

# Systems and Software Technology Conference 2006



## Evolutionary Acquisition and Spiral Development Revisited

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# Acknowledgements

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    - **Dr. Barry W. Boehm**, University of Southern California

# Agenda

- **Objective**
- **Introduction**
  - ❖ Evolutionary Acquisition and Spiral Development Execution Concerns
  - ❖ Root Causes To Be Discussed
  - ❖ What We Learned Last Year ...
- **Discussion of Concerns**
  - ❖ Spiral(?) Acquisition
  - ❖ DOD and NSS Acquisition Life Cycle Phases
  - ❖ Spiral Development Definition Ambiguities
  - ❖ Politics
  - ❖ The Acquisition Challenge
- **Conclusions**
- **Acronyms**
- **Bibliography**
- **Backup Slides**

# Objective

- **Convey the message that even though ambiguity and political issues surround the Evolutionary Acquisition and Spiral Development **policy**, still**
  - ❖ Evolutionary Acquisition (EA) is a viable and prudent **strategy**
  - ❖ Spiral Development (SD) is a viable and prudent **process**
- **Why are we “revisiting” the subject?**
  - ❖ The EA/SD controversy is still with us, policy change is anticipated
  - ❖ New considerations since Author’s 2005 SSTC presentation\*

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*\* Hantos, P., Life Cycle Models for the Acquisition and Development of Software-Intensive Systems, SSTC 2005, Salt Lake City, UT*

# Selected\* EA/SD Execution Concerns

- **Incorrect mapping of development spirals into acquisition increments**
- **Attempt to run concurrent spirals**
- **Spiral development “spirals out of control”**
  - ❖ When asked, programs can not tell
    - How many spirals they are planning
    - What processes and products are associated with each spiral
- **Managing user expectations**
  - ❖ The EA/SD approach is inconsistent with the user’s expectation of fielding a 100% solution in the beginning

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*\* Numerous sources deal with EA/SD concerns during the acquisition of weapon systems, e.g., (Johnson 2002). The selection criterion for this presentation though is to discuss top concerns typical in the software-intensive system area, even though EA/SD poses tough challenges in the acquisition of hardware-dominated weapon systems as well.*

# Root Causes To Be Discussed

- **The DOD 5000.2 EA/SD Policy is ambiguous\***
  - ❖ The acquisition life cycle models of DOD 5000.2 and NSSAP 03-01 are poorly aligned with the realities of software-intensive system development
  - ❖ EA/SD Terminology is ambiguous
- **Technical definitions of Spiral Development are ambiguous\*\***
  - ❖ Model is powerful but too generic
  - ❖ Model's spiral metaphor is confusing
  - ❖ Role and execution of **risk management** is misunderstood
  - ❖ The meaning of **concurrent engineering** is misunderstood
- **Politics**
  - ❖ Government and press concerns

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*\* For a detailed exposure see the excellent article by R.K. Sylvester and J.A. Ferrara (Sylvester 2003). This slide only enumerates issues not raised by the authors.*

*\*\* For the same reasons, while they are very important, “hazardous spiral look-alikes” as they were documented by B. Boehm are not discussed here either (Boehm 2000).*

# What We Learned Last Year ...

| <b>Conceptual Terms</b>                  | <b>Objectives</b><br>... to be accomplished by the process                           | <b>Deliveries</b><br>... to be completed to achieve part of the objectives                  | <b>Steps</b><br>... to be taken in order to complete one Delivery              |
|--|--|---|--|
| <b>Acquisition Terms</b>                 | <b>Capability</b><br>... to be provided to the government as a result of the process | <b>Increments</b><br>... to be delivered to provide some parts of the required capabilities | <b>Phases</b><br>... to be completed while delivering an Acquisition Increment |
| <b>System/Software Development Terms</b> | <b>Requirements</b><br>... given to the engineers to be implemented                  | <b>Increments</b><br>... to be constructed to satisfy some parts of the requirements        | <b>Activities</b><br>... to be completed in order to create one single Build   |
|  |  | <b>Build</b><br>... to be put together to actually deliver an Increment                     |  |

# A (Literally) Tongue-In-Cheek Clash of Metaphors

- **“Teaching the Elephant to Dance: Agility Meets Systems of Systems Engineering and Acquisition”**  
(Title of Professor Barry Boehm’s keynote talk at GSAW 2005)
- **In Software-Intensive System development, we don’t want to dance with the Elephant, we want to eat it...**

