Cost Estimating without a Point Design

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Timeframe of Interest

A-team

Team X

Cocktail Napkin

Trade Space

Baseline Concept

Initial Feasibility

Point Design

Integrated Concept

CML 1  CML 2  CML 3  CML 4  CML 5  CML 6  CML 7  CML 8

Preliminary Implementation Baseline

Integrated Baseline
Framing the Question

- Most cost models are mass-driven with ancillary cost inputs like power, pointing, etc.
- Early in a design, it is often too early to reasonably bound these parameters

Should an estimator wait patiently until a mission design has the maturity required to use traditional cost models?
The Effect

In this scenario, a mission gets into an inefficient serial loop attempting to optimize design given a cost constraint.

Cost is not an integrated part of the mission trade space criteria.

Suboptimal design

Cost/Schedule growth
Get the Best Design from the Beginning

Sufficiently Bound Concept...

Perform Trades...

Perform cost/design trades to develop an optimal baseline design

Form an Acceptable Technical Baseline...

Propose and Implement

Early formulation cost/design tools provide platform to assess feasibility and bound the problem before deciding on a point design.
JPL has begun creating an adaptable and integrated set of cost/design tools, based on concept maturity level, using all cost & design data available.

**Potential Solution (CML 1)**

**CML 1: Idea Inception**

<table>
<thead>
<tr>
<th>Input Considered</th>
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</thead>
<tbody>
<tr>
<td>Mission Category</td>
</tr>
<tr>
<td>Target Body</td>
</tr>
<tr>
<td>Flight Element Type</td>
</tr>
<tr>
<td>Data Type</td>
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</table>

Q: How does a mission fall into family with other missions?
A: Use Cluster Analysis to understand analogous family of missions and a range of potential cost.

The “Cocktail Napkin”:
- Broad range of costs identified, large uncertainty
**Potential Solution (CML 2)**

### CML 2: Feasibility

Q: Is this mission feasible within cost/design constraint?

A: Building off Cluster Analysis, use PCA & Bayesian methods to understand cost and uncertainty

<table>
<thead>
<tr>
<th>Input Considered</th>
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<tbody>
<tr>
<td># instruments on element</td>
</tr>
<tr>
<td>Phase E duration</td>
</tr>
<tr>
<td>Payload complexity/cost</td>
</tr>
<tr>
<td>Power Source</td>
</tr>
<tr>
<td>Mission Risk Class</td>
</tr>
<tr>
<td>Prop System Type</td>
</tr>
<tr>
<td>Primary Telecom Band</td>
</tr>
<tr>
<td>CDS?</td>
</tr>
<tr>
<td>Radiation Dose (krad)</td>
</tr>
</tbody>
</table>

**Input fed to CML 2**

**Mission Category**
- Target Body
- Flight Element Type
- Data Type
Potential Solution (CML 3)

After initial feasibility is determined, integrated models can perform real-time design/cost trades until an optimal point design is achieved.

CML 3: Trade Space Exploration
Integrate CERs into Design models

<table>
<thead>
<tr>
<th>Object</th>
<th>Formula</th>
<th>Metric</th>
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</thead>
<tbody>
<tr>
<td>Subsystem 1</td>
<td>CER 1: Cost = fn(Param1, Param2,...)</td>
<td>$XX.xx</td>
</tr>
<tr>
<td>Task</td>
<td>Effort = fn(Param1, Param2,...)</td>
<td>YY Hrs</td>
</tr>
<tr>
<td>Subsystem 1</td>
<td>CER 2: Cost = fn(Param1, Param2,...)</td>
<td>$ZZ.zz</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
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Mechanical Models
Simulations
Design Space Exploration Analyses

SysML Product and Process Model
Potential Solution (CML 4-5)

Costing Tools
- NICM
- PCEC
- ...

Technical Tools
- Multidisciplinary teams
- Computer models
- Multiple simulation tools
- Data repositories

Parameter DB

Dry Mass

Yes!

Do we mean the same thing?
Conclusion

Instead of a serial design and cost process:

Design → Cost → Redesign → Re-cost

We will have an iterative, integrated process:

Balanced Design and Cost Assessment
Summary

- At completion, we will have a set of dynamic models for early formulation where...
  - design and cost are integrated models, enabling a cost-effective design at inception
  - inputs are tailored for concept maturity, such that we don’t need to wait for a point design to bound mission cost
  - all available data is used in an appropriate manner