Impact of Scope Changes on Software Growth

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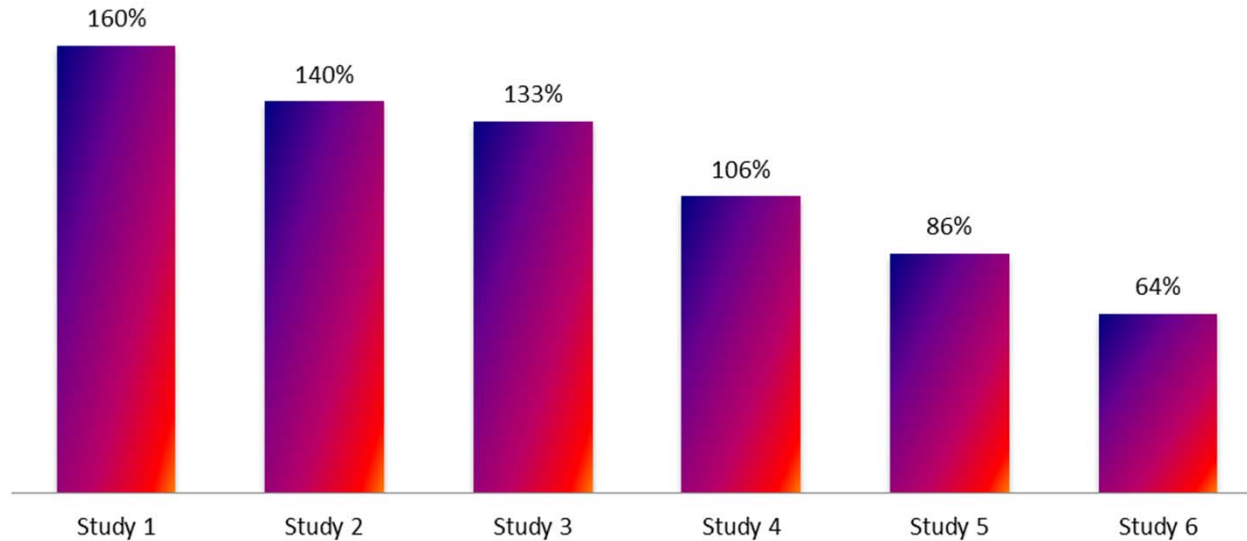
June 2018

Agenda

- **Background**

- **Software Growth Defined**

- **Analysis Methods and Results**

- **Model Description and Results**

- **Summary and Q&A**

Software Growth

Sources:
- Average of SRDR Data Compilation Pairs, dated 16 OCT 2017
- ICEAA June 2015 NCCA Software Growth Analysis (SW15) - Logical SLOC only
- Exploring DoD Software Growth: A Better Way to Model Future Uncertainty by Lanham and Wallshein (SW09), June 2015
- SEI DoD SW Factbook, 2017 (CMU/SEI-2017-TR-004)

❑ Survey of recent studies measuring software growth

❑ Most calculated growth using initial and final reported source lines of code (SLOC) or equivalent SLOC (ESLOC)

❑ Method captures total growth including any growth owing to scope increases

What is the magnitude of the impact of scope growth on reported software growth?

Software Growth Example

Initial Software Size
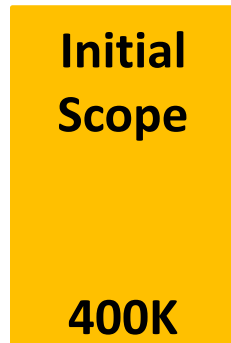
Final Software Size

400K

400K ESLOC

100% Growth

❑ **Direct comparison of final to initial ESLOC includes all sources of growth if not adjusted**

800K

800K ESLOC

Software Growth Example (cont'd)

Initial Software Size

Final Software Size

Initial Scope

400K

400K ESLOC

25% Growth

Initial Scope

500K

New Scope

300K

New
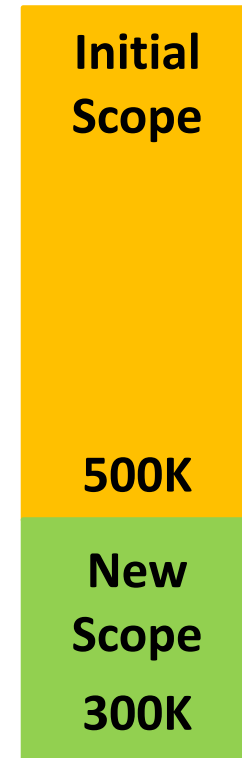
800K ESLOC

- ❏ Adjusting for scope growth would give a truer picture of the actual growth of initial software scope
- ❏ Requires information not currently captured in SRDRs

To differentiate between the two growth metrics, we need to define some terms.

Software Size Growth

Module 12 of the ICEAA Cost Estimating Body of Knowledge (CEBoK®)	2008 NCCA Software Development Cost Estimating Handbook*	2007 Software Code Growth**
Underestimating required SLOC	Size projection errors	Underestimating the amount of new SLOC
Poor understanding of initial requirements	Requirements volatility	Underestimating the software complexity
Code reuse optimism	Product functionality changes	Overestimating the expected use of existing SLOC, i.e. modified and unmodified SLOC
New requirements added during development	Human errors	

* Defense Acquisition University. NCAA [Naval Center for Cost Analysis] *Software Development Cost Estimating Handbook Volume 1,* September 2008.
**Jones, R. P., & Hardin, P. (2007). *Software Code Growth: New Approach Based on Historical Analysis of Actuals.* ISPA/SCEA Joint Annual International Conference and Workshop (p. 15). New Orleans, LA: Technomics.

Software Size Growth (cont'd)

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Software Size Growth (cont'd)

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New requirements added during development	Human errors	

Software Growth Definition:

- Underestimating required SLOC
- Poor understanding of initial requirements
- Code reuse optimism
- New requirements added during development

Definition of Pure Software Growth

Total Growth

Pure Growth + **Scope Growth**

- Underestimating required SLOC

- Poor understanding of initial requirements

- Code reuse optimism

- New requirements added during development

Software Growth Definition:

- Underestimating required SLOC

- Poor understanding of initial requirements

- Code reuse optimism

- New requirements added during development
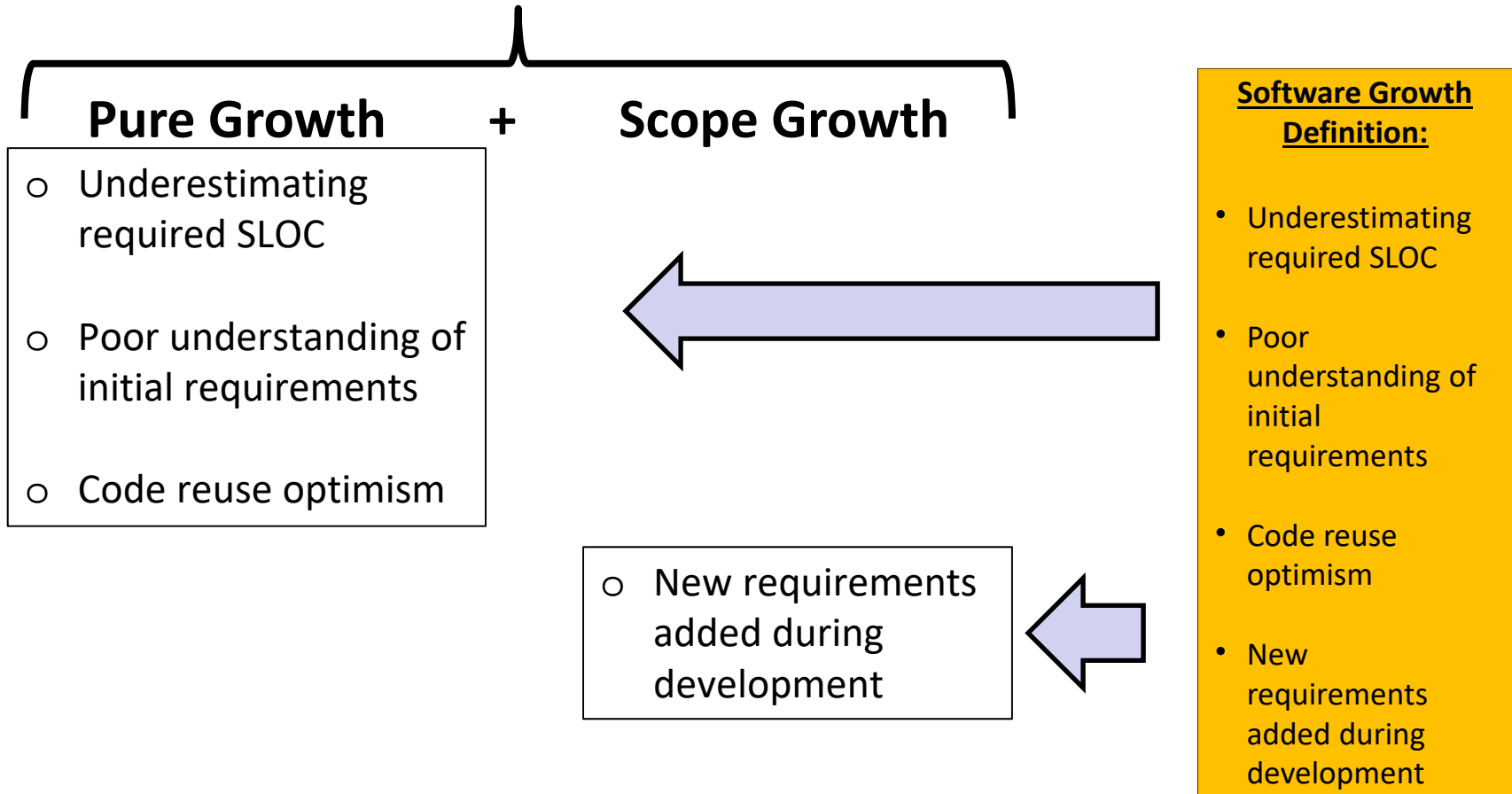
Completely unrelated scope additions should be estimated separately and adjusted for in historical data.

