Headquarters U.S. Air Force

I n t e g r i t y - S e r v i c e - E x c e l l e n c e

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

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2011 ISPA/SCEA Conference

June 9, 2011

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Abstract

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- **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.**

I n t e g r i t y - S e r v i c e - E x c e l l e n c e

Outline

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- ■ **ERP Overview**

- ■ **Data Collection and Analysis**

- ■ **Work Breakdown Structure**

- ■ **Cost Estimating Relationships**

- ■ **Schedule Estimating Relationships**

- ■ **Way Forward**

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ERP Overview

What is ERP?

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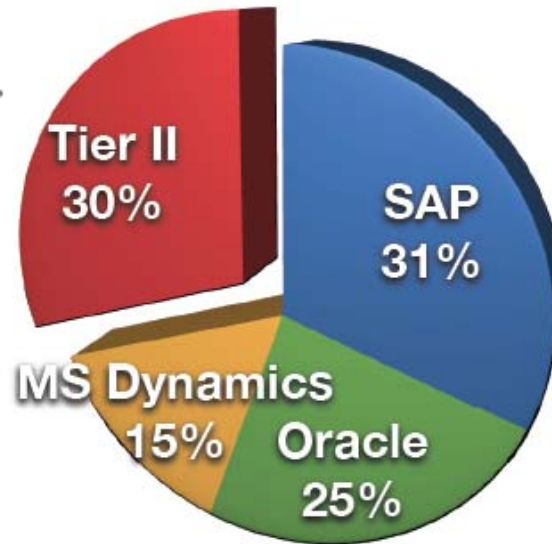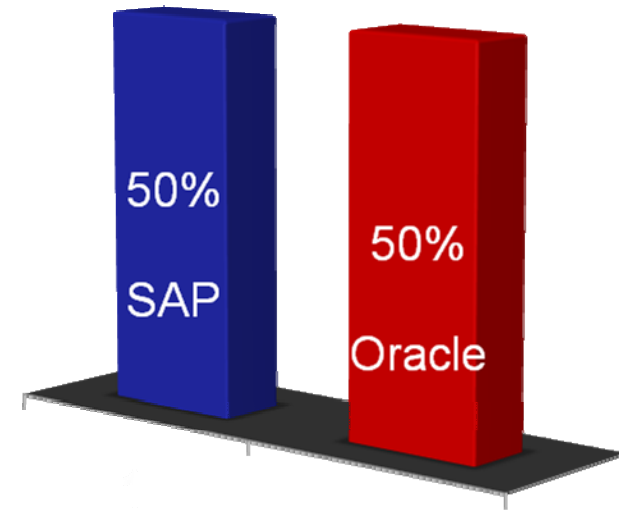
How is it implemented?

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- **Business processes are automated via an integrated COTS software application:**
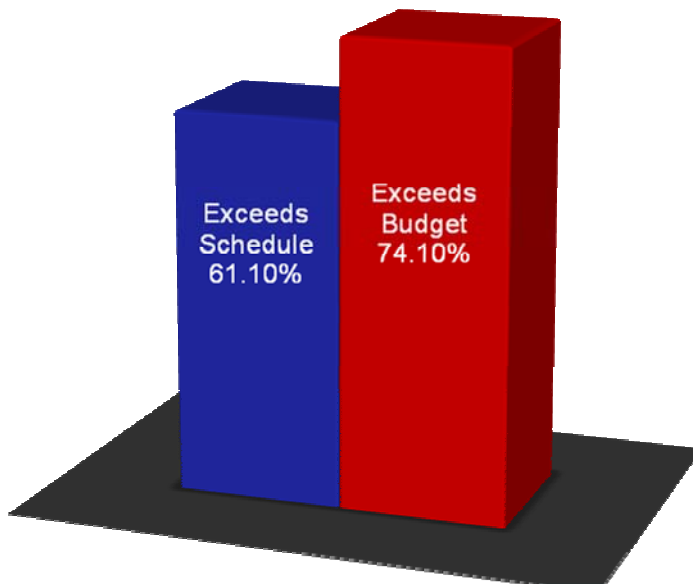
2009 Market Share

FY10 Major DoD Programs

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Why are we interested?

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Lack of Accurate Cost and Schedule Estimates!

Industry-wide

Exceeds Schedule 61.10%

Exceeds Budget 74.10%

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?

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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

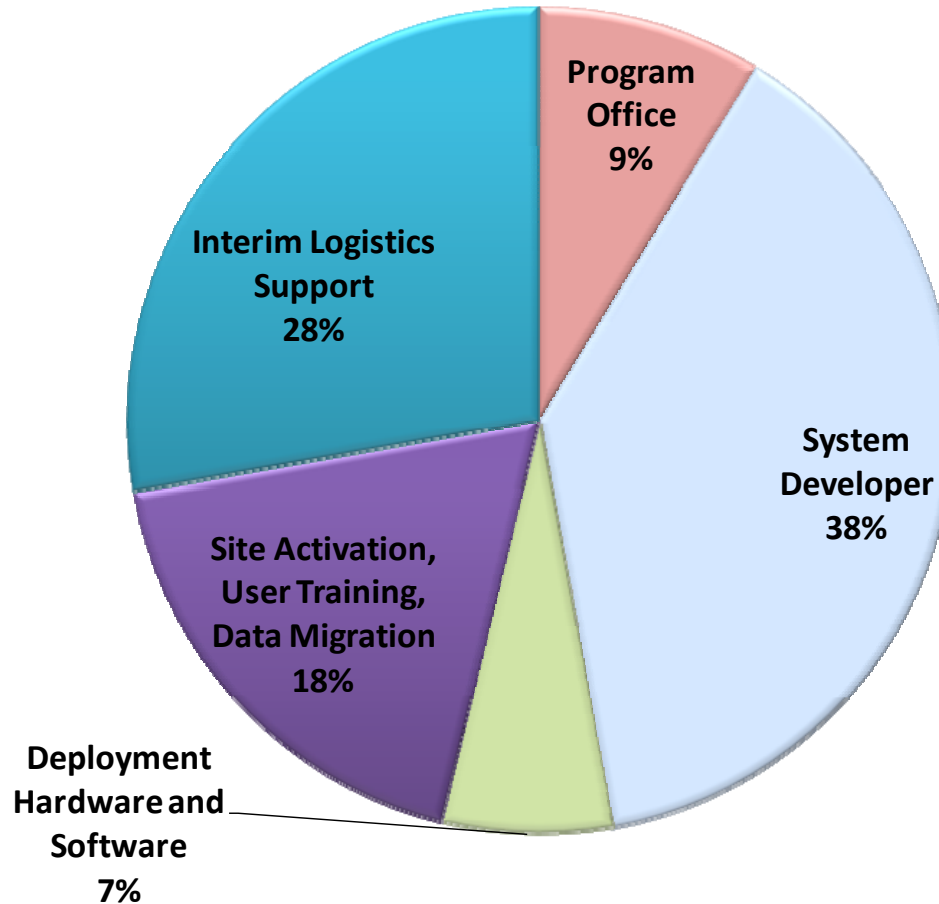By 2009, data had been collected from 20 programs government-wide including 17 programs from DoD.

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

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Investment Cost Allocation

Pie chart: Investment Cost Allocation
- Program Office 9%
- System Developer 38%
- Site Activation, User Training, Data Migration 18%
- Deployment Hardware and Software 7%
- Interim Logistics Support 28%
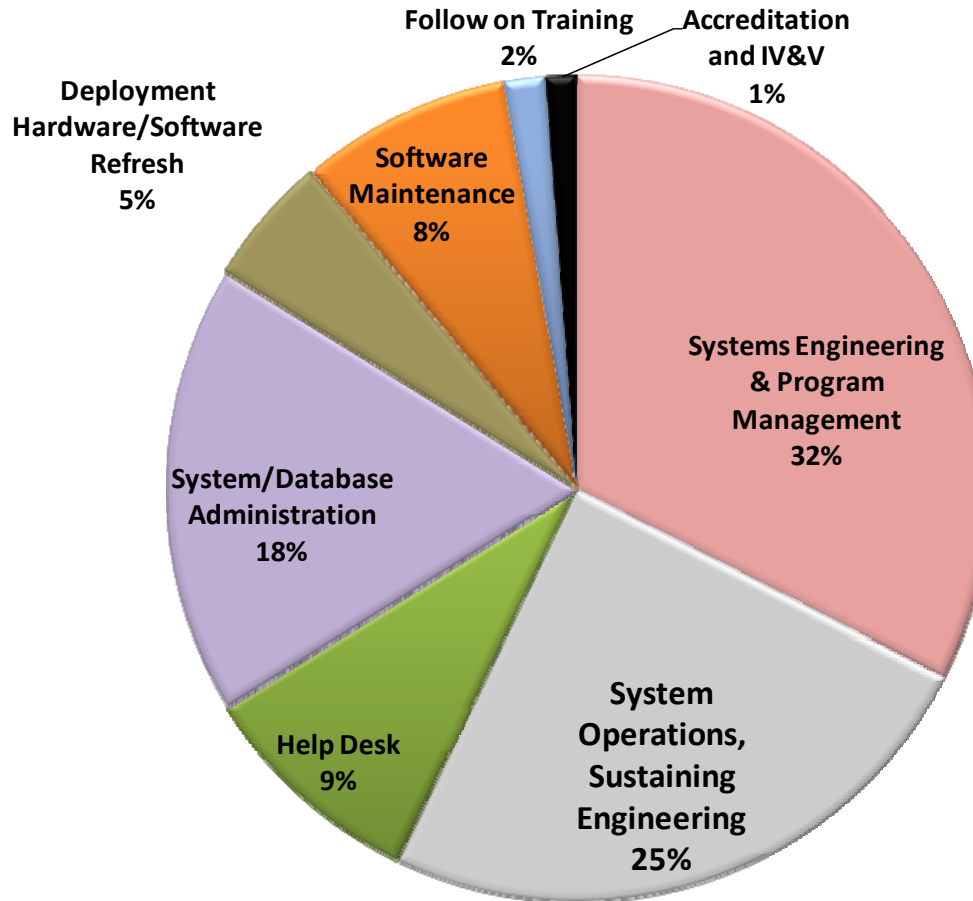
MIL-STD-881C Reference:
- Program Office (L.6.1, L.6.2, L.6.3) = **Government** Program Management (PM), Systems Engineering (SE), Change Management (CM)
- System Developer (K.4.2.3, L.6.1, L.6.2, L.6.3, L.6.4.1, L.6.5) = **Contractor** Prime Mission Product, SE, PM, CM, Development Test & Evaluation, Training, Other

