A Cost Estimating Methodology for Very Small Satellites

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Background

- Since September 2009 The Aerospace Corporation (Aerospace) has been engaged in developing a cost methodology for estimating the cost of “Very Small Satellites”
- The “Very Small Satellites” are those with masses <<50kg, with primary focus on satellites with10kg and below- the picosats, including CubeSats
- Initial study suggested current traditional and existing small satellites cost models can NOT be applied to this range of satellites
  - Models are derived from databases of satellites with very large masses (>>100 kg) way out of the very small satellites mass range. When applied results are skewed and cost fidelity not acceptable
  - Require knowledge of detailed technical and physical parameters such as mass, power, data rate that are not easy to obtain for the very small satellites
  - The mass and power variations are very small, they CANNOT be cost parameters

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Motivation

- The very small satellite cost information not available to the public
- System unit cost is known to the developing team lead only, and is based on funding availability
- The system architecture and requirements are changing throughout the development period
- Cost of system I&T, which is a major contributor to system's cost is not known
- The system uses many purchased, COTS parts, packaged and formed tightly, however, their costs are not known
- Software frequently makes up the major part of the system cost, yet, it is not known
- Cost of testing the purchased parts can be a major cost parameter, yet not accounted for
- The system development team consists mainly of students or less experienced engineers, in small or large groups

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A new cost methodology is needed that accounts for the unique challenges and requirements of picosatellites

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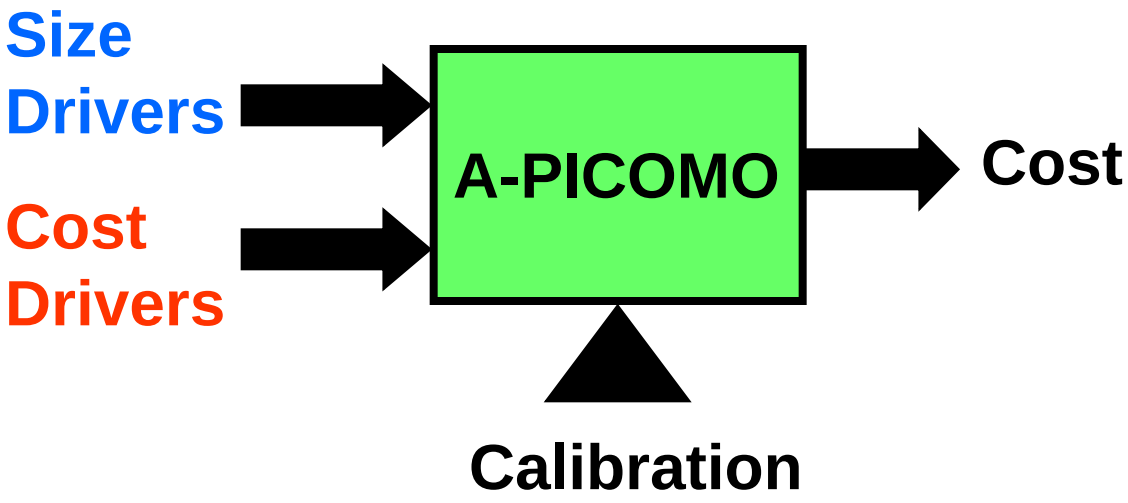
Objectives

Develop a predictive cost model to estimate the development cost of these very small satellites “CubeSats”



A-PICOMO (Aerospace Picosatellite Cost Model)

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Aerospace Very Small Satellite Cost Model

A-PICOMO

- It is a parametric cost model driven by our findings from the small satellite community
- Estimates the satellite cost using some exclusively derived cost drivers from measurable systems engineering parameters specific to the very small satellite systems, such as use of COTS, I&T, lifecycle period, …etc
- It is developed in coordination with subject matter experts
- Assumes that developing a satellite will follow the standards of systems engineering activities, such as team activities, system integration and tests, procurement of parts and components, therefore, can be validated through scientific enquiries and hypotheses of the cost drivers and their adaptability and management
- It can be applied at any stage of project life cycle (so far it is being applied for “Development” period- before launch)

