



Future Ground System Software Estimation and Metrics

GSAW Working Group Summary
Session 11F
March 4, 2010



Working Group Topics

- Air Force Cost Analysis Agency Study Overview
- Next Generation Software Estimation and Metrics
- Proposed Metrics Definition Highlights
- Productivity Data Analysis and Issues



Study Background

- Goal is to improve the quality and consistency of estimating methods across cost agencies and program offices through guidance, standardization, and knowledge sharing.
- Project led by the Air Force Cost Analysis Agency (AFCAA) working with service cost agencies, and assisted by University of Southern California and Naval Postgraduate School
- We will publish the AFCAA Software Cost Estimation Metrics Manual to help analysts and decision makers develop accurate, easy and quick software cost estimates for avionics, space, ground, and shipboard platforms.



Stakeholder Communities

- Research is collaborative across heterogeneous stakeholder communities who have helped us in refining our data definition framework, domain taxonomy and providing us project data.
 - Government agencies
 - Tool Vendors
 - Industry
 - Academia



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AFCAA Software Cost Estimation Metrics Manual

Chapter 1: Software Estimation Principles

Chapter 2: Product Sizing

Chapter 3: Product Growth

Chapter 4: Effective SLOC

Chapter 5: Historical Productivity

Chapter 6: Model Calibration

Chapter 7: Calibrated SLIM-ESTIMATE

Chapter 8: Cost Risk and Uncertainty Metrics

Chapter 9: Data Normalization

Chapter 10: Software Resource Data Report

Chapter 11: Software Maintenance

Chapter 12: Lessons Learned



Next Generation Software Estimation and Metrics Summary

- Current and future trends create challenges for systems and software data collection and analysis
 - Metrics and “productivity:” “equivalent” size; requirements/design/product/value metrics; productivity growth and decline phenomena
 - Cost drivers: effects of complexity, volatility, architecture
 - Alternative processes: rapid/agile; systems of systems; evolutionary development
 - Model integration: systems and software; cost, schedule, and quality; costs and benefits
- Updated systems and software data definitions and estimation methods needed for good management



Incremental Development Productivity Decline (IDPD)

- Example: Site Defense BMD Software
 - 5 builds, 7 years, \$100M; operational and support software
 - Build 1 software productivity over 200 LOC/person month
 - Build 5 software productivity under 100 LOC/PM
 - Including Build 1-4 breakage, integration, rework
 - 318% change in requirements across all builds
 - IDPD factor = 20% productivity decrease per build
 - Similar trends in later unprecedented systems
 - Not unique to DoD: key source of Windows Vista delays
- Maintenance of full non-COTS SLOC, not ESLOC
 - Build 1: 200 KSLOC new; 200K reused@20% = 240K ESLOC
 - Build 2: 400 KSLOC of Build 1 software to maintain, integrate



Proposed Metrics Definition Highlights

- Data quality and standardization issues
 - No reporting of Equivalent Code Size Inputs: Design Modified, Code Modified, Integration Testing Modified, Software Understandability, Programmer Unfamiliarity, Type (Modified, Reused, Adopted, Managed, and Used Code)
 - No common SLOC reporting – logical, physical, etc.
 - No standard definitions – Application Domain, Build, Increment, Spiral,...
 - No common effort reporting – analysis, design, code, test, CM, QA,...
 - No common code counting tool
 - Product size only reported in lines of code
 - No reporting of quality measures – defect density, defect containment, etc.



Proposed Metrics Definition Highlights

- Limited empirical research within DoD on other contributors to productivity besides effort and size:
 - Operating Environment, Application Domain, and Product Complexity
 - Personnel Capability
 - Required Reliability
 - Quality – Defect Density, Defect Containment
 - Integrating code from previous deliveries – Builds, Spirals, Increments, etc.
 - Converting to Equivalent SLOC
- Reported code sizes for Modified, Reused, Adopted, Managed, and Used add no value to a cost estimate unless they translate into “equivalent SLOC.”
- Manual will discuss and address these issues



Productivity Analysis from SRDR Data

| Application Domain | Operating Environment | | | | | | Total |
|-------------------------------|-----------------------|--------------|-----------|---------------|-----------|----------------|------------|
| | Avionics | Fixed Ground | Missile | Mobile Ground | Shipboard | Unmanned Space | |
| Business Systems | | | | 4 | | | 4 |
| Command & Control | 1 | 8 | | 5 | | | 14 |
| Communications | 1 | 35 | | | 2 | 1 | 39 |
| Controls & Displays | 2 | 1 | | 1 | 3 | | 7 |
| Executive | | | | | 3 | | 3 |
| Information Assurance | | 1 | | | | | 1 |
| Infrastructure or Middleware | | 2 | | | 1 | | 3 |
| Mission Management | 12 | 2 | 3 | 1 | | | 18 |
| Mission Planning | 1 | 4 | | | | | 5 |
| Process Control | | | | 4 | | | 4 |
| Scientific Systems | | | | | 3 | | 3 |
| Sensor Control and Processing | | 2 | | | 10 | | 12 |
| Simulation & Modeling | | 9 | | | 3 | | 12 |
| Spacecraft Payload | | | | | | 1 | 1 |
| Test & Evaluation | | 1 | | | | | 1 |
| Tool & Tool Systems | | 3 | | | | | 3 |
| Training | | | | 1 | | | 1 |
| Weapons Delivery and Control | 4 | | 7 | | | | 11 |
| Total | 21 | 68 | 10 | 16 | 25 | 2 | 142 |

