

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

16 June 2008

Dr. Peter Hantos  
Software Acquisition and Process Department  
Software Engineering Subdivision

Prepared for:  
Space and Missile Systems Center  
Air Force Space Command  
483 N. Aviation Blvd.  
El Segundo, CA 90245-2808

Contract No. FA8802-04-C-0001

Authorized by: Engineering and Technology Group

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## GSAW/ACE 2008

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

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## Acknowledgements

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- This work would not have been possible without the following:
  - ❖ **Reviewers**
    - Mary Jo Gura, Software Architecture and Engineering Department
    - Dr. Leslie J. Holloway, Software Acquisition and Process Department
    - Mary A. Rich, Software Engineering Subdivision
  - ❖ **Sponsor**
    - Michael Zambrana, USAF Space and Missile Systems Center, Directorate of Systems Engineering
  - ❖ **Funding source**
    - Mission-Oriented Investigation and Experimentation (**MOIE**) Research Program (Software Acquisition Task)
  - ❖ **Inspiration**

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

# Agenda

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- 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

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- 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)

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- 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

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- **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

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- 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

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

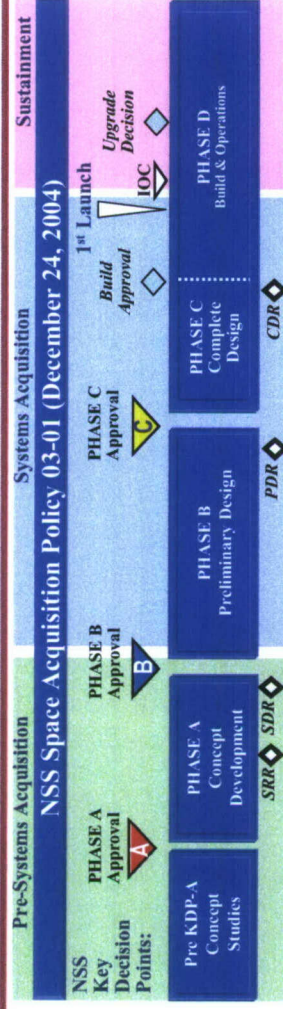
## The Reasons Behind Time Certain Development

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- **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?

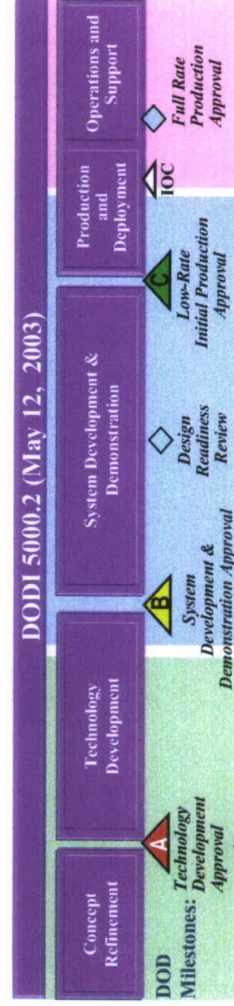
## National Security Space (NSS)



80%  
("High Confidence")  
Estimate

"Time-to-Need"

## Department of Defense (DOD)



80%  
("High Confidence")  
Estimate

"Time-to-Need"

---

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Acronyms:

CDR: Critical Design Review  
DOD: Department of Defense  
DODI: Department of Defense Instructions  
IOC: Initial Operational Capability  
NSS: National Security Space  
PDR: Preliminary Design Review  
SDR: System Design Review  
SRR: System Requirements Review

