Benchmark Benefits to System Designers Considering Complex Trade Spaces

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Systems Engineering Conference

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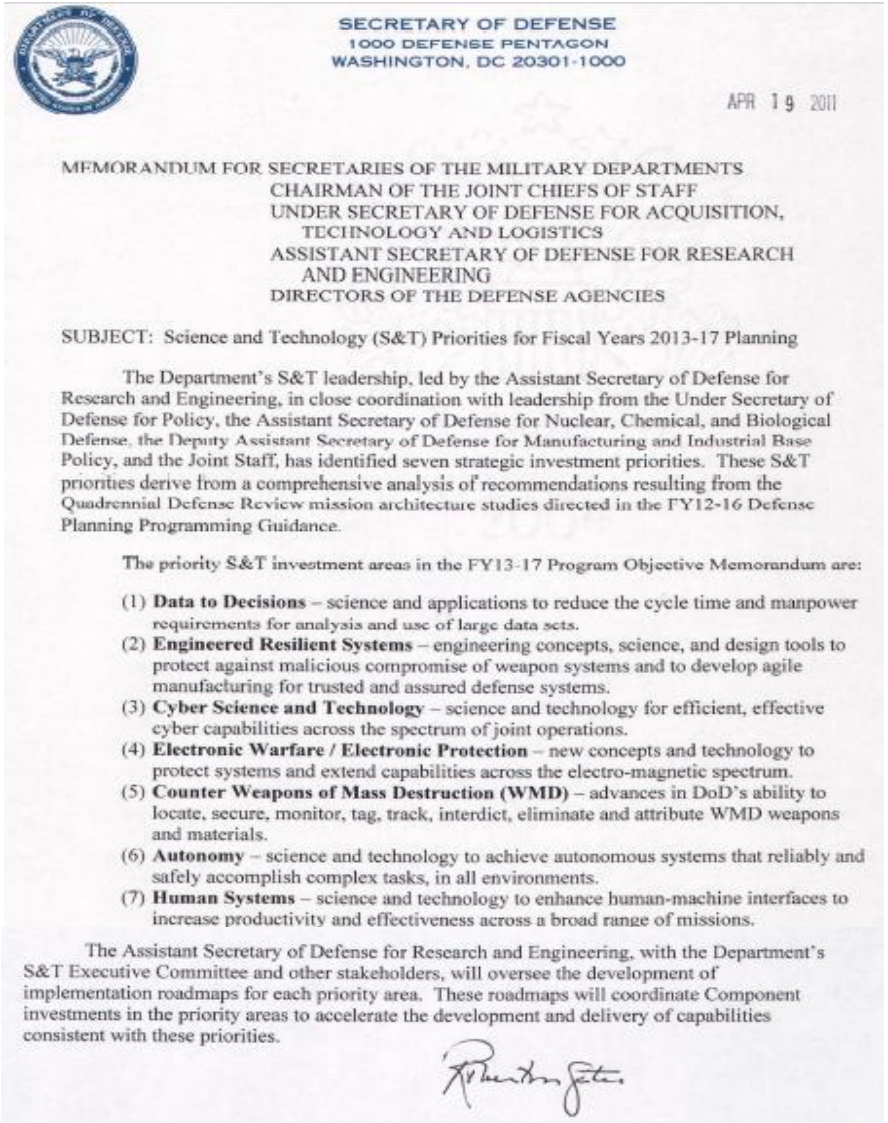
Mission Effectiveness Benchmarks for Design

- **Need Effectiveness Estimates**
  - Realistic Mission Training Simulations – Lightweight
  - Mission Success Metrics – performance metrics support
  - Calibrated Using Experts in the Loop
  - Integrated, Joint, Coalition
- **Enable Exploration of Large Design Space**
  - Hardware, Software, Human Elements – baseline and notional
  - Broadly Available to Industry – e.g. Networked PCs
  - Flexible – i.e. Modest Fidelity
- **Gain Confidence in Capability Based Assessments**
  - Operator CONOPS and TTPs
  - Trade Space Analyses within Mission

Initial Push



SECRETARY OF DEFENSE
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WASHINGTON, DC 20301-1000

APR 19 2011

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS
CHAIRMAN OF THE JOINT CHIEFS OF STAFF
UNDER SECRETARY OF DEFENSE FOR ACQUISITION, TECHNOLOGY AND LOGISTICS
ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING
DIRECTORS OF THE DEFENSE AGENCIES

SUBJECT: Science and Technology (S&T) Priorities for Fiscal Years 2013-17 Planning

The Department's S&T leadership, led by the Assistant Secretary of Defense for Research and Engineering, in close coordination with leadership from the Under Secretary of Defense for Policy, the Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense, the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy, and the Joint Staff, has identified seven strategic investment priorities. These S&T priorities derive from a comprehensive analysis of recommendations resulting from the Quadrennial Defense Review mission architecture studies directed in the FY12-16 Defense Planning Programming Guidance.