Examples of Pure vs Total Growth

❑ **Four large DoD software programs were selected based on relevance and for availability of data**

❑ **Scope changes were determined using data outside available SRDRs, which included**

– Monthly or quarterly ESLOC reports

– Systems Engineering Technical Review briefs

– Program schedules

– Software metric reports

– Identified and interviewed subject-matter experts when possible to validate interpretations of data
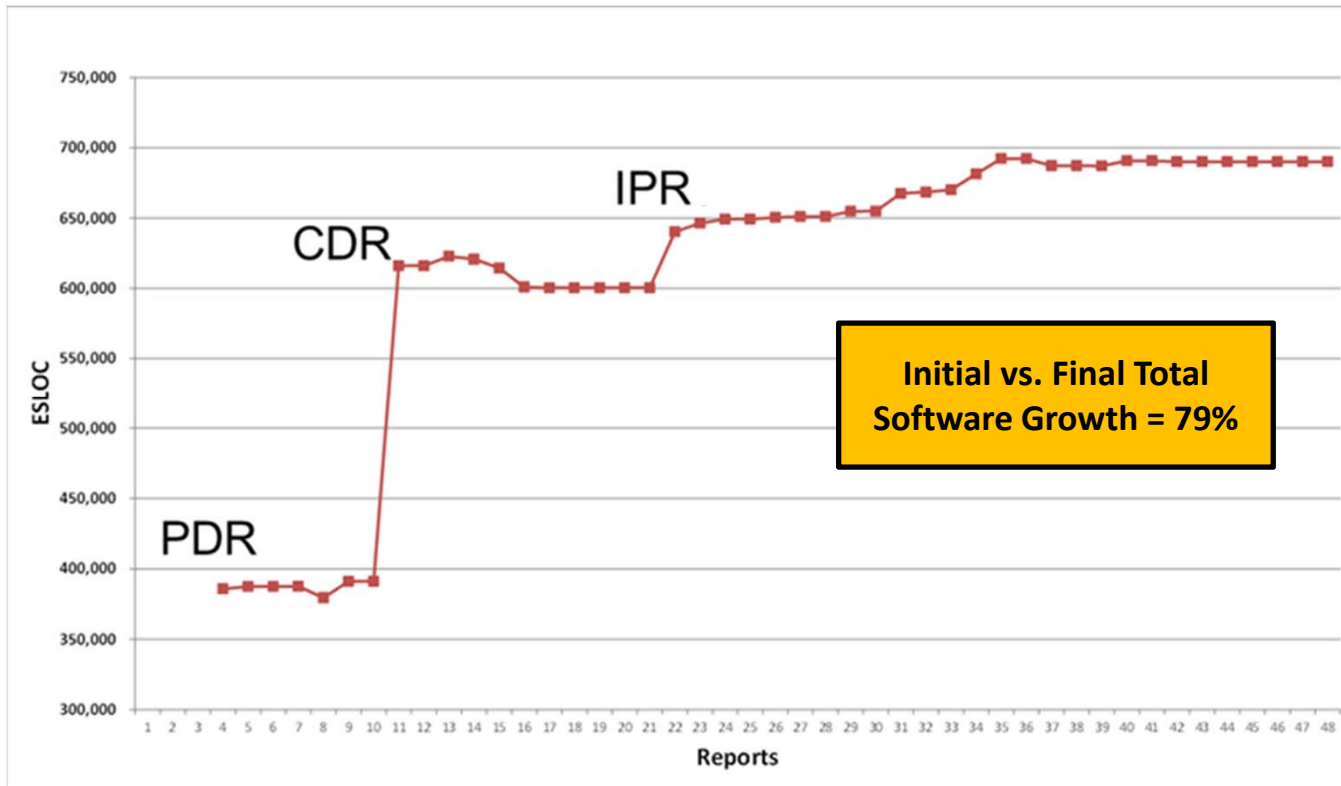
Pure vs Total Growth Program 1
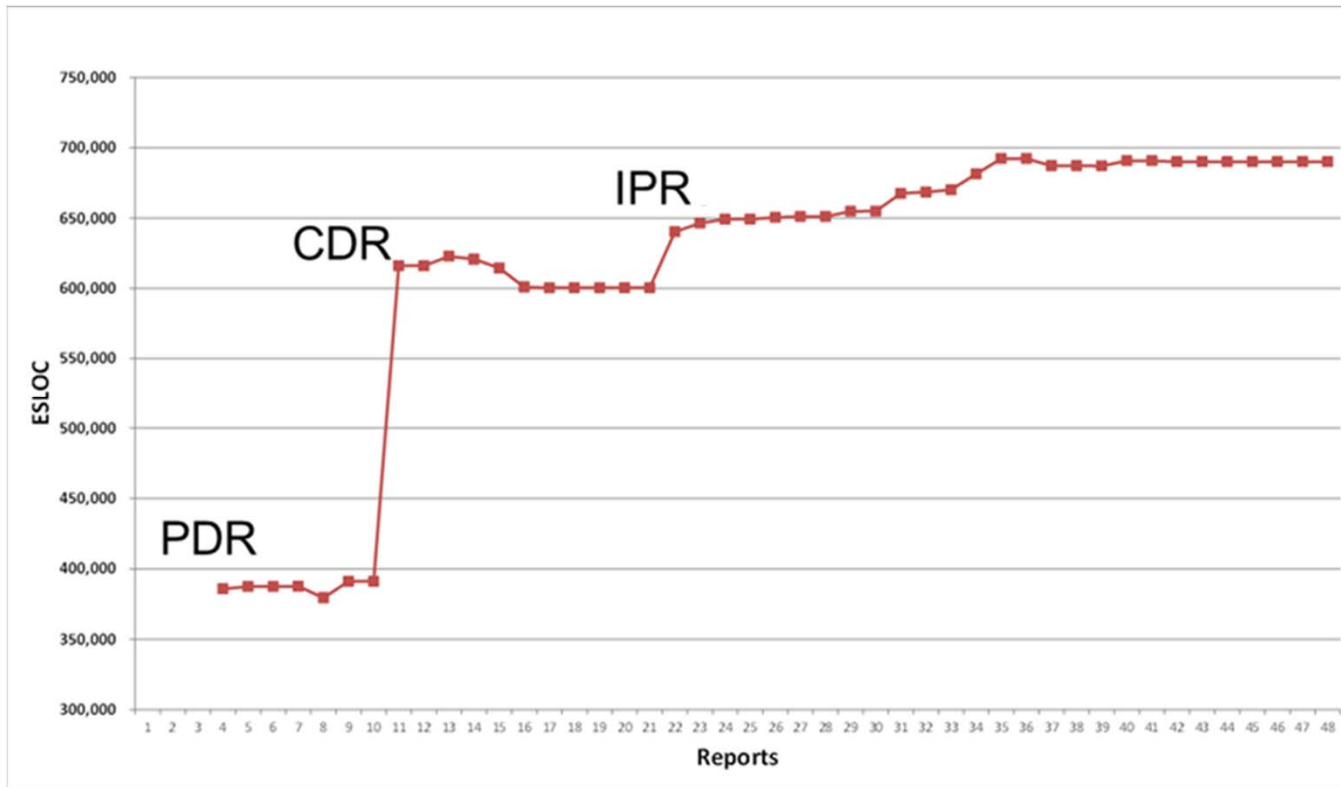
Program Description