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Summary Results

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O&S Cost Allocation

- Systems Engineering & Program Management 32%
- System Operations, Sustaining Engineering 25%
- System/Database Administration 18%
- Help Desk 9%
- Software Maintenance 8%
- Deployment Hardware/Software Refresh 5%
- Follow on Training 2%
- Accreditation and IV&V 1%

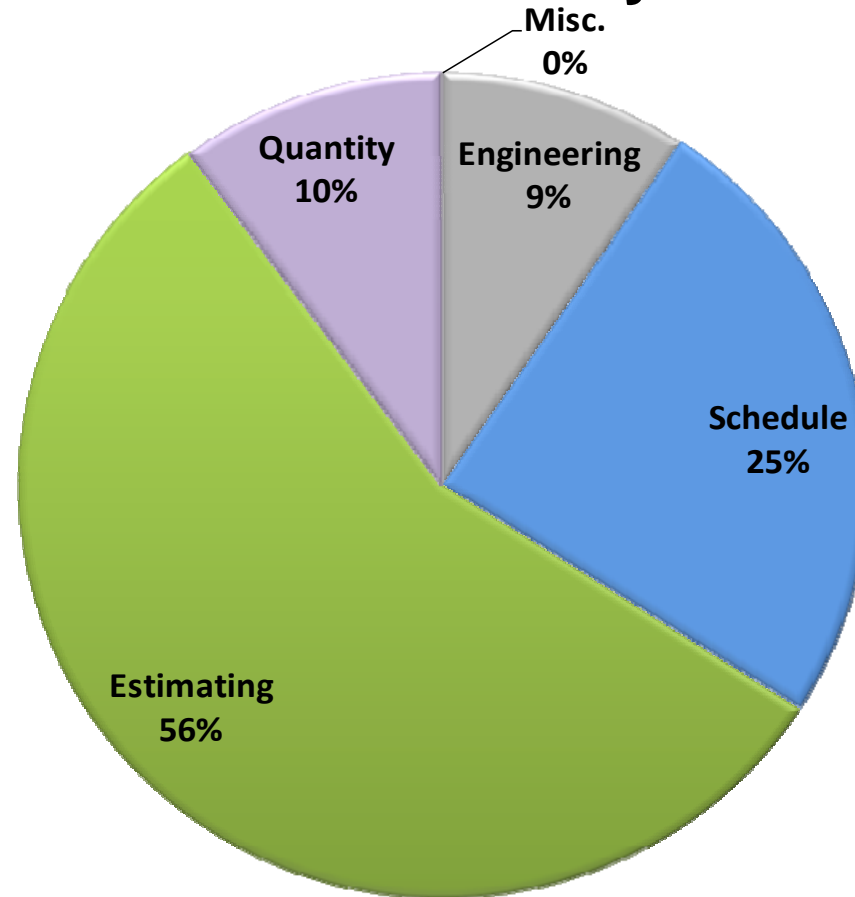# *Summary Results*

*Contribution to Cost Growth by Variance Category

*Investment Phase Only: Program Insertion through "Go-Live"

Reasons for Cost Growth

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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**

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Data Collection and Analysis

Instrumentation and Dataset

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- **Data collected from 20 programs government-wide including 17 programs from DoD**

- **Data collected using a modified version of the <u>ERP Software Resource Data Report (SRDR)</u> 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?

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- **RICE/W (Product Size)** is method of identifying specific requirements not supported by the COTS product

- **RICE/W provides both direct and indirect relationships to the various aspects of ERP implementation.**

  - **Reports:** *Number and type of reports (both internal and external.)*
  - **Interfaces:** Number of systems to be linked, data transfer methods, etc.
  - **Conversions:** Effort involved in transferring data from legacy systems.
  - **Extension, Workflow, Bolt-on:** Additional programming functionality required; Required coordination of the people involved, the work steps required, and the data to be processed; 3rd Party COTS Integration

- **Cost Estimating Relationships (CERs) are developed using ordinary least squares (OLS) and linear regression to relate RICE/W requirements to the overall implementation effort.**

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Data Segmentation: RICE Range

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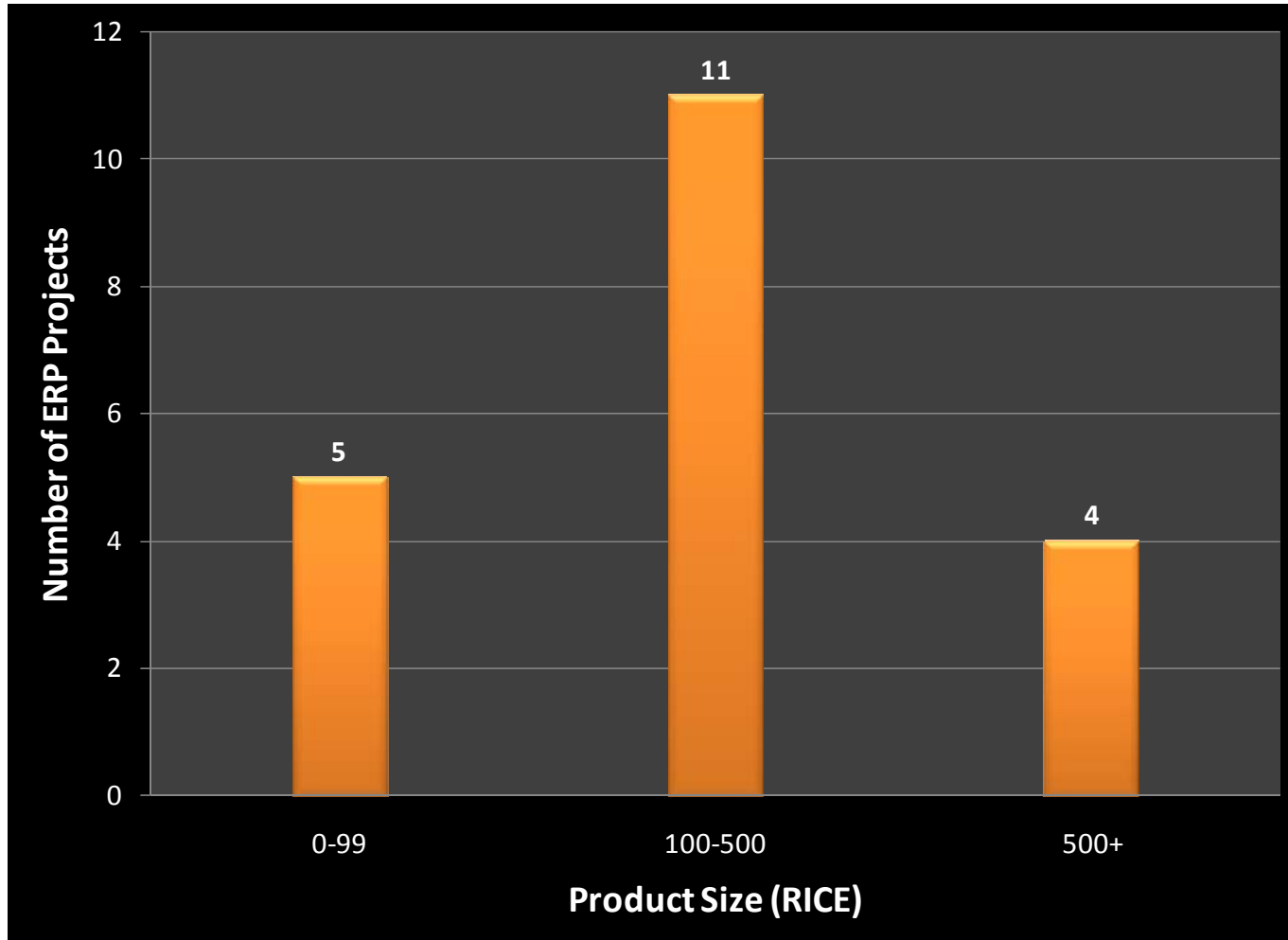
Data Segmentation:
$/RICE by Business Area

