Modeling & Simulations in support of Program Management

Introduction

Our Goal:

To make you an

"Educated Consumer"

regarding Modeling and Simulation as it relates to Acquisition

Introductions

CAPT (Sel) Dave Johnson - Chief, DMSO Operations Div

703-998-0660

djohnson@msis.dmso.mil

Tom Stanford - Project Leader

703-933-3343

tstanfor@msiac.dmso.mil

Steve Hicks - Instructor

407-282-6482

shicks@msiac.dmso.mil

Ed Degnan - Instructor

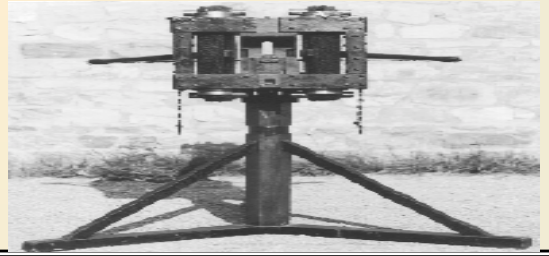
407-658-5079

edegnan@ist.ucf.edu

M&S in Acquisition: Historic View

Early Weapon Development

"...if only we could try our weapons on every type of land prior to combat!"
Roman Legionnaire 46 AD



Technical knowledge on catapults was lacking, fewer quality engines could be built and employed.

The Roman Army had difficulty acquiring and distributing catapults due to a lack of defined procedures and processes.

Weapon capabilities could be determined only through live testing!

M&S in Acquisition: Historic View

Translated Calculator Sheet - 134 AD

BALLISTA CALCULATOR

Diameter of skein = 1.1 * POWER(X * Y * 100, 1/3) * Z

Where: X = Weight in minas, pounds or grams

Y = The weight conversions factor Z = The length conversion factor

When x is in:	Minas	Pounds	Grams
Values for Y are:	1	0.96	436
Values fo Z are:	1	0.76	1.93
The result is in:	Dactyls	Inches	Centimeters

Weight Conversions			Length Conversions		
Minas	Pounds	Grams	Dactyls	Inches	Centimeters
1	0.96	436	1	0.76	1.93
Enter weight below			**Diameter in:**		
Minas	Pounds	Grams	Dactyls	Inches	Centimeters
10.00	9.61	8,720	11.00	8.36	26.75
	10.00	20.00		11.00	13.86
9.61		19.22	8.36		10.53
4,360	4,359		21.23	21.23	

Density of stone shot			
LB / IN3	0.072254	2.00	GM / CM3
Volume of shot			
INCH3	133.00	4,360	CM3
Radius = POWER(3 * volume / (4 * PI()),1/3)			
INCH	3.166583622	10.13442921	CM3
Diameter of spherical stone shot			
	6.33	7.98	Inches
	16.09	20.27	Centimeters
	8.33	10.50	Dactyls

DoD's Goals for Acquisition Year 2000 (Established 1997)

Vice President's National Performance Review

Cut delivery time for new systems by 25%

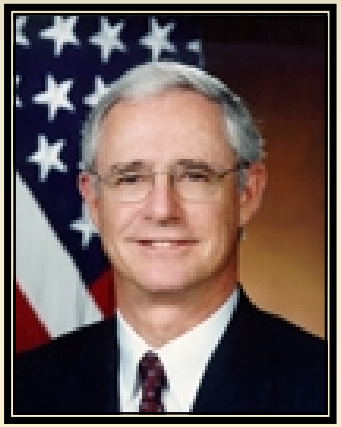
Department of Defense

- Stretched goal to cut delivery time for new systems by 50%
- Set goal to reduce Total Ownership Cost

Defense Systems Affordability Council

- Recognized potential of M&S
- Set SBA as one of the top initiatives to realize the stretched goal

Message From the Top



"We are *committed to reforming the acquisition system* and recognize that *an essential tool* for accomplishing that reform will be *modeling and simulation*."

Dr. Jacques S. Gansler
Under Sec Def (Acquisition, Technology, and Logistics)
DMSO Industry Day
2 Jun 1998

M&S Required in Acquisition
DoD Directive 5000.2

"PMs shall integrate...M&S within program planning...; ...and plan for life-cycle application, support, and reuse M&S."

"Accredited M&S shall be applied, as appropriate, throughout ...the system life-cycle..."

"... and integrate M&S across ...functional disciplines."

Demonstrated Value of M&S in Acquisition

Intrepid is the first car to be fully designed, constructed, and tested by computer before ever being built in metal

Cost Avoidance

- Requires *6.5 hours* to build vs.*19 hours* to build a Neon
- Plant investment is less than $300 million, about one-third typical
- 33 % reduction in tooling costs

Other Benefits

2000 different *engines tested before actually built. Design errors fixed* in *days or even minutes* rather than weeks.
Engineers *resolved* over *1500* space availability and clearance *issues prior* to building *prototype.*

For the *first time* in automobile *advertising*, *actual engineering imagery* is used rather than animation.The goal was *"to educate audiences"* ...

DoDD 5000.59
DoD Modeling and Simulation Management - Jun 94

Establishes DoD policy, assigns responsibilities, and prescribes procedures for the management of M&S.

Establishes the DoD Executive Council for Modeling and Simulations (EXCIMS).

Establishes the Defense Modeling and Simulation Office (DMSO).

