
SIMPLE IS NOT NECESSARILY BETTER- Why Software Productivity Factors Can Lead to Bad Estimates

**Presented At:
38th Annual DoD Cost Analysis Symposium**

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The problem...

- The use of simple productivity factors to estimate software development cost injects unnecessary risk into the program.

SOFTWARE COST ESTIMATING USING THE PRODUCTIVITY METHOD

SIZE ESTIMATE
(ESLOC)

X

PRODUCTIVITY
FACTOR
(HRS/ESLOC)

=

ESTIMATED
EFFORT
(HRS)

- ESLOC (Equivalent New Source Lines of Code) is a weighted sum of New, Modified, Reused, etc. The weights used for modified and reused, etc are typically less than 1 which implies that the cost of this code is less than the cost of new code.
- In almost all cases, $ESLOC \leq \text{Delivered SLOC (DSLOC)}$

- Based on either an analogy to a similar completed project development or based on an average of productivities of several analogous projects
- Frequently reflects only 'core' software development activities (Design, Code, Unit Test)
- Method for computing ESLOC may differ from method used to compute estimated ESLOC

- Estimated effort will reflect the set of activities included in the productivity factor
- Additional activities (e.g. Requirements, System Integration & Test, etc) are estimated as a factor of the 'core' software development estimate

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Risks Associated With Productivity Factors

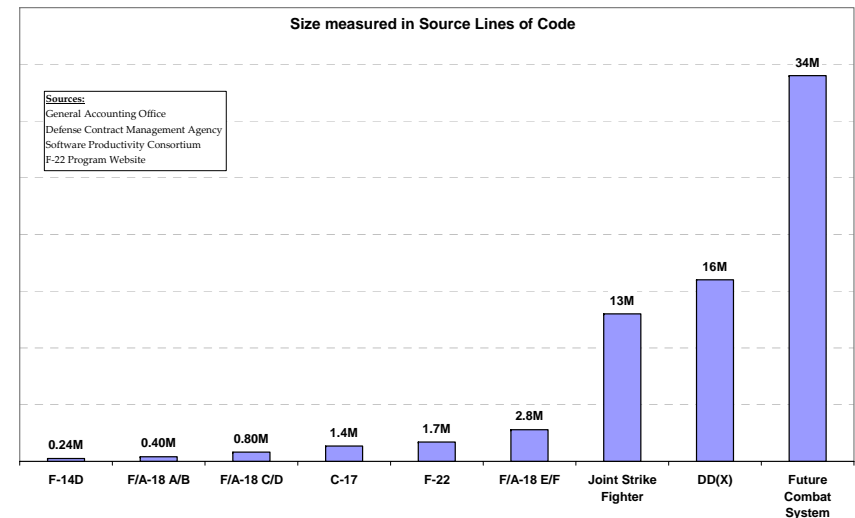
1. Linear extrapolation fails to account for diseconomies of scale
2. Error can be exacerbated when the estimate is treated discretely rather than as a whole system
3. May neglect to properly count ESLOC for incremental developments
4. Leads to erroneous use of adjustment factors to account for missing software development activities

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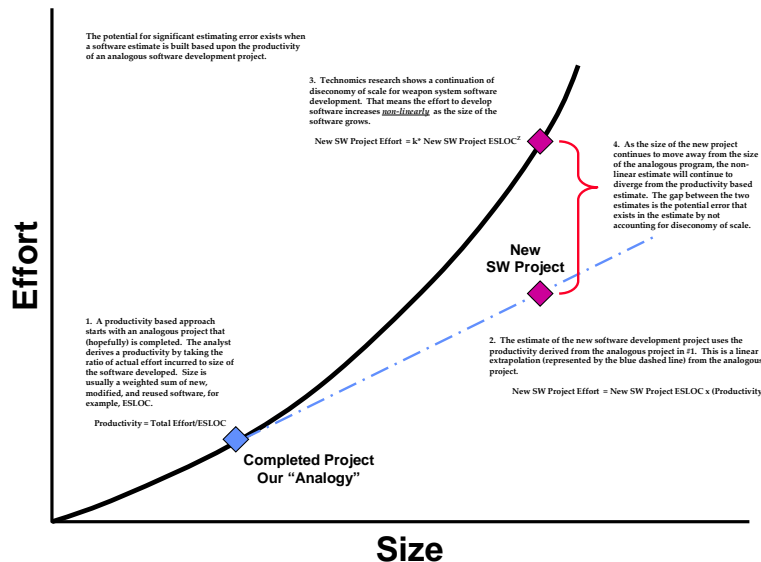
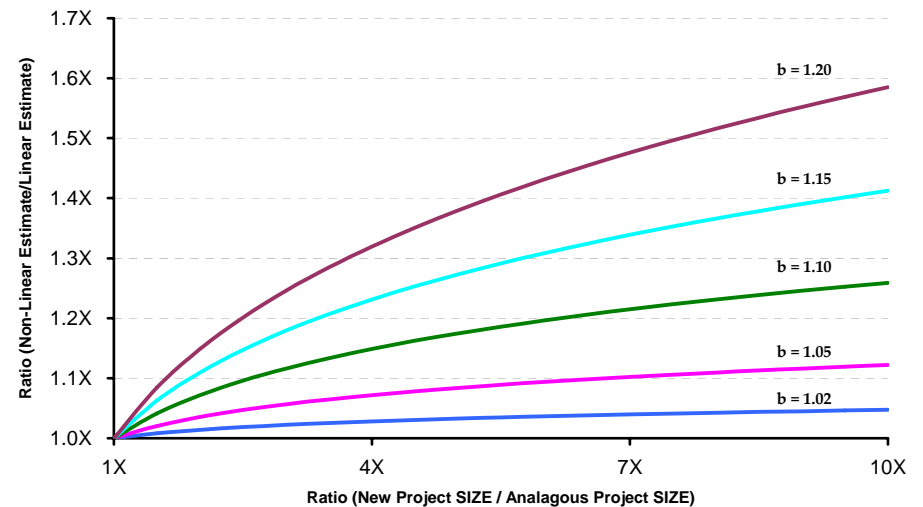
Risk #1: Linear Extrapolation

- Diseconomies of scale remains prevalent in DoD software projects
 - Effort = $a * \text{Size}^b$; $b > 1$
- Productivity methods use a linear relationship
 - Effort = $a * \text{Size}^1$
- Impact: a potentially large underestimation of effort when size of project is substantially larger than its analogy

Trend in DoD Weapon System Software Size



Potential Error Arising from the Use of a Linearly Extrapolated Productivity Analogy to Estimate SW Development Effort