Dollars in Base Year 2010

Work Breakdown Structure
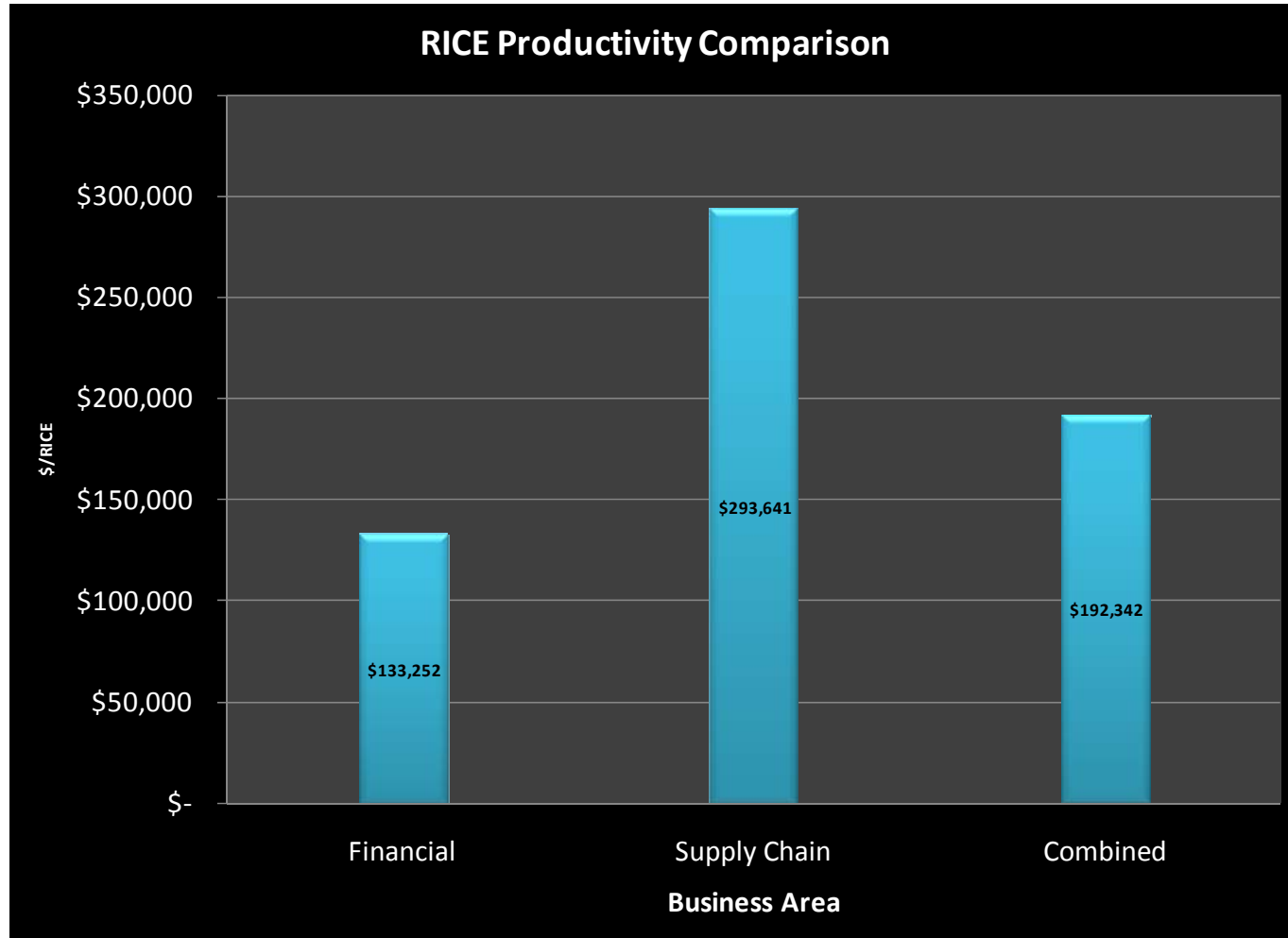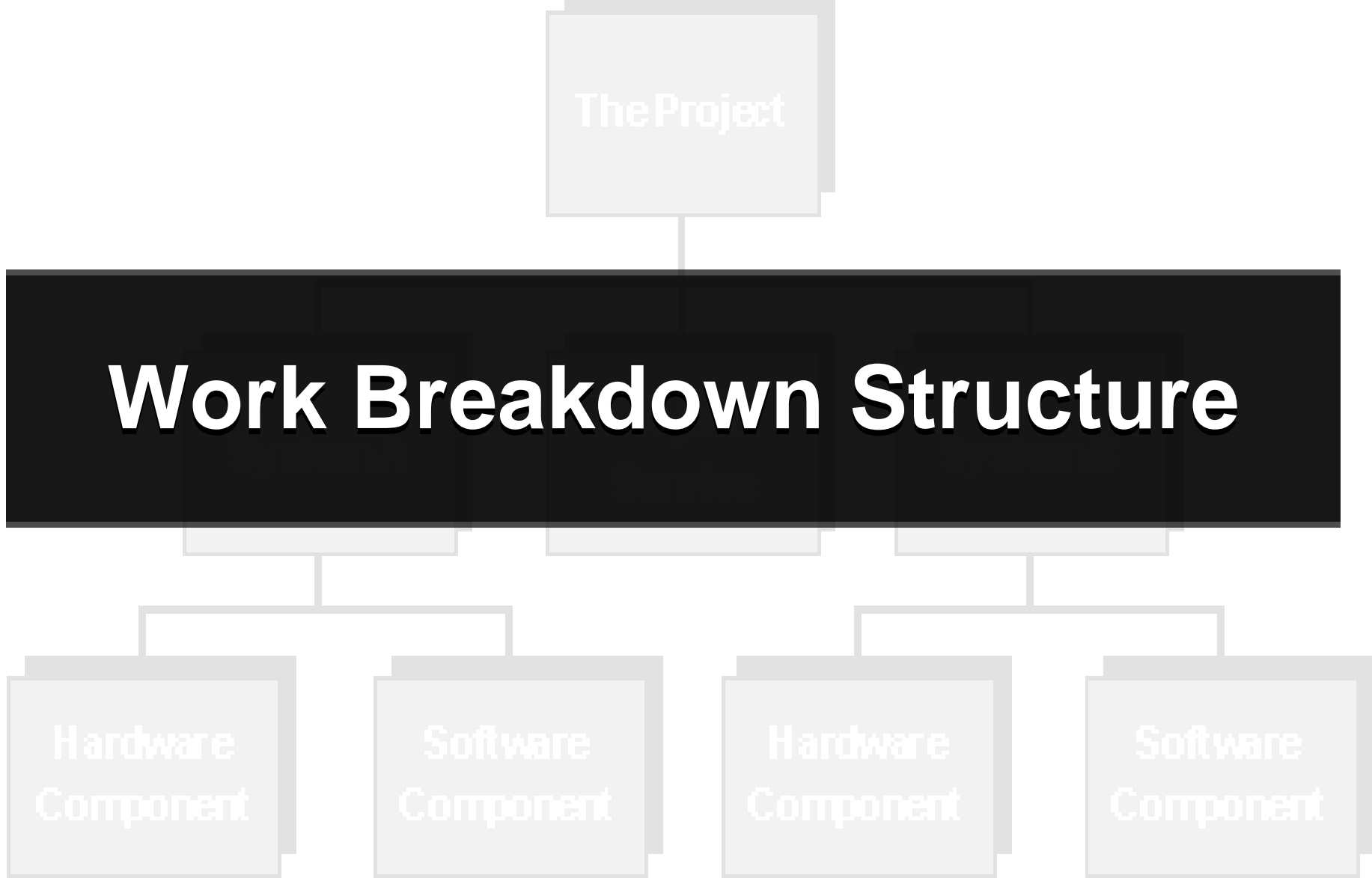
Figure 42.2. A large project WBS.