- ❑ **Real time**
- ❑ **Command and control**
- ❑ **Combat Management System (CMS) upgrade**
- ❑ **Software program: ~5000K DSLOC**
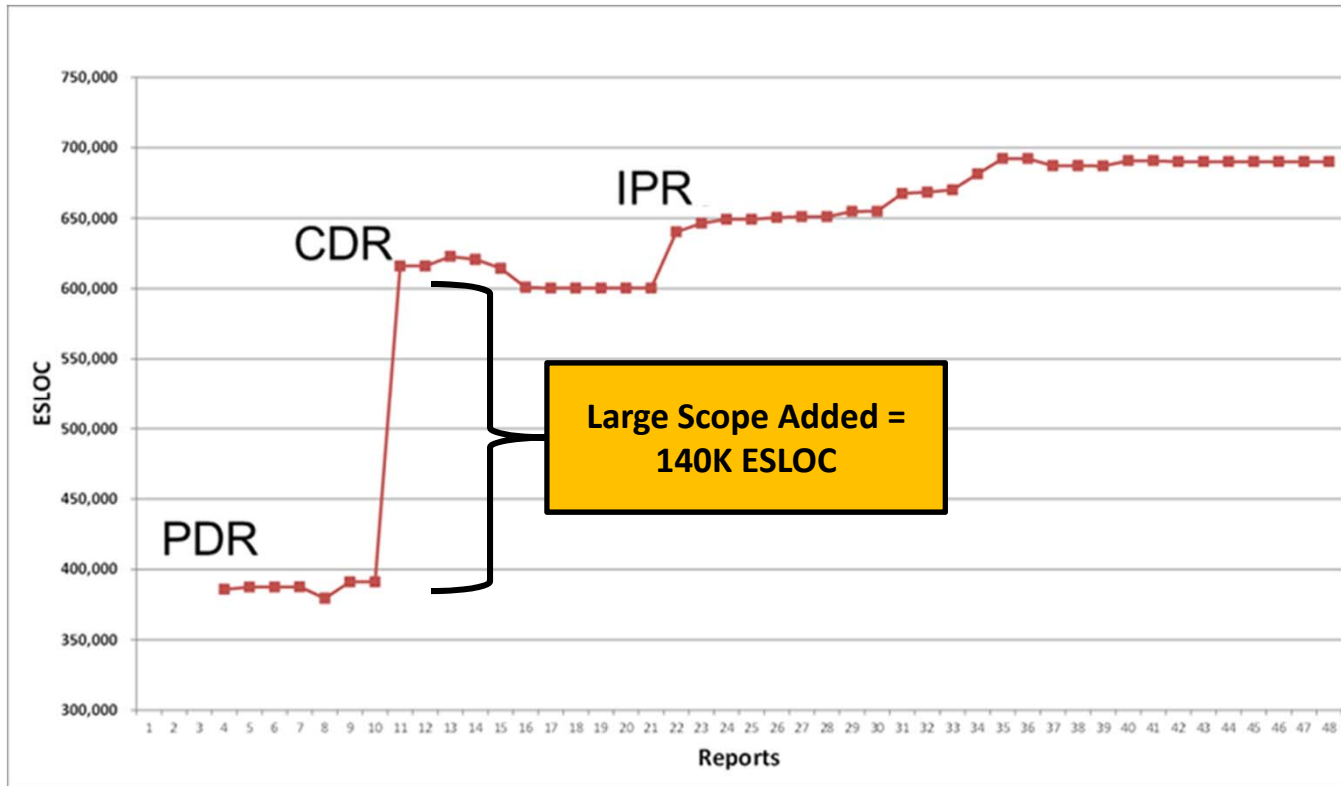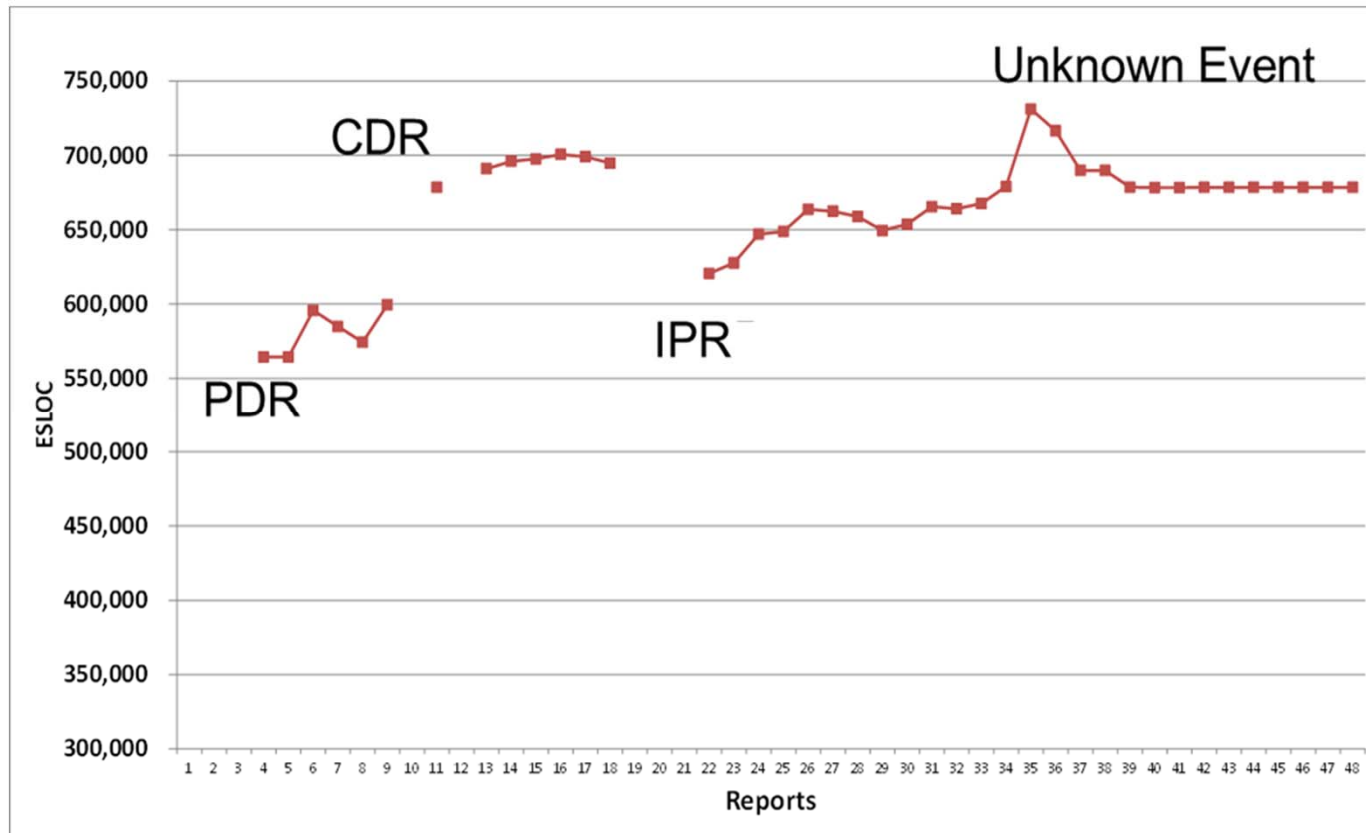
Pure vs Total Growth Program 1 (cont'd)

Program Description

- ❑ **Real time**
- ❑ **Command and control**
- ❑ **Combat Management System (CMS) upgrade**
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Initial vs. Final Total Software Growth = 79%

Pure vs Total Growth Program 1 (cont'd)

Program Description

- ❑ Real time
- ❑ Command and control
- ❑ Combat Management System (CMS) upgrade
- ❑ Software program: ~5000K DSLOC

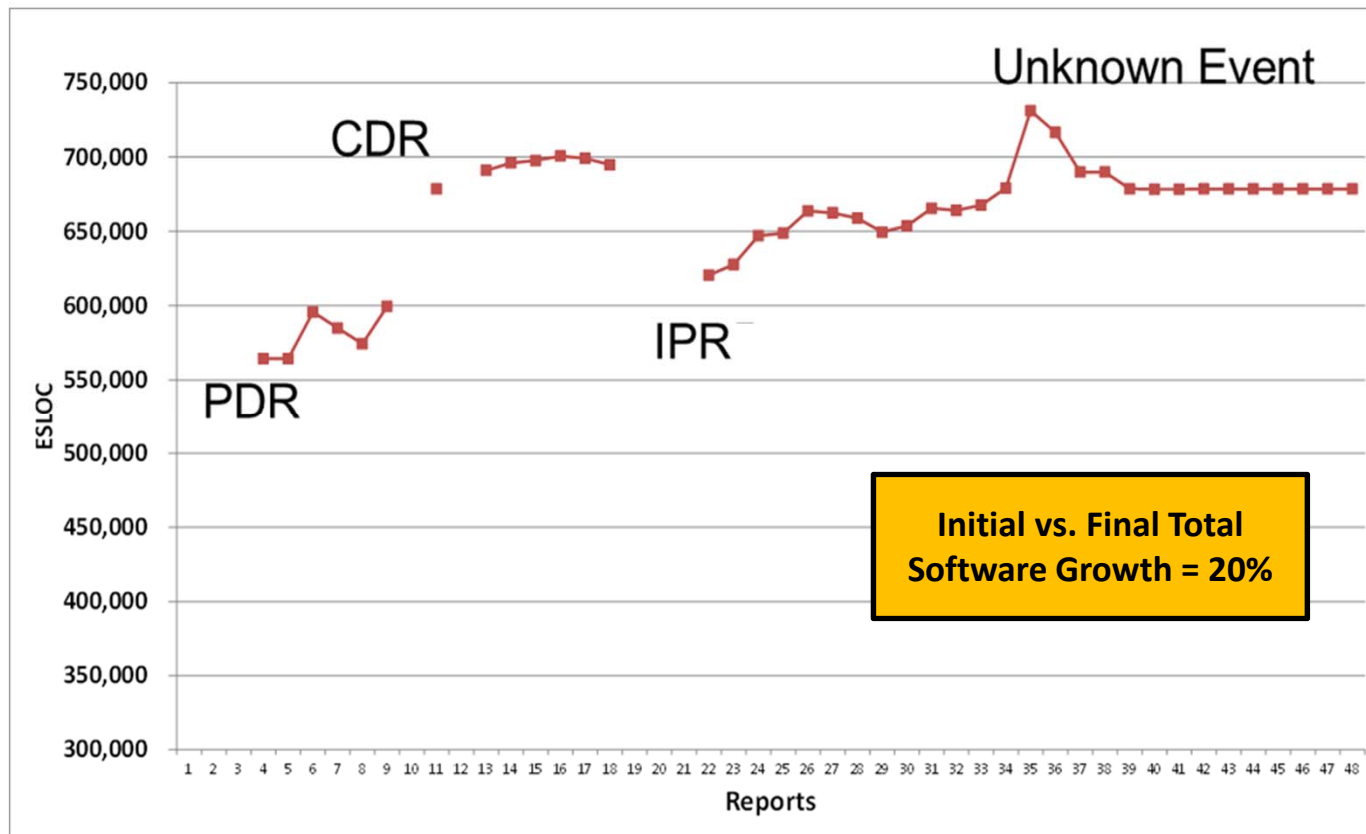| Pure Growth	28%
Scope Growth	51%
Total Growth	79%

Pure vs Total Growth Program 2

Pure vs Total Growth Program 2 (cont'd)

Program Description

- ❑ **Real time**
- ❑ **Command and control**
- ❑ **CMS upgrade**
- ❑ **Software program: ~4000K DSLOC**

