Efficacy of Modeling & Simulation in Defense Life Cycle Engineering

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Topics

- Introduction
- DoD M&S View
- DoD Acquisition
- Military Logistics
- M&S Tool Example
- Conclusions

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HPDC

High Performance Distributed Computing Laboratory

Salim Hariri, Ph.D (HPDC, CAC Director).

Don Cox, MS

NEW!

National Science Foundation

WHERE DISCOVERIES BEGIN

Center for Autonomic Computing

www.ece.arizona.edu

Introduction

- US DoD is world's largest single consumer
- Simulation Based Acquisition
- Logistics M&S lags engineering
- Increasingly important – selection discriminator

DoDD 5000.1 DoDI 5000.2
Defense Acquisition Guidebook

Definition of Simulation Based Acquisition (SBA)/(SMART)

The Army's vision for SMART is a process in which we capitalize on Modeling and Simulation (M&S) technology to address the issue of system development and life-cycle costs through the combined efforts of the requirements, training and acquisition communities.

Importance of M&S

Lessons Learned Through Acquired Experience

Apache
(Legacy system upgrades using M&S)

Crusader
(Relied heavily on M&S to support systems engineering)

Comanche
(Down select based on M&S)

Grizzly
(Revitalized the program with M&S)

Aerial Common Sensor
(Using virtual prototypes for source selection)

Future Scout and Cavalry System
(Collected Data)

Army Model & Simulation Office

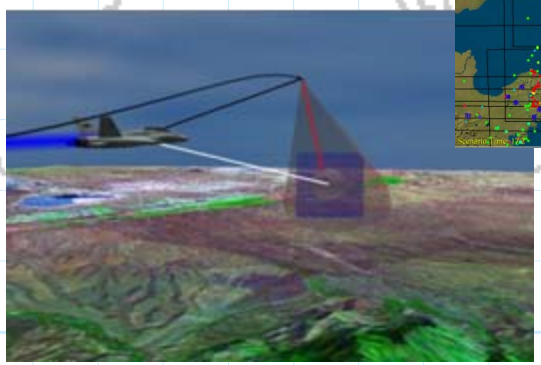
Characterized Levels of DoD M&S

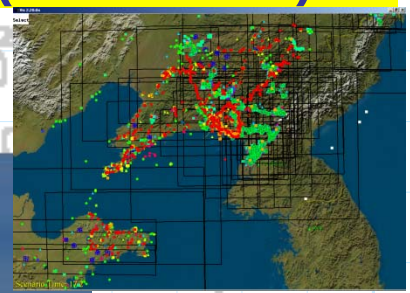
1. "Live" (Man vs Man)

- Training
- Development
- Test & Evaluation
- Operations

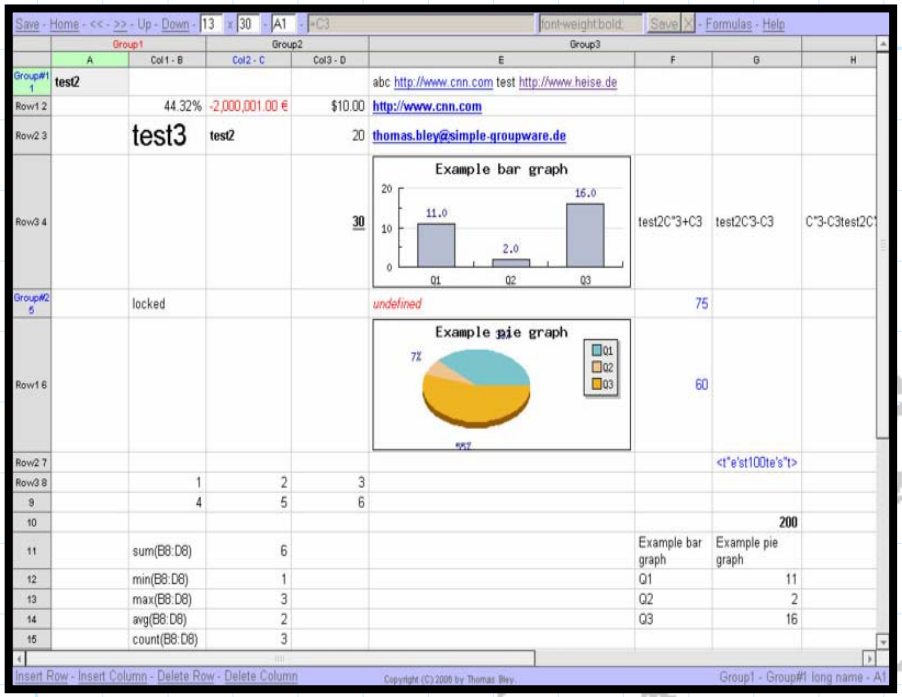
2. "Virtual" (Man vs Simulation)

