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Defense Acquisition Performance Assessment – The Recommendation for Time Certain Development: Architectural Considerations

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All I really need to know about estimation I learned in kindergarten and from Dr. Barry Boehm…

Agenda

- **Objectives**
- **Defense Acquisition Performance Assessment (DAPA) Recommendations**
  - ❖ What is DAPA
  - ❖ Recommendations to be discussed
  - ❖ The reasons behind Time Certain Development
- **March 14, 2007 Air Force Memorandum**
- **What is Time Certain Development?**
- **Confidence in a Software Estimate – The Cone of Uncertainty**
  - ❖ Estimating software size
  - ❖ The Fallacy of Seamless Size-Effort-Time Trade
  - ❖ Conceptual Trade Space for Architectural Options
- **Space-specific Considerations**
- **Accuracy Dependency on the Development Life Cycle Phase**
- **The Experts' Voices**
- **Conclusions**
- **Acronyms**
- **References**

Objectives

- Explain the context and background of the DAPA recommendation for Time Certain Development
- Explore the underlying estimation issues impacting successful implementation of the DAPA recommendation for Software-Intensive Systems
- Emphasize the importance of software architecture in software cost estimation

DAPA (Defense Acquisition Performance Assessment)

- **What is DAPA?**
  - ❖ The **DAPA project** is an integrated assessment of every aspect of military acquisition, including requirements, organization, legal foundations, decision methodology, oversight, and checks and balances
    - – It is a response to a 2005 DOD Directive by Mr. Gordon England, then Acting Deputy Secretary of Defense
  - ❖ The **DAPA report** is the result of this project
    - – Developed by a panel led by Lieutenant General Ronald Kadish (Retired), USAF
    - – 107 experts and 130 other government and industry acquisition professionals were interviewed
    - – The full report is available at [DAPA 2006]

DAPA Recommendations to be Discussed

- **Budget**
  - ❖ Transform and stabilize the Planning, Programming, Budgeting, and Execution process
    - – Adjust program estimates to reflect high confidence
      - – **High confidence programs defined as a program with an 80% chance of completing development at or below estimated cost**
    - – Major acquisition programs would be fully funded at a level that would cover the program from **Milestone A** through the first delivery of low rate production
- **The Acquisition Process**
  - ❖ Establish Time Certain Development as the preferred acquisition strategy for major weapons system development
    - – Time Certain Development adds "time" as a factor critical to the discussion of the need to balance cost and performance
    - – Deliver useful military capability within a constrained period of time
    - – Make time a KPP (Key Performance Parameter)

