

# Early Formulation and Development Success

Does NASA Sink Projects Before They Even Start?

Ron Ray

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# Is There a Recipe for Development Success?

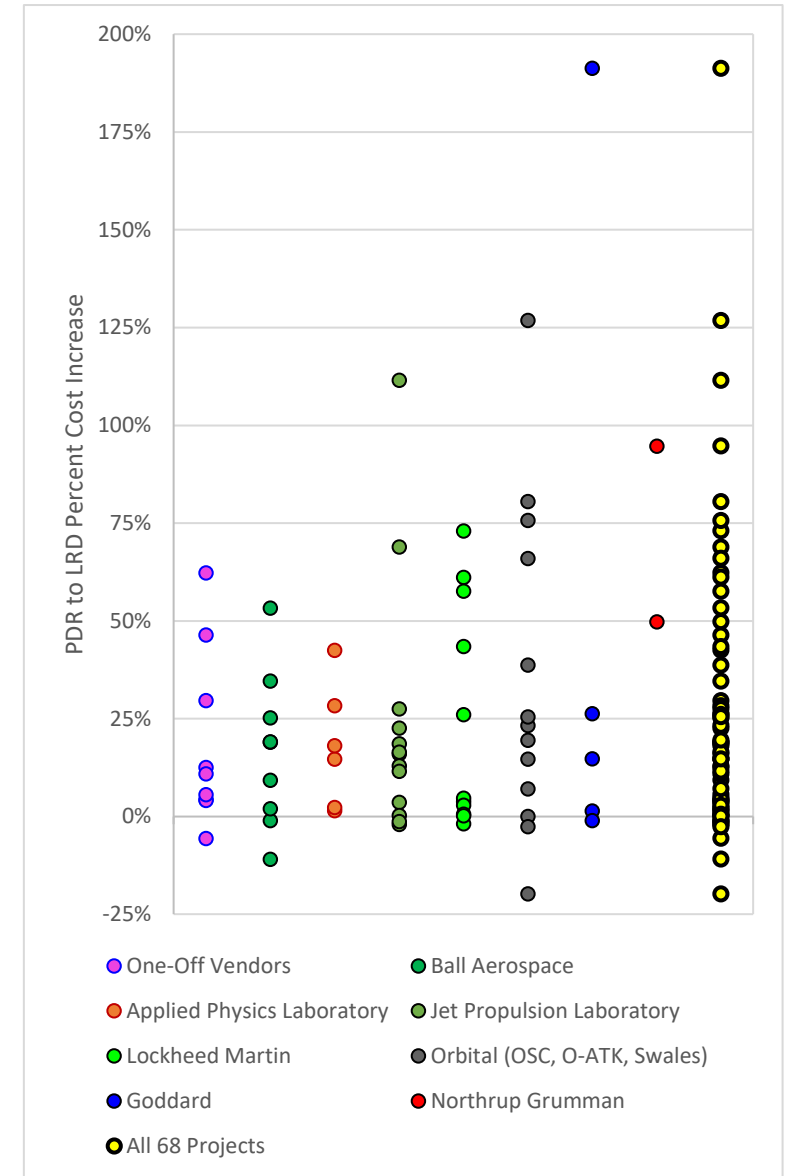
- Multiple statistical studies have looked at various project characteristics, individually and in combination, for correlation with development performance
- Consensus is mild correlations between some individual characteristics and better outcomes, but overwhelmed by unexplained variability
- Different approach for this study:
  - Non-statistical, case study comparative analysis
  - Focus on early strategic formulation for NASA budget requests
    - Predates Agency Baseline Commitments, Management Agreements, and often formal Phase A effort
    - Do early decisions build a budgetary “box” around a proposed project, from which the project cannot escape?

# Analyst's Observations

- NASA has no definition of “success”, and studies usually fall back on cost or cost and schedule as measures
  - One study attempted a comprehensive measure, which excluded schedule
  - Most studies start with PDR cost and schedule, rather than earlier “marketing” costs which are often used for Agency budget formulation
- Focusing on factors for success suggests a formulaic recipe- “Do X, Y, Z; sign the paperwork; and success is assured” (7120?)- while letting human decisions off the hook
- Early Agency budget decisions MATTER
  - NASA is reluctant to record or discuss how early decisions affect projects
  - 7120 tradition is for success of single projects. Does NASA have an appropriate strategic, portfolio-level budget decision tradition?
  - Agency leadership changes faster than project lifetimes
    - Deciders usually aren't around to make their decisions work during project development
    - Succeeding leaders aren't aware of problems built into promises that project isn't meeting

# Brief Detour- Vendor as latest Characteristic explored

- Looked at Cost performance of 68 projects from PDR to LRD, then sorted by prime vendor
- Variability of individual vendors approaches that of entire dataset
- Vendors with better averages avoided one or two projects at the high end of overruns, but otherwise resemble all other vendors and the dataset as a whole
  - Could not determine if avoiding one or two projects was random variability (likely, given low- $n$ ) or something about the vendors
- Conclusion: Vendor is no help explaining variability



