Acquisition Research Program:
Creating Synergy for Informed Change

Too Little Too Soon?

Modeling the Risks of Spiral Development

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CSIS Center for Strategic & International Studies

PROVIDING STRATEGIC INSIGHTS AND POLICY SOLUTIONS

HOME

EVENTS

ABOUT CSIS | EXPERTS | RESEARCH FOCUS | CSIS & CONGRESS | PUBLICATIONS | PRESS CENTER | EVENTS

SEARCH

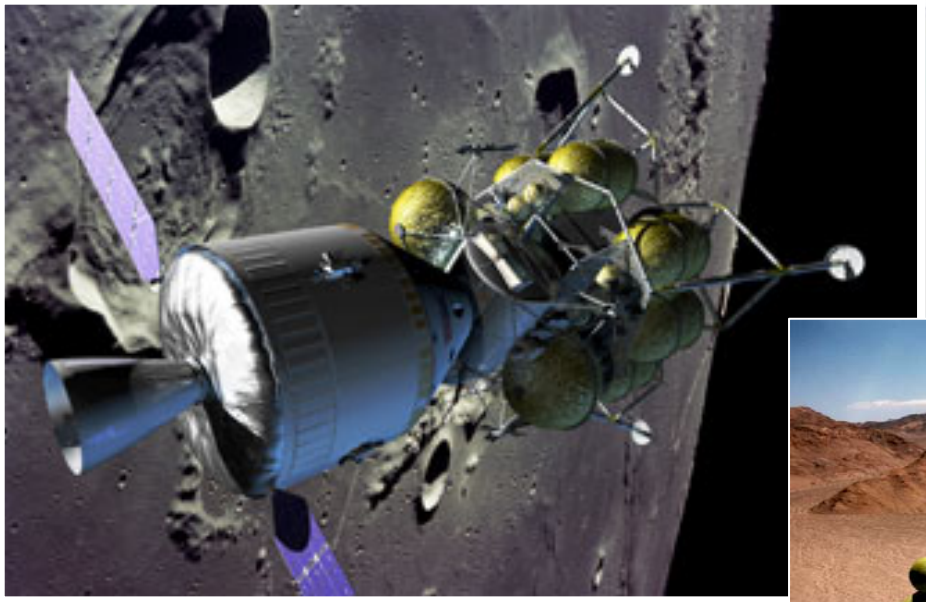
All Sections

Events

Home page » Events » Spiral Development, Real Options, and Other Development Methodologies

OPEN EVENT DETAIL

SPIRAL DEVELOPMENT, REAL OPTIONS, AND OTHER DEVELOPMENT METHODOLOGIES



DATE: June 5, 2006

TIME: 8:30 a.m. - 12:15 p.m.

LOCATION: CSIS
B-1 Conference Center
1800 K Street, N.W.
Washington, D.C.

United States Government Accountability Office

GAO

Report to Congressional Committees

March 2007

DEFENSE ACQUISITIONS

ATACMS

JAVELIN

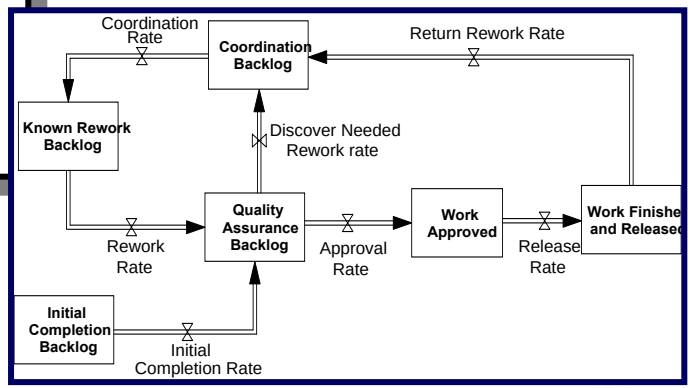
RAND PROJECT AIR FORCE

RESEARCH BRIEF

"Evolutionary Acquisition" Is a Promising Strategy, But Has Been Difficult to Implement

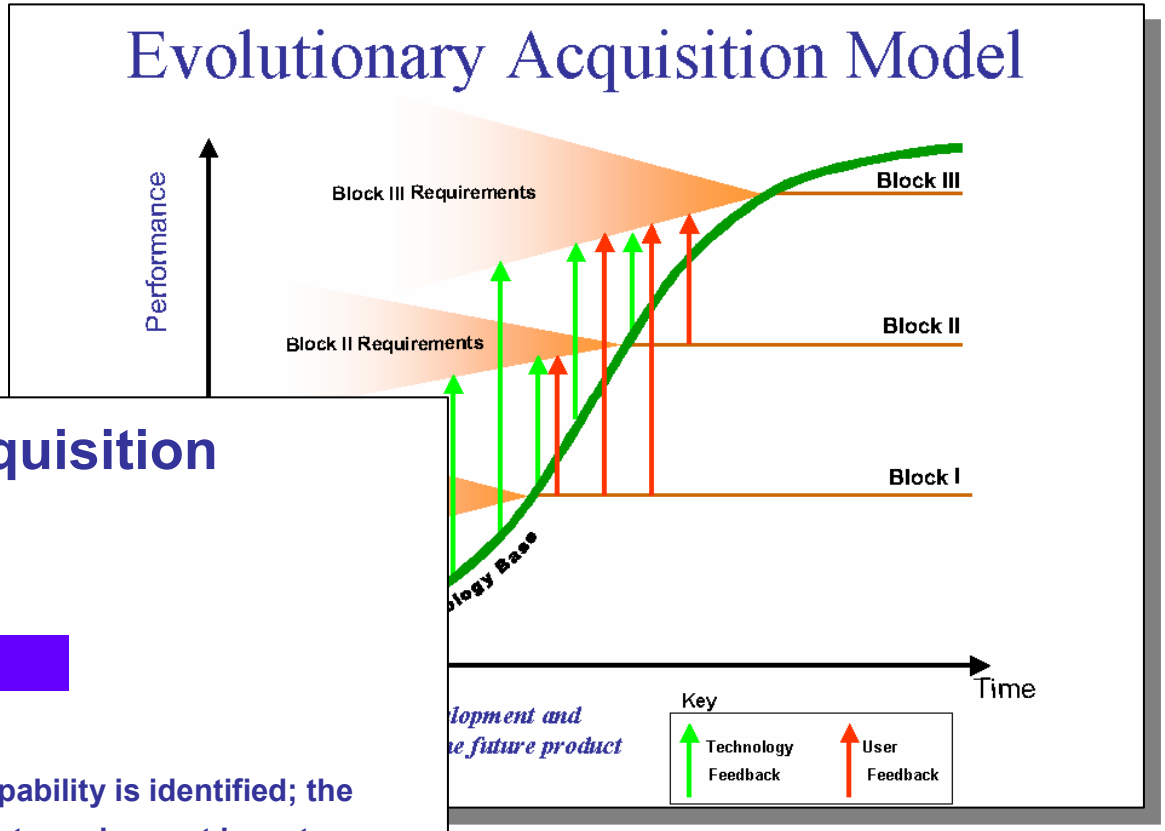
RAND RESEARCH AREAS
THE ARTS
CHILD POLICY
CIVIL JUSTICE
EDUCATION
ENERGY AND ENVIRONMENT
HEALTH AND HEALTH CARE
INTERNATIONAL AFFAIRS
NATIONAL SECURITY
POPULATION AND AGING
PUBLIC SAFETY
SCIENCE AND TECHNOLOGY

In 2003, the U.S. Department of Defense (DoD) specified evolutionary acquisition (EA) as the preferred approach to weapon system acquisition, and spiral development as the preferred means of implementation. EA strategies aim to develop new capabilities in multiple increments, as opposed to the traditional strategy of developing a full capability in a single, lengthier step. EA strategies are meant to reduce the time it takes to field operationally useful equipment, control technical risk and cost growth, and make cost estimates more reliable for each stage of development, while allowing greater flexibility to evaluate and improve a program based on experience in the field. This greater flexibility arises in part from the fact that, with the spiral development approach, the end-state requirements are not known at program initiation, but rather emerge and evolve through an iterative process of phased development and



"Evolutionary acquisition strategies shall be preferred approach to satisfying operational needs."

