Modeling and Simulation, Technology, and Transformation

June 25, 2002

Dr. Ron Sega

Director, Defense Research and Engineering

Overview

- **Transformation: Capabilities-Based Approach**
- **S&T Investment and Transformation**
- **Modeling and Simulation**
- **Technology Transition**
- **National Security Workforce**

Definition of Transformation

“The Evolution and Deployment of Combat Capabilities That Provide Revolutionary or Asymmetric Advantages to Our Forces”

- QDR (Sep 30, 2001)

QDR Critical Capabilities

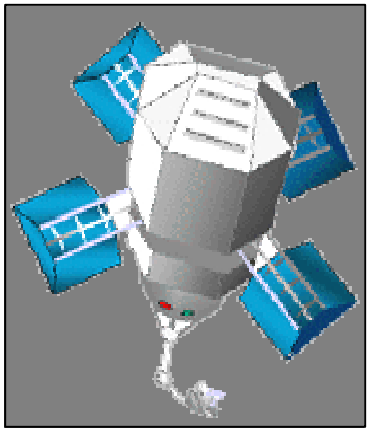
- **Protect Bases of Operations**
- **Conduct Information Operations**
- **Project and Sustain US Forces**
- **Deny Enemy Sanctuary**
- **Conduct Space Operations**
- **Leverage Information Technologies**

Protecting Bases of Operations

- ***Combating Terrorism***
- ***Chemical/Biological Defense***
- ***Missile Defense***
- ***Consequence Management***

Conduct Information Operations

- ***Defensive IO and Information Assurance***
- ***Offensive IO***



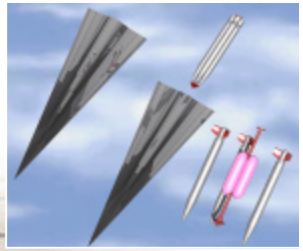
Project and Sustain US Forces

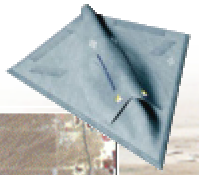
- ***Anti-Access Capabilities***

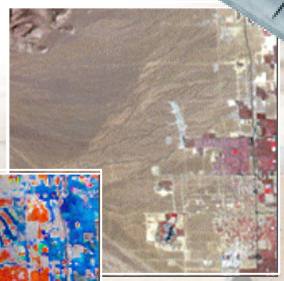
Deny Enemy Sanctuary

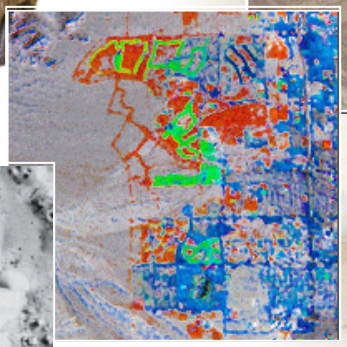
Persistent Surveillance, Tracking and Rapid Engagement with Precision Strike

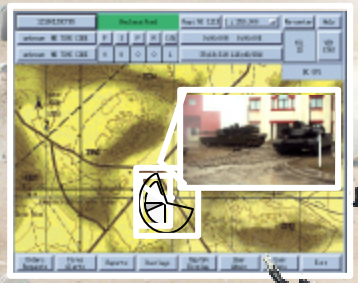
- ***Remote Sensing/Enhanced C4ISR***
- ***Unmanned Aerial Vehicle***
- ***Long-Range Precision Strike***
- ***Small-Diameter Munitions***
- ***Defeat Hard and Deeply Buried Targets***





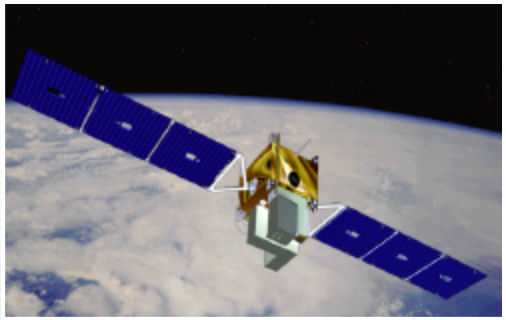


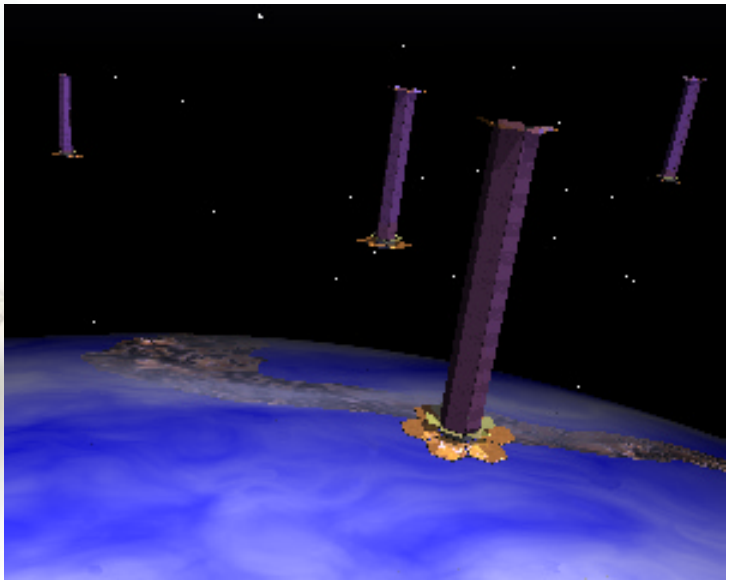




Conduct Space Operations

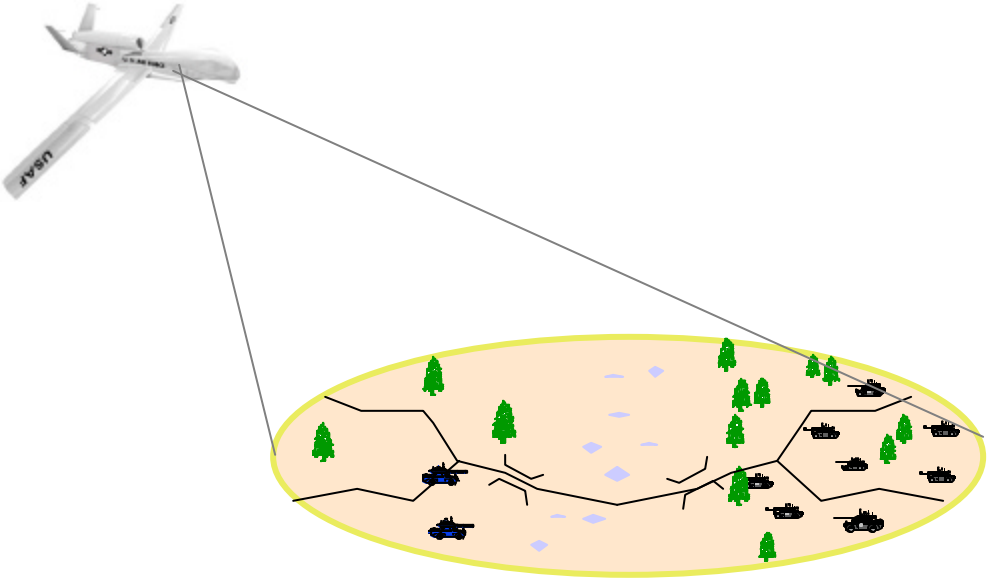
- ***Ensure Access to Space***
- ***Protect Space Assets***
- ***Space Surveillance***
- ***Control Space***
- ***Sub-Orbital Space Vehicle***

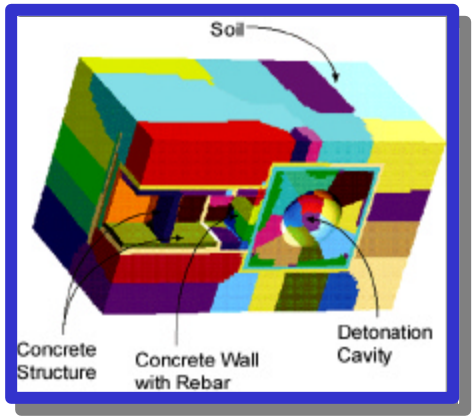




Leverage Information Technologies

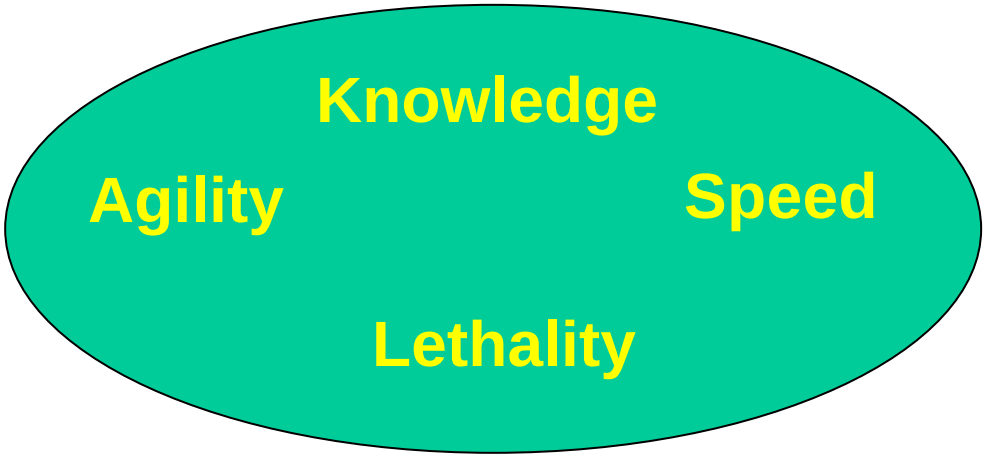
- ***High-capacity Interoperable Communications***
- ***Survivable, Improved, Tactical and Strategic Communications***
- ***End-to-end C4ISR***