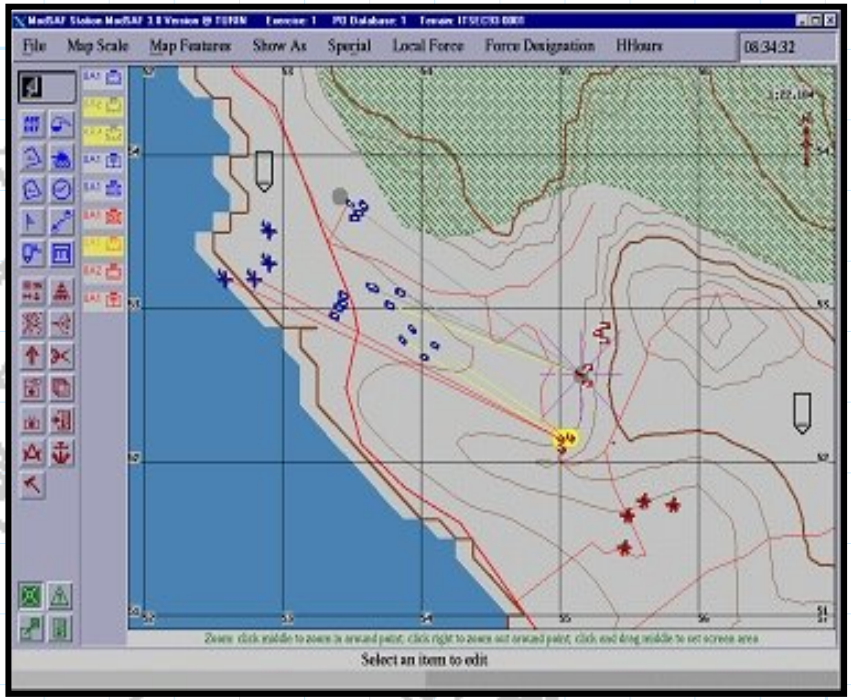
3. "Constructive" (Sim vs Sim)





Static (Steady State) & Dynamic



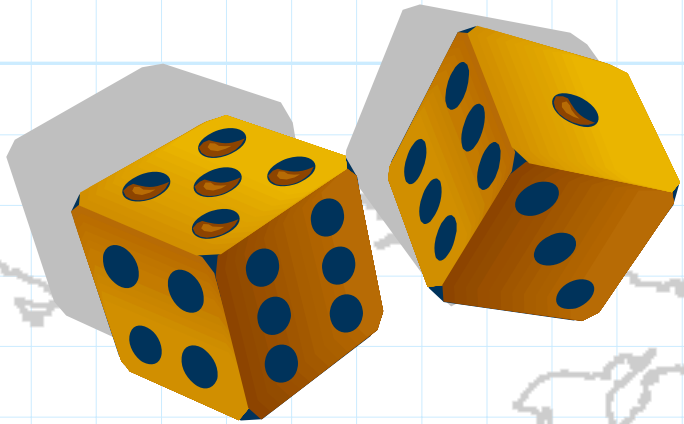


- Relationships mathematically defined
- Dependant/Predefined (1:1)
- Equilibrium seeking
- No dynamic temporal effects

- Relationships defined many ways
- Independent & Dependent (1:n)
- Equilibrium no factor
- Dynamic temporal effects

Deterministic & Stochastic

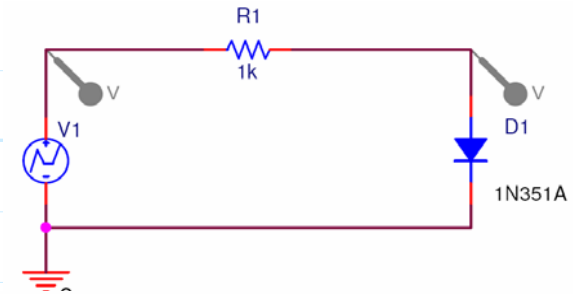
- Totally causal events & decisions
- No random events
- No “degrees of freedom”

