Estimating Small Scale Software Integration Efforts with a Large Scale Code Base

International Cost Estimating and Analysis Association

Professional Development and Training Workshop

Atlanta, GA

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Introduction

- Case Study Overview
- Typical Software / Integration Considerations
- Challenge
- Existing Large Scale Code Base
- Integrating Small Scale Code
- Recommendation

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Case Study Overview

- Major defense acquisition program (aircraft)
- Currently in production
- Software upgrades ongoing
- Stakeholders skeptical about high cost of software integration

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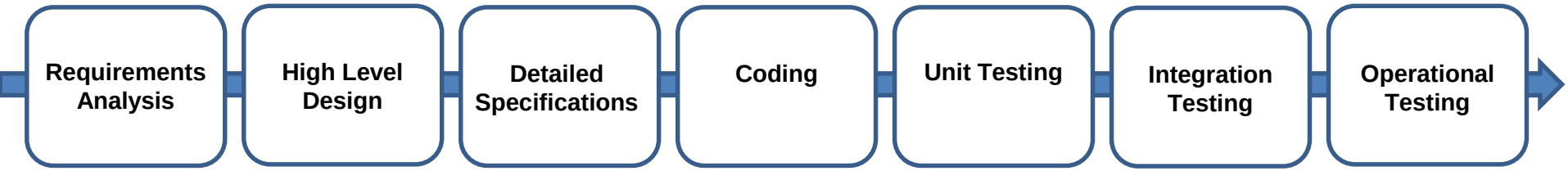
Software Process



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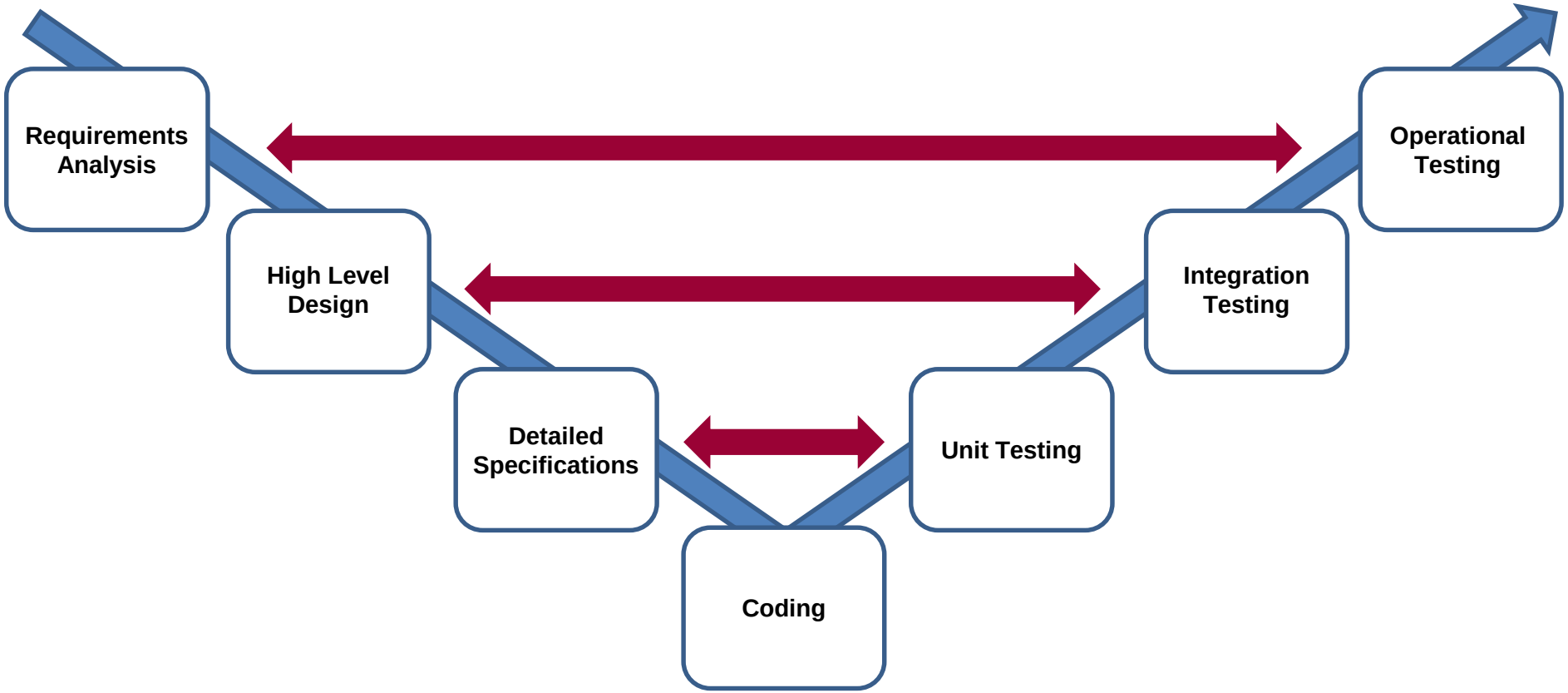
System Engineering "V" Application



