Software Cost Estimation Metrics Manual for Defense Systems

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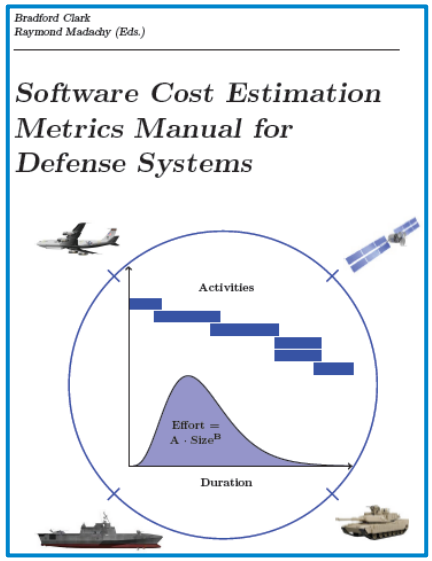
Overview

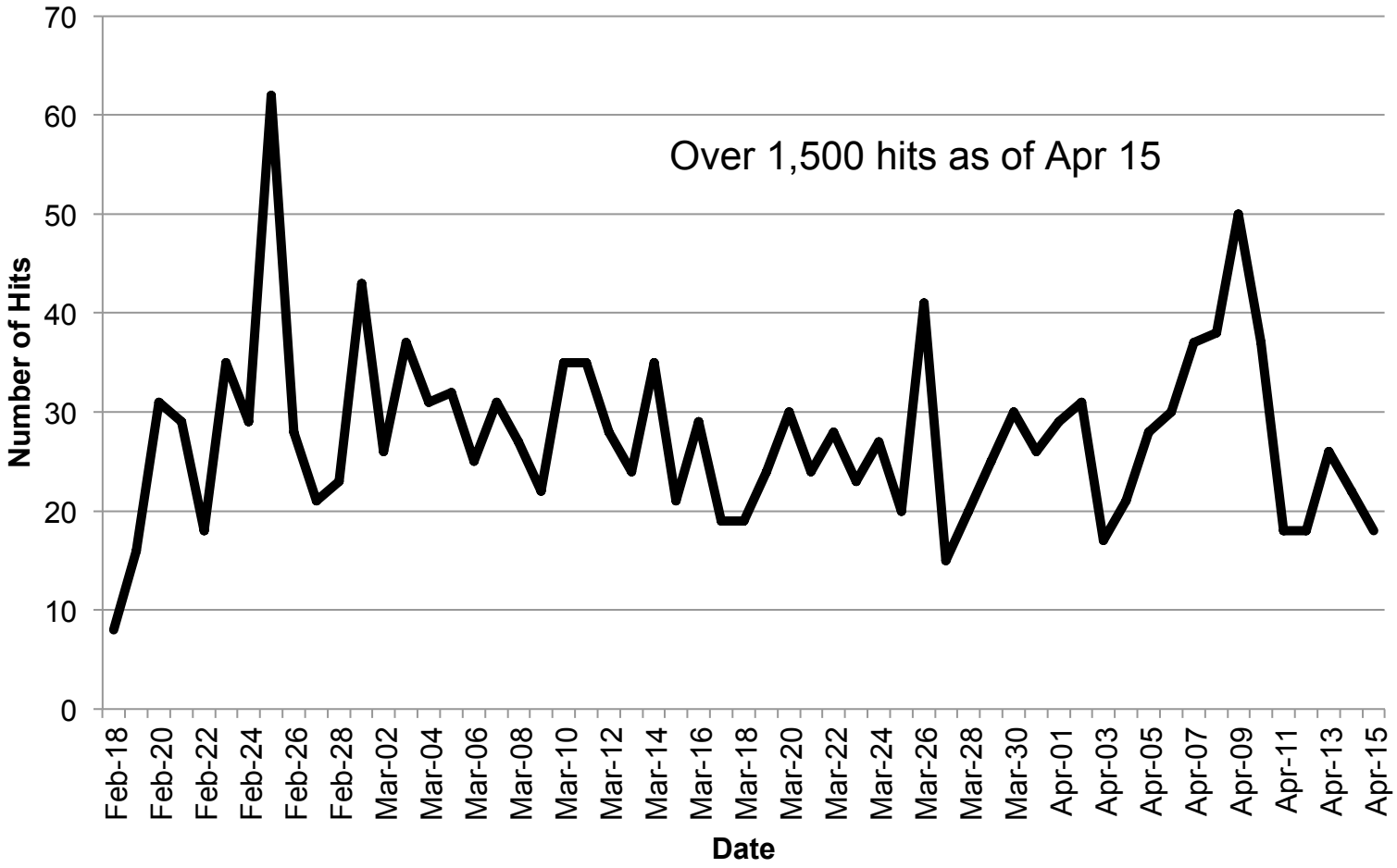
- DoD Systems Engineering Research Center (SERC) research transition e-book:

  B. Clark and R. Madachy (Eds.), *Software Cost Estimation Metrics Manual for Defense Systems*, Software Metrics Inc., Haymarket, VA, 2015.



