Estimating Cost of Class D Payloads and Missions

April 8, 2015

Guidance for Costing Class D

- NASA is now conducting competitions for Class D payloads and missions in several competed program lines.
- Many NASA sponsored cost models were developed using Class B or C payloads and missions.
- NASA has sought guidance from Cost model developers on how frequently used cost models can be adjusted to reflect Class D.
- The following charts provide guidance for proposers on costing class D with the assumptions defined in the document “TMC expectations for Class D payloads” that is in the EVI-3 program library and NPR 8705.4.
- The following charts cover three cost models, SEER, PCEC, and NICM.
- Following this guidance is not a requirement on proposers.
- This document may be updated in the future as more research is completed on estimating the cost of Class D instruments and missions.

SEER Overview

- SEER Estimating Suite
  - SEER-H: SEER for Hardware, Electronics & Systems
    - Estimates cost of hardware development (Phases B-D)
  - SEER-EOS (Electro-Optical Sensors)
    - The EOS add-in is an extension to the core SEER-H
  - SEER-IC (Integrated Circuits)
    - The IC add-in is an extension to the core SEER-H for estimation of micro-electronics (i.e., FPGAs, ASICs)
  - SEER SEM: SEER for Software
    - Used only when enough data is provided
- SEER is a component-level modeling tool, i.e., inputs describe boards, mechanisms, sensors, thermal elements, etc.
- SEER contains Knowledge Bases (K-bases) for default parameter inputs on flight components, PM/SE/MA and I&T.
- Key costs drivers are component-specific and may or may not use mass inputs. For example:
  - EOS Optical Device requires parameter inputs for: spectrum (UV, Visible, IR, etc.), aperture, surface shape, etc.
  - EOS Detector requires parameter inputs for: array (#rows, #columns), frame rate, pitch, etc.
  - Mechanical/Structural requires parameter inputs for: mass, etc.
  - FPGA requires parameter inputs for: feature size, clock speed, # logic cells or # system gates, etc.

Points to consider when using SEER to model Class D payloads

- EM, Prototype, Flight & Spares
  - Any limited engineering model and/or flight spare hardware assumptions should be reflected in the MEL and in the SEER model's prototype and production quantity parameters.
- Qualification, Acceptance, Protoflight
  - Any reduction in testing level can be reflected in SEER's Certification/Reliability parameters for a given element and within SEER's rollup level System Test Operations (STO) & Integration Assembly and Test (IAT) parameter complexities settings as appropriate.
- Characterization of Parts
  - Part quality level (i.e. NEPAG Level 1,2,3, etc) requirements should be reflected in model's certification/reliability settings for the element affected.
- Reviews
  - No adjustment should be necessary for lower program review rigor. Since Program Management, System Engineering, Mission Assurance (PMSEMA) is calculated at a rollup level over model elements, this will naturally adjust top level costs as lower level elements are adjusted. If an extra adjustment is warranted, then the model's rollup Systems Engineering and Program Management complexities parameters could be lowered slightly.
- Component Maturity
  - This should be reflected in the selection of SEER acquisition knowledge bases as appropriate. It is recommended that COTs parts be modelled as Space Procure-to-Print.

Project Cost Estimating Capability (PCEC) Overview

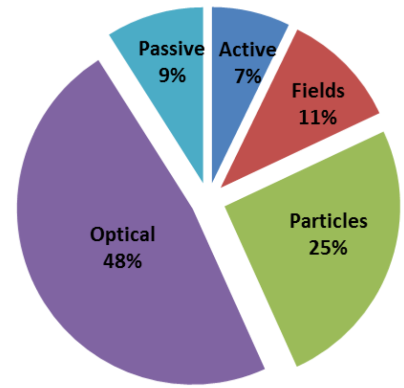
- PCEC is the “next generation” version of NAFCOM:
  - Primary cost estimating tool for launch vehicles, CEV, landers, rovers, and other flight hardware elements.
  - Parametric cost model based on over 155 NASA and Air Force space flight hardware projects.
- PCEC model, can use the NAFCOM12 multi-variable estimating CERs
  - Multi-variable estimating methodology is data driven, statistically based and allows users to document estimating assumptions rather than using complexity factors - supportable, repeatable and verifiable.
- Key costs drivers:
  - Mass
  - Approach: Prototype vs. Protoflight
  - New Design: variable addresses Heritage
  - Management cost drivers: Manufacturing Method, Engineering Management, Funding Availability, Test Approach, Integration Complexity & Pre-Development Study