“Back to Basics” Air Force Directive

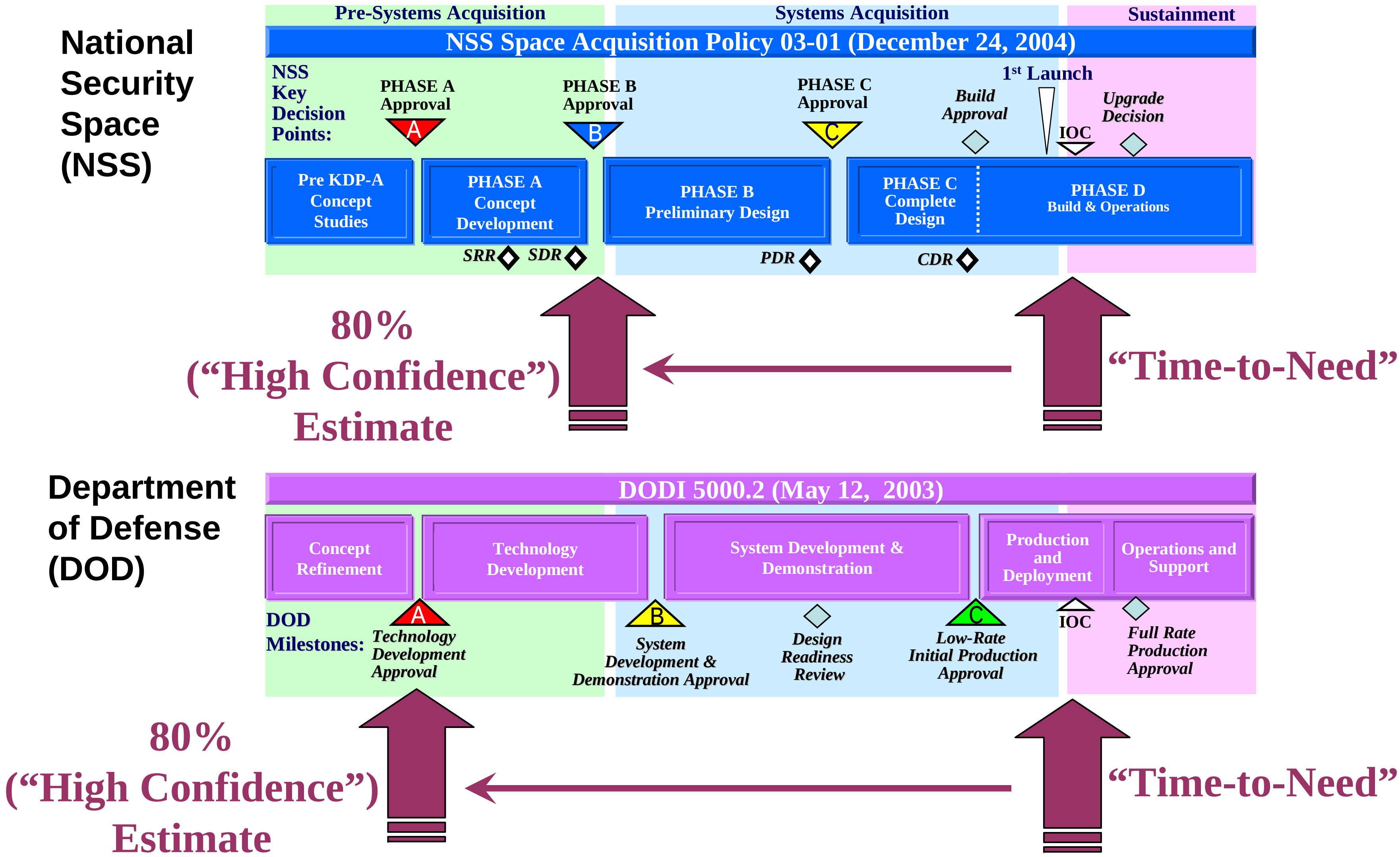
- **Relevant elements of the March 14, 2007 Memorandum by the Under Secretary of the Air Force***
  - ❖ Delivery times should be based on a Time Certain Development principle
    - – A specific time frame must be established in which a specific block of capability will be fielded, starting at **Key Decision Point B (KDP B)**
  - ❖ Program estimates should be based on an 80% confidence level by KDP-B

****** Undersecretary of the Air Force Memorandum, Subject: “Back to Basics” and Implementing a Block Approach for Space Acquisition, March 14, 2007.***

