Headquarters U.S. Air Force

Integrity - Service - Excellence

Building CERs & SERs for Enterprise Resource Planning (ERP) Programs

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2011 PSM Users' Group Conference

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Abstract

- All Major DoD ERP Programs have exceeded original cost and schedule estimates by more than 30%! A lack of understanding of the new technology and high dependence on traditional parametric models drives this error rate. The costs of these technologically advanced capabilities cannot be predicted using traditional models because their datasets are based on third generation capabilities captured during the late 1980s and early 1990s.
- In an effort to mitigate this shortcoming, the Air Force Cost Analysis Agency (AFCAA) has developed cost estimating relationships (CERs) and schedule estimating relationships (SERs) from 20 programs. In this paper, we will share the result of those CERs and SERs for major cost elements such as prime mission product, program management, systems engineering, system test & evaluation, training, sustaining engineering, software maintenance and help desk. We will also introduce the first-ever MIL-STD-881 WBS and Software Resource Data Report for ERPs.

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Outline

- ERP Overview
- Data Collection and Analysis
- Work Breakdown Structure
- Cost Estimating Relationships
- Schedule Estimating Relationships
- Way Forward


ERP Overview

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What is ERP?

Enterprise Resource Planning (ERP) systems integrate an organization's core business functions around a unified data base.

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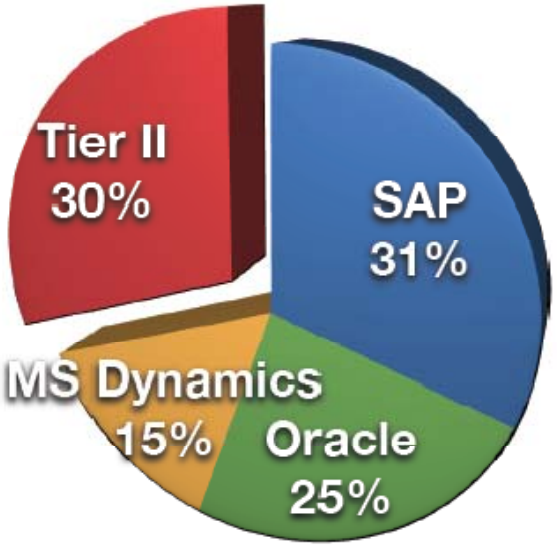
How is it implemented?

- **Business processes are automated via an integrated COTS software application:**

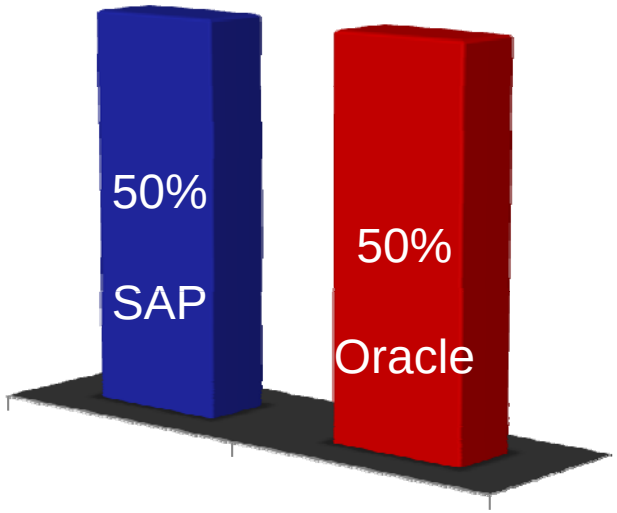
Microsoft Dynamics

SAP

ORACLE



2009 Market Share



FY10 Major DoD Programs

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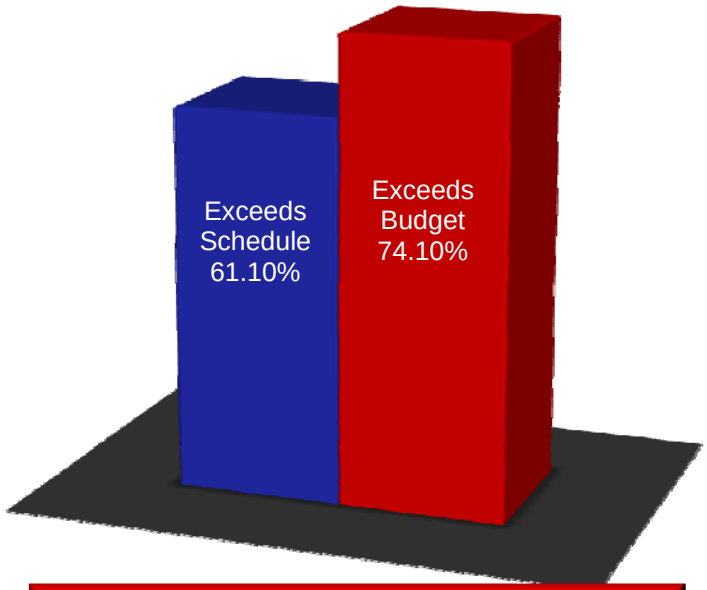
Why are we interested?

Lack of Accurate Cost and Schedule Estimates!

Industry-wide



2010 Results of Industry Survey of 185 Implementers

DoD

All Major DoD ERP Programs Have Exceeded Original Cost and Schedule Estimates!

As of Dec. 2009, DoD had invested $5.8B in their ERP programs!

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What has been done?

In 2006 the Air Force (AFCAA), the Navy (NCCA), and the Army (DASA-CE) formed a team to collect cost, schedule and technical data on ERP projects

By 2009, data had been collected from 20 programs government-wide including 17 programs from DoD.

Cost Estimating Relationships (CERs) have been developed on the basis of this data and are the subject of this presentation.

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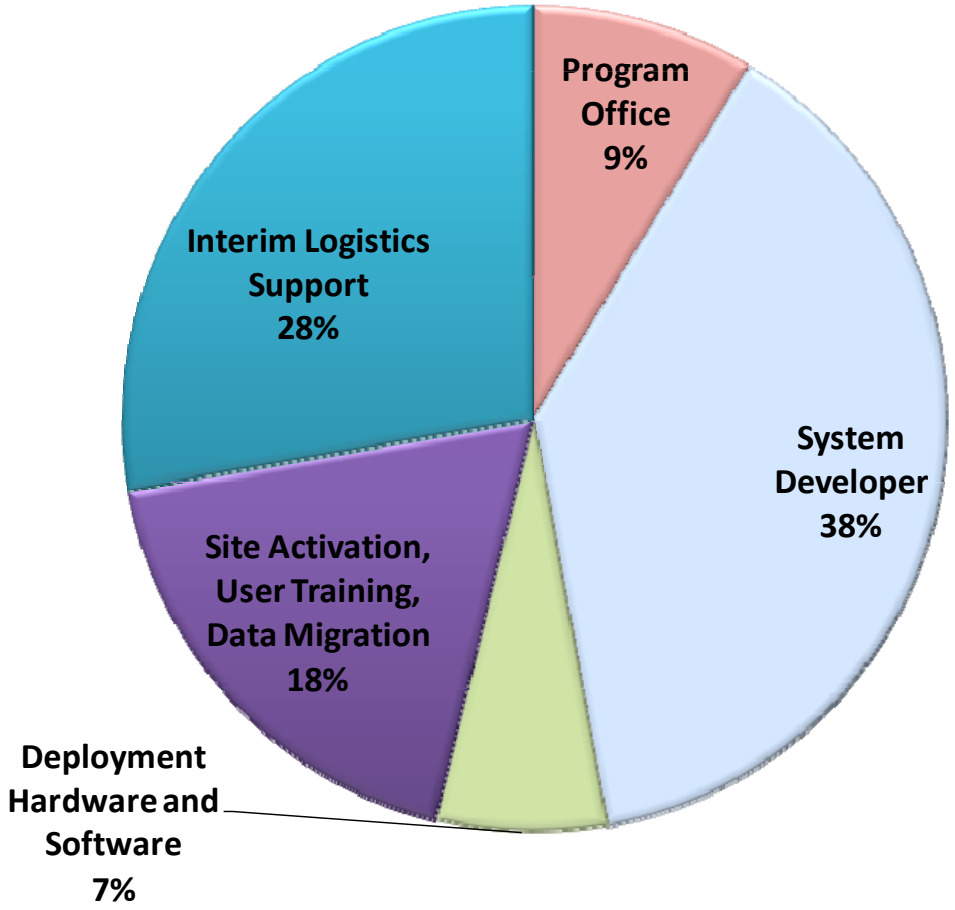
Summary Results

Investment Cost Allocation



MIL-STD-881C Reference:
•Program Office (L.6.1, L.6.2, L.6.3) = **Government** Program Management (PM), Systems Engineering (SE), Change Management (CM)
•System Developer (K.4.2.3, L.6.1, L.6.2, L.6.3, L.6.4.1, L.6.5) = **Contractor** Prime Mission Product, SE, PM, CM, Development Test & Evaluation, Training, Other

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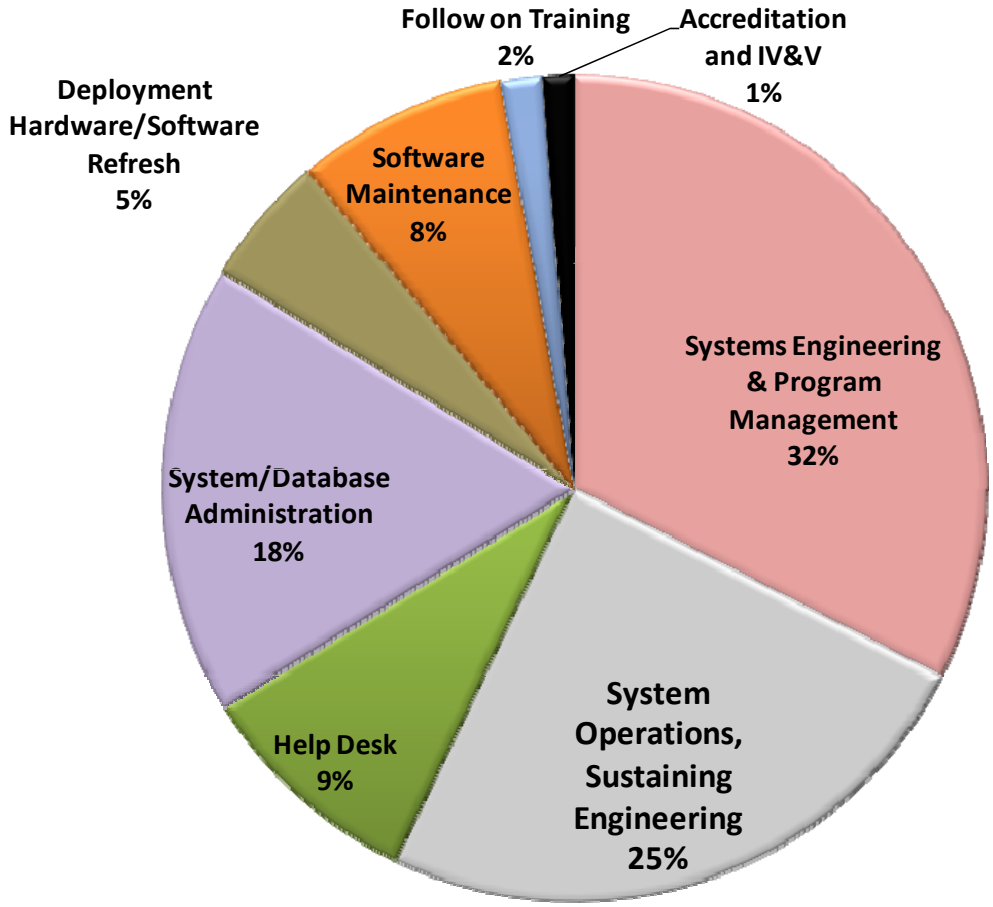
Summary Results

