Space Systems Affordability

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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.