Initial vs. Final Total Software Growth = 20%
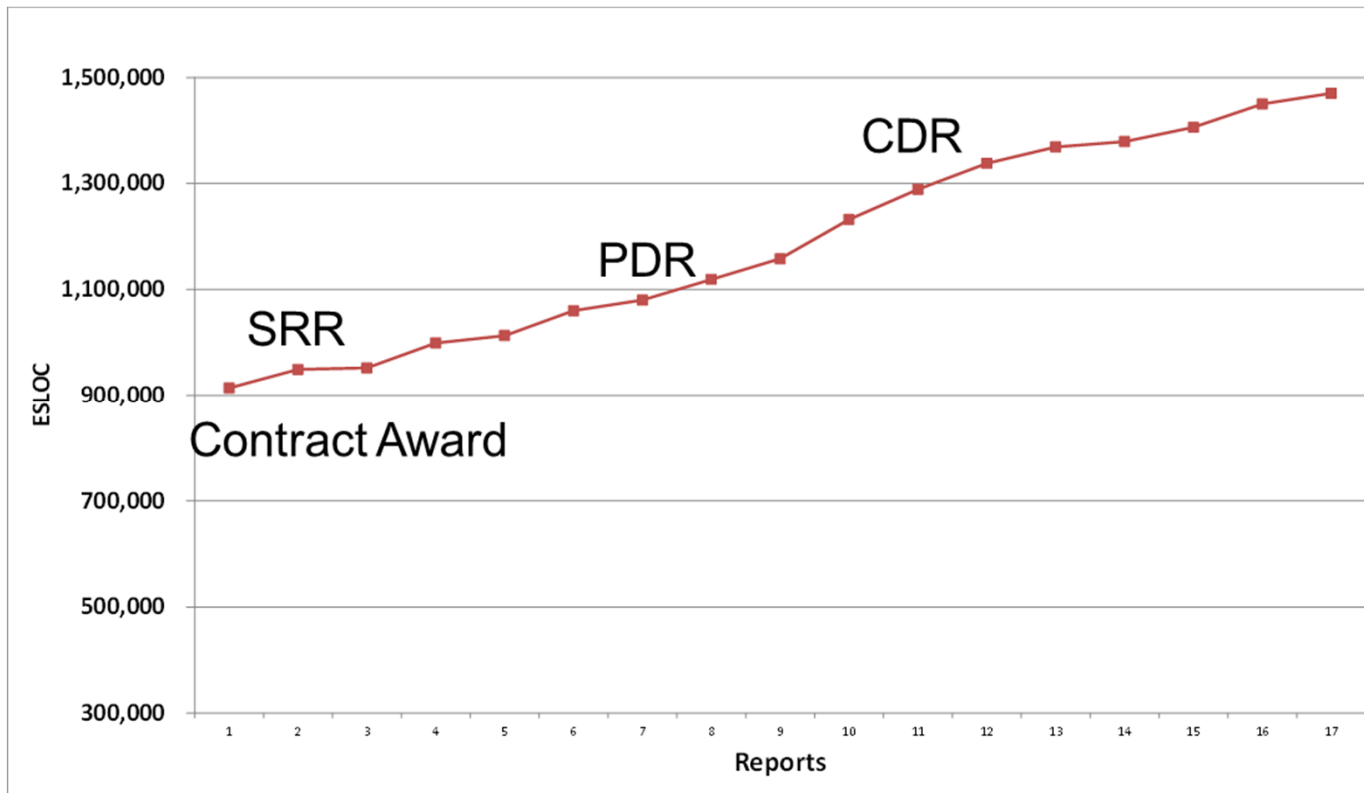
Pure vs Total Growth Program 2 (cont'd)
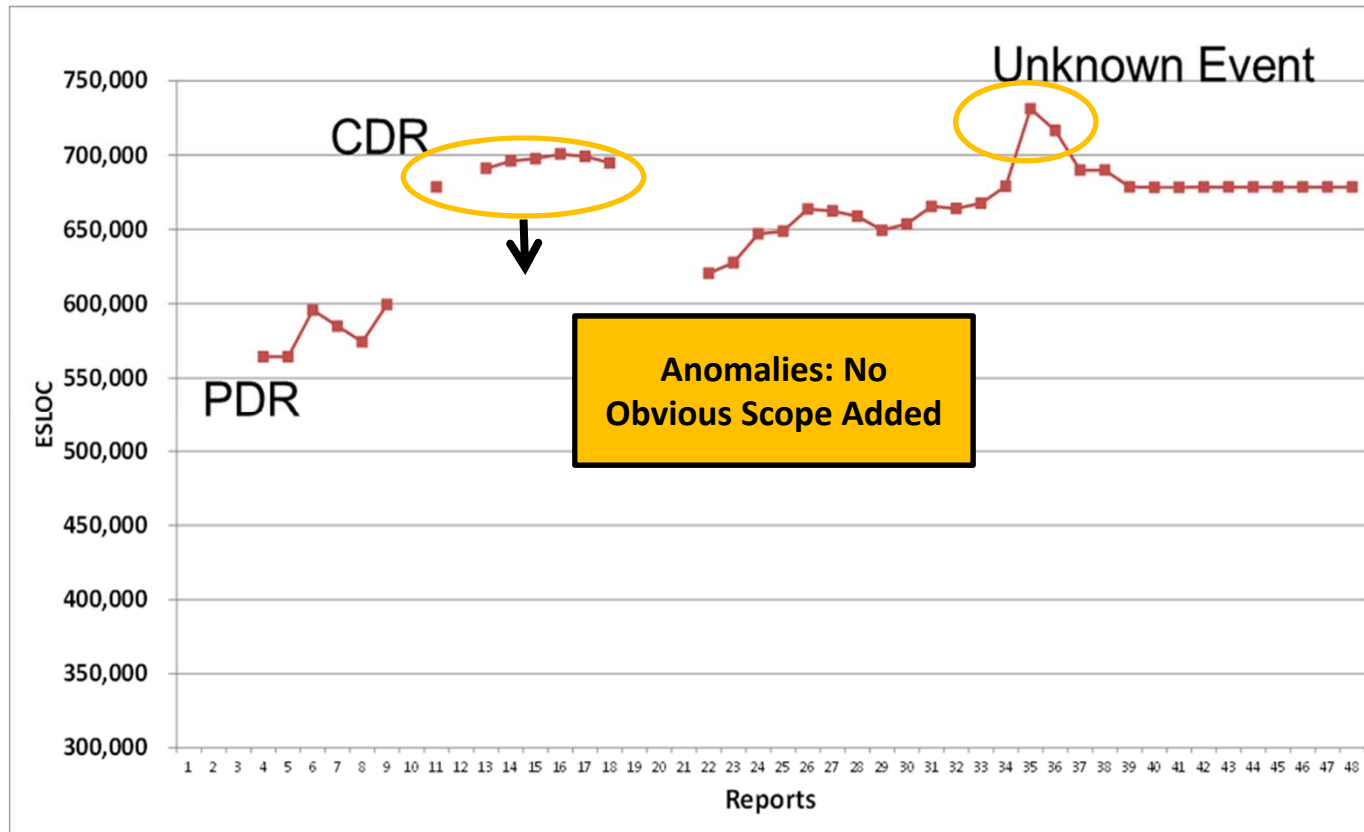
Program Description

- ❏ **Real time**
- ❏ **Command and control**
- ❏ **CMS upgrade**
- ❏ **Software program: ~4000K DSLOC**

Pure Growth	20%
Scope Growth	0%
Total Growth	20%

Pure vs Total Growth Program 3

Program Description

- ❑ **Real time**
- ❑ **Command and control**
- ❑ **CMS upgrade**
- ❑ **Software program: ~4000K DSLOC**

Pure vs Total Growth Program 3 (cont'd)
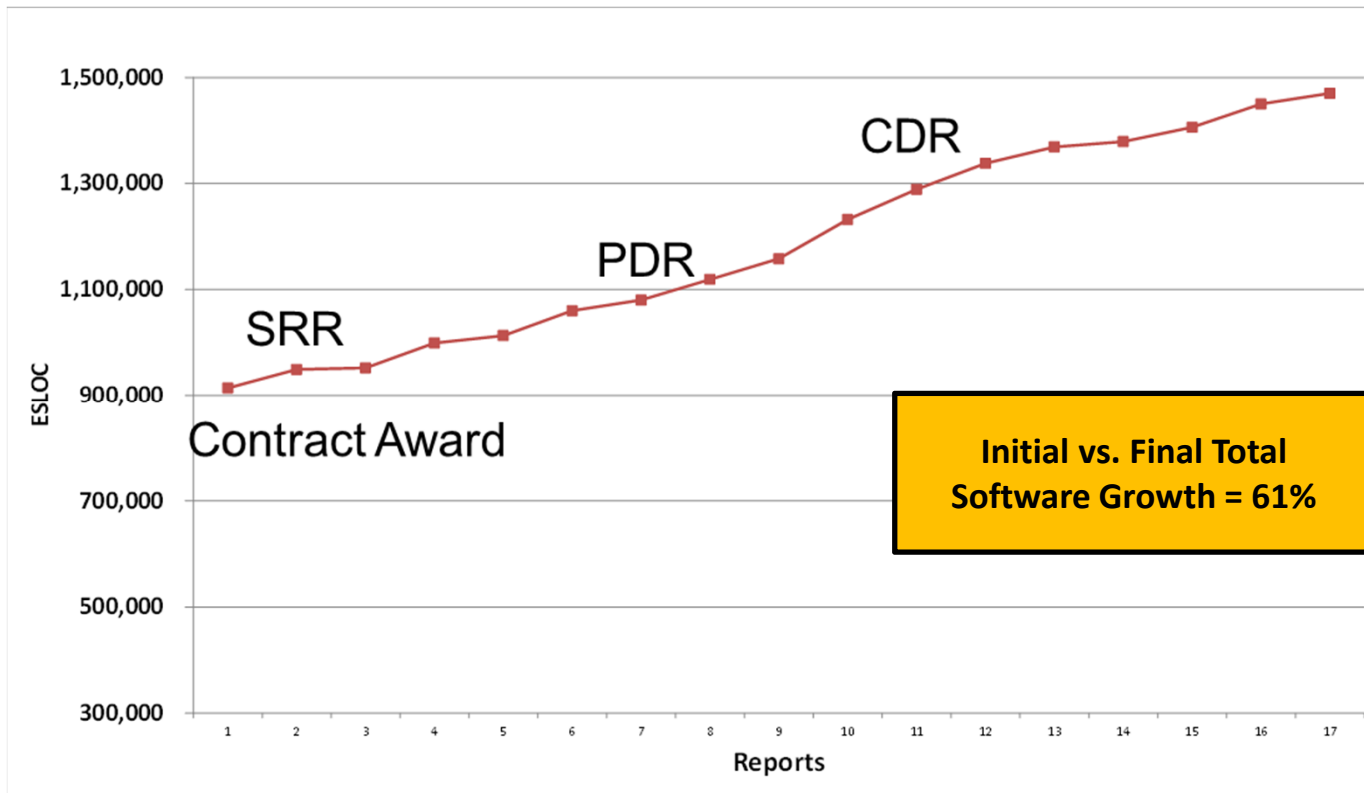
Program Description