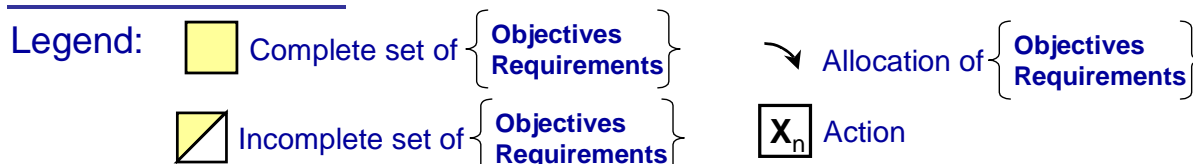
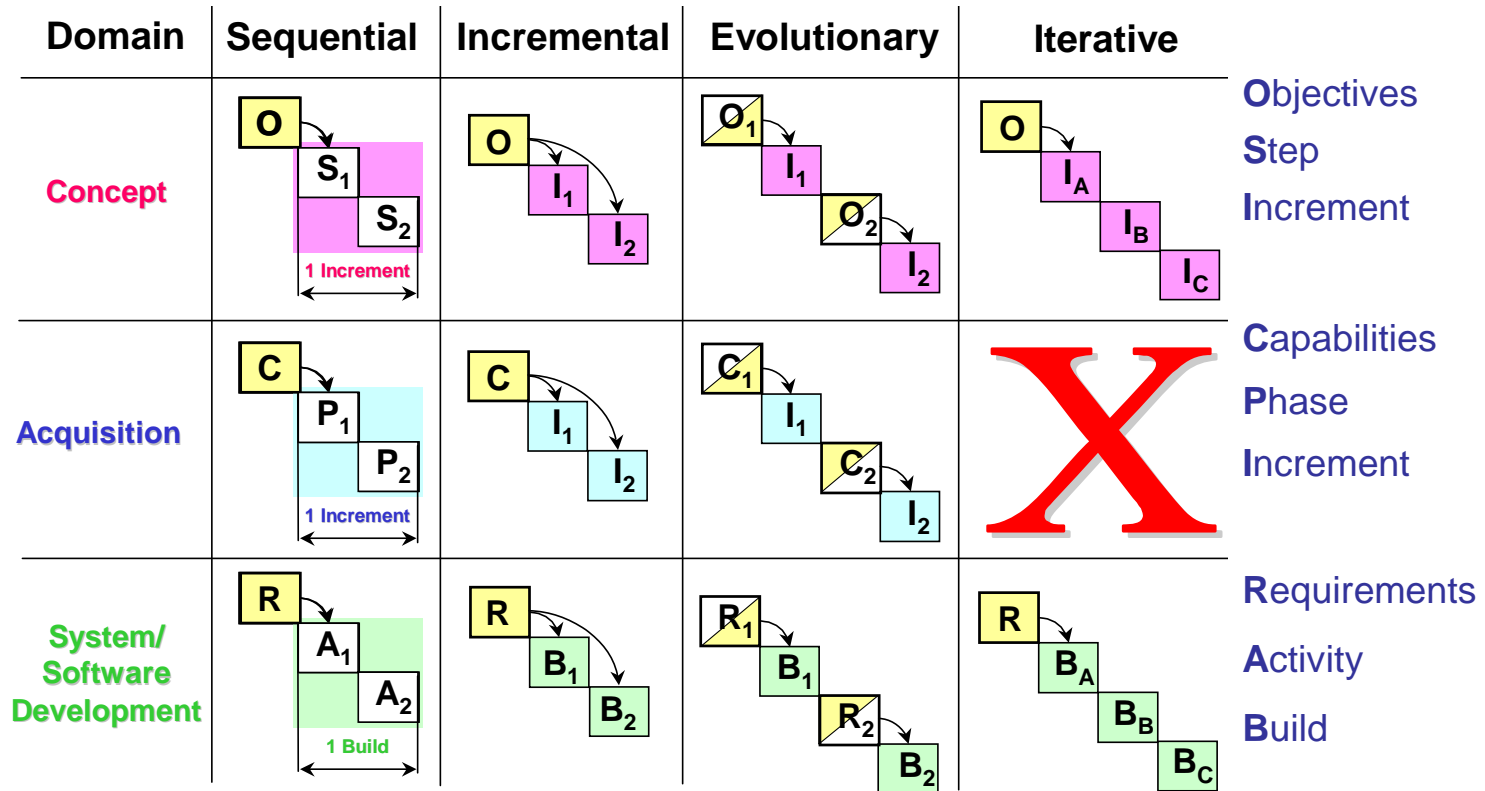
❖ Paraphrased joke:

**Q: How do you eat an Elephant?**

**A: One increment at a time!**



# The Symmetry of Basic Acquisition and Development Life Cycle Modeling Patterns



# So Is There Such Thing As Spiral Acquisition?

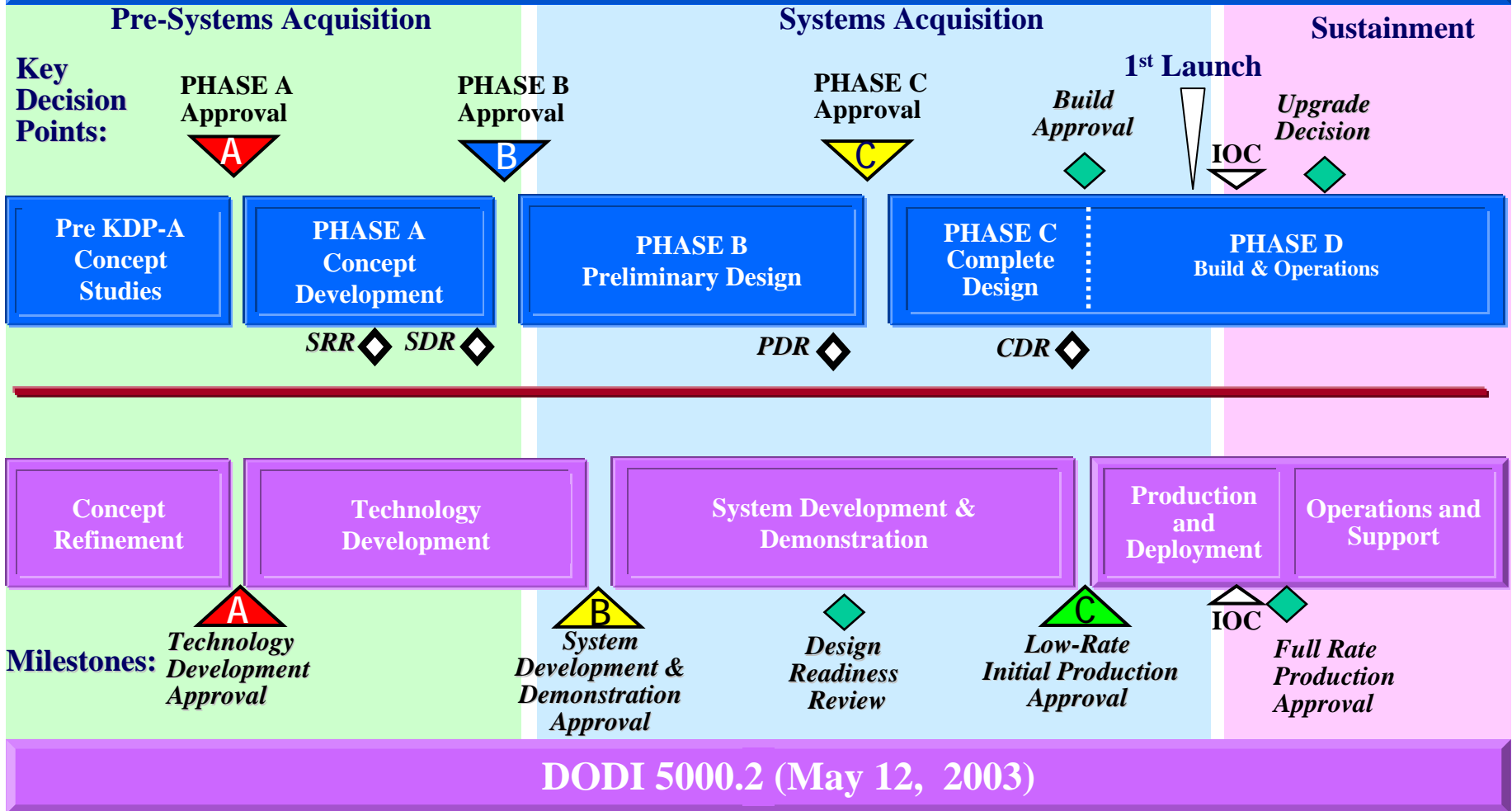
"... the Army restructured FCS [*Future Combat System*] development and procurement into a **spiral acquisition** where subsets of the new systems are delivered in four "spirals" beginning in 2008. This approach allows the Army to deploy those elements of FCS that are ready first, while providing enough time to test and develop more challenging components for introduction in later spirals."

--- *Source: Office of Management & Budget Website – FY06 Budget Priorities*

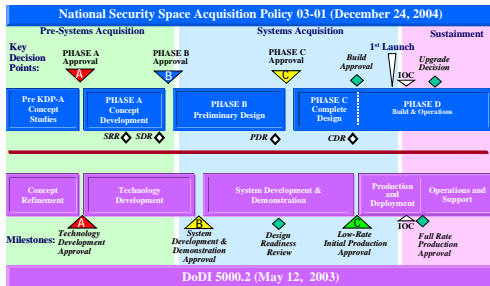
- **No, there is not. FCS is a clear example of Evolutionary Acquisition**
  - ❖ Ironically, authors in the mentioned article (Sylvester 2003) criticized Pete Aldridge, former USD/AT&L for using inconsistent EA/SD terminology back in 2002
  - ❖ This example for the use of misleading terminology above is very recent
  - ❖ Clearly, ambiguity and confusion did not go away
- **Discussion of more ambiguity (and more confusion) to follow**