The priority S&T investment areas in the FY13-17 Program Objective Memorandum are:

(1) **Data to Decisions** – science and applications to reduce the cycle time and manpower requirements for analysis and use of large data sets.
(2) **Engineered Resilient Systems** – engineering concepts, science, and design tools to protect against malicious compromise of weapon systems and to develop agile manufacturing for trusted and assured defense systems.
(3) **Cyber Science and Technology** – science and technology for efficient, effective cyber capabilities across the spectrum of joint operations.
(4) **Electronic Warfare / Electronic Protection** – new concepts and technology to protect systems and extend capabilities across the electro-magnetic spectrum.
(5) **Counter Weapons of Mass Destruction (WMD)** – advances in DoD's ability to locate, secure, monitor, tag, track, interdict, eliminate and attribute WMD weapons and materials.
(6) **Autonomy** – science and technology to achieve autonomous systems that reliably and safely accomplish complex tasks, in all environments.
(7) **Human Systems** – science and technology to enhance human-machine interfaces to increase productivity and effectiveness across a broad range of missions.

The Assistant Secretary of Defense for Research and Engineering, with the Department's S&T Executive Committee and other stakeholders, will oversee the development of implementation roadmaps for each priority area. These roadmaps will coordinate Component investments in the priority areas to accelerate the development and delivery of capabilities consistent with these priorities.

"Priority S&T Investments … FY13"

"Human Systems … effectiveness across a broad range of missions"