- ❑ **Real time**
- ❑ **Command and control**
- ❑ **CMS upgrade**
- ❑ **Software program: ~4000K DSLOC**

Chart labels: SRR, Contract Award, PDR, CDR

Initial vs. Final Total Software Growth = 61%

Pure vs Total Growth Program 3 (cont'd)
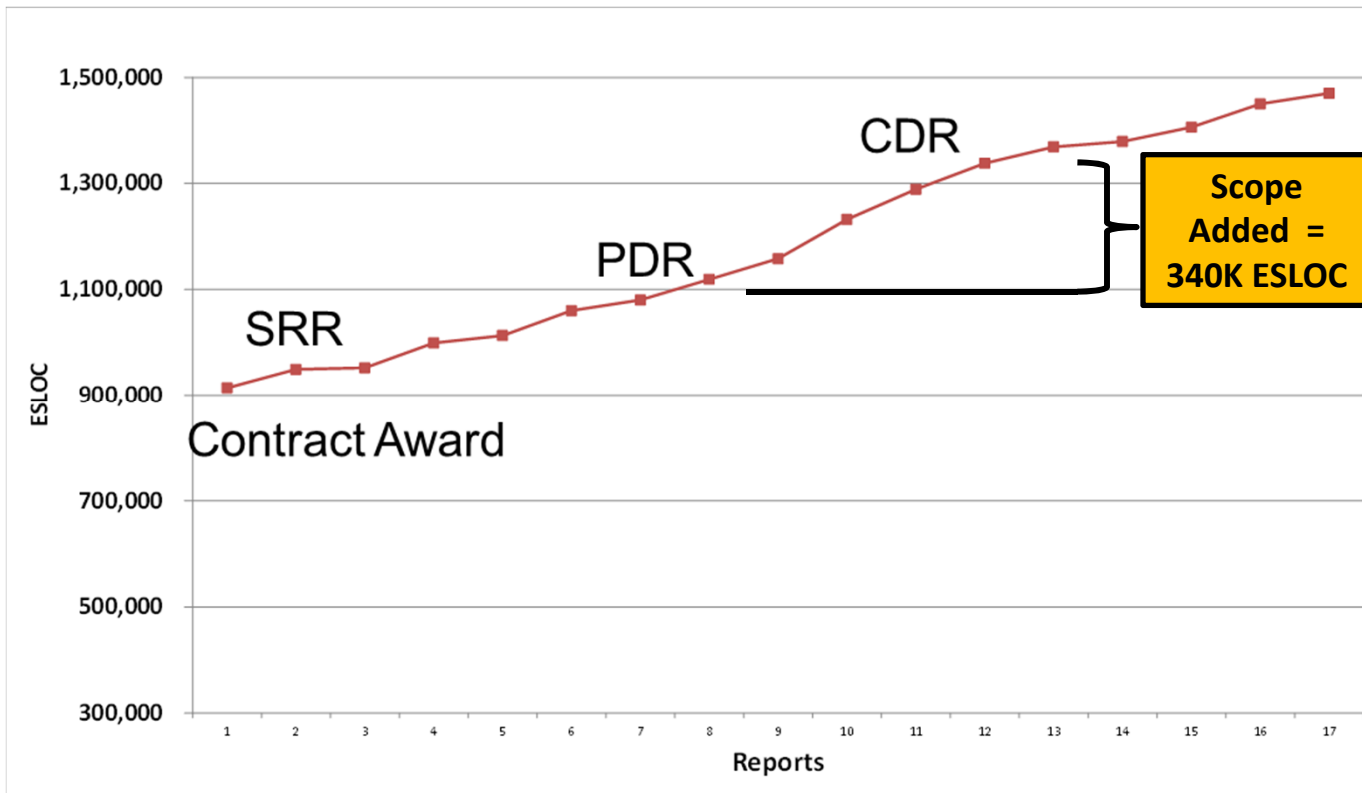
Program Description

- ❑ **Real time**
- ❑ **Command and control**
- ❑ **CMS upgrade**
- ❑ **Software program: ~4000K DSLOC**

