Thinking Inside the Box: Concurrent Engineering Approaches to Low-Cost Planetary Instrument Formulation at the Jet Propulsion Laboratory

Alfred Nash
Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109, USA
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Low-Cost Planetary Missions Conference 10

The Low Cost Planetary Mission Challenge: Navigating Between Scylla and Charybdis
The Historical Approach: Disadvantages of the Waterfall

Waterfall formulation is time consuming, often leads to solutions outside the resource constraints, and can result in proposal weaknesses in Science (pruning), Technical (reaching), Management (cobbling) and/or Cost (pricing)
Alternative to the Waterfall: Concurrent & Collaborative Engineering

Science

Engineering  Cost

Enables quick convergence, within the boundaries, and minimizes potential weaknesses
$ = f(kg, W, kbps, ...)$

- Left to Right
  - Traditional waterfall direction
- Right to Left
  - Starts *individuals* in “likely” parameter spaces
  - Speeds convergence of team
  - Creates the dynamic tension needed to drive innovation
• The traceability of each requirement is linked by some *rationale*.

• Whether through the result of a prejudice, or thorough trade study, untested, the rationale can push the architecture outside the selectable zone

• Systems engineering best practices recommend solving the problems at the lowest possible level
E.g., Characteristics of Discovery Missions
- Single Planetary Body Orbiters (5 Missions)
  - 6 ± 2 Instruments
- Multi Body Rendezvous (2 Missions)
  - 6 ± 2 Instruments
- Sample Return (2 Missions)
  - 3 ± 2 instruments
- Lander (3 Missions)
  - 6 ± 3 Instruments

Provides a reference for the state of the art in class.
Can be used to reveal trends (e.g., destination in class)
Reveals potentially selectable solutions consistent with proposal reviewers’ expectations (less likely to generate findings of Major Weaknesses)
Better than the Waterfall: Constraint Driven Innovation

- Quickly gets all disciplines looking for solutions in most likely parameter spaces
- Leads to solutions within the resource constraints
- Results in selectable solutions consistent with proposal reviewers’ expectations (less likely to generate findings of Major Weaknesses)

“Necessity is the mother of invention”
Think Inside the Box
Because It’s Bigger On The Inside