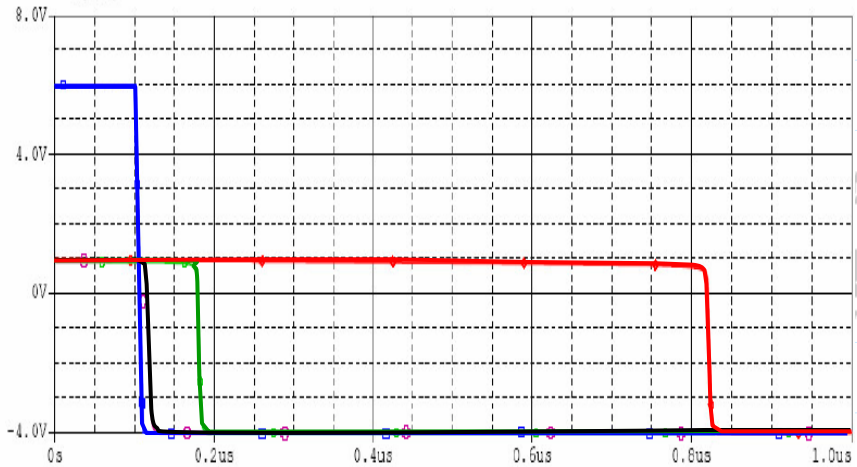


Monte Carlo

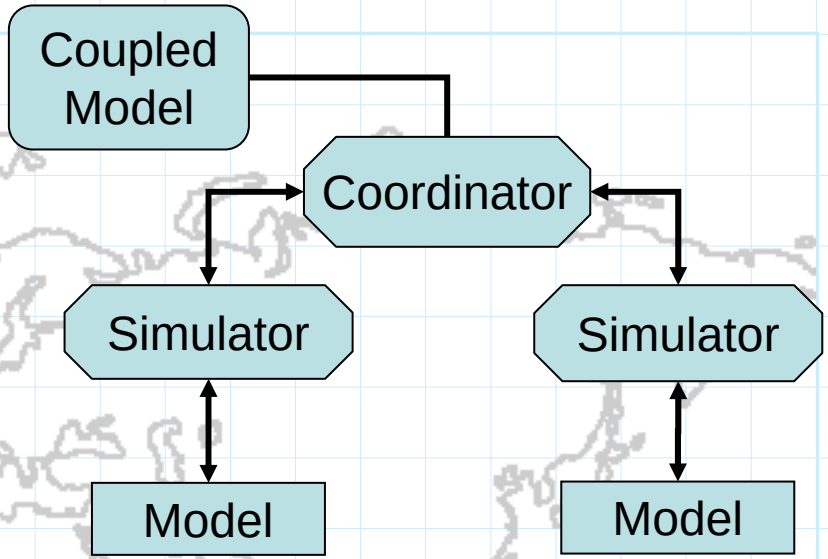
- Indexed collection of variables
- Random number generators
- Multiple degrees of freedom

Continuous & Discrete Event





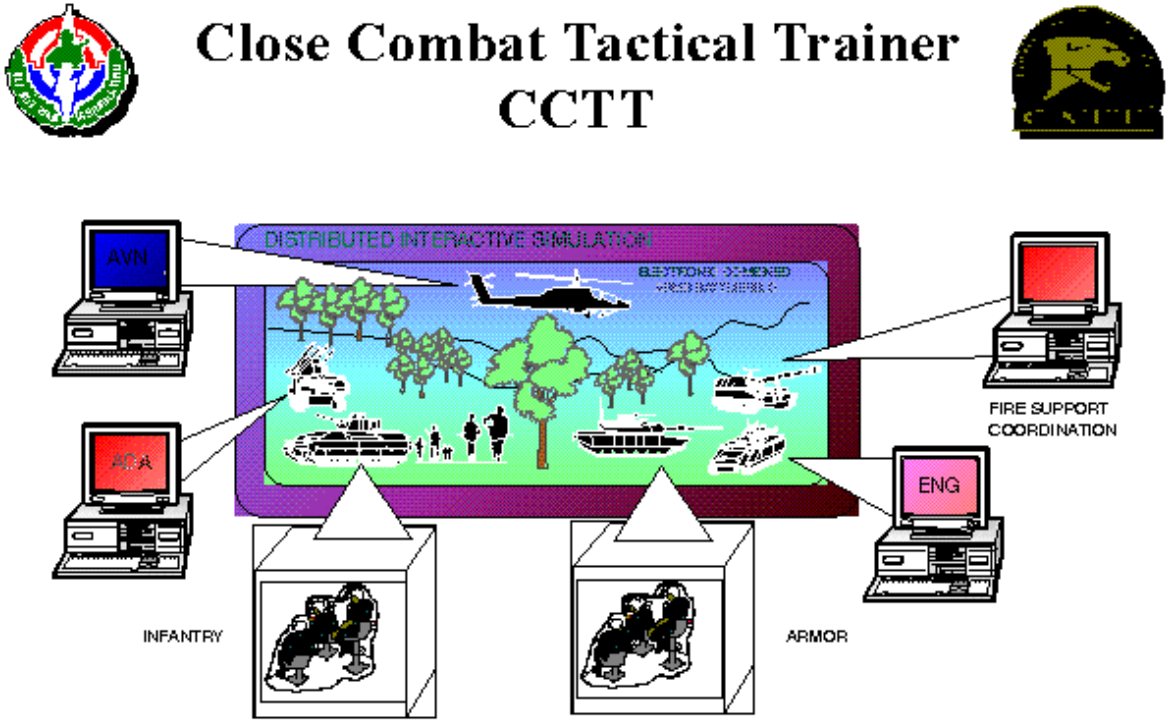
- **Analog computing**
- **Differential Equation (partial/ordinary)**
- **Continuous between *f(x)* limits**
- **Approximated by digital computers**



