Headquarters U.S. Air Force

Integrity - Service - Excellence

Air Force Approach to Disruptive Technologies and Transition

April 20, 2006

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Associate Deputy Assistant Secretary
(Science, Technology and Engineering)

Outline

- **Introduction**
- **Disruptive Technologies**
- **Transition**
- **Summary**

Air Force S&T Program

- Technology Options for Future Warfighting Capabilities
  - Upgrades for fielded systems
  - New systems
- Broad and Balanced Set of Technologies
  - Evolutionary improvements
  - Revolutionary capabilities
- Research Laboratory Provides Technical Expertise
  - Assist operational users
  - Help make the Air Force a smart buyer
  - Conduct unique/niche in-house research

Outline

- Introduction
- Disruptive Technologies Definition
  - Smaller is Better
  - All Encompassing Battlefield
  - Directed Energy
- Transition
- Summary

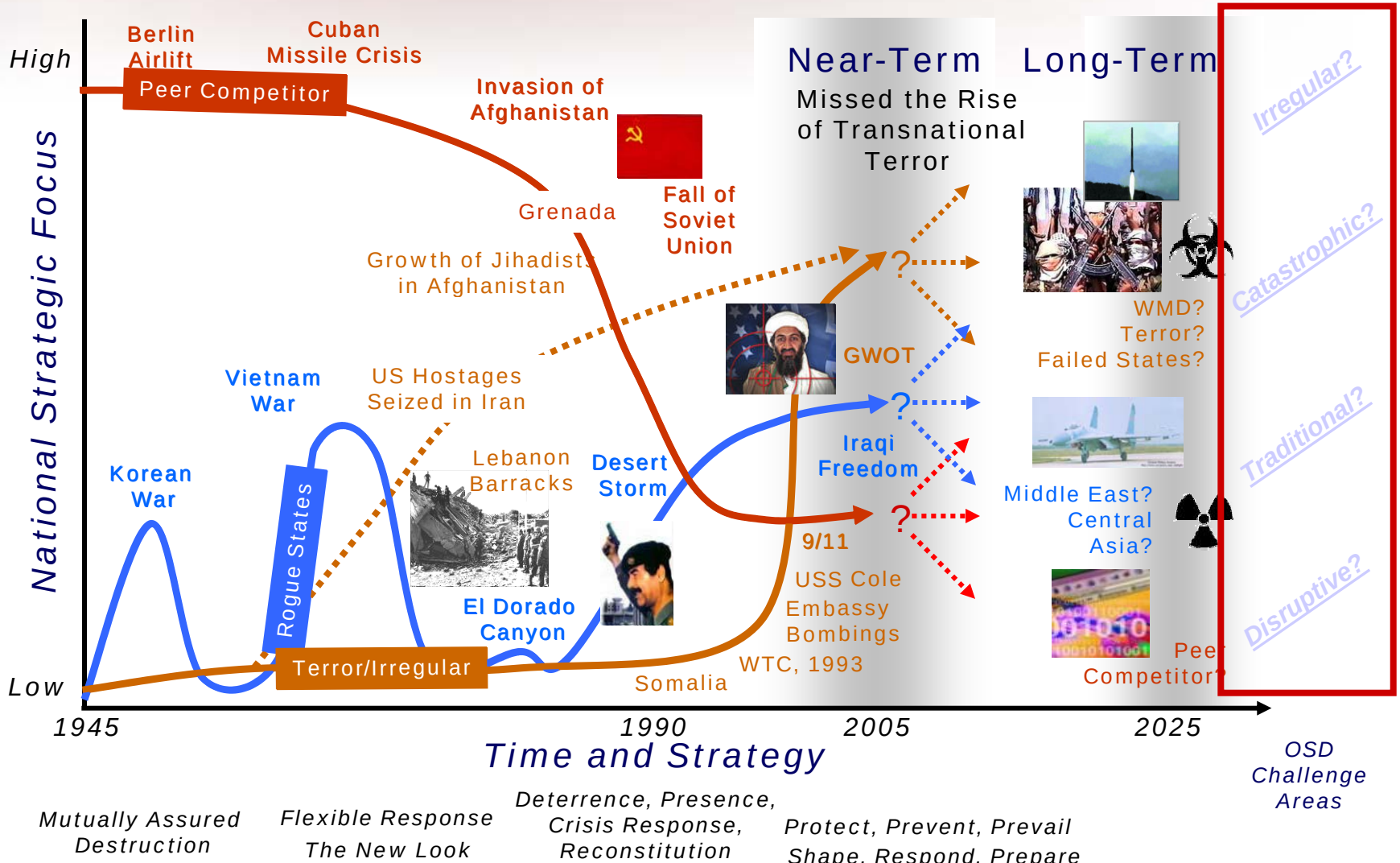
It's an Uncertain World Out There

Disruptive Technologies

- *Disruptive Technologies* **are those technologies that can change the nature of military competition and fundamentally alter our concepts of warfare. Examples of disruptive military technologies include: nuclear weapons, reconnaissance satellites, stealth, and global positioning