- Downloadable from
  - Book site http://softwarecost.org
  - DoD SERC http://www.sercuarc.org/software-cost-estimation-metrics-manual-for-defense-systems1/
  - Other sites forthcoming

SoftwareCost.org Traffic



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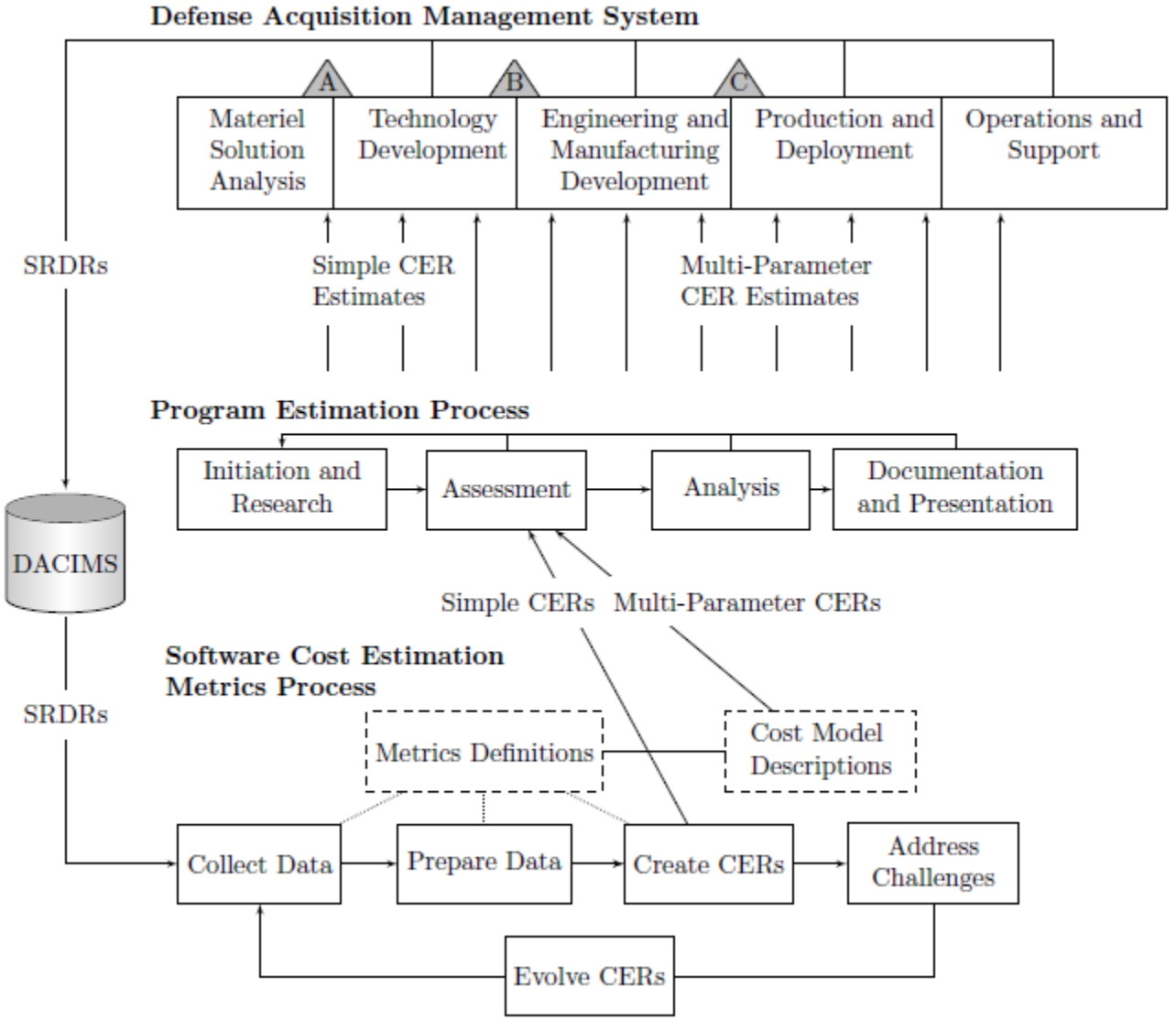
  - Galorath Systems
  - PRICE Systems
  - Quantitative Software Management
  - Softstar Systems

Table of Contents

Purpose

- Assist analysts and decision makers early software cost estimates for different types of DoD systems and operating environments
- The intent is to improve quality and consistency of early software estimating through guidance, standardization, and knowledge sharing.
- We have analyzed DoD empirical software cost data and are transitioning the results back in this open access manual.
- We describe our processes for data normalization, analysis, derivation of Cost Estimating Relationships (CERs) and productivity benchmarking.