# DOD and NSS Acquisition Life Cycle Phases

## National Security Space Acquisition Policy 03-01 (December 24, 2004)



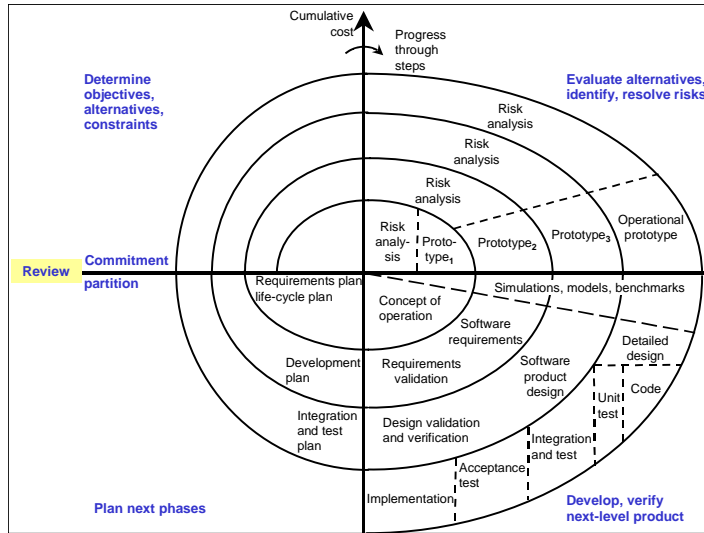
# What is Wrong With This Picture?



- **Common interpretation:**
  - ❖ DOD 5000 is Spiral Development
    - **CR** is the first spiral, **TD** is the second, **SDD** is the third ...
    - Entry criteria for every KDP includes a risk management activity
- **However,**
  - ❖ The acquisition phases seem to be “Waterfall” segments of a single acquisition increment
    - The DOD 5000 life cycle model (Even more than NSSAP 03-01) is hardware-biased
    - The “Waterfall” in software context is prone to delayed problem discovery and resolution
    - It is very difficult (if not impossible) to reconcile risk-driven, spiral life cycle planning with the Waterfall structure.

# The “Evolution” of Spiral Development

Boehm 1988



Boehm 2000

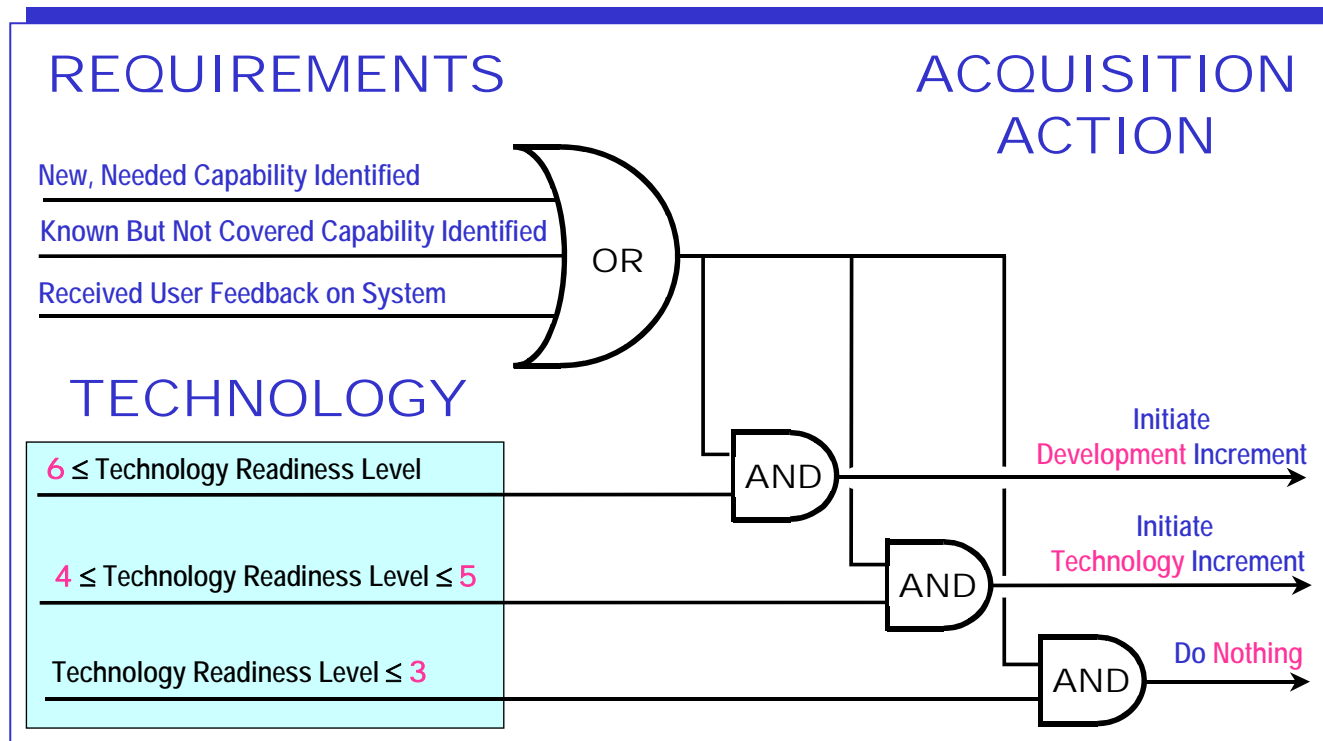
The Spiral Development Model is a risk-driven process model generator for guiding multi-stakeholder concurrent engineering of software-intensive systems. Its distinguishing features include a cyclic approach for incrementally growing a system's degree of definition and implementation, and a set of anchor point milestones for ensuring feasibility of the incremental definitions and implementations.