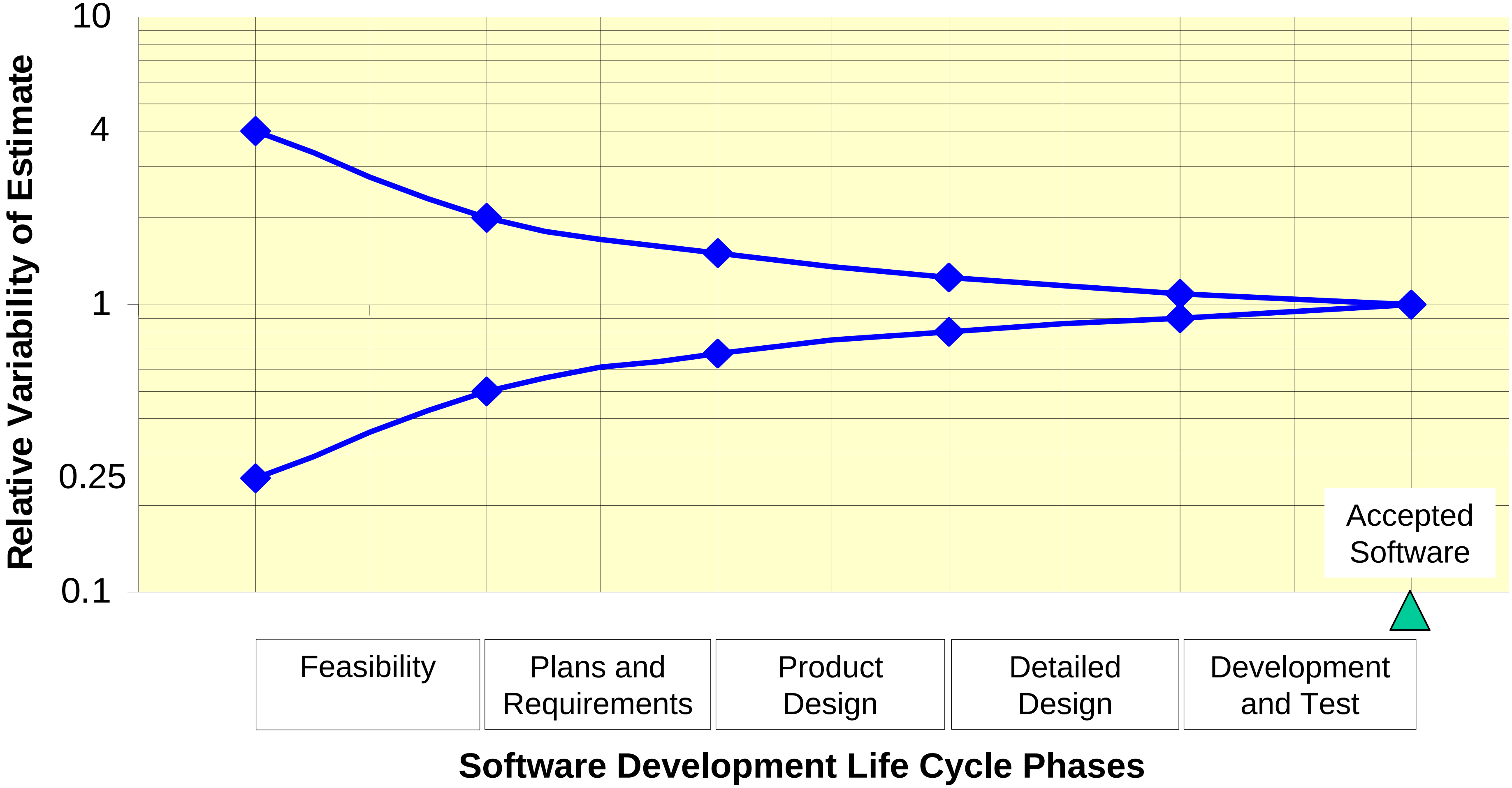
The Reasons Behind Time Certain Development

- **Tension between the DOD acquisition culture and the needs of Combatant Commanders**
  - ❖ The prevalent culture is to strive initially for the 100% solution in the first article delivered to the field
  - ❖ On the other hand, Combatant Commanders have urgent needs that are tied to ongoing operations
- **Making time a KPP seems to be the vehicle to express this customer urgency to the Developer**
  - ❖ Making time a KPP is a value statement of the Customer

What is Time Certain Development?