Technology and Transformation

- **Transformation Attributes**



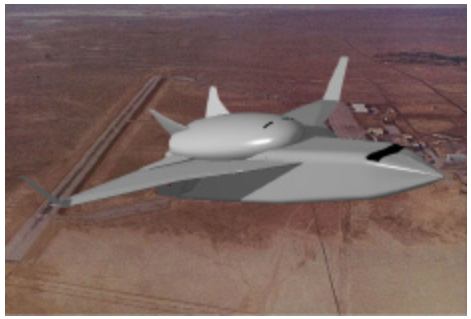
- **Transformation Technology Initiatives**
  - **National Aerospace Initiative**
  - **Surveillance and Knowledge Systems**
  - **Energy and Power Technologies**

National Aerospace Initiative
- *Technology Framework*

- **Hypersonics**
  - **Strategic Strike, Time Critical Targets, Suborbital Vehicles, UCAVs, Fast Transportation, etc.**
- **Access to Space**
  - **TSTO: 1st - Air Breathing, 2nd - Rocket; SSTO**
- **Advanced Space Technologies**
  - **Microsats, Multifunction Satellites, etc.**

National Aerospace Initiative Approach

Space Access



Weapons

RLV (Affordable, timely access to space)

Hypersonic Cruiser (Global Reach/Attack)

Far-Term

Supersonic/Hypersonic Missiles (Time-critical targets)

Mid-Term

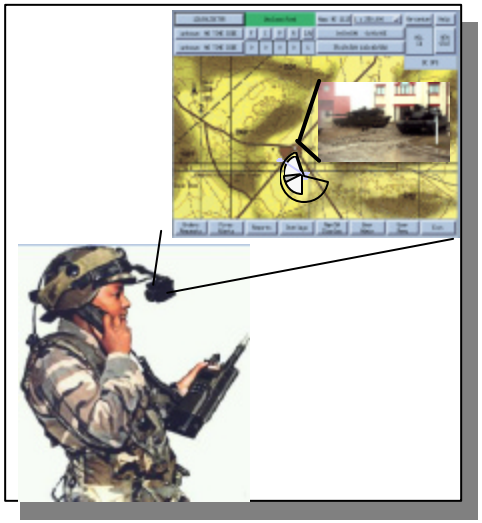
Pursue Stepping-Stone Approach

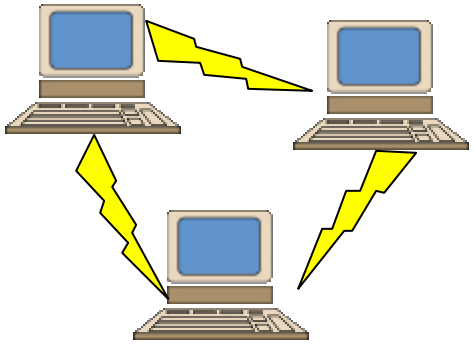
Near-Term

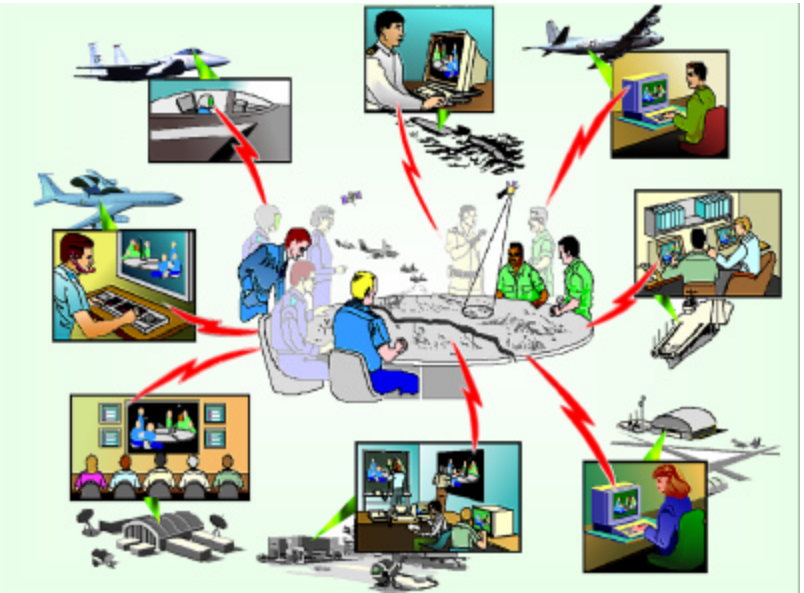
Surveillance & Knowledge Systems - *C4ISR*

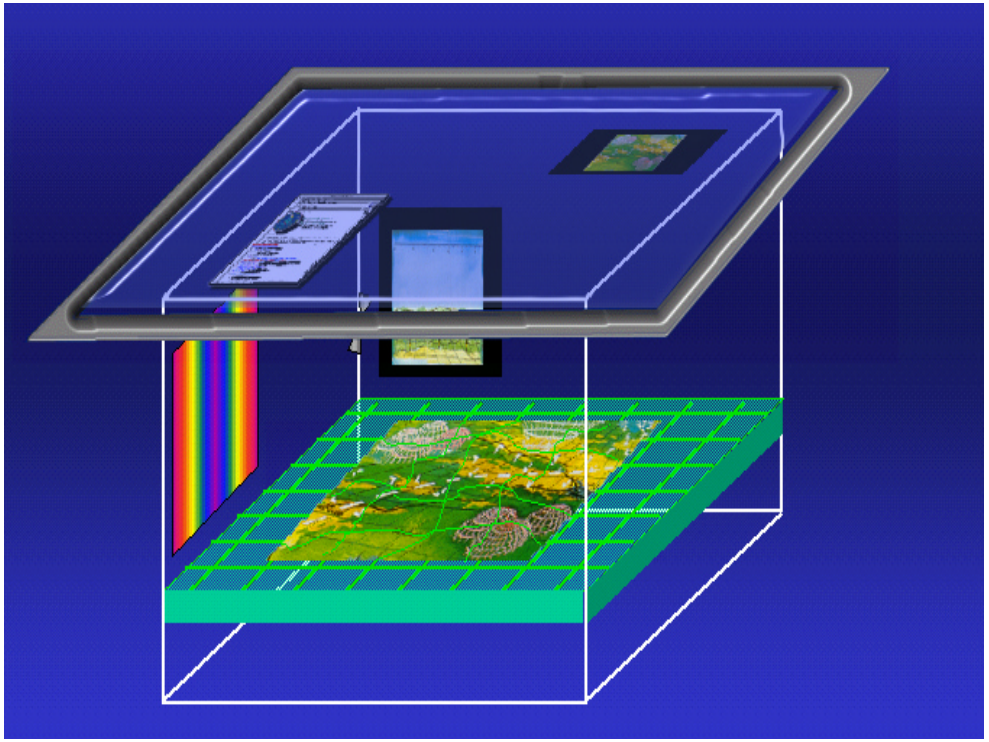
- **Sensors and Unmanned Vehicles**
  - **Bio Sensors, Robotics, UAVs, etc.**
- **High Bandwidth Communications / Information Assurance**
- **Information / Knowledge Management Systems**
- **Cyber Warfare**

Surveillance & Knowledge Systems









Energy and Power Technologies
- Enabling An "Electric" Force

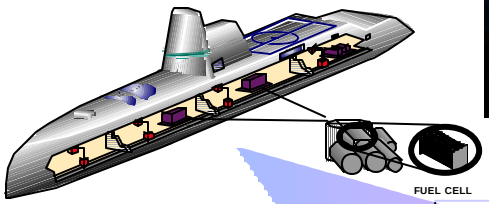
- **Power Generation**
  - **Nuclear, Diesel, Jet Engine, Solar Array, Fuel Cells, etc.**
- **Energy Storage**
  - **Batteries, Fly Wheels, Capacitors, Energetics, etc.**
- **Power Management and Control**
  - **Energy Conversion, Catapults, etc.**
- **Directed Energy Weapons**
  - **Lasers, Microwave, etc.**