NSSAP 03-01, AP1.1.3, paragraph a)

**In this process, a desired capability is identified, but the end-state requirements are not known at program initiation. Those requirements are refined through demonstration and risk management, there is continuous user feedback, and each increment provides the user the best possible capability. The requirements for future increments depend on feedback from users and technology maturation.**

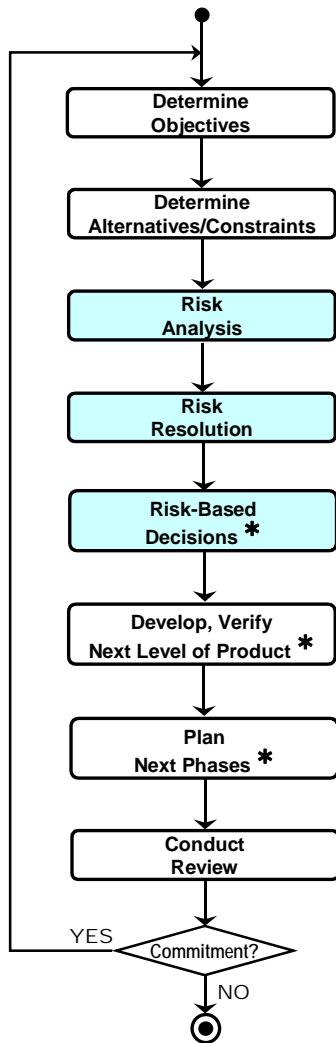
# Requirements Are Driven By Technology Maturation?

- **DOD 5000.2/NSSAP 03-01** on requirements for future increments:
  - ❖ “The requirements for future increments depend on feedback from users and technology maturation”



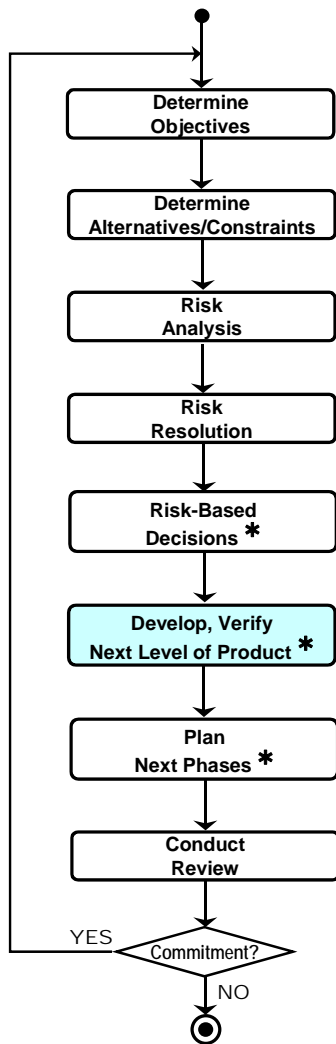
*Note: Technology Readiness Level ratings are notional. For more details see backup slides.*