DoDI 5000.2



Evolutionary Acquisition

Further defined:

- ***Incremental Development***: A desired capability is identified; the end-state requirement is ***known***; and that requirement is met over time by developing several increments, each dependent on available, mature technology.
- ***Spiral Development***: A desired capability is identified, but the end-state requirements are ***not known*** at program initiation. Requirements are refined through demonstration and risk management; there is continuous user feedback; and each increment provides the user the best possible capability.

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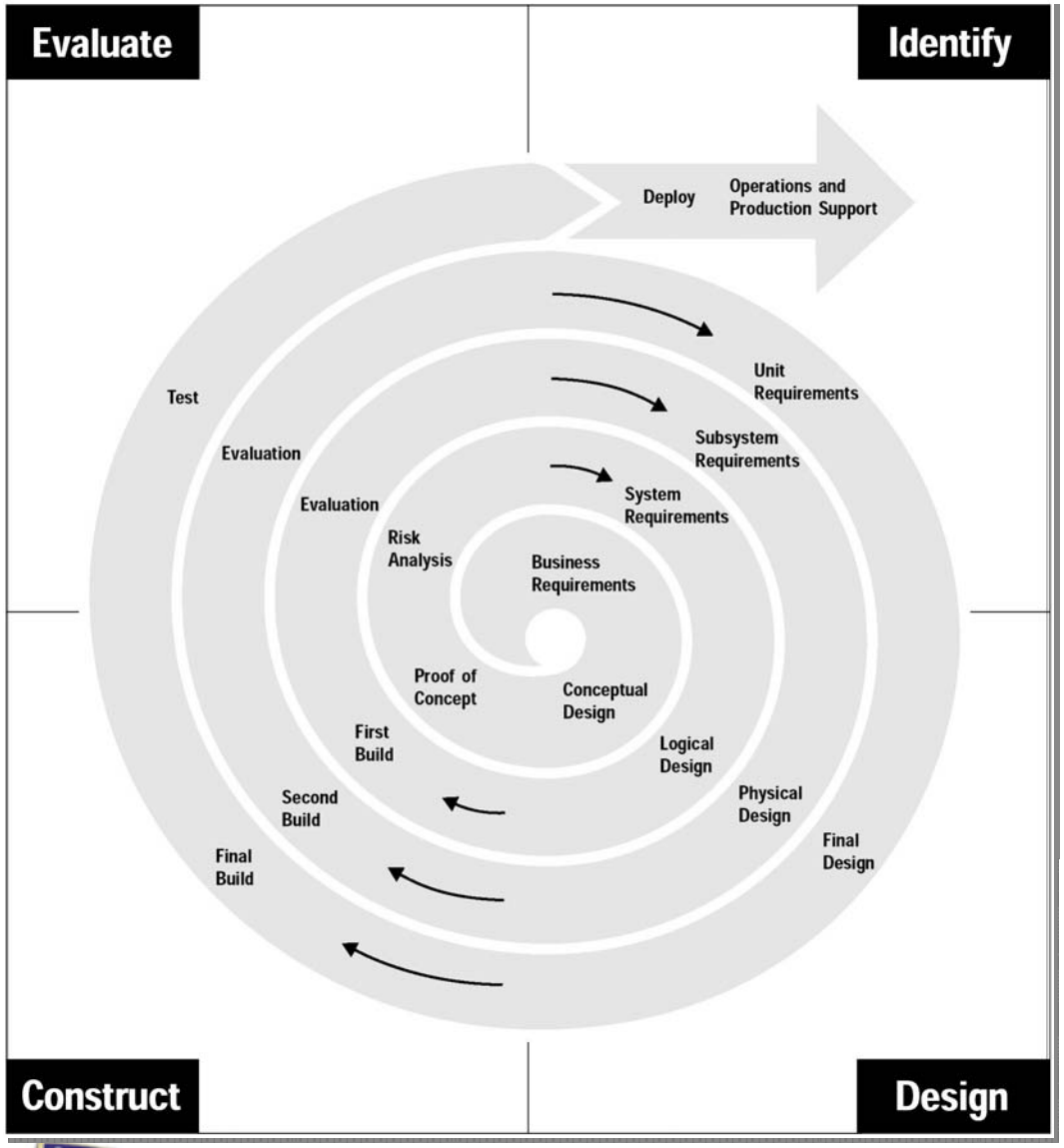
"Paradigms influence our study between revolutions" Kuhn

Paradigm

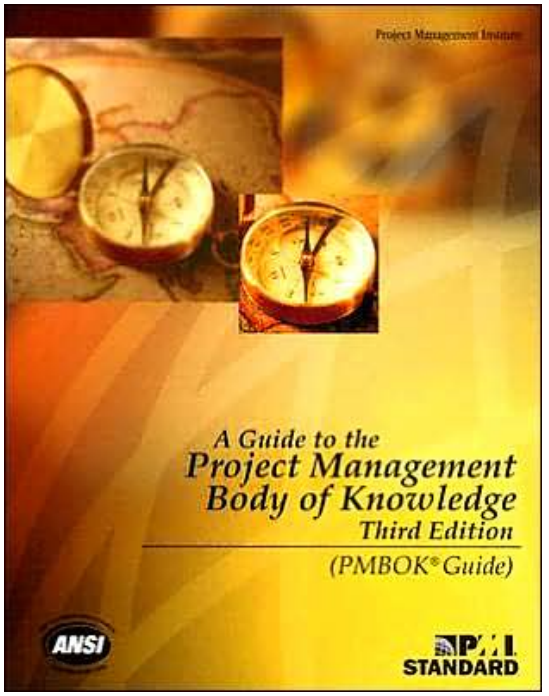
Paradigm

Paradigm

Barry Boehm's Spiral Model of Software Development



PMI's PMBOK:



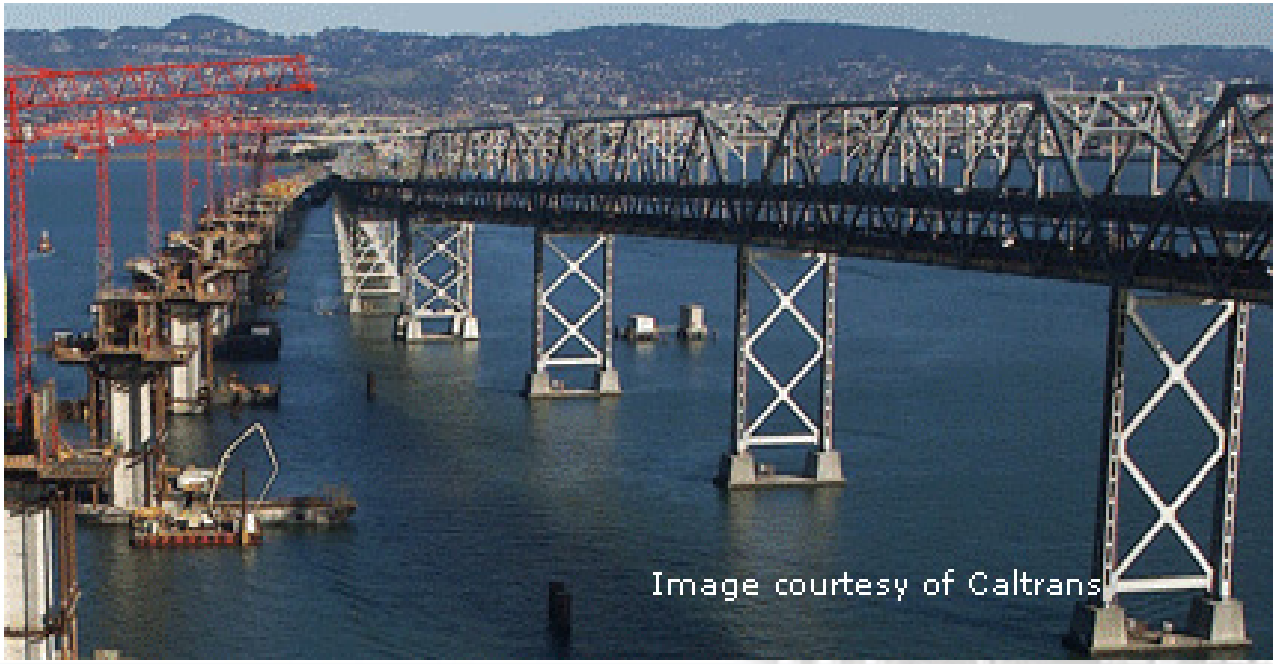
"Progressive Elaboration"

Evolutionary Acquisition Issues

- Number of OSD-Level Reviews
  - Off-Core Activities
  - Significant Transaction Costs
- Unplanned work is inestimable.
- Fielding of obsolete technology -- if SDD isn't short
- Continued conceptual and definitional ambiguity (RAND)
- 1st increment: Militarily useful vs. all desired capabilities
- Organizational impacts of concurrent production and development of follow-on increments
- Maintaining of funding priority for follow-on increments
- GAO examples are mostly from cyclical commercial models, versus fleet ownership (i.e., United, UPS, Fedex)
- Variety brings benefits and costs

Everything Changes, But…

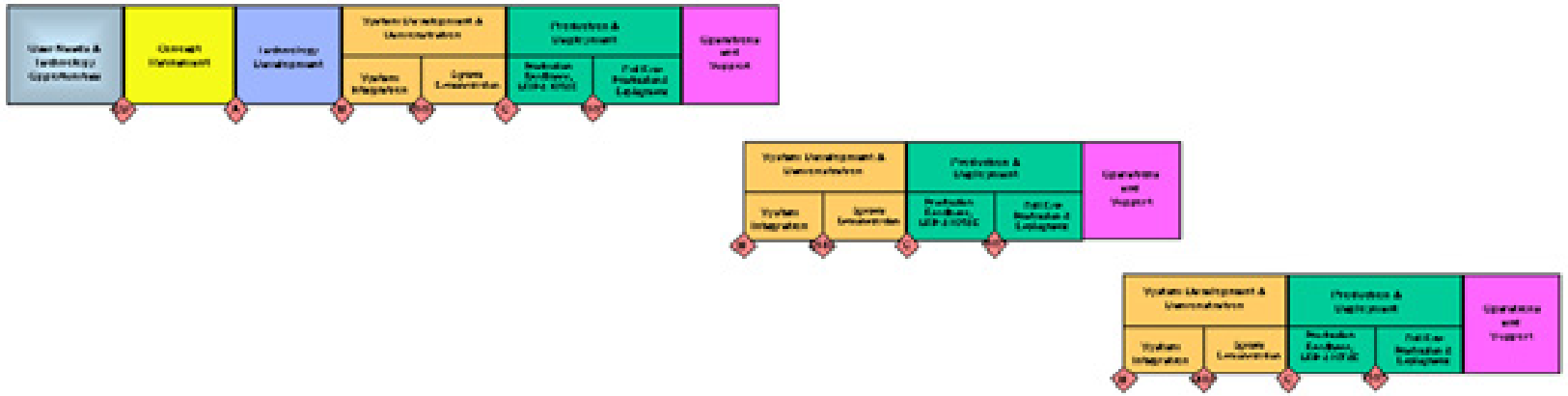
A *one-size-fits-all* development methodology may not be appropriate for all product commodities.



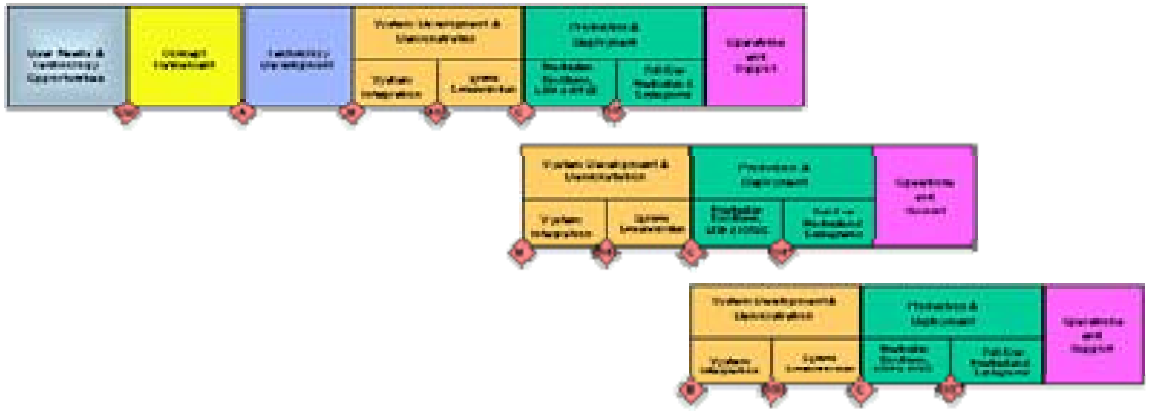
Product Attributes May Affect the Development Strategy

- Mutability
- Range of Requirement Attainment (Binary vs. Continuous)
- User Risk (Safety and Time Criticality)
  - Time-critical or enhanced survivability systems (NMD, ARCI)
  - Non-man-rated Systems (UAVs)
  - Man-rated Systems (munitions)
  - Production Quantity (not a factor)
- Logistical Support Planned During Service/Shelf Life
- Net Amount of Change - and the Lure of Modularity
  - Changes propagate with relative modular interdependency

