Analysis of JPL Mission Cost Estimate Drivers

Tommy Sebastian
November 10th, 2005
Presentation in Brief

• Statistically significant common drivers occurred in late 1999-early 2000
• Project-specific drivers were identified through documents and interviews
• Better understanding of cost estimate drivers that could result in higher fidelity cost estimates
Outline

- Project description
- Information gathering process
- Contextualized cost estimate histories
- Identification of common drivers
- Statistical analysis
- Conclusions
- Future work
- Concluding remarks
Project Description and Context

• Objectives
  – Gather and consolidate data from key project personnel
  – Better understand factors that drive cost growth events
  – Follow the project lifecycle from formulation through implementation

• Purpose
  – Derive empirical principles that can increase the fidelity of early cost estimates

• JPL Context
  – New JPL Cost History Database consolidates actual charged costs
  – Current project complements Database with history of formulation estimates and EACs
  – Gain insight on primary common drivers that affect cost estimates
  – Previous studies examined Phases B/C/D
Information Gathering Process

- Interviews
  - PMs, PRAs, and other key individuals
- Documents and other sources
  - EDS
  - Project Financial Workforce Database
  - Technical Cost Database
  - DocuShare
  - Task orders
  - Project libraries
  - Personal files
Analysis of JPL Mission Cost Estimate Drivers

Cost Estimate Histories

- All values converted to FY05
  - Gives a better idea of true cost
  - Used NASA New Start Inflation Index (2005)
- Context generated primarily from interview notes
- Perceived driving factors differ between project personnel
- Cost estimates should not be considered single point events
  - Cost estimates are generated over a period of time
  - The indicated points correspond to dates of published information
- Data gaps may exist between estimates and events
Contextualized Cost Estimate Histories

Imaginary JPL Mission Cost Estimate History

- Phase A/B
- Phase C
- Phase D
- Phase E

- Chromosphere Sample Return Complication
- Artificial gravity integration problems
- Launch on Saturn XLV
- Chinese contribution withdrawn
- 10-year share price minimum for Orbital

- Project internal
- JPL/NASA internal
- Project external
- Project external (market based)
- Launch/land/sample return
- Failure


$ Billions
Normalized Cost Estimate History

- 1984
- 1985
- 1986
- 1987
- 1988
- 1989
- 1990
- 1991
- 1992
- 1993
- 1994
- 1995
- 1996
- 1997
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005

- Mars Observer
- JPL workforce peak
- JPL annual budget peak
- Mars Polar Lander
- Mars Climate Orbiter
- Columbia
- NASDAQ peaked (peak of the "dotcom boom")
- Tom Young report
- Challenger
Normalized Cost Estimate History

- NASDAQ peaked (peak of the "dotcom boom")
- Mars Climate Orbiter
- Mars Polar Lander
- Tom Young report
Statistical Analysis

- Two-factor Analysis of Variation (ANOVA) was performed on a time period from October 1998 to November 2001
  - Compares means by comparing measures of variability
  - Large enough project population to make viable statistical conclusions
  - Lack of data replication makes event isolation impossible
- Statistical effect of factor “project” much greater than factor “time”
  - Projects cover different missions and types with different governing paradigms…expected this behavior
  - Refocus on the effect of factor “time”
- Maximum variance occurs in January 2000
Primary Drivers

- JPL/NASA Mission Investigations
  - Seem to most affect missions that haven’t launched yet
  - Cost increases due to increased reviews that compete with development time and often result in launch slips
  - Certain risks no longer considered acceptable
    - “They’re all Class A on the launch pad.” ~Dave Swenson

- Dotcom boom
  - “Brain drain” effect felt primarily by private industry
  - JPL contractors took longer to fulfill obligations and work quality slipped

- Administrative/governmental cost increases/funding delays
- Inadequate initial estimates and reserves
- Inadequate initial understanding of project complexity
  - Technical “scrambling”
Conclusions

• Some combination of events occurring near January 2000 had an effect on mission cost estimates for most of the investigated projects
• It is unlikely that a single event can be blamed for any particular cost estimate increase
• JPL is doing well considering the nature of its work
Future Work

• For future researchers
  – Comparative analysis with other centers to isolate drivers
  – Search for other significant factors
    • Project work force attrition
    • Look at directed versus competed missions and in-house versus system contracted
    • Follow paradigm shifts

• For JPL
  – Standard and enforced procedure for documenting cost estimation history
  – More accessible documentation
Acknowledgements

- Brent Sherwood (mentor)
- Linda Rogers (Space Grant)
- SURF Program Office
- Gary Ball
- Leigh Rosenberg
- Bill Heinrichs
- Mark Johnson
- Numerous PMs and PRAs
Questions?
Tommy Sebastian’s Bio

• Senior @ NC State pursuing B.S. in Aerospace Engineering w/ a minor in Physics  
  – Seeking concentration in space systems development
• Graduate from the SC Governor’s School for Science and Mathematics
• Electronics Development Team, Space Senior Design team leader (2005)
• USA TODAY All-USA College Academic Team (2005)
• NIAC Student Award Winner (Fall 2004)
• Publications
Project Timeline

- Week 1 (June 6-10) Identify personnel to interview
- Week 2 (June 13-17) Consolidate existing documentation regarding mission histories
- Weeks 3, 4 (June 20-July 1) Complete identification of key knowledge carriers and augment existing foundation data with interviews
- Weeks 5, 6 (July 4-15) Consolidate information into databook
- Week 7, 8 (July 18-29) Analyze total foundation data and identify empirical principles
- Weeks 9, 10 (August 1-10) Author final JPL report, final report (public), and present findings