Ground System Costs Breakout

- Justifying the cost of ground system upgrades and enhancements is often difficult because the impact on the mission is hard to trace to a ground system upgrade.
- Panel and audience discussion of ground system cost estimating work that covers the entire life cycle of a ground system
- The group will develop a list of recommendations for collaboration, data collection, and attributes of good ground system cost models.

Panelists

- Budgeting for Ground System Costs
  - Raymond Covert, The Aerospace Corporation
- Estimating Ground System Costs
  - “Software Cost and Productivity Model”, Lutrell Long, The Aerospace Corporation
  - “Sizing Systems Engineering Effort Via Requirements”, Marilee Wheaton, The Aerospace Corporation
- Issues in Developing Ground System Costs
  - Steven Cohen, Boeing Corporation
  - Steven Book, MCR

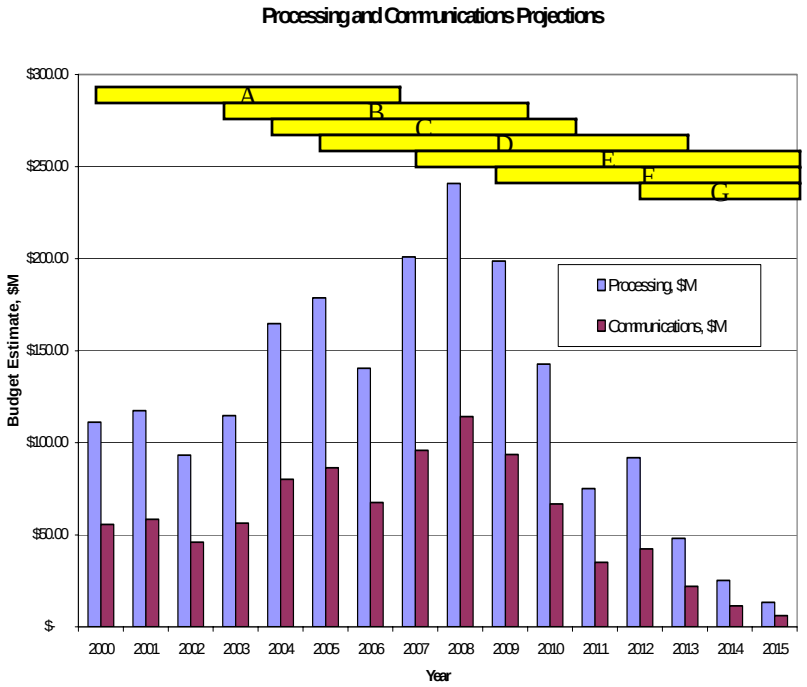
Ground System Cost Estimating

- Government Cost
  - » Based on historic costs
  - » Includes cost of Contract Changes
- Contractor Cost Estimating
  - » Must estimate cost of work proposed in contract
    - – Cannot include cost of probable contract changes or work that is needed but not asked for in RFP
- Several ways ground cost modeling is performed
  - » Grass roots approach
    - – Buildup by software, hardware and common services
    - – Use of SEER, PRICE, COCOMO-II, HW Pricing forecasts, wrap factors
  - » Development Models (Command & Control and Antenna Terminal)
    - – Ground Cost Model (G-COST) [Ref. 1,2]
    - – Fixed and Transportable Earth Station (FATES), Cost Estimating Relationships (CERs) and Cost Libraries [Ref.3]
  - » Operations Models (Operations and Maintenance)
    - – Mission Operations Cost Model (MOCM) and Space Operations Cost Model (SOCM) - NASA

Model Results Summarized

- With the constellations, message traffic, and schedule defined, we find
  - » Increased investment is required in the 2004-2008 timeframe when there are 4 active satellite systems
  - » Decreased investment in 2010 - 2015 with 3 active satellite systems