- **Time referenced events**
- **Models independent of simulators**
- **Models respond to events**
- **DEVS: Formalization = less errors**

Bernard P. Zeigler, Herbert Praehofer, Tag Gon Kim,
"Theory of Modeling and Simulation", 2nd Edition, Academic Press, 2000

Unitary vs Distributed Simulation



- High Level Architecture (HLA).
- Test and Training Enabling Architecture (TENA)
- Aggregate Level Simulation Protocol (ALSP)
- Distributed Interactive Simulation (DIS)

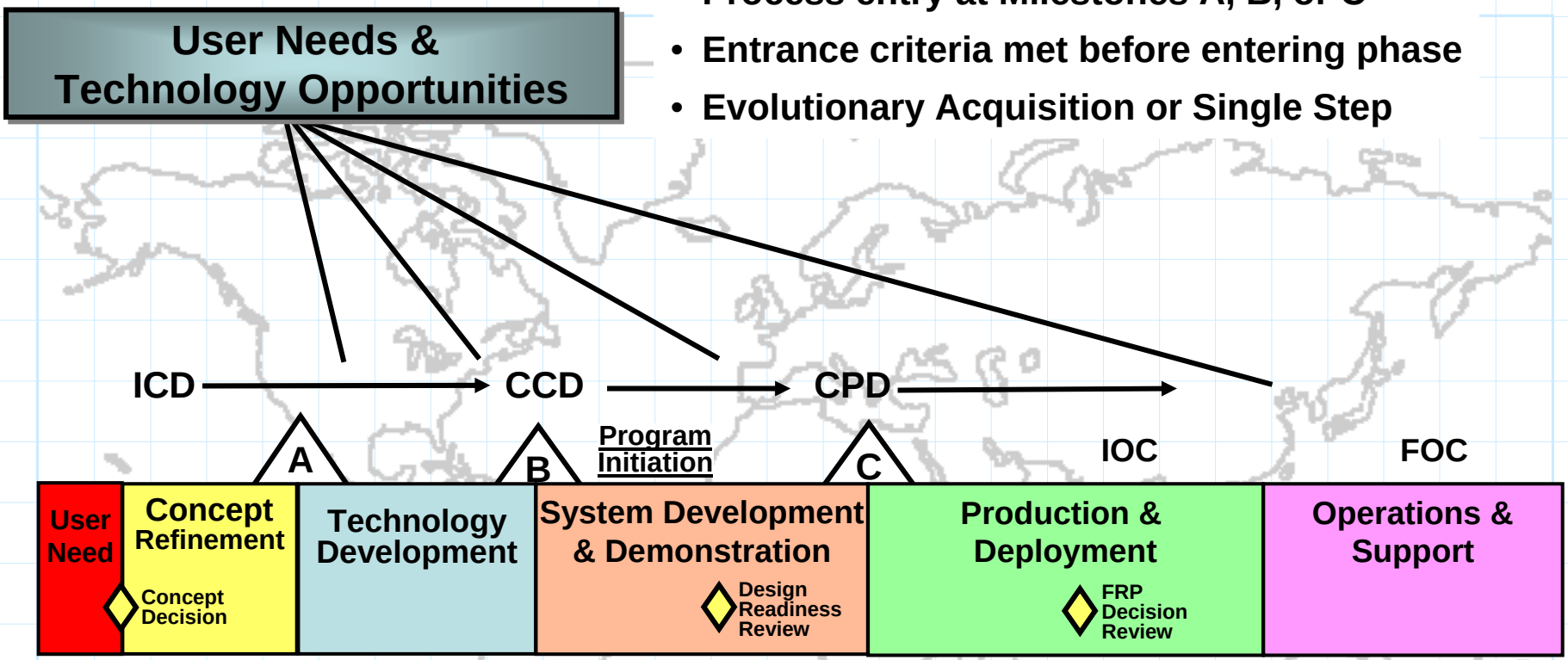
Military Logistics

- Military logistics is the science of planning and carrying out the movement and maintenance of armed forces. In its most comprehensive sense, those aspects of military operations that deal with:
  - a. design and development, acquisition, storage, movement, distribution, maintenance, evacuation, and disposition of materiel;
  - b. movement, evacuation, and hospitalization of personnel; acquisition or construction, maintenance, operation and disposition of facilities; and acquisition or furnishing of services.