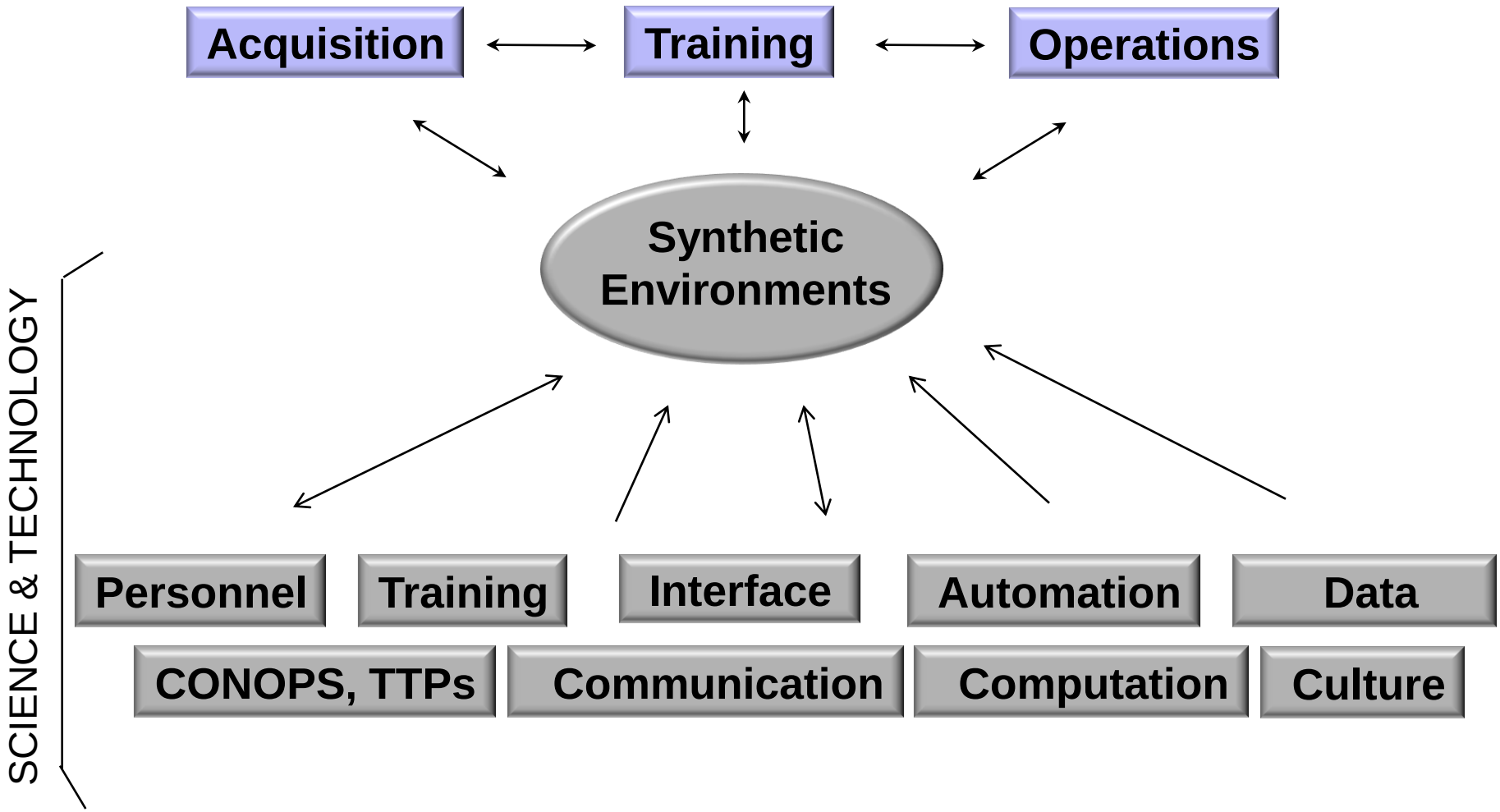
OSD – Priority Steering Councils

Continued Push -- Strategic Guidance

January 2012

- **President**
  - … focus on … Asia Pacific …. deepening partnerships
  - … military is agile, flexible, and ready for the full range of contingencies
- **DepSecDef**
  - … Joint Force of the future that will be smaller and leaner, but will be agile, flexible, ready, and technologically advanced.
  - … led by the highest quality, battle-tested professionals
- **Primary Missions**
  - Counter Terrorism and Irregular Warfare
  - Deter and Defeat Aggression
  - Provide a Stabilizing Presence
  - Conduct Stability and Counterinsurgency Operations
  - Conduct Humanitarian, Disaster Relief, and Other Operations
- **Joint Force**
  - … resist the temptation to sacrifice readiness
  - … limited resources may better tuned to their requirements
  - … encourage innovation in concepts of operation

Synthetic Environments for Assessment



Bottom Line: SE's Implement Top-Down Approach to Science

Synthetic Environment for Assessment (SEA)

Working Definition of SEA:

Modeling and simulation experiments with human operators to estimate mission effectiveness in realistic mission scenarios under "interesting" perturbations.

- Personnel
- Training
- Interface
- Automation
- Physiology
- Sensors
- Communication
- Computation
- Platforms
- CONOPs
- TTPs

The Problem Space

For many domains of interest, requirements shift too fast for the conventional "research, design, build, test" cycle of acquisition

- –What is the impact of new capability "x" on training, team performance, retention, etc?
- –Given new mission profile "y," what new capabilities are required for team T to meet performance standards?

This is what Simulation Based Acquisition hasn't solved… until now

- –SEA is an architecture that allows interoperable models to be reconfigured in infinitely many ways to test many different hypotheses
- –SEA is not a "system" that you plug models into (like SAF)
- –SEA facilitates validated collections of models that provide calibrated simulations for testing new ideas and concepts.

SEA Impacts Multiple Levels of the Acquisition Process

Provide objective assessment and trade-offs of alternative real options in terms of total ownership cost in the context of usability and effectiveness
- To manage independent and dependent variables in simulation
- Include acquisition, training, logistics, maintenance, replacement, retirement

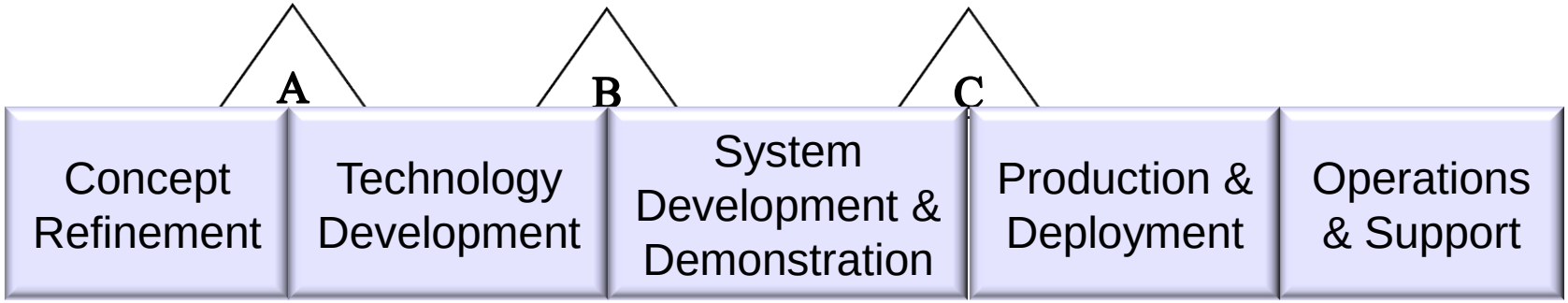
Operations
- CONOP (re)formulation
- Estimates of readiness and robustness