DoD M&S Vision

"Defense modeling and simulation will provide readily available, operationally valid environments for use by DoD components

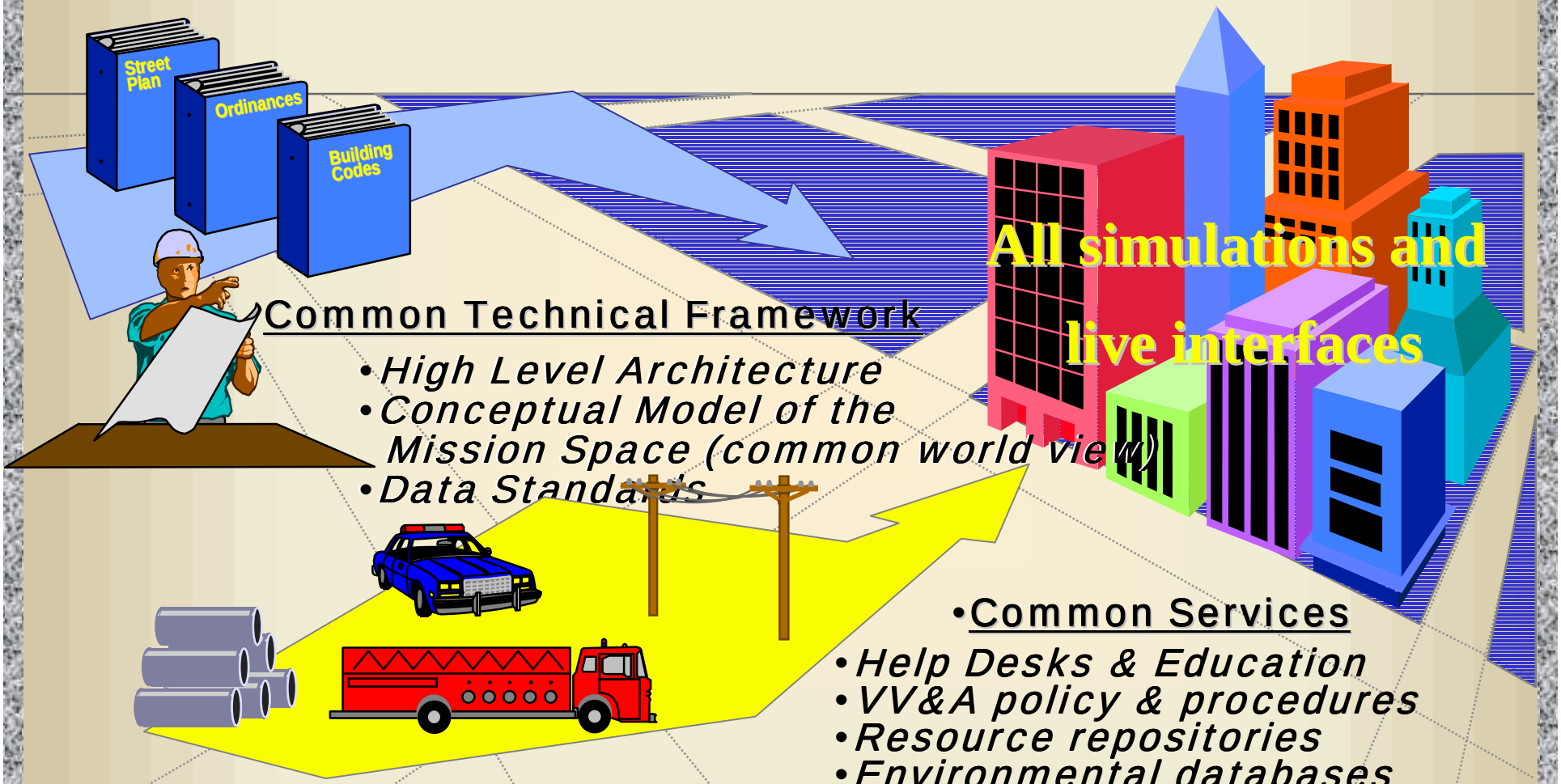
- **to train jointly, develop doctrine and tactics, formulate operational plans, and assess warfighting situations, as well as**
- **to support technology assessment, system upgrade, prototype and full scale development, and force structuring.**

Furthermore, common use of these environments will promote a closer interaction between the operations and acquisition communities in carrying out their respective responsibilities. To allow maximum utility and flexibility, these modeling and simulation environments will be constructed from affordable, reusable components interoperating through an open systems architecture."

DoD Executive Council on Modeling and Simulation (EXCIMS), March 13, 1992
Revalidated Spring 99

DoD M&S Strategy: An Analogy to City Planning

Payoffs: Interoperability and reuse = capability and cost-effectiveness



Common Technical Framework

- *High Level Architecture*
- *Conceptual Model of the Mission Space (common world view)*
- *Data Standards*

- **Common Services**
  - *Help Desks & Education*
  - *VV&A policy & procedures*
  - *Resource repositories*
  - *Environmental databases*
  - *Communications*
  - *Supporting software & tools*

Strategy Being Executed Through DoD-wide M&S Master Plan

Objective 1	Objective 2	Objective 3	Objective 4	Objective 5	Objective 6
Develop a common technical framework for M&S	Provide timely and authoritative representations of the natural environment	Provide authoritative representations of systems	Provide authoritative representations of human behavior	Establish an M&S infrastructure to meet developer and end-user needs	Share the benefits of M&S
Sub-objectives	*Sub-objectives*		*Sub-objectives*	*Sub-objectives*	*Sub-objectives*
1-1 High-level architecture	2-1 Terrain		4-1 Individuals	5-1 Field systems	6-1 Quantify impact
1-2 Conceptual models of the mission space	2-2 Oceans		4-2 Groups and organizations	5-2 VV&A	6-2 Education
1-3 Data standardization	2-3 Atmosphere			5-3 Repositories	6-3 Dual-use
	2-4 Space			5-4 Communications	
				5-5 Coordination Center	