O&S Cost Allocation



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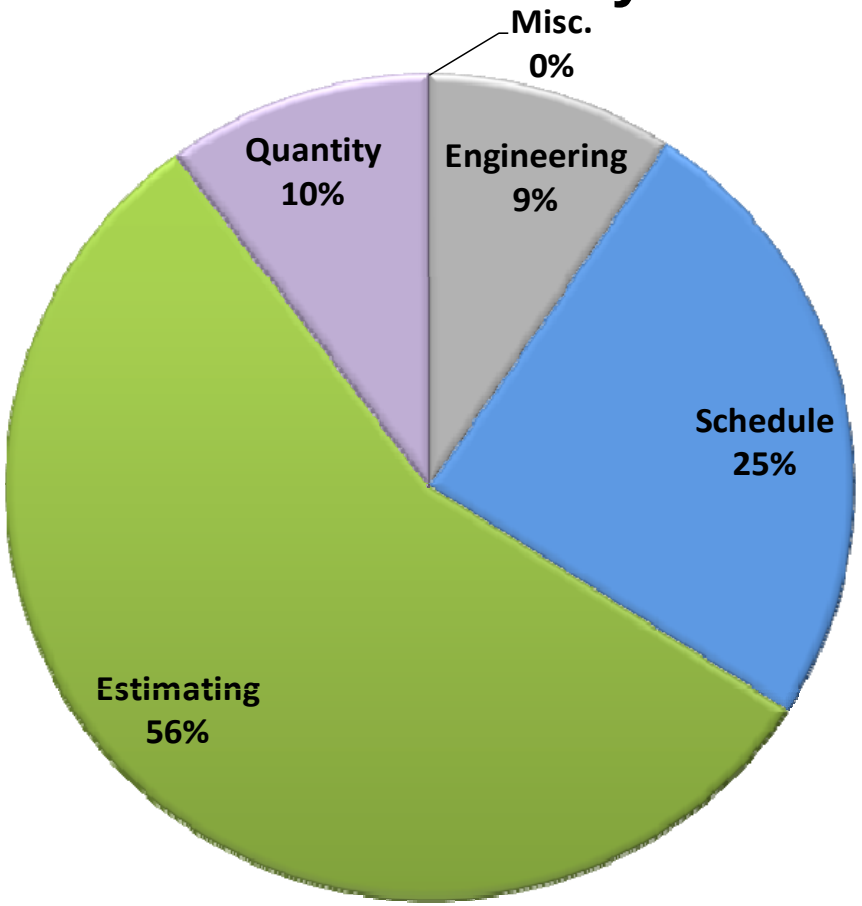
Summary Results

*Contribution to Cost Growth by Variance Category



*Investment Phase Only: Program Insertion through “Go-Live”

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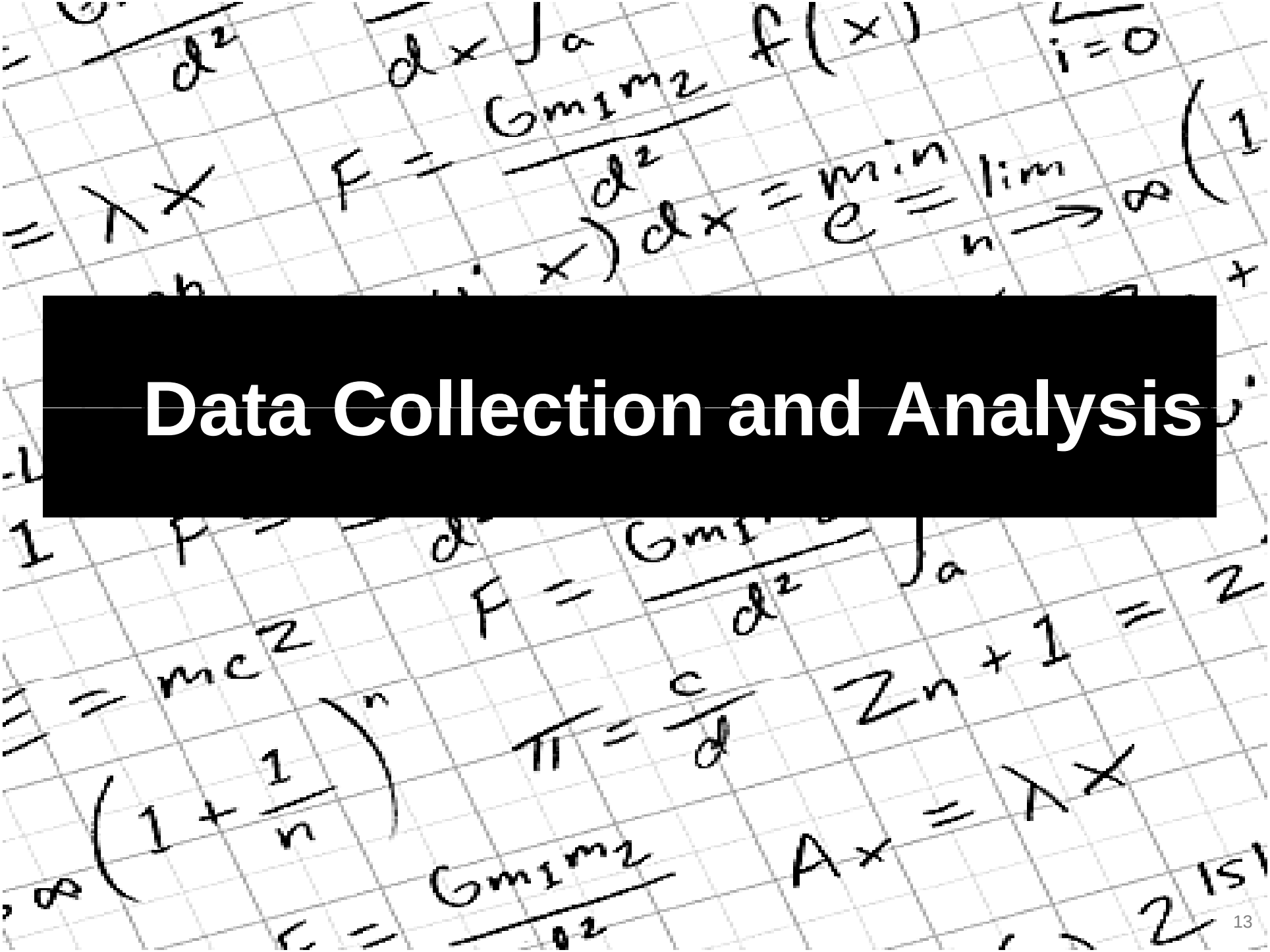
Reasons for Cost Growth

1. **Estimation: A lack of understanding of the new technology and business environment led to the use of obsolete cost models (1980-1990s) and dubious estimating methods**
2. **Schedule: limited budgets have forced decision makers to extend the period of performance of "Level of Effort" related tasks – Civilian, Contractor, and Military FTEs**
3. **Engineering: Inexperience with Oracle/SAP Customization has led to underestimation of requirements. Difficulty changing business processes to match ERP processes**
4. **Quantity: war-fighter need has led some program offices to reassess user and implementation requirements**



Data Collection and Analysis

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Instrumentation and Dataset

- Data collected from 20 programs government-wide including 17 programs from DoD
- Data collected using a modified version of the ERP Software Resource Data Report (SRDR) questionnaire *
  - Original questionnaire allowed the collection of data on requirements, product size, effort, and schedule
  - New fields were added to collect data on infrastructure -- operational sites, users, software licenses, servers, CPUs, etc.
- Questionnaire has been used on multiple programs
  - DEAMS, GFEBS, ECSS, NAVY ERP, GCSS-Army

*Defense Cost and Resource Center (DCARC)

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What is RICE? and How do we use it?

- **RICE* is a software sizing method of identifying specific requirements not supported by the COTS Software Application**
- **RICE* stands for: Reports, Interfaces, Conversions, Extensions**
  - **Reports: Standard application tables requiring customization**
  - **Interfaces: External files requiring up to 6 transactions in upload**
  - **Conversions: Pre-extracted Data requiring formatting**
  - **Extensions: Additional programming functionality required for initial & detail screens, menu extensions, user exits with substitution logic, step-loop to maintain header & detail, database updates, etc.**
- **Empirical analyses from Air Force Cost Analysis Agency, prime vendors (SAP, Oracle), and system developers reveal that RICE has a significant impact on prime mission product and test & evaluation**

*Reports may include forms, and Extensions may include Workflow and Bolt-ons

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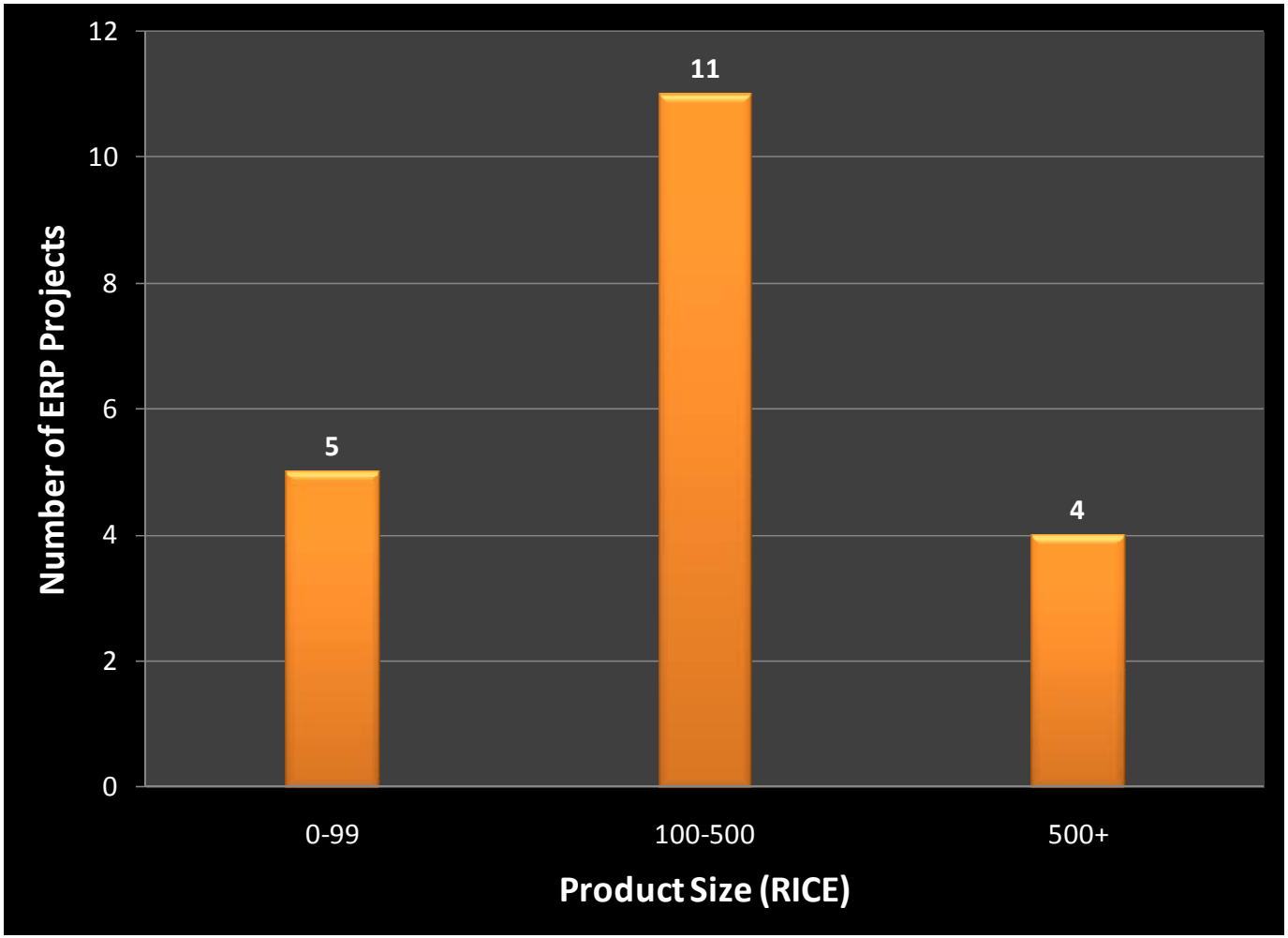
Data Segmentation: RICE Range