Acquisition
- Build confidence in revolutionary designs
- Modular approach to scale
- Quantify cost/benefit of candidate designs

Training
- Valid benchmarks with metrics
- Blur the distinction between training and operations
- Operationalize the phrase “train as you fight”

Science & Technology
- Common tool for cross/multi-disciplinary work
- Complex scenarios for model building, theory testing

Use Cases for SEA in Support of Acquisition



User Groups	Uses
Science and Technology	Hypothesis testing, theory development Concept exploration, trust building
Acquisition Professionals	New technology testing Risk identification Design space exploration
Analysts	Doctrine analysis Testing new organizational structures

Priority Steering Council Human Systems

- **Big Ideas**
  - Training: Enable Engineering & Assessment for Joint Mission Effectiveness
    - Baseline Effectiveness Using Realistic Mission Training Scenarios
    - Extend Mission Training Scenarios to Joint Missions
    - Provide Synthetic Environments for Collaboration with Industry, Others
  - Interface: Natural interfaces to manage multiple scale, multiple role systems
    - Develop common representation schemes for system/data interaction
    - Develop natural language and gestural system interaction
    - Develop operator state monitoring technology

Training for Readiness; Interface for Effectiveness

Training for Readiness

Problem: Complex Evolving Threats Outpace Readiness Training

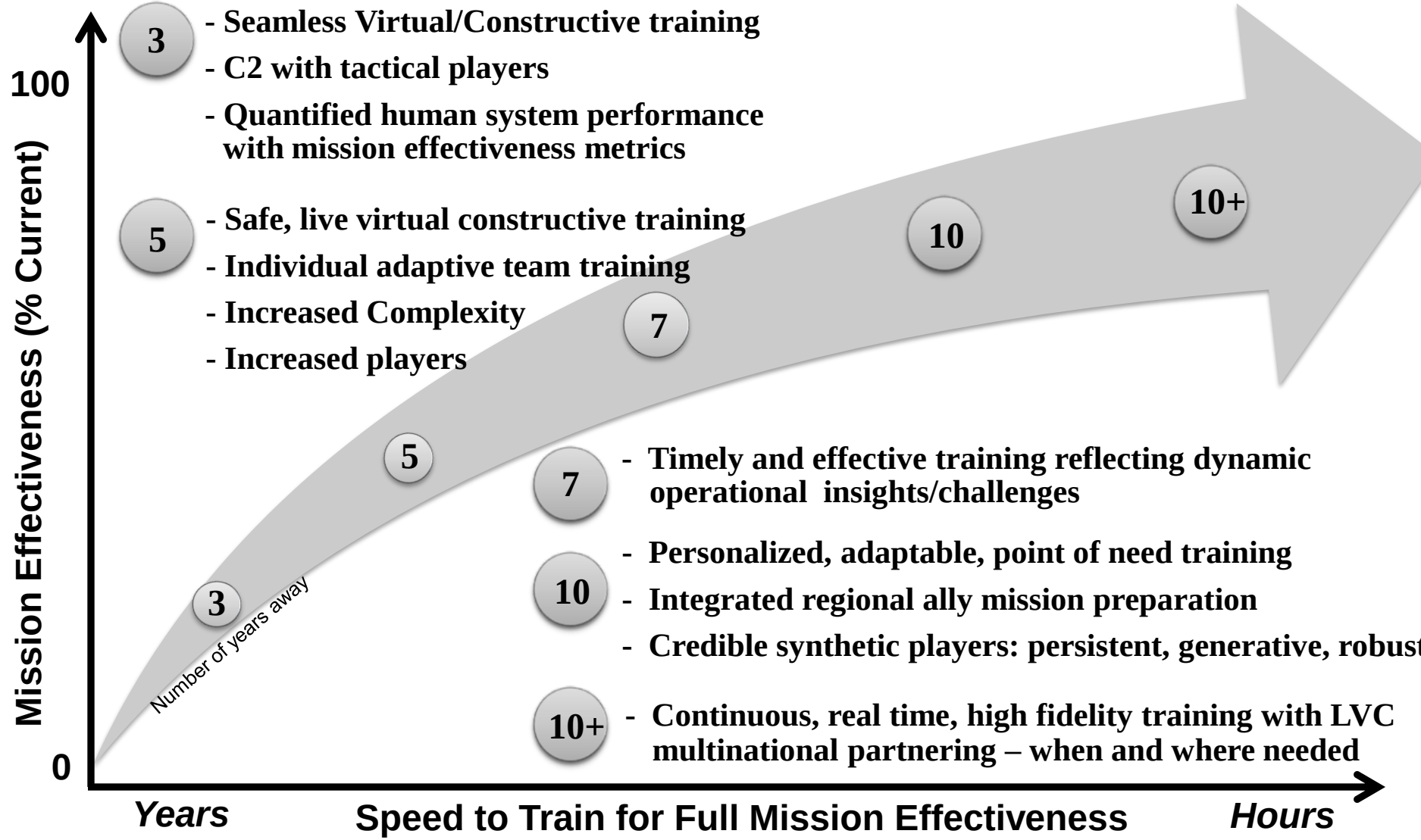
- Warriors train for tomorrow's fight using yesterday's technology, methods, and strategies
- Current training scenarios not matched to evolving mission complexity and dynamics
- Warfighters are trained to doctrine -- fight strategically and dynamically to meet new threats
- Training is costly
  - Live systems deplete inventory, consume fuel, require maintenance & wear out
  - Ranges & role players are expensive – lack fast responsiveness to changing scenarios
  - Training ranges not designed for flexible scenarios and throughput is inadequate