system. Disruptive technologies affect the operational capability balance, either defensive or offensive. Strategically, we must be attentive to the consequences and opportunities offered by disruptive technological breakthroughs, and plan and invest accordingly.**

Source: OSD

The Planner's Dilemma: Then, Now, and in the Future



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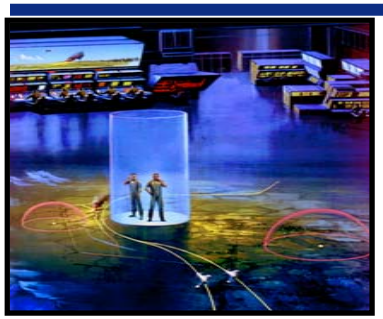
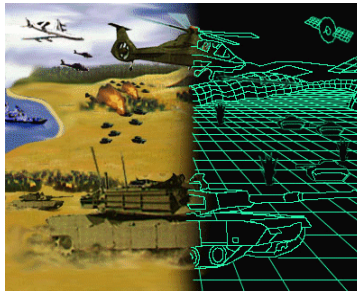
U.S. AIR FORCE

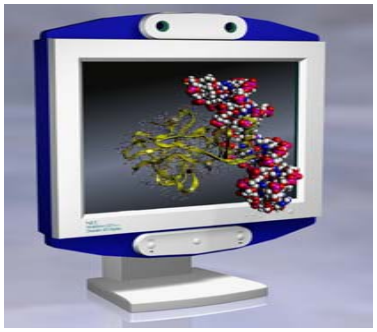
The Changing Landscape of Research



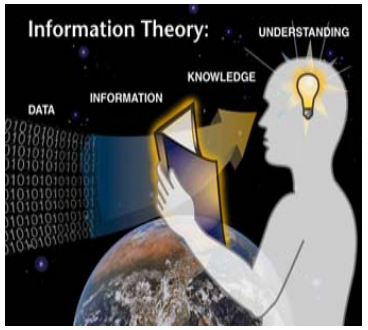
Virtual Worlds



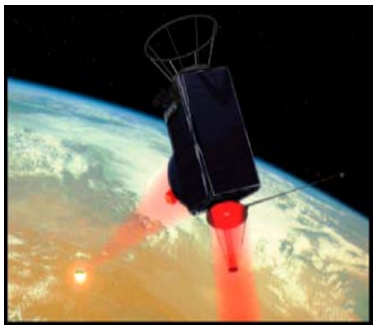
Virtual Presence



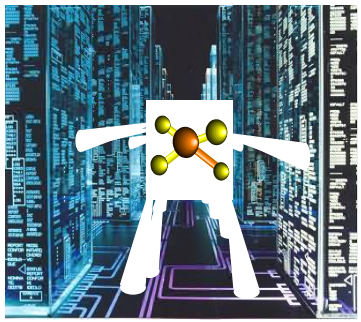
Advanced Computing



Cognitive Sciences



IT in Space



Cyber World

BioTechnology

- Bio-inspired Architectures
- *Bacteriorhodopsin* Memory
- BioComputing

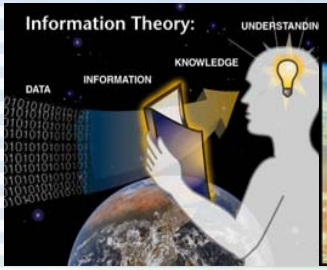
NanoTechnology

- Micro Electro-Mechanical Systems-based PicoSat Inspector
- Nanotechnology

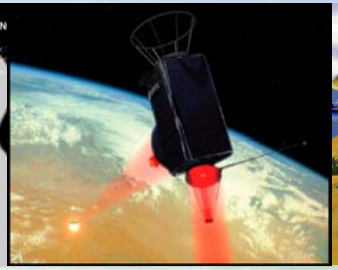
Quantum Technology

- Quantum Information Systems
- Quantum Communications

21st Century: Landscape of RESEARCH



Advanced Computing



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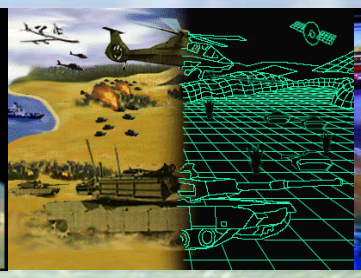