DoD 5000.59-P, Modeling and Simulation Master Plan, October 1995

www.dmso.mil

Each Service and DOD Component has a responsibility to use M&S in acquisition

Joint M&S Management

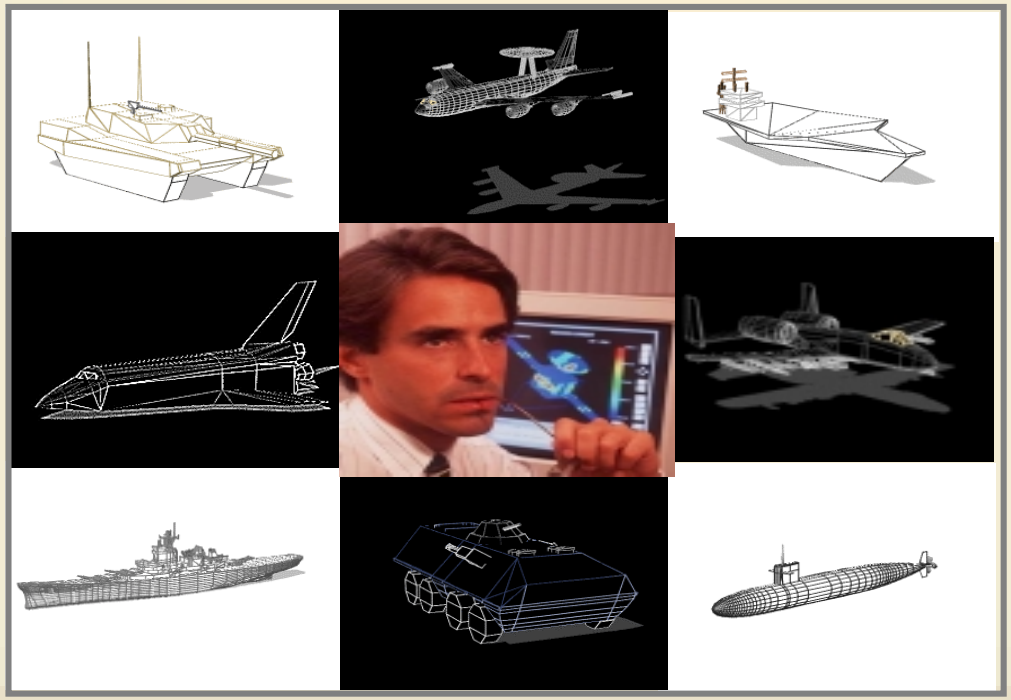
- **Organization:** Joint Staff
- **POCs:** (Under direction of Vice Director, Joint Staff)
- **Mission/Responsibilities (defined in CJCSI 8510.01):**
  - J-8 - overall Joint Staff M&S focal point; Master Plans; oversees analytical JM&S
  - J-7 - oversees training and exercise JM&S.
  - J-6 - oversees C4I JM&S; primary interface to DISA, C4ISR DSC, and JBC.

M&S Basics, Overview of M&S in Acquisition

Model vs. Simulation

Model **- "A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process."**
Simulation **- "A method for implementing a model over time."**

A PMO uses many types of models and simulations over the course of an acquisition program.



DoD M&S GLOSSARY Jan 98
www.dmso.mil

Types of Models

"A *mathematical model* is a symbolic model whose properties are expressed as mathematical symbols and releationships."

"A *physical model* is a model whose physical characteristics resemble the physical characteristics of the system being modeled."

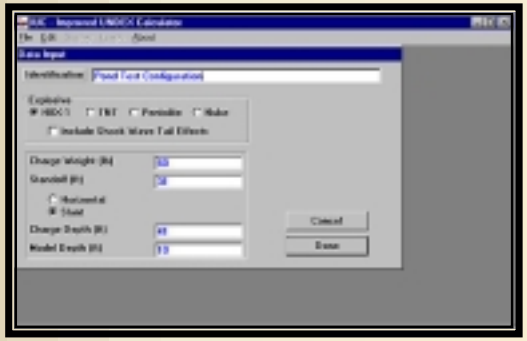
"A *process model* models the processes performed by a system."

DoD M&S GLOSSARY Jan 98
www.dmso.mil

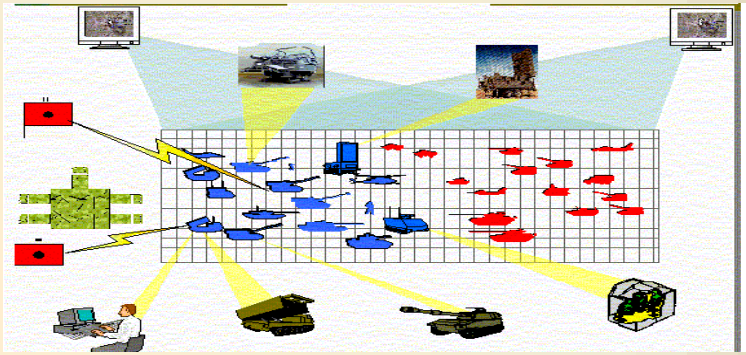
Types of Simulation: Constructive

Simulated people operating simulated equipment

Real people make inputs to such simulations, but are not involved in determining the outcome



MIDAS: A Constructive Simulation for Human-System Analysis



FireSimXXI: Analysis Tool for Fires-related Combat Development Studies

- ***With data input, calculate solutions to cost, performance, design, logistics questions***
- ***Facilitate analyses of system performance at the engagement or mission level***
- ***Involve a large number of established legacy models***

DoD M&S GLOSSARY Jan 98

www.dmso.mil

Types of Simulation: Live

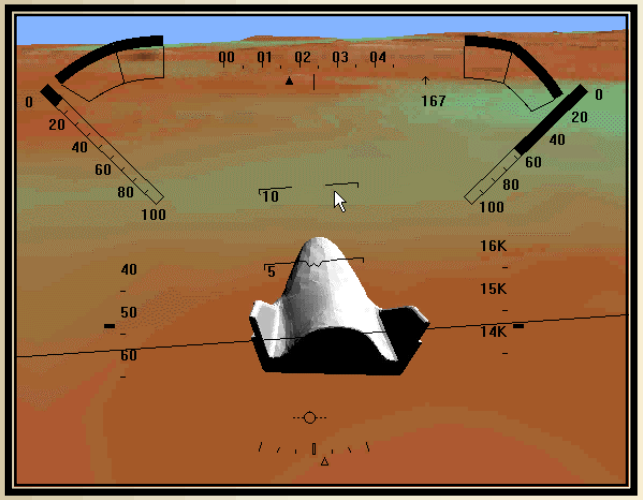
Real People; Real Equipment

- *May deploy with actual equipment*
- *May be similar to area of operations*
- *May cause large resource expenditure*
- *Can be mixed with virtual and constructive; models and simulations*

DoD M&S GLOSSARY Jan 98
www.dmso.mil

Types of Simulation: Virtual

Real People; Simulated Equipment



Active Flight

Virtual Flight Deck

AAAV Crew Station Simulator (CSS)

- *Closely replicates or uses actual equipment*
- *Various levels of fidelity/risk*
- *Enables performance of "dangerous" tasks*

DoD M&S GLOSSARY Jan 98
www.dmso.mil

Distributed Simulation (DS)

Simulations interact through current state-of-the-art communication systems.