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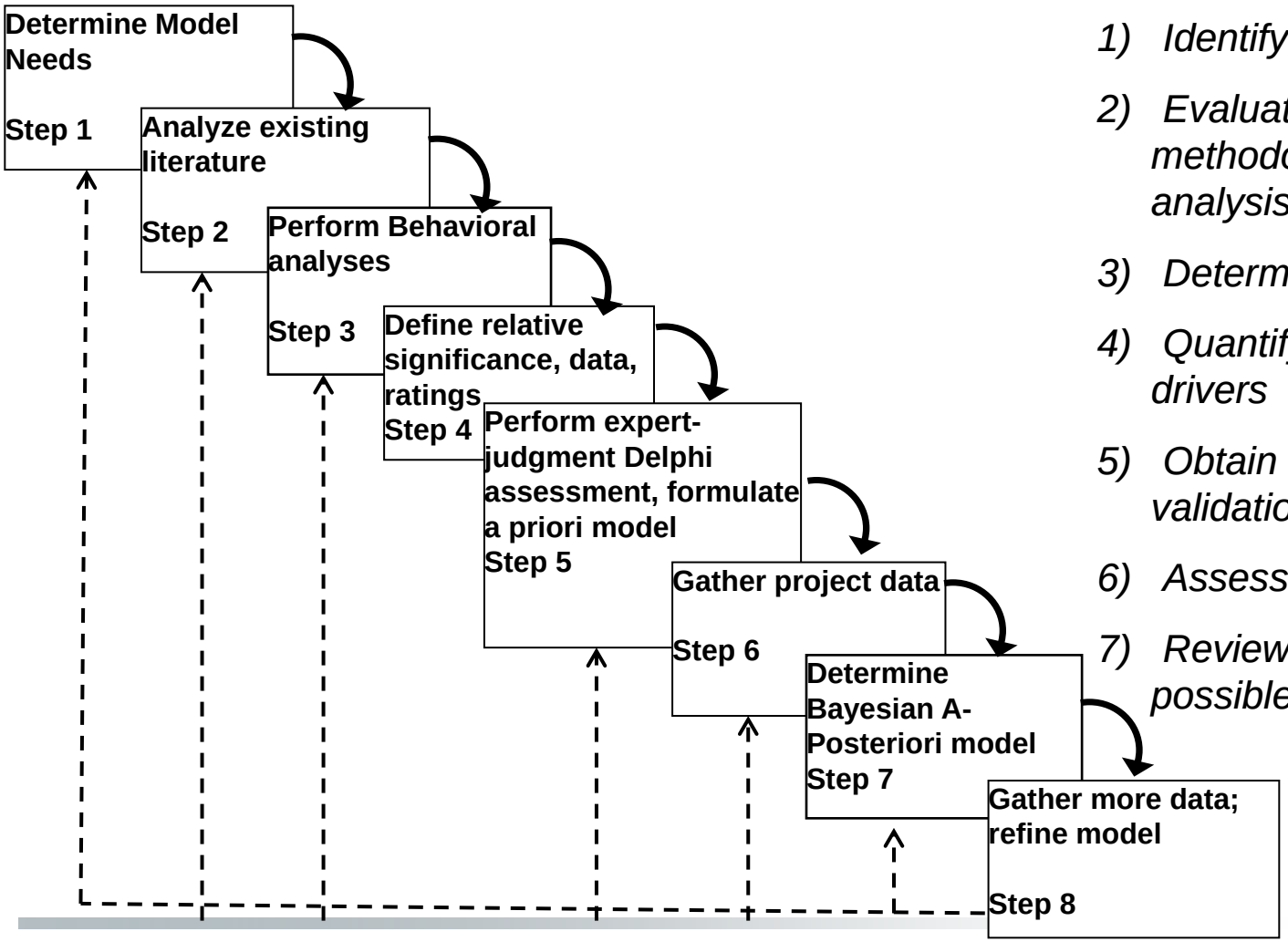
Cost Model Development Methodology