Relative Concurrency of Increments



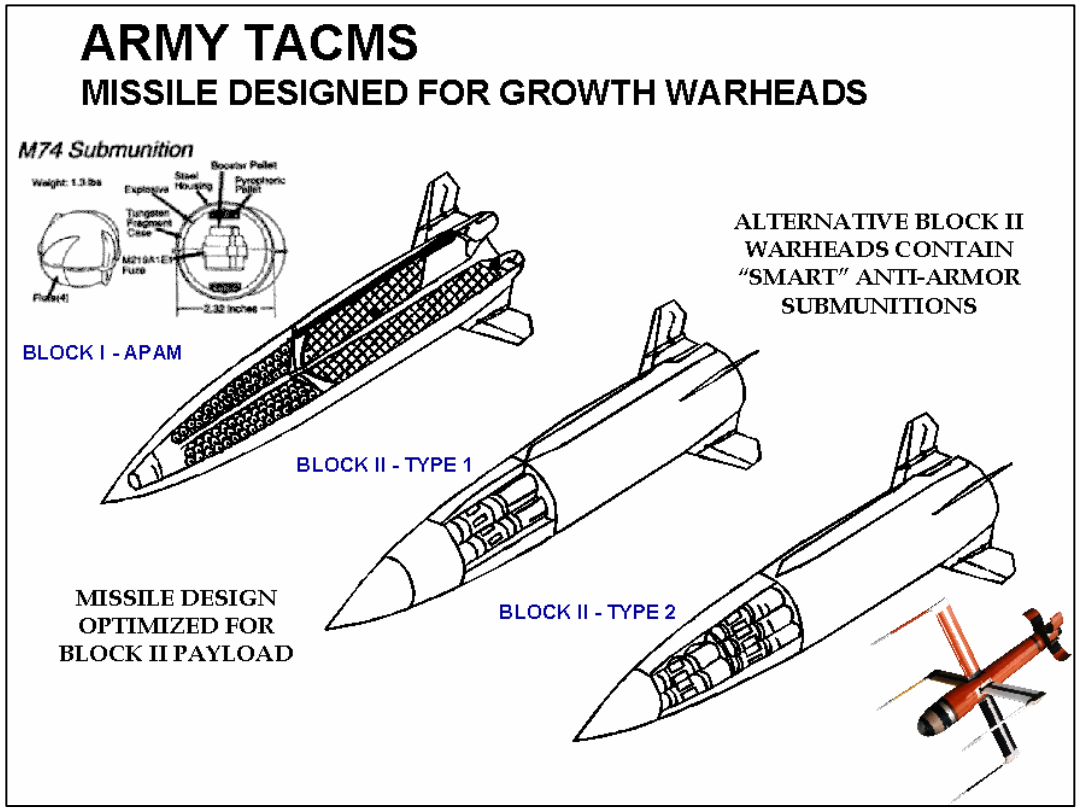
Development Increments Concurrent with Later Production



Development Increments Concurrent with Initial Production

A Tale of Two Missiles

Spiral and Incremental Development



Single Step to Full Capability

A Tale of Two Missiles:

Technology Maturity – A Key Difference

Key Program Characteristics - First Increment of Capability

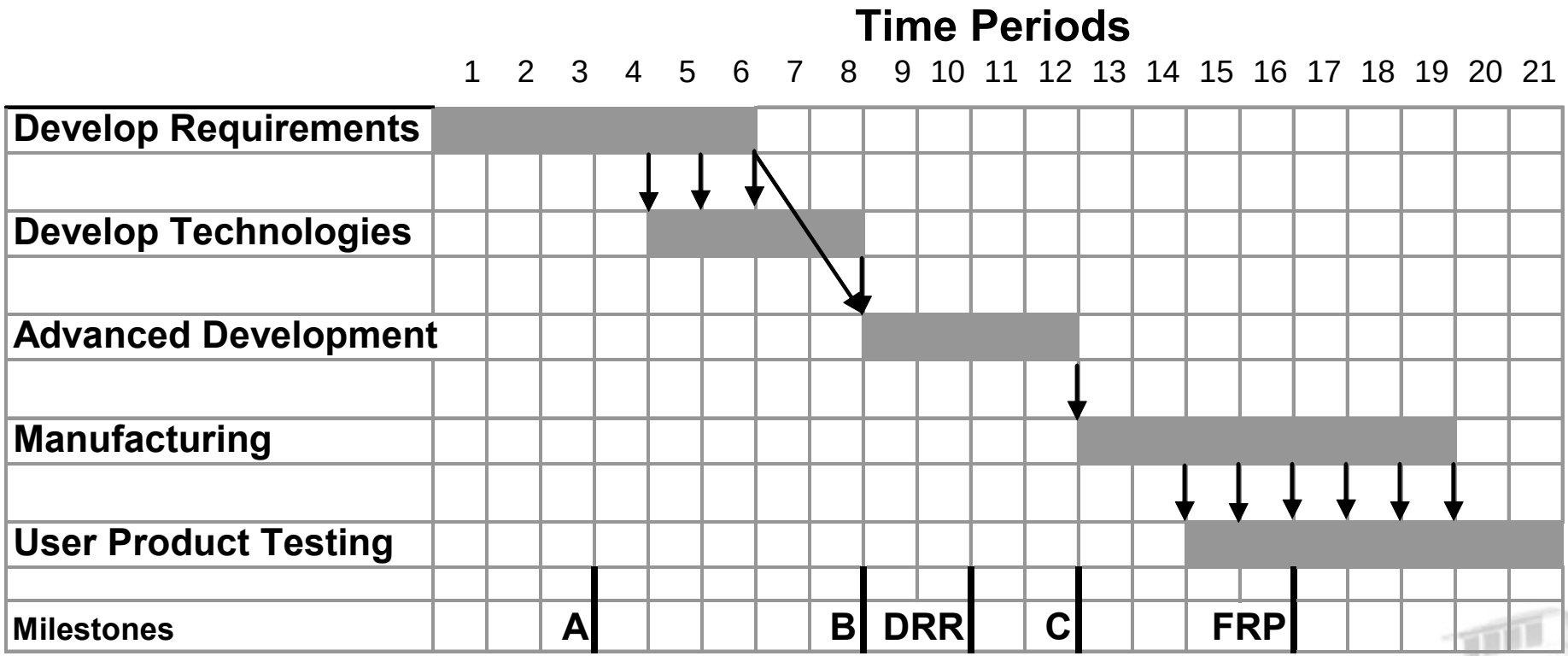
Program Aspects	ATACMS	JAVELIN
DARPA Predecessor	Assault Breaker 1977-82	Tank Breaker 1981-82
Ultimate Capability	*"Deep Attack"*	*"Fire & Forget"*
Critical Technologies & Readiness Levels:		
Munition	9 - Lance M74 Bomblet	5 - Tandem Shaped Charges
Propulsion	9 - Solid Rocket Motor	5 - Two-Stage Solid Rocket Motor
Flight Control	9 - Fin surfaces	6 - Fins + Thrust Vector Control Vanes
Guidance and Control	9 - Inertial	4 - Tracker Software Algorithm
Safe/Arm Fusing	7 - Mechanical	4 - Electronic
Software Function (Target Acquisition, Fire Control, etc.)	6 - Various	6 - Various
Sensor	N/A	5 – Focal Plane Array
Capability Leap Area	Range	Range, Lethality, Survivability
Cost of development	~$700M	~$700M
Contract Type	Fixed Price	Cost Reimbursable
Tech Development Phase	0 Months	27 Months
Advanced Development Phase - Planned	48 Months	36 Months
Advanced Development Phase - Actual	51 Months	54 Months
Total Time in Development	51 Months	81 Months
Advanced Development Phase Contract Cost Growth	0%	>150%