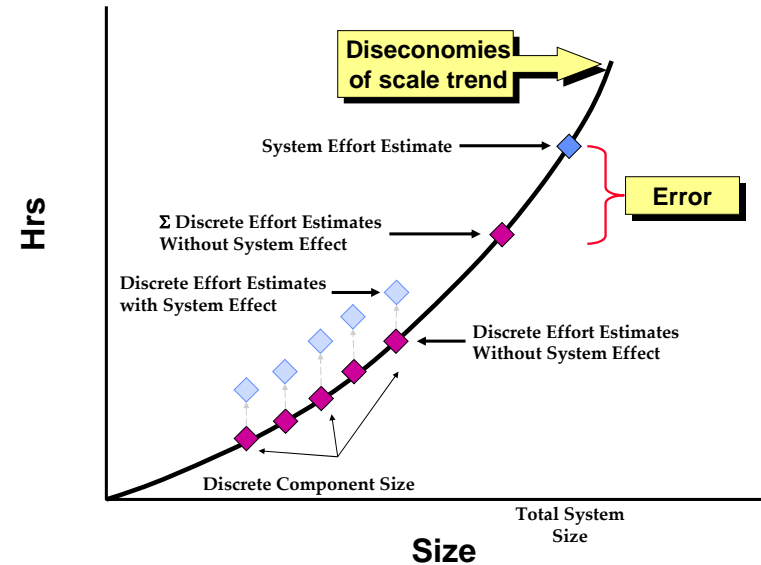


Simple productivity factors fail to reflect diseconomies of scale

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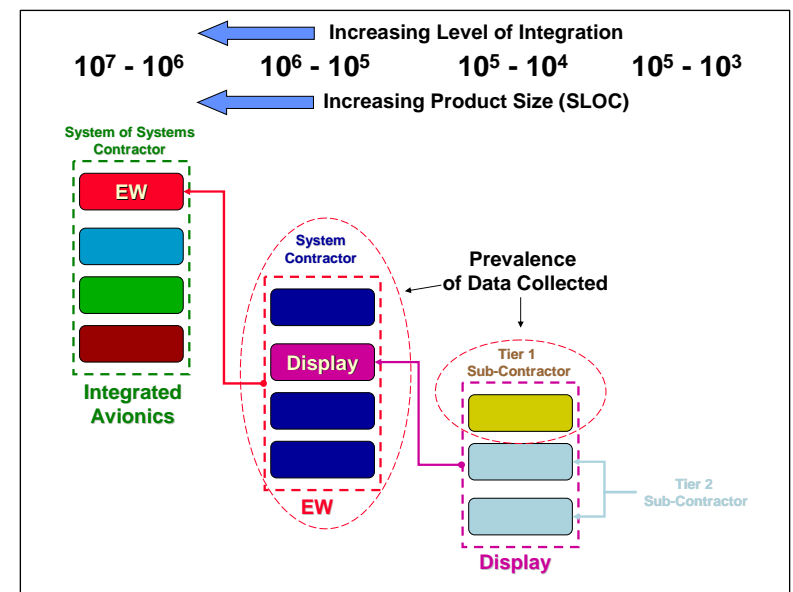
Risk #2: Ignoring System Effects

- The whole (i.e. system) is greater than the sum of its parts (i.e. components and sub-systems)



Existing DoD databases have perpetuated this problem

- Systems are broken up and sanitized to protect proprietary data
- Little if any insight into the number of development organizations by system
- Few (if any) total system data points

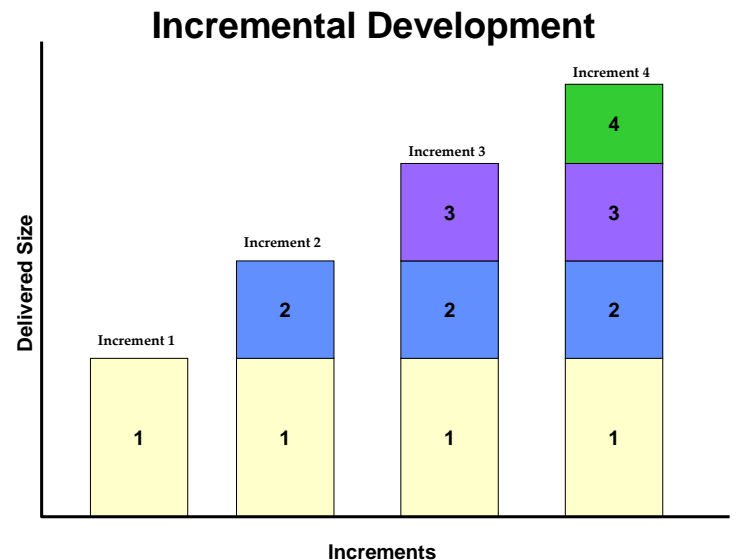
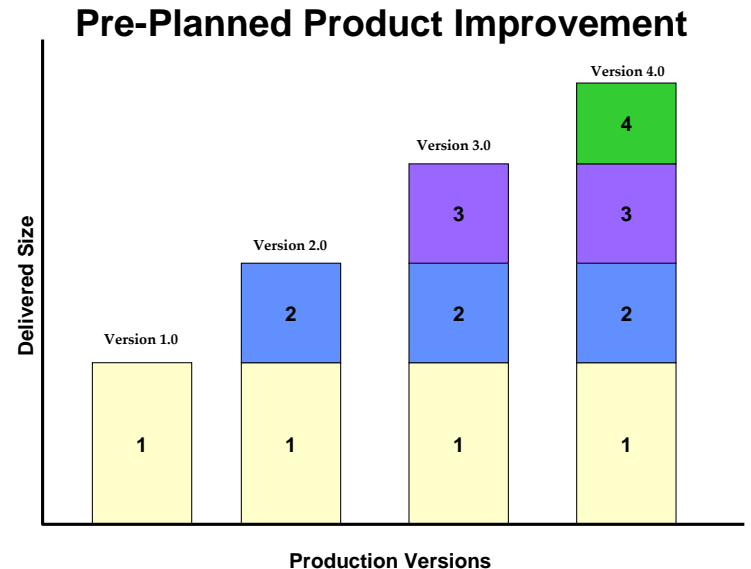


Current DoD data and analyses miss the 'big picture'

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Risk #3: Incremental Development

- Incremental development looks suspiciously like pre-planned product improvement
 - Successive deliveries of software are built upon pre-existing base of software
 - Cost to build, integrate and test the latest product build is a function of the product's cumulative size
- Estimates should incorporate pre-existing base in the ESLOC computation

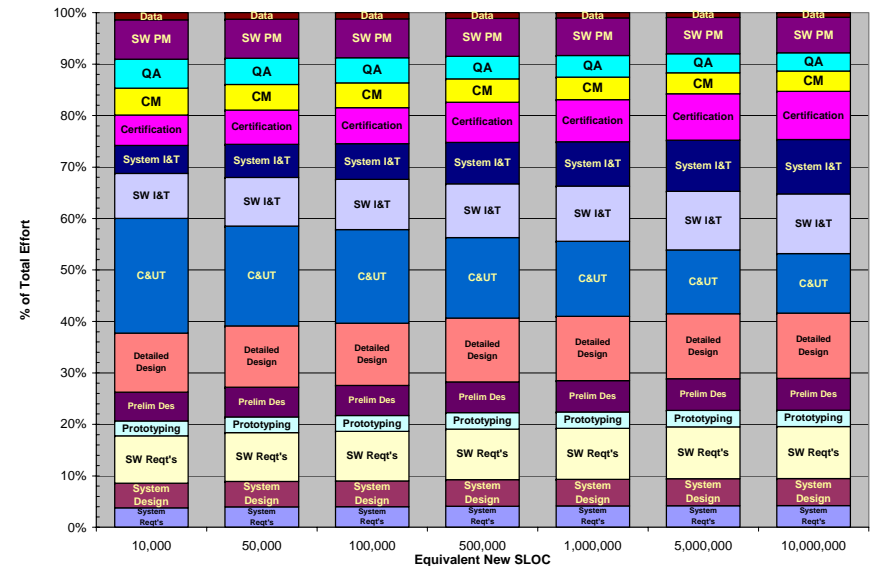
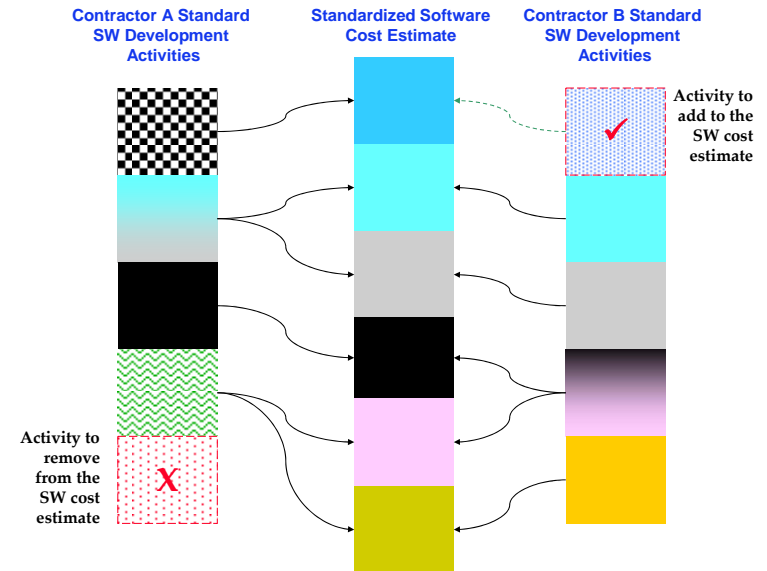