Cone of Uncertainty in Software Cost Estimation*



** Based on [Boehm 1981]*

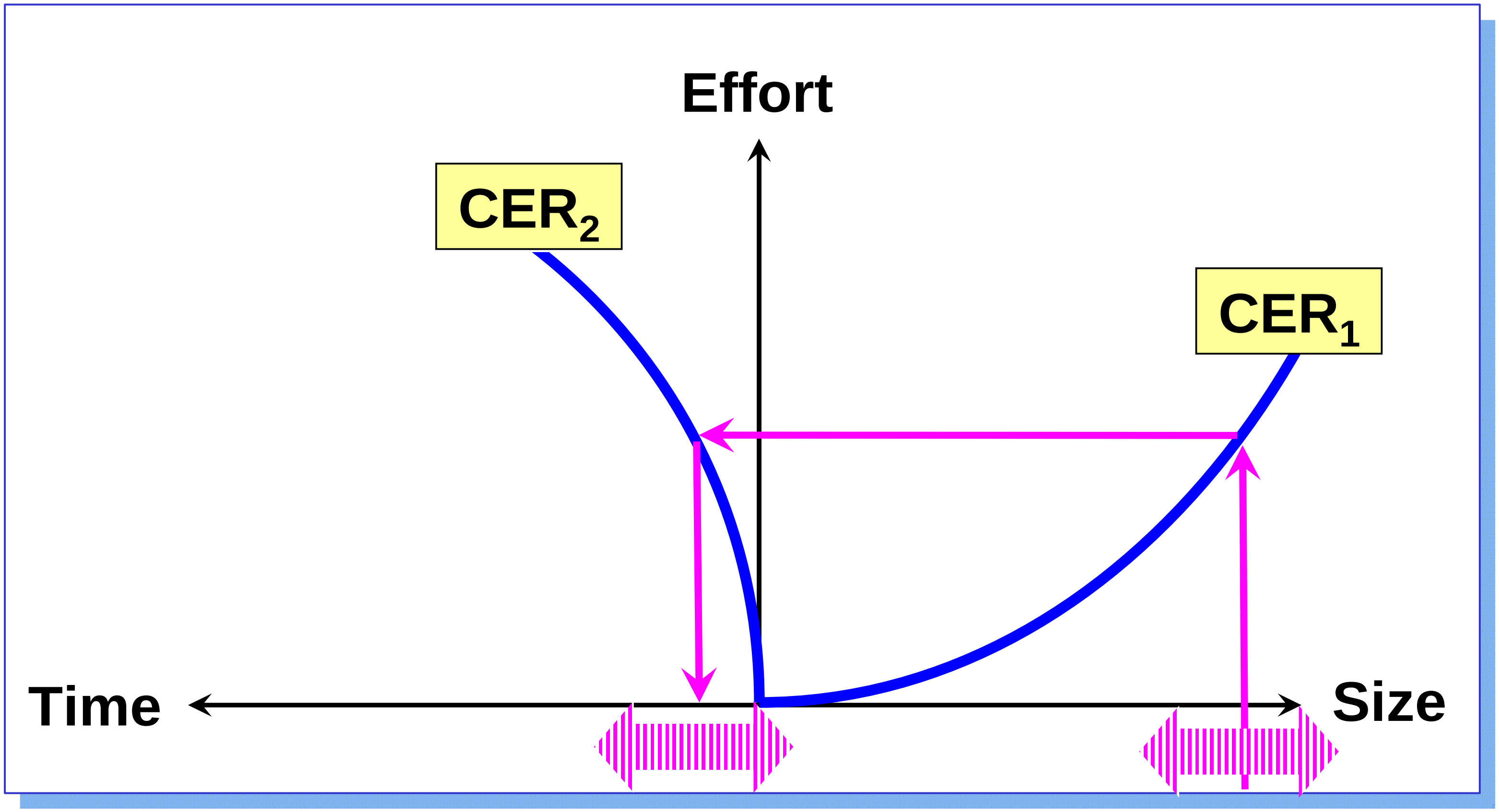
Software Size Is Always Chronically Underestimated

- **Software cost estimation's "dirty little secret":**
  - ❖ For most parametric cost estimation models software size is a major driver but size estimation accuracy is not part of the published cost estimation model accuracies
    - – Software Cost Estimation Model accuracy data assumes a 100% software size accuracy
- **Estimating software size is actually quite difficult**
    - – The **following** Actual/Estimate KSLOC (**T**housand **S**ource **L**ines **O**f **C**ode) data was published for three different datasets [Bozoki 2005]:

Datasets* Of Examined Programs	Actual Size Range for Accepted Software (KSLOC)	Ratio of Mean Actual/Estimate KSLOC Values
A	6 - 71	1.61
B	45 - 320	2.38
C	8.7- 877	1.49