Virtual Worlds

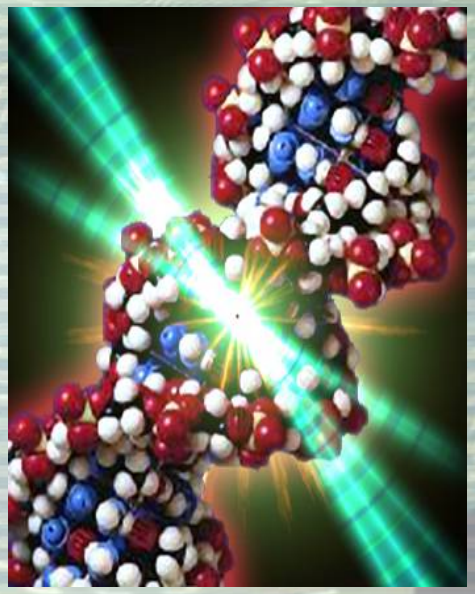
Virtual Presence

Nano Technology

Miniature aerospace vehicles (Info-Crafts) that can perform defensive and offensive “Cyber – Ops”

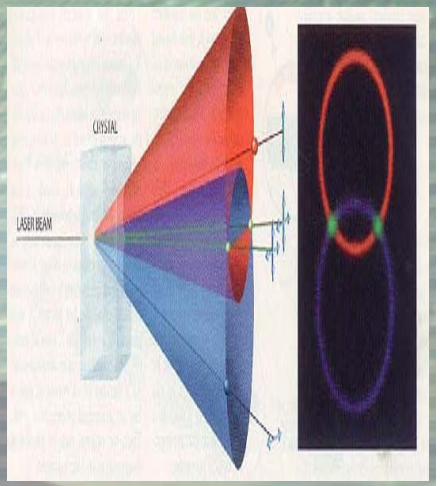
Bio Molecular

Full integration of hybrid Bio-Molecular Computing capabilities into C4ISR system



DNA Memory

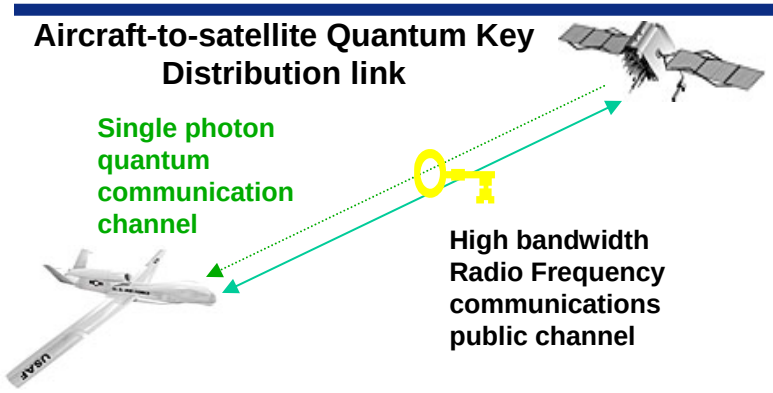
Started with **1600** Magnetic tapes and have reduced that to **10^{15} bits per cm^3**

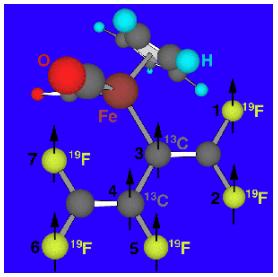


Quantum Technologies

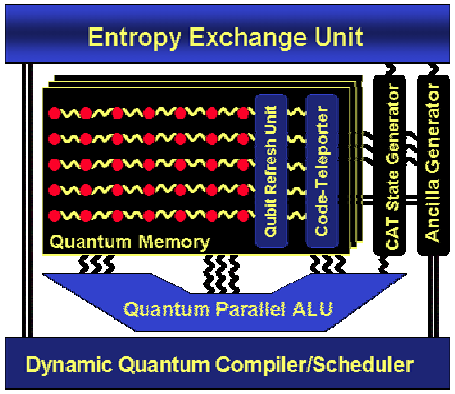
Next Generation in computing power. Millions of Courses of Action (COAs) in nanoseconds possible