ESLOC computations must include cumulative reuse

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Risk #4: Flawed Adjustment Factors

- Developer's definition of software effort may not align with cost analyst's standardized definition of effort
- It is common practice to apply simple (fixed) factors to add or remove software development activities
- However, distribution of activities changes as the size of the software changes –*Result: too much (or too little) addition or removal of effort*



Application of fixed factors increases estimating error

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How to Mitigate These Risks

Problem	Our Approach
Linear Extrapolation	Use proper parametric estimating relationships
System Effect	Derive equations at the system level; specify equations below system level
Incremental Sizing	Include 'Carryover' in ESLOC computation
Flawed Adjustment Factors	Use parametric estimating relationships to add/remove activities

A new Technomics model (VERA) implements these approaches

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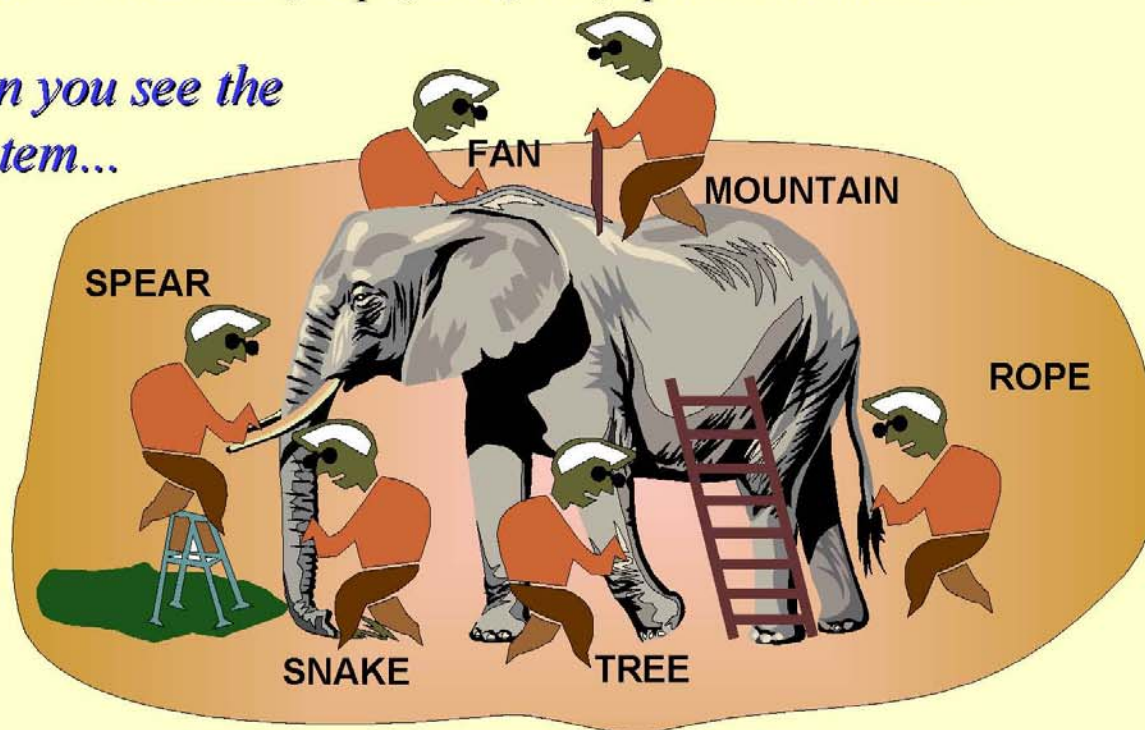
Final Thought

Source: "Engineering of Systems for Navy Interoperability", Version 5.8 dated April 2003 by Eric Honour, Honourcode, Inc.
<http://jax.acqconf.com/Presentations/Power%20Points/SE-Interop.pdf>

System Thinking

The 6 blind wise men think the elephant is a set of components consisting of a mountain, rope, tree, fan, spear and snake . . .

But when you see the total system...