MIL-STD-881C WBS

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- **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

WBS Tailored for ERP

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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
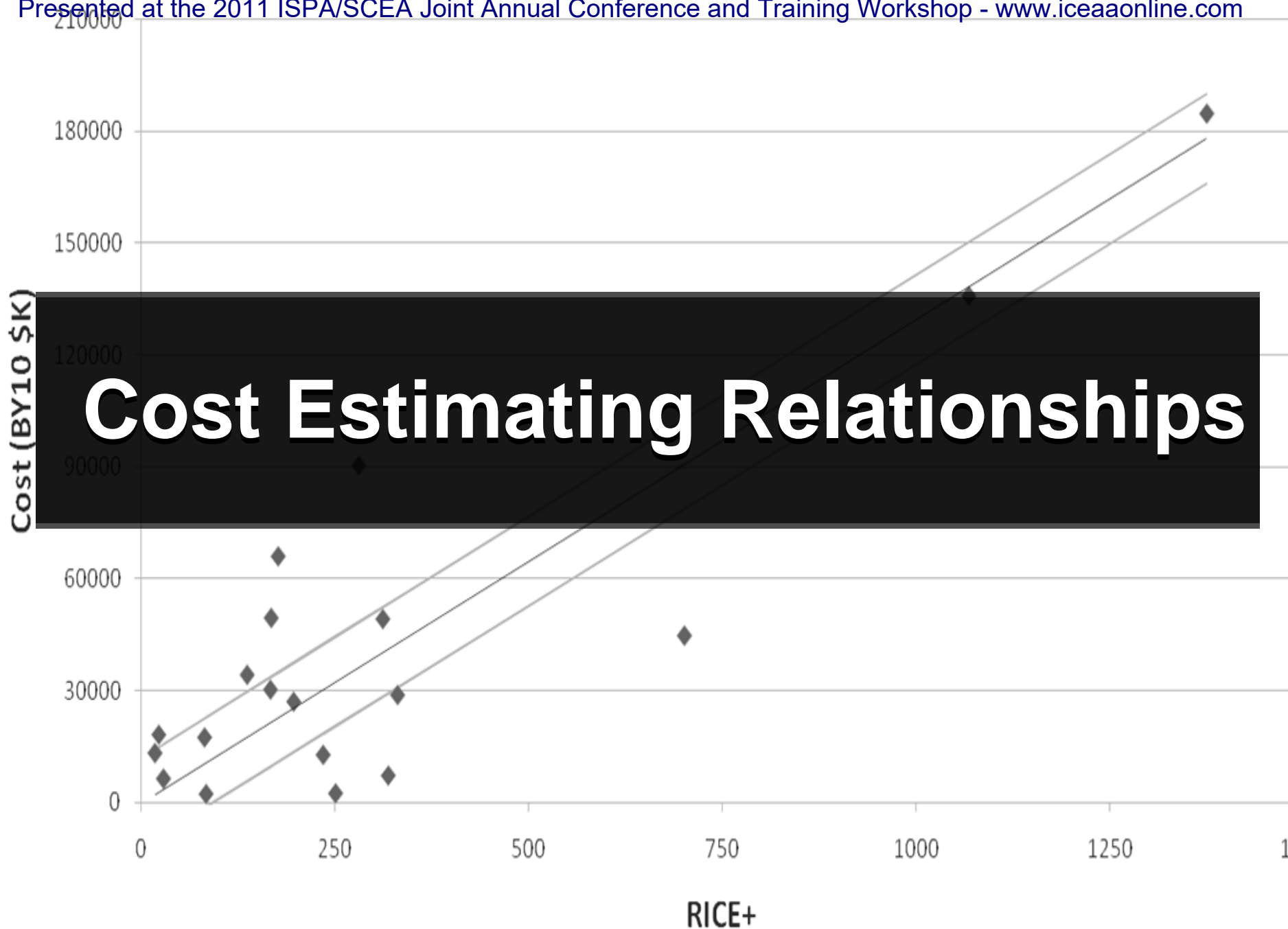
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Cost Estimating Relationships

Prime Mission Product Available CERs by WBS

```
          ┌─────────────────────┐
          │       K.4.2         │
          │   Prime Mission     │
          │     Product         │
          └─────────────────────┘
                     │
          ┌─────────────────────┐
          │      K.4.2.3        │
          │    Enterprise       │
          │ Information System  │
          └─────────────────────┘
                     │
           ┌─────────┴─────────┐
  ┌────────────────┐   ┌────────────────┐
  │   K.4.2.3.1    │   │   K.4.2.3.2    │
  │ Business Area  │   │ Business Area  │
  │   Hardware     │   │   Software     │
  └────────────────┘   └────────────────┘
```

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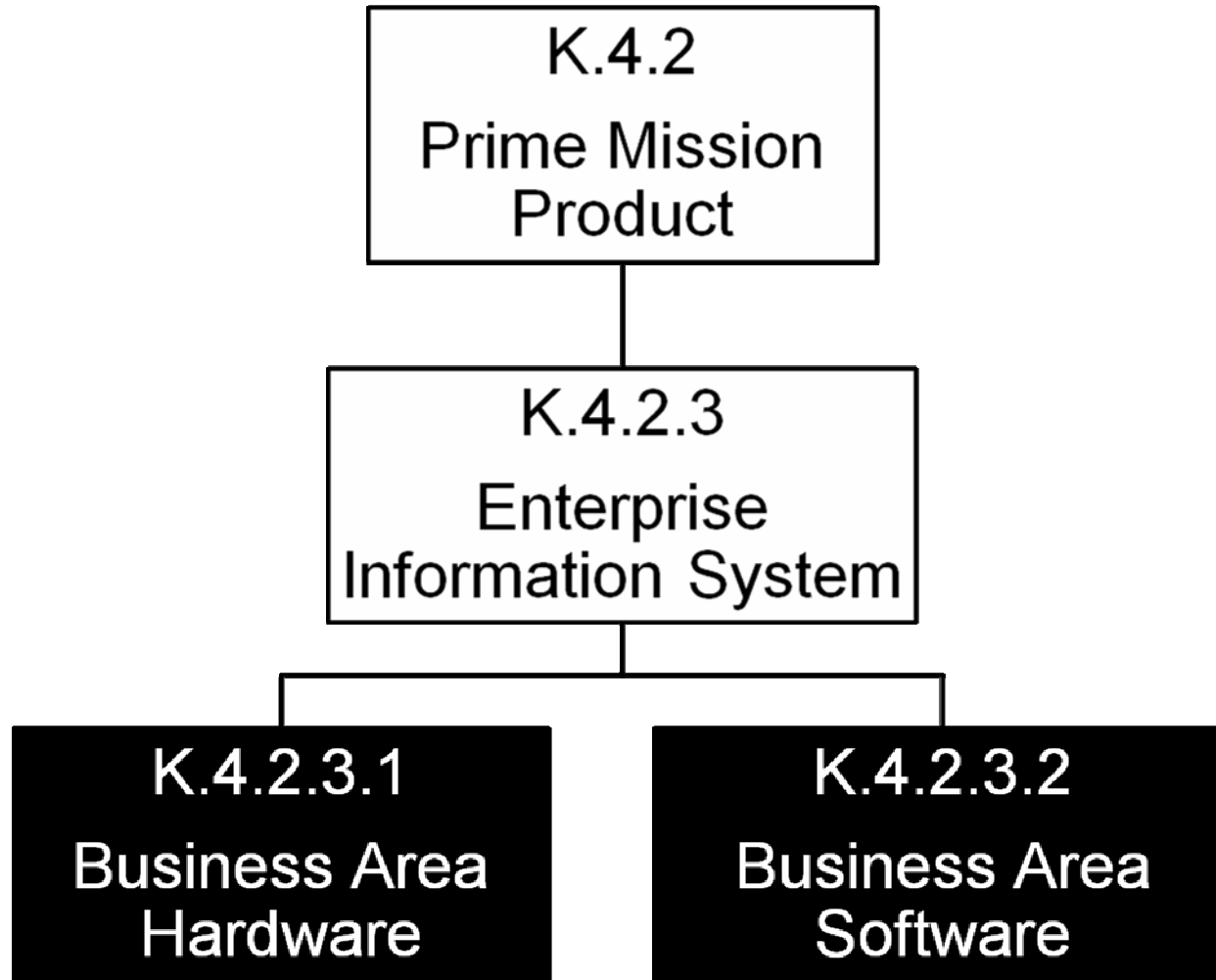
Prime Mission Product WBS Definition

- **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, forms, interfaces, conversions, workflows**, 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

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ID	WBS Element	UNIT	FORM	R^2	F-Stat	CV(%)	N
					METRICS		
CER 1	Business Area Software	Hours	204.4*Report + 2021*Interface + 2713*Conversion + 496.8*Extension	82%	41.90	47.85	20
CER 2	Business Area Software	Hours	18340 + 186.1*Report + 2094*Interface + 2350*Conversion + 479.1*Extension	81%	19.89	49.37	20
CER 3	Business Area Software	Hours	932.5 * RICE+	85%	114.57	58.77	20
CER 4	Business Area Software/Hardware	BY10$K	129.5 * RICE+	85%	113.46	55.63	20
CER 5	Business Area Software/Hardware	BY10$K	7984 + 117.9 * RICE+	72%	49.94	55.59	20

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

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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CER 4 = 129.5 * RICE+