Pure Growth	24%
Scope Growth	37%
Total Growth	61%

Pure vs Total Growth Program 4

Program Description

- ❑ Real time
- ❑ Command and control
- ❑ CMS upgrade
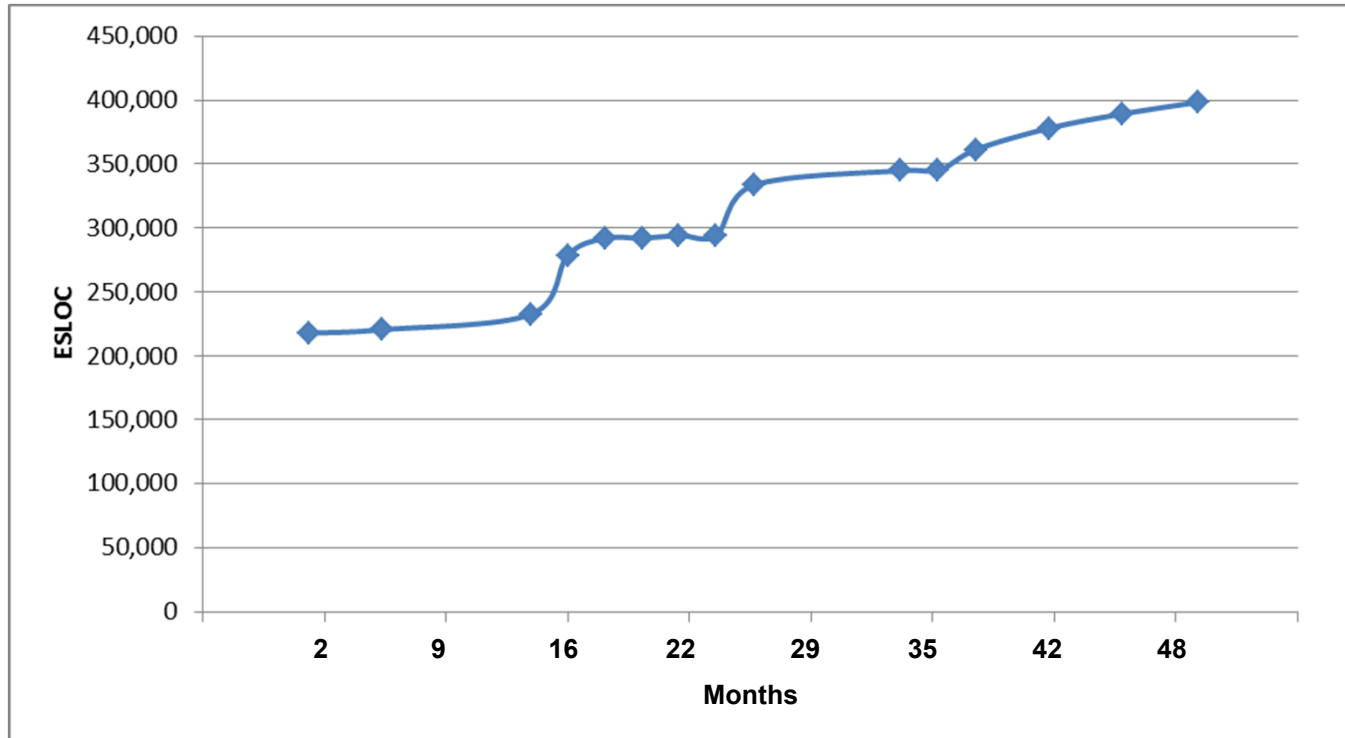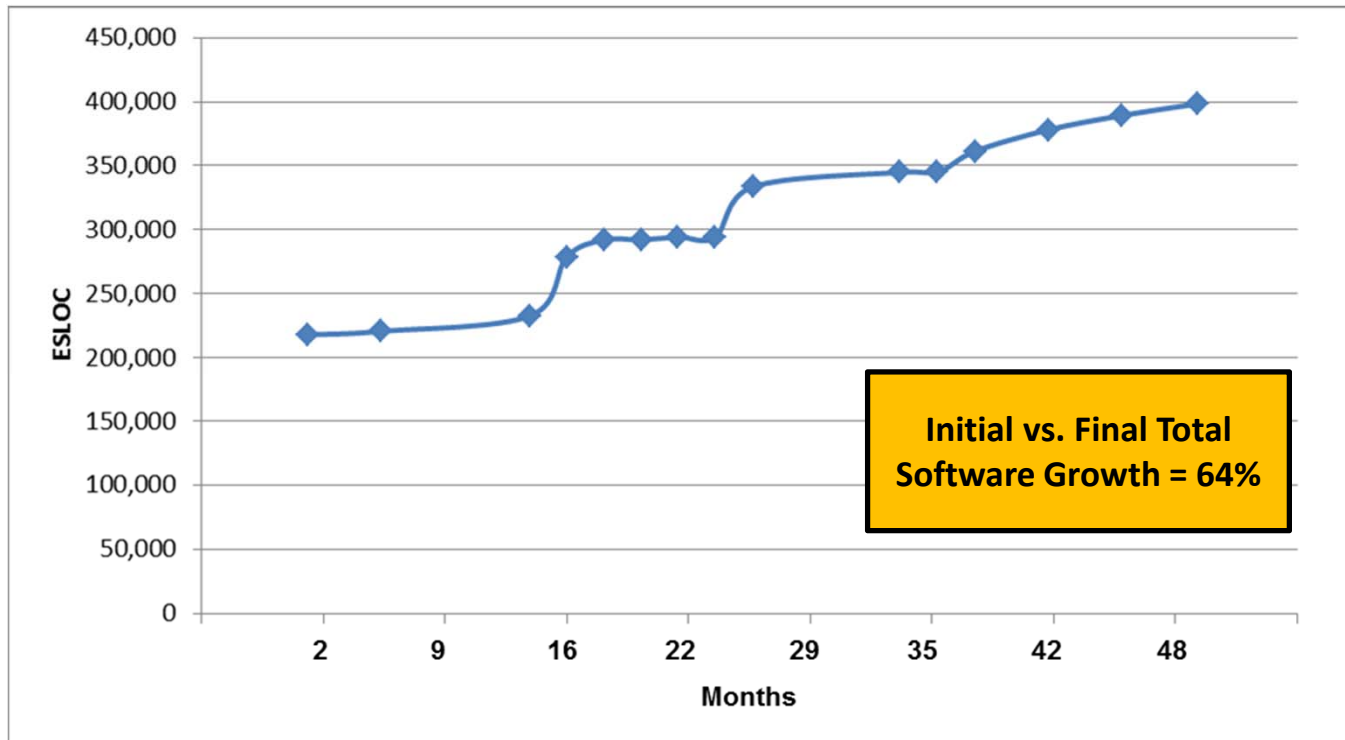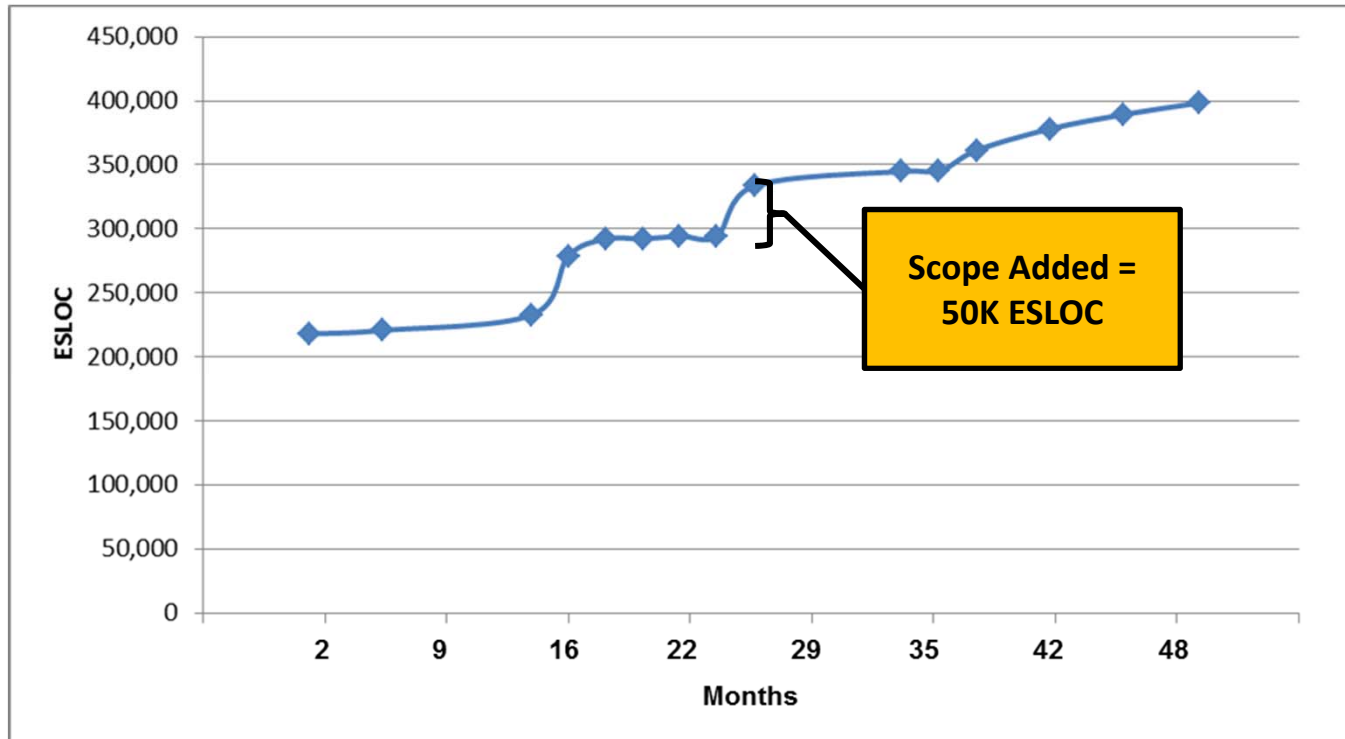- ❑ Software program: ~2000K DSLOC

# Pure vs Total Growth Program 4 (cont'd)

Initial vs. Final Total Software Growth = 64%

Program Description

- ❏ **Real time**
- ❏ **Command and control**
- ❏ **CMS upgrade**
- ❏ **Software program: ~2000K DSLOC**

Pure vs Total Growth Program 4 (cont'd)

Scope Added = 50K ESLOC

Program Description

- ☐ Real time
- ☐ Command and control
- ☐ CMS upgrade
- ☐ Software program: ~2000K DSLOC

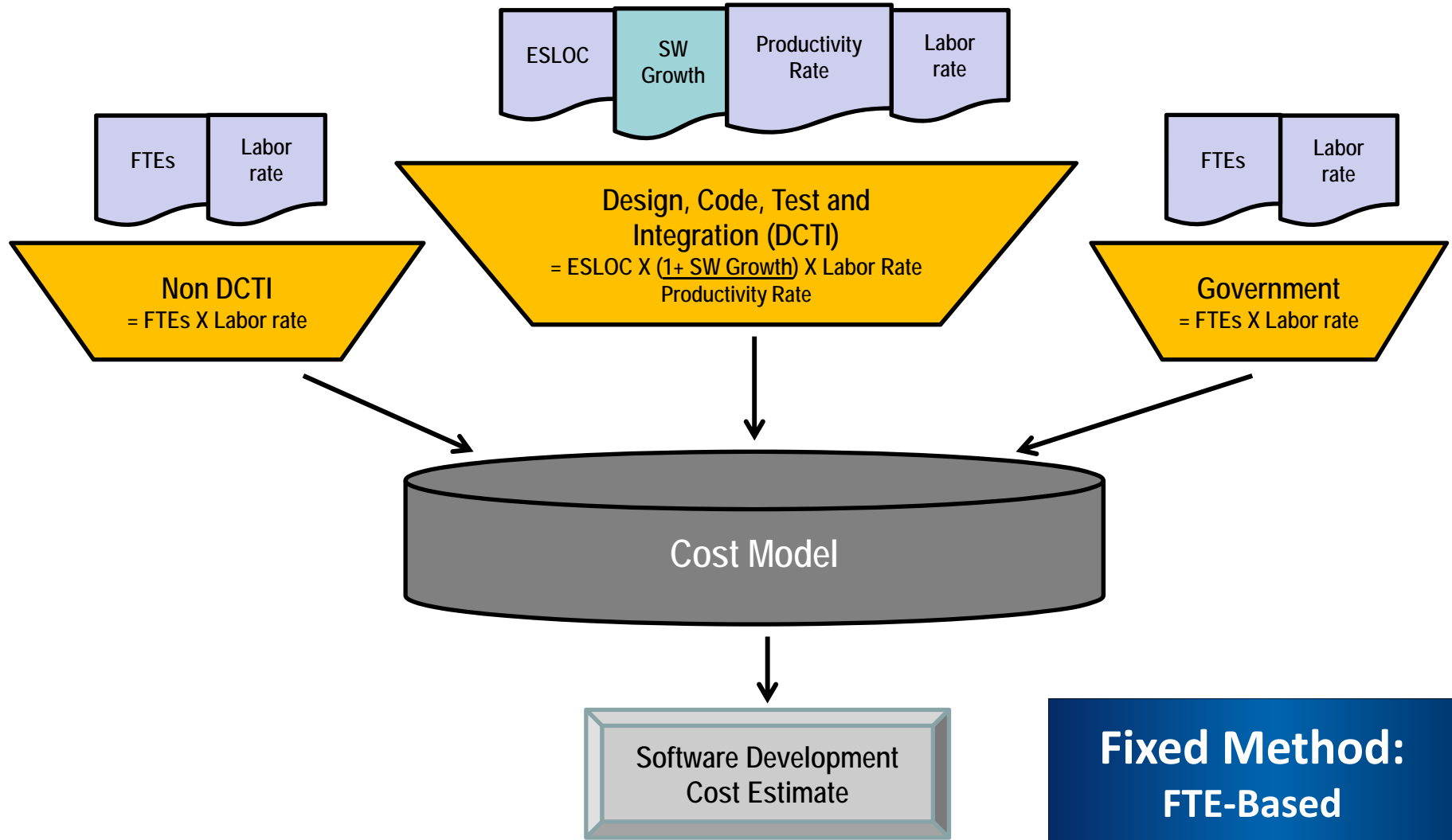| Pure Growth	46%
Scope Growth	18%
Total Growth	64%