... AN ELEPHANT IS AN ELEPHANT

Engineering of Systems for Navy Interoperability

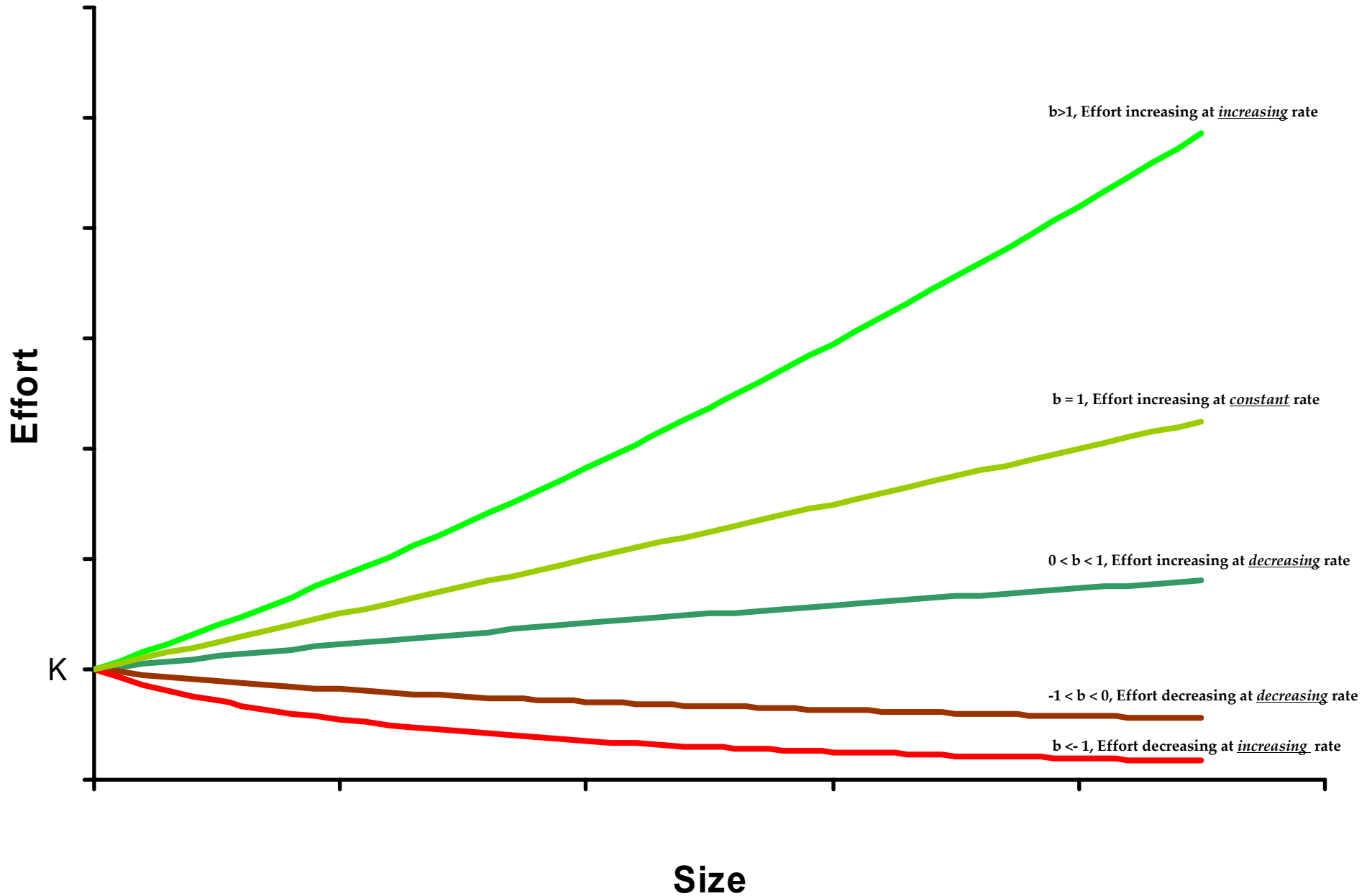
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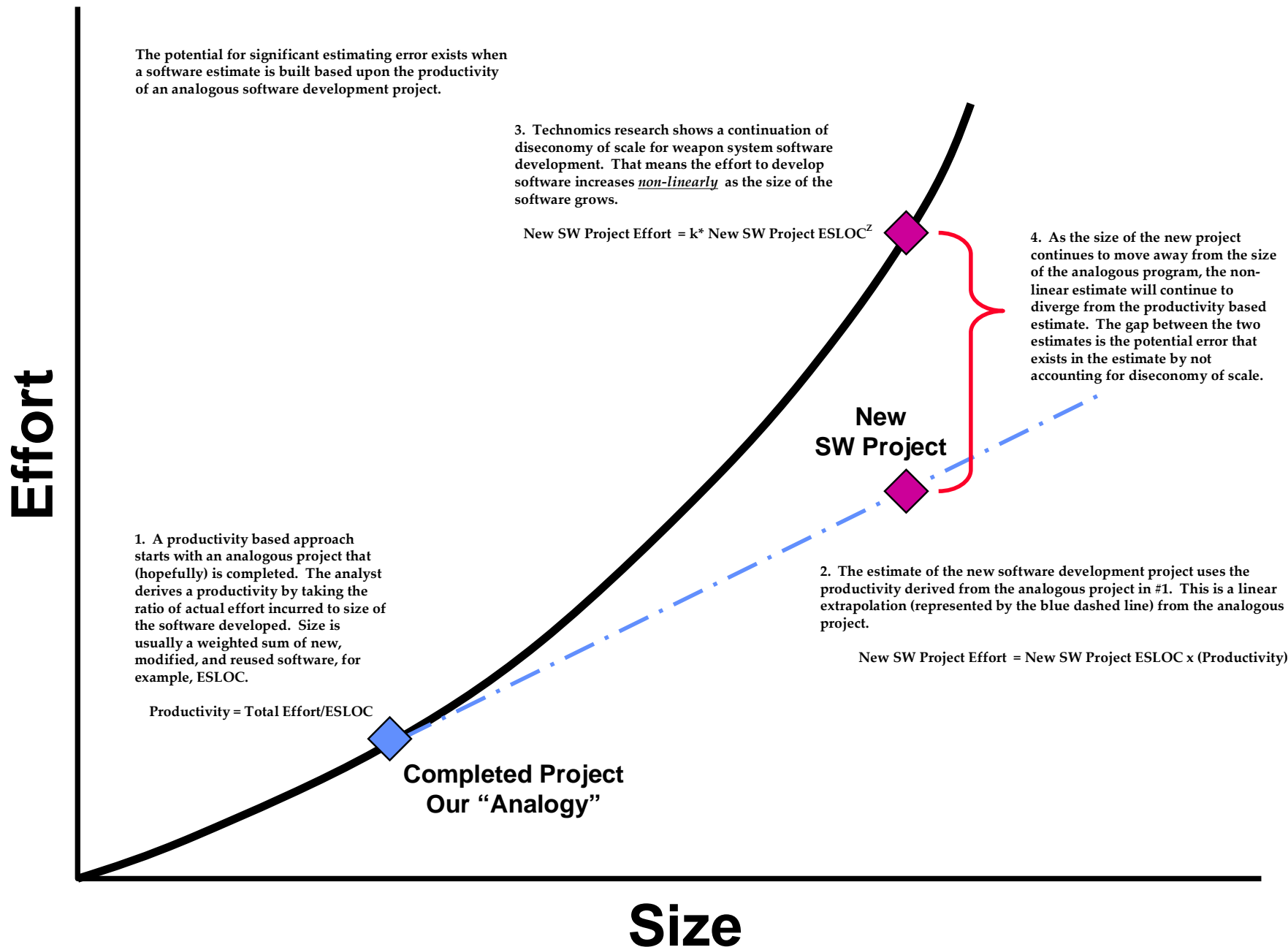
Hyperlink Graphics Slides