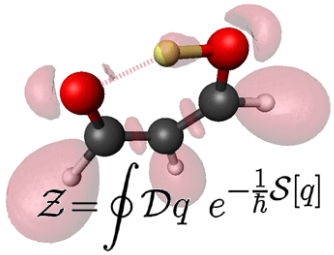
Quantum Information Science





Quantum Internet



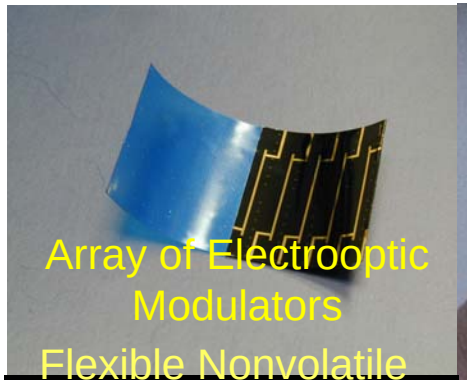


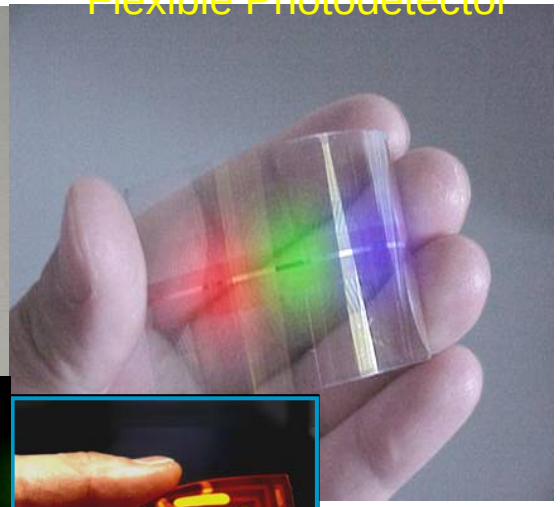
- **Ultra-secure communication**
  - **Virtually unlimited channel capacity**
- **Develop *revolutionary computing and communication* capabilities:**
  - **Calculate difficult/impossible tasks classically**
    - Factoring large numbers
    - Simulating large quantum systems
  - **Rapid sorting of large databases**
    - Functional optimization for wargaming
  - **Exact logistics and planning solutions**
  - **Ultra-precise metrology**

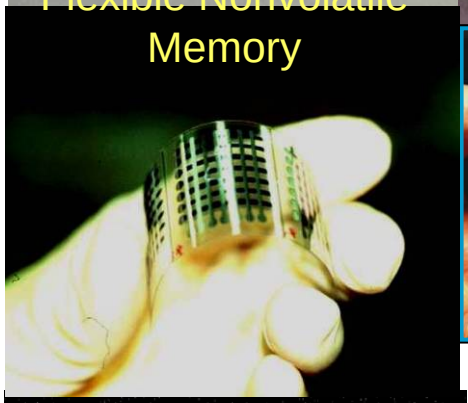
U.S. AIR FORCE

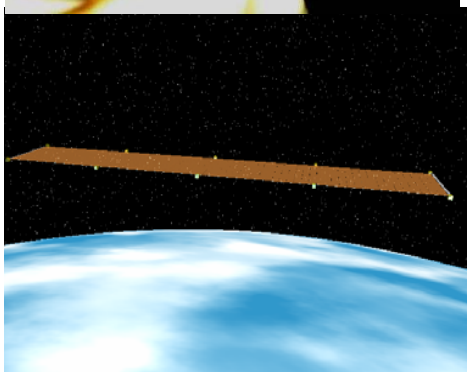
Flexible Multifunctional Structures

- Multifunctional Sensor Carpet
  - Power Generation
    - Flexible Photovoltaic
  - Power Storage
    - Flexible Supercapacitor
  - Flexible Data Memory
  - Flexible Electronics
  - Flexible Sensors
- Flexible RF Transmit-Receive Antenna Module
  - Photonic Antenna