** Note that actual program details are hidden due to confidentiality reasons*

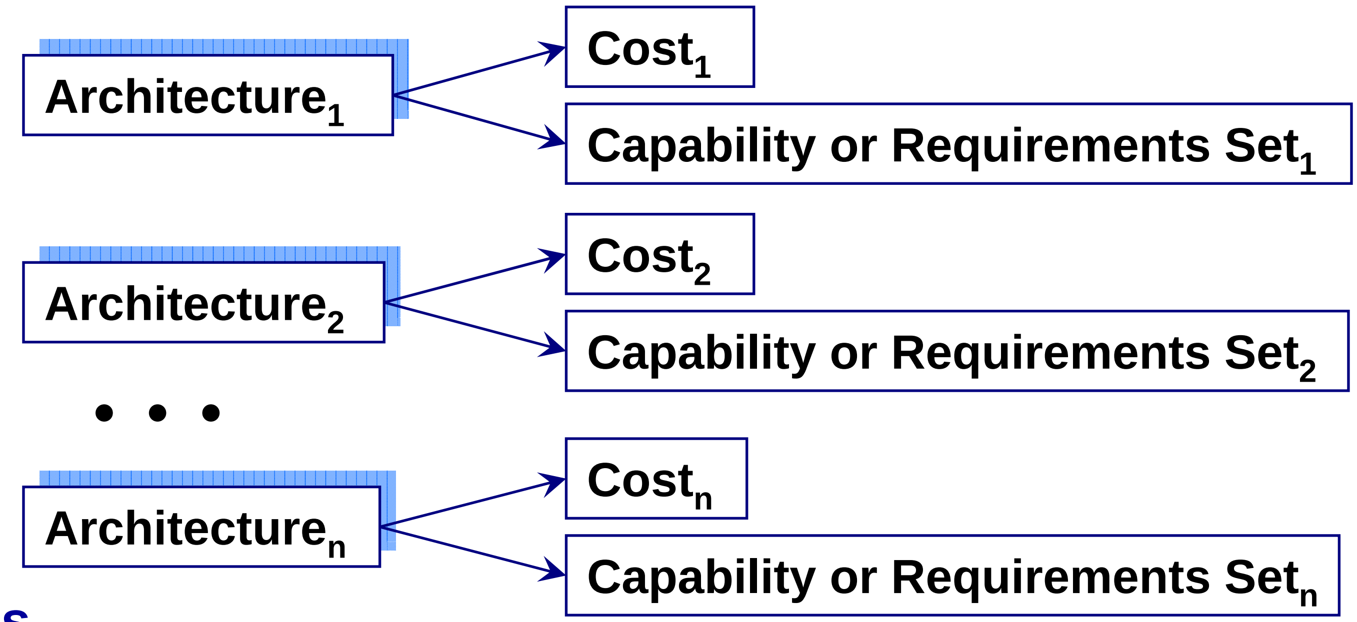
The Fallacy of Seamless Size-Effort-Time Trade



However, in reality there are only a finite number of architectural options.

Legend: CER – Cost Estimation Relationship

The Conceptual Trade Space for Architectural Options (Solution Sets)*



- **Consequences**
  - ❖ During initial estimation:
    - – For the ***Cost – Schedule – Capabilities*** trade we have only a few options
  - ❖ During development:
    - – Requirements can not always be simply “dropped” in order to maintain cost or schedule objectives