Estimation and Metrics Processes

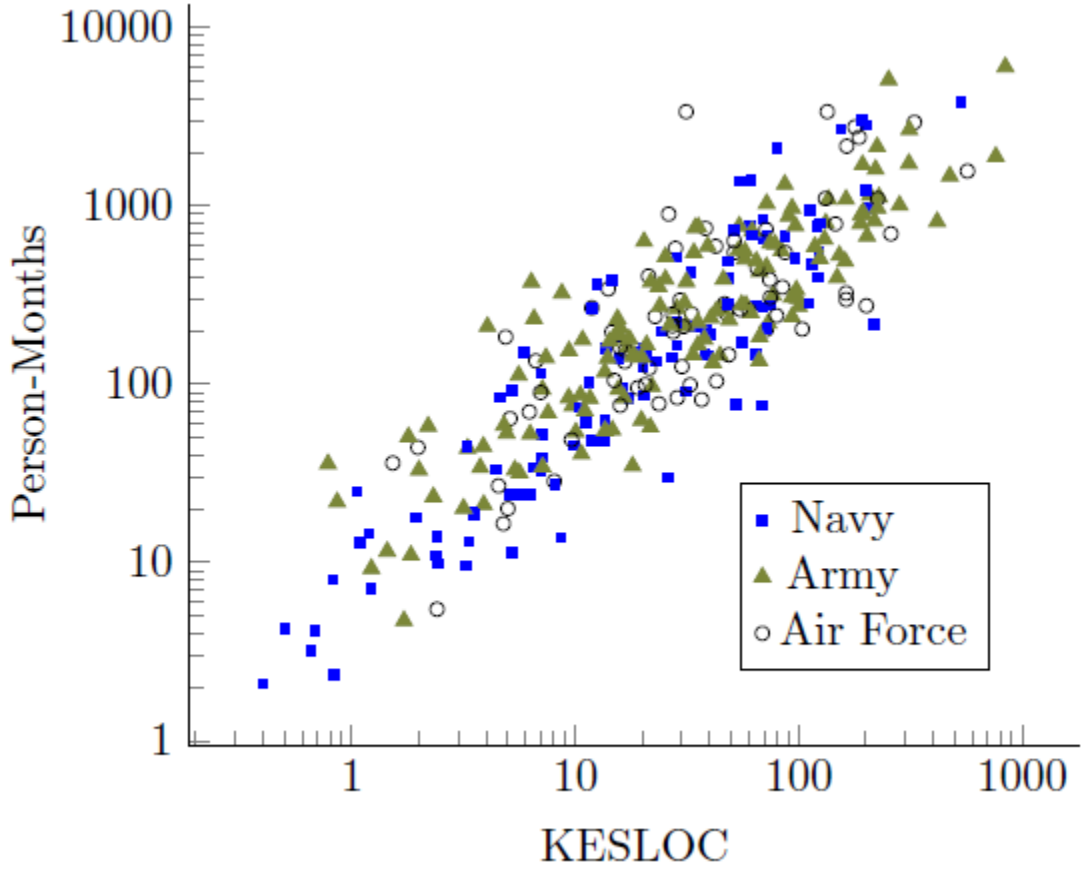


Ch-2. Software Resources Data Report

- Overview
- Collecting Organization
- Repository
- Reporting Frequency
- SRDR Content
- Further SRDR Resources

Dataset Summary

- Analysis based on 317 SRDRs reported from recent DoD projects during 2004-2013.
- Normalized Effort vs. Equivalent Size in SRDRs:



Ch-3. Metrics Definitions

- Overview
- Product Size Measures
- SLOC Count Definitions
- ESLOC Summary
- Functional Size Measures
- Development Effort
- Development Duration

Metrics Definitions Examples

- Software Size Types

Size Type	Description
New	New software created for the first time.
Adapted	Pre-existing software that is used as-is (Reused) or changed (Modified).
Reused	Pre-existing software that is not changed with the adaption parameter settings: • Design Modification % (DM) = 0% • Code Modification % (CM) = 0%.
Modified	Pre-existing software that is modified for use by making design, code and / or test changes: • Code Modification % (CM) > 0%.

- SLOC Count Definitions

	Logical		NCSS		Physical		Total	
Statement Type	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Executable	✓		✓		✓		✓	
Nonexecutable								
Declarations	✓		✓		✓		✓	
Compiler directives	✓		✓		✓		✓	
Comments		✓		✓	✓		✓	
Blank lines		✓		✓		✓	✓	

Ch-4. Data Assessment

- Gather Collected Data
- Inspect each Data Record
- Determine Data Quality Levels
- Correct Missing or Questionable Data
- Normalize Size and Effort Data
- Convert Raw SLOC into Equivalent SLOC

Data Assessment Examples

- Data Quality Rating Scale

Attribute	Value	Condition
Size:	1	if size data present
	0	if no size data
Size Count Type	1	if size is Logical SLOC
	0.7	if size is Non-Commented Source Statements
	0.5	if size is Physical Lines (Comment and Source Statements)
	0.4	if size is Total Lines (all lines in file: blank, comment, source)
	0	if no size data
ESLOC Factors: (See Section 3.2.2.2)	1	if modification factors are provided for Auto-gen, Modified & Reuse code counts from out-

- Software reuse proxy values for DM, CM and IM

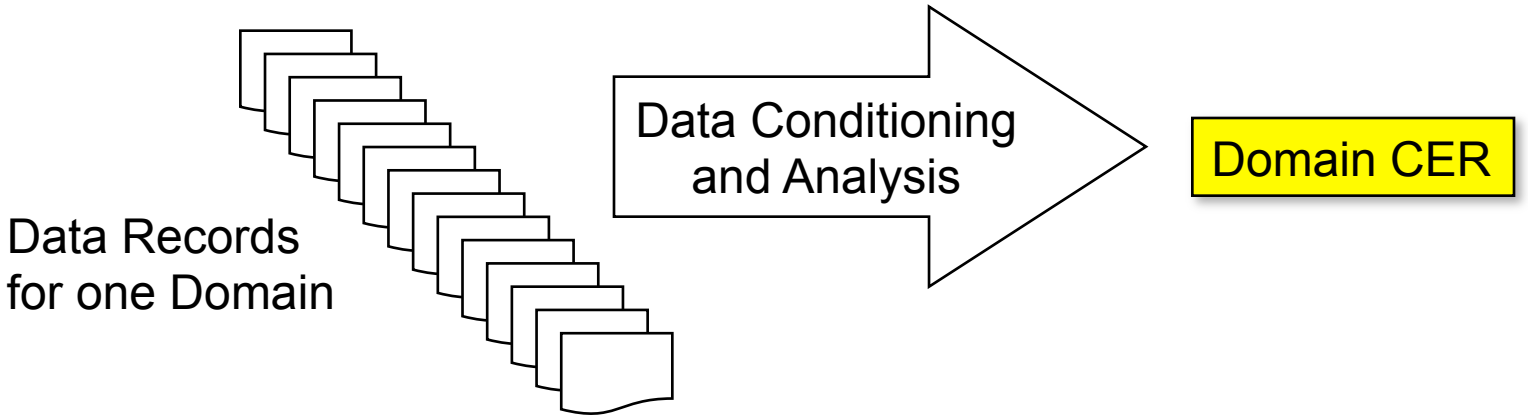
Code Type	#	DM Range	DM Mdn.	CM Range	CM Mdn.	IM Range	IM Mdn.	AAF
New		N/A		N/A		N/A		1.0
Modified	101	0-100%	31%	1-100%	44%	3-100%	72%	0.47
Reused	145	0%		0%		0-100%	10%	0.03
Auto-Gen	6	0%		0%		0-100%	50%	0.15