Systems Acquisition Life Cycle: The Traditional View

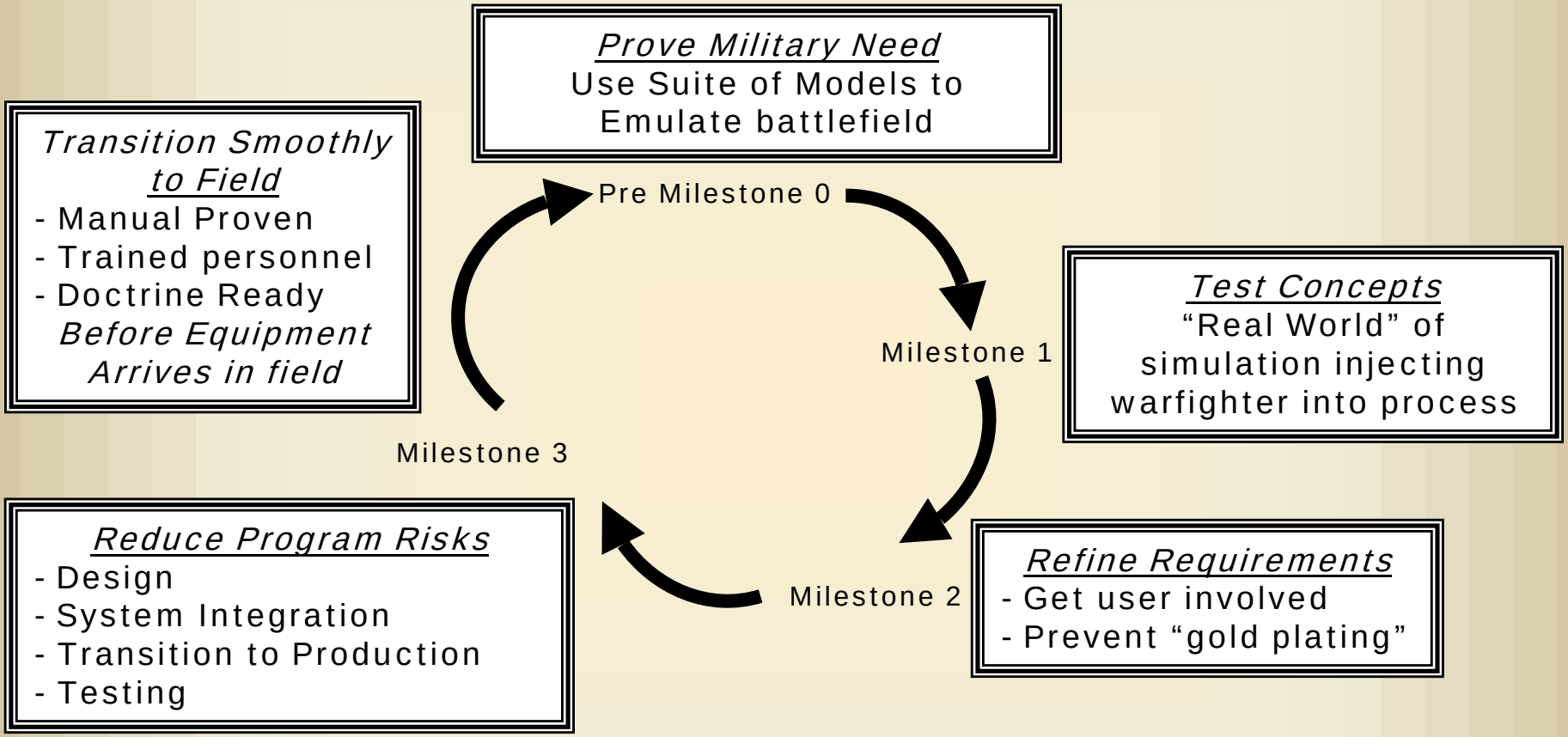
Major Phase Activities

Mission Area Assessments	Analysis of Alternatives	Systems Engineering, DT&E	Systems Engineering, OT&E	Operational Support, Configuration Management

Determination of Mission Need	PHASE 0	PHASE I	PHASE II	PHASE III	Demilitarization & Disposal
	CONCEPT EXPLORATION	PROGRAM DEFINITION & RISK REDUCTION	ENGINEERING & MANUFACTURING DEVELOPMENT	PRODUCTION, FIELDING/ DEPLOYMENT, & OPERATIONAL SUPPORT	