# SD Technical Definition Ambiguities



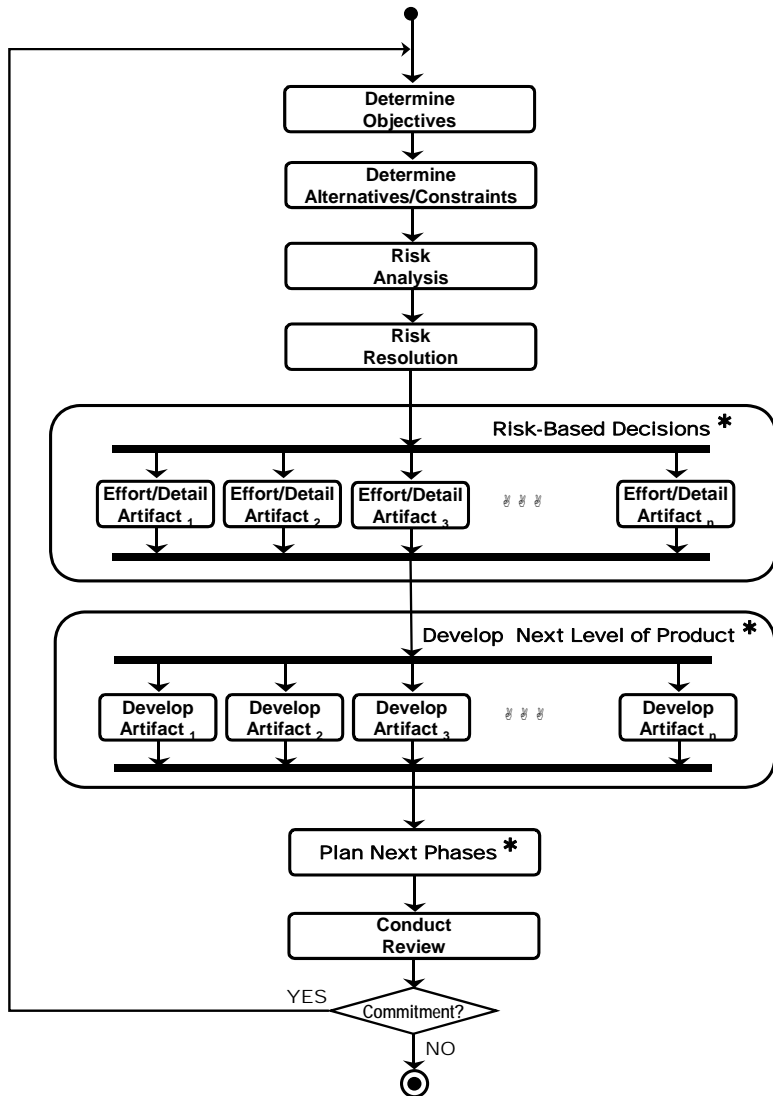
- **Spiral metaphor is confusing**
  - ❖ The purpose of the metaphor to emphasize the economic dimensions of software engineering
    - However, the original diagram is highly conceptual and does not lend itself to easy application
      - **A UML (Unified Modeling Language) Activity Diagram** depiction of the Spiral is presented to clarify the sequence of activities (Hantos 2006)
      - “\*” is the UML syntax to express dynamic concurrency (to be discussed later)
- **Role of risk management is misunderstood**
  - ❖ The common view is that risk management is a continuous activity
    - This notion implies that risk management is practiced concurrently with development
  - ❖ However, **risk-based planning** of successive cycles must precede the development of the “Next Level of Product” and can not be done concurrently

# SD Technical Definition Ambiguities (Cont.)

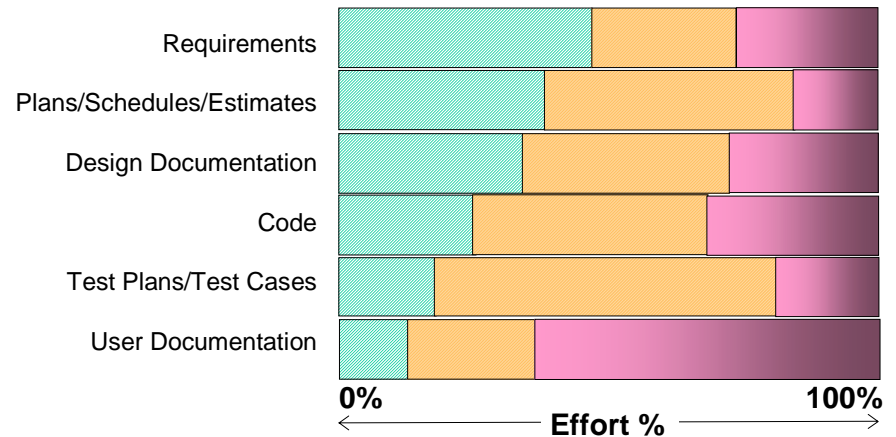


- **The Spiral is a process model generator**
  - ❖ “Next Level of Product” does not have discipline-dependent details
    - Note that the model does not specify either the “**What**” or the “**How**”
    - Consequently, the model can be used as a shell to generate systems engineering, software engineering, or even hardware engineering processes
  - ❖ This generality is attractive, but in reality it is both a blessing and a curse
- **The model’s flexibility poses a mission assurance challenge**
  - ❖ Using the Spiral is no guarantee that robust processes would be actually generated
    - One extreme: TSPR (Total System Performance Responsibility) approach – “The Contractor Knows Best”
    - Other extreme: The old MIL-STD mindset – “Headquarters Knows Best” (Everything can be - and should be - specified in advance and full details by the acquirer)
    - The challenge is to find the proper balance
  - ❖ **This challenge should not be addressed via policy**
    - **Common sense and technical proficiency can not be legislated**

# Concurrent Engineering in Spiral Development



## Artifacts



## Legend:

■ 1st Cycle   
 ■ 2nd Cycle   
 ■ 3rd Cycle

- **Concurrent Engineering**
  - ❖ Refers to the concurrent development of **artifacts**, not WBS elements
  - ❖ Effort/Detail determination for artifacts is a risk-based decision
  - ❖ Concurrency is **dynamic**
    - A certain level of iteration is needed amongst the concurrent activities

# Politics – Introductory Thoughts

- **Fowler:**

- ❖ “I can’t offer you any serious advice on this, because I am not a skilled corporate politician. I strongly suggest that you find someone who is.”