Modeling the Drivers and Impacts of Evolutionary Acquisition

- Need to validate the impacts of Evolutionary Acquisition suggested by the ATACMS and Javelin cases
- Need to identify other, less clearly visible, impacts of Evolutionary Acquisition
- Need to understand impacts using many strategies

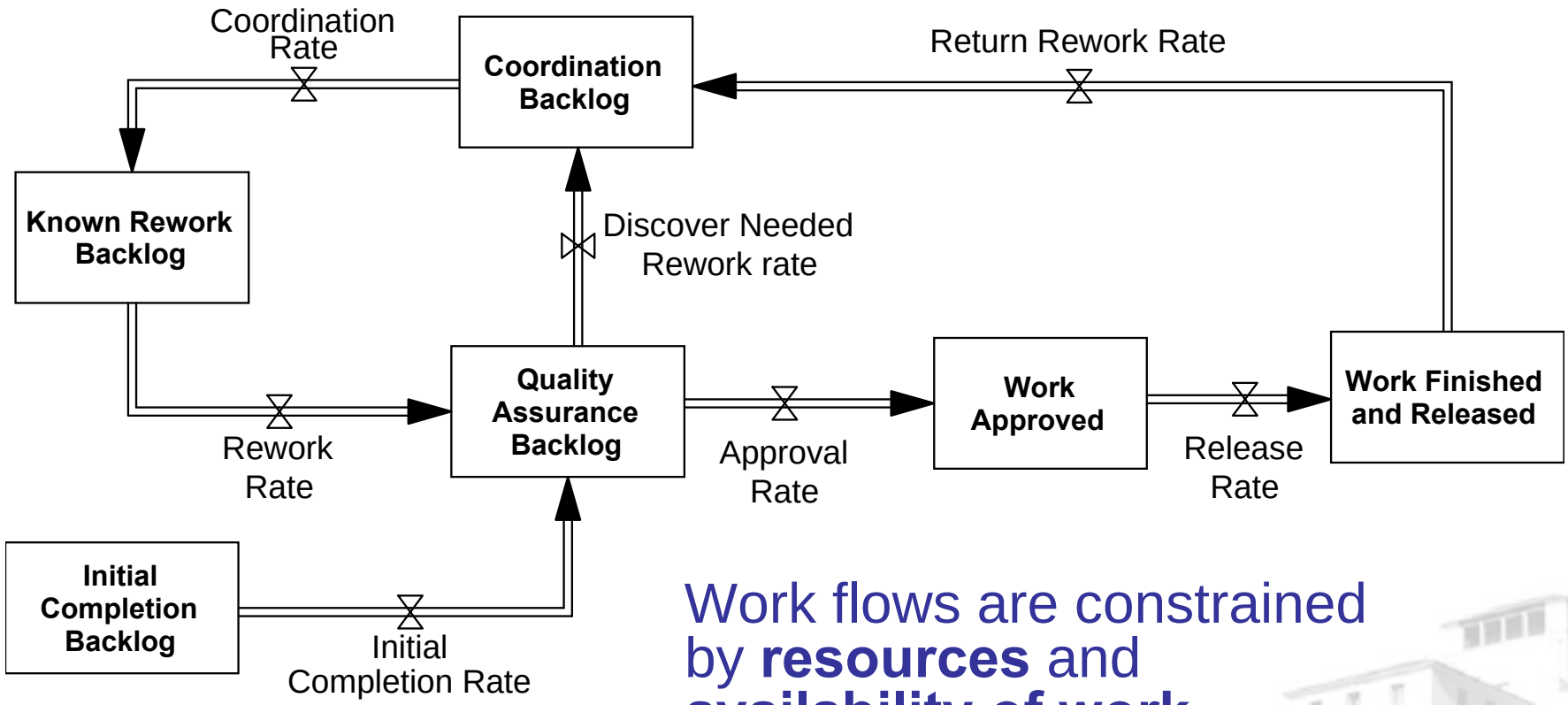
Built computer simulation model of work and information in an Evolutionary Acquisition project

Information Flows in a Single-block Acquisition Project



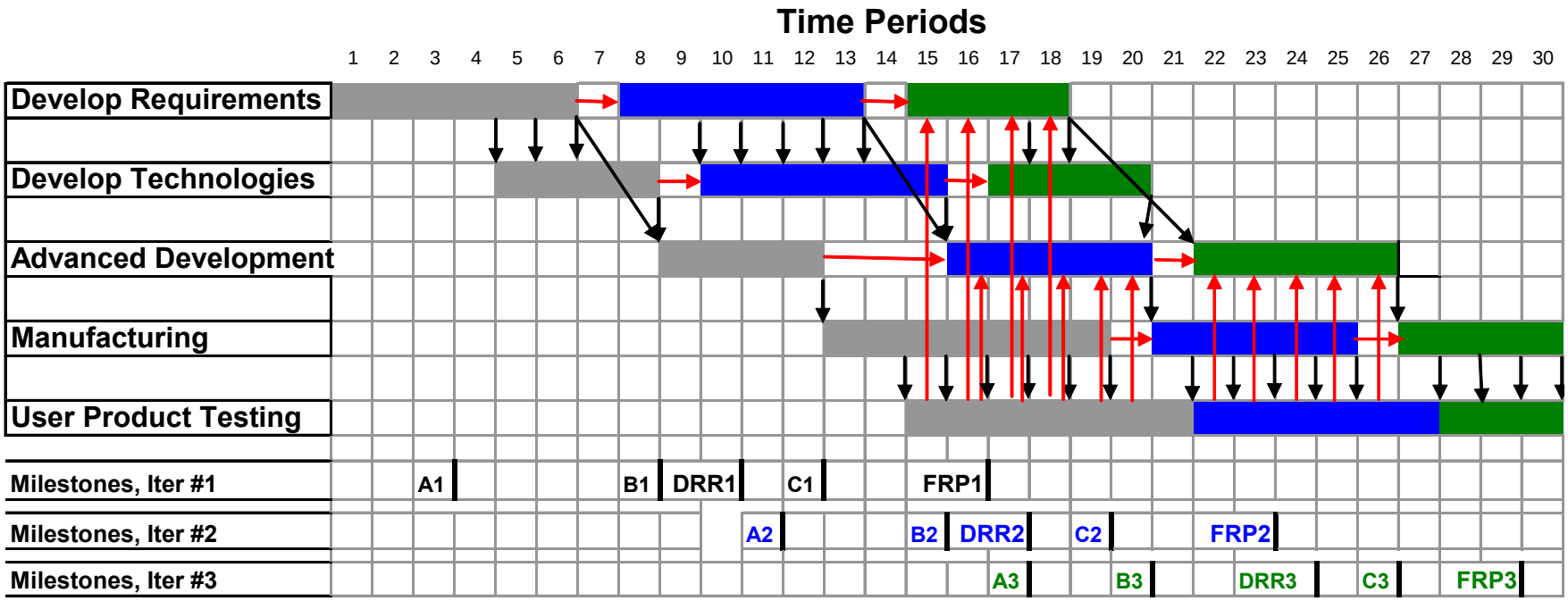
Models inter-phase concurrence & information dependencies