Notes:
SRDR: Software Resources Data Report



Simple Cost Estimating Relationships

$$PM = A * (EKSLOC)^B$$

| Domain Name | Data # | Estimation Formula | R-Square |
|-----------------------------|--------|-------------------------|----------|
| Command & Control | 14 | $Y = 13.48 * X^{0.70}$ | 0.84 |
| Communications | 39 | $Y = 19.58 * X^{0.59}$ | 0.62 |
| Control & Displays | 7 | $Y = 53.84 * X^{0.44}$ | 0.70 |
| Mission Management | 18 | $Y = 17.62 * X^{0.79}$ | 0.58 |
| Mission Planning | 5 | $Y = 33.03 * X^{0.42}$ | 0.64 |
| Sensor Control & Processing | 12 | $Y = 144.74 * X^{0.27}$ | 0.15 |
| Simulation | 12 | $Y = 68.97 * X^{0.26}$ | 0.21 |
| Weapons Delivery & Control | 11 | $Y = 9.42 * X^{0.84}$ | 0.73 |

Preliminary Results - Do Not Use!

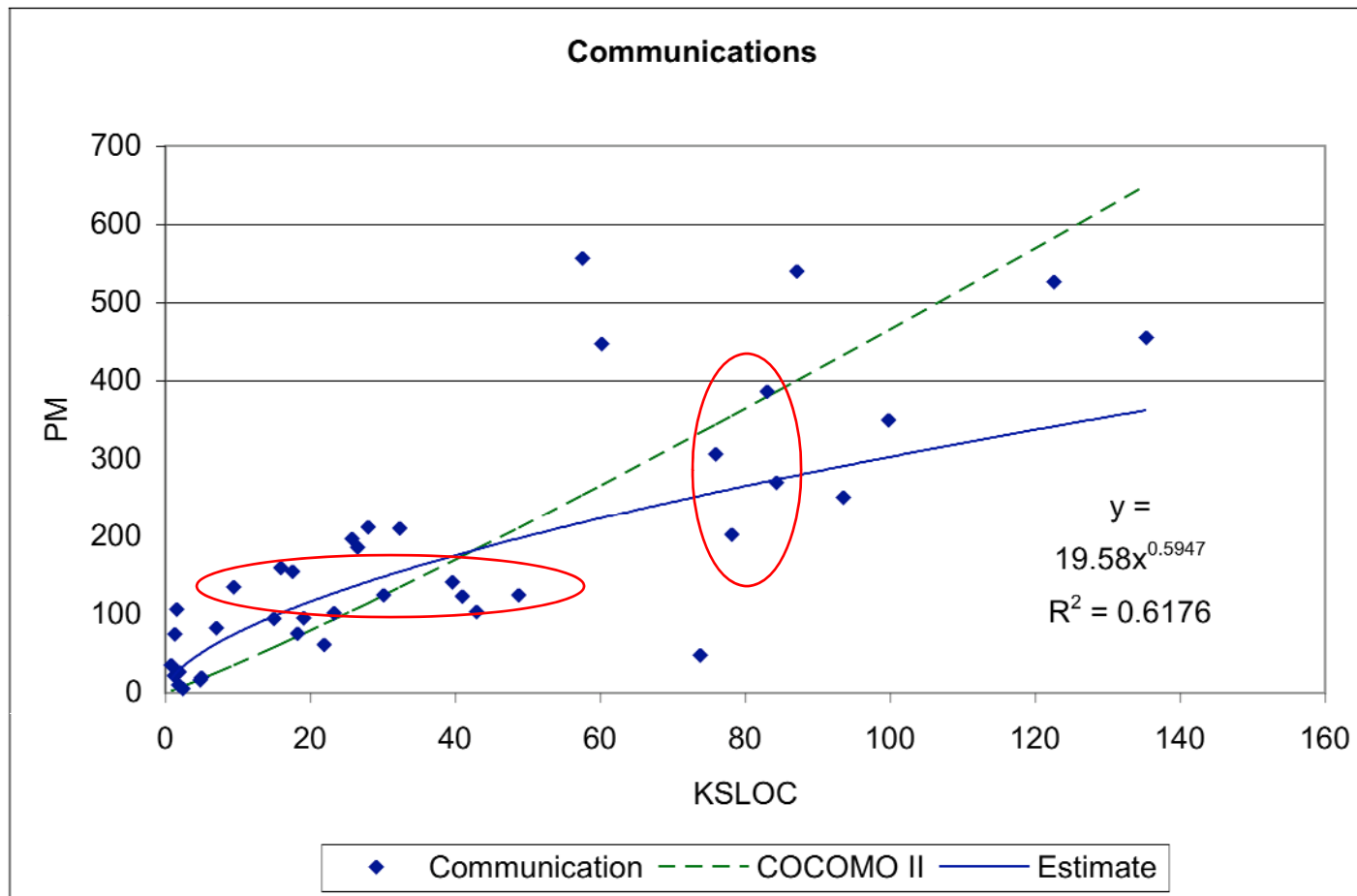
Notes:

PM: Person Months (152 labor hours / month)

EKSLOC: Equivalent Thousands of Source Lines of Code



Data Analysis Issues



Preliminary Results - Do Not Use!



Productivity Analysis Issues

- Why do some data have the same amount of effort for widely varying size?
- Why do some data have similar sizes for widely varying effort?
- Will the information that explains the differences be available early in the lifecycle?
- Are there too many Application Domains (18) and Environments (6)?



If you are interested in viewing draft copies of the AFCAA Software Cost Estimation Metrics Manual, contact:

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