Energy and Power Technologies

POWER GENERATION
- Fuel Cells & Fuel Reforming
- Novel Power

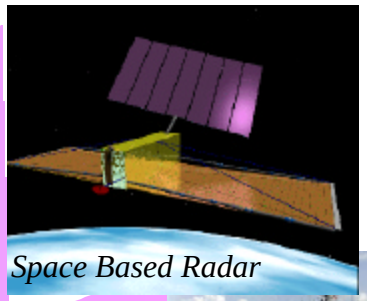
ENERGY STORAGE
- Batteries
- Capacitors

POWER MANAGEMENT & CONTROL
- Switching & Conditioning
- Power Transmission & Distribution
- Thermal Management



Electric Warship

More Electric Aircraft

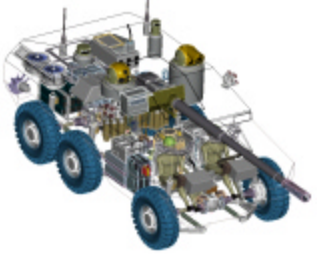


Space Based Radar

Electric Warship

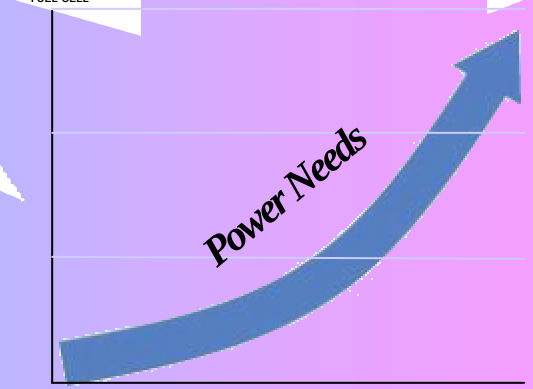
Warrior

High Power Microwave



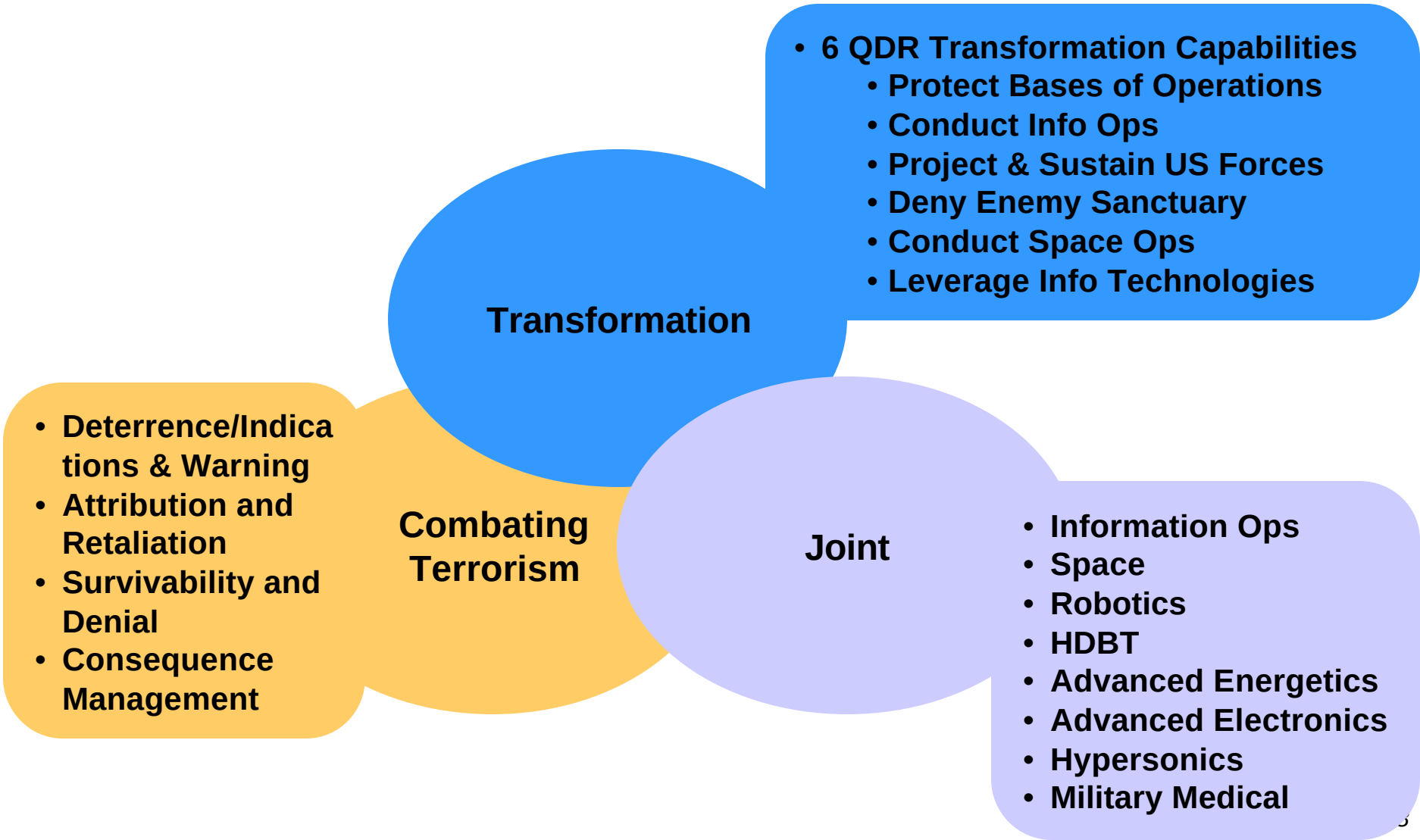
Hybrid/Electric Combat Vehicle

Electric/Hybrid Weapons

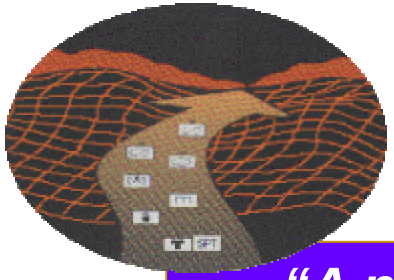


New Operational Capabilities

Science & Technology (S&T) Emphasis Areas



The Transformation Process - Modeling and Simulation is a Key Enabler

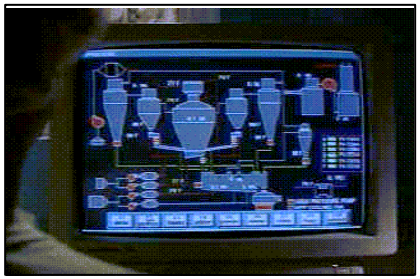


"A new generation of models and simulations will be needed to support distributed training; robust and continuous experimentation; and operational planning, execution, and assessment tools." – Transformation Study Report, Executive Summary, 27 April 2001.