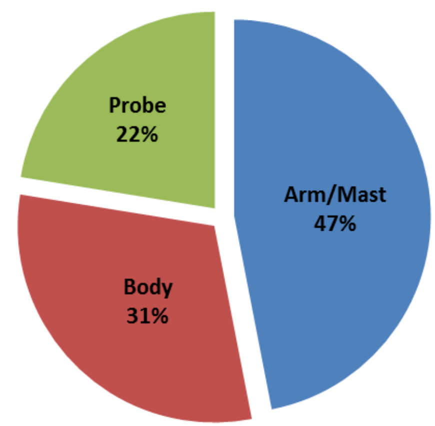
PCEC estimation of Class D Payloads

- Select Earth Orbiting category
- Select Protoflight approach
- Single Point failure: Reflected in MEL. Therefore, will show up in model project's file structure.
- Reduce System Test Hardware % below standard 55% of Flight Unit
  - Recommend setting System Test Hardware to between 15% and 30%, depending upon the amount of new design.
- Show no redundancy in ACS subsystem (only subsystem with a redundancy variable)
- Use lowest setting for Manufacturing Method, Engineering Management, Funding Availability, Test Approach, Integration Complexity & Pre-Development Study
- Reviews: No further adjustment to be made. Since PMSEMA is factored on PCEC model elements, this will naturally adjust the level of efforts that might correspond to the rigor of the reviews.

NICM Vic Overview

- NICM VIc database consists of normalized B-D cost data for 175 instruments
  - 138 remote sensing instruments including:
    - Optical
    - Active micro/sub-millimeter wave
    - Passive micro/sub-millimeter wave
    - Particles
    - Fields
  - 37 in-situ instruments including: Body-mounted instrument
    - Arm/Mast instruments
    - Atmospheric Probe instruments





- Costs driven primarily by mass and power
- Includes only First Unit costs (no multiple builds)
- NICM can be run at system or subsystem level
  - baseline approach for SMEX MO will be the System level of Subsystem level as needed (proposals that are not full
- Instrument software is included in estimated cost.

NICM-E CER Overview

- NICM-E is a unique NICM VIc Cost Estimating Relationship (CER) developed to address University led Explorer-like instruments.
- 20 historical NICM data points were determined to exhibit 4 key characteristics that result in a lower cost than similar instrument development efforts
  - Class C
  - Earth orbiting (vs planetary)
  - University led, and also performs the majority of the instrument development (design through delivery and integration)
  - Significant inheritance.

NICM VIc estimation of Class D Payloads

- **Single Point Failures:** Reflected in MEL. Therefore, will show up in model cost results
- **EM, Prototypes, Spares:** NICM cost reflects an average level of EMs/Prototypes/Spares for Earth Orbiting and Planetary missions. No adjustment made to this parameter.
- **Qualification, Acceptance, Protoflight:** No adjustment made in NICM.
- **Characterization of Parts:** No adjustment made in NICM.
- **Reviews:** No further adjustment to be made. Since PM/SE/MA is factored off NICM instrument development, this will naturally adjust the level of efforts that might correspond to the rigor of the reviews.

Some, but not all, of the Class D payload parameters can be adjusted in NICM. This can result in somewhat conservative NICM ICE estimate for Class D.

CLASS D Guidance for NICM Vic versus NICM-E

- A NICM-E cost estimate can be considered a “cost upper bound” for Class D instruments if other NICM-E assumptions are met which includes it is earth orbiting, it is University led as defined above, and there is significant inheritance.
- A NICM Vic estimate can be considered a “cost upper bound” for Class D instruments if the NICM-E assumptions are NOT met.