# Case Study Approach

- Look at early formulation, predating Agency Baseline Commitments and Management Agreements, and often formal Phase A
  - Do early decisions “box in” a project, and lead to problems later in development?
- Developed formulation case studies for Galileo, Hubble, Webb, Curiosity, New Horizons, and Voyager
  - Lack of readily-available data on early formulation of project proposals limits cases to those where someone has literally “written the book” on the project, AND includes good data on early formulation
- Look for themes associated with significant cost overruns, or with largely meeting proposed cost, schedule, and technical content
  - Some projects appear in both categories, where overruns were driven by external factors largely outside the project’s control
- Audience is Agency leadership and management, as they typically define the box that the project eventually has to work within

# Characteristics Associated with Large Cost Overruns

- Vulnerability to performance and schedule problems in other projects or externally provided components (Galileo, New Horizons)
- Gross trimming of estimates to win political approval (Hubble)
- Failing to recognize and plan for emerging cost reality, ultimately driving final costs higher (Hubble, Curiosity)
- First-of-kind missions improperly viewed as straight-forward evolution from heritage of prior missions (Hubble, Webb, Curiosity)
- Good project planning and implementation in one area cannot overcome problems in other areas (Galileo, Hubble, New Horizons)
- Unsupportable optimism in estimates, cause of optimism undetermined (Webb)

# Characteristics Associated with Largely Meeting Proposed Cost / Schedule / Content

- Ample and conservative cost, schedule, and technical margins (New Horizons, Voyager)
- Use of previously flown instruments, with minimal modification (Galileo, New Horizons)
- Straight-forward heritage continued from successful missions (Voyager)
- Use of extended pre-Phase A to mature technology and instruments (New Horizons, Voyager)
- Lack of external cost pressures (Galileo, New Horizons, Voyager)

# Galileo Discussion

- Mission concept repeatedly changed due to:
  - Space Shuttle development cost overruns
  - Performance shortfalls on both Shuttle and proposed upper stages
  - Unachieved aggressive Shuttle schedule to meet most favorable launch opportunity
  - Mission concept changed between one or two spacecraft, direct trajectory or multiple gravity assists, thermal design for 1 AU or 0.7 AU, different upper stages
- Challenger accident drove additional delays and mission changes
- Positives:
  - Complexity fell between previous Pioneer and Mariner missions
  - Instrumentation largely from previous missions
  - External cost pressures appear minor and not directed specifically at Galileo
- Could Galileo have met proposed cost absent Shuttle problems?



# Hubble Discussion

- Marketed as evolutionary from previous space telescopes, but magnitude of improvements was much more first-of-kind
- Higher-risk spares, testing, procurement, and oversight strategies attempted to halve cost from internal estimates
- No relief from NASA leadership when cost cap became unrealistic
  - Project's attempts to stay within cap arguably increased final costs
- 12 years elapsed between initial study contract and formal project start, but Hubble does not appear to have benefitted from what should have been ample time for early formulation, technology development, and reasonably accurate estimates

# Webb Discussion

- Infamously proposed at “\$500 M”
  - Estimate actually about \$825 M when missing content is added
- Last gasp of “better, faster, cheaper”, and possibly the most extreme example of that approach
  - Technology, commercial systems, innovative and streamlined business and management practices were to prevent high final costs of previous projects
    - Implementation and monitoring approaches were not identified
    - Technology was not developed
  - Hubble, Spitzer, and commercial communications satellites cited as how to reduce costs, without support and often contradiction
- Huge increase in complexity over previous observatories not acknowledged
- Much higher independent estimated suppressed by NASA leadership

# MSL/Curiosity Discussion

- Complexity makes Curiosity much more first-of-kind than evolution and heritage from successful Sojourner and Spirit/Opportunity
- Extra two years between proposed 2007 launch and funded 2009 launch was not used to develop technology and buy down risk
- Forced slip from 2009 to 2011 did buy down risk in areas not driving the slip to 2011

# New Horizons Discussion

- Increases to launch services and RTG almost match development cost increase, and exceed total cost increase
- As-launched science capability exceeded proposal, and transit time was 3 years shorter than proposal
- New Horizons effectively had an extended pre-Phase A
  - 3 instruments were under development for cancelled Pluto-Kuiper Express and other 2 were already flown or through CDR and in build
  - Work on Europa Orbiter and Solar Probe also contributed
- Announcement of Opportunity requirements appear to coincide with what mission proponents felt could be delivered with reasonable cost, schedule, and technical margins
  - Avoided both high-risk/low-cost “better, faster, cheaper” and high-cost flagship

# Voyager Discussion

- Technology work started for technologically ambitious and expensive Thermo-Electric Outer Planets Spacecraft
- Concept quickly fell back to Mariner-class, but with successful TOPS technology and Viking heritage
- Descope retained:
  - Longer development schedule than Mariner missions
  - Robust budget with multiple hardware units and spares and margin for problems
  - Additional capability beyond previous Mariners
  - Recent experience with Mariner series and Viking