Four Functional Areas for M&S

Experimentation

Training

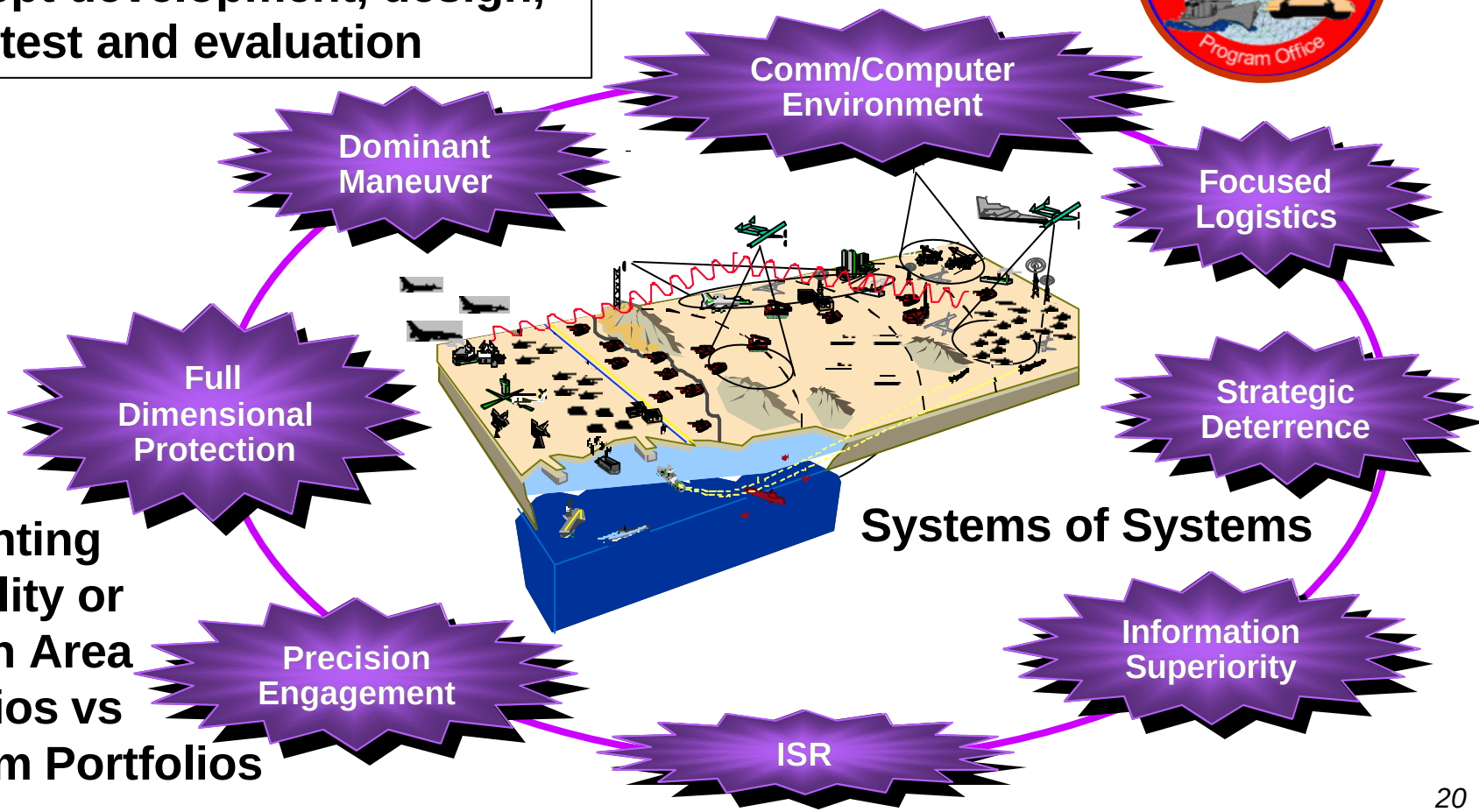


Analysis

Acquisition

The Transformation Process: Platform-Centric to Network-Centric Acquisition

Need credible M&S to support the spectrum of SBA activities: concept development, design, test and evaluation

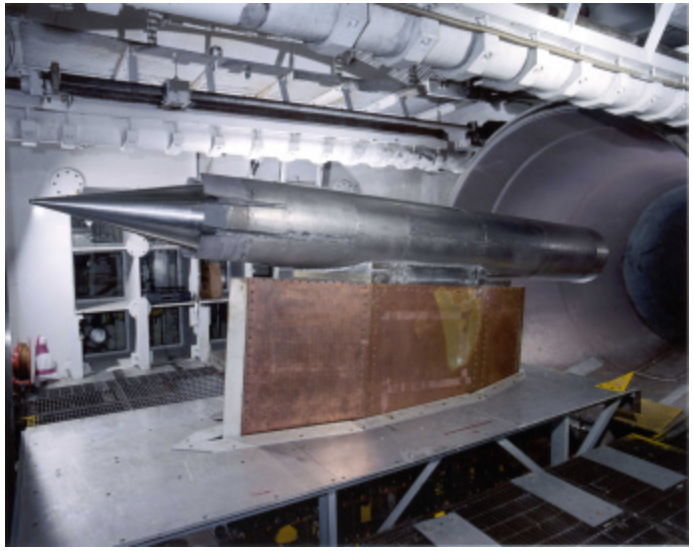


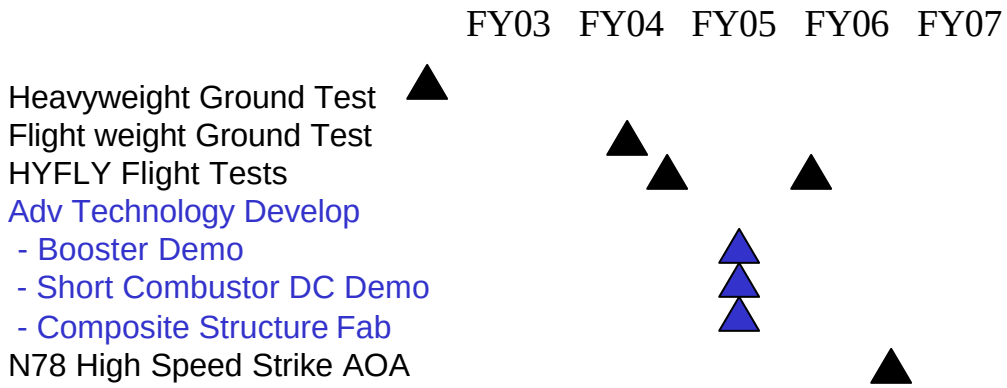
A Common Vision Representation

- Supporting multiple functional areas
- Through Live, Virtual, and Constructive Simulation
- With Joint, Interoperable, Re-useable models

Navy/DARPA Scramjet R&D

Hypersonic Flight Demonstration Program (HYFLY)

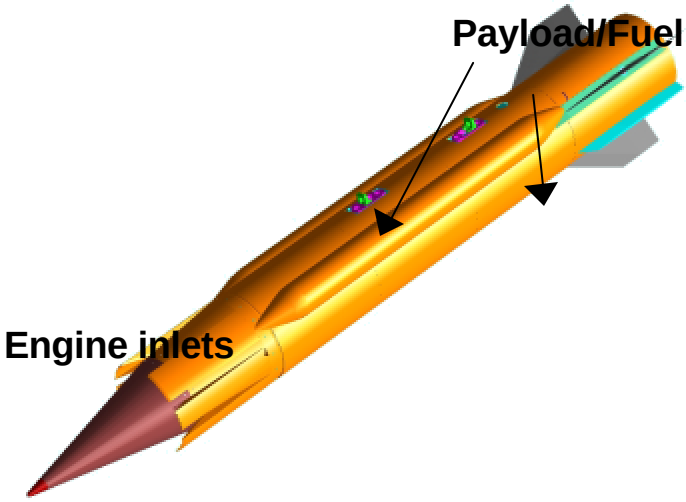




Successful Ground Test - May 30, 2002

HYFLY Weapon Characteristics

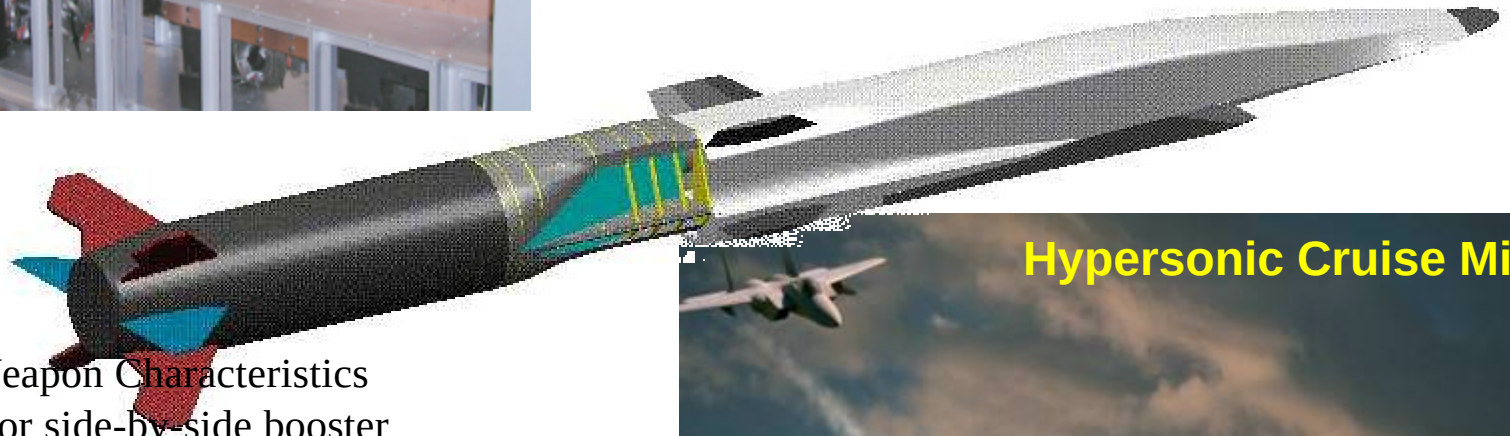
- **2150 lb Launch Weight, Length 183”**
- **250 lb Penetrator**
  - **F/A 18 E/F Compatible 400 Nmi Flyout**
  - **VLS Compatible - 600 Nmi Flyout**