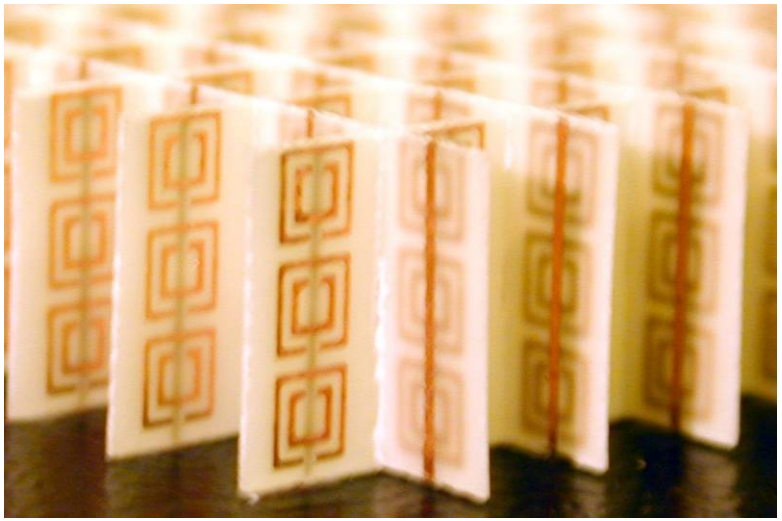


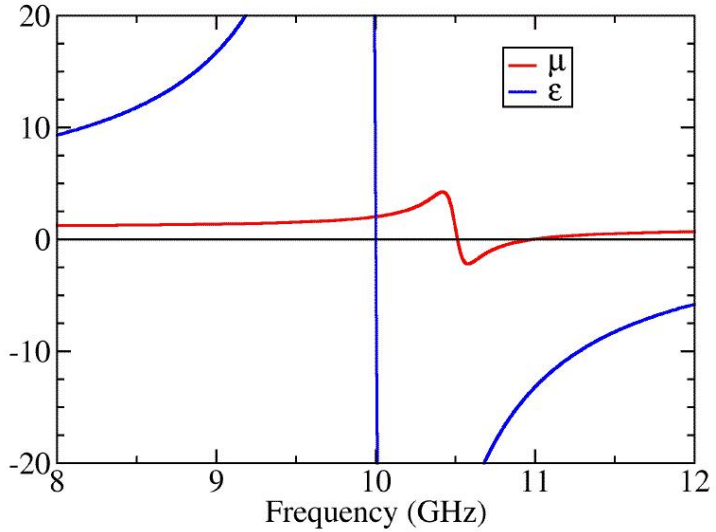


Flexible Light Emitting Diode

Plastic Sensor Carpet for Space Surveillance

Left-Handed Material (Metamaterial)

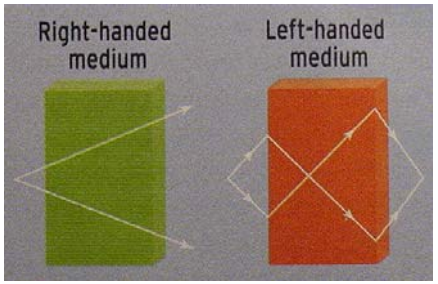




Index of refraction (n) is given by: $n = \sqrt{\frac{\varepsilon\mu}{\varepsilon_o\mu_o}}$

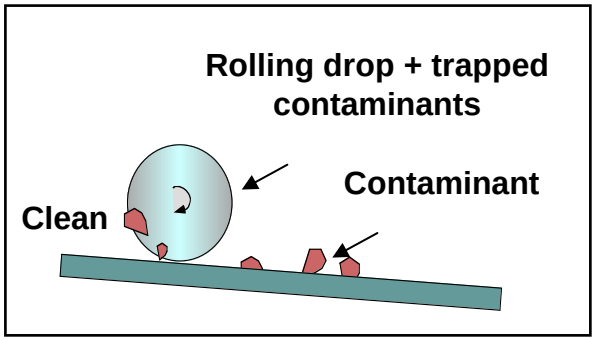
Both the permittivity (ε) and permeability (μ) are negative from about 10.4 GHz to 11 GHz.

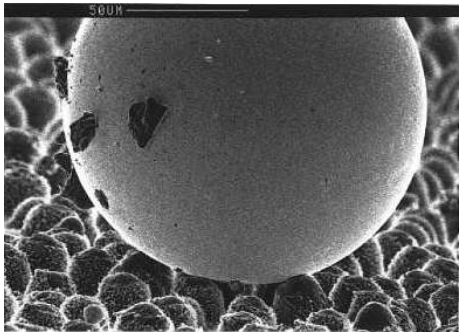
- **Negative index of refraction**
- **Focus radiation from a point source back to a point**
- **Smaller, lighter, more precise filters, communication, antennas, other electromagnetic devices**



Ultrahydrophobic Coatings for Corrosion Prevention

- Prevent water from reaching metal substrate; inhibits corrosion
- 30% of corrosion related cost could be reduced through better design
- Ultrahydophobic surfaces created through hierarchal micro/nano structures
- Self Cleaning





Water droplet on Lotus flower