Defense Technical Information Center

DoD Acquisition Framework

- Process entry at Milestones A, B, or C
- Entrance criteria met before entering phase
- Evolutionary Acquisition or Single Step



Graphics Sourced from the Defense Acquisition University

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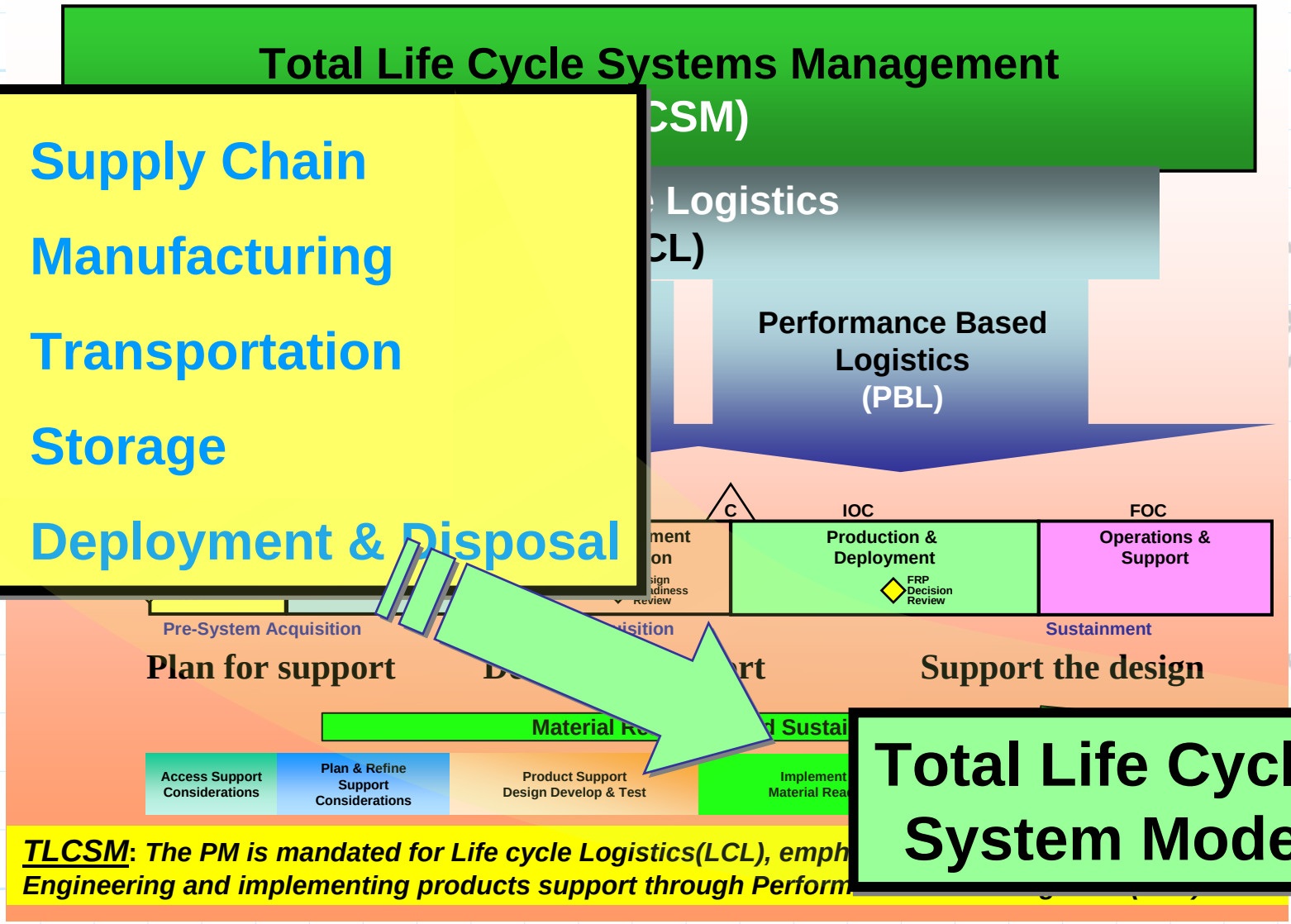
New Cargo Jet Specification

Military Logistics

Defense Acquisition Guidebook (Chap. 5.0)