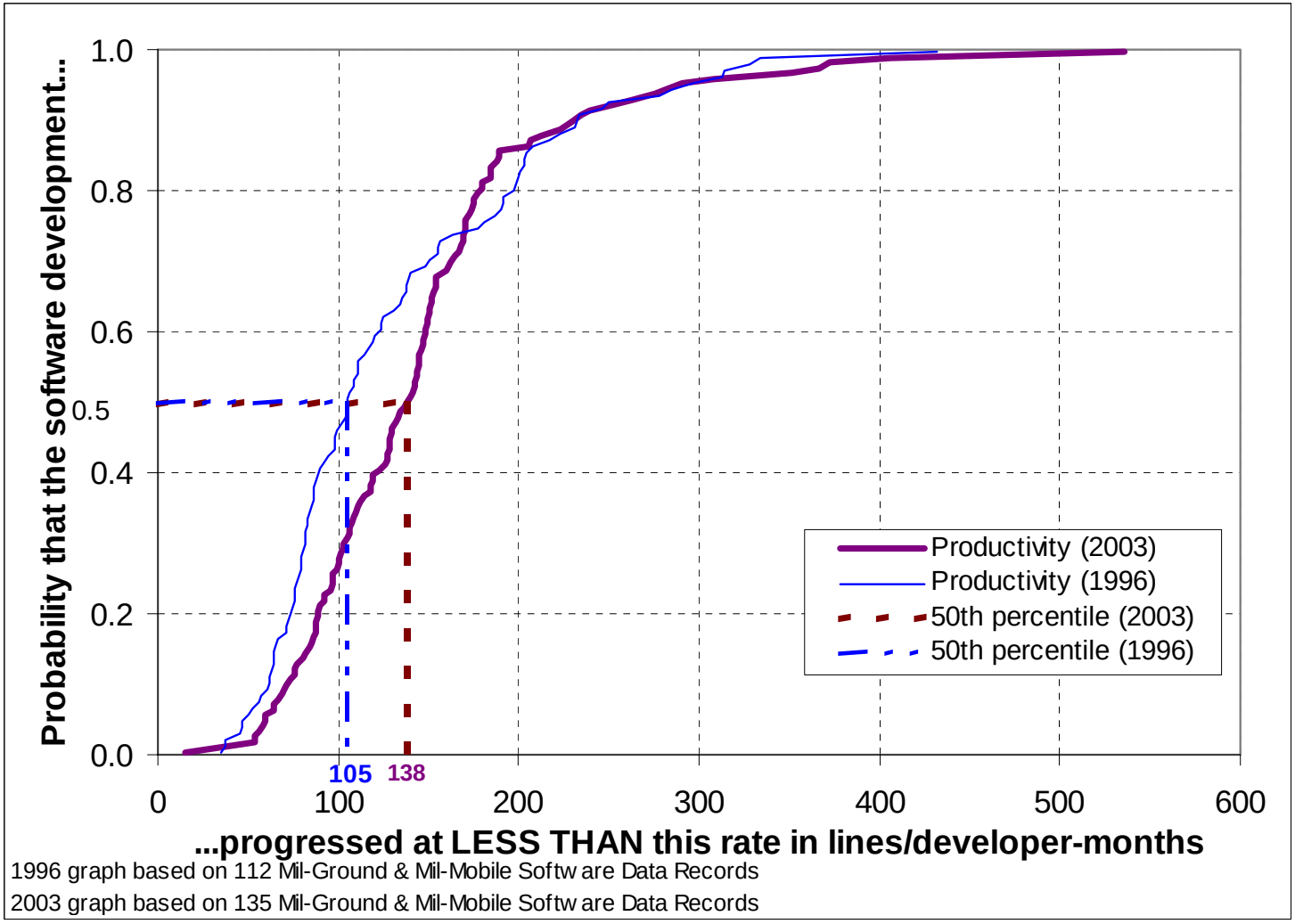
Satellite ID	Sat Type	Message BW	Activation Yr	Deactivation YR
a1	A	5000	2000	2005
a2	A	5000	2001	2006
a3	A	5000	2002	2007
b1	B	10000	2003	2010
b2	B	10000	2003	2010
b3	B	10000	2004	2011
c1	C	50000	2004	2011
d1	D	100000	2005	2012
d2	D	100000	2006	2013
e1	E	500000	2007	2015
e2	E	500000	2008	2016
e3	E	500000	2008	2016
f1	F	1000000	2009	2019
f2	F	1000000	2010	2020
g1	G	5000000	2012	2022