Ch-5. Cost Estimating Relationships

- Overview
- Data Segmentation
- Estimating Relationships
- SRDR-Derived CERs
- SRDR-Derived Benchmarks
- Limitations and Future Work

Data Analysis Objectives

- Make collected data useful to oversight and management entities
  - Provide guidance on how to condition data to address challenges
  - Segment data into different Application Types and Operating Environments
  - Analyze data for simple Cost Estimating Relationships (CER) within each domain
  - Develop rules-of-thumb for missing data



Operating Environment

- Represents the platform that the software operates in.
- Complexity of a software also driven by environment
- It is important to determine the appropriate environment before analyzing your software project:

Environment	Type
Ground Site (GS)	Fixed (GSF) Mobile (GSM)
Ground Vehicle (GV)	Manned (GVM) Unmanned (GVU)
Maritime Vessel (MV)	Manned (MVM) Unmanned (MVU)
Aerial Vehicle (AV)	Manned (AVM) Unmanned (AVU)
Space Vehicle (SV)	Manned (SVM) Unmanned (SVU)
Ordnance Vehicle (OV)	Unmanned (OVU)





Application Type

- Complexity is influenced by its Application Type
- Application Types are groups of application domains that are environment independent, technology driven and characterized by:

1. Required software reliability
2. Data processing requirements
3. Product complexity
4. Integration complexity
5. Real-time operating requirements
6. Platform volatility
7. Target system volatility
8. Special display requirements
9. Development re-hosting
10. Quality assurance requirements
11. Security requirements
12. Assurance requirements
13. Required testing level

- Determining the appropriate productivity type is critical as it allows you the select the most appropriate model and benchmark

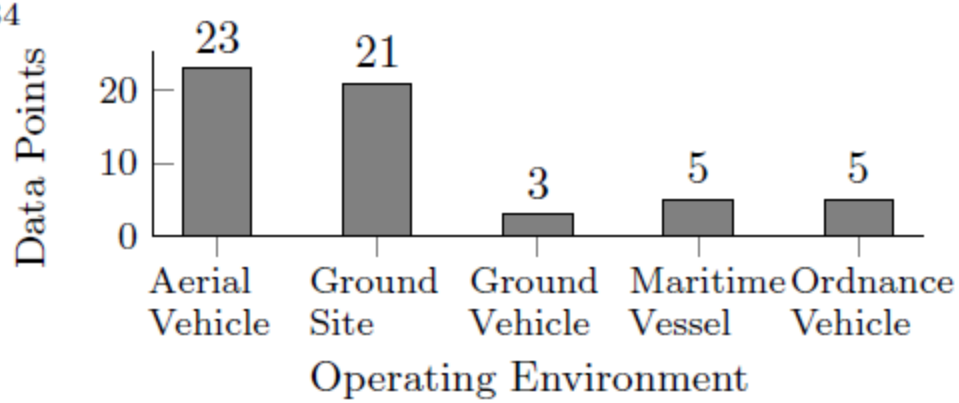
Application Types

1. Sensor Control and Signal Processing (SCP)
2. Vehicle Control (VC)
3. Vehicle Payload (VP)
4. Real Time Embedded (RTE)
5. Mission Processing (MP)
6. Process Control (PC)
7. System Software (SYS)
8. Planning Software (PLN)
9. Scientific Software (SCI)
10. Training Software (TRN)
11. Telecommunications (TEL)
12. Software Tools (TOOL)
13. Test Software (TST)
14. Intelligence & Information Software (IIS)

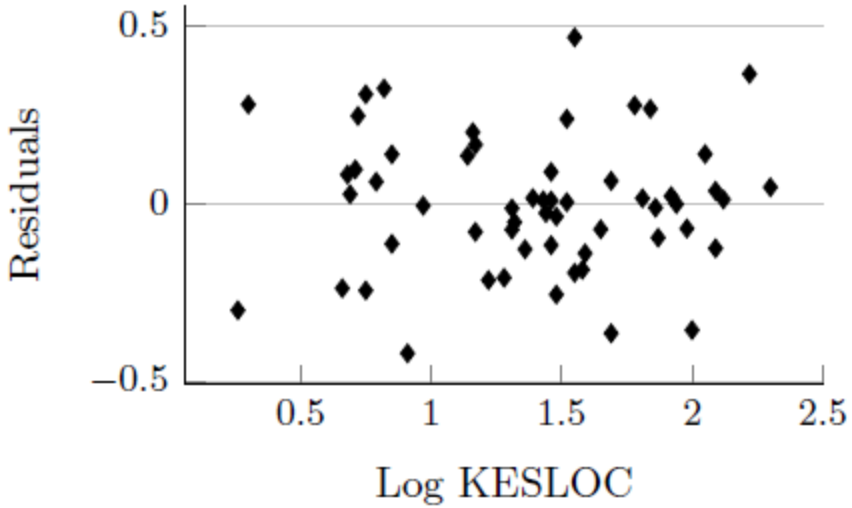
Example CER: Real Time Embedded (1/2)