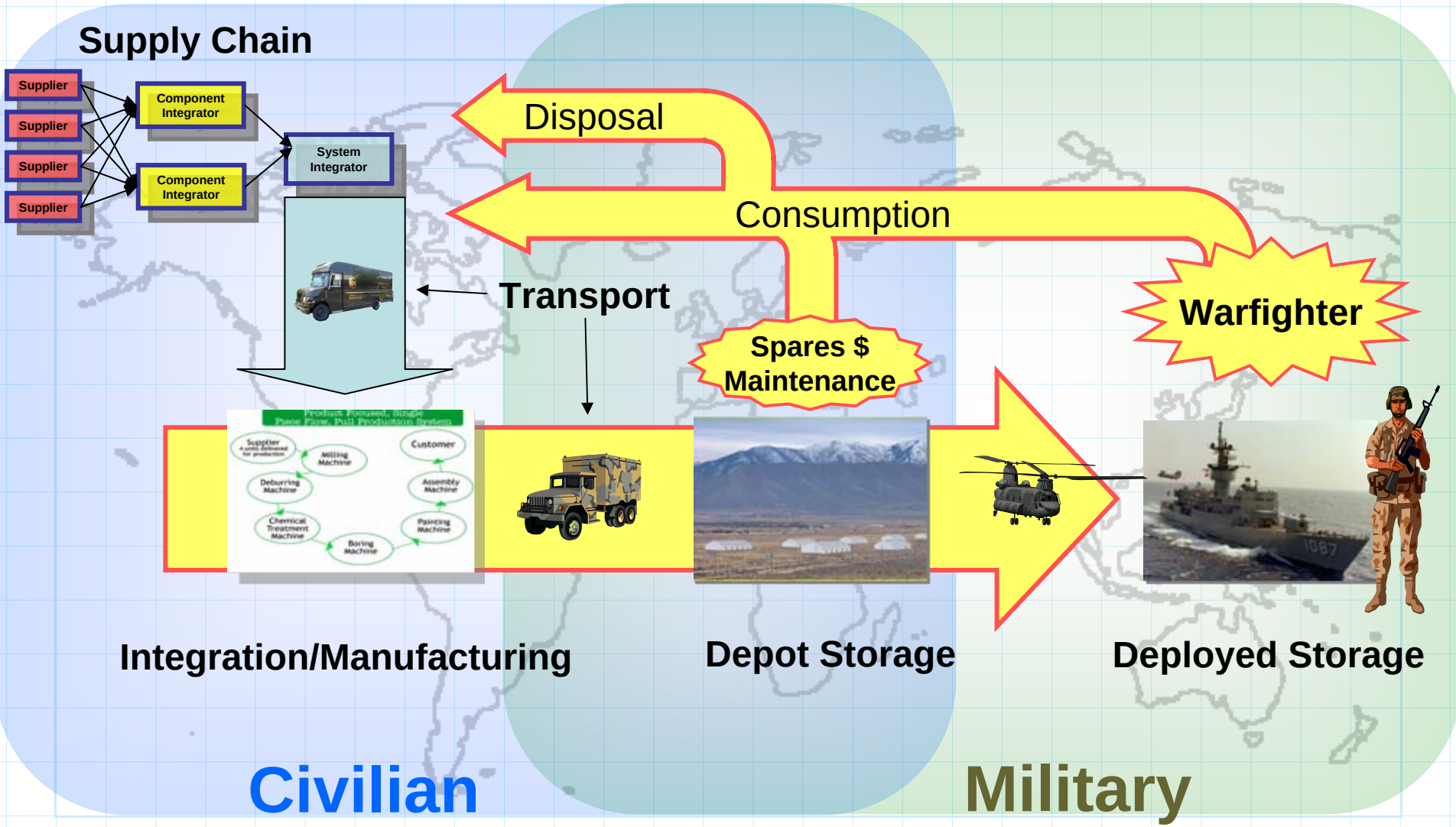
1. Supply Chain
2. Manufacturing
3. Transportation
4. Storage
5. Deployment & Disposal



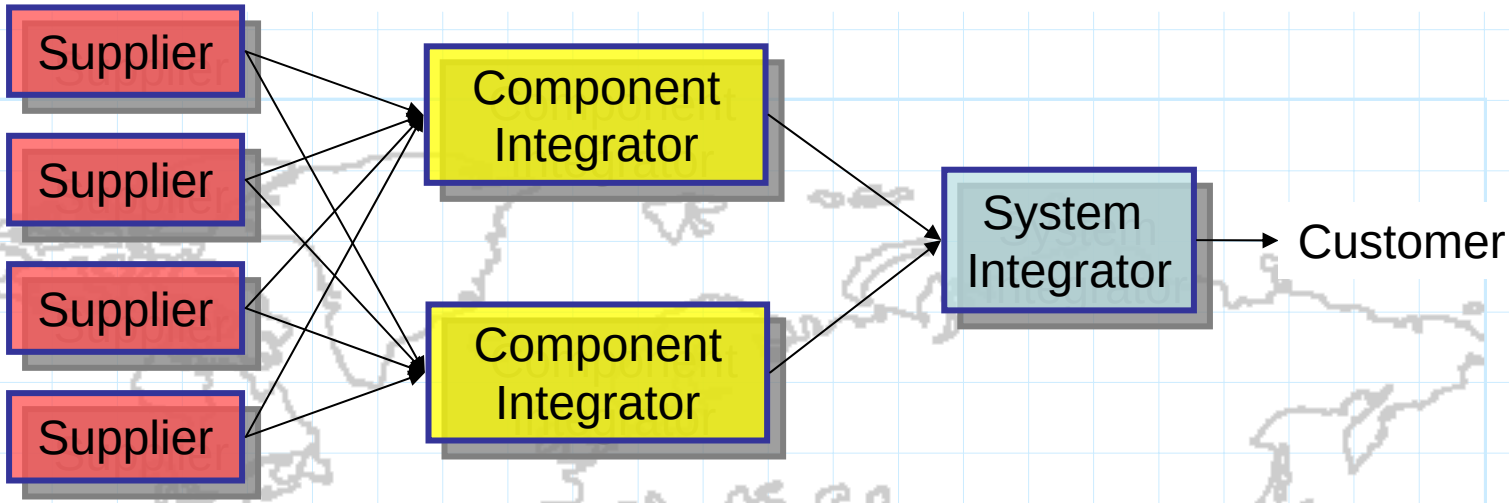
***TLCSM**: The PM is mandated for Life cycle Logistics(LCL), emph*
Engineering and implementing products support through Perform