A-PICOMO Development Process



1) *Identify capability gap*
2) *Evaluate existing methodologies, conduct market analysis, collect available data*
3) *Determine key project drivers*
4) *Quantify impact of project drivers*
5) *Obtain data for calibration and validation*
6) *Assess predictive accuracy*
7) *Review results, iterate for possible improvements*

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Cost Model Development Methodology

A-PICOMO- Drivers Type and Sources

- Size drivers (examples)
  - *# of Requirements Verification Test- Bus & Payload*
  - *# of New Required Features (Items)- Bus & Payload*
- Cost drivers (examples)
  - *Multisite Coordination CubeSat Team*
  - *Team Level of Understanding to CubeSat Architecture*
- Sources (examples)
  - *Universities (Cal Poly, Morehead State Univ., Univ. of Michigan, Univ. of Colorado, Missouri S&T, UC Berkeley, etc.), The Aerospace Corporation, NASA- AMES & GSFC, Air Force, NRL*

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Cost Model Development Methodology

A-PICOMO- Data Collection

- THE LIST OF COST DRIVERS
  - Derived from system development activities, and inputs from subject matter experts
  - Considers factors such as organization, team/personal , and project specific drivers, such as I&T, Software use, dollar spent on purchased parts, documentation, schedule, … etc
  - More than 20 drivers have been identified so far

- THE LIST OF SIZE DRIVERS

  Estimate the System Size Drivers “System Complexity” measured in (hours required to complete the project) under nominal conditions

  # of Performance Verification Tests for the Bus and the Payload

  # of New Functions/Subsystems for the Bus and the Payload

  # of Reused Functions/Subsystems for the Bus and the Payload

  # of New Optional Functions/Subsystems for the Bus and the Payload

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Cost Model Development Methodology

A-PICOMO-

- NEXT STEP
  - *Continue historical data collection*
  - *Refine cost estimating relationship based on data updates*
  - *Elicit expert input on cost model structure and parameter weights via wideband Delphi survey*

- IMPLICATIONS
  - *Helps people reason about the cost of decisions they make*
  - *Helps cost forecasting, identify risk*
  - *Provides planning framework*
  - *Reduces guess work by formalizing costing process*