$$PM = 13.20 \cdot KESLOC^{0.84}$$

Data Points = 57
KESLOC Min = 2
KESLOC Max = 201

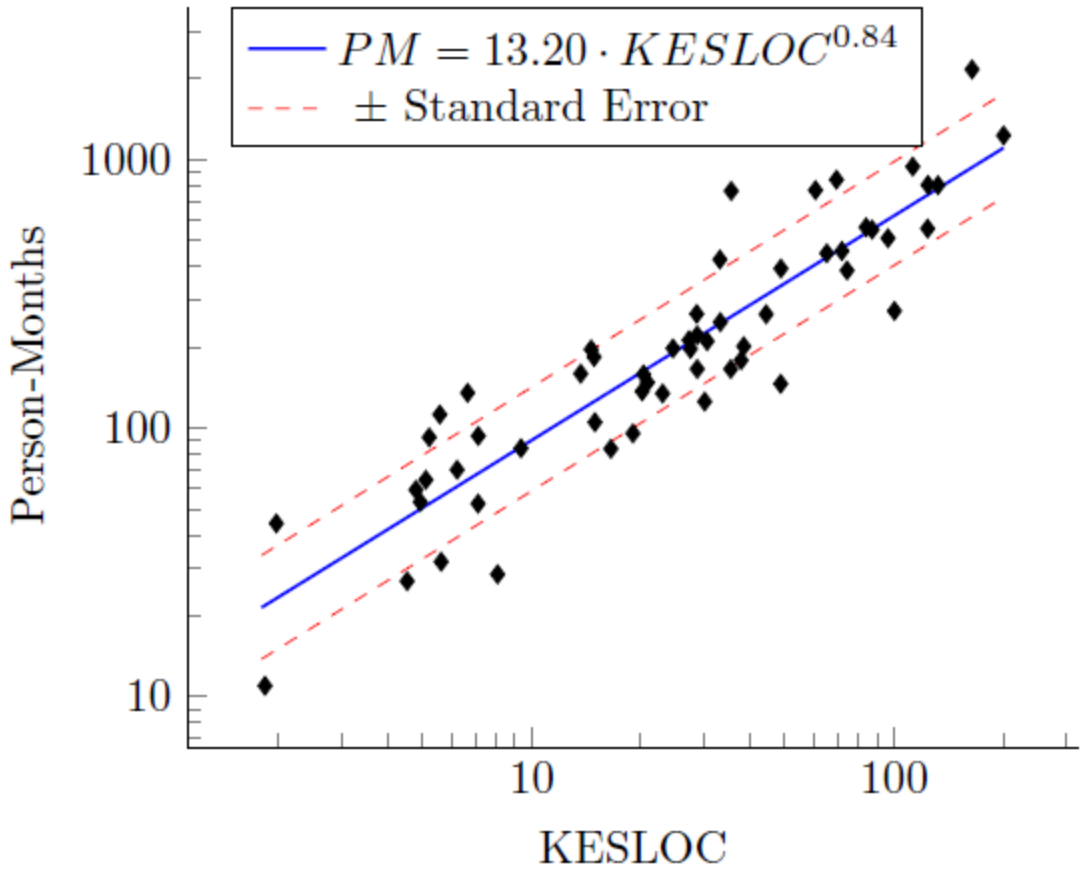


$R^2 = 83\%$
SE = 211 PM
PRED = 54%



Example CER: Real Time Embedded (2/2)

Coefficient	Value	T-Stat	P-Value	LCI	UCI
A	13.16	14.7	1.00E-20	9.26	18.69
B	0.84	16.2	1.48E-22	0.73	0.94



