COSYSMO: Constructive Systems Engineering Cost Model

Status Briefing: GSAW 2002

February 2002
Agenda

• Introduction to COSYSMO
  – Goals of effort and scope
• The COSYSMO reference system
• The COSYSMO model
  – Model mathematics
  – Size and cost drivers
• Plans and milestones
• Current status of effort
• Summary and conclusions
Goals of Effort

- Build a COCOMO II-like model for estimating effort and duration of system engineering tasks
  - Member of the COCOMO family of models
- COSYSMO (Constructive System Engineering Model) developed to fill the holes not covered by COCOMO II software model

Inception   Elaboration   Construction   Transition

MBASE life cycle model phases
Scope of Effort

- Use USC seven step model building process
- Keep things simple
  - Start with Inception phase now, other phases later
  - Use EIA 632 to bound systems engineering effort
  - Focus on software intensive systems
- Build on previous cost modeling work
- Shoot for having something meaningful done by mid-March 2002
  - Much of the work done by volunteers, so must be conservative in estimates
Participants

- Chris Abts, Texas A&M
- Elliot Axelband, USC
- Kim Bell, Aerospace
- Joe Betser, Aerospace
- Barry Boehm, USC
- Linda Brooks, TRW
- Sunita Chulani, IBM
- Lisa Finneran, SPC
- Don Greenlee, SAIC
- Gary Hafen, LMCO
- Gloria Isler, LMCO
- Cheryl Jones, US Army
- Tony Jordano, SAIC
- W. Kelberlay, Raytheon
- Ray Kile, CSM
- Dan Ligett, Softstar
- Karen Lum, JPL
- Chris Miller, SPC
- Karen Owens, Aerospace
- Don Reifer, USC
- Garry Roedler, LMCO
- Walker Royce, Rational
- Evin Stump, Galorath
- Gary Thomas, Raytheon
- Ariel Tonnu, US Air Force
- Ricardo Valerdi, USC
- Marilee Wheaton, TRW
Reference System

• Framed using a Satellite Ground System as a reference system
  – Identified system engineering activities
  – Defined the components of the effort estimates

• System facilitated the definition of system engineering tasks in terms of:
  – Systems, Hardware, Software, and Communications Architecture (interfaces view)

• COSYSMO scope based on the example system
System Description

- External to system are elements of network operations
  - These elements provide the antennas used to track satellites, the communications equipment for TT&C and centralized resource management functions

- Internal to the system are the hardware and software to perform:
  - Mission planning - Orbit data processing
  - Telemetry processing - Attitude data processing
  - Satellite commanding

- Simulation and resource management are outside the scope of the system in this analysis
System Context Diagram

- Network operations external to boundary
- Satellite operations includes:
  - COTS hardware
  - Software
  - Communications
- Signals to control antennas and remote facilities assumed to be digital in form
COSYSMO Operational Concept

- Requirements
- Interfaces
- TPM’s
- Scenarios
- Modes
- Platforms
- Algorithms

COCOMO II-based model

Size
Cost Drivers

Effort
Duration

Calibration

- Application factors
  - 7 factors
- Team factors
  - 8 factors

WBS guided
By EIA 632
COCOMO II Effort Equations

Basic Equation

\[
\text{EFFORT} = a \prod_{i=1}^{n} (EM)_i \text{[Size]}
\]

Where:

- \(a\) = constant
- \(\text{Size}\) = estimate of the size of the system engineering effort or the volume of work involved
- \(SD_j\) = size drivers
- \(EM_i\) = effort multipliers

\[
\text{Size} = \sum_{j=1}^{m} SD_j
\]
EIA Scope Drivers

• From EIA 632:
  – Supplier Performance
  – Technical Management
  – Requirements Definition
  – Solution Definition
  – Systems Analysis
  – Requirements Validation
  – Design Solution Verification
  – End Products Validation/Purchased Products
# Size Drivers (First Pass)