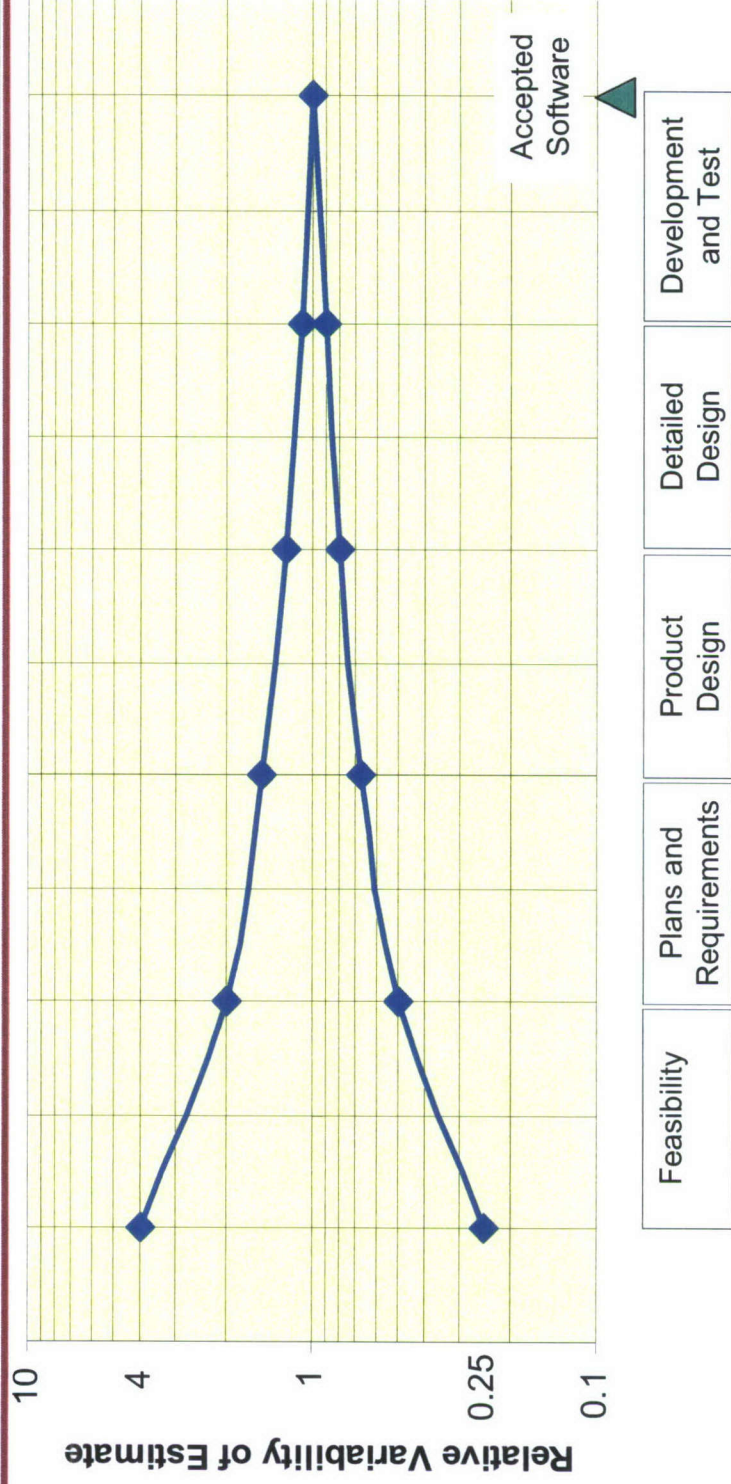
Notes:

\* DODI 5000.2 has a single acquisition life cycle model only. The chart compares the DOD model to the NSS' *Small Quantity System Model*, showing the first acquisition increment.

Trick question: What do you think why is "Build approval" in the NSSAP 03-01 model not a formal, major milestone?



## Cone of Uncertainty in Software Cost Estimation\*



### Software Development Life Cycle Phases

\* Based on [Boehm 1981]

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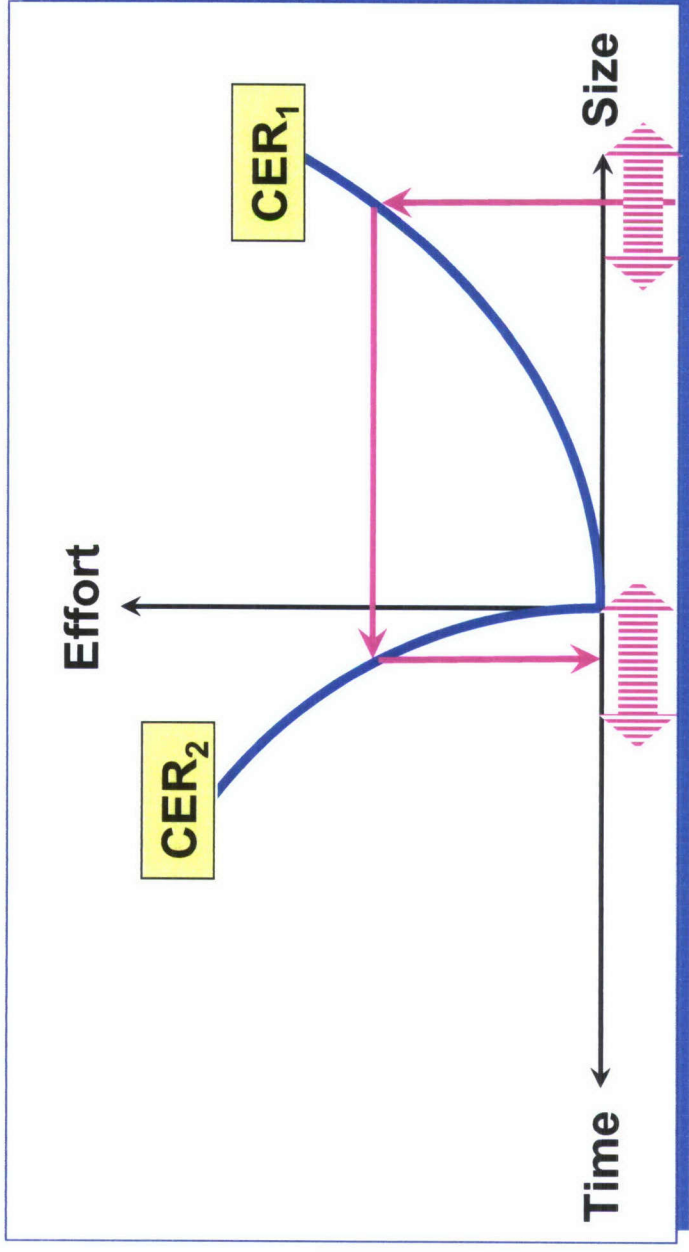
# Software Size Is Always Chronically Underestimated