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Software Parametric Estimation

Cost drivers:
Magnitude and Functionality

CERs:
Estimates material cost and labor requirements, generates schedule

Cost Object

- AKA "The Deliverable"
- Typically CSCI level
- Contains preset activities and resources

Activities

- Work to be done to create deliverable
- Each activity contains one or more assigned resources

Resources

- Anything you spend money on when performing activities
- Labor hours and material dollars

Effort by Activity & Resource × *Resource Rates & Activity Adjusters* = **Program Costs by Activity & Resource**

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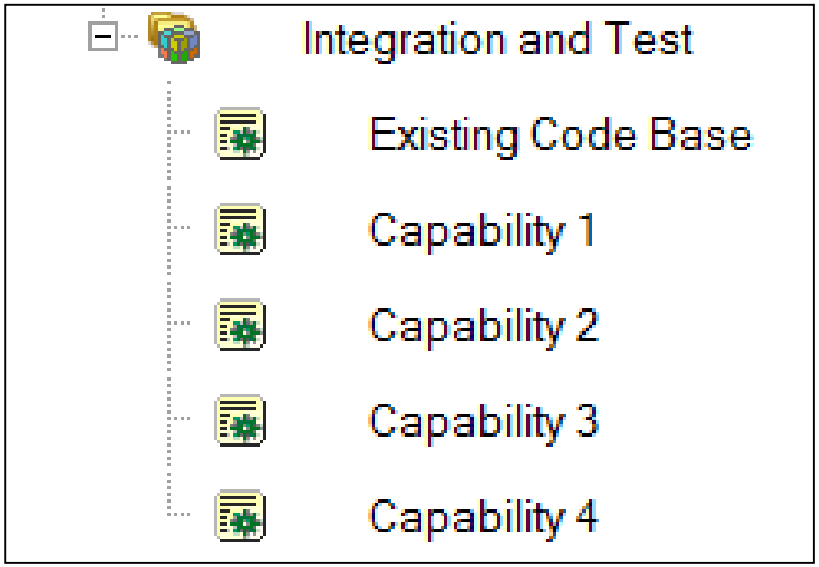
Modeling Typical Software Efforts

- Integration activities
  - Requirements Definition and Analysis
  - System Design
  - Software Integration and Test
  - Hardware – Software Integration and Test
  - Operational Test and Evaluation
- Software activities
  - Software Requirements Analysis
  - Software Design
  - Code and Unit Test
  - Software Integration and Test
  - Software Qualification Test