Work Flows and Backlogs through a Development Phase



Work flows are constrained by **resources** and **availability of work**

Information Flows in an Incremental Acquisition Project



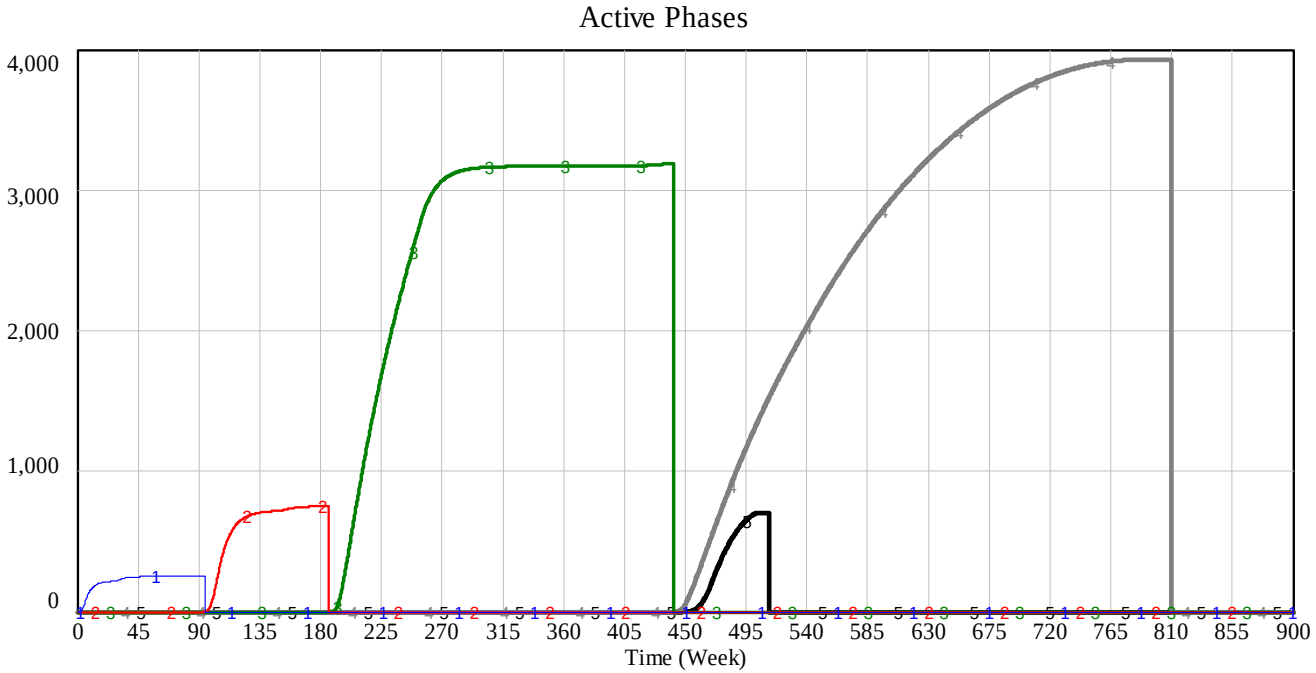
- Contracting, etc. modeled with indirect work at start of each phase
- Reviews modeled with indirect work at end of each phase

Modeling Performance and Resources

- **Acquisition Project Performance**
  - ***Schedule*** – when how many requirements are satisfied
  - Total project ***cost*** (labor as proxy)
  - ***Risk*** of satisfying requirements by a deadline
- **Resources**
  - *Two workforces*: Development & Project Management
  - Resource progress rate = allocated workforce * productivity
  - Development allocated to reduce work backlogs
  - Project management allocated to coordinate development activities

Model Calibration and Testing

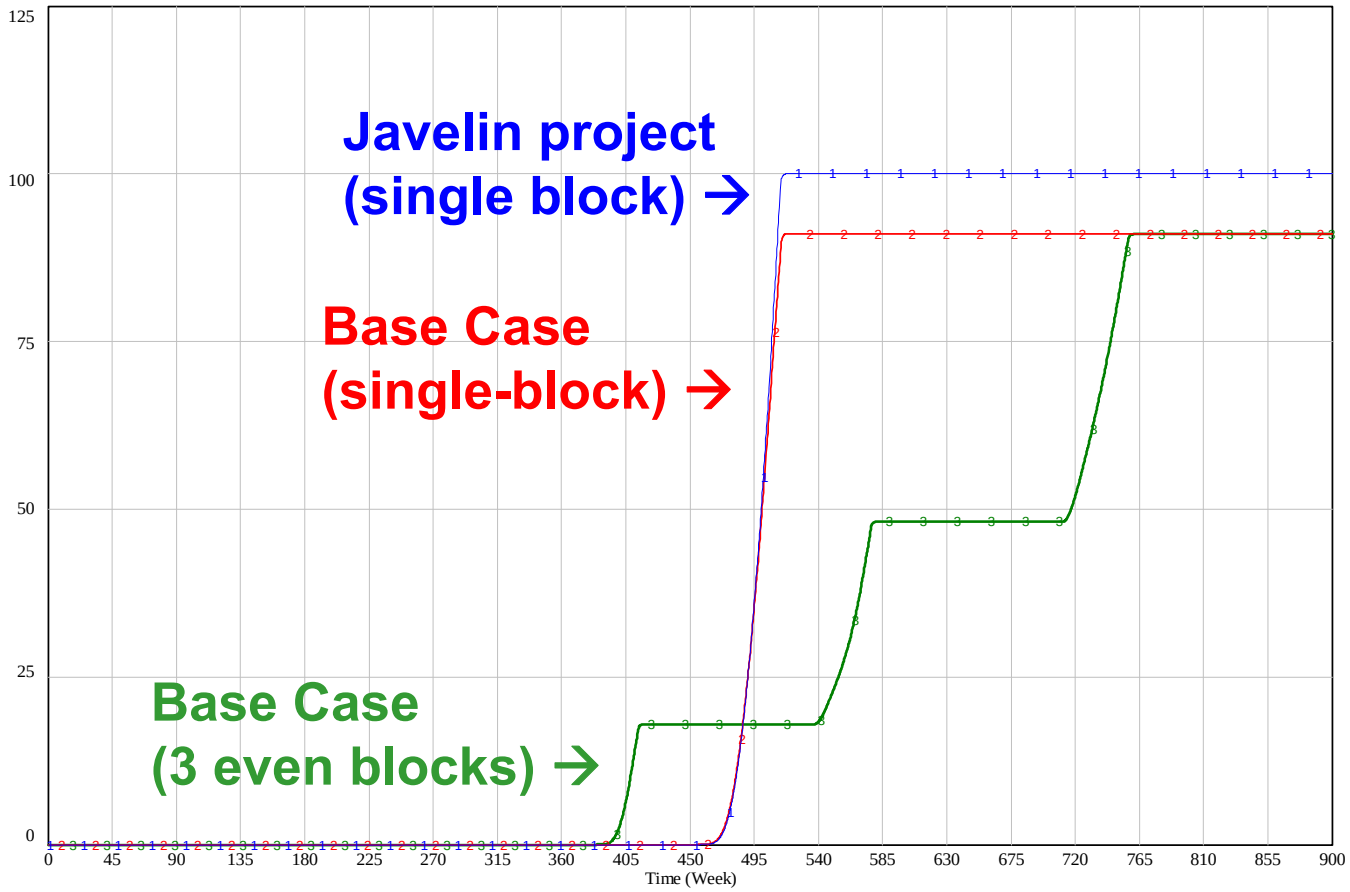
- **Model was calibrated to Javelin project**