- **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 (Thousand Source Lines Of Code) data was published for three different datasets [Bozoki 2005]:

| Datasets*<br>Of Examined<br>Programs | Actual Size Range<br>for Accepted<br>Software (KSLOC) | Ratio of Mean<br>Actual/Estimate<br>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.

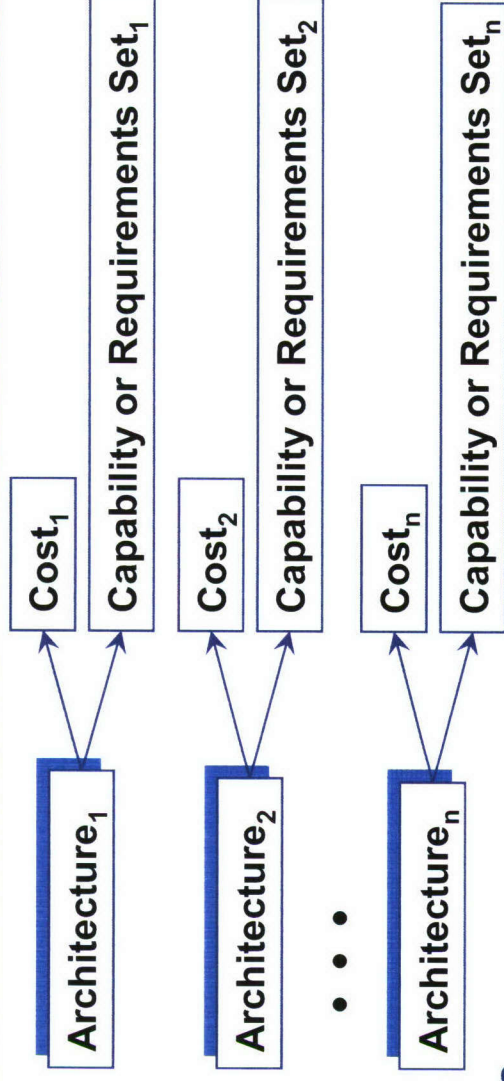
*Legend: CER – Cost Estimation Relationship*

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# 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

\* *Diagram is based on [Rice 2000]*

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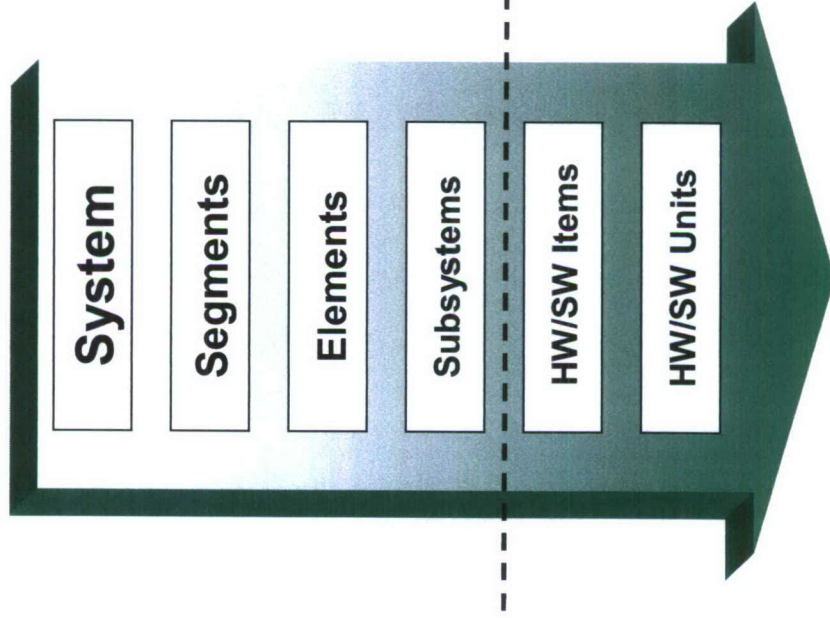
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# Space-Specific WBS (Work Breakdown Structure)