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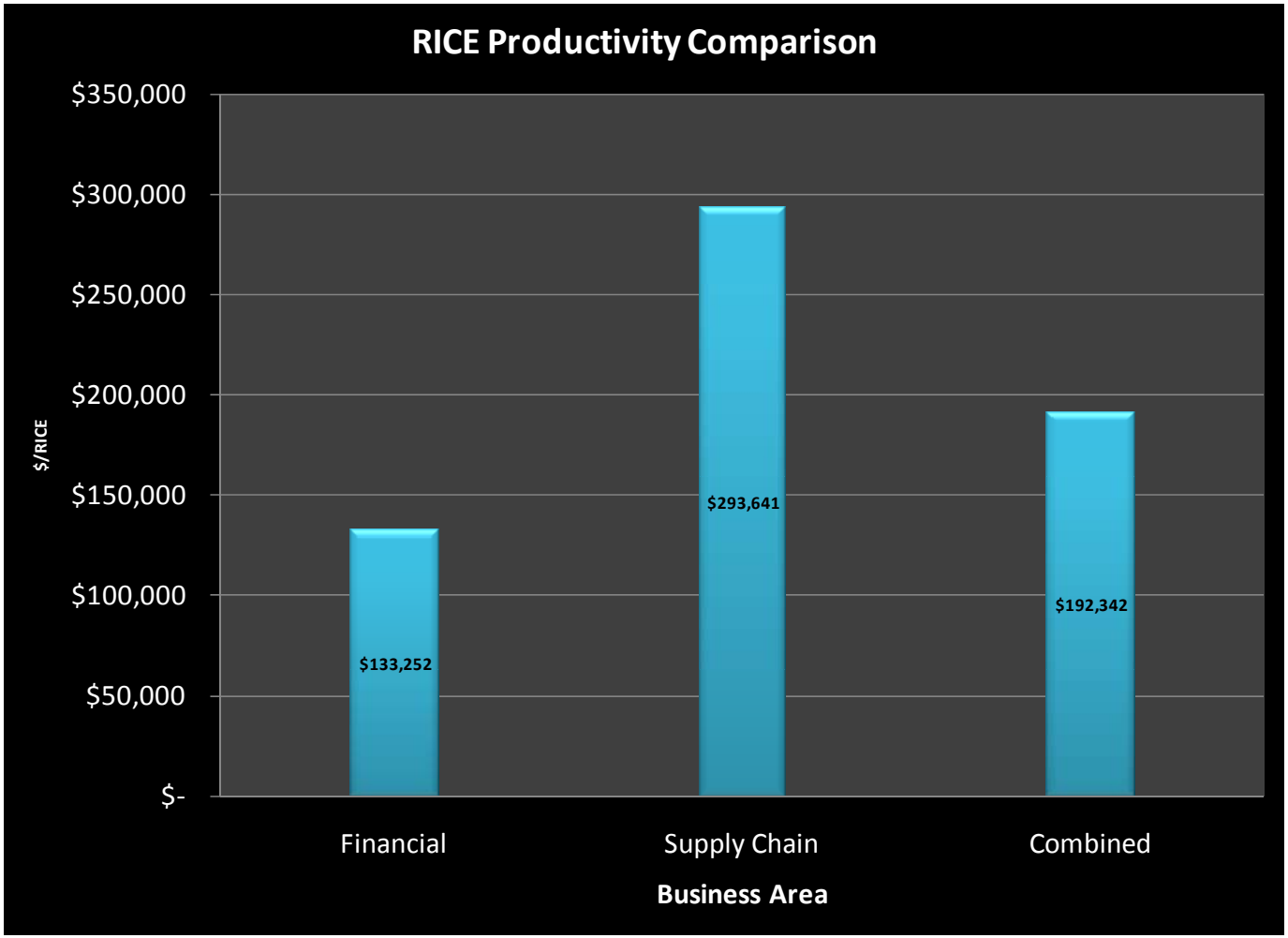
Data Segmentation:
$/RICE by Business Area

Dollars in Base Year 2010



Minimizing Threats to Validity

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- **Cost Driver Selection:**
  - **Chosen on the basis of their significant effect on acquisition costs via empirical analyses. Results are consistent with the 2007 Joint Information Technology Team Market Research -- SAP, Oracle, CSC, Deloitte, IBM, Accenture, BearingPoint**
- **Model Validation:**
  - **Ordinary least squares regressions selected as the Normal plot of the residuals showed no significant outliers, multicollinearity**
  - **Validated on 3 recent Air Force/Navy deliveries (SE*< 15%)**
- **Ensuring high Data Quality and Integrity:**
  - **Standard Collection Form to ensure consistent reporting**
  - **Actual Program Measurements (Effort, Cost, etc.)**
  - **Quality Checked data fields via interviews with Data Sources**

*SE = standard error

Work Breakdown Structure

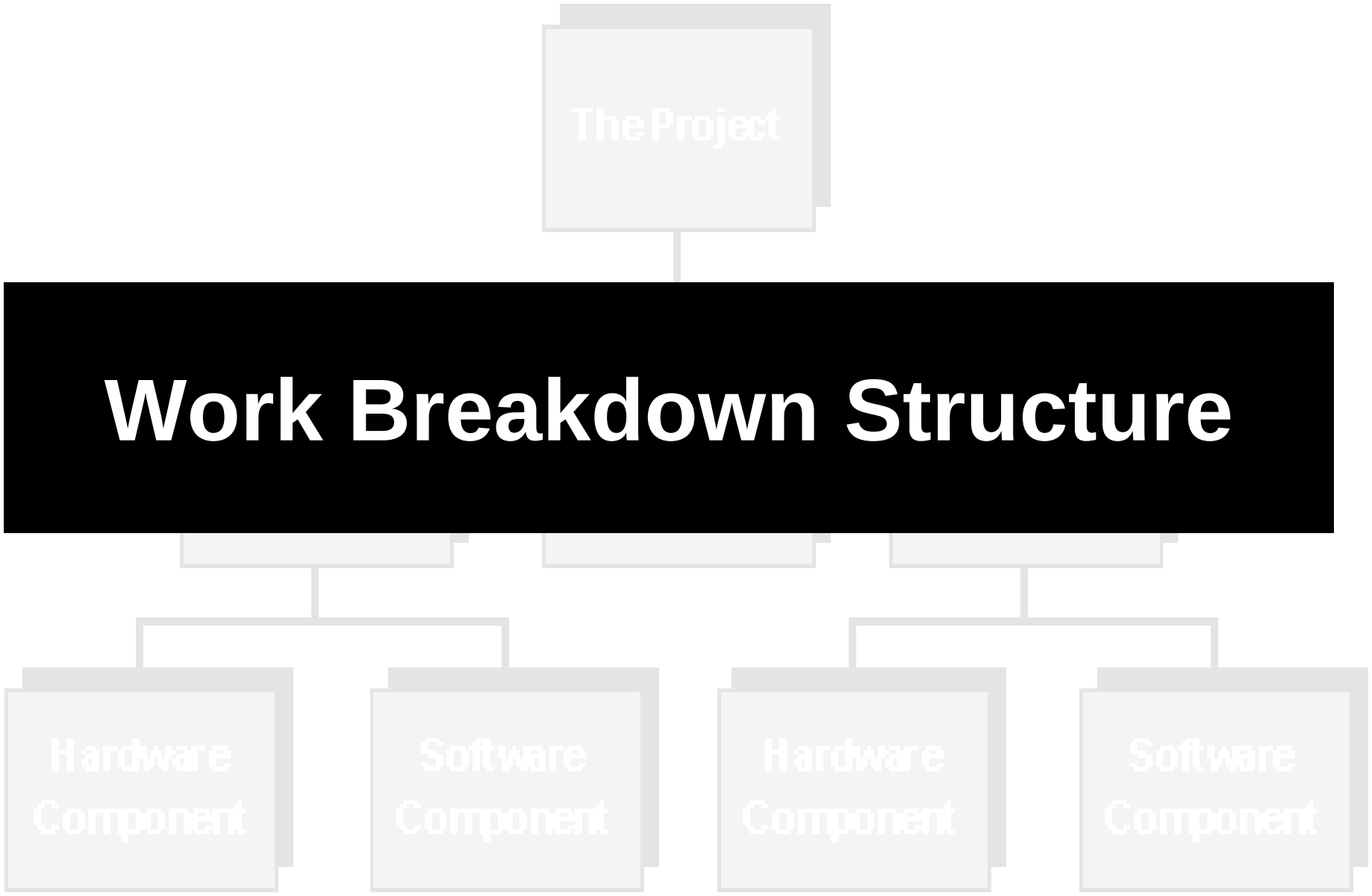

Figure 42.2. A large project WBS.

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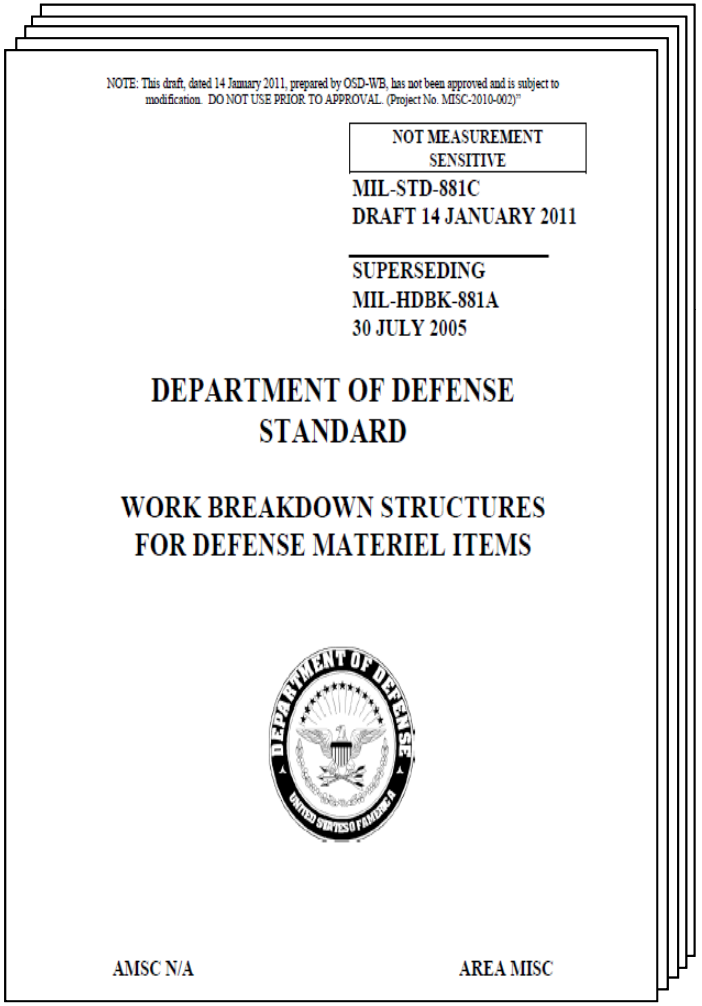
MIL-STD-881C WBS

- First-Ever WBS for ERP
- MIL-STD-881 C Reference
  - Appendix K accounts for Prime Mission Product Elements
  - Appendix L.6 accounts for Common Elements such as Program Management, Systems Engineering, etc.



NOTE: This draft, dated 14 January 2011, prepared by OSD-WB, has not been approved and is subject to modification. DO NOT USE PRIOR TO APPROVAL. (Project No. MISC-2010-002)"