AF Scramjet R&D

Hypersonic Technology Single Engine Flight Demo (HYTECH)

- Flight demo of HyTech scramjet & waverider airframe technologies
- Uses existing ATACMS booster
- Scramjet take-over at Mach 4.5
- Cruise at Mach 6.5 to 7.0
- Five flights (FY06 1st flight)



Potential Weapon Characteristics

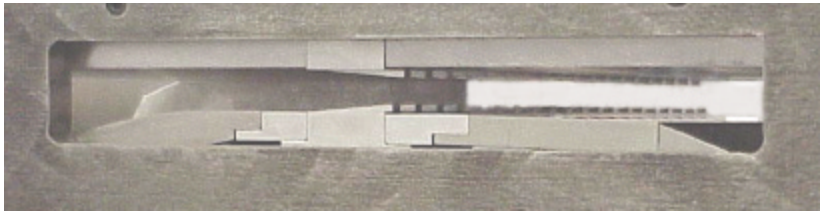
- Tandem or side-by-side booster
- 2300 lb launch weight
- Range: 600 nm in 10 minutes
- 250 lb payload (penetrator, smart submunitions, or explosive)

Army/NASA Scramjet R&D

Hypersonic H2 Scramjet Engine Development

HYPER-X Inlet

Full-Scale, H2 Scramjet Test – Feb 02
(Mach = 10)



HYPER-X Combustor

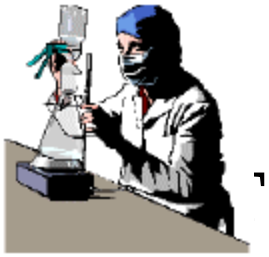
Technology Transition

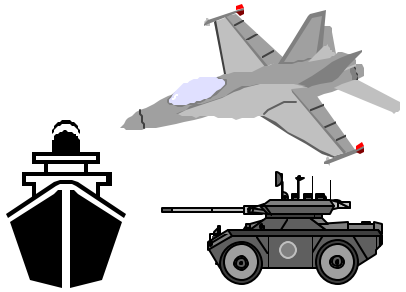
- **S&T Investment Aligned With DoD Goals**
  - **Transformation, Combating Terrorism, and "Jointness"**
  - **Strong S&T Base is Critical for Rapid Technology Transition**
- **Technology Transition Effort Has Many Facets**
- **Early Emphasis on Systems Engineering Facilitates Technology Transition**
  - **Modeling and Simulation Plays a Key Role**
  - **Communications, Platforms, Common Manufacturing, Test, O&M, Logistics, etc.**

Best Practices

All Services are moving their acquisition processes

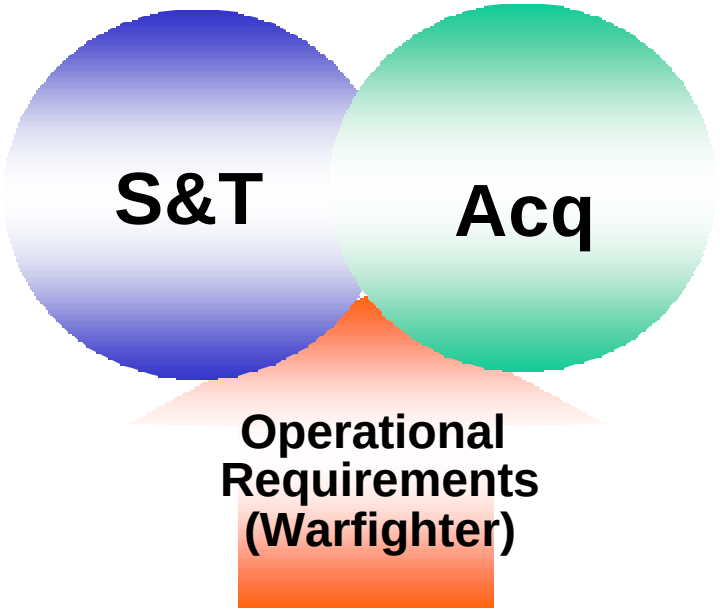
FROM





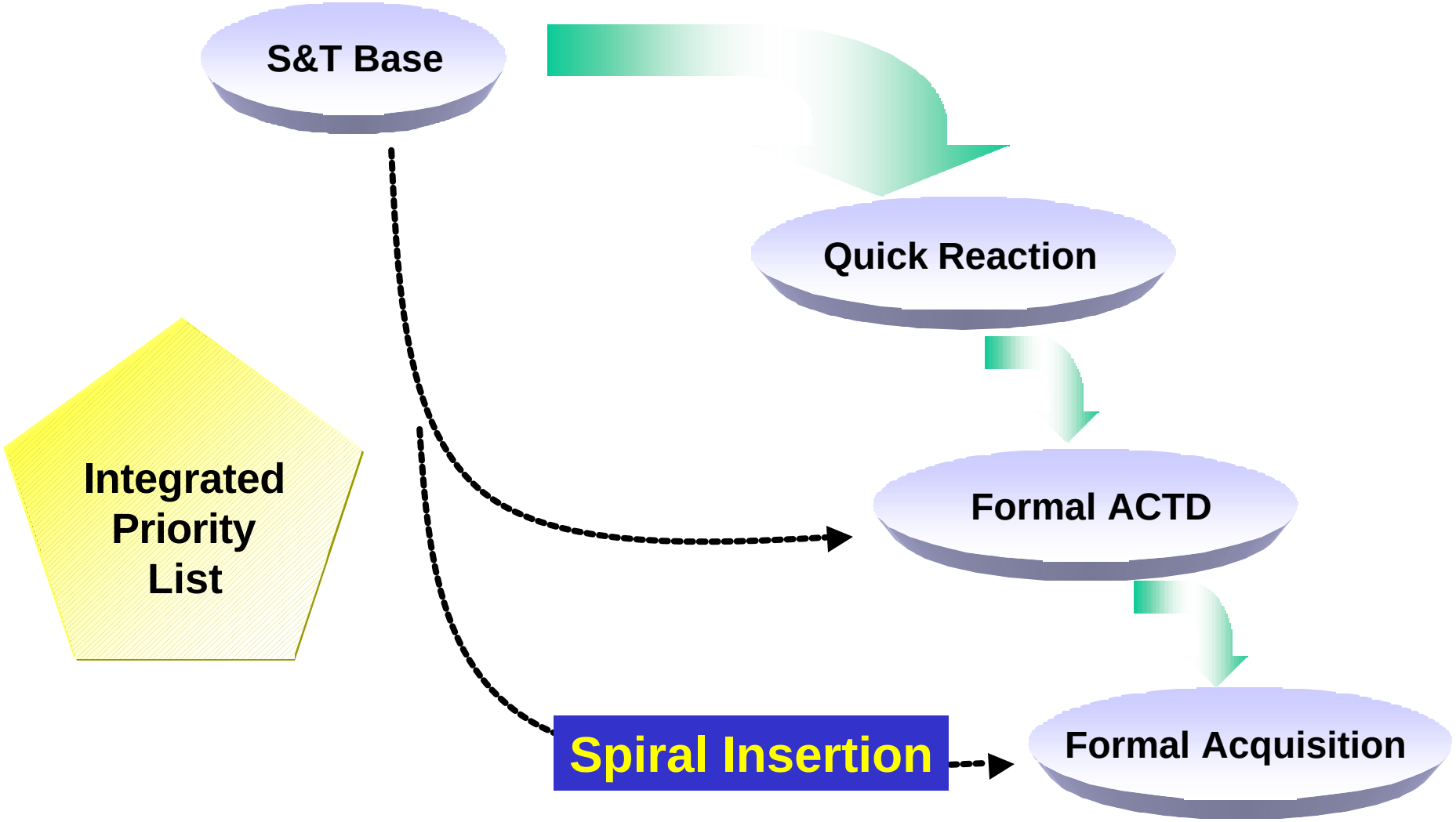
Acq

TO



Right
- *Technology*
- *People*
- *Time*

Complimentary Transition Efforts



Thermobaric Weapons
Case Study In Rapid Technology Transition

- **A "Quick Reaction" type development, enabled by base S&T program and ACTD Framework**
- **Chronology: Program Approved Sept 21, 2001**
  - **Small Quantity Lab Testing – Oct**
  - **Full Up Static Test – Nov 17**
  - **Flight Test - Dec 14**
- **Team: USN, DTRA, USAF, DOE**

Chemistry → Weapon

3 months

Predator
ACTD Technology Transition

- Developed as an Advanced Concept Technology Demonstration (ACTD)
- Successfully Demonstrated in Bosnia
- Rapid Progression From Demo to Operational Use
- First ACTD to Transition to the Operational Air Force
- Operating Command - ACC
- Sustainment - AFMC