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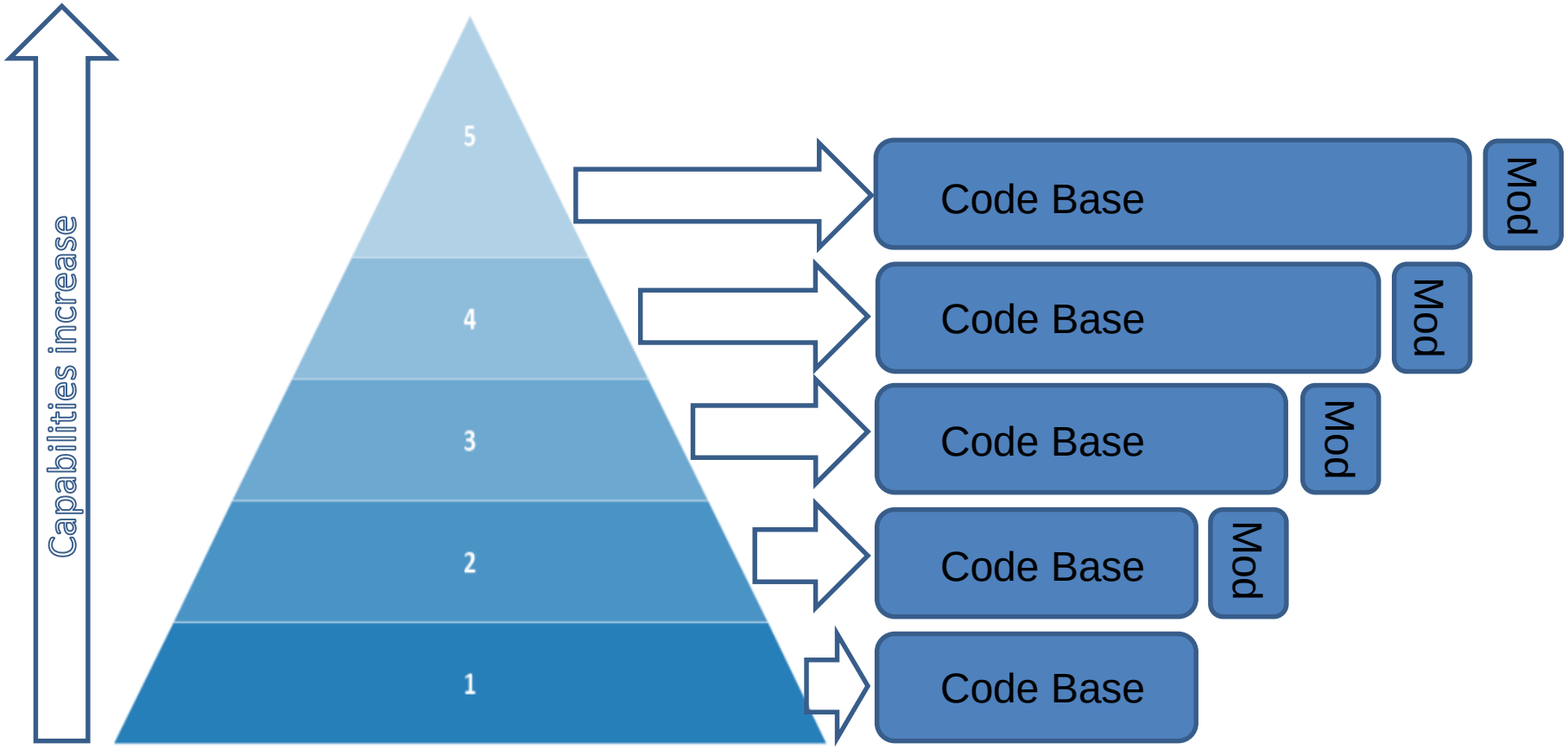
Case Study Scenario

- Initial code base is continually built upon with new capabilities
- As software increments build upon each other, code base increases



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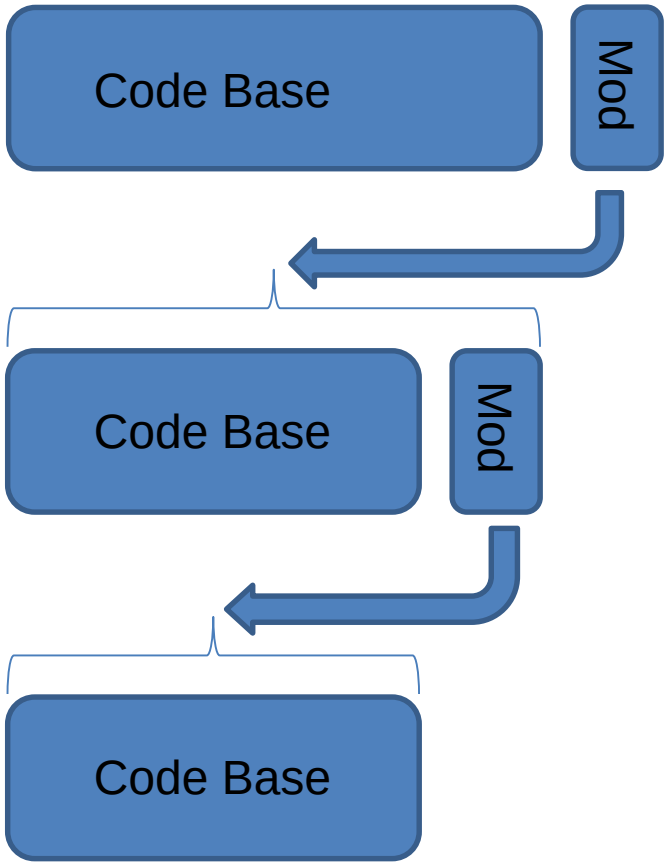
Case Study Overview

- We can readily estimate the cost of the new capability
- As code base increases, cost of integration and testing grows



In reality, we rarely integrate ONE mod at a time. More likely, several mods are packaged together to comprise an upgrade.