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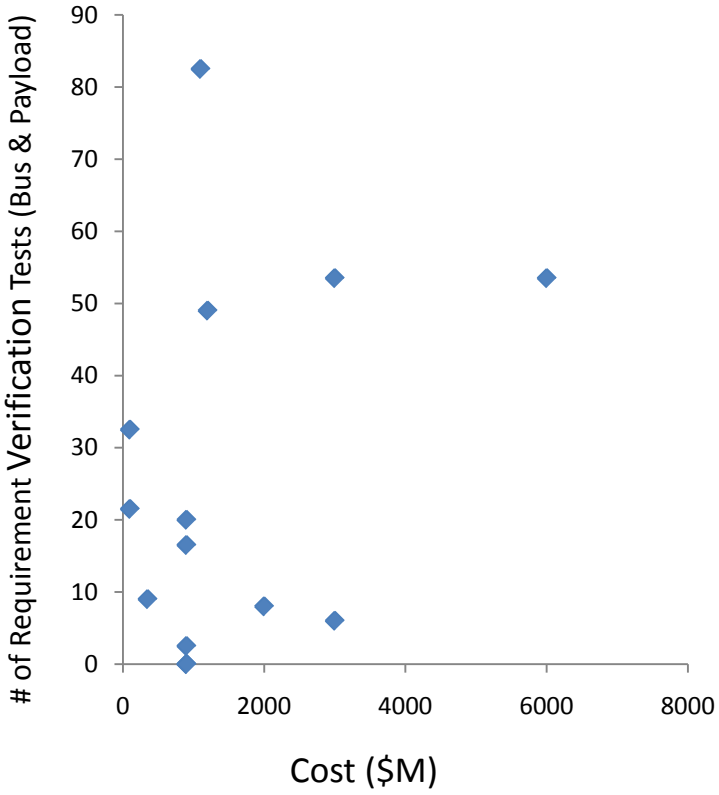
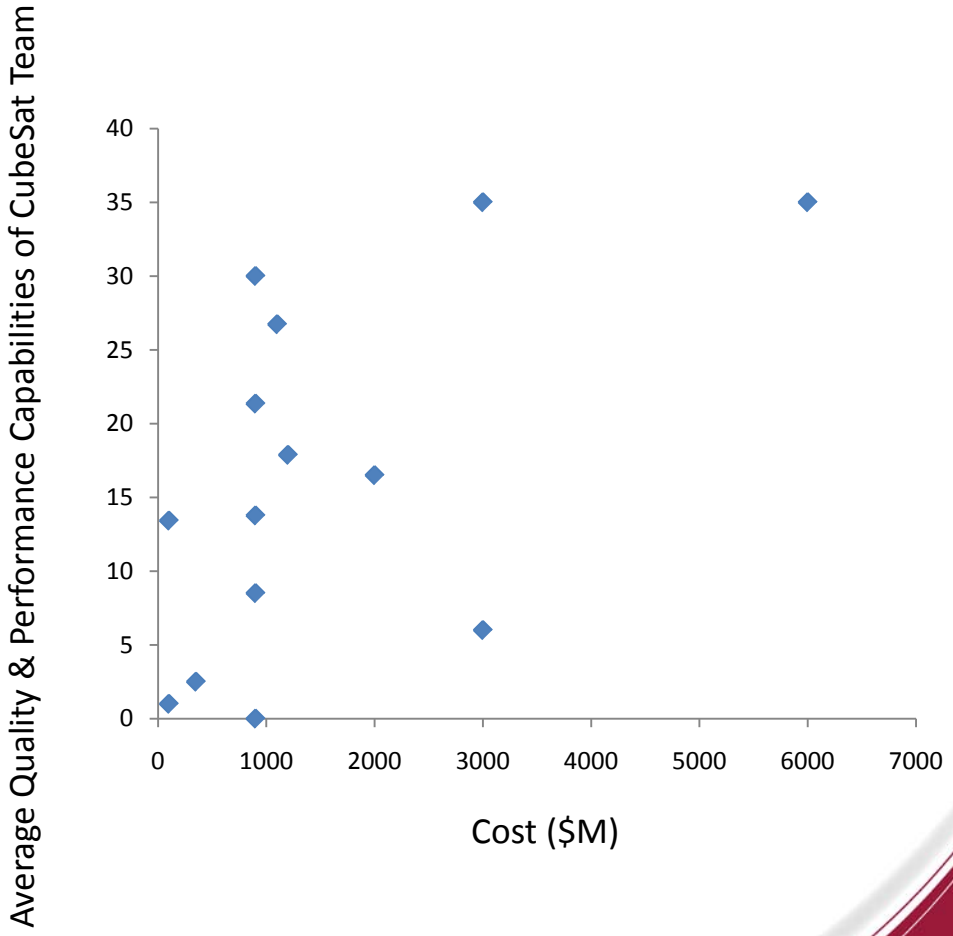
Cost Model Development Methodology

A-PICOMO- Preliminary analysis





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Aerospace has been in the business of developing small satellites cost models for the last twenty years. Its SSCM, COBRA, Activity Based (Bottom-Up) models and others are widely used by the community. A-PICOMO (**A**erospace **Pi**cosatellites **CO**st **MO**del) is an added value, targeted to mainly the Very Small Satellites, including CubeSats

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Thank you