Graph of Effort = $K * SIZE^b$



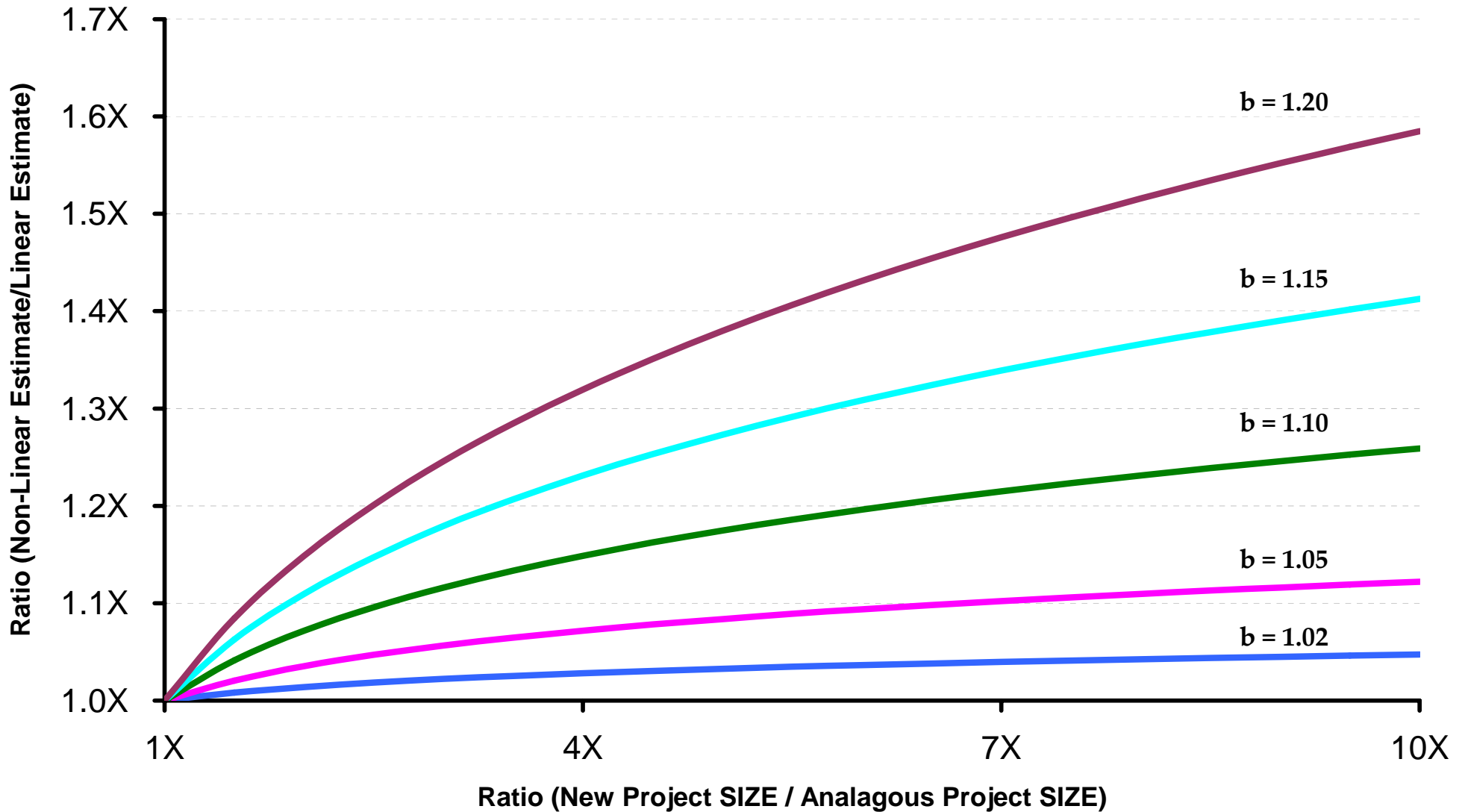
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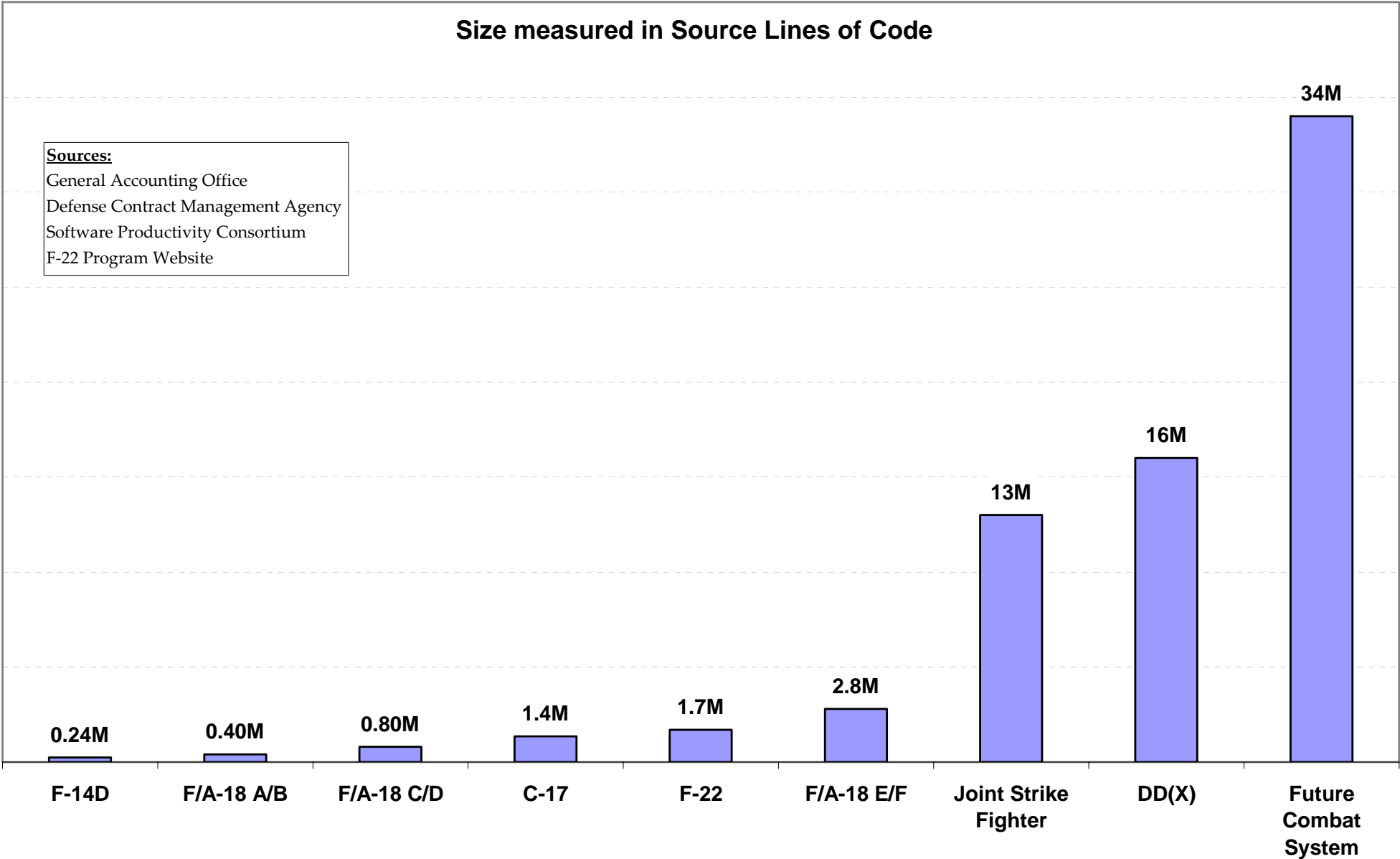
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Potential Error Arising from the Use of a Linearly Extrapolated Productivity Analogy to Estimate SW Development Effort