--- *Martin Fowler in “UML Distilled”, Second Edition, Addison-Wesley 2000, pp 25*

- **Hantos:**

- ❖ “Even if you are not skilled in navigating the political waters, you can not afford not being aware of the political dimensions of both acquisition and development.”

# Are Evolutionary Acquisition and Spiral Development Political Concepts?

"...Fortunately, there is a middle ground between delay and a premature program start. It lies in a President George W. Bush administration concept called spiral development, basically an **evolutionary path to revolutionary results.**"

--- *Loren Thompson*  
*Space News, January 19, 2004, commentary article titled "Fastest Path to Transformational Communications Is A Spiral"*

"...Yet the administration is going ahead with hollow defense plans to soon activate the first missile silos along the Pacific Coast in a **ludicrous pretense called evolutionary acquisition.**"

--- *The New York Times Editorial,*  
*December 16, 2004, titled "The Naked Shield"*

# Conflict between PPBE and Spiral Development

“ ... Transitions [*between the spirals*] represent a ‘use and learn’ cycle, and have proven difficult to fund. Without a way to reduce the two-year [**PPBE**] cycle, ‘use and learn’ spiral development can not be realized.”

--- *Tim Spaulding, in the “Budgeting for Evolutionary Acquisition and Spiral Development” presentation at the Lean Aerospace Initiative/MIT conference on March 26, 2003*

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*PPBE (Planning, Programming, Budgeting, and Execution): Congress’ appropriation budget cycle*

# “Congress vs. the Pentagon?”

“...As part of the new May 2003 weapons acquisition policy, Secretary of Defense Donald Rumsfeld indicated that all missile defense projects would be exempted from the 5000 series, and instead gave the authority to determine development to the MDA.

How can missile defense, which has been reportedly used as a shining example of spiral development, not be designated as such and be included in the report to Congress?

... [*the Pentagon*] wants the flexibility in what Missile Defense can deliver by qualifying it as a program undergoing spiral development, yet it doesn't want to have to follow through with any of the reports and responsibilities that such programs require. **Congress has little ability to exercise its right of oversight and power of the purse.**”

--- *Victoria Samson, in “Missile Defense is Spiraling Out of Congress’ Control”, on the Center for Defense Information website, December 18, 2003*

# More Spiral Confusion ...

- **What is a “Spiral Development Program”?**
  - ❖ A special, constrained version of the Evolutionary Acquisition strategy for designated, major\* defense acquisitions
    - Described in Sec. 803 of 116 STAT. 2604 Public Law 107-314
    - Per NSSAP 03-01:
      - The Space System Program Director/Program Manager (SPD/PM) should describe the program’s Evolutionary Acquisition strategy in the program’s Acquisition Strategy
      - The Integrated Program Summary (IPS) constitutes the “spiral development plan” for programs using the spiral development process
    - More details on the next slide
  - ❖ Caveat: Unfortunately, anybody can call their own programs “Spiral”
    - See the results of the web-search for “Spiral Development Program” references later

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*\* The term is specifically defined by Title USC 2430, and repeated in Paragraph 3 of NSS 03-01, describing the applicability of the policy.*

# Section 803: Spiral Development Under Major Defense Acquisition Programs

- **Key limitations on Spiral Development Programs**
  - ❖ Authorization by the Secretary of Defense
    - On the basis of an approved Spiral Development Plan (see below)
  - ❖ Conducted in discrete phases, resulting in **fieldable prototypes**
  - ❖ Can not proceed into acquisition until specific performance parameters met
- **Spiral Development Plan includes at a minimum:**
  - ❖ Rationale for dividing the Research & Development program into spirals
    - Preliminary identification of spirals
  - ❖ Program strategy
    - Including overall cost, schedule, and performance goals
  - ❖ Specific details for the first spiral to be conducted
    - Cost, schedule, performance parameters, measurable exit criteria
  - ❖ A testing plan to verify that exit criteria are met
  - ❖ Limitation on the number of prototype units to be produced
  - ❖ Specific performance parameters and measurable exit criteria that must be met before proceeding into production
    - “Production” is interpreted as exceeding the set limit on the number of prototype units