Work packages being developed
(also proxy for development effort)

- **Model structure and behavior is consistent with the Javelin project**

Impacts of Multiple Development Blocks



Requirements Tested and Approved by Users
(% of all project requirements)

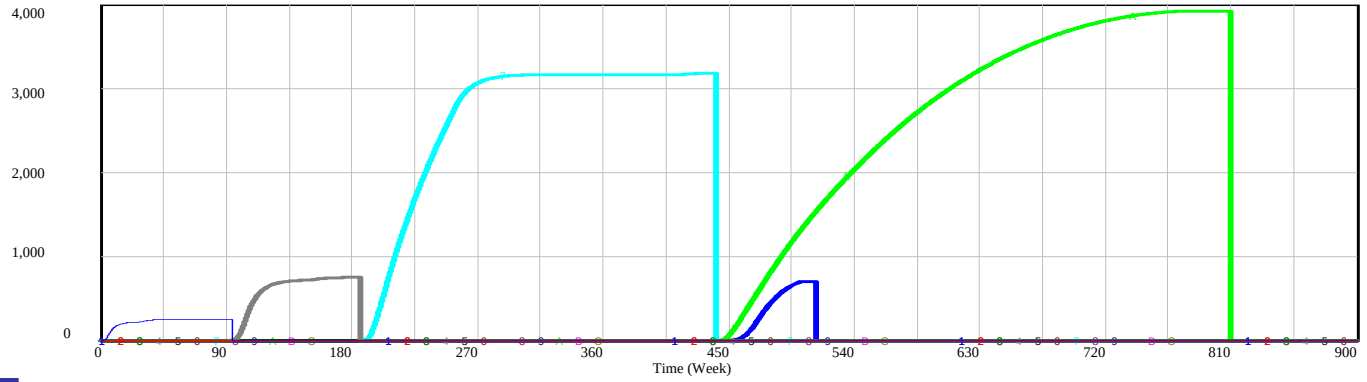
Impacts of Multiple Development Blocks

Performance Measure	Units of Measure	Project Scenario: Javelin (single block)	Project Scenario: Base Case (single block)	Project Scenario: Base Case (3 blocks)	Best Performance
Duration to first requirement satisfied	weeks	471	470	397	Base Case (3 blocks)
Duration to max. requirements satisfied	weeks	520	518	762	Base Case (single block)
Total development cost	$1,000,000	722	719	1,555	Base Case (single block)
Requirements satisfied by deadline	% of requirements developed	100	91	18	Javelin (single block)
Final requirements satisfied	% of requirements developed	100	91	91	Javelin (single block)

The (dis)advantages of Evolutionary Acquisition depend on what performance measures are most important.

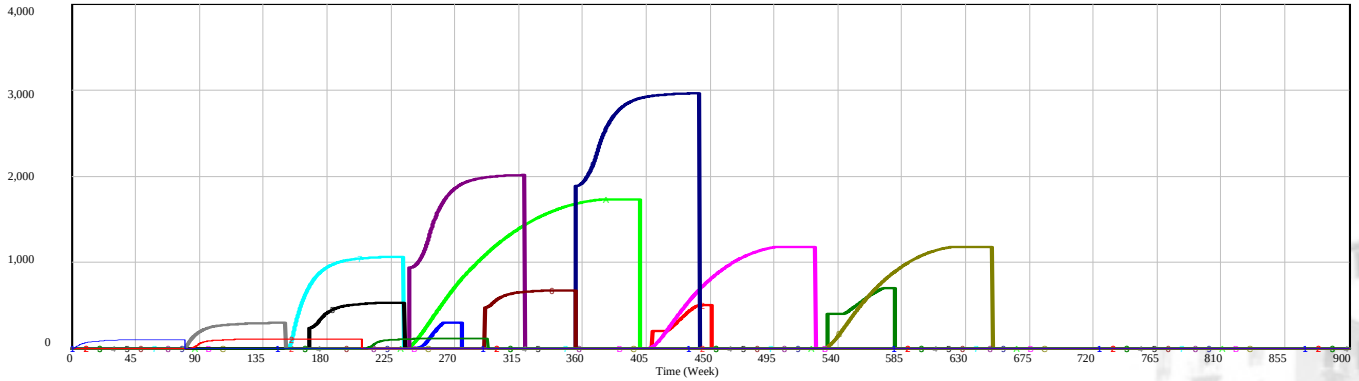
Managing Iterative Development

Base Case (single block)