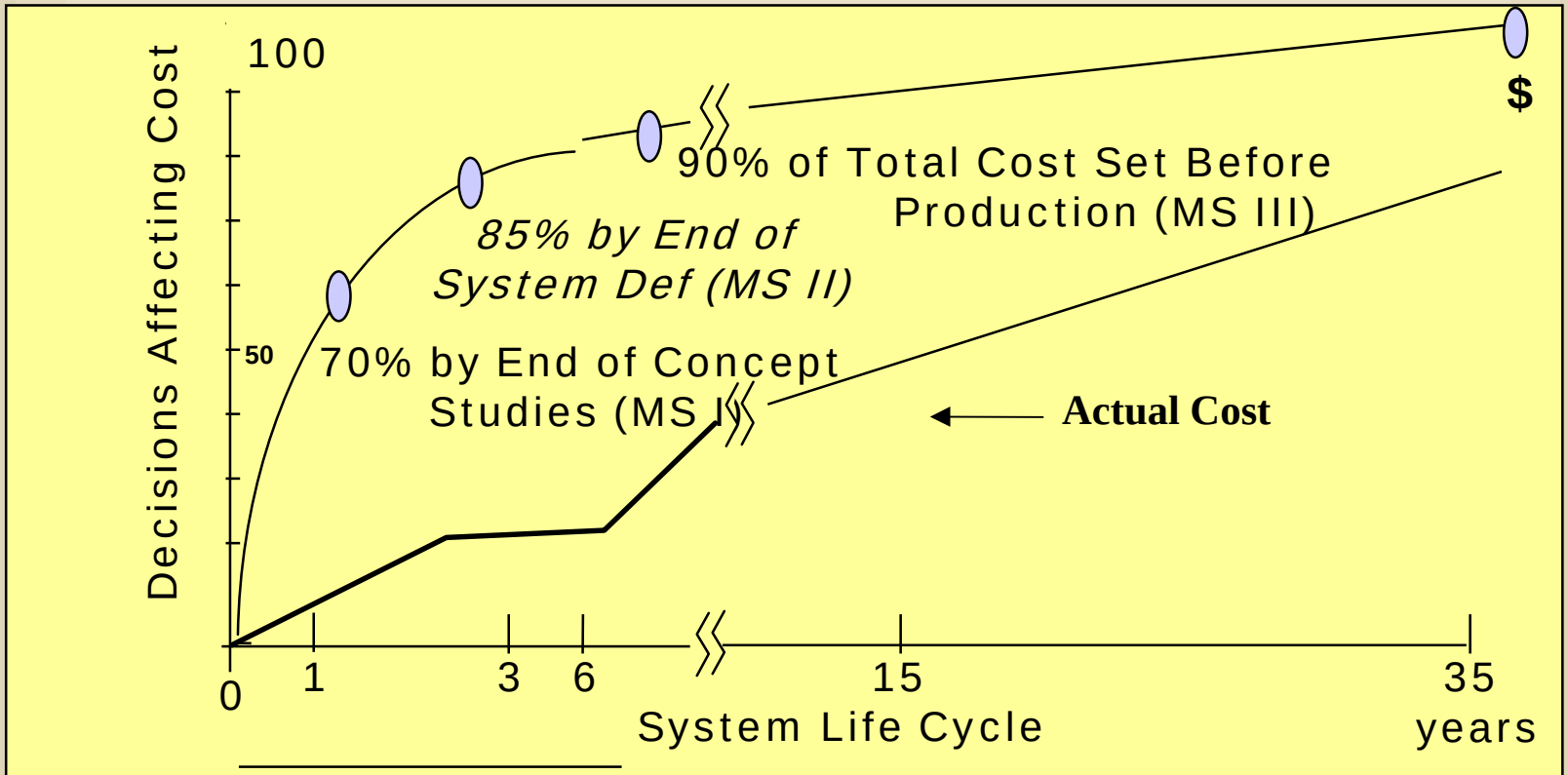
MS 0	MS I	MS II	MS III
Approval to Conduct Concept Studies	Approval to Begin a New Acquisition Program	Approval to Enter Engineering & Manufacturing Development	Production or Fielding/ Deployment Approval

Iterative Acquisition Process



Simulation and Reform of the Acquisition Process.
Adapted from Shiflett et al. (1995)

Why M&S? Where Is Cost Determined?



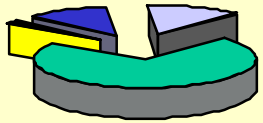
Logistic Support Analysis Handbook, J. Jones

Life Cycle Costs Are Locked in During the Up-front Design and Development Process

SBA Roadmap Presentation, Robin Frost, SIW Spring 99

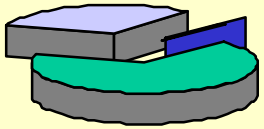
DRIVERS OF LIFE CYCLE COST

Acquisition Costs (28%)



Fabrication	72%
Documentation	2%
Design	12%
Installation & Checkout	14%

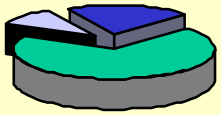
Operations Costs (12%)



Personnel	67%
POL	32%
Misc	1%

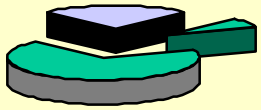
Logistics Support Costs (60%)

Recurring Spt (92%)



Maint Labor	70%
Repair Materiel	10%
Replen Spares	20%

Investment (8%)



Initial Training	7%
Initial Spares	68%
Other	25%

SBA Roadmap Presentation, Robin Frost, SIW Spring 99

Overview of M&S in Acquisition

Pre-Milestone 0

Mission Area Assessments
Use Suite of Models & Simulations

MNS
Use Campaign & Theater Level Models in Conjunction With Results of Lower Level Models

Distributed Product Description (DPD)
Air Force used DSM

Concept Exploration
(Phase 0)

ORD Generation
Use Operational Effectiveness & Supportability Models

Analysis of Alternatives
Use Cost & Operational Effectiveness Models
Use Support Models

RFP
Specify Government-Owned M&S Products
Identify M&S Requirements

System Cost Elements
Use Cost Models (Program & Life Cycle)

Program Planning
Use Schedule, Risk, Plans Models

DPD

PD&RR

Acquisition Strategy
M&S Strategy
Use Repository
VV&A

Systems Engineering
Use Engineering M&S of Proposed Systems for Specification Development
Use HW/SW-in-the-loop for Design Evaluation & Risk Reduction
Use CAD/CAM for Design & Producibility Planning
Use Support & Operational Models to Evaluate Logistics/ Combat Support Concepts & Plans

TEMP
Plan M&S Applications to be Used in DT&E, OT&E
Plan Use of DT&E to Validate Models
Establish Test Facility M&S Compatibility Requirements

DPD

EMD

Review M&S Requirements & Products Being Used

T&E
Use M&S to Quantify Test conditions, Design Tests, and Predict, Quantify & Extrapolate Test Results

Continue VV&A Activities
Coordinate with Repository for M&S
Use Production Planning
Use Manufacturing Process DPD Models
Use Factory Simulations

Logistics Planning
Use M&S to Identify Logistics Support Tasks & Requirements, and Complete Support Plans

DPD

Production, FD & O/S

Update Manufacturing Process Models & Factory Simulations
Use Operations & Support Tracking & Prediction Models & Update M&S Tools for FOT&E
Provide M&S Applications Descriptions to Repository
Evaluate Operations & Support Deficiencies and Analyze Alternative Corrective Actions