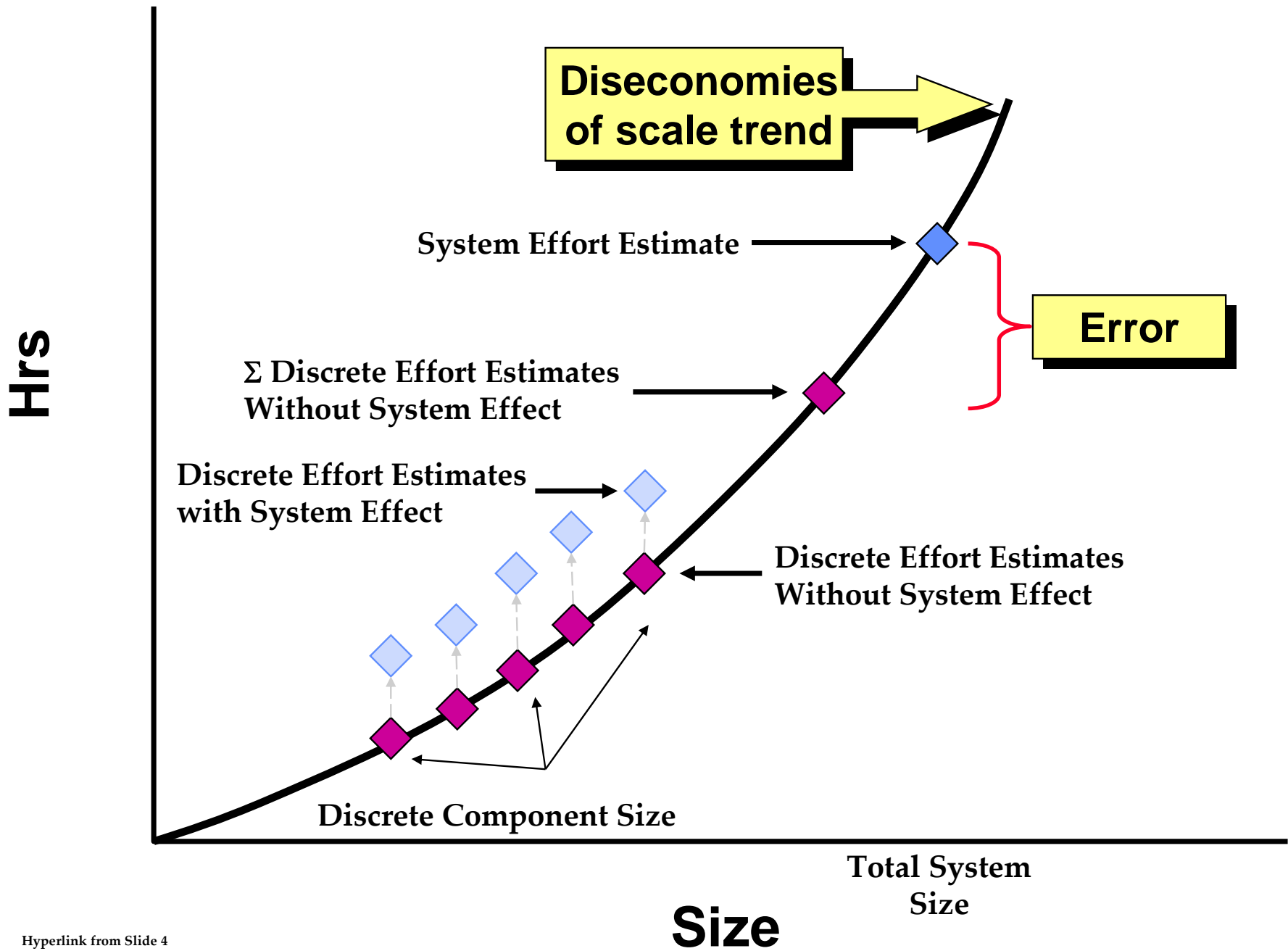


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Trend in DoD Weapon System Software Size