R^2 = 84.9%
CV = 55.6%
—— 95% Confidence Interval
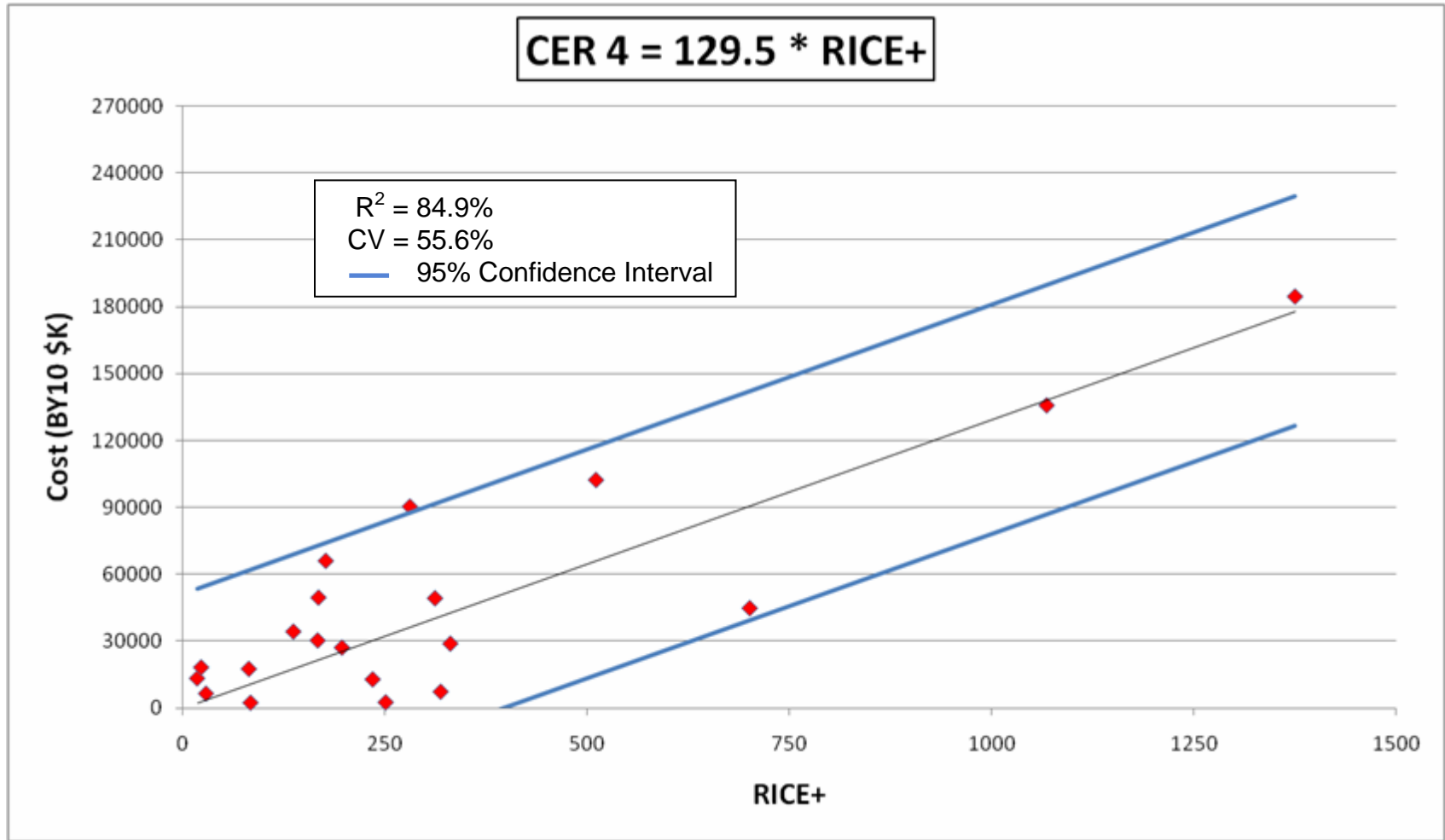
Acquisition Support
Available CERs by WBS

Acquisition Support

- L.6.1 Systems Engineering
- L.6.2 Program Management
- L.6.3 Change Management
- L.6.4.1 Development Test & Evaluation
- L.6.5 Training Development
- Other
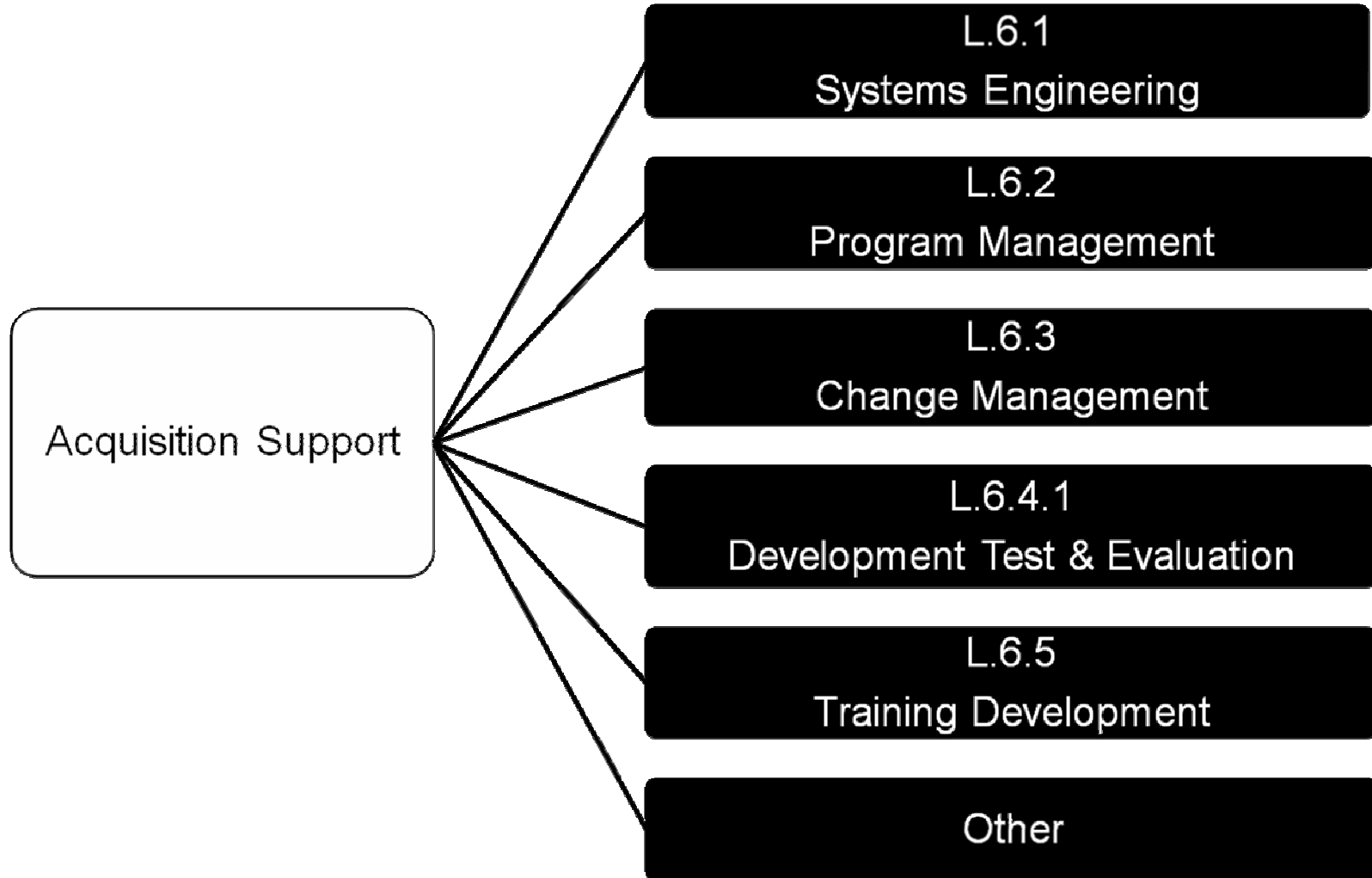
Acquisition Support - CERs

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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**: $2M (LOW), $200M (HIGH)**

Limitation

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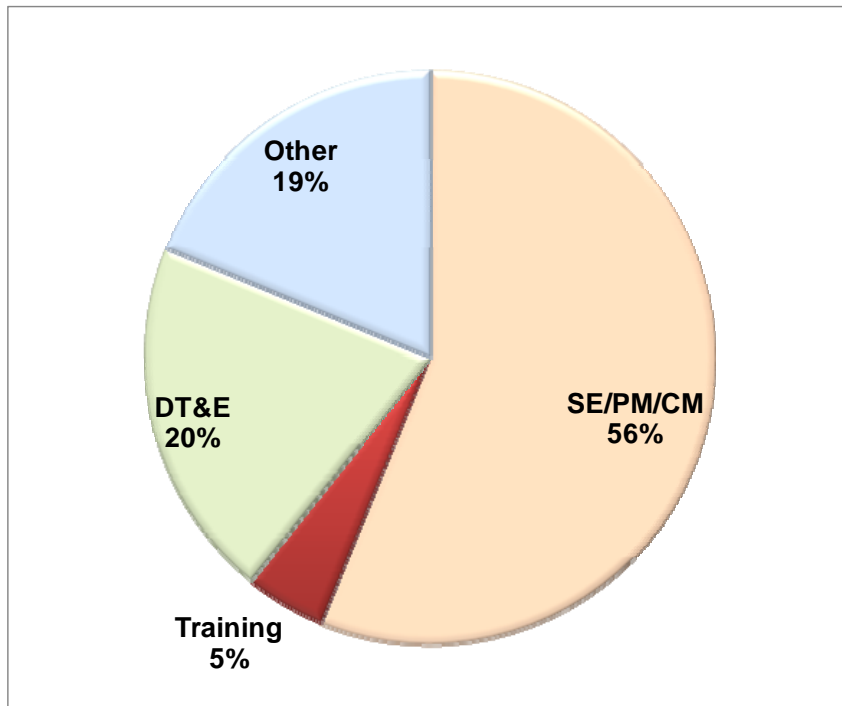- Dataset only captures Government Sector ERPs