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Challenge

- It has become common to estimate capabilities as “a la carte”
- Overarching costs and integration efforts are allocated to capabilities, artificially increasing cost per capability
- Stakeholders view options as “swappable” or having linear cost impact
- If we eliminate 50% of the capabilities from an upgrade…
  - What happens?
    - *Decrease 50%?*
    - *Decrease 10-20%?*
    - *Increase X%?*
  - All the above!

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Impacts

- What decreases 50%?
  - Capability
  - NOT cost!
- What decreases 10-20%?
  - Total cost
- What increases?
  - Cost per capability

- Why doesn't cost decrease linearly with reduction in capabilities?
- Answer: Software integration effort with large existing code base is heavily dependent on TOTAL (not incremental) size and complexity

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Impacts

- Three scenarios, three different requirements per capability

Scenario	Hours	Percent of Total
Integration – 1M Existing LOC	128773	74.9%
Capability 1 – 15K LOC	10778	6.3%
Capability 2 – 15K LOC	10778	6.3%
Capability 3 – 15K LOC	10778	6.3%
Capability 4 – 15K LOC	10778	6.3%
Total Hours	**171883**	100.0%
Average Hours per Capability	**42971**	

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Impacts

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Scenario	Hours	Percent of Total
Integration – 1M Existing LOC	122672	85.1%
Capability 1 – 15K LOC	10778	7.5%
Capability 2 – 15K LOC	10778	7.5%
Total Hours	**144227**	100.0%
Average Hours per Capability	**72113**	

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Impacts

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Scenario	Hours	Percent of Total
Integration – 500K Existing LOC	63817	59.7%
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Impacts

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Total Hours	**106927**	100.0%
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-16.1% Hrs

+67.8% per Capability

-37.8% Hrs

-37.8% per Capability

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Integrating Small Code

- Whether integrating one capability or fifty, large code base must be tested to ensure operability
- Effort to "re-test" existing large code base exists without regard to number or size of capabilities added
  - Depends on integration impact of new capabilities!

New Capabilities

Integration

Code Base

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Recommendations

- Educate stakeholders on integration, affected by:
  - Size of existing code base
  - Integration complexity of individual capabilities
  - Size and number of capabilities
- View integration as a "fixed cost" or even as a separate capability

***Cost** = f(Software Size, Integration Complexity)*

***Software Size** = f(Total Qty of New, Adapted, Reused Code)*

***Integration Complexity** = f(Developer Skill, Integration Scope)*

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Recommendations

- Accurately describe all drivers to integration
  - Size
    - *New vs. Reused vs. Adapted/Modified*
    - *Design Repeat*
  - Complexity
    - *Functionality of new capabilities*
    - *Functionality of impacted code base*
  - Skill
    - *Same experience between developers of original code base and new capabilities?*
    - *Was original code designed with "expansion" in mind?*
  - Scope
    - *Do additional capabilities really impact entire code base?*
    - *Can impacts be isolated to determine true need for regression testing?*

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Recommendations

- This is not all bad news
- Opportunities exist for cost savings
  - Efficient planning of modification activities at depot
  - Consolidate / reduce number of mod increments
  - Plan for integration in initial architecture
- Integration issues can be applicable for hardware mods as well

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Questions?

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Mr. Joe Bauer is a Solutions Consultant with PRICE Systems. He is the primary technical focal point for Air Force customers, providing training, mentoring, and consulting. In addition to the Air Force, Joe supports several defense contractors in the US, as well as key government / defense agencies in Canada. Joe joined PRICE Systems after twenty years of service in the US Air Force. Prior to joining PRICE Systems, Joe was the lead hardware estimator for the F-22 Raptor program office. Joe earned a Master of Science degree in Cost Analysis from the Air Force Institute of Technology in 2009. He earned an MBA from the University of Phoenix in 2005. Joe is also a Certified Cost Estimator / Analyst (CCEA) with the International Cost Estimating and Analysis Association (ICEAA). He can be contacted at Joe.Bauer2@pricesystems.com

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