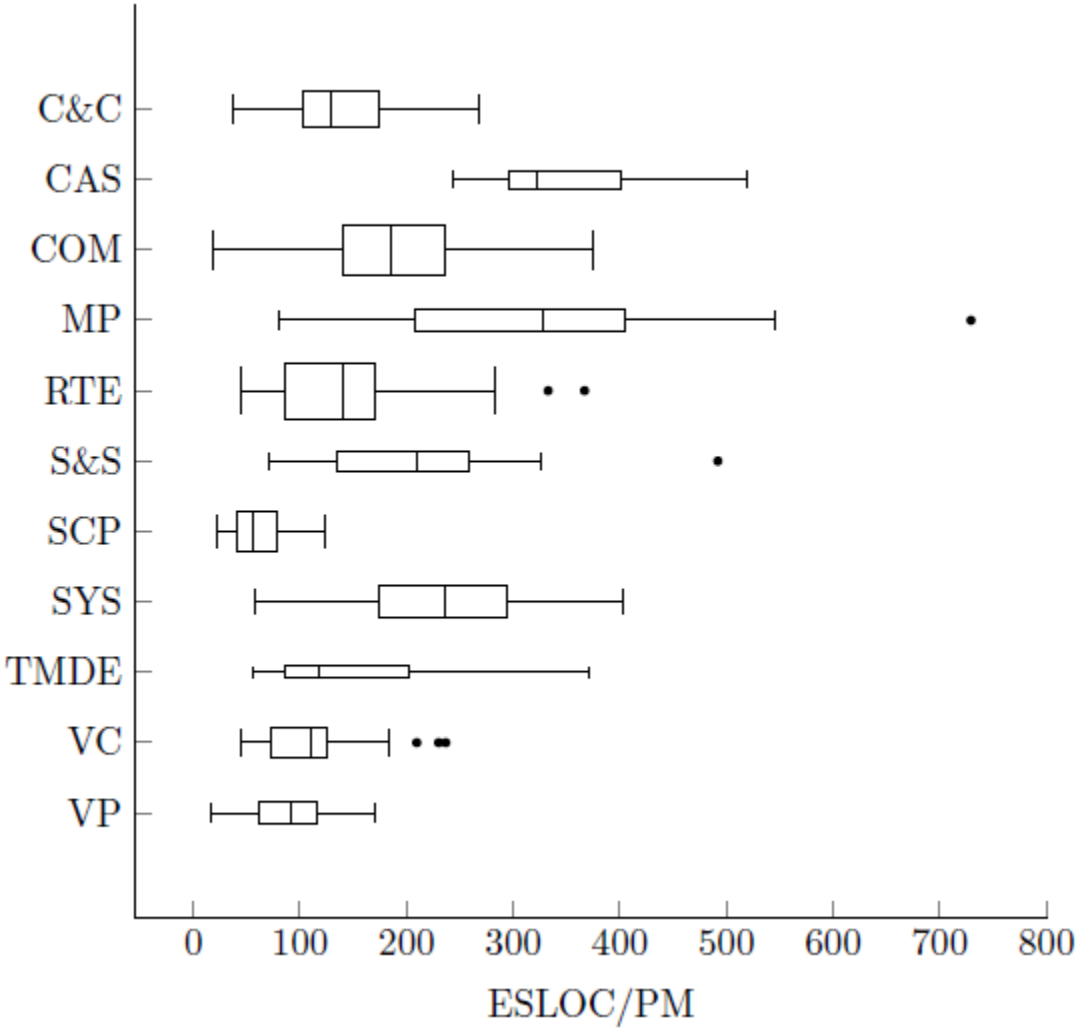
Operating Environment CERs

Op Env	Effort Equation	N	R^2	SE	PRED	KESLOC Min	KESLOC Max
AV	$PM = 9.41 \cdot KESLOC^{0.93}$	87	77%	516	39	0.7	329.9
GS	$PM = 12.6 \cdot KESLOC^{0.79}$	134	74%	478	56	0.8	842.1
GV	$PM = 15.1 \cdot KESLOC^{0.82}$	26	74%	178	54	7.2	283.1
MV	$PM = 5.44 \cdot KESLOC^{1.12}$	42	87%	206	33	0.4	123.8
OV	$PM = 27.45 \cdot KESLOC^{0.71}$	25	79%	11	48	0.9	221.1