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Acquisition Support - CERs Cost Allocation
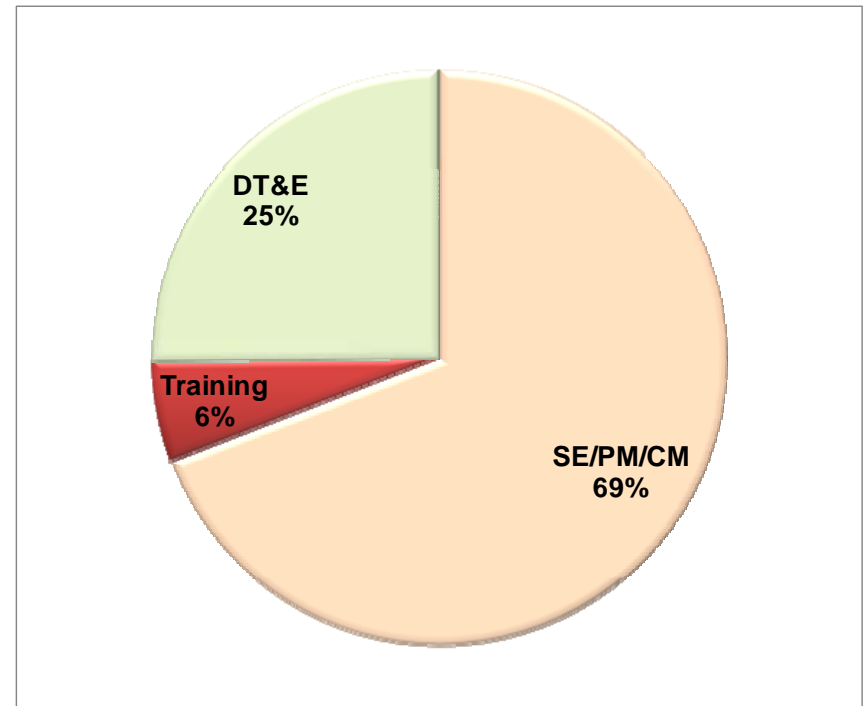
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CER 8 and CER 9

Other 19%

DT&E 20%

Training 5%

SE/PM/CM 56%

CER 6 and CER 7

DT&E 25%

Training 6%

SE/PM/CM 69%

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

CER 6 = 1.861 * Prime Mission Product

R^2 = 87%
CV = 41%
—— 95% Confidence Interval
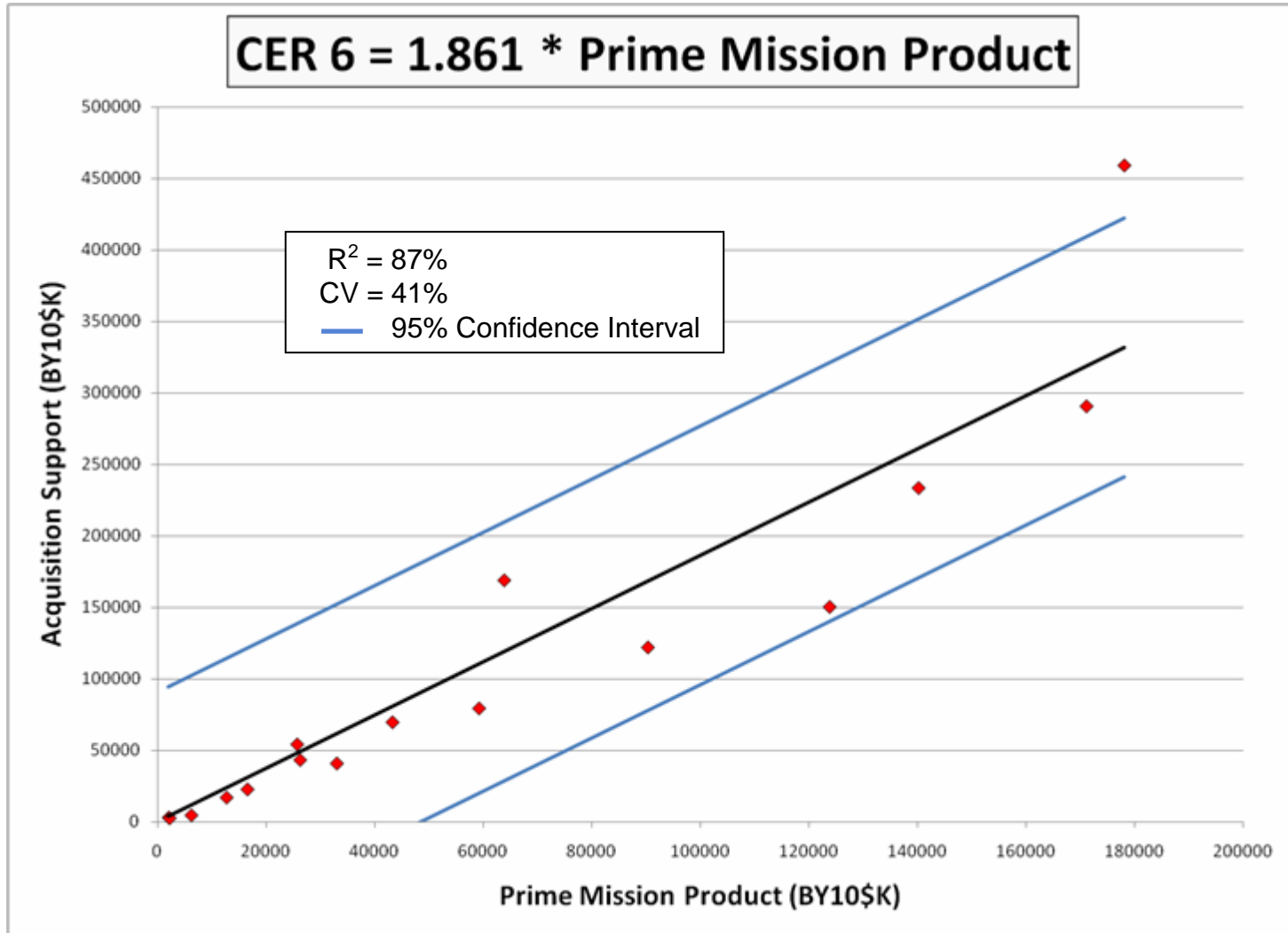
Help Desk (Tier I & II) Available CER by WBS

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L.6.9
Operational Site Activation

L.6.9.1
Interim Logistic Support

L.6.9.1.3
Help Desk
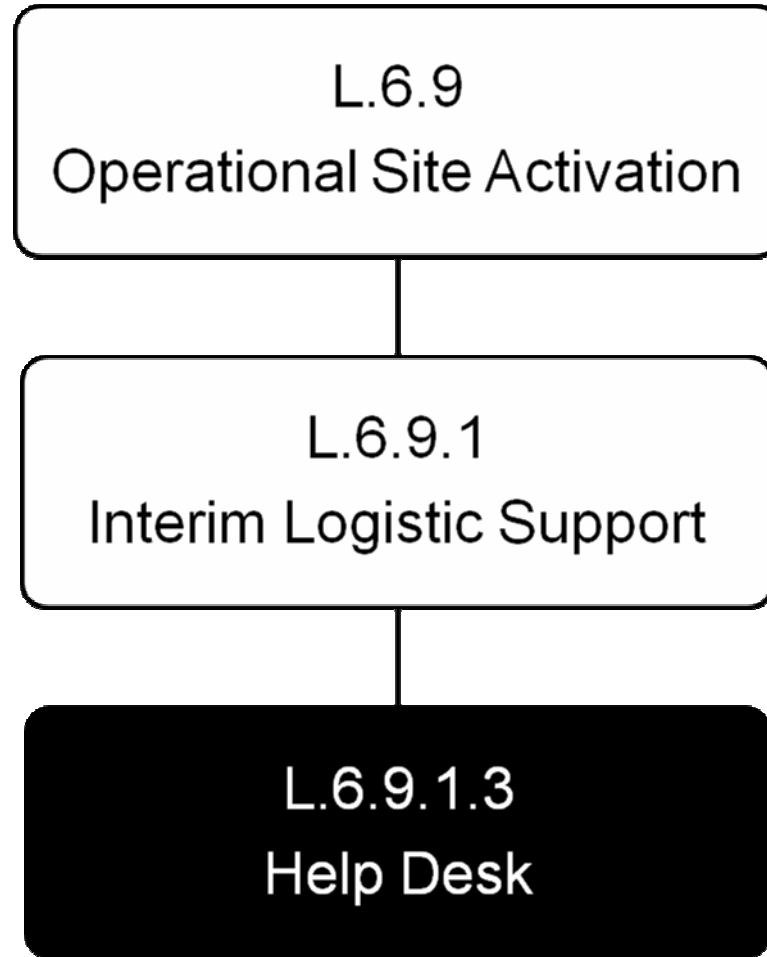
Help Desk (Tier I & II)