DPD

"Modeling and Simulation in Support of the Air Force Acquisition Process," Acquisition Policy 97A-004, Nov 97

M&S in Acquisition
Pre-Milestone 0

Extended Air Defense Simulation (EADSIM)

Mission Area Assessments
Use suite of models & simulations

Mission Need Statement (MNS)
Use campaign & theater level models in conjunction with results of lower level models

EADSIM is an example of a constructive model at the mission level.

www.jasa.mil

"Modeling and Simulation in Support of the Air Force Acquisition Process," Acquisition Policy 97A-004, Nov 97

M&S in Acquisition
Phase 1: Program Definition &Risk Reduction (PDRR)

Acquisition Strategy
M&S Strategy
Use repository
VV&A

Systems Engineering
Use Engineering M&S of proposed systems for specification development
Use HW/SW-in-the-loop for design evaluation & risk reduction
Use CAD/CAM for design & producibility planning
Use support & operational models to evaluate logistics/combat support concepts& plans

TEMP
Plan M&S applications to be used in DT&E, OT&E
Plan use of DT&E to validate models
Establish test facility M&S compatibility requirements

Hydrodynamic Test Rig (4/5 Scale)

Used to validate Computational Fluid Dynamics model used for water-jet propulsion design

http://www.dote.osd.mil/reports/FY97/navy/97aaav.html

M&S in SBA, Benefits, STEP

Simulation Based Acquisition (SBA)

Definition of SBA

An *iterative, integrated product and process approach to acquisition*, using modeling and simulation, that enables the warfighting, resource allocation, and acquisition communities to fulfill the warfighter's material needs, while maintaining *Cost As an Independent Variable* (CAIV) over the *system's entire lifecycle* and within the DoD's *system of systems.*

SBA: A New Approach, 1997-1998, DSMC Military Research Fellows

Simulation Based Acquisition (SBA)

Vision

...to have an Acquisition Process in which DoD and Industry are enabled by robust, collaborative use of simulation technology that is integrated across acquisition phases and programs.

Goals

- Substantially reduce the time, resources and risk associated with the entire acquisition process;
- Increase the quality, military worth and supportability of fielded systems, while reducing their operating and sustaining costs throughout the total life cycle;
- Enable Integrated Product and Process Development (IPPD) across the entire acquisition lifecycle.

SBA Special Interest Area www.msiac.dmso.mil/sba/

SBA Roadmap Presentation, Robin Frost, SIW Spring 99

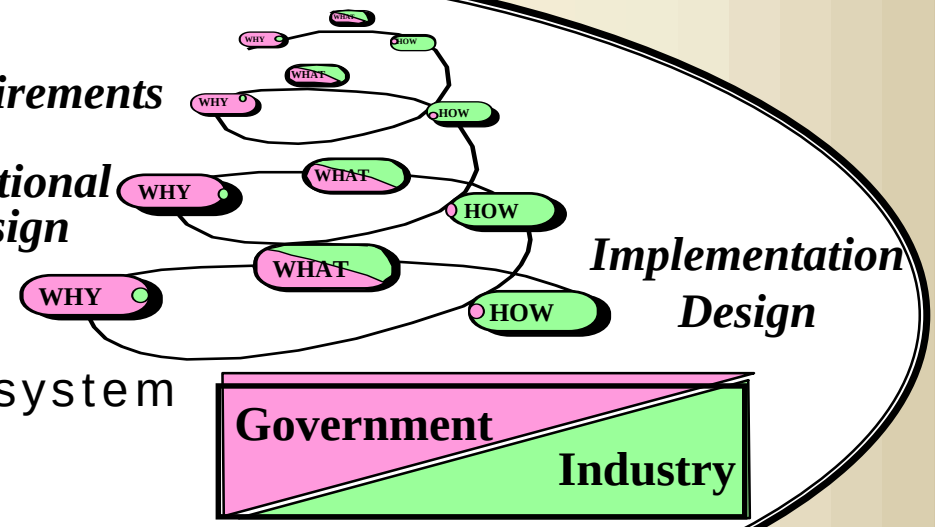
SBA

SBA - Not just M&S; A New Engineering Environment, Process, & Culture

SBA

Process

Iterative Acquisition Process



- Iterative spiral process
- Electronic exchange of system models
- Rapid evaluation of multiple options

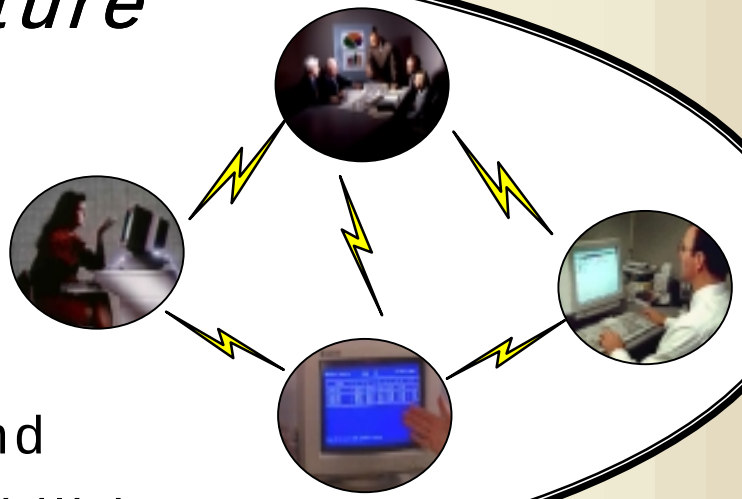
SBA Roadmap Presentation, Robin Frost, SIW Spring 99

SBA

Culture

Evolved Acquisition Culture

- Enabled Integrated Process Teams
- Changing roles and responsibilities



SBA Roadmap Presentation, Robin Frost, SIW Spring 99

SBA

Environment

Integrated Advanced Engineering and Management Enterprise

- Collaborative distributed engineering
- Info Repository - DIRR, CCBK
- Integrated design data schema