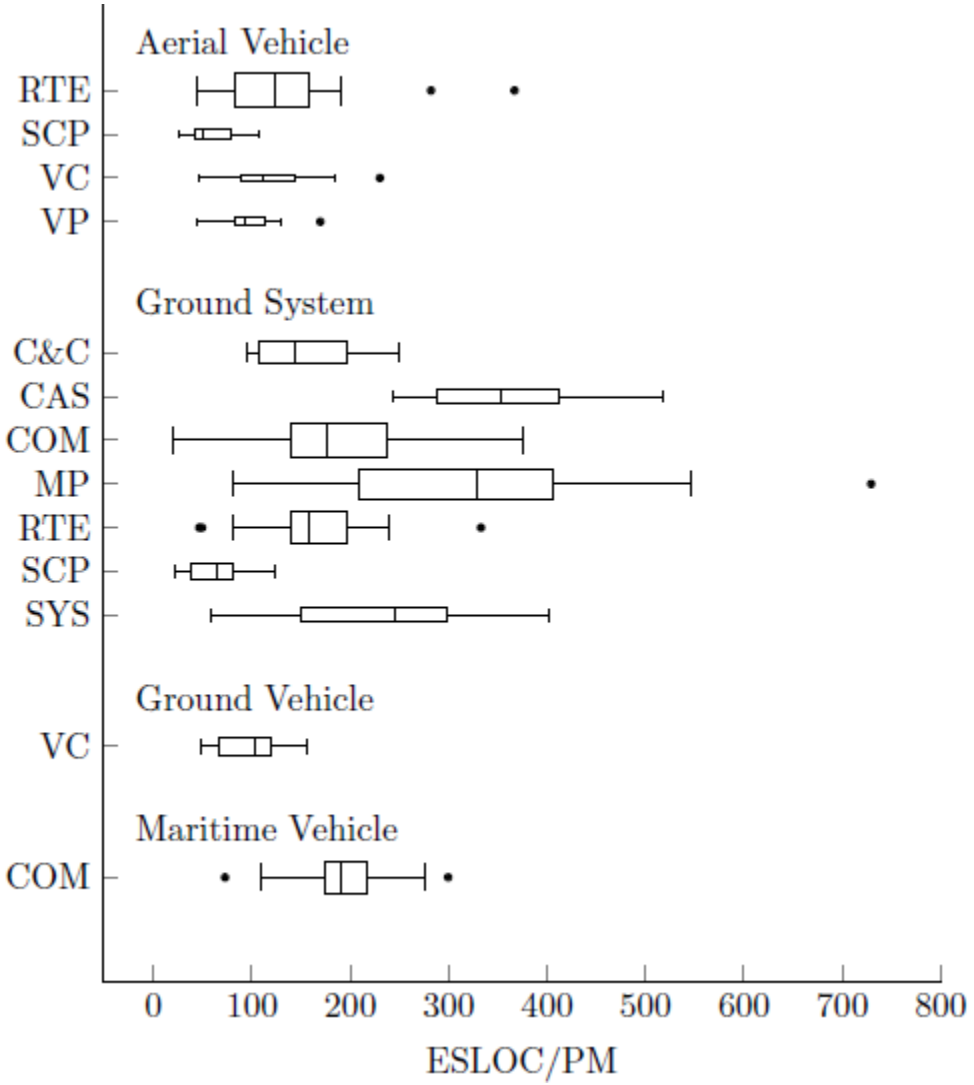
Application Type CERs

App Type	Effort Equation	N	R^2	SE	PRED	KESLOC Min	KESLOC Max
CAS	$PM = 2.64 \cdot KESLOC^{1.02}$	16	97%	135	88	2.4	417.1
COM	$PM = 7.30 \cdot KESLOC^{0.91}$	47	88%	253	60	0.4	532.4
C&C	$PM = 6.60 \cdot KESLOC^{1.05}$	33	88%	449	52	0.8	229.0
MP	$PM = 6.14 \cdot KESLOC^{0.86}$	20	77%	220	55	9.6	570.0
RTE	$PM = 13.20 \cdot KESLOC^{0.84}$	57	83%	211	54	1.8	200.6
SCP	$PM = 26.5 \cdot KESLOC^{0.87}$	36	91%	346	50	0.8	192.9
S&S	$PM = 7.43 \cdot KESLOC^{0.91}$	17	85%	176	53	4.4	225.8
SYS	$PM = 5.06 \cdot KESLOC^{0.98}$	27	93%	585	48	0.8	842.1
TMDE	$PM = 7.42 \cdot KESLOC^{1.00}$	11	92%	454	27	0.5	313.0
VC	$PM = 9.05 \cdot KESLOC^{1.02}$	27	92%	303	48	0.7	329.9
VP	$PM = 22.27 \cdot KESLOC^{0.81}$	18	89%	111	56	1.1	221.1

Application Type Productivity Benchmarks



Application Type and Operating Environment Productivity Benchmarks



Ch-7. Estimation Process (Based on GAO)

- Overview
- Estimation Purpose
- Program Definition
- Estimation Scope
- Data Collection and Normalization
- Estimate Creation
- Sensitivity Analysis
- Risk and Uncertainty Analysis
- Estimate Documentation and Packaging

Risk and Uncertainty Analysis

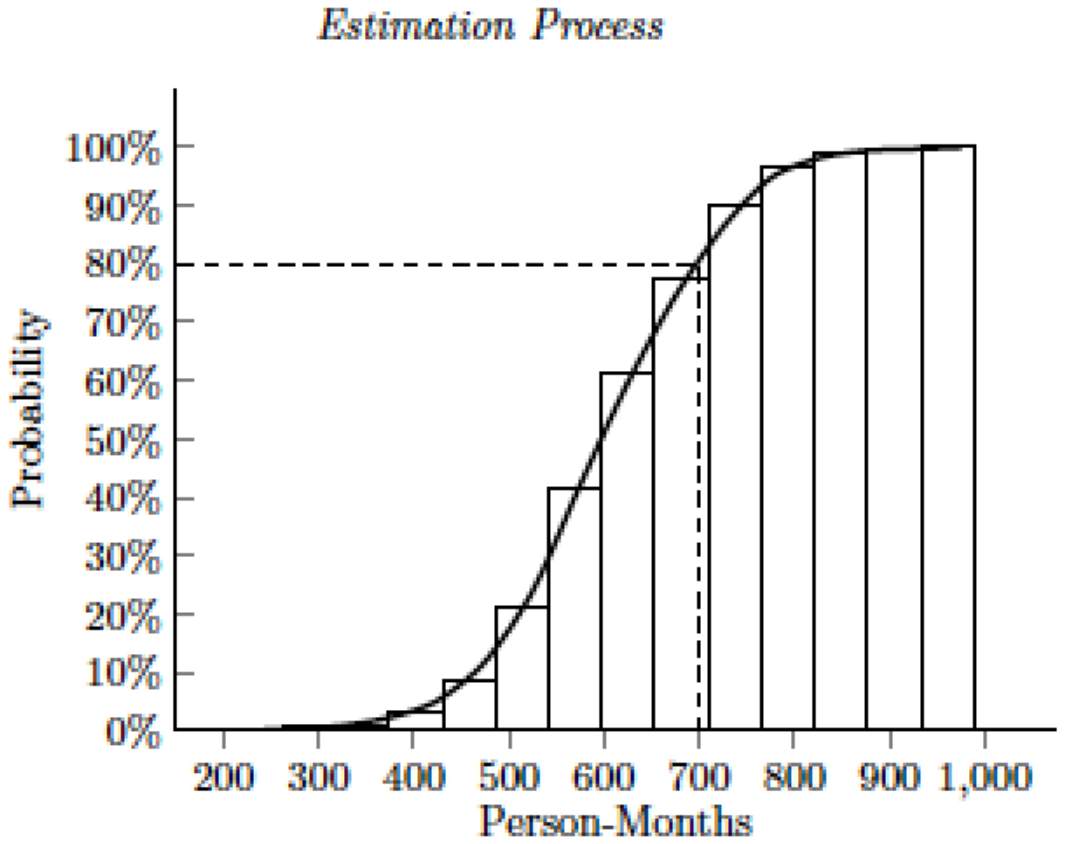


FIGURE 7.7: RTE Effort Cumulative Distribution Function

Future Work

- More SRDR data is collected each year. The SRDR data requirements are periodically revised to collect more and higher quality data.
  - The intent is to keep this manual relevant with future editions incorporating new information from contributors.
- Much future work is identified in the current manual.
- This manual is hosted and maintained at http://softwarecost.org
  - Readers will find errata, updates to its content, and a place to submit suggestions and comments.