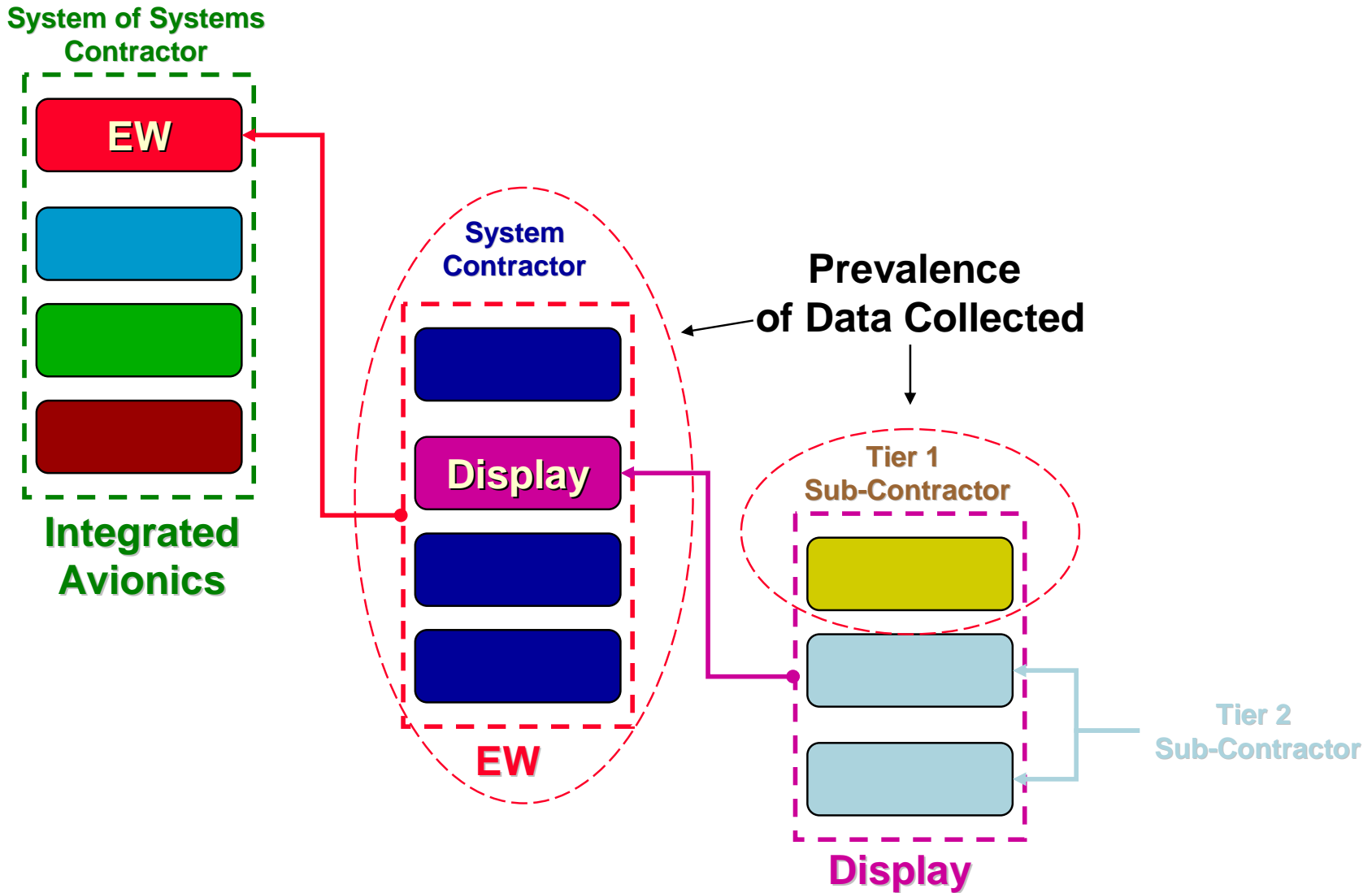


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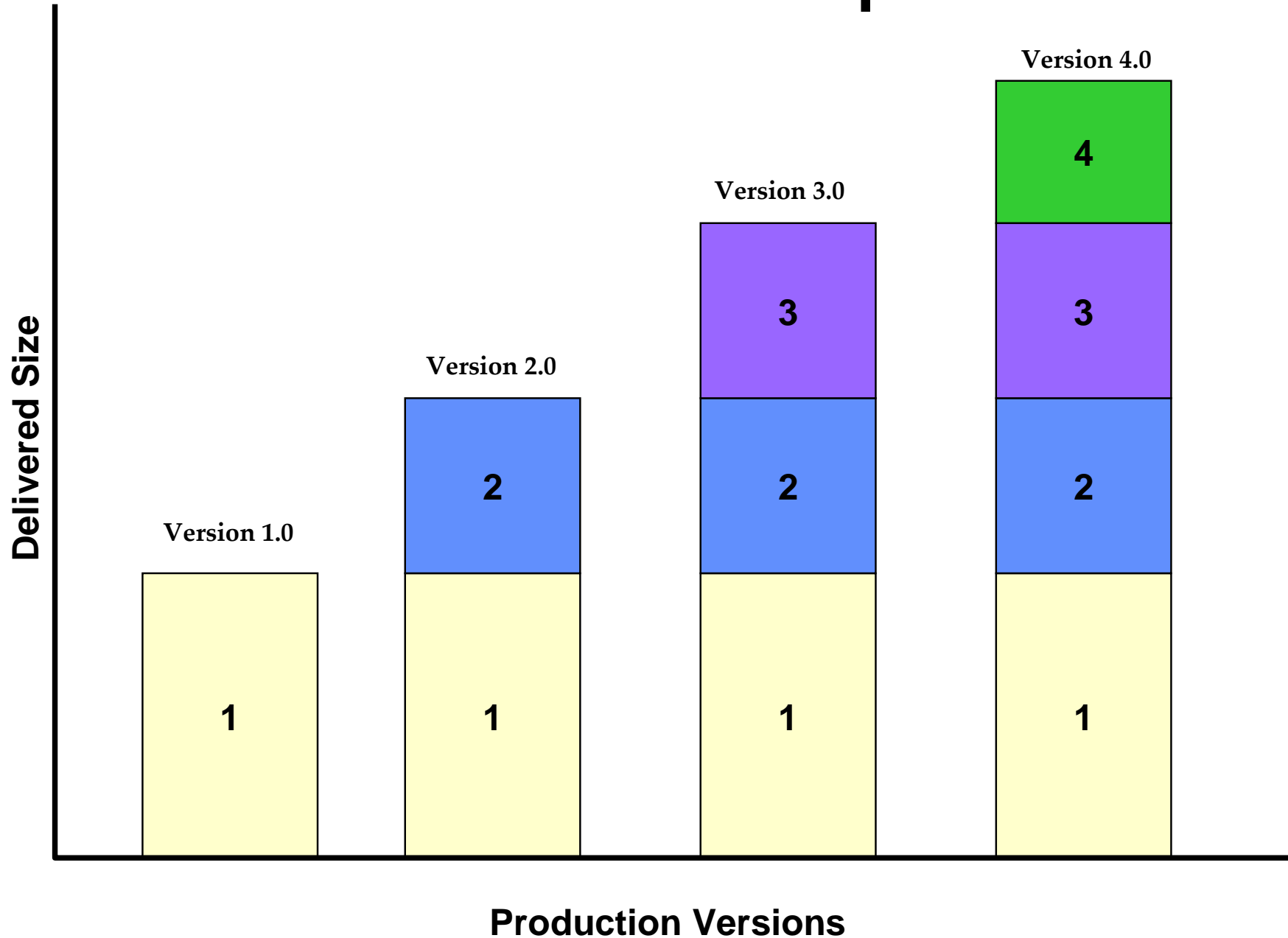
$10^7 - 10^6$ ← Increasing Level of Integration $10^6 - 10^5$ $10^5 - 10^4$ $10^5 - 10^3$
 ← Increasing Product Size (SLOC)



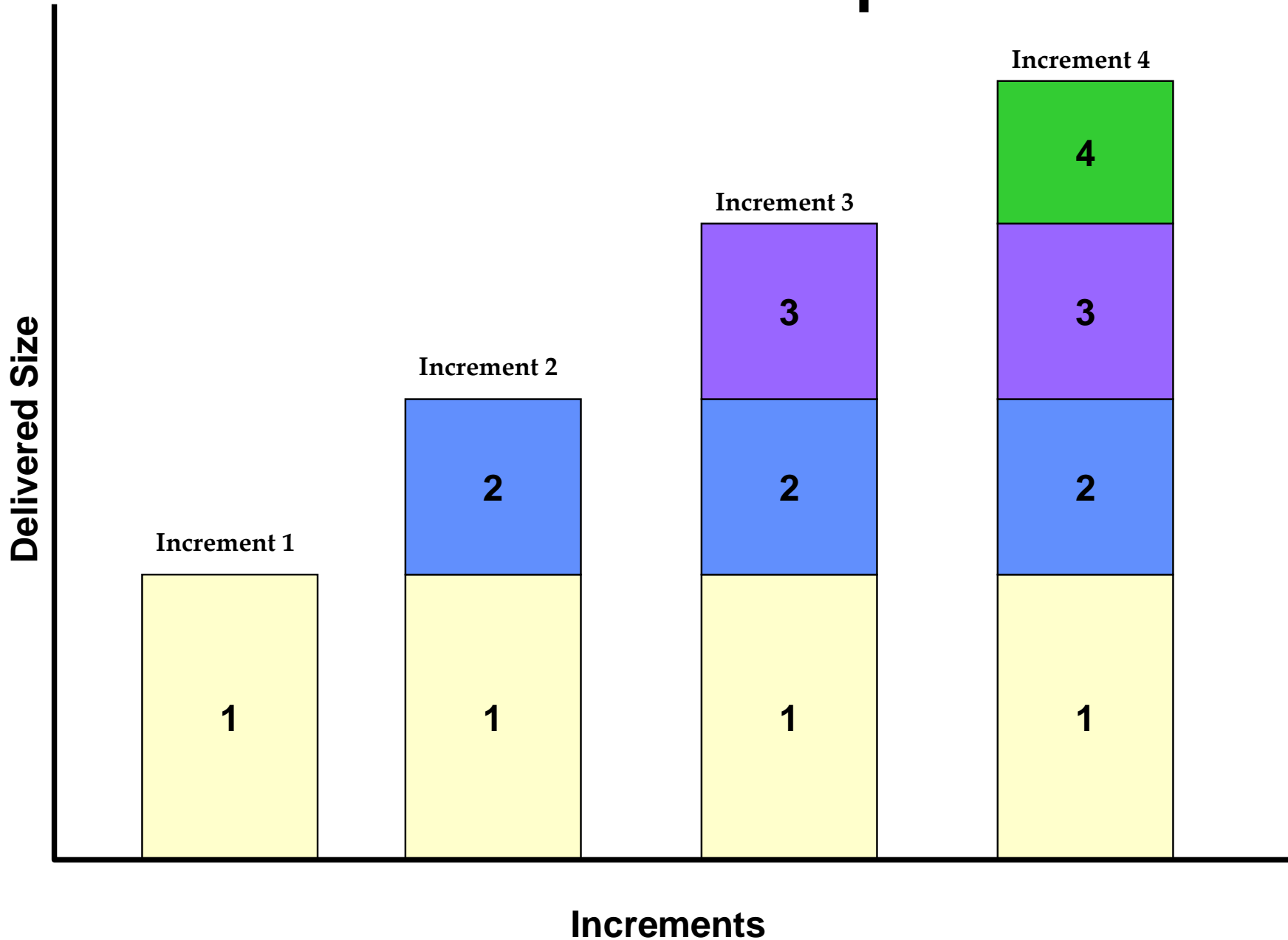
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Pre-Planned Product Improvement