Interface for Effectiveness

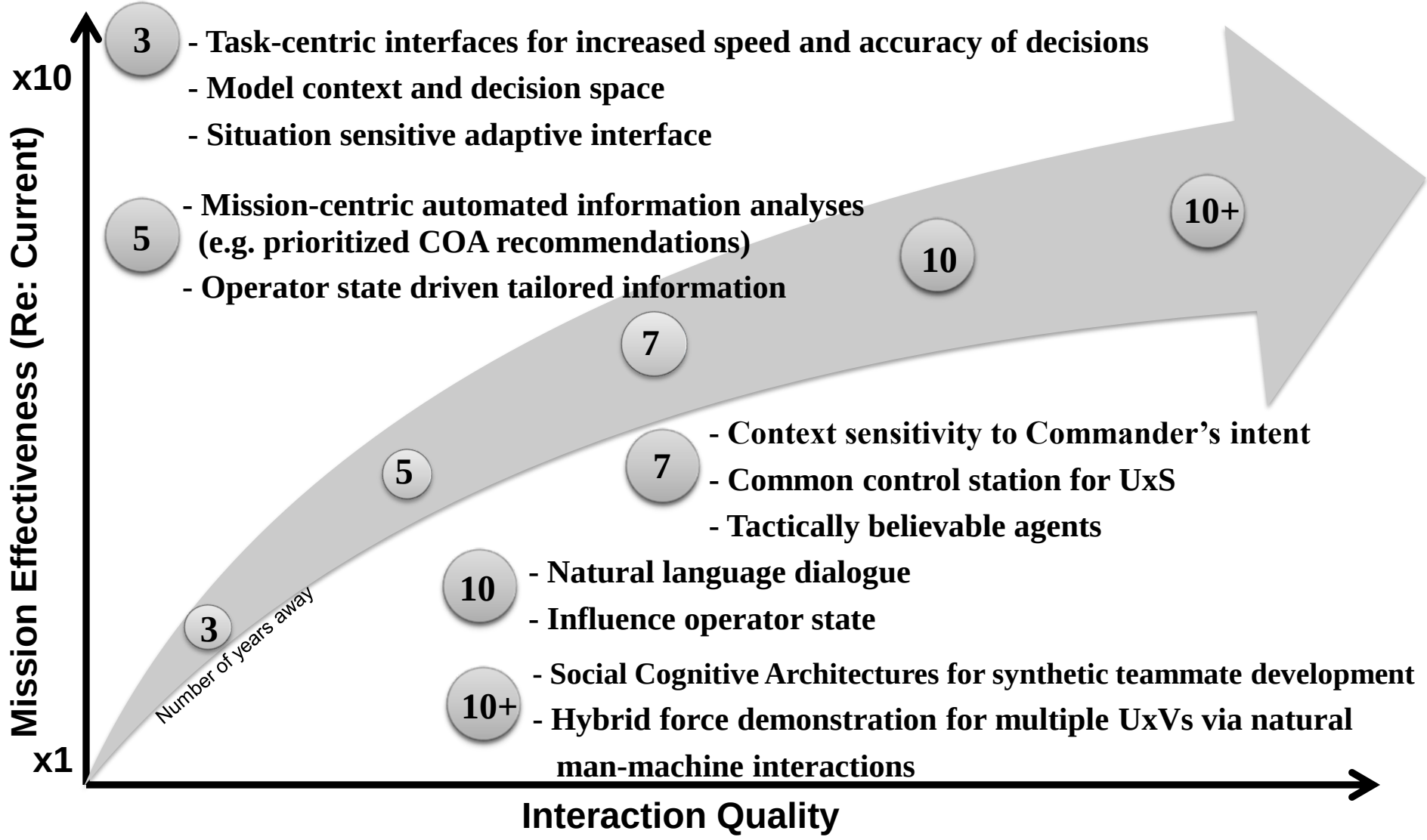
Problem: Current system operation is rigidly data-centric vice flexibly information-centric