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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;

R^2 = 95%
CV = 29%
—— 95% Confidence Interval

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Post Go-Live System Developer Available CER by WBS

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```
                    ┌──────────────────────────────────┐
                    │              L.6.9               │
                    │      Operation & Support*        │
                    │ (Post Go-Live System Developer)  │
                    └──────────────────────────────────┘
                         │                        │
          ┌──────────────────────┐    ┌──────────────────────┐
          │  System Operations   │    │ Software Maintenance │
          │ Sustaining Engineering│   │                      │
          └──────────────────────┘    └──────────────────────┘
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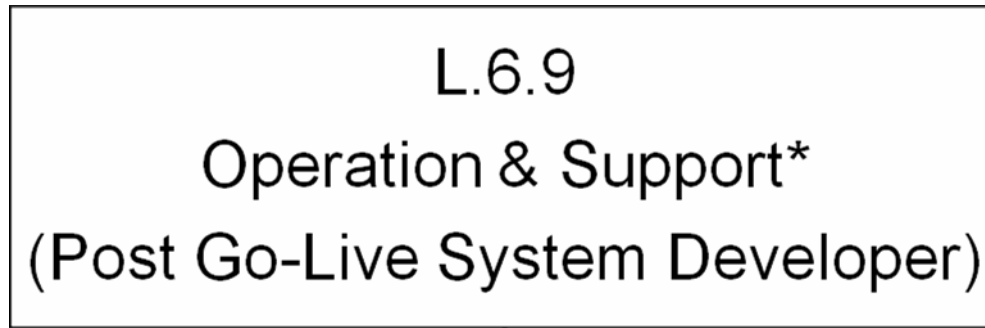
Post Go-Live System Developer
Staffing level as % of Go-Live Year
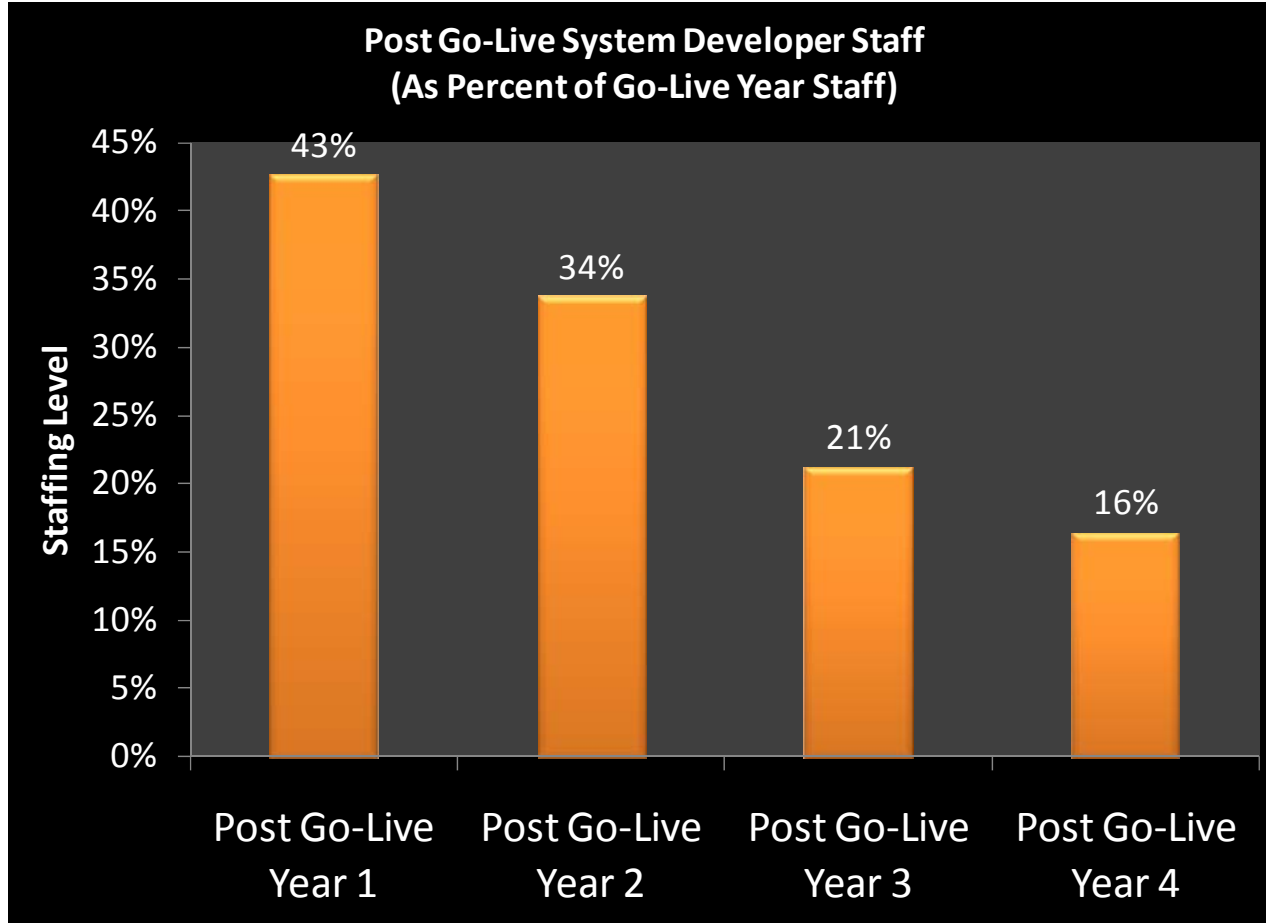
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Post Go-Live System Developer Staff
(As Percent of Go-Live Year Staff)

- 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
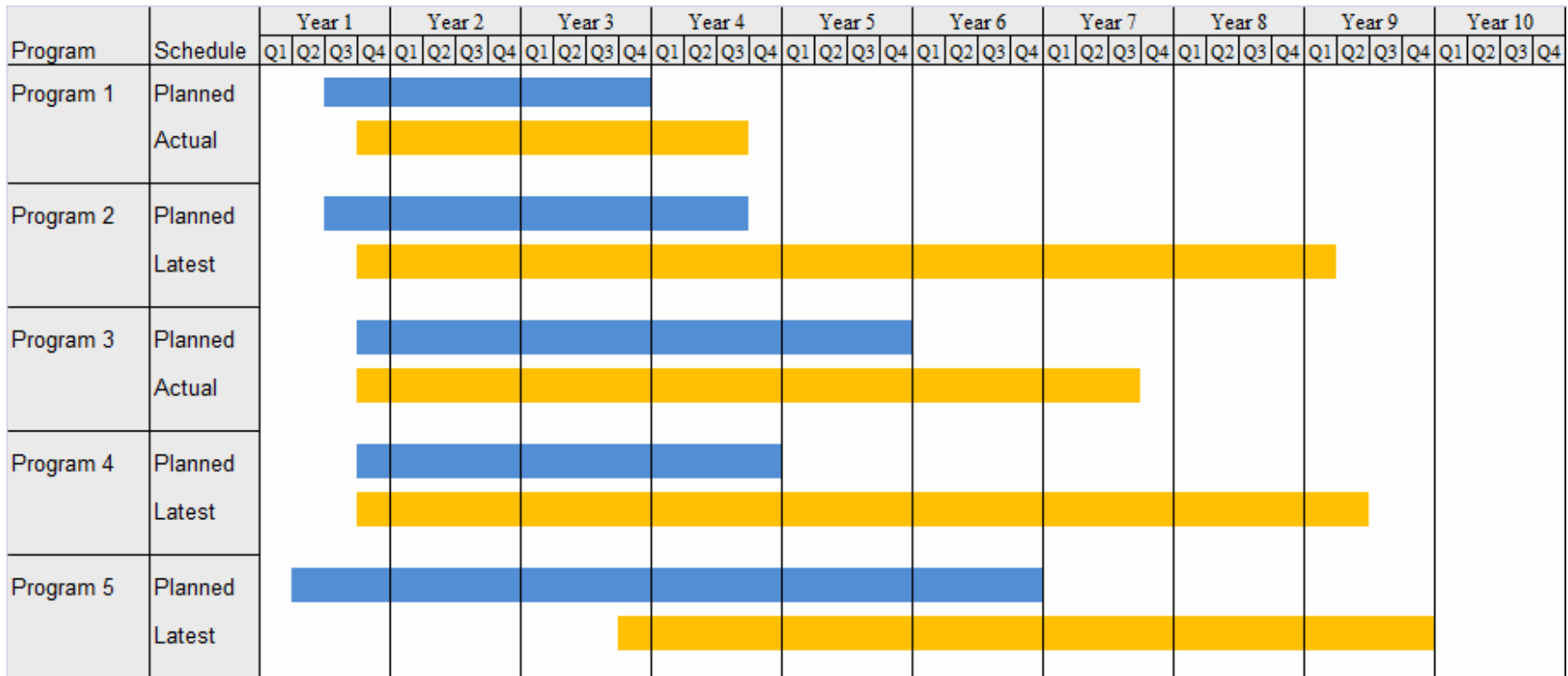- Recommend using Year 4 percentage as constant for years 5 and after