NOT MEASUREMENT SENSITIVE

MIL-STD-881C
DRAFT 14 JANUARY 2011

SUPERSEDING
MIL-HDBK-881A
30 JULY 2005

DEPARTMENT OF DEFENSE
STANDARD

WORK BREAKDOWN STRUCTURES
FOR DEFENSE MATERIEL ITEMS

AMSC N/A AREA MISC

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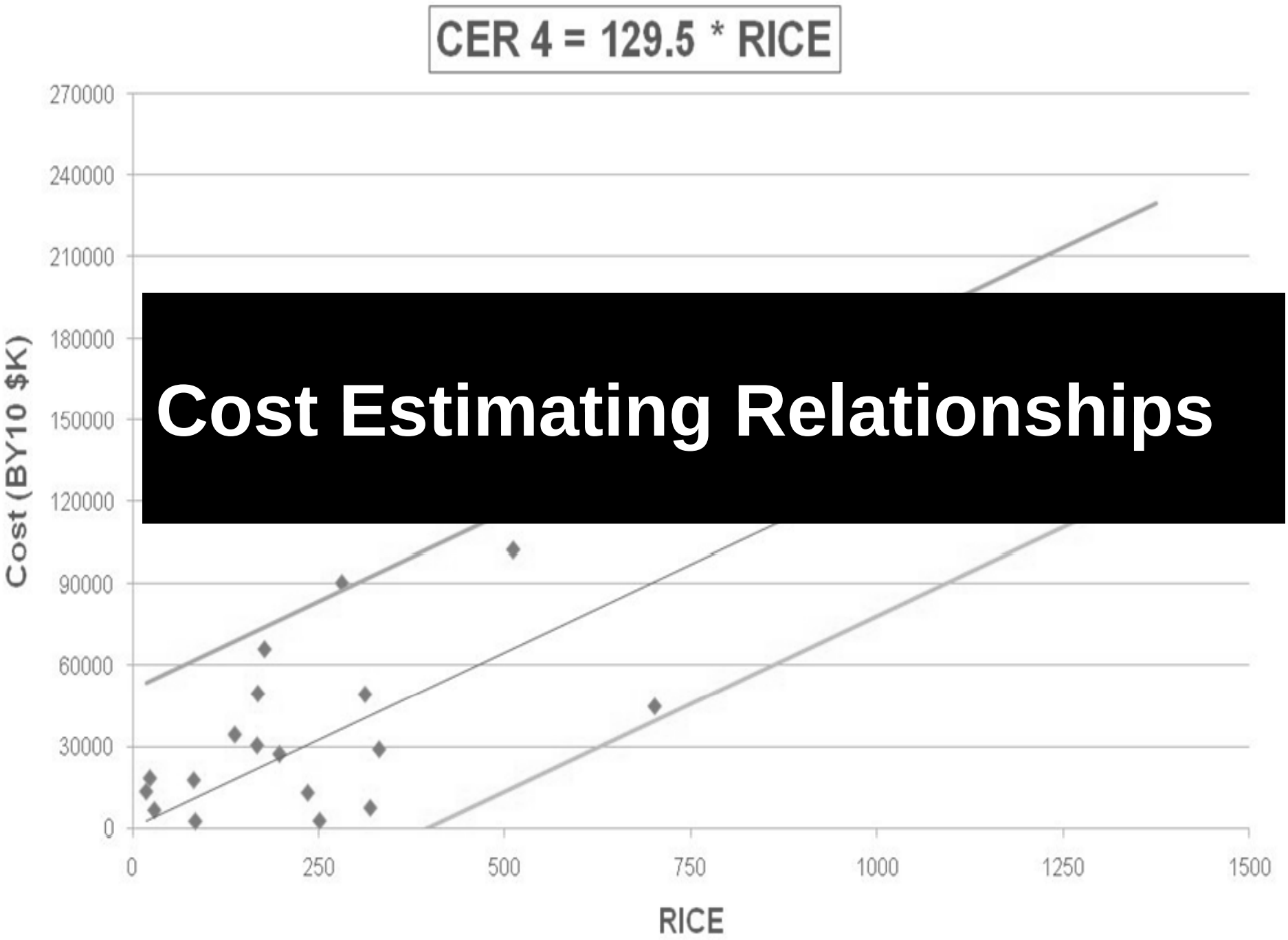
WBS Tailored for ERP

MIL-STD-881 C Reference	Level 1	Level 2	Level 3	Level 4
K.4.1	Automated Information System (AIS)			
K.4.2		Automated Information System Prime Mission Product Release/Increment X		
K.4.2.1			Custom Application Software 1..n	
K.4.2.2			Enterprise Service Element1..n	
K.4.2.3			Enterprise Information System 1..n	
K.4.2.3.1				Business Area Hardware
K.4.2.3.2				Business Area Software CSCI (1..n)
K.4.2.3.3				Business Area Integration, Assembly, Test and checkout
K.4.2.4			External System Interface Development1..n	
K.4.2.5			System Level Integration	
L.6.1		System Engineering		
L.6.2		Program Management		
L.6.3		Change Management		
L.6.4		System Test and Evaluation		
L.6.4.1			Development Test and Evaluation	
L.6.4.2			Operational Test and Evaluation	
L.6.5		Training		
L.6.9		Operational/Site Activation		
L.6.9.1			Site Type 1	
L.6.9.1.1			Deployment Hardware and Software.	
L.6.9.1.2			Site Activation	
L.6.9.1.3			User Training	
L.6.9.1.4			Data Migration	
L.6.9.1.5			Management/Engineering Support.	
L.6.9.1.6			Interim Logistics Support.	
				Systems Engineering and Program Management
				System Operations / Sustaining Engineering
				Help Desk
				System Database Administration
				Deployment Hardware/Software Refresh
				Software Maintenance,
				Follow on Training
				Accreditation
				Independent Verification and Validation
L.6.9.1.6	Operations & Support			

Available CERs

Cost Estimating Relationships



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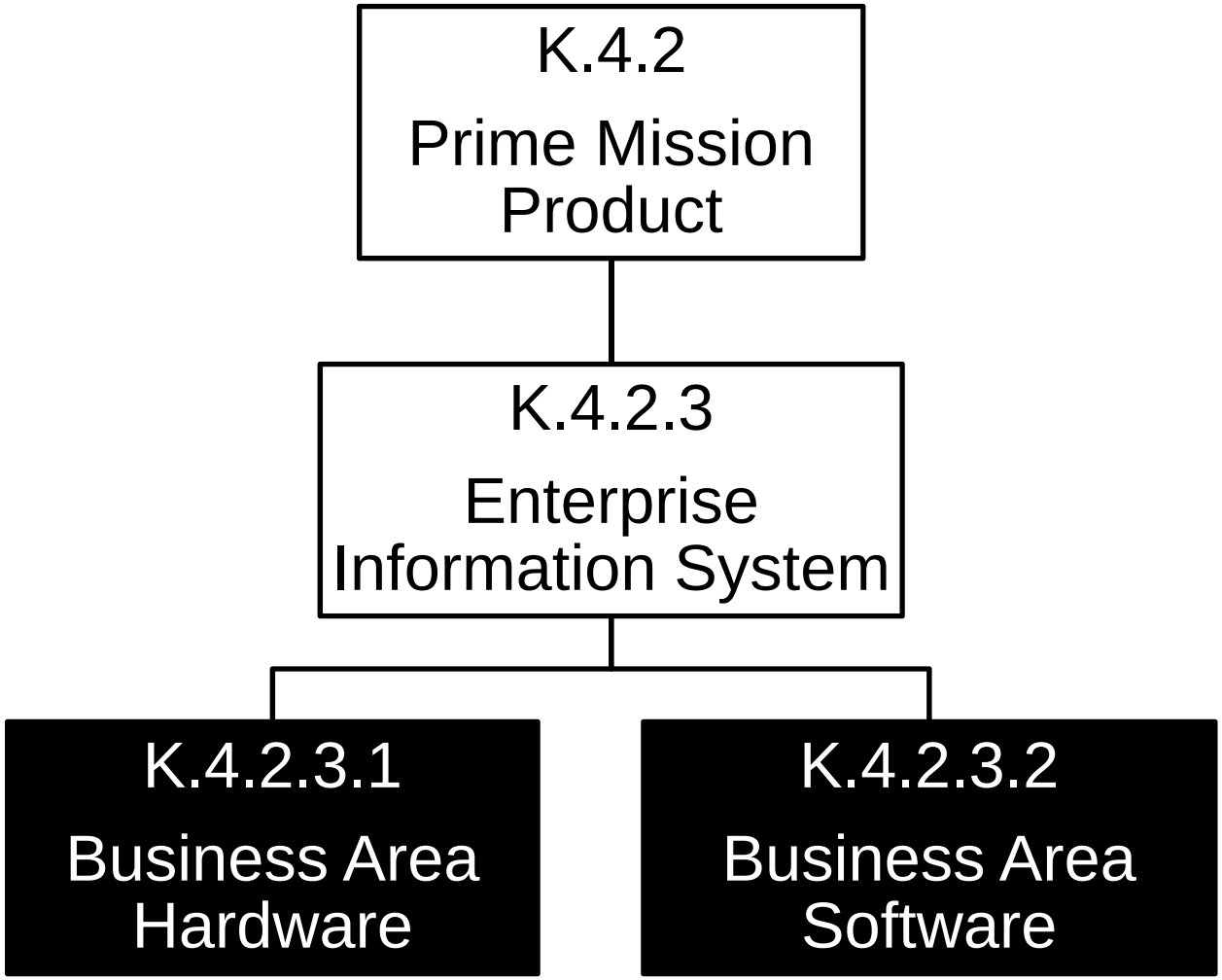
Prime Mission Product Available CERs by WBS



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Prime Mission Product WBS Definition

- **K.4.2.3.1 Business Area Hardware**...associated hardware equipment needed at the system developer's facility for planning, analyzing, designing, building, and testing functionalities that can be attributed, …, to a specific …business area or module within the [ERP] system.
  - Includes, for example development and test hardware
  - **Excludes, for example deployment hardware at each operational site**
- **K.4.2.3.2 Business Area Software CSCI (1..n)…**associated effort needed at the system developer's facility for planning, analyzing, designing, building, and testing functionalities that can be attributed, …, to a specific…business area or module within the [ERP] system.
  - all necessary labor …for analyzing, designing/building/configuring, and testing the required business objects **– reports, interfaces, conversions, extensions**, fact tables, dimension tables, scripts, enhancements, etc…
  - effort for assessing and tailoring COTS software applications or modules …

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Prime Mission Product RICE Productivity CERs

ID	WBS Element	UNIT	FORM	METRICS R^2	F-Stat	CV(%)	N
CER 1	Business Area Software	Hours	204.4*Report + 2021*Interface + 2713*Conversion + 496.8*Extension*	82%	41.9	47.85	20
CER 2	Business Area Software	Hours	18340 + 186.1*Report + 2094*Interface + 2350*Conversion + 479.1*Extension*	81%	19.8	49.37	20
CER 3	Business Area Software	Hours	932.5 * RICE*	85%	114.5	58.77	20
CER 4	Business Area Software/Hardware	BY10$K	129.5 * RICE*	85%	113.4	55.63	20
CER 5	Business Area Software/Hardware	BY10$K	7984 + 117.9 * RICE*	72%	49.9	55.59	20

*Reports may include Forms, and Extensions may include Workflow and Bolt-ons

Use

- CER 2 and CER 5 appropriate for small programs (1-30 RICE) as the impact of FIXED Costs (intercept) is significant
- CER 1, CER 3, CER 4 appropriate for med-large programs (30-1500 RICE) as impact of FIXED Costs is not significant
- CER 1, CER 2, and CER3 **ONLY** predicts associated labor for design, build, and unit test activities
- CER 4 and CER 5 predicts associated labor and material costs for design, build, and unit test activities

Limitation

- Dataset only captures Financial and Supply Chain ERPs
- Dataset only captures Government Sector ERPs

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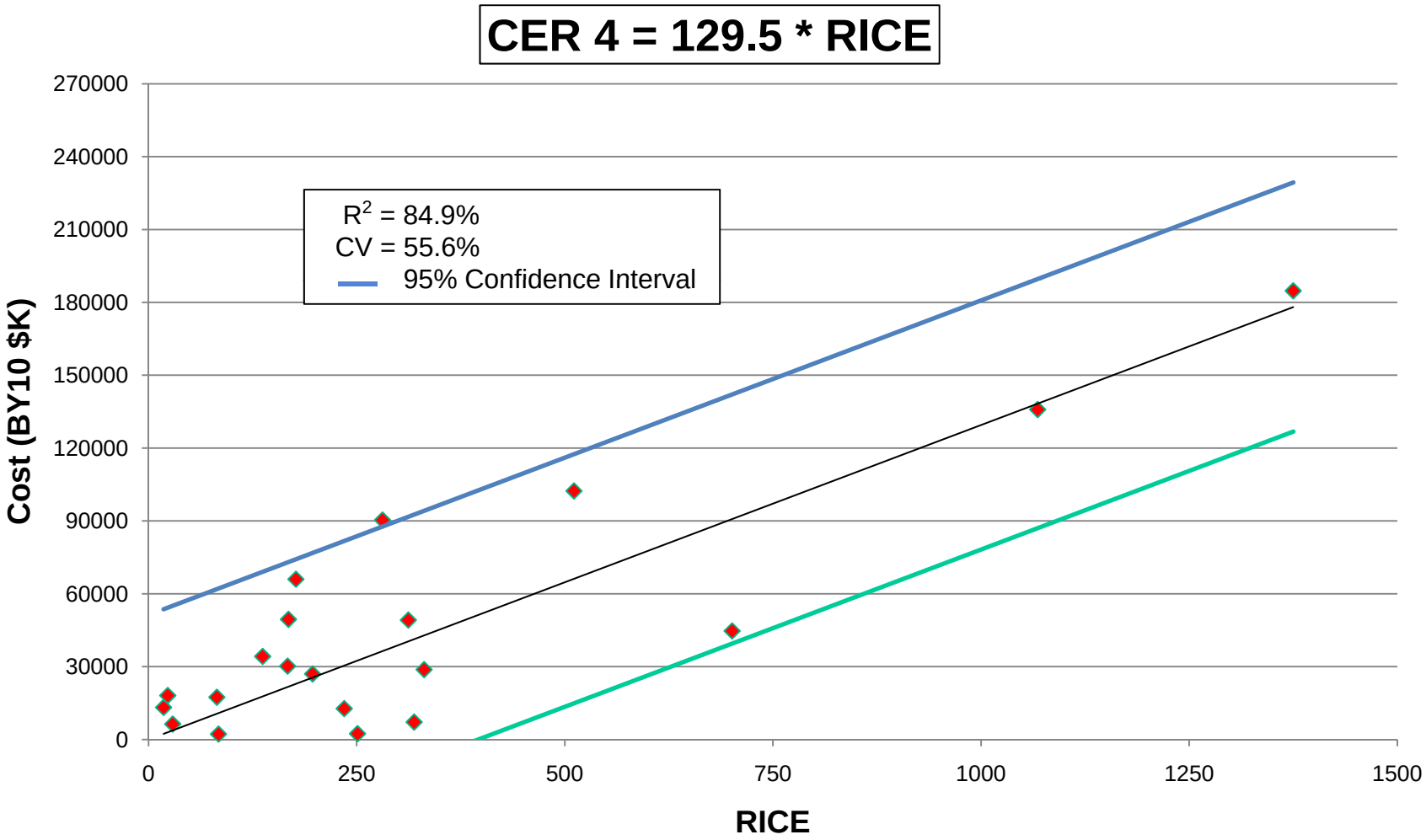
Prime Mission Product – CERs
CER 4 Regression Plot