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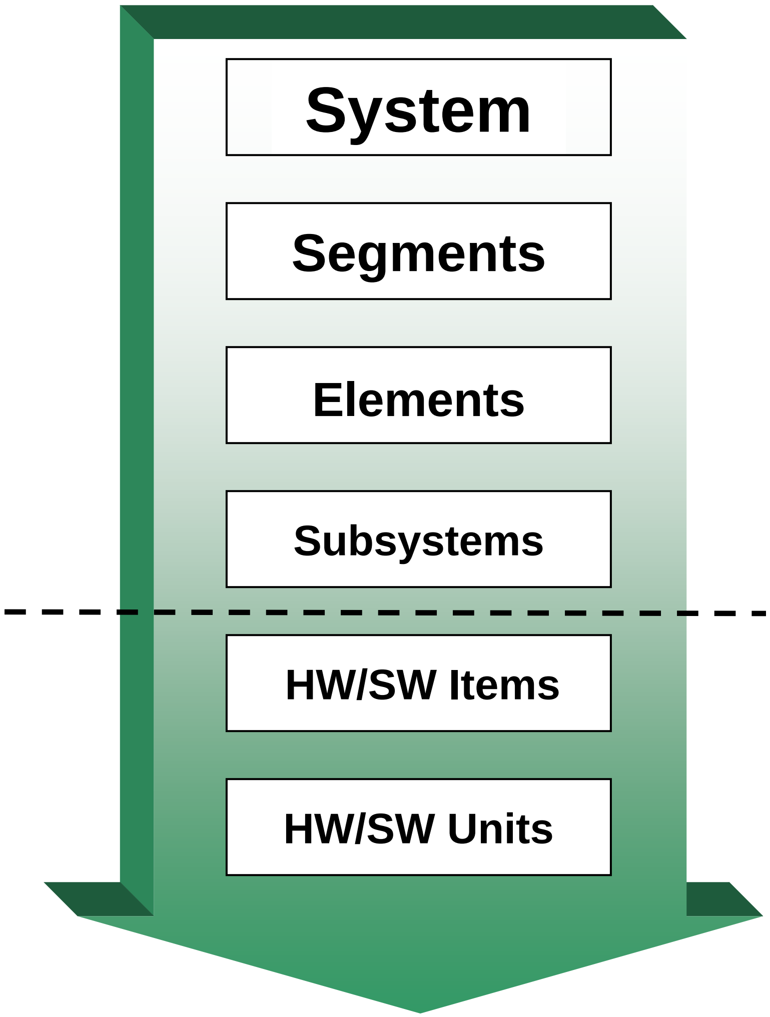
** Diagram is based on [Rice 2000]*

Space-Specific WBS (Work Breakdown Structure)

Typical WBS Hierarchy



Example (Ground Thread)

Satellite

Ground, Space, User, Launch

Ground Elements: Mission Control, TT&C, Support

Mission Control Subsystems: Master Control, Ground Antenna Control

Master Control SW Items: Mission Planning, Payload Planning

Mission Planning SW Units: Generate Timeline, Define Vehicle Configuration, Plan Orbital Maneuver