# 2003 Status on Section 803 Spiral Development Programs

- “... DOD's current draft report states that there are no research and development programs that have been approved as spiral development programs as of September 30, 2003. Section 803 requirements were implemented in DOD Instruction 5000.2, which was effective in May 2003. DOD anticipates that there will be approved spiral development programs to report in 2004.”
- **Source:**
  - *General Accounting Office, **Defense Acquisitions – DOD’s Revised Policy Emphasizes Best Practices, but More Controls Are Needed**, Report to the Senate and House Committees on Armed Services, November 2003*

# 2005 Status on Section 803 Spiral Development Programs

- In December, 2004 a Google search for “Spiral Development Program” produced about 545 hits; in February of 2005, 611 hits; and in January 2006, 729 hits
  - ❖ Clearly the interest is there and growing
  - ❖ Closer review of those entries showed, however, that people were very liberally using the term, and it was impossible to determine if any of the references were to legitimate, DOD-authorized Section 803 Spiral Development Programs.
- Direct inquiry in 2005 to the GAO indicated that apparently there was no need to release a final version of the earlier draft:  
“The report you cited is the most recent GAO report on the subject. Thank you for contacting GAO Research Services.  
Tim Johnson, Reference Analyst  
Requester: Peter Hantos  
Date submitted: Wed Feb 9 14:00:46 EST 2005”

# The Acquisition Challenge

- **The Acquisition challenge is**
  - ❖ **Managing Stakeholder Expectations**
  - ❖ **Balancing Stakeholder Tension**
- **Summary of stakeholder perspectives**
  - ❖ **Congress** - Controlling the purse
  - ❖ **DOD Departments** - Protecting budget
  - ❖ **Defense industry** - Profit
  - ❖ **Comptroller Community** - Ensuring accountability
  - ❖ **Users** - Getting the best value
  - ❖ **Test & Evaluation Community** - Operational effectiveness and suitability

# Conclusions

- Acquisition of software-intensive systems is a complex and large-scale undertaking with high stakes
- Acquisition is a zero-sum-game on multiple levels
- Acquisition and development are fundamentally social activities with inherent ambiguity
  - ❖ This ambiguity can not be resolved via policies
- **Risk-driven, scalable and incremental approach is a must**

# Actually It is More Than a Zero-Sum-Game ...



Acquisition is a Contact Sport!

# Acronyms

|          |   |
|----------|---|
| CDR      | Critical Design Review  |
| DOD      | Department of Defense   |
| EA       | Evolutionary Acquisition  |
| FCS      | Future Combat System  |
| GSAW     | Ground System Architecture Workshop                               |
| IOC      | Initial Operational Capability                                    |
| KDP      | Key Decision Point  |
| LCM      | Life Cycle Model  |
| MDA      | Missile Defense Agency  |
| MIL      | Military  |
| MOIE     | Mission-Oriented Investigation and Experimentation                |
| NSSAP    | National Security Space Acquisition Policy                        |
| PDR      | Preliminary Design Review   |
| PPBE     | Planning, Programming, Budgeting, and Execution                   |
| SBR      | Space Based Radar   |
| SD       | Spiral Development  |
| SDR      | System Design Review  |
| STD      | Standard  |
| TSPR     | Total System Performance Responsibility                           |
| UML      | Unified Modeling Language   |
| USAF     | United States Air Force   |
| USD/AT&L | Under Secretary of Defense/Acquisition, Technology, and Logistics |
| USC      | University of Southern California                                 |
| WBS      | Work Breakdown Structure  |

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- Sylvester 2003** R.K. Sylvester and J.A. Ferrara, *Conflict and Ambiguity Implementing Evolutionary Acquisition*, Acquisition Review Quarterly, Winter 2003

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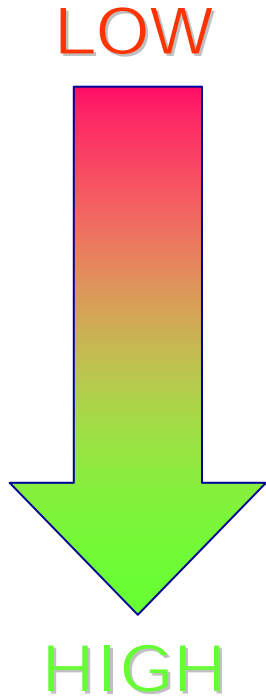
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# Backup Slides

# Technology Readiness Levels\*



1. Basic principles observed and reported
2. Technology concept and/or application formulated
3. Analytical and experimental critical function and/or characteristic proof of concept
4. Component and/or breadboard validation in laboratory environment
5. Component and/or breadboard validation in relevant environment
6. System/subsystem model or prototype demonstration in a relevant environment
7. System prototype demonstration in an operational environment

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*\* Source: (Graettinger 2002). Meant to be applicable for both hardware and software technology readiness levels.*

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