- Modern technologies exacerbate critical manning and talent pool deficiencies by ignoring role of Mission, Task & Context – Moving & presenting data vice information
- Current adaptive planning tools do not allow rapid "course of action" analysis and generation
- Information displays typically non-interactive, adapting little to changing needs
- Data quantity will continue to increase nonlinearly

Training Technology End States



Interface Technology End States



Proposed Criteria for SEA

- **Simulation in Form, but Fidelity Traded for Flexible Experimental Use**
- **Support Multiple Task Scenarios within the Environment, functionally equivalent to Operational Tasks**
- **Scenarios linked to Naval Mission Effectiveness Metrics**
- **Calibrated Metrics Using Naval Operators**
- **Distributed to Broad Science and Technology Community**

Enable an Engineering Approach to Unified System Design, Training, and Operation.

Call to Action

Join!

- **NDIA Human Systems Mission Statement:**

To promote the exchange of technical information and discussions between government, industry, and academia, and the expansion of research and development in areas related to the human as a system whose performance must be integrated into any system of systems

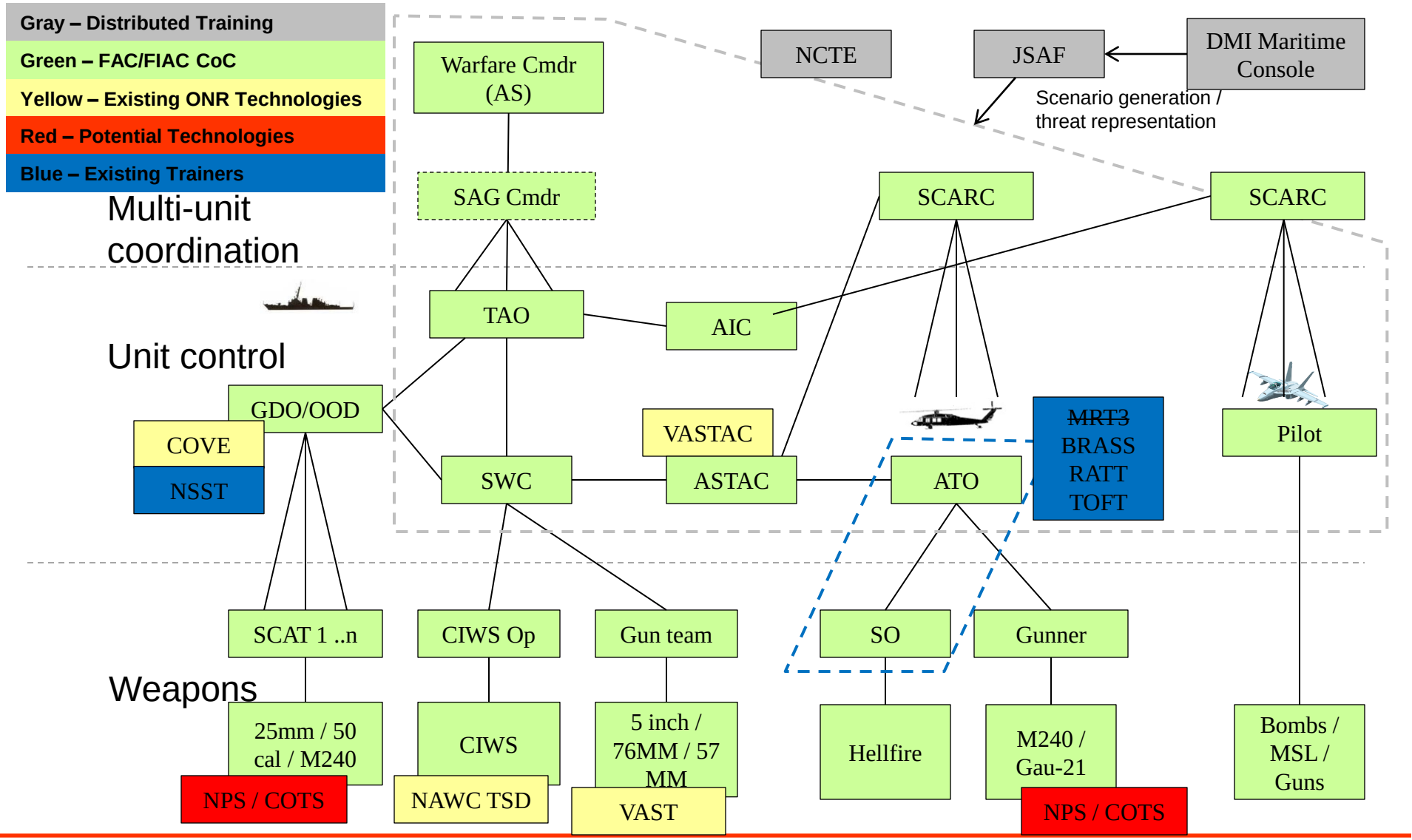
Visit!