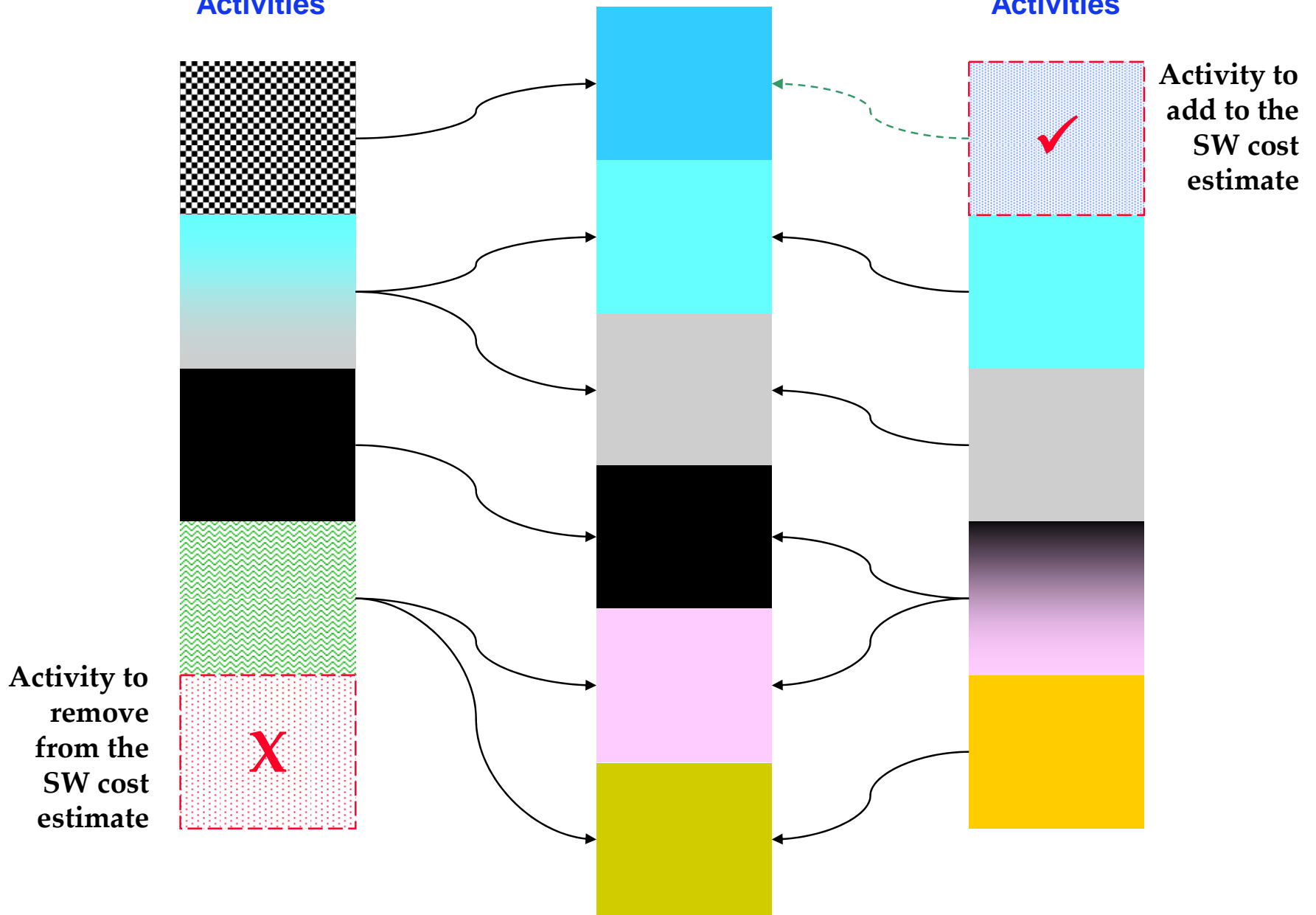
Incremental Development



Contractor A Standard SW Development Activities

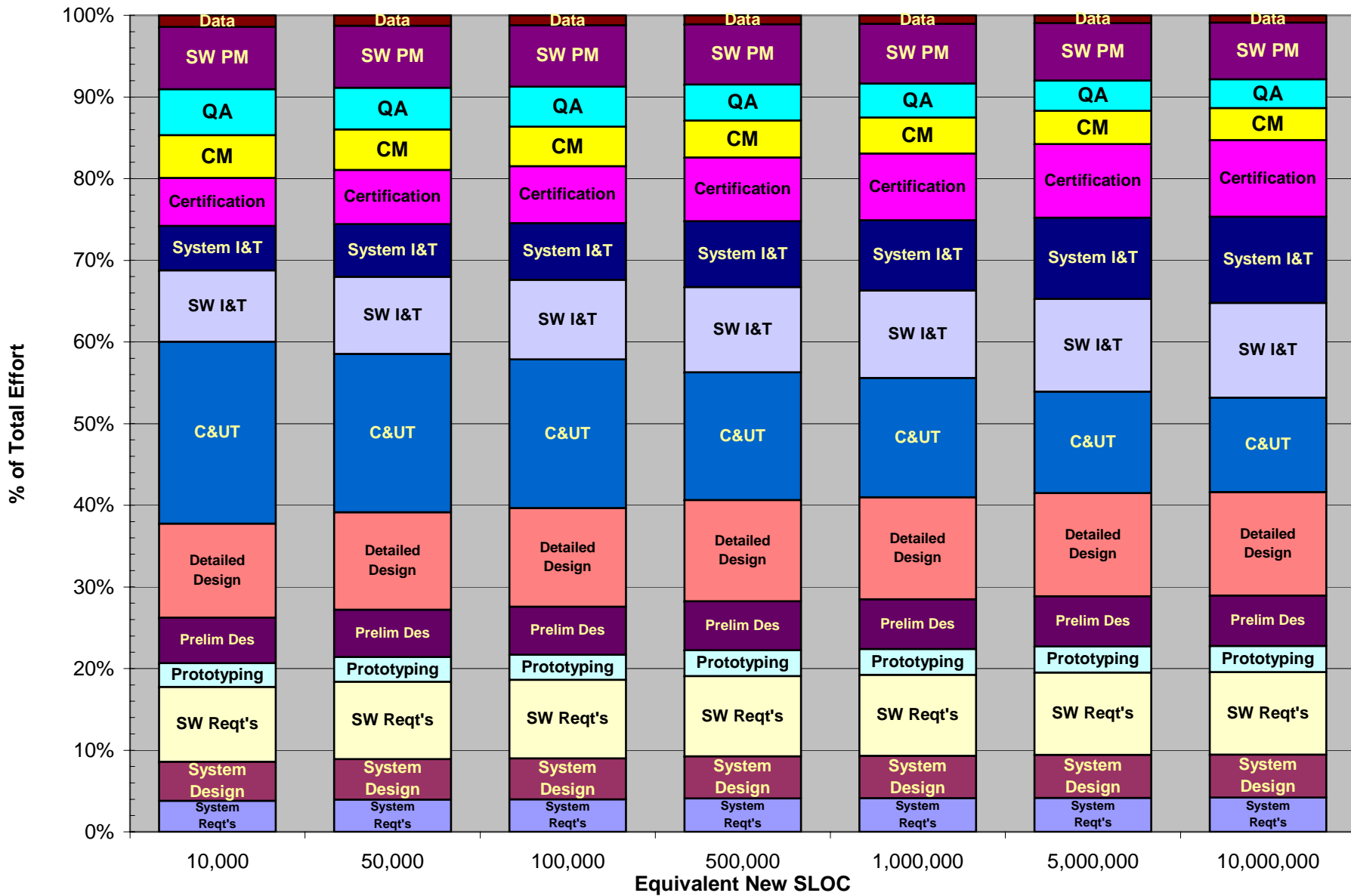
Standardized Software Cost Estimate

Contractor B Standard SW Development Activities



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