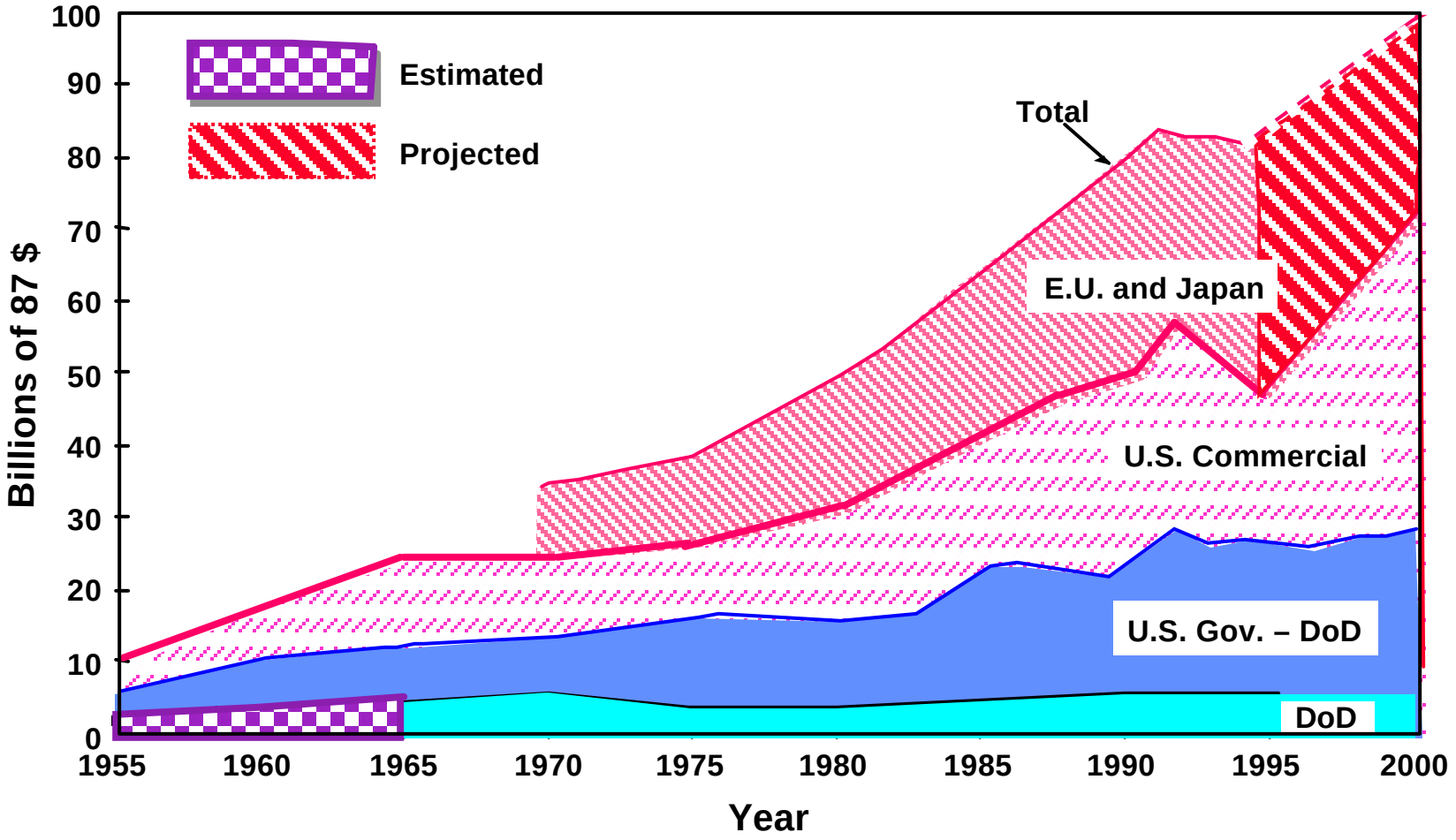
Joint Strike Fighter
Formal Acquisition

Technology Readiness Assessments (TRA) provide systematic review of technology maturity and readiness for transition

- **First Milestone B TRA Conducted On The Joint Strike Fighter**
- **Critical Technology Areas Were Assessed**
- **Focuses Technology Resources On Risk Mitigation Planning**
- **Commonality between Service Variants Addressed**

Bringing the Technology and Acquisition Community Together

U.S. and Worldwide Research Base Since WWII



Source: Report of the Defense Science Board Task Force on the Technology Capabilities of Non-DoD Providers; June 2000; Data provided by the Organization for Economic Cooperation and Development & National Science Foundation

Summary

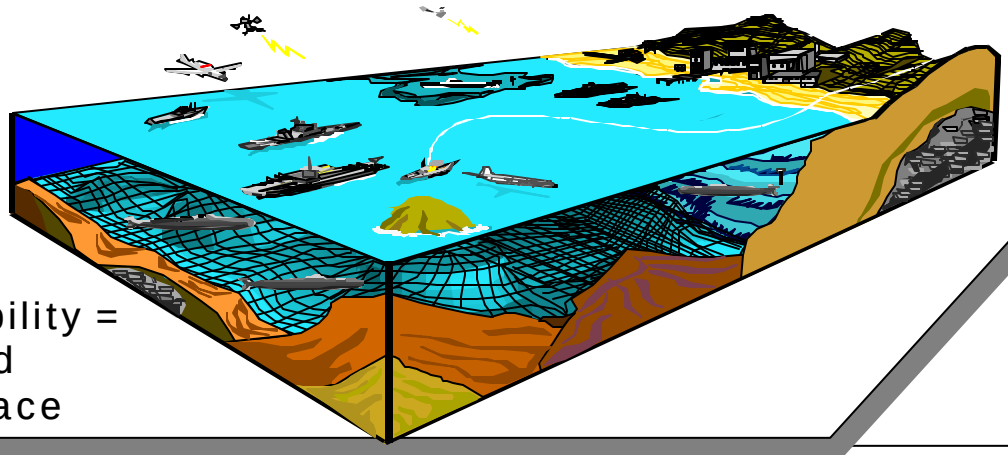
- **Technology is a Foundation for Transformation**
- **Modeling and Simulation – A Key Enabler**
  - **Simulation-Based Acquisition**
  - **Advanced Systems Engineering Environment**
- **Accelerating Technology Transition is Critical**

BACKUPS

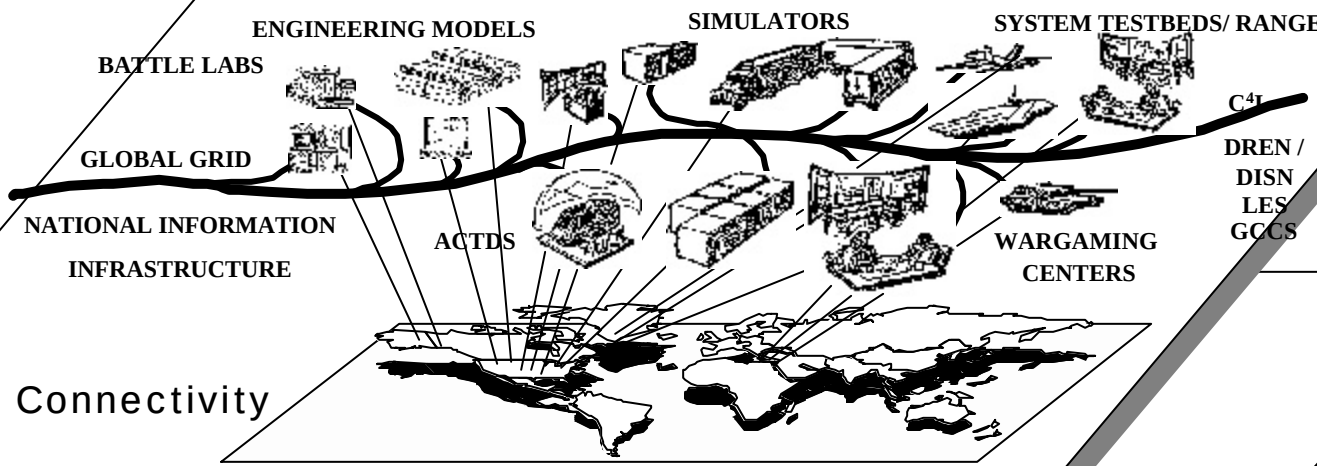
National Security Workforce and Laboratories

- DoD Investment in University-Based Research Increases the National Workforce in Critical Technology Areas
- Expanded Use of Workforce Pilot Programs Will Strengthen Labs
- Laboratories Supporting National Security Need to Modernize Infrastructure

Simulation of Mission Space



Desired Capability = Simulated Mission Space



Comm Connectivity

- POLICY & DIRECTIVES
- COMMON TECHNICAL FRAMEWORKS
- PROTOCOLS & STANDARDS
- COMMON REPRESENTATIONS
- COMMON SERVICES
- CONFORMANCE

Interoperability & Reuse

Terminology

M&S Defined

Model: "A physical, mathematical or otherwise logical representation of a system, entity, phenomenon, or process."