- **www.defenseinnovationmarketplace.mil**

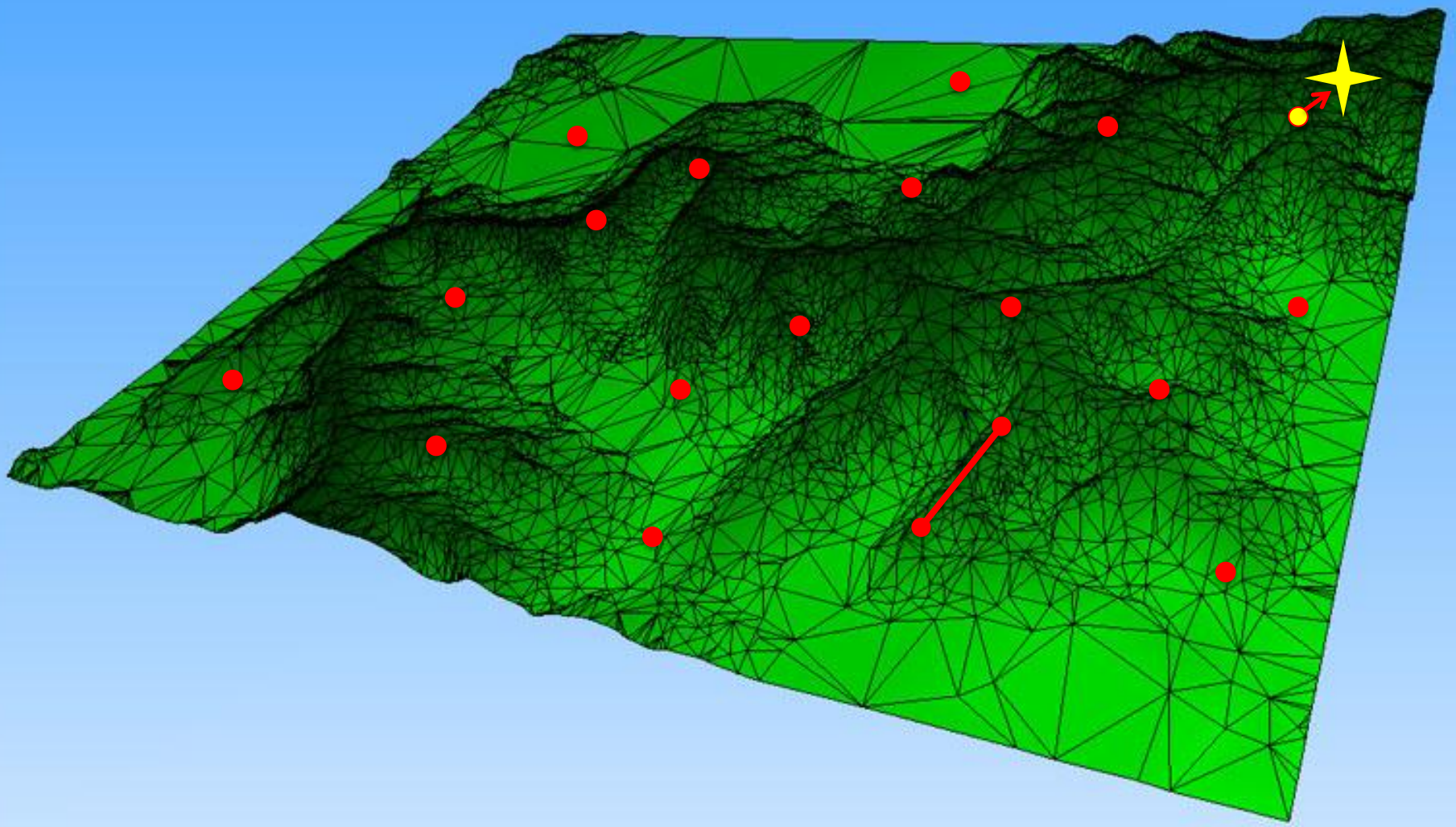
The Defense Innovation Marketplace is a centralized online resource to better connect industry with government customers and enhance innovation.