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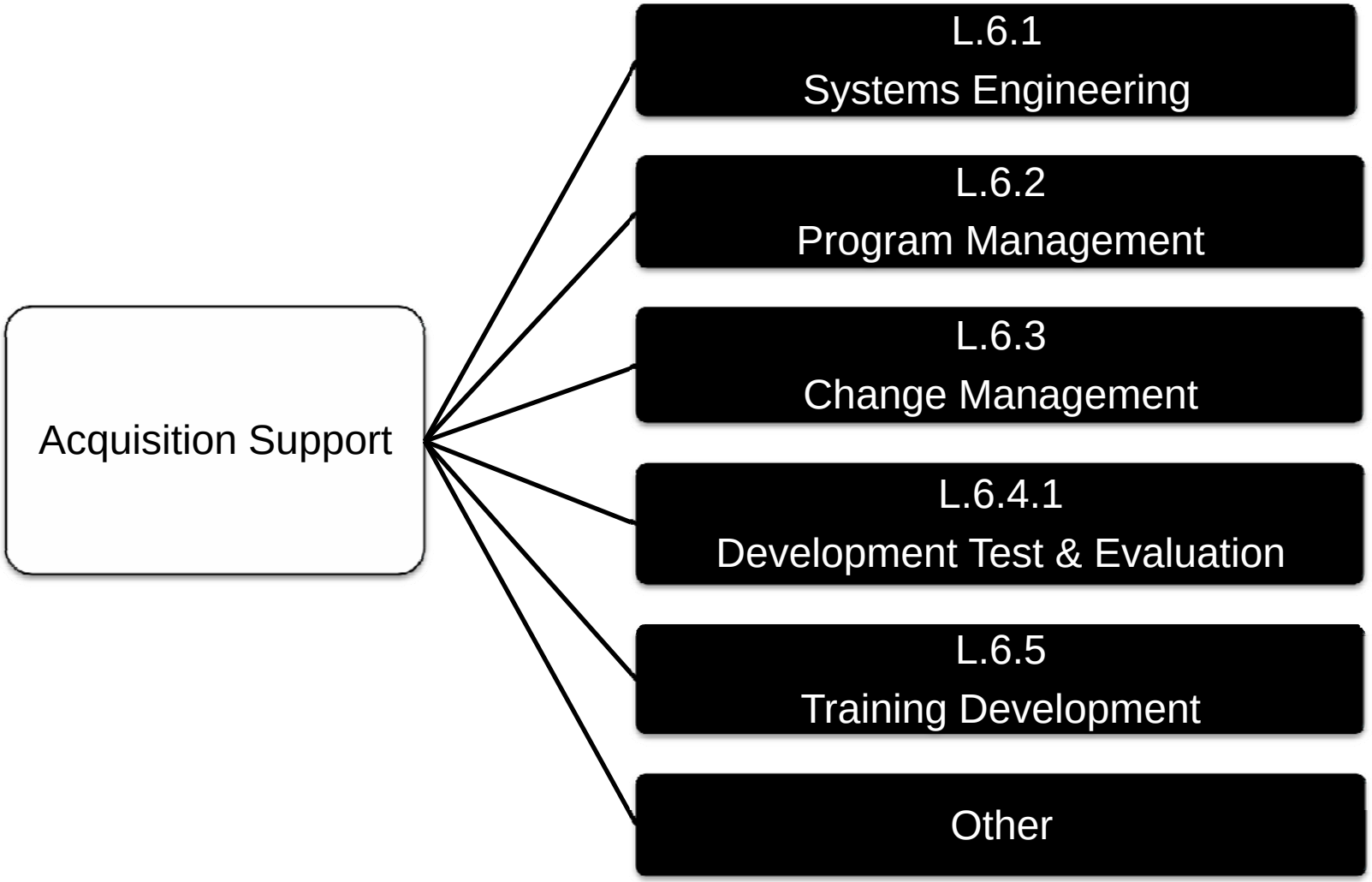
Acquisition Support Available CERs by WBS



Acquisition Support - CERs

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CER ID	CONTENT	UNIT	FORM	METRICS				
				R^2	SE	F-Stat	CV(%)	N
CER 6	SE/PM/CM/DT&E/TRAIN	BY10$K	**1.861** * PMP	87%	45208.35	197.43	41.10	16
CER 7	SE/PM/CM/DT&E/TRAIN	BY10$K	**0.439** * PMP ^ **1.118**	87%	45491.50	472.65	41.35	16
CER 8	SE/PM/CM/DT&E/TRAIN/Other	BY10$K	**2.202** * PMP	93%	37400.80	404.11	27.62	16
CER 9	SE/PM/CM/DT&E/TRAIN/Other	BY10$K	**1.457** * PMP ^ **1.034**	93%	38257.51	339.58	28.25	16
CER 10	SEPM	BY10$K	**1.347** * PMP	82%	41847.59	120.69	55.01	16
CER 11	DT&E	BY10$K	**0.4132** * PMP	57%	19722.54	51.16	71.25	16
CER 12	TRAINING	BY10$K	**0.1047** * PMP	47%	6643.43	27.87	86.35	13

SE = Systems Engineering; PM = Program Management; CM = Change Management; DT&E = Development Test & Evaluation; TRAIN = Training; PMP = Prime Mission Product; Other = Limited Oversight and Support for Operational Site Activation Activities

Use

- Dollars in Thousands, Base Year 2010 (BY10$K)
- Prime Mission Product (PMP) Range**: $2,000K (LOW), $200,000K (HIGH)**

Limitation

- Dataset only captures System Developer Cost
- Dataset only captures Government Sector ERPs

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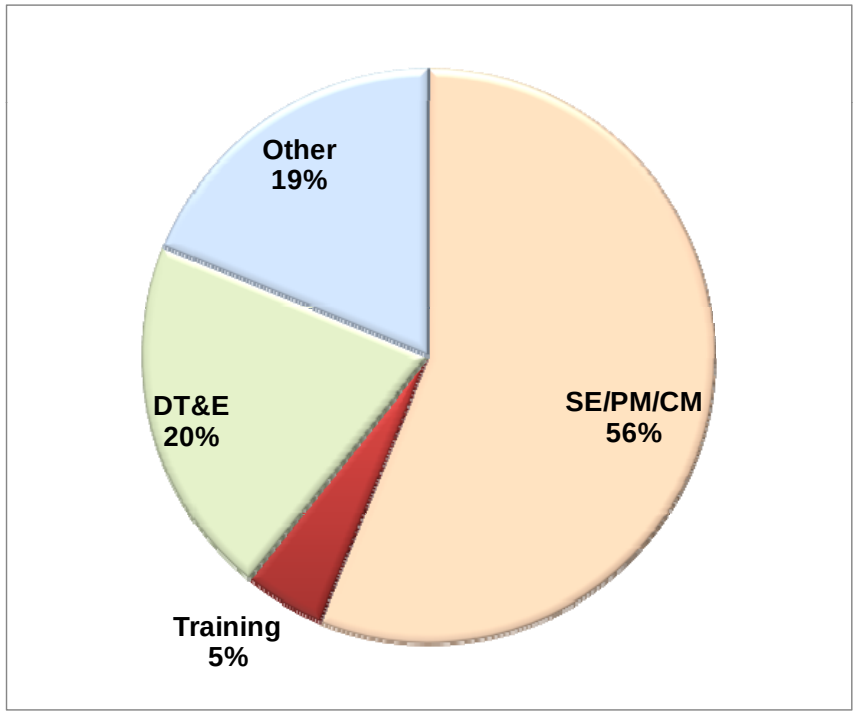
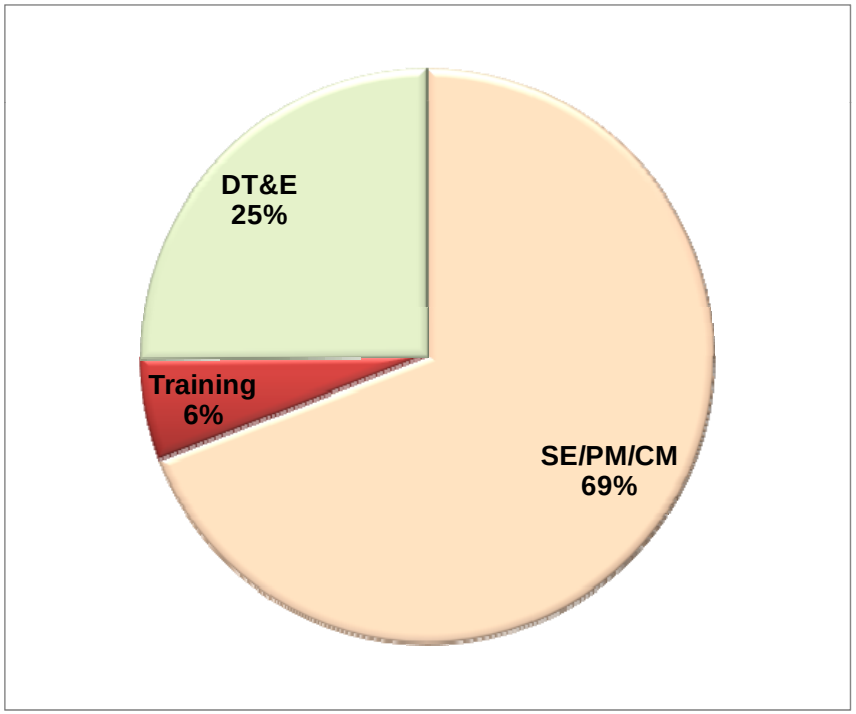
Acquisition Support - CERs Cost Allocation

CER 8 and CER 9



CER 6 and CER 7



SE = Systems Engineering; PM = Program Management; CM = Change Management; DT&E = Development Test & Evaluation
Other = Limited Oversight and Support for Operational Site Activation Activities

