Costing of X Ray Science Mission Concepts: Approach Overview

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X ray SAG, August 15, 2012

Costing of X Ray Mission Concepts: Approach

- Early mission life cycle phases (Conceptual, pre Phase A) rely on models for cost estimation
  - Grassroots estimates are labor intensive and mission teams lack adequate resources in these early mission phases to support detailed mission definition and grass roots costing. (This was true for X Ray Study Team)
  - GSFC Instrument Design Lab (IDL) and Mission Design Lab (MDL) are ideally suited for supporting early mission concept ROM costing.

- The IDL and MDL provide an environment that facilitates multi-disciplinary, concurrent, space system engineering design and analysis activities, to allow rapid (one week) development of science instrumentation and mission architecture concepts.
  - Staffed by over a dozen discipline engineers in a single facility, the IDL and MDL develop an internally consistent instrument or mission design, respectively.
  - The X-ray Study team, as the "customer," was integrated into the design lab process providing input and feedback as the instrument or mission design unfolded.
  - Note that an MDL design represents a best effort to satisfy mission requirements for the lowest possible costs, but it is ***not optimized*** and only a few cost saving methods can be explored.

- The IDL and MDL use PRICE H model for costing hardware elements, combined with experienced based estimates for costing other mission WBS elements.
  - X Ray study team used the IDL and MDL notional mission set hardware costs, and adaption's of prior CONX and IXO costing for non hardware elements, to arrive at notional mission costs

Costing of X Ray Mission Concepts: Pricing Models

- PRICE H Model requires a 'master equipment list' (MEL) as input
  - IDL and MDL generate MEL for instrument and s/c bus, respectively
  - Pass through costs are accepted in the model; design lab protocol require sufficient basis of estimate documentation to use pass through cost data
- PRICE H Model can vary, for each items on the MEL:
  - Technology Readiness Levels (TRL)
  - Structural/Electronic Complexity
  - Mass
  - Grade of Part (Class B, Class S)
- PRICE H Model takes into account:
  - Integration within subsystems
  - Integration of subsystems with each other
  - Supporting procurement and engineering design activities surrounding purchased items
  - Instrument or s/c bus development schedule with key mission dates
- The following grassroots estimates are added to the PRICE H estimate, as a % of costs, for completeness:
  - Extent and depth of test program for instrument or s/c bus, including environmental test program
  - Flight software development costs (simulators, procurements, GSE)
  - FPGA Development
  - GSE
- PRICE H Strengths
  - Provide a ROM cost estimate based on continually updated aerospace component cost history
- PRICE H Weaknesses
  - Requires detail definition through the MEL that is often lacking in early definition phase (different mission classes, e.g., Class A or Class B, are defined by MEL content)

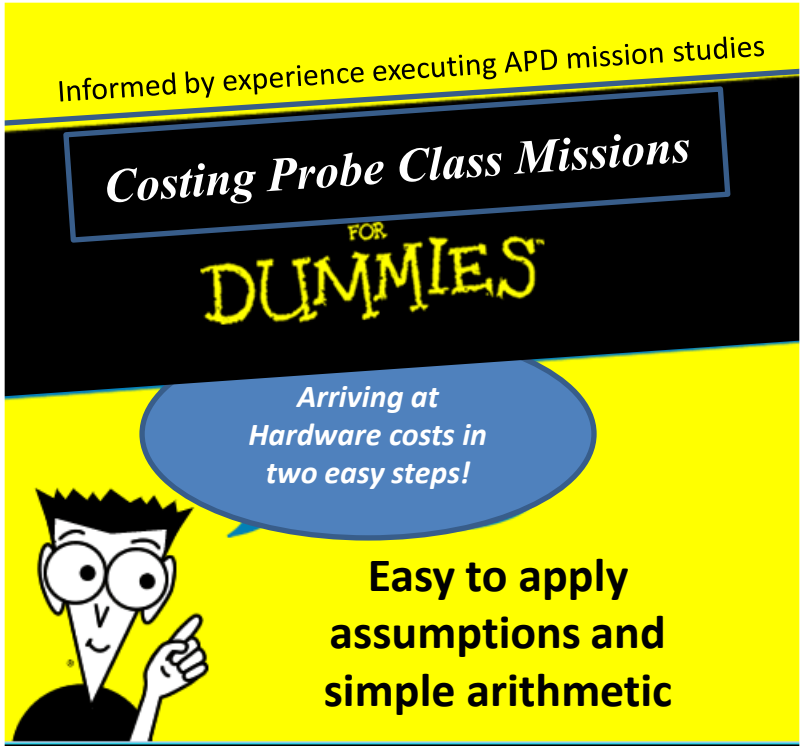
Costing of X Ray Mission Concepts: Master Equip. List

- Design lab environment is ideally suited for generating a 'point design' MEL in early phases of mission conceptualization
  - Study team provides top level science overview, mission requirements, schedule, concept of operations
  - Study team may also take an existing MEL, and update it outside the design lab environment
  - Study team can offer "pass through costs" for MEL items with proper basis of estimate documentation
- Design Labs produces a technical data set for the entire instrument and/or spacecraft, at subsystem level, and for all aspects of mission concept (e.g. flight dynamics, mission operations)
  - Technical data provides input for MEL generation
  - Design lab costing engineer works with other lab engineers to add lower level fidelity to the MEL
- Design lab produces a PRICE H Model cost of the instrument and/or spacecraft bus and notional grass roots for other elements of the mission (Project Mgmt, Systems Engineering, I&T, etc.)
- Design lab environment is not suited for optimizing mission design
  - Usually one or two major trades can be studied, but only if not significant ripple through all subsystems
  - Effectiveness of Design Lab increases as the fidelity of the design concept brought through the front door increases

Costing of X Ray Mission Concepts: Racking Up Costs

- Mission Rack Up Spreadsheet is used to calculate overall mission costs
  - PRICE H costs for instrument and s/c bus are direct plug ins
  - Spreadsheet is set up to calculate non hardware costs of mission as a % of hardware costs, as well as reserves
    - %'s are based on historical averages
    - Study teams may disable auto calculations in favor of inserting notional grass roots inputs for non hardware mission elements, e.g. science, mission operations, etc.
    - Study team may adjust reserve % (No reserves placed on Launch Vehicle costs)

Costing of X Ray Mission Concepts: Arriving at ROM Hardware Costs



Assumption 1: All Mission WBS Elements have 30% cost reserves applied

Assumption 2: All non H/W WBS Elements are a % 'wrap' of instrument and s/c bus costs

Step 1: Subtract LV Costs from $900M ($250M for EELV, $140M for Falcon 9)

Step 2: Take 62% of remaining costs

This remainder is amount for instrument and s/c bus, including reserves. ($403M for an EELV, and $471 for F9 Probe Class Missions)

Costing PAG?

- How does community develop standardized mission costing approach/process for:
  - Mid Decadal consideration?
  - Decadal consideration?
  - Response to RFI's?
  - Other?

  ….so decision makers may compare science and costs in an apples to apples fashion