BACKUP

SEA Example
Complex Command and Control

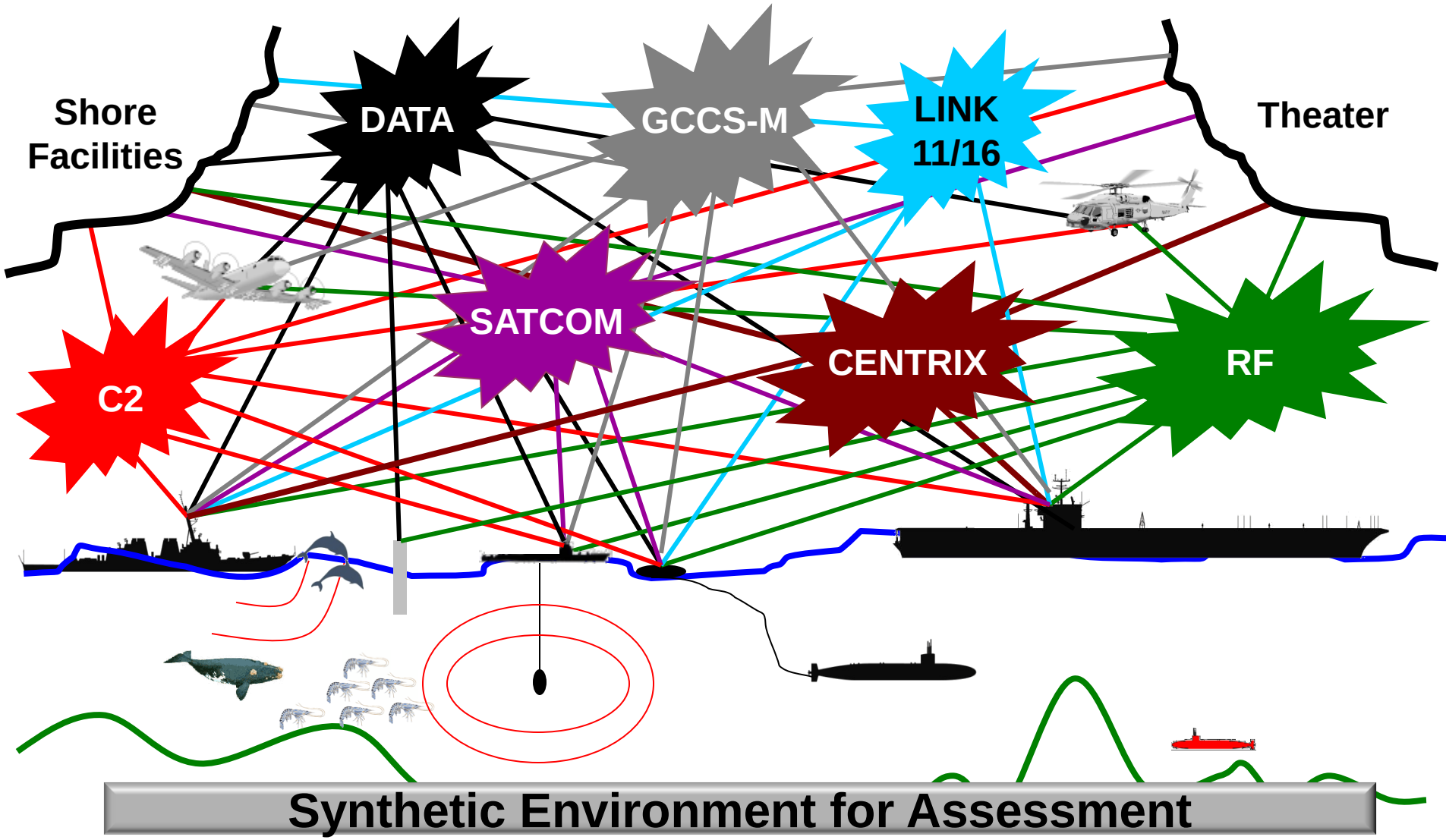


Design “Search Space” of Alternatives



Live and Synthetic Training

"This is how we fight"



Summary

- **Engineering and Assessment for Joint Mission Effectiveness**
- **Natural interfaces to manage multiple scale multiple role systems**