<table>
<thead>
<tr>
<th>Size Drivers</th>
<th>Measure of:</th>
<th>Counted By:</th>
</tr>
</thead>
<tbody>
<tr>
<td># requirements</td>
<td>Functional requirements</td>
<td># shalls in System Spec</td>
</tr>
<tr>
<td># requirements</td>
<td>Performance requirements</td>
<td># Measures of Performance/</td>
</tr>
<tr>
<td># interfaces</td>
<td>Interface requirements</td>
<td># Measures of Effectiveness</td>
</tr>
<tr>
<td># interfaces</td>
<td></td>
<td># interfaces needed to be bounded via ICD’s/MOA’s</td>
</tr>
<tr>
<td># TPMs</td>
<td>Managerial requirements</td>
<td># of TPMs to be reported</td>
</tr>
<tr>
<td># scenarios</td>
<td>Operational requirements</td>
<td># operational threads and/or system level use cases</td>
</tr>
<tr>
<td># modes</td>
<td>Operational requirements</td>
<td># operational modes to be supported</td>
</tr>
<tr>
<td># platforms</td>
<td>Operational requirements</td>
<td># platforms to be supported</td>
</tr>
<tr>
<td># algorithms</td>
<td>Operational requirements</td>
<td># of new algorithms that system engineering must develop to solve problem</td>
</tr>
</tbody>
</table>
Cost Drivers (Initial List)

- **Application factors**
  - Requirements understanding
  - Architecture understanding
  - Level of service requirements, criticality, difficulty
  - Legacy transition complexity
  - COTS assessment complexity
  - Platform difficulty
  - Required process

- **Team factors**
  - Number and diversity of stakeholder communities
  - Stakeholder team cohesion
  - Personnel capability
  - Personnel experience/continuity
  - Process maturity
  - Multi-site coordination
  - Formality of deliverables
  - Tool support

Initial definitions distributed as part of our Delphi exercise
# Plan of Action & Milestones

<table>
<thead>
<tr>
<th>Task</th>
<th>Due Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Develop reference system</td>
<td>11/01/01</td>
<td>Complete</td>
</tr>
<tr>
<td>2. Define cost drivers</td>
<td>11/16/01</td>
<td>Complete</td>
</tr>
<tr>
<td>3. Define size drivers</td>
<td>11/16/01</td>
<td>Complete</td>
</tr>
<tr>
<td>4. Define effort scope</td>
<td>11/16/01</td>
<td>Complete</td>
</tr>
<tr>
<td>5. Finalize survey instrument</td>
<td>11/30/01</td>
<td>Complete</td>
</tr>
<tr>
<td>6. Send materials out for review</td>
<td>12/03/01</td>
<td>Complete</td>
</tr>
<tr>
<td>7. Hold net meeting/discuss results</td>
<td>12/11/01</td>
<td>Complete</td>
</tr>
<tr>
<td>8. Updates done/Delphi defined</td>
<td>01/14/02</td>
<td>Complete</td>
</tr>
<tr>
<td>9. Send Delphi out</td>
<td>01/15/02</td>
<td>Complete</td>
</tr>
<tr>
<td>10. Complete Delphi round</td>
<td>02/15/02</td>
<td>In Progress</td>
</tr>
<tr>
<td>11. Update done based on results</td>
<td>03/05/02</td>
<td></td>
</tr>
<tr>
<td>12. Present results at annual review</td>
<td>03/12/02</td>
<td></td>
</tr>
</tbody>
</table>

* Axelband/Boehm involved in all activities
Delphi Round 1

• Objectives:
  – Calibrate the model based on expert opinions

• Questionnaire divided into three sections
  – Scope, size and cost

• Questionnaire will be used to determine the range for size driver and effort multiplier ratings

• Data from completed systems will then be used to statistically confirm or deny initial ratings

• Initial Delphi inputs due 15 February 2002
Summary and Conclusions

• Making significant progress with the model development activities
• Team of volunteers from industry, academia and government doing a great job
• Team needs inputs from system engineering experts to make Delphi exercise successful
• Any of you who would like to participate are encouraged to do so