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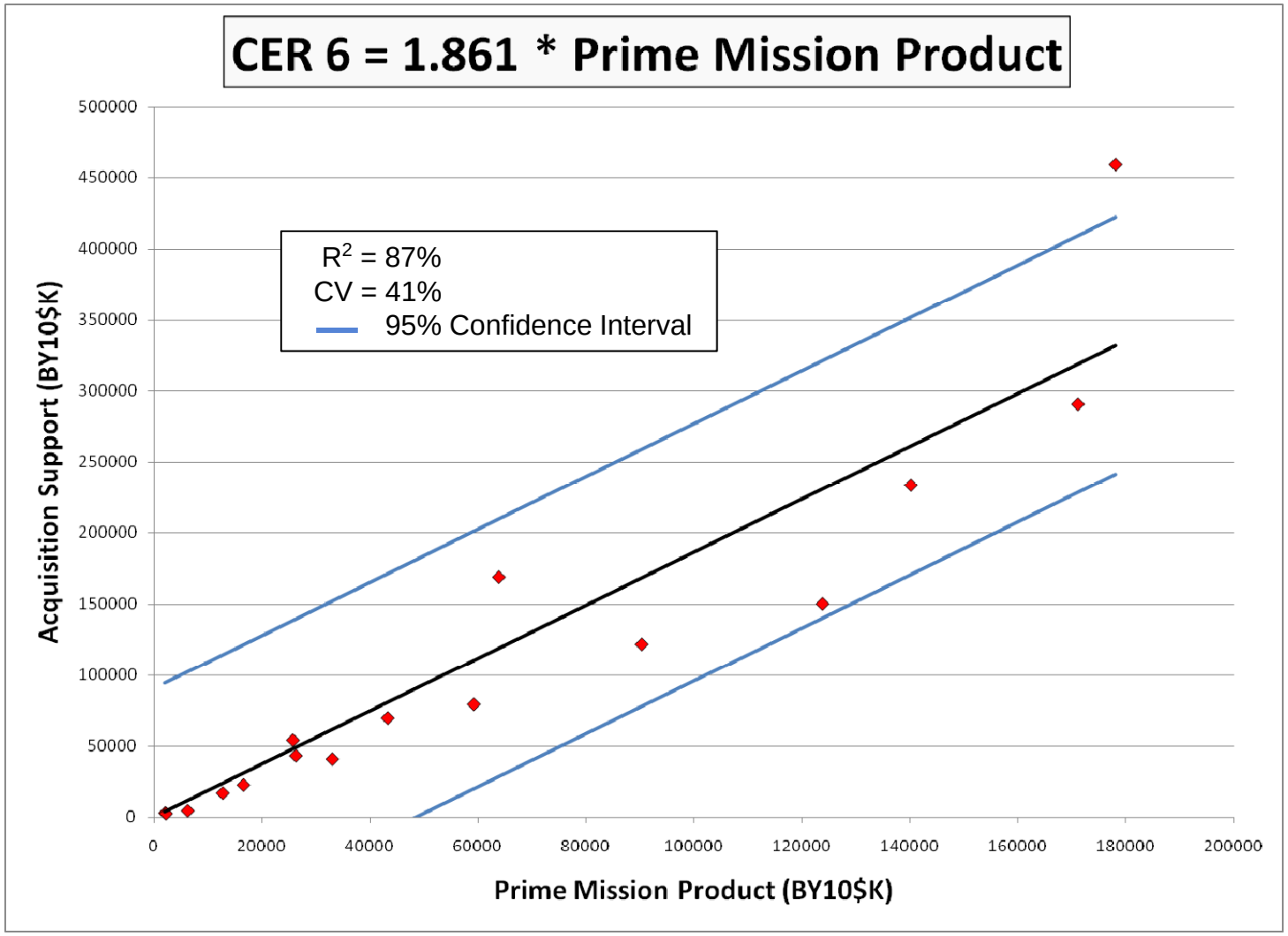
Acquisition Support - CERs
CER 6 Regression Plot



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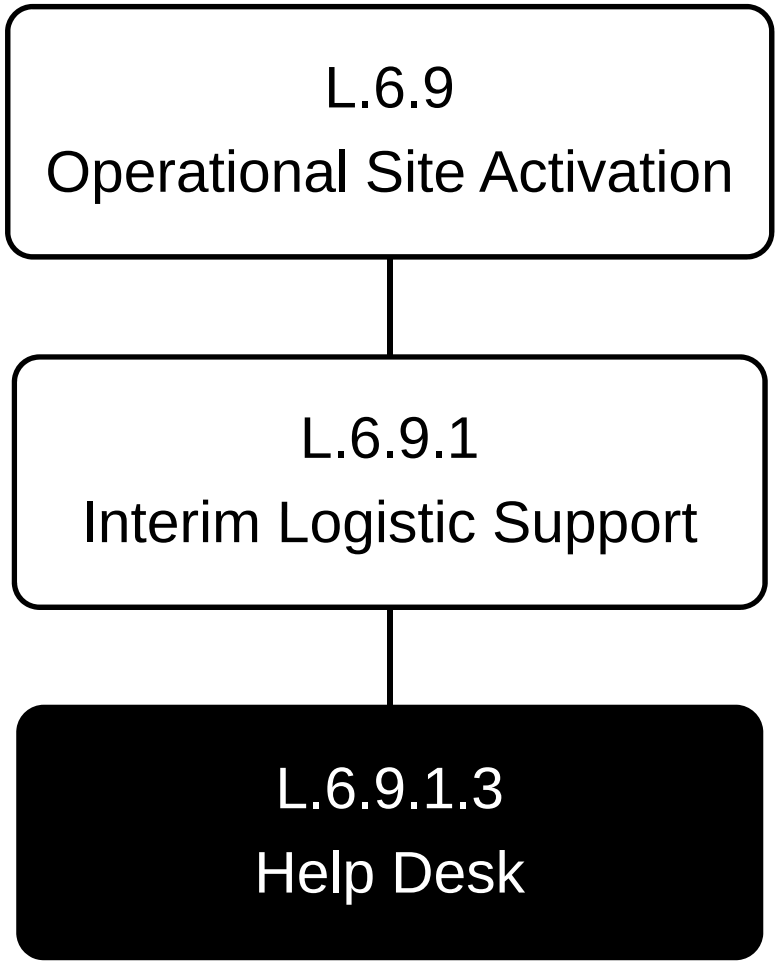
Help Desk (Tier I & II) Available CER by WBS



Help Desk (Tier I & II)

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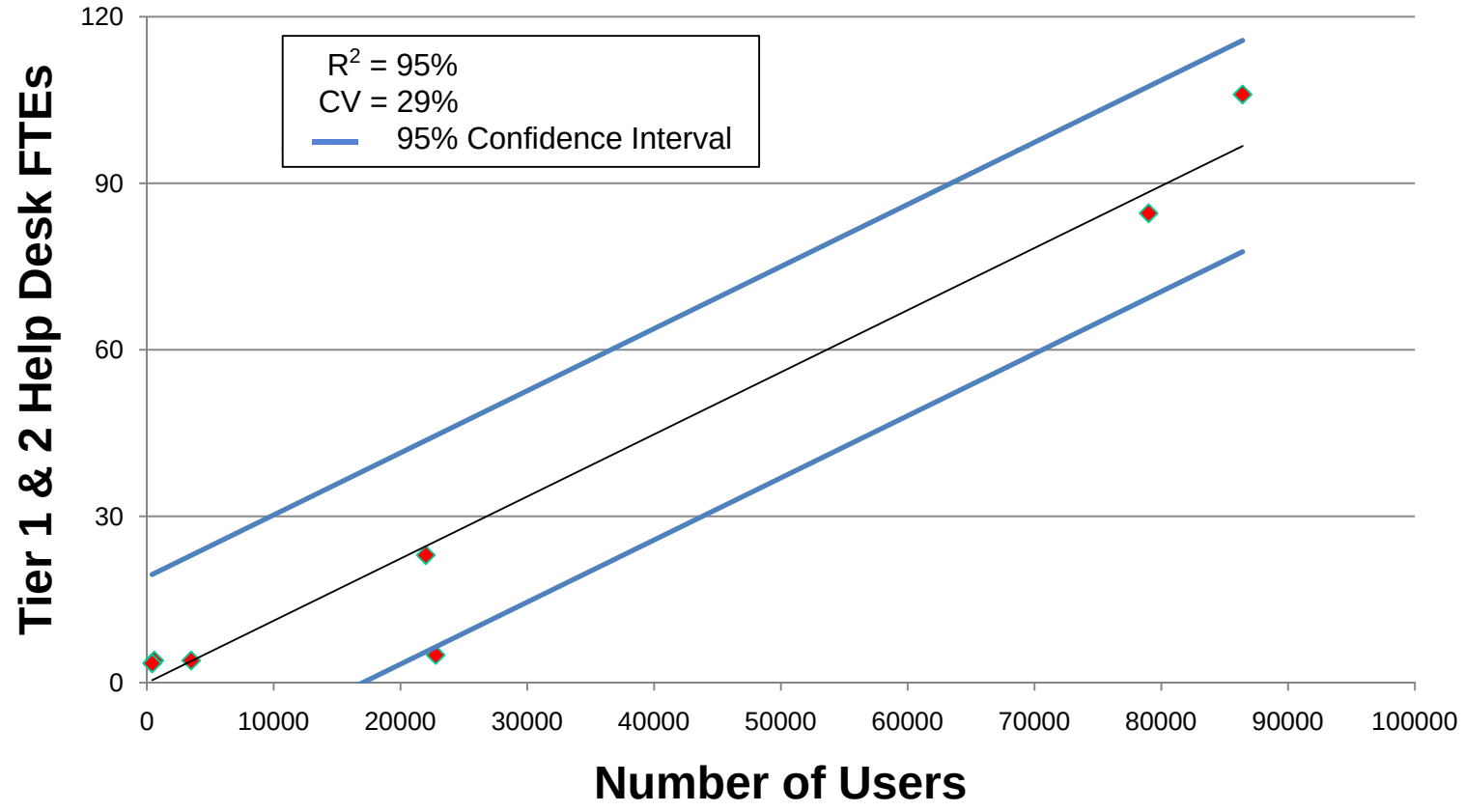
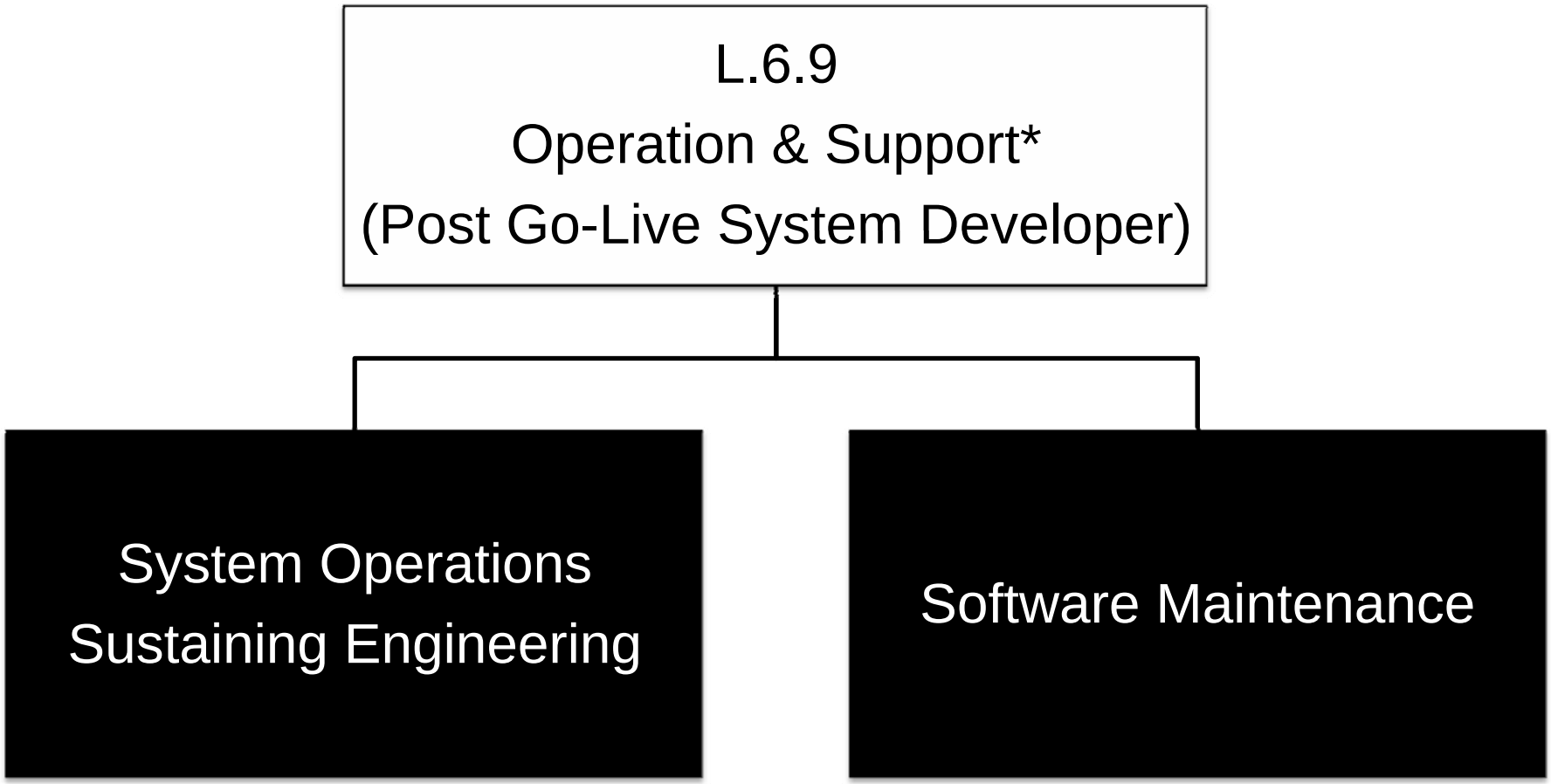
CER ID	CONTENT	UNIT	FORM	METRICS				
				R^2	SE	F-Stat	CV(%)	N
CER 13	Help Desk (Tier I & II)	FTE	0.001119 * USERS	95.24%	9.52	203.39	28.97%	7