Simulation: "A method for implementing a model over time....."

DoD M&S Glossary, Jan 1998

Simulation Domains

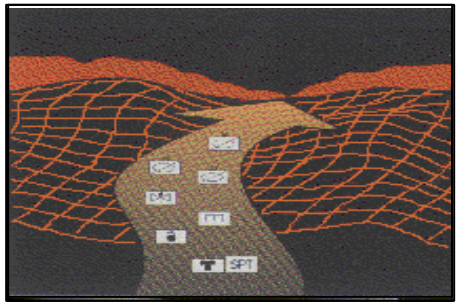
Live

Virtual

Constructive

Functional Areas

Acquisition



Experimentation & Analysis

Training & Operations

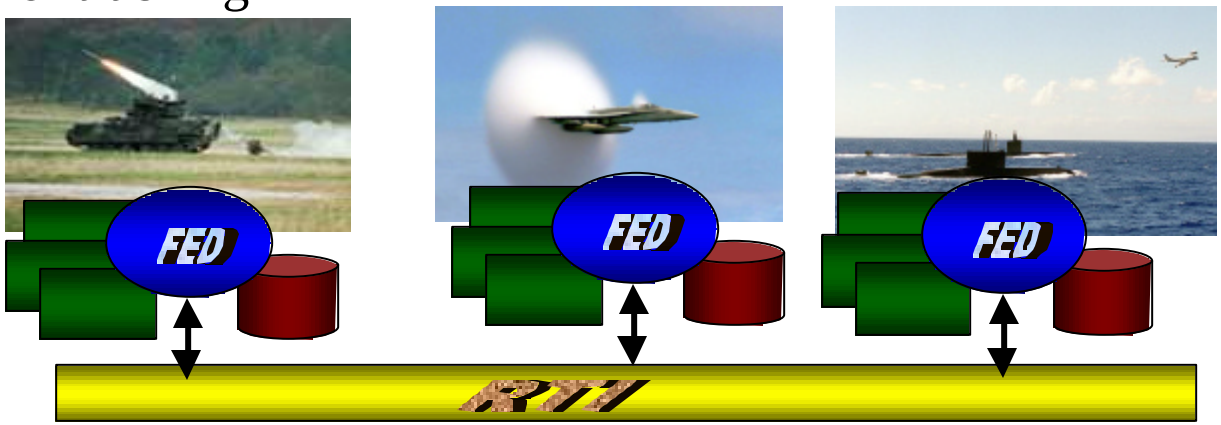
Simulation Environment

- Standards Based Infrastructure
  - Capable of linking new, legacy systems
- Authoritative Data
  - Shared environments with reusable pieces
- New Design Structures
  - Common, reusable servers, composable models
- Metrics and Evaluations
  - VV&A, error tracking

Environment:

Data

Model



National Defense Domain Evaluation of Current M&S

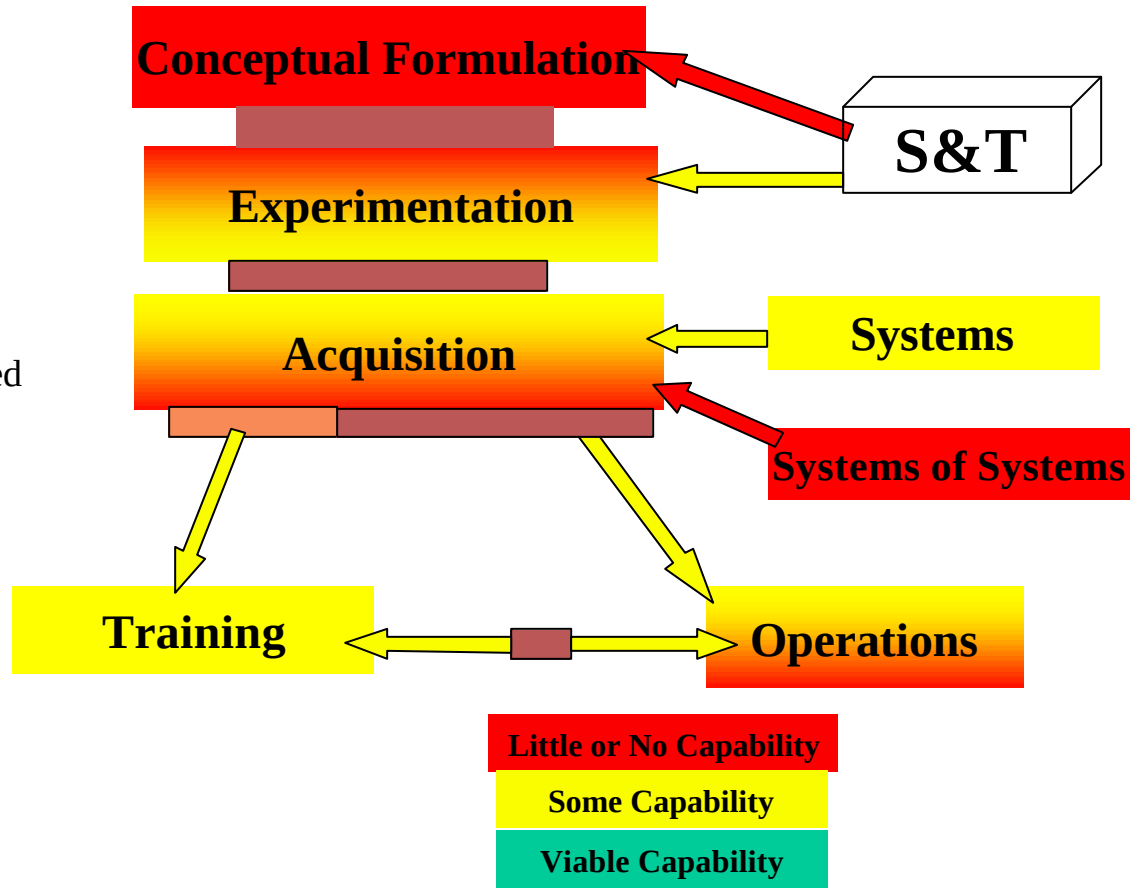
Conceptual Formulation:
- Scope limited to cold war ideas
- Do not have flexible tools good enough to stimulate creative thinking
- Insufficient participation from academia, industry, military, other gov agencies

Experimentation
- Initiated, but not robust and responsive
- "J" efforts need to be truly joint & integrated

Acquisition
- Tools designed only for single system
- Lack metrics, inadequate process for systems of systems

Training
- Service Specific/Stove-piped solutions
- Tools need to be better, shared, joint

Operations
- Need Joint, Collaborative Planning/Rehearsal systems needed
- Insufficient training for new conflict



Communities are separate, lack incentives to work across boundaries

Common Threads: Repositories don't describe models for reuse and classification
M&S is often hard to use, inflexible, opaque and underfunded