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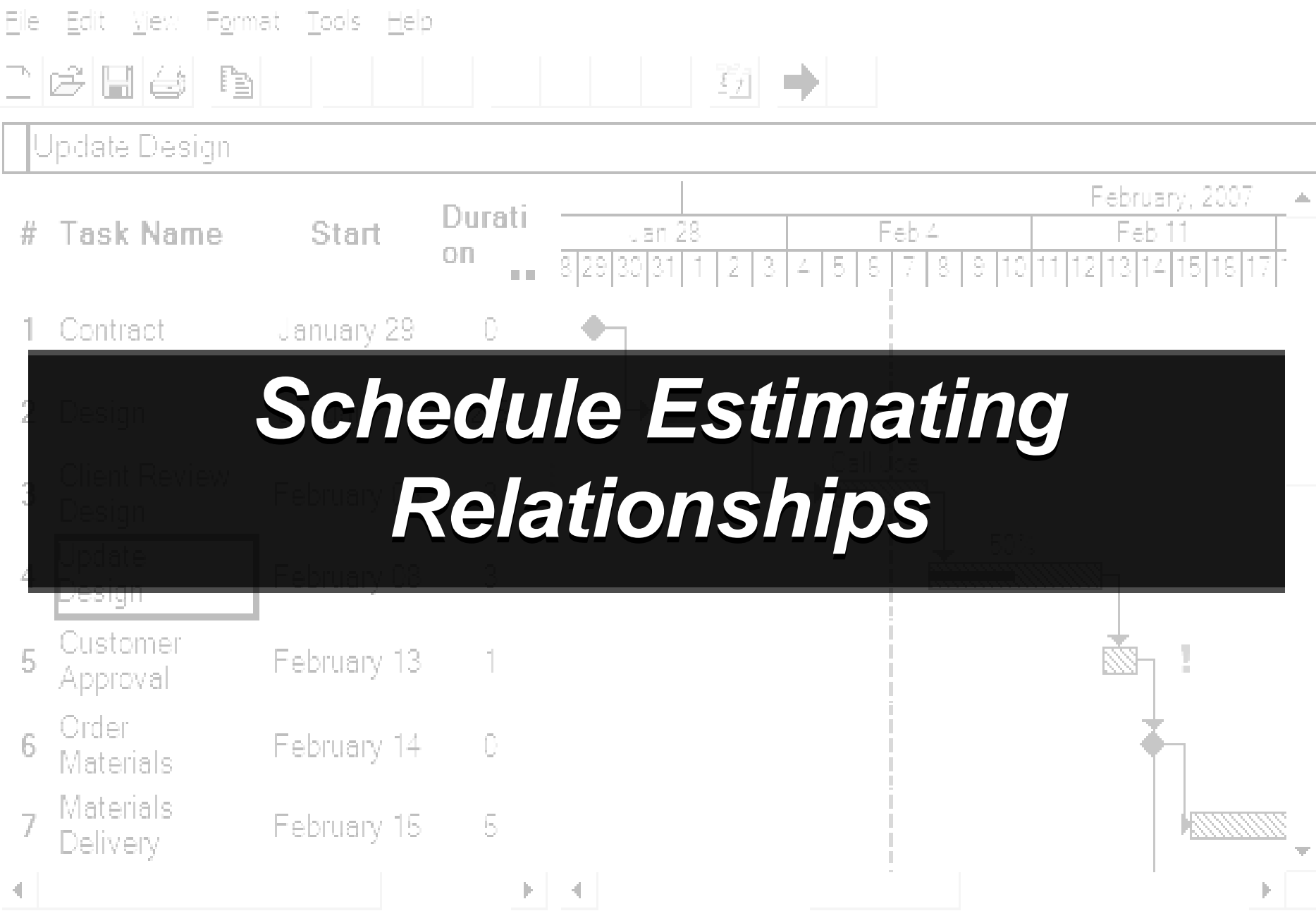
Schedule Estimating Relationships

Schedule Analysis!!! Why Important?

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- ### All Major DoD ERP have Exceeded Original Schedule

- ### Schedule Overrun ranges between 10% and 140%

Program	Schedule	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Program 1	Planned										
	Actual										
Program 2	Planned										
	Latest										
Program 3	Planned										
	Actual										
Program 4	Planned										
	Latest										
Program 5	Planned										
	Latest										

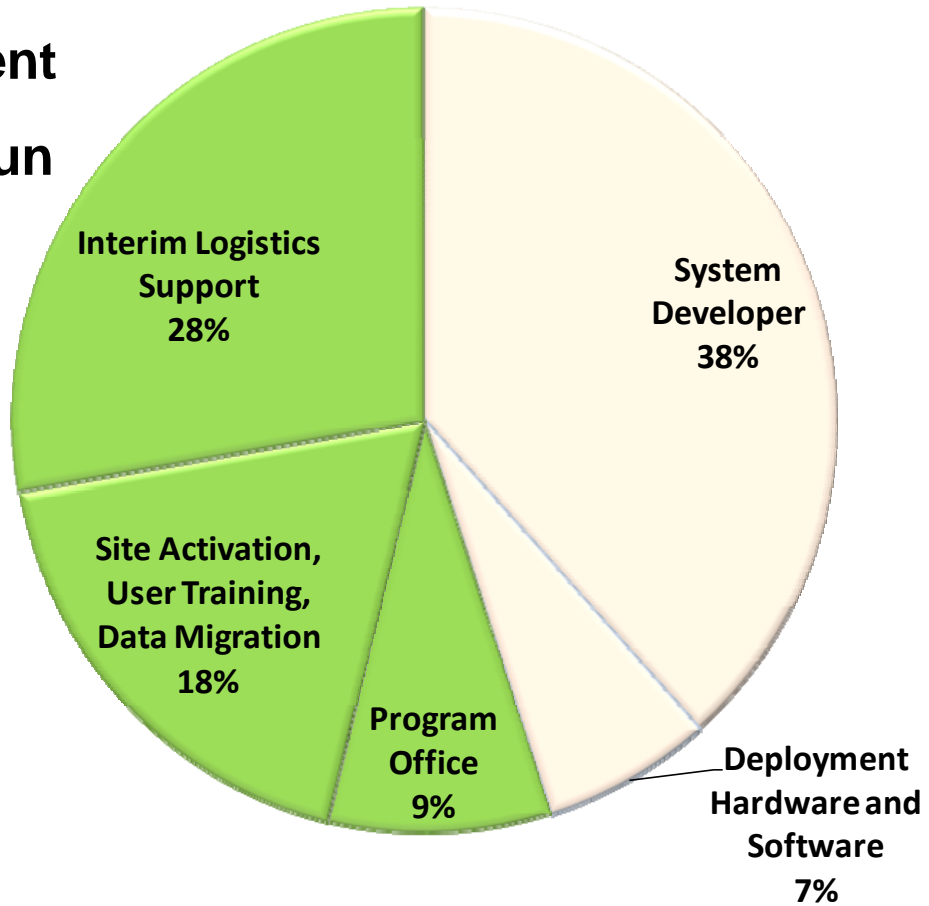*I n t e g r i t y - S e r v i c e - E x c e l l e n c e*

Impact of Schedule Overruns?

Extends "Standing Army" costs!!!

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

LEGEND
- 🟩 "Standing Army" Costs
- ⬜ Final Project Product

Pie chart:
- Interim Logistics Support 28%
- System Developer 38%
- Site Activation, User Training, Data Migration 18%
- Program Office 9%
- Deployment Hardware and Software 7%

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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K.4.2

Prime Mission Product

K.4.2.3

Enterprise Information System

Prime Mission Product - SER

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SER ID	CONTENT	UNIT	FORM	METRICS				
				R^2	SE	F-Stat	CV(%)	N
SER 1	Prime Mission Product	Months	RICE $^{0.5135}$ * PMP Staff $^{-0.02114}$	98.39%	0.3403	429.68	39.97%	14

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

Application

- Duration in Months
- Dataset Range (RICE) **= 15 (LOW) , 1400 (HIGH)**

Limitation

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

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System Test & Evaluation
Available SER by WBS

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┌─────────────────────┐
│        L.6.4        │
│                     │
│   System Test &     │
│     Evaluation      │
└──────────┬──────────┘
           │
┌──────────┴──────────┐
│       L.6.4.1       │
│                     │
│  Development Test   │
│   & Evaluation      │
└─────────────────────┘
```

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Development Test & Evaluation- SER

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

Application

- 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
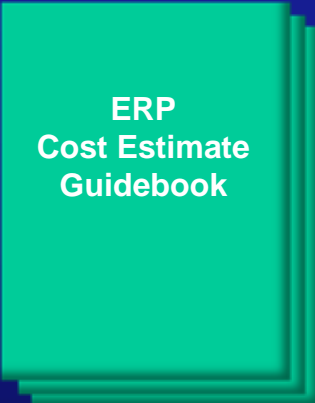- Dataset only captures Government Sector ERPs

I n t e g r i t y - S e r v i c e - E x c e l l e n c e

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Way Forward

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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

**ERP
Cost Estimate
Guidebook**

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