Total Life Cycle System Model

Life Cycle System Model

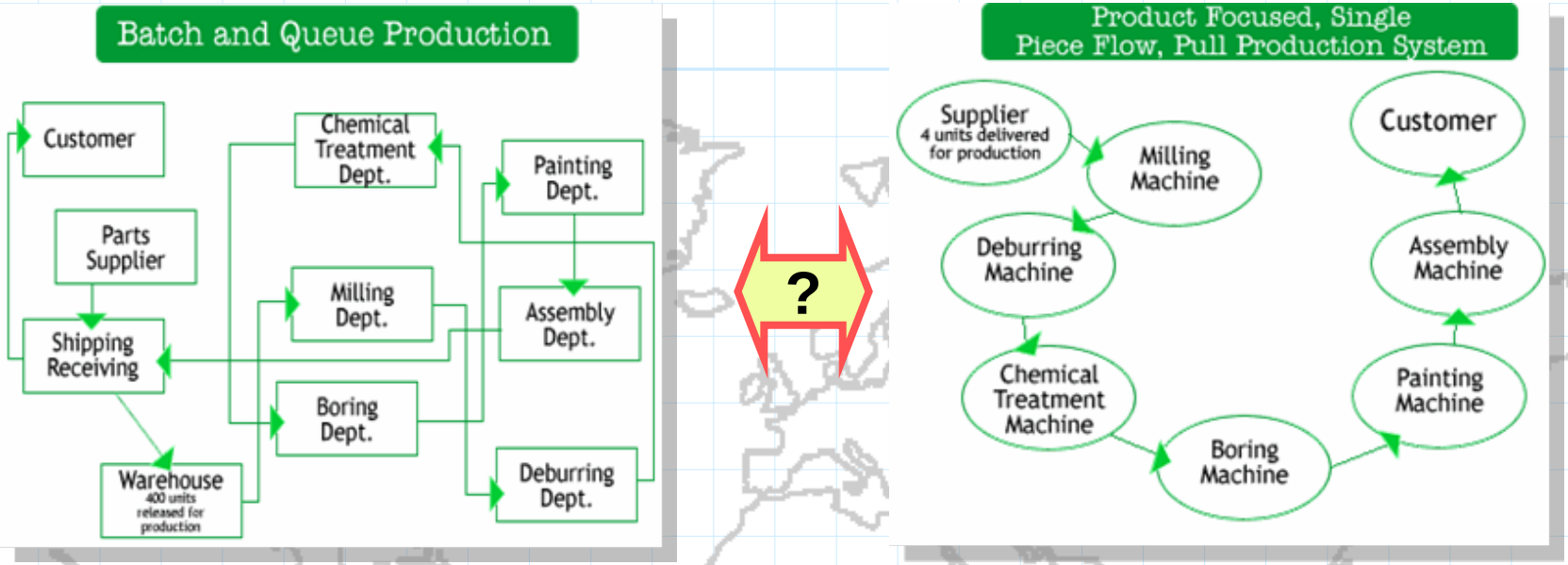


Supply Chain



- **Manufacturing Process**
- **Low fidelity models - parameterize assumptions**
- **Obsolescence management**
- **Socio-political & economic effects**
- **KPPs:**
  - **Consumption driven – model demand drivers**
  - **Cost, capacity, lead-time, etc**

Manufacturing (Integration)



- **Optimize processes & material flow**
- **Cost (risk) reduction**
  - **Dynamic – Discrete Event Simulation**
  - **Supply Chain model integration**
- **KPPs**
  - **Cost, Process, Flow**
  - **Resource Allocation, etc.**

Transportation

- Military & Civilian
- Touch Labor
- Damage
- KPPs
  - Reliability, Availability
  - Lead Time (customs, etc.)
  - Cost, Choke Points
  - Sustainment, Surge