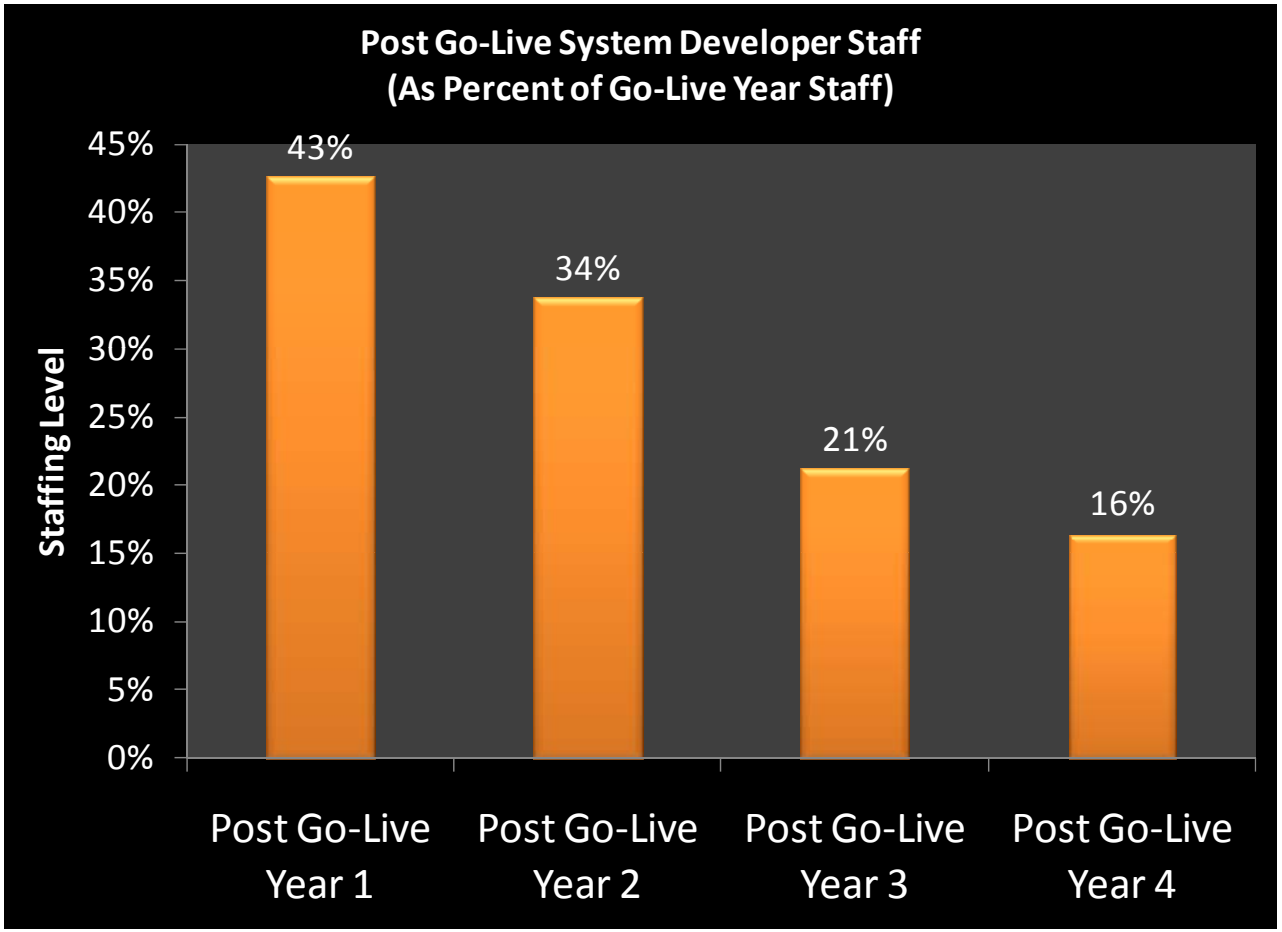
FTE = Full Time Equivalent;



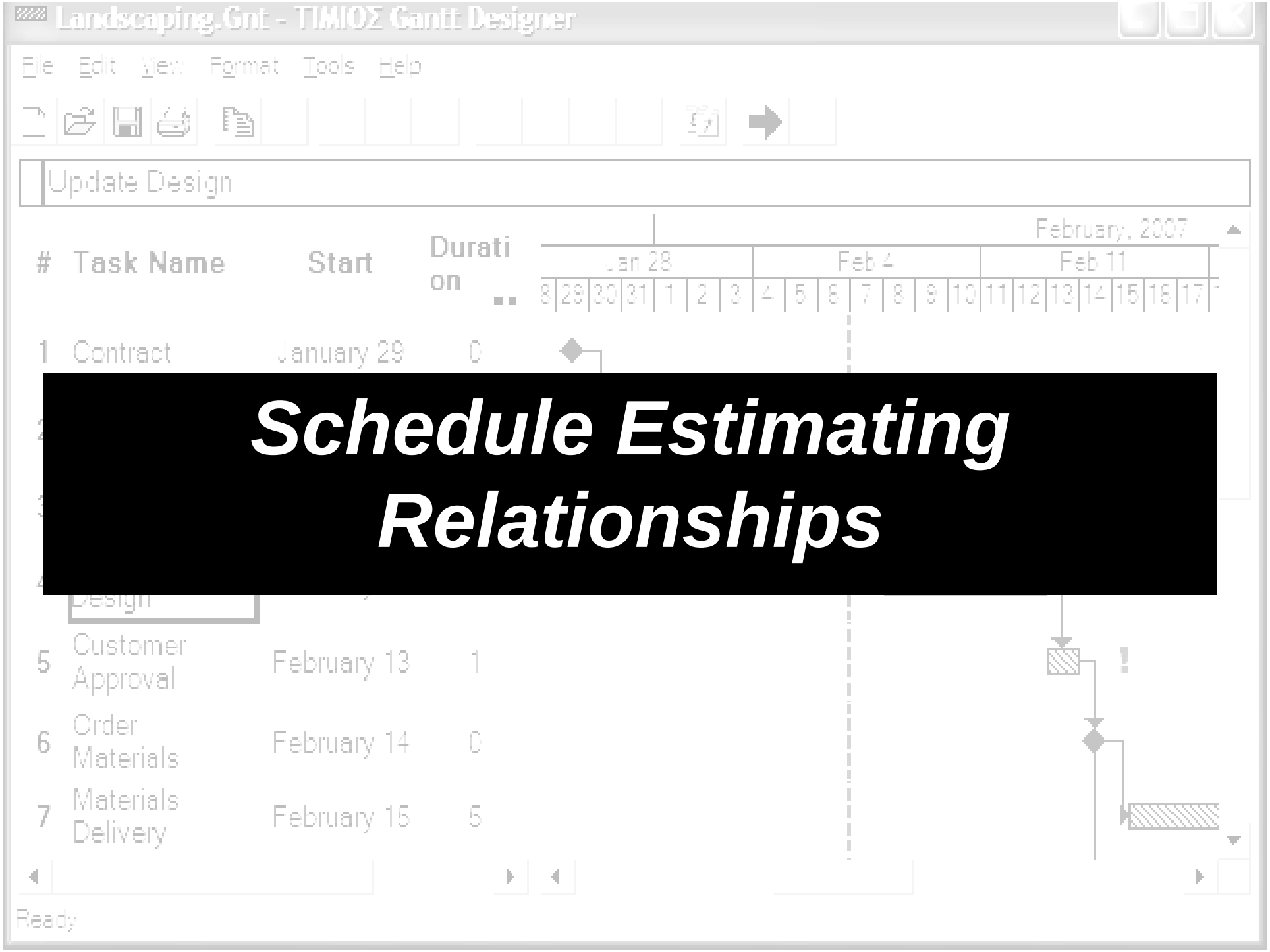
Post Go-Live System Developer Available CER by WBS



Post Go-Live System Developer
Staffing level as % of Go-Live Year



- Post Go-Live System Developer Staff = Go-Live System Developer Staff x **Percentage**
- Post Go-Live System Developer scope -- sustaining engineering, system operations, and software maintenance



Schedule Estimating Relationships

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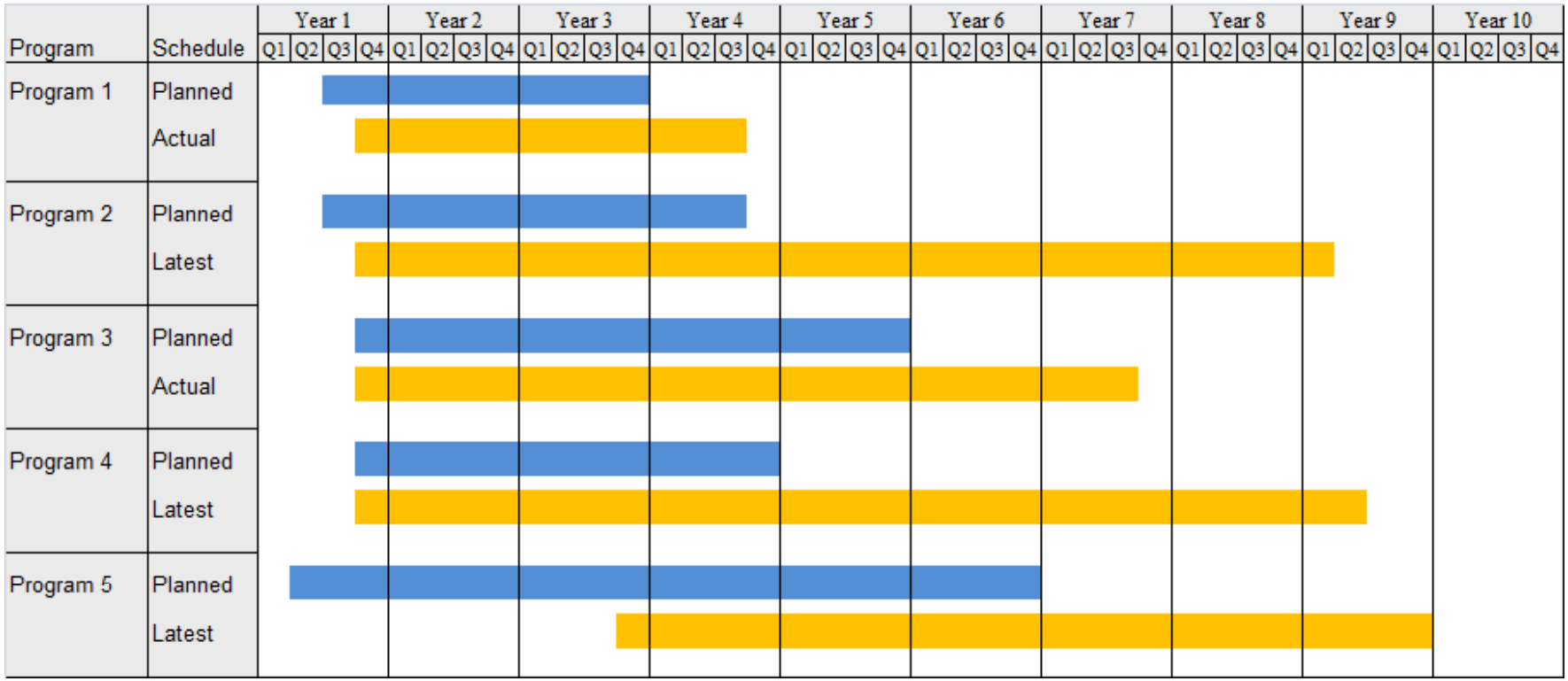
Schedule Analysis!!! Why Important?

