The participating organizations are committed to the value of co-design and to making the necessary cultural changes