Summary of Productivity Analysis

- Median software productivity appears to have increased since 1996 study
  - » Use of newer languages (e.g., C, C++) may be major factor
  - » In 1996 study, most languages reported were Fortran, Jovial, and other "higher order languages"
- Comparing productivity distributions with 1996 data indicates an increase in median productivity levels
  - » 31% increase in combined military ground & military mobile environments (2003 study median: 138 SLOC/DM)
  - » 33% increase in combined military-spec avionics & unmanned space (2003 study median: 64 SLOC/DM)
- Median productivity of C/C++ in the combined military ground & military mobile environments is 148 SLOC/DM
- Code growth continues to be an issue
  - » Low: 0.52; Average: 1.49; High: 5.01

Productivity (Military Ground & Military Mobile)



1996 graph based on 112 Mil-Ground & Mil-Mobile Softw are Data Records

2003 graph based on 135 Mil-Ground & Mil-Mobile Softw are Data Records

COSYSMO: Overview

- Parametric model to estimate system engineering costs
- Covers WBS tasks that cover the entire system engineering lifecycle
- Focused on use for
  - » Effort estimation
  - » Investment Analysis
  - » Concept Definition phases estimation
  - » Tradeoff analyses
  - » Risk analyses

Software Costing Concerns

- Standard Cost-Estimating Paradigm for Hardware is not Applicable to Software
  - » Software Requirements Cannot Be Fully Captured in Any Finite List: True List of Requirements Is Virtually Infinite
  - » Software Development Is Uniquely Personnel-intensive: Even Within Same Company or Workgroup, Productivity May Vary As Much As 100 to 1 Among Programmers
  - » Programming is the Easy Part – Figuring Out a Software Solution to the Technical Problem is What's Difficult
- There Are No "Technical" Characteristics Such As Weight, Power, etc., that Play the Role of Cost Driver
  - » Primary "Measurable" Cost Driver is Number of Lines of Code, which is Notoriously Difficult to Estimate
  - » Naval Center for Cost Analysis Found Average Lines-of-Code Growth of 63% for Software Projects of Various Types (http://www.ncca.navy.mil/software/handbook/software.htm)

COTS is not spelled F-R-E-E

- COTS is an Attractive Addition to a Ground-System Cost Estimate
  - » It Looks Inexpensive
  - » It's Politically Correct
  - » It's a "New Way of Doing Business"
- But, in Order to Really Incorporate COTS Software into the System …
  - » The COTS Software Has to be Thoroughly Tested for Situations in which It May Act Erratically or "Crash" the System
  - » Integration ("Glue") Code Has to be Written and Tested
  - » Non-COTS Portion of System Often Has to be Designed Suboptimally to Accommodate COTS

Government Furnished Equipment (GFE)

- GFE: A Great Way to Reduce Ground-System Cost Estimates … but Not Necessarily Ground-System Costs
- GFE is a Popular "Code Word" that Contractors (and Government Project Managers) Use to Lower the Proposed Cost of a Program
  - It is Advertised to Do the Job
  - It is Low-Cost or Sometimes Even No-Cost
  - GFE is Usually Free to the Proposer, so It Adds Zero to his Bid (and to the required budget)
- GFE is a Trap Set for the Government
  - It's Free to Proposer, so It Doesn't Appear in his Bid (but changes will show up in ECPs)
  - The Government Assumes the Obligation (and Risk) to Deliver that Portion of System
  - Most Often, However, GFE Does Not Do Job Anticipated and incurs additional cost to fix

How can the Government help?

- Be willing to accept realistic cost and schedule estimates
- Fund programs to higher percentage of estimated cost
- Don’t try to save too much money by cutting corners, especially in the Systems Engineering/Planning phases
- Train Government to understand ground system issues and costs