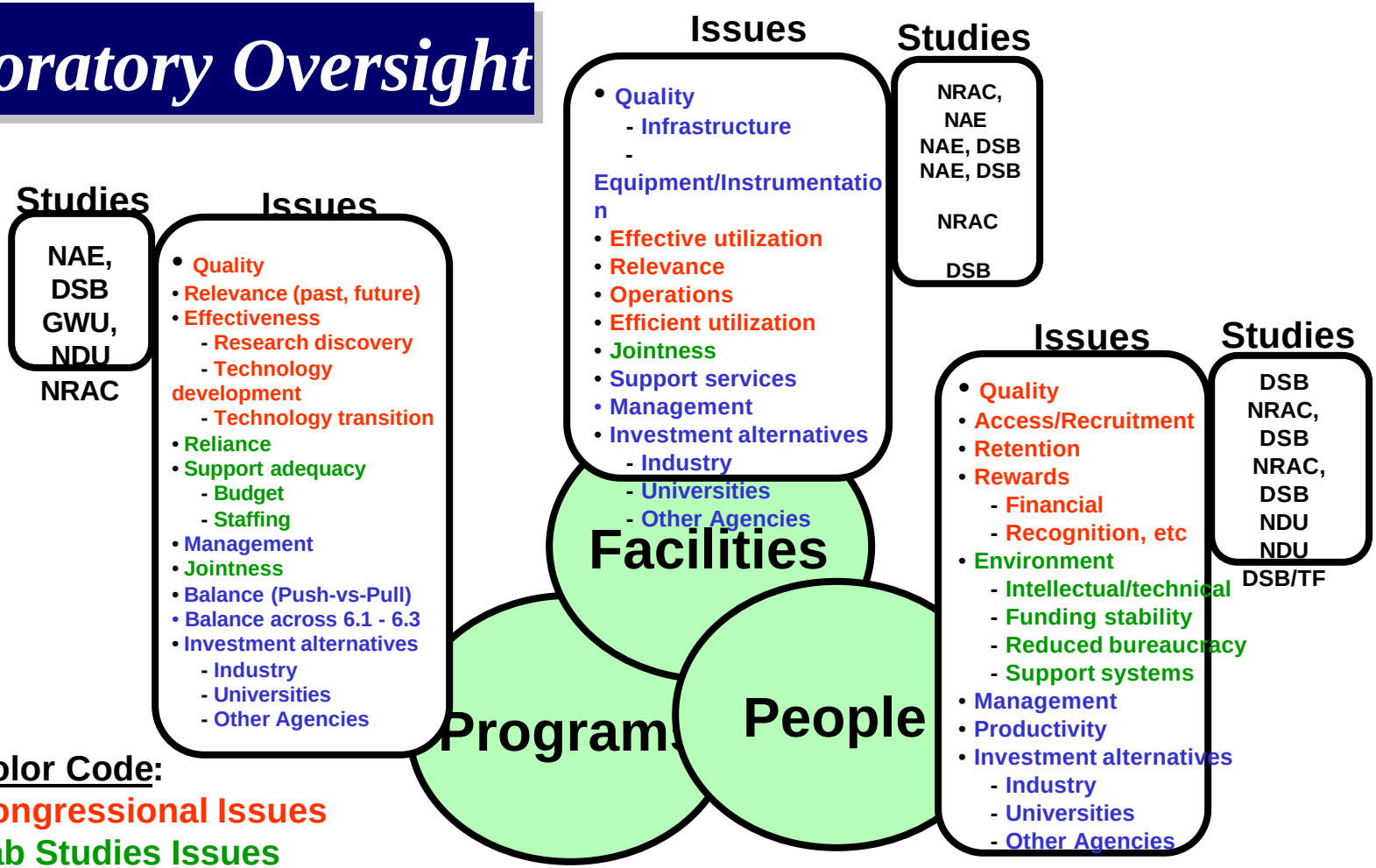
Warfighter's M&S Needs

Combatant Commander M&S Needs (WARMOND Data Base)

- Link to C4I systems (w/reach-back)
- Faster, less costly database development
- Standardized (reusable) components
- Reduced overhead
- Operational data collection
- Access to terrain for operational areas
- Tools for operational decision-making
- Improved human performance modeling

Laboratories & People

"Laboratory Oversight



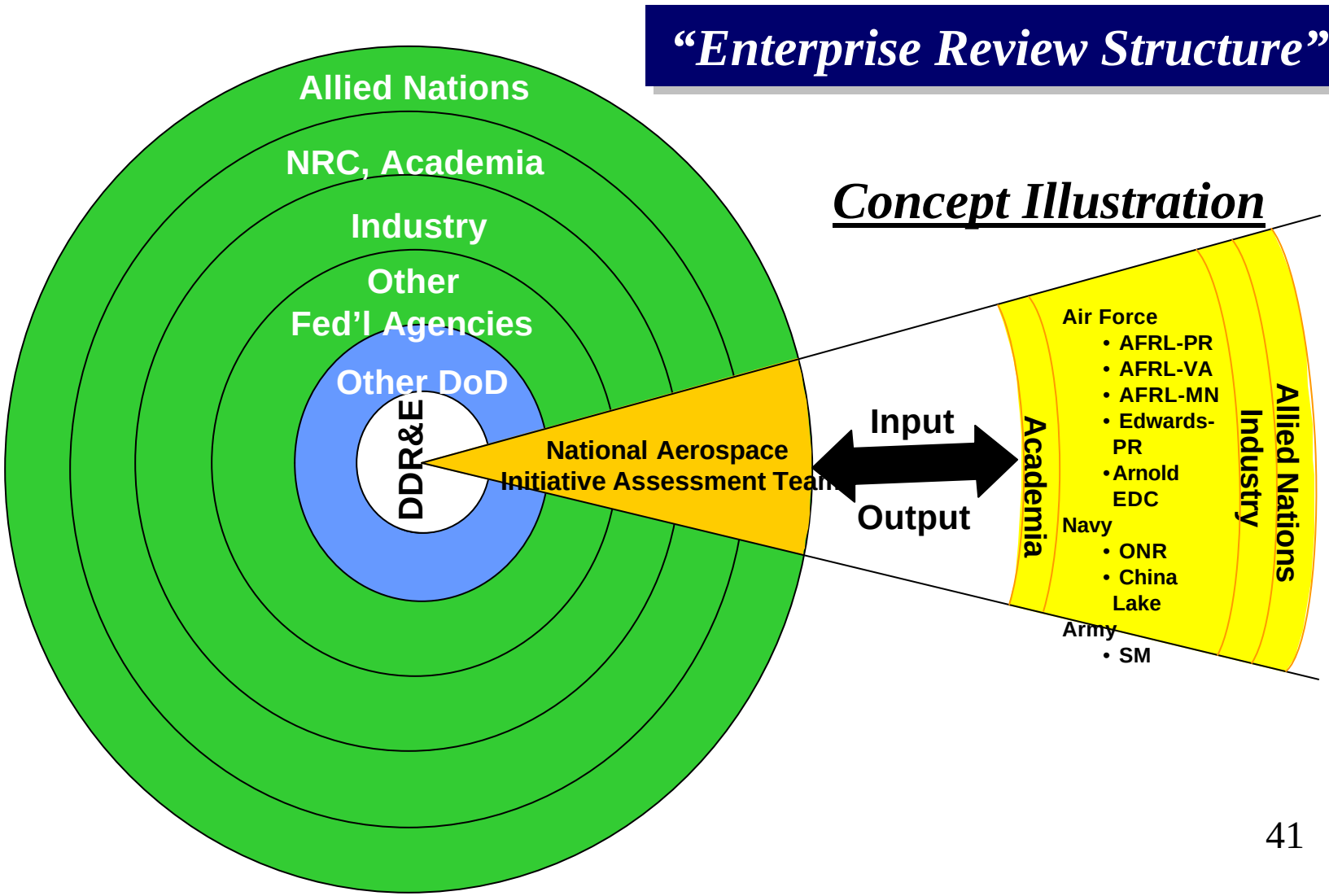
Color Code:

Congressional Issues

Lab Studies Issues

DDRE Oversight Issues

Laboratories & People



Joint Direct Attack Munition (JDAM)
Example of Interoperability

DoD CTO Responsibilities

- **Principal Advisor to the "CEO" (SECDEF) for Technical Matters**
- **Responsibilities**
  - **Provides Oversight / Assessment of the "State of the Art" in militarily relevant technologies:**
  - **Leads Change of Development of New/Transformational capabilities**
  - **Assesses Application of Technology to Acquisition Programs**
  - **Shapes the DoD Laboratories and Workforce**
- **Mechanisms**
  - **Policy**
  - **Financial**

Simulation Based Acquisition (SBA) of the USMC Medium Tactical Vehicle Replacement (MTRV)

by

D. Gunter

Impact to DoD: *High performance computers are being used to develop tools capable of accurately predicting vehicle performance. This allows DoD to make informed acquisition decisions in less time and reduces the risk of buying vehicles that do not meet performance requirements.*

Objective

To develop tools capable of accurately predicting dynamic vehicle performance under the limited time constraints of the SBA of the United States Marine Corps (USMC) MTVR.

Methodology

Three-dimensional, multi-body dynamic model templates of various truck designs were developed before convening of Source Selection Evaluation Board (SSEB) using LMS-CADSI's Dynamic Analysis and Design System (DADS) modeling and simulation methodology. A performance matrix of simulations suitable for identifying whether proposed vehicles meet stringent MTVR performance requirements was developed. Data was submitted throughout the source selection process by proposed vehicle developers. The data was then incorporated into the model, which was used to perform analysis in a signficantly reduced timeframe.

Results

Executing models of the contractor designs over a specified performance matrix allowed the SSEB to evaluate the capability of each vehicle's system meeting the stringent on- and off-road performance requirements laid out in the MTVR Performance Specification, before vehicle build and test. This allowed the SSEB to make informed decisions in a reduced amount time. The ground work done prior to convening the SSEB, combined with the computational speed of today's supercomputers, resulted in a capability to determine vehicle performance more rapidly.

Significance

The capabilities developed through this effort allow the DoD to use modeling and simulation to make informed acquisition decisions in less time and reduces the risk of buying vehicles that do not meet performance requirements.

Computer Resources: SGI PCA and SGI Origin 2000 [TARDEC DC]

CTA: CSM

JWCO: Joint Readiness and Logistics and Sustainment of Strategic Systems