## Typical WBS Hierarchy

## Example (Ground Thread)



Satellite

Ground, Space, User, Launch

**Ground Elements:** Mission Control, TT&C, Support

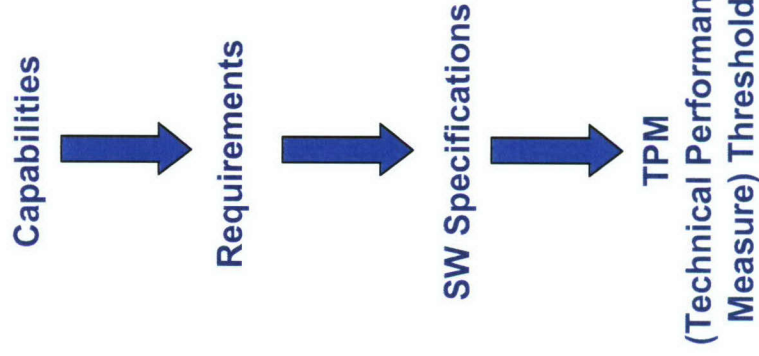
**Mission Control Subsystems:** Master Control, Ground Antenna Control

**Master Control SW Items:** Mission Planning, Payload Planning

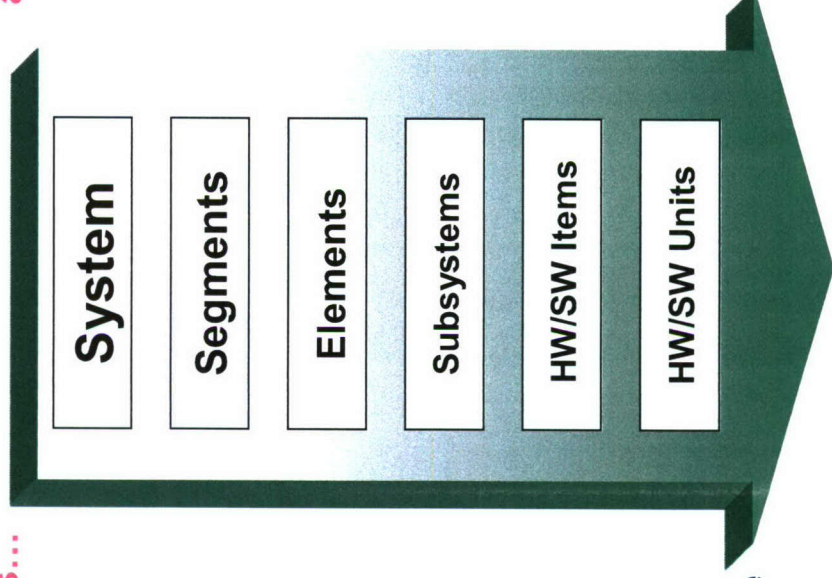
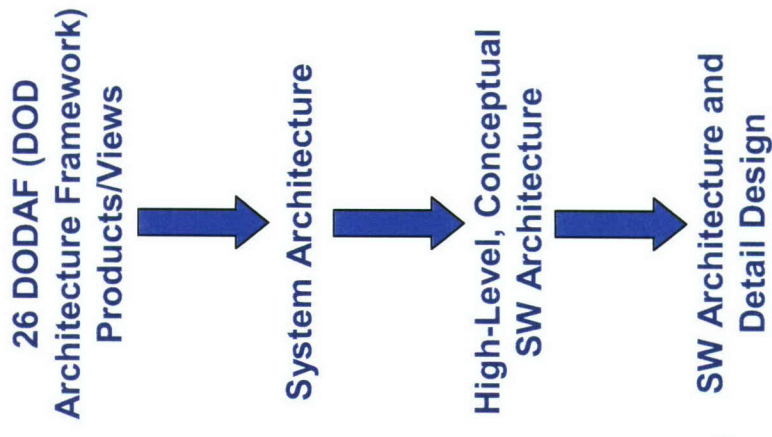
**Mission Planning SW Units:** Generate Timeline, Define Vehicle Configuration, Plan Orbital Maneuver

# Space-Specific Software Discussion

There are Requirements and  
there are Requirements...



... and there is Architecture  
and there is Architecture.



# Accuracy Dependency on the Development Life Cycle Phase

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- 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

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\* *Source [Boehm 2000]*

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## The Experts' Voices

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- **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

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

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