  - *User transparent Web style access*

  - *Seamless integration of engineering disciplines*

Common Project Data Repository

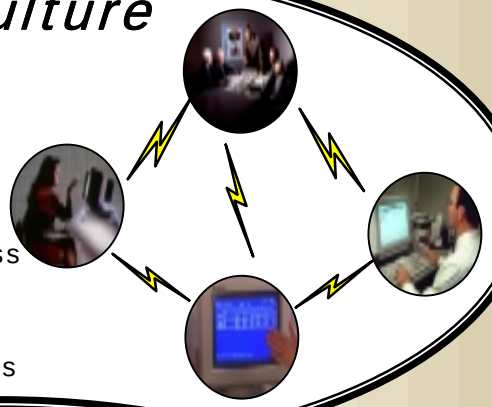
SBA

Culture

Evolved Acquisition Culture

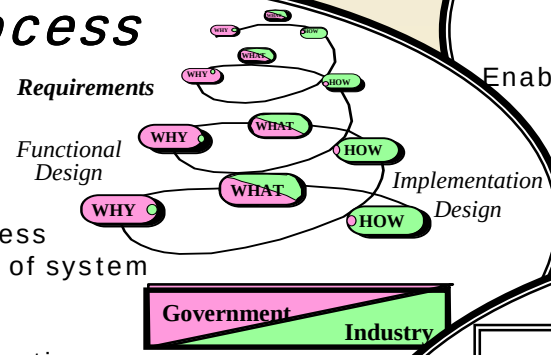
Enabled Integrated Process Teams

•Changing roles and responsibilities



Process

Iterative Acquisition Process



- Iterative spiral process
- Electronic exchange of system models
- Rapid evaluation of multiple options

Environment

Integrated Advanced Engineering and Management Enterprise

Common Project Data Repository

- Collaborative Distributed Engineering
- Info Repository - DIRR, CCBK
- Integrated design data schema

- User transparent Web style access

- Seamless integration of engineering disciplines

SBA - Not just M&S, A New Engineering Environment, Process, & Culture

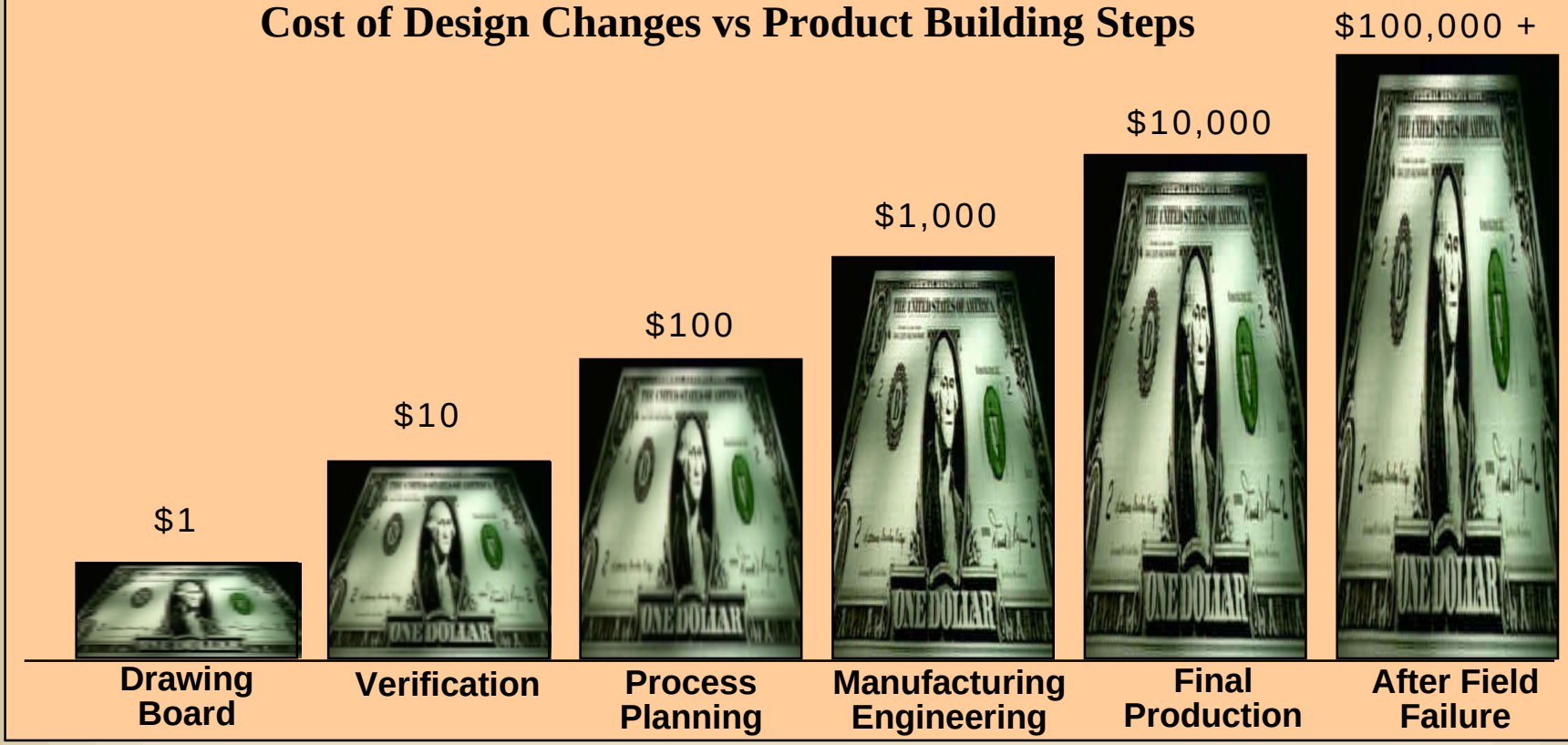
An unprecedented quality of enterprise-wide, collaborative decision making across the acquisition life-cycle...

SBA Roadmap Presentation, Robin Frost, SIW Spring 99

A Good M&S Plan Can Curb Costly Mistakes

Using desktop manufacturing techniques, design changes can be made earlier in the cycle (during verification) when they are less expensive.