Pure vs Total Growth Comparison
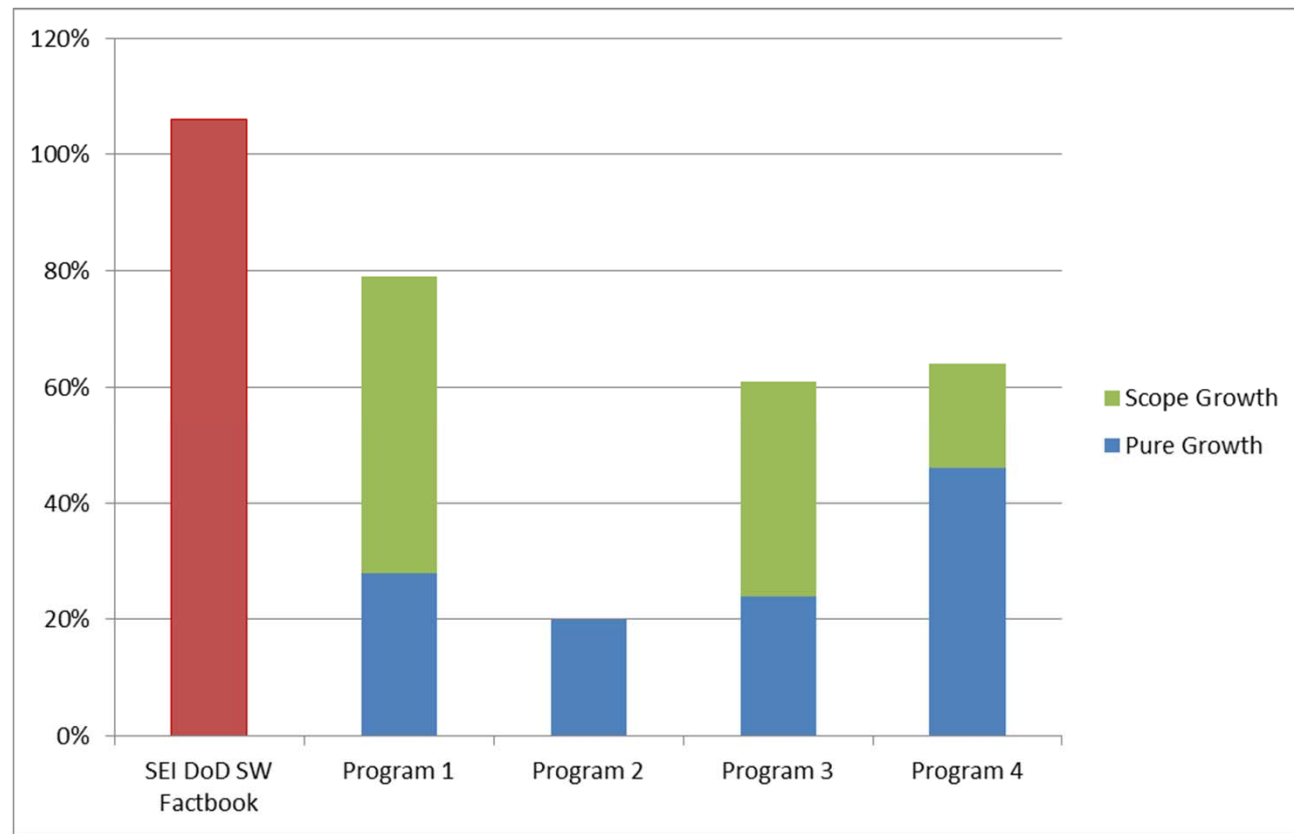
**Scope growth is likely a large contributor to total software growth.
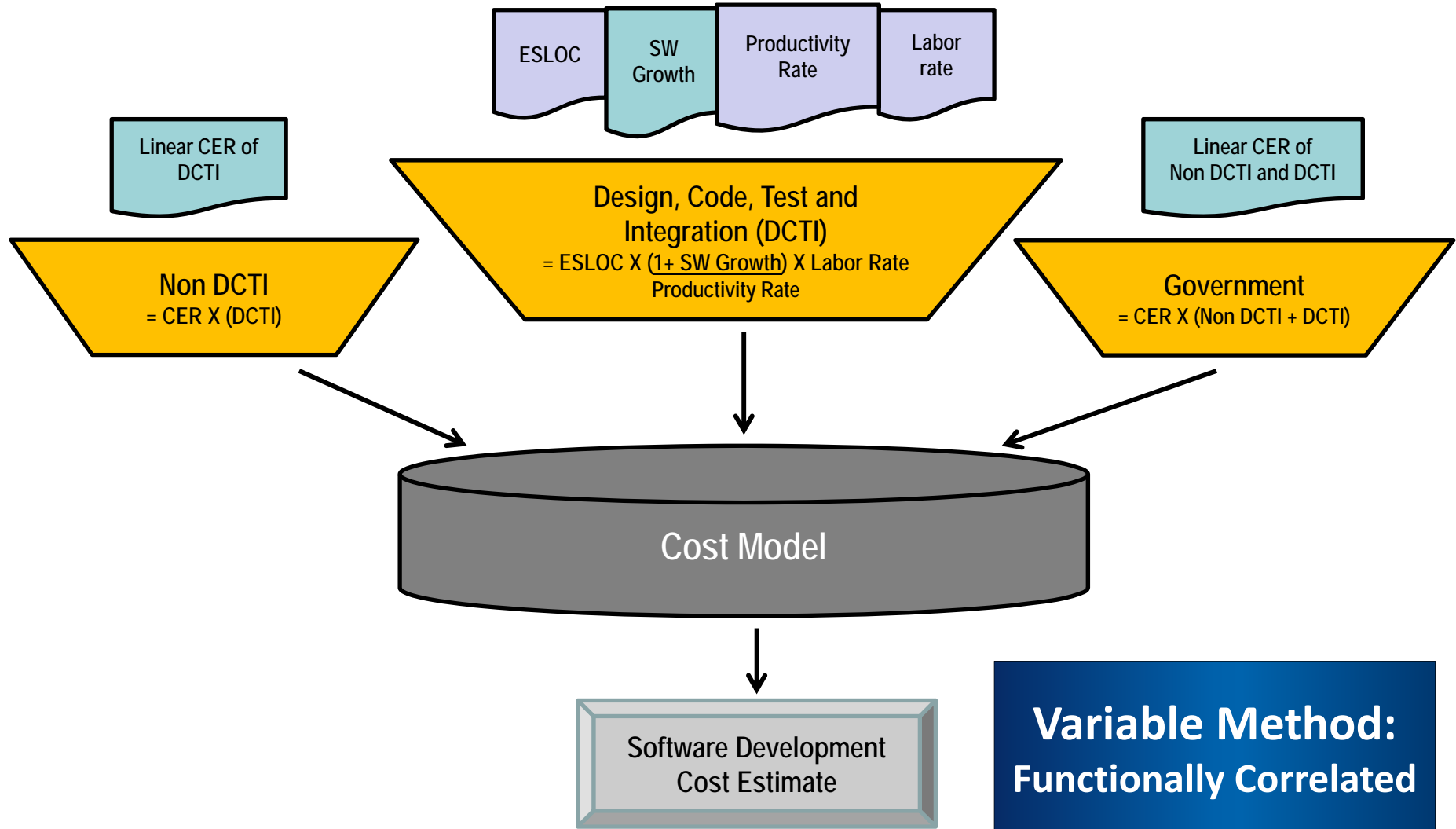What is the magnitude of this difference on software cost estimates?**

Example Software Development Model: Fixed Method

ESLOC | SW Growth | Productivity Rate | Labor rate

FTEs | Labor rate

FTEs | Labor rate

Design, Code, Test and Integration (DCTI)
$$= \frac{ESLOC \times (1+ SW\ Growth) \times Labor\ Rate}{Productivity\ Rate}$$

Non DCTI
= FTEs X Labor rate

Government
= FTEs X Labor rate

Cost Model

Software Development Cost Estimate
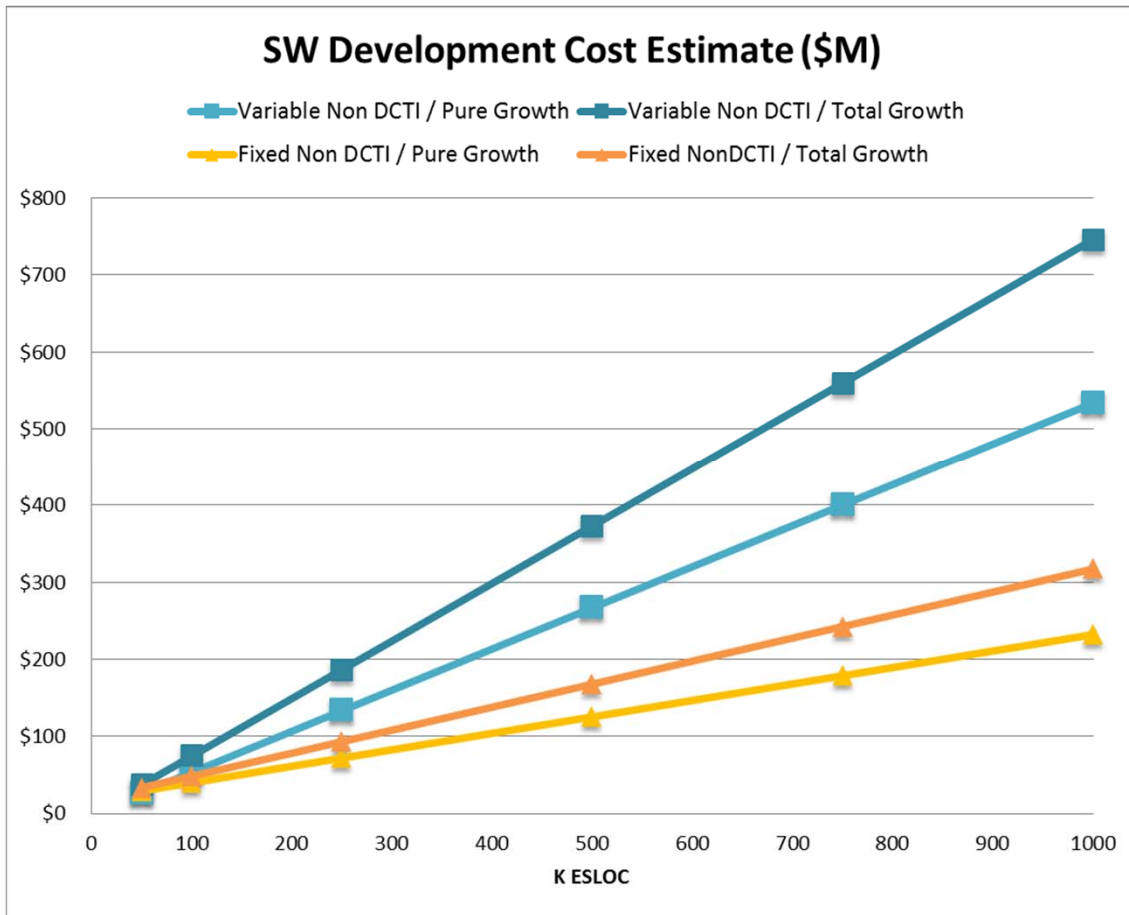
Fixed Method:
FTE-Based

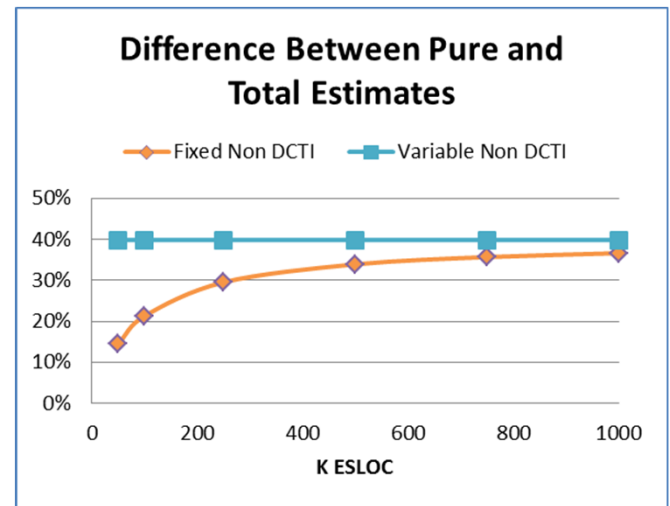# Example Software Development Model: Variable Method

Impact of Pure Growth on Model Results

❑ **Given the large impact on a software development estimate, documenting whether pure or total growth is used is critical**

Using total vs. pure software growth can result in 15–40% difference in software development cost

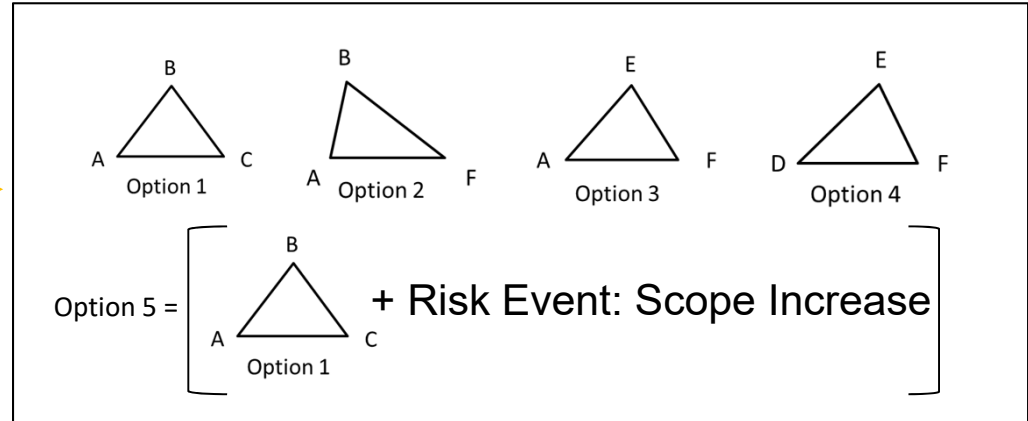# Impact of Pure Growth on Uncertainty

Risk applied to variable method, with 50% probability

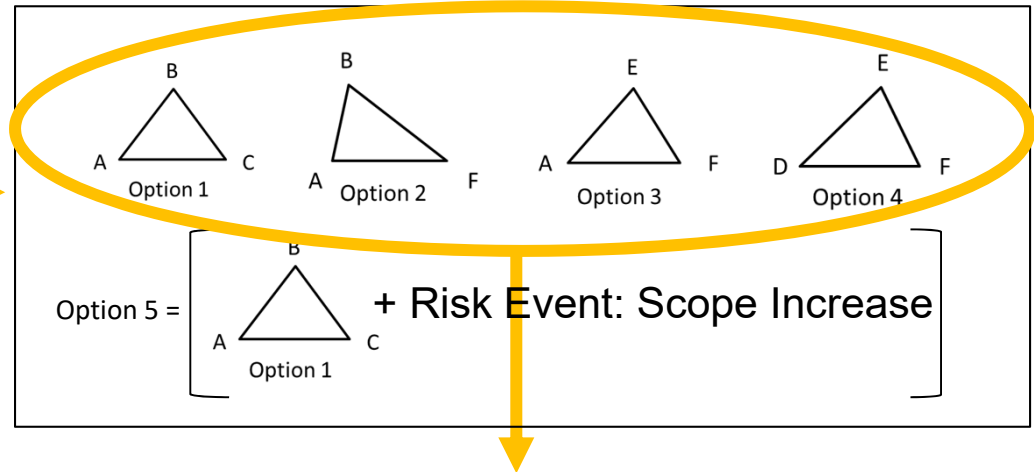|	Pure Growth	Total Growth
Low	A (min)	D
Most Likely	B	E
High	C	F (max)

Some Options for Risk Distribution

Impact of Pure Growth on Uncertainty (cont'd)

Risk applied to variable method, with 50% probability

	Pure Growth	Total Growth
Low	A (min)	D
Most Likely	B	E
High	C	F (max)

Some Options for Risk Distribution

Option 5 = [Option 1 triangle] + Risk Event: Scope Increase

SW Development Cost Estimate ($M)

5%

30%

> **Your choice of pure or total software growth and risk boundaries *will* impact your estimate and should be documented.**
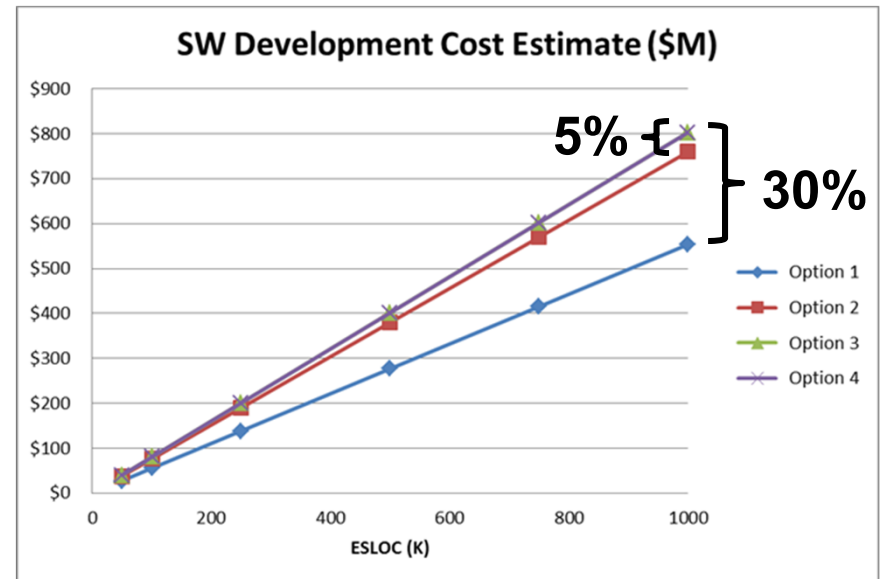
Summary

❑ **Pure growth + Scope growth = Total Growth**

❑ **Initial vs final comparisons of ESLOC measure total software growth**

– Examples demonstrate that scope growth likely contributes a large amount to total software growth and to variance in the historical dataset

❑ **The choice of pure vs total software growth can impact your software development model 15–40%**

– Given the impact, it is crucial to document your assumption on what is included

– Using total software growth without adjustment is equivalent to assuming estimate includes software scope growth

❑ **The choice of risk boundaries will impact your software development estimate**

– It is essential to document your risk boundaries and assumptions to support them.

Conclusion

Questions,

Answers,

and Discussion

NSWCDD V11

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BACKUP

Model Inputs

DCTI Inputs		Value
ESLOC	=	50000 or otherwise
ESLOC Total Growth	=	0.79
ESLOC Pure Growth	=	0.28
Productivity Rate (ESLOC/hr)	=	1.2
Non-DCTI Inputs		
Contractor Fixed (FTEs)	=	40 or otherwise
Contractor Variable	=	DCTI$
Government Inputs		
Government Fixed	=	0.25*Fixed Non DCTI
Government Variable	=	0.25 * Total Contractor estimate
Other Inputs		
Labor rate ($ / hr)	=	200
Contractor hrs / year	=	1872
Government hrs / year	=	1800

Risk Inputs	Low	PE	High
L-Pure, PE-Pure, H-Pure (Option 1) =	0	0.28	0.56
L-Pure, PE-Pure, H-Total (Option 2) =	0	0.28	1.58
L-Pure, PE-Total, H-Total (Option 3) =	0	0.79	1.58
L-Total, PE-Total, H-Total (Option 4) =	0.1	0.79	1.58