- All Major DoD ERP have Exceeded Original Schedule
- Schedule Overrun ranges between 10% and 140%



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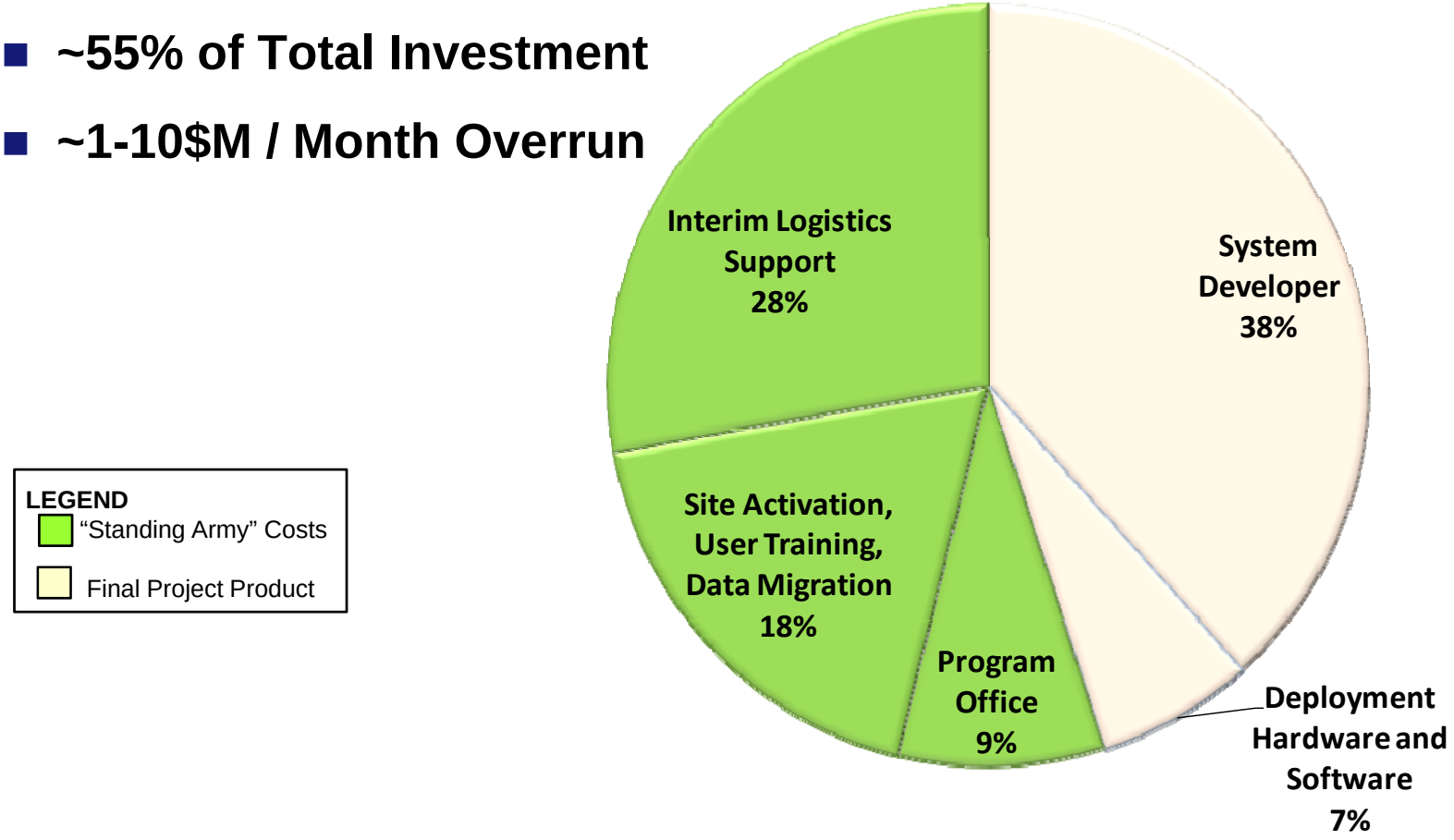
Impact of Schedule Overruns?

Extends "Standing Army" costs!!!

- **Impact of "Standing Army" Costs (Major DoD ERPs)**
  - **~55% of Total Investment**
  - **~1-10$M / Month Overrun**



Standing Army -- Level of Effort activities… not itself a work item directly associated with accomplishing the final project product, service or result, but rather one that supports such work, its duration is based on the duration of the discrete work activity it is supporting

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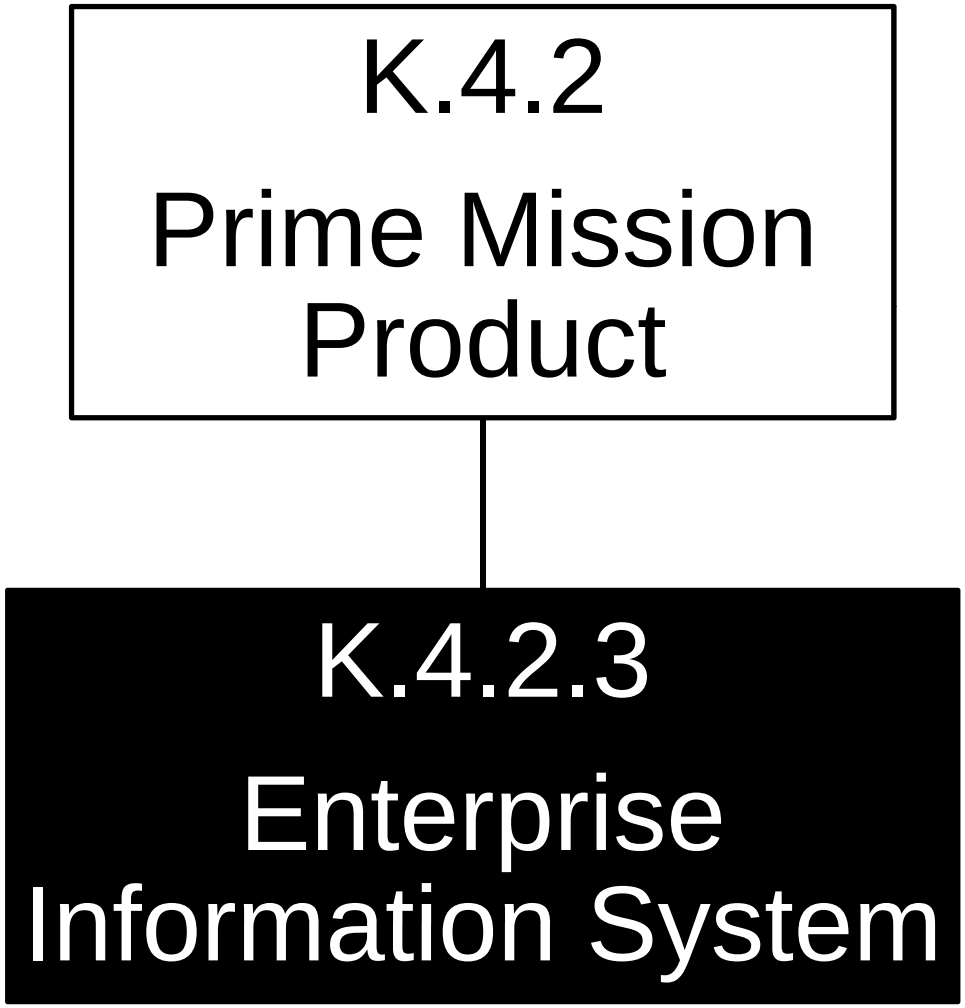
Prime Mission Product Available SER by WBS



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Prime Mission Product – Duration (Months Required) SER

SER ID	CONTENT	UNIT	FORM	METRICS				
				R^2	SE	F-Stat	CV(%)	N
SER 1	Prime Mission Product	Months	5.995 * RICE $^{0.4621}$ * PMP Staff $^{-0.3332}$	79.04%	0.2877	25.5165	32.03%	14

PMP = Prime Mission Product; PMP Staff = Prime Mission Product Average Staff; RICE = Report, Interface, Conversion, Extension

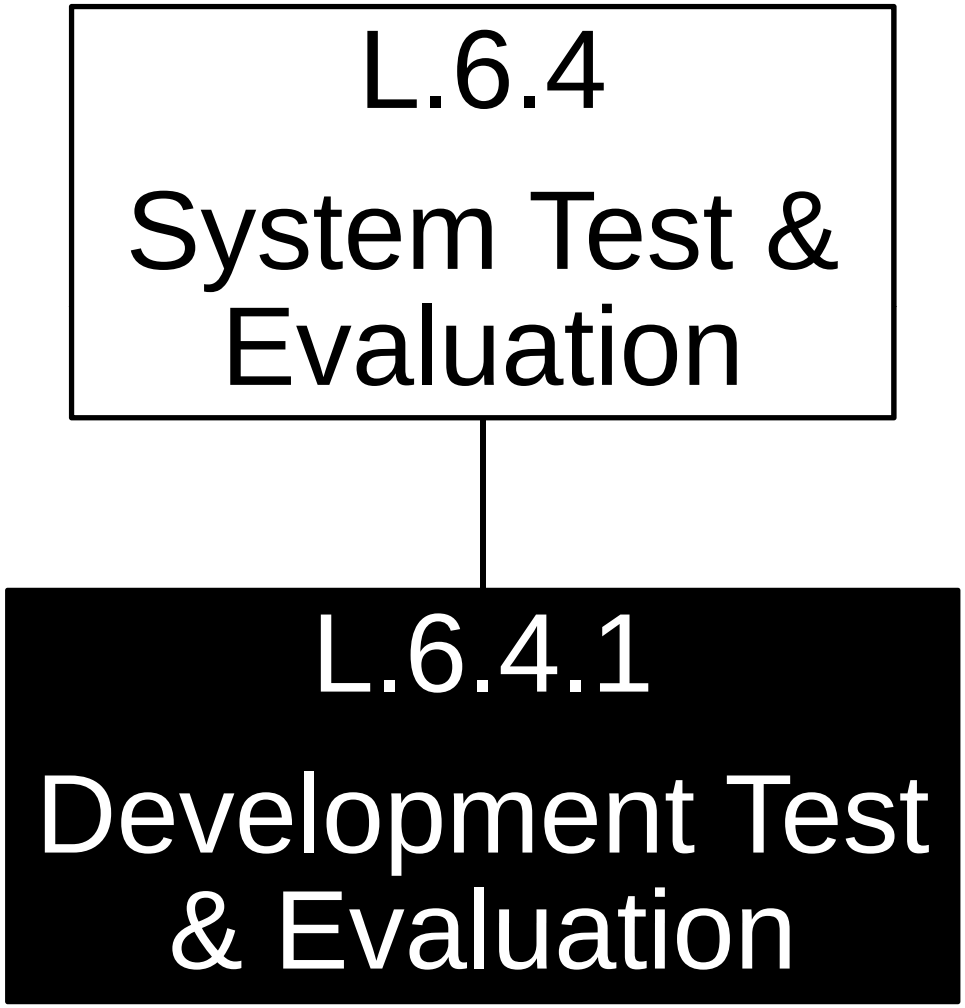
Application

- SER 1 predicts the number of month for completing all prime mission product activities prior to development test & evaluation
- Duration in Months
- Dataset Range (RICE) **= 15 (LOW) , 1400 (HIGH)**

Limitation

- Dataset captures System Developer and Government Staff
- Dataset only captures Government Sector ERPs

System Test & Evaluation
Available SER by WBS



Development Test & Evaluation (Months Required) - SER

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SER ID	CONTENT	UNIT	FORM	METRICS				
				R^2	SE	F-Stat	CV(%)	N
SER 2	Development Test & Evaluation	Months	DTE Staff $^{-0.4434}$ * TEST CASE $^{0.597}$	95.83%	0.4032	115.844	40.95	10

SER = schedule estimating relationship; DTE = development test & evaluation;

Application

- SER 2 predicts the number of month for completing all development test & evaluation activities. Exclude prime mission product activities
- Duration in Months
- Dataset Range (TEST CASES) **= 170 (LOW) , 2800 (HIGH)**
- Dataset Range (TEST CASE/PERSON/MONTH) **= 0.3 (LOW) , 2.2 (HIGH)**

Limitation

- Dataset captures System Developer and Government Staff
- Dataset only captures Government Sector ERPs

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Way Forward

An ERP Cost Estimate Guidebook is underway, that provides a basic understanding of ERP systems and their implementation, focusing on providing :

- Descriptions of likely implementation problems
- ERP Cost estimating processes and procedures
- CER Catalog as well as guidance on how to use them

Estimated Delivery Date: August 2011