Cost of Design Changes vs Product Building Steps

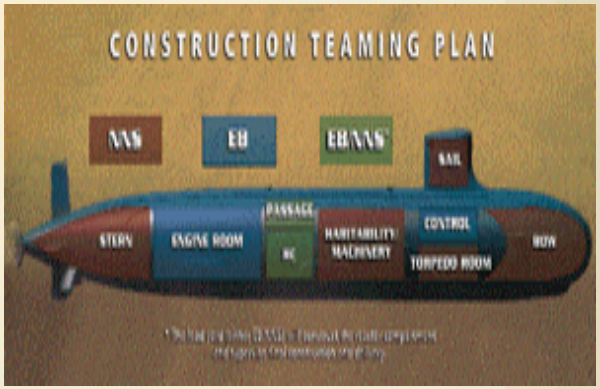


SBA Roadmap Presentation, Robin Frost, SIW Spring 99

Potential Payoffs / Benefits

Reduces Test & Evaluation Costs - Advanced Amphibious Assault Vehicle

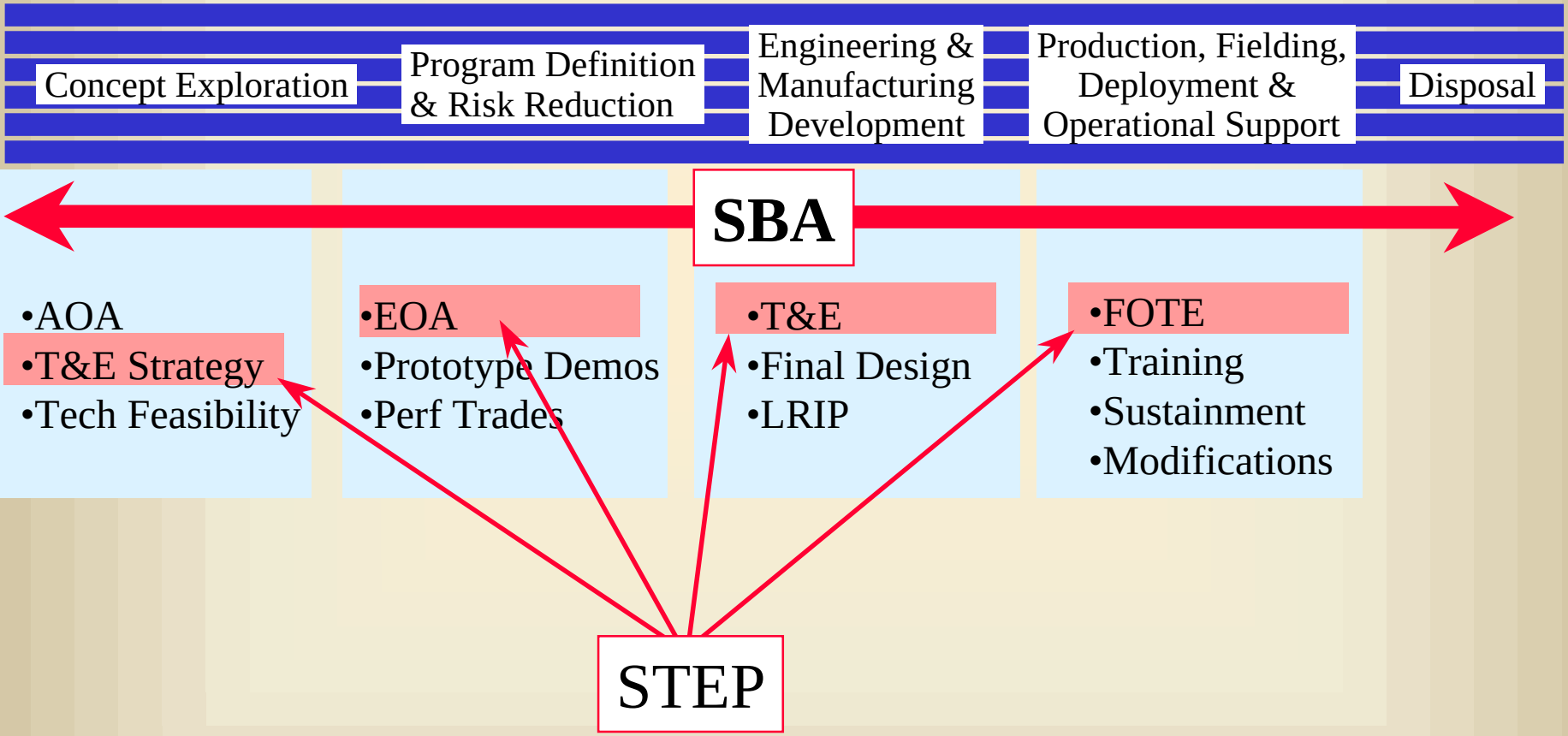
www.gdls.com/programs/aaav.html



Augments "Test-Fix-Test" with Re-configurable "Model-Test-Model"- New Attack Submarine

www.chinfo.navy.mil/navpalib/cno/n87/nssn.html

SBA & Simulation Test and Evaluation Process (STEP) in the System Life Cycle



STEP is a sub-process of SBA

Simulation Test and Evaluation Process (STEP)

"...an iterative process that integrates simulation and test for the purpose of interactively evaluating and improving the design, performance, joint military worth, survivability, suitability, and effectiveness of systems to be acquired and improving how those systems are used."

- Oct '95 USD(A&T) announced that STEP would be an integral part of Test and Evaluation Master Plans (TEMP).

- STEP reengineers the way M&S is used with T&E to support Acquisition Reform.

- Approach moves from ***"test, fix, test"*** to ***"model, simulate, fix, test, iterate"***

STEP Guidelines - December 1997

STEP Fundamentals

- Provides methodology for updating M&S with test data
  - Verification, Validation & Accreditation/Certification plans
  - Data must have documented “pedigree” for legacy
- Uses credible data for evaluation
  - Best balance of simulated and live events
  - Implies cost-benefit analysis
- Testing focuses on evaluating military worth
  - Effectiveness and suitability
  - Expect few design specifications on which to base testing