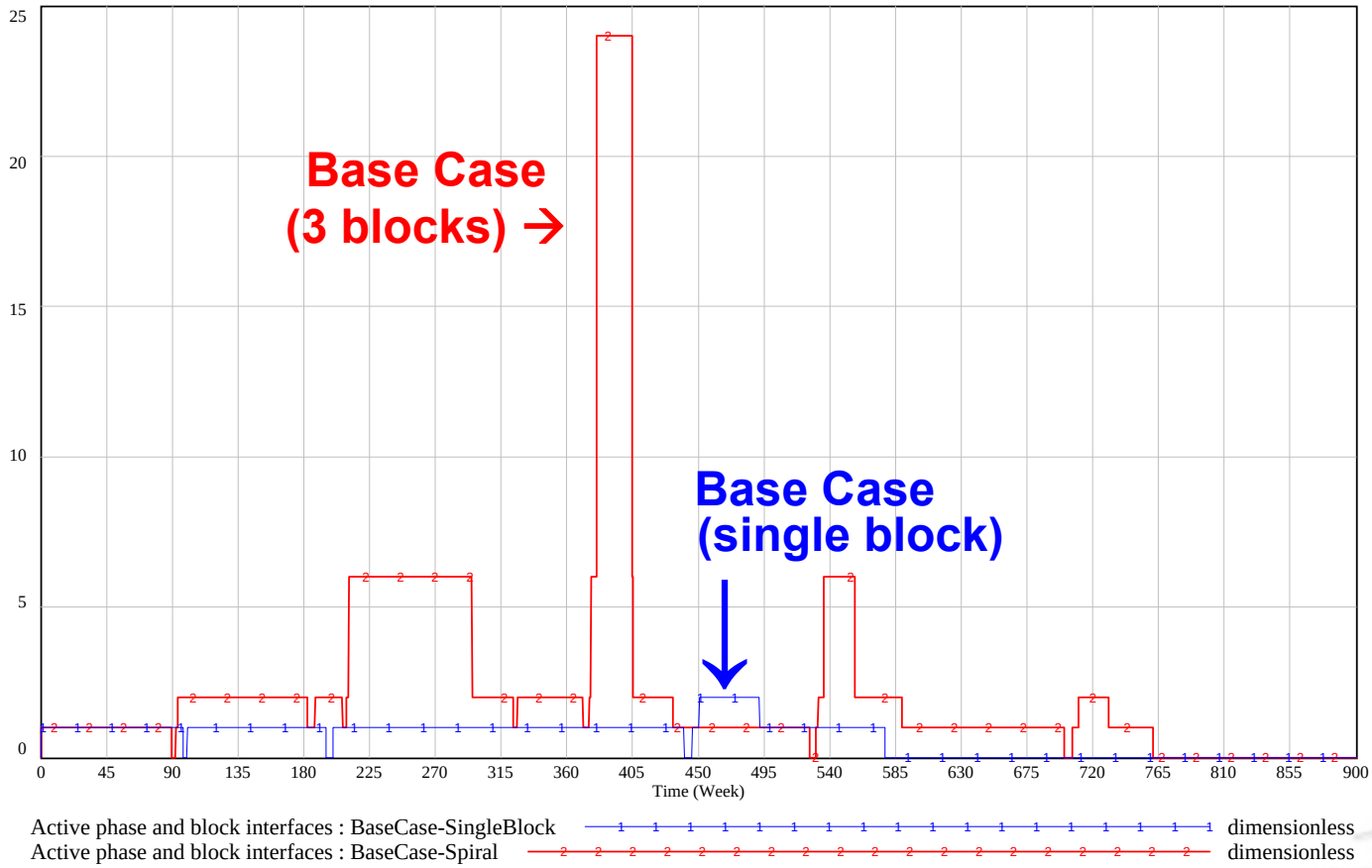
Work being Developed

Base Case (3 blocks)



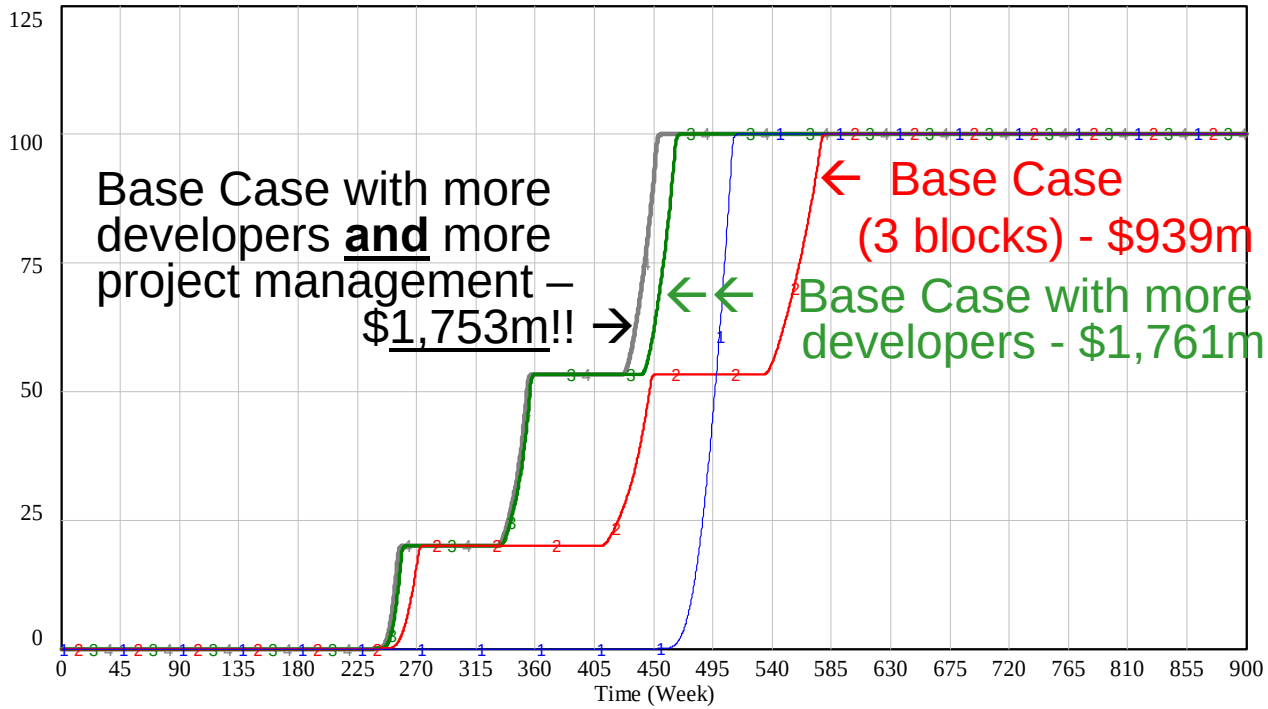
Managing Iterative Development

Number of Active Phase Interfaces



Managing Iterative Development

Requirements Tested and Approved by Users



Conclusions –Evolutionary vs. Single Block Development Approaches…

- First Unit Equipped with some (but not all) requirements satisfied ***faster***
- Satisfies requirements in ***multiple steps***
- Requires ***more time*** to satisfy all requirements
- ***Costs more*** than single-block development for same requirements
- High risk of not satisfying all requirements by the time single-block development can satisfy all requirements

Implications for Evolutionary Acquisition Project Managers

- More development phases and activities to manage and coordinate: ***larger and different PM needs***
- More concurrence and resulting complexity: ***bottlenecks change and move…are more difficult to identify and manage*** ← focus more on this
- Creates counterintuitive behavior (e.g.reductions in project cost by adding resources) – ***opportunities to improve performance…IF you develop a deep understanding of the drivers and constraints of Evolutionary Acquisition progress.***

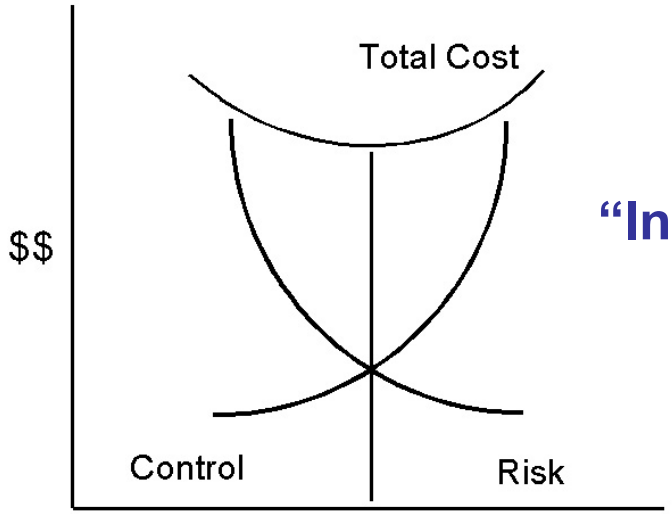
  Need more investigation of more EA projects.

Our Bottom Line on Risks

- DoD uniquely outsources development for internal use
  - *owns* the product over its life cycle
- There are inherent potential risks with incremental development
  - inefficiencies from re-work (duplication)
  - risk of project error (from discontinuous membership)
  - organizational impacts (queuing theory)
  - relative concurrency drives risk
  - variety in the fleet (support, failure cause, training, etc.)
- Don't defer what you can do now
- Defer what you cannot do now – tech readiness
- Product attributes may affect development strategy

Our Top Line on Control

- **Rigorous Preliminary Effort on *Architecture***
- **Meticulous *Configuration Management***
- **Individual *Accountability***
- **Other control measures to *balance risks***
  - **T&E, Interface Control, Peer Review**
  - **GPR, MOSA & OA Incentives, etc.**



Perceived Relationships Among Project Cost, Control and Risk (adapted from Wysocki 2003)

"Intelligent design is way faster than evolution."

Robert N. Metcalfe

Questions?