Space-Specific Software Discussion

There are Requirements and there are Requirements…

Capabilities

↓

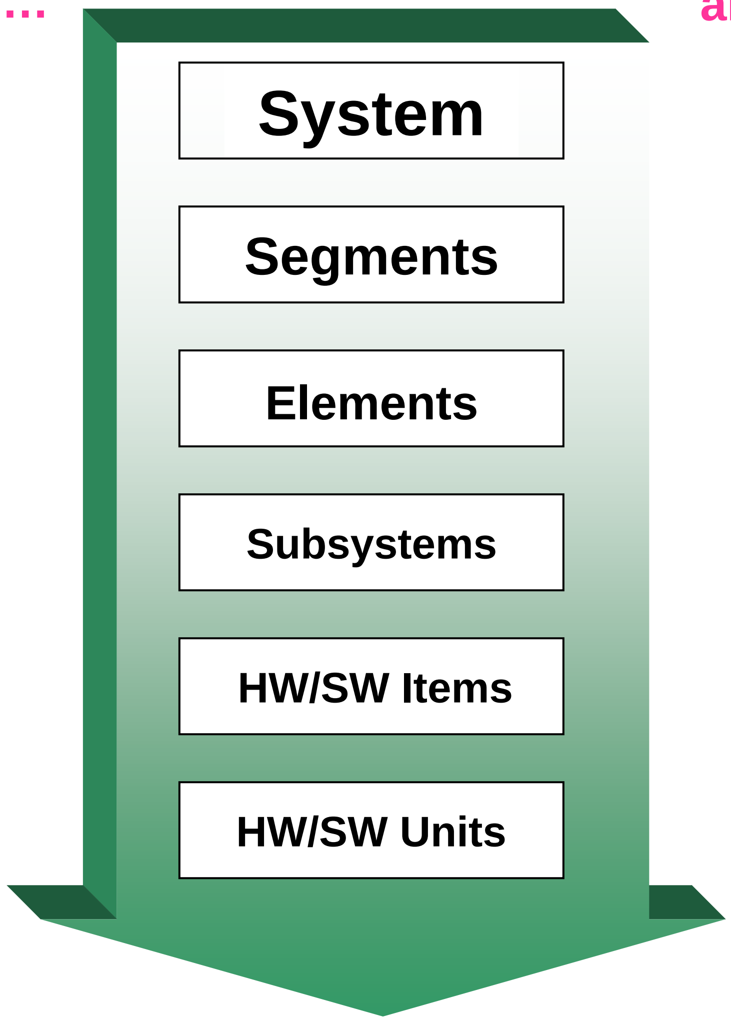
Requirements

↓

SW Specifications

↓

TPM (Technical Performance Measure) Thresholds



… and there is Architecture and there is Architecture.

26 DODAF (DOD Architecture Framework) Products/Views

↓

System Architecture

↓

High-Level, Conceptual SW Architecture

↓

SW Architecture and Detail Design

Accuracy Dependency on the Development Life Cycle Phase

- **E.g., the COCOMO II (Constructive Cost Model) family of models* distinguishes between three different estimation strategies/objectives associated with life cycle phases:**
  - ❖ **Early prototyping** stage
    - – The objective is to estimate the cost of early risk-reduction activities.
  - ❖ **Early design** stage
    - – The objective is to explore the cost of alternative software/system architecture options and the concept of operations.
  - ❖ **Post-architecture** stage
    - – The objective is to estimate the cost of actual development for the software product.
- **Caveats:**
  - ❖ The number of available data-points for calibration (and consequently the estimation accuracy) is low for the early stages
  - ❖ The models can only be used successively, and their use is dependent on facts learned and design decisions made in prior stages

**** Source [Boehm 2000]***

The Experts' Voices

- **Barry Boehm [Boehm 1981]**
  - "Whatever the strengths of a software cost estimation technique, there is no way we can expect the technique to compensate for our lack of definition or understanding of the software job to be done. Until a software specification is fully defined, it actually represents a range of software products, and a corresponding range of software development costs."

- **George Bozoki [Bozoki 2005]**
  - "SSM (Software Sizing Model) can be employed in any phase of the software development cycle in which the user can partition the software project into modules or components whose operational and functional characteristics are defined."

- **Steve McConnell [McConnell 2006]**
  - "Meaningful commitments are not possible in the early, wide part of the Cone. Effective organizations delay their commitments until they have done work to force the Cone to narrow."

Conclusions

- **Time Certain Development – as an acquisition strategy – poses very difficult engineering challenges**
  - ❖ Even state-of-the-art estimation and engineering approaches could not support successful implementation for large programs
- **Accurate size estimation requires the full comprehension of the implementation consequences of "illities"**
  - ❖ Such analysis can only be based on a detailed and adequately documented software architecture
- **The root-cause of the dissatisfaction with the performance of the Acquisition System lies with misstated or misunderstood, unrealistic, and mismanaged expectations**
  - ❖ While improving estimation accuracy is certainly beneficial, further improvement efforts should focus on deeper understanding of engineering practices and the human dimensions of the Acquisition System
- **Topics for further discussion**
  - ❖ Pros and cons of making time a KPP
  - ❖ How to really address the concerns of the commanders in the field

Final conclusion: Estimating the unprecedented remains a black art…

Acronyms

CDR	Critical Design Review
CER	Cost Estimation Relationship
COCOMO	Constructive Cost Model
DAPA	Defense Acquisition Performance Assessment
DOD	Department of Defense
DODAF	Department of Defense Architecture Framework
DODI	DOD Instruction
IOC	Initial Operational Capability
KDP	Key Decision Point
KPP	Key Performance Parameter
KSLOC	Thousand Source Lines of Code
MOIE	Mission-Oriented Investigation and Experimentation
NSS	National Security Space
PDR	Preliminary Design Review
PPBE	Planning, Programming, Budgeting, and Execution
SDR	System Design Review
SRR	System Requirements Review
TPM	Technical Performance Measure
USAF	United States Air Force
USC	University of Southern California
WBS	Work Breakdown Structure

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