Storage

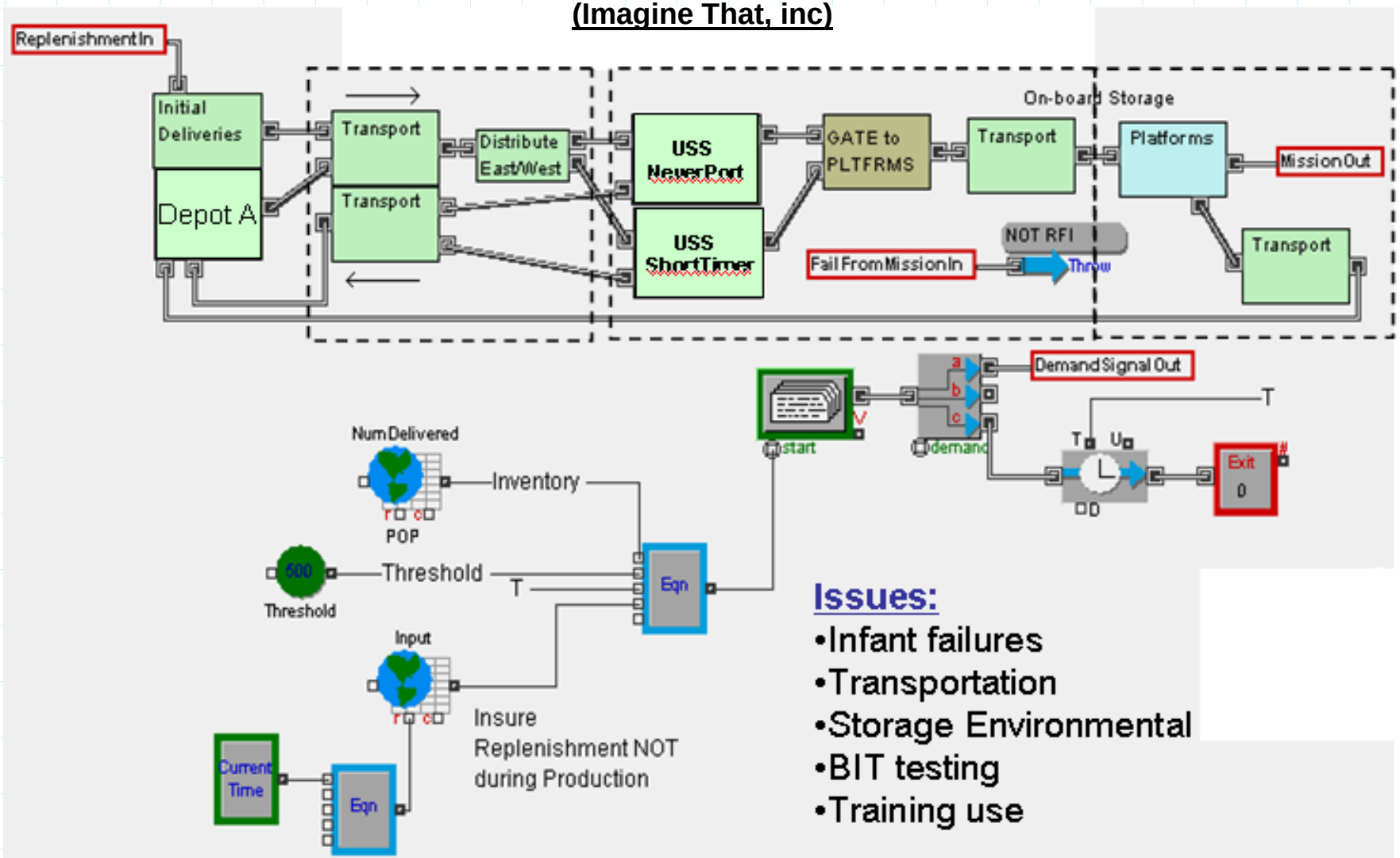
- **Location**
  - **Depots (Strategic)**
  - **Theater (tactical)**
- **KPPs**
  - **Inventory (operations, spares)**
  - **Cost, availability, reliability**
  - **Assembly**

Deploy & Dispose

- Inventory levels
- Asset visibility
- Surplus or Destroy ?
- Life Extension
  - Training
  - Recycle

M&S Tool Example

Extend®
(Imagine That, inc)



Issues:

- Infant failures
- Transportation
- Storage Environmental
- BIT testing
- Training use

M&S Resources

- **Military**
  - Defense Modeling & Simulation Office (DMSO)
  - Modeling and Simulation Information Analysis Center (MSIAC)
  - Advanced Air Force Modeling & Simulation (AFAMS)
  - Navy Modeling & Simulation Office (NMSO)
  - Army Modeling & Simulation Office (AMSO)
  - Army Simulation, Training & Instrumentation (PEO STRI)
  - National Security Council (NSC)
- **Industry**
  - Simulation Interoperability Standards Organization (SISO)
  - Association of Computing Machinery (ACM)
  - Society for Modeling and Simulation International (SCS)
- **Academia**

University of Arizona
Georgia Institute of Technology
University of Pennsylvania
INFORMS College on Simulation
Old Dominion University
California State University
University of Magdeburg
University of Central Florida

Conclusion

- M&S is increasingly important in Military Logistics
  - Contractually required by many DoD programs
- Beneficial in all phases of life cycle
- Highly useful in logistic modeling & management
  - Highly granular (high fidelity)
  - Dynamic inventories & environments
  - Interoperable with engineering & operational models
- Source selection discriminator
  - Total Lifetime Cost analysis (TLC)
  - Logistic support capability

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