



Space Systems Affordability

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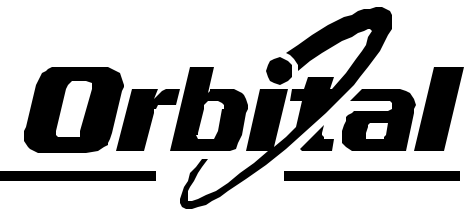
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What Does “Affordability” Mean?

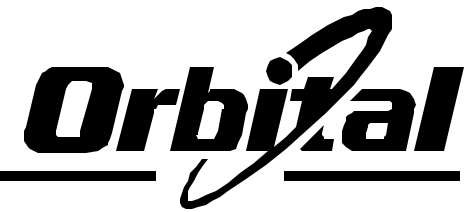
- Low Cost?
 - Development?
 - Life Cycle?
 - Funding Profile?
- Favorable Cost/Benefit Ratio?
 - Must Address Relevance and Effectiveness.
 - Probably Still Subject to Annual and Total Cost Constraints.
- Opportunity Cost?
 - What Isn’t Done, If We Do “This”?
- Risk?
 - What is the Cost of Not Doing “This”?
 - The Most Expensive Thing in the World is the Second-Best Defense.
- “Affordability” is Probably a Combination of All of These Things
 - Weighting Factors Can Be Highly Subjective

Some Orbital Experience



- Pegasus
 - Short Development Time: 3 Days Short of 3 Years
 - Technical Performance Measures (e.g. Payload, Accuracy) Within 5% of Original Estimates
 - Development Cost (to First Flight) < \$50M (Within 10% of Initial Estimate). A *posteriori* NASA Estimate of Cost for Same Scope: \$250M
 - Recurring Cost, Including Operations, About Twice the Initial Estimate
 - Lessons Learned:
 - Customers' Price vs. "Illities" Trade Preference Did Not Match Orbital's Initial Assumptions.
 - Beware of Diseconomies of Scale Caused by Fixed Costs (e.g. Range Costs, Airplane Costs).

Some Orbital Experience (cont.)



- X-34
 - Development Cost (to First Flight Article) Within 5% of Original, FFP Price.
 - Technical Performance Measures (e.g. Dry Weight, Maximum Mach Number) Within 5% of Original Estimates (so far).
 - Development Time Increased Due to:
 - “Losing” Technical Gambles (Composite Tooling for Propellant Tanks).
 - Political Intervention in Program (Multiple Development Ranges vs. Single Range).
 - Lessons Learned: Too Early to Identify.



Some Orbital Experience (cont.)

- APEX (High Radiation Environment, Low Cost, One of a Kind)
 - Original Estimate: \$14M, 28 Months, Achieved: \$17M, 42 Months.
 - Design Life: 6 Months, Achieved: 22 Months.
 - Lessons Learned:
 - Unimpeded Flow of Communications Between Team Members.
 - Co-location of Team and Hardware, Especially During System Integration Phase.
 - Minimize Concurrent Development (e.g. Space and Ground Segments).
 - FPI Is a Bad Contract Model for a One-of-a-Kind Development.



Keys to Affordability

- Demanding External/Internal Cost/Schedule Constraints
 - You can't spend money you don't have.
 - Time is money.
 - "Lean" approach can be overdone -- need to incorporate some margin.
- Flat Organization
 - One or, at most, two steps between major projects and the Corporate COO.
- Small, *Self-Contained*, Capable Project Teams
 - Favors tight decision loops and cohesive execution.
- Control of Technology Insertion
 - New technology can clearly enable a paradigm shift in what is possible, but...
 - Should be used only where absolutely required, with fallbacks if possible.
 - Can't afford "science projects" on cost/schedule constrained projects.
- Commercial Practices/Systems/Parts Where Appropriate
 - COTS software/hardware whenever possible.



Keys to Affordability (cont.)

- Requirements Challenged at All Levels
 - Top-Level as Well as Derived
 - Farther Down the Design Process than Usual
 - Example: Downcargo Requirements for Space Station Resupply Lead to Consideration of C/CTV As a Replacement for Shuttle
- Use of Simple vs. Complex Objectives
 - Quantitative Objectives: Ideally a Single (Scalar) Performance Function vs. Multivariate (Weighted) Performance Metric
 - Qualitative Goals: Sharply Defined Specific vs. Generic Goals
- Architecture
 - BSTS vs. SBIRS-Low (Brilliant Pebbles)
 - International Space Station vs. Skylab
- Stable Customer Requirements
 - Change (good or bad) costs money and time.