Future Work

- The intent is to keep this manual relevant for assisting analysts and decision makers with early software cost estimates and commitments
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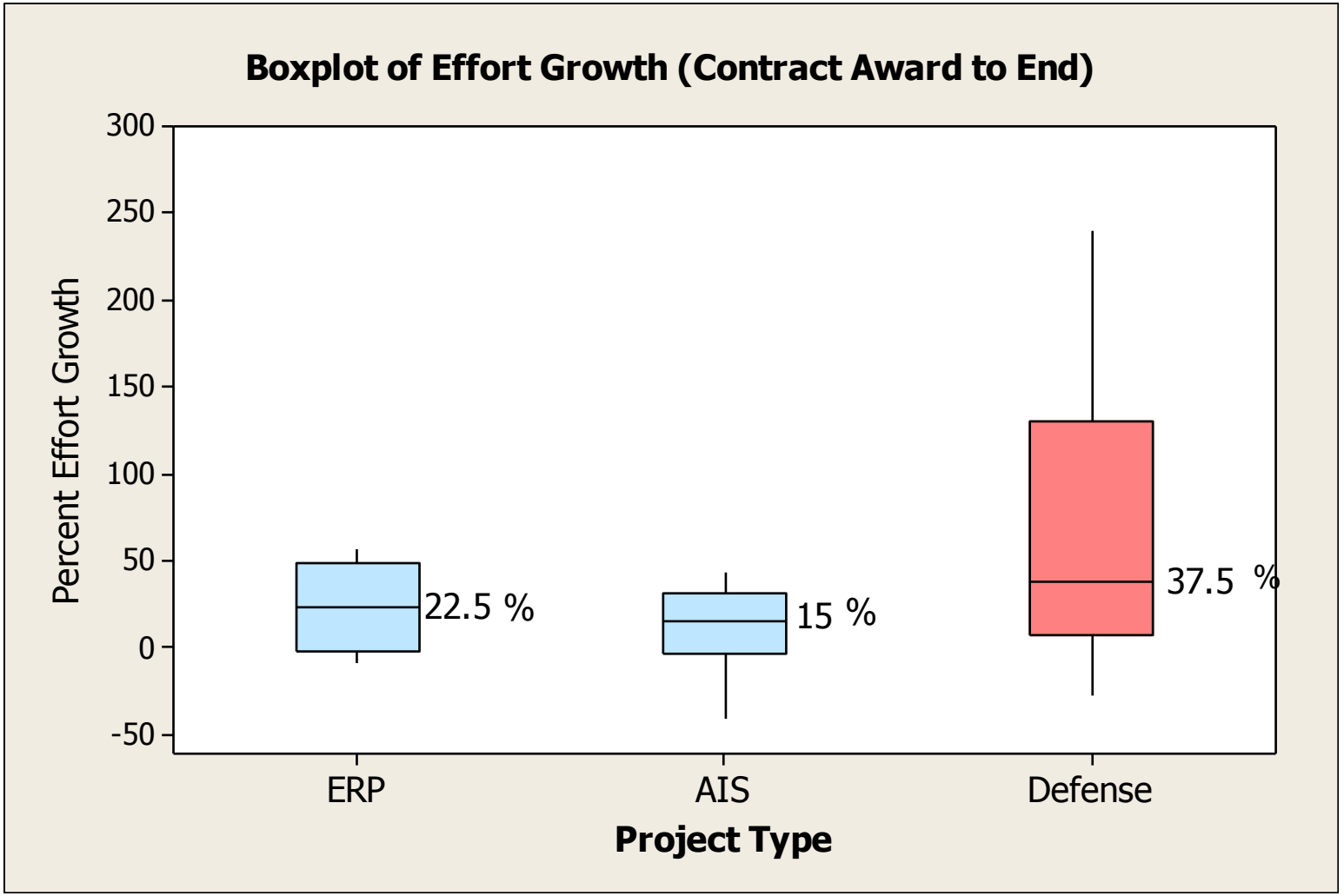
Effort Growth Contract Award to End



Effort Model Based on Requirements

Equation:

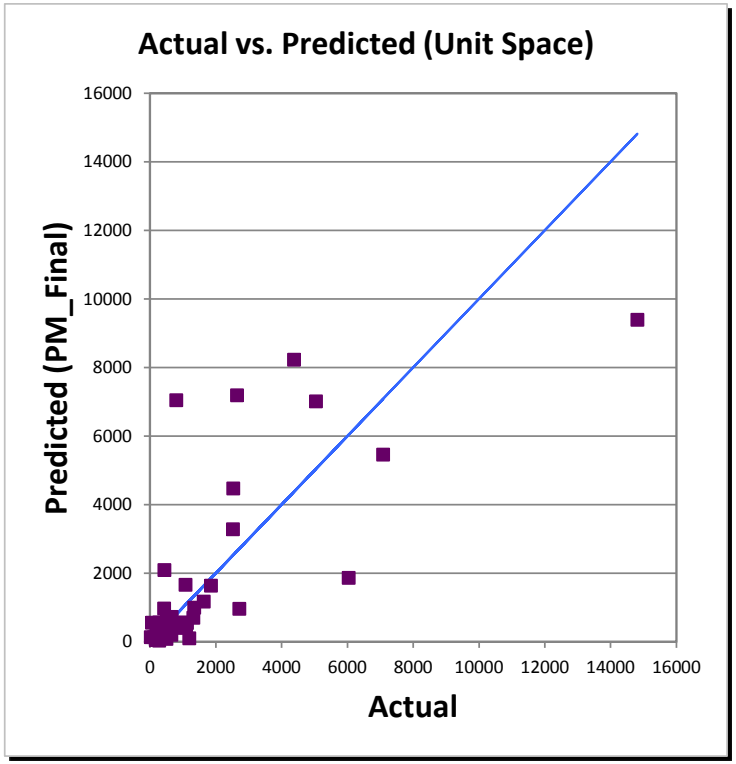
Model Form	N	R^2	CV	Mean	F-stat	REQ Min	REQ Max
PM = aREQ$^{0.9679}$	40	97	63	1718	1659	35	12716

Where:

PM = Actual effort (in Person Months)

aREQ = Actual total requirements

Variable	Coeff	T stat	P value
aREQ	0.9679	40.7	0.0000



Schedule Model Based on Actual Effort

Equation:

Model Form	N	R^2	CV	Mean	F-stat	PM Min	PM Max
TDEV = aPM$^{0.5051}$	40	95	48	38	887	27	14819

Where:

TDEV = Actual Duration in Months

aPM = Actual Effort (in Person Months)

Variable	Coeff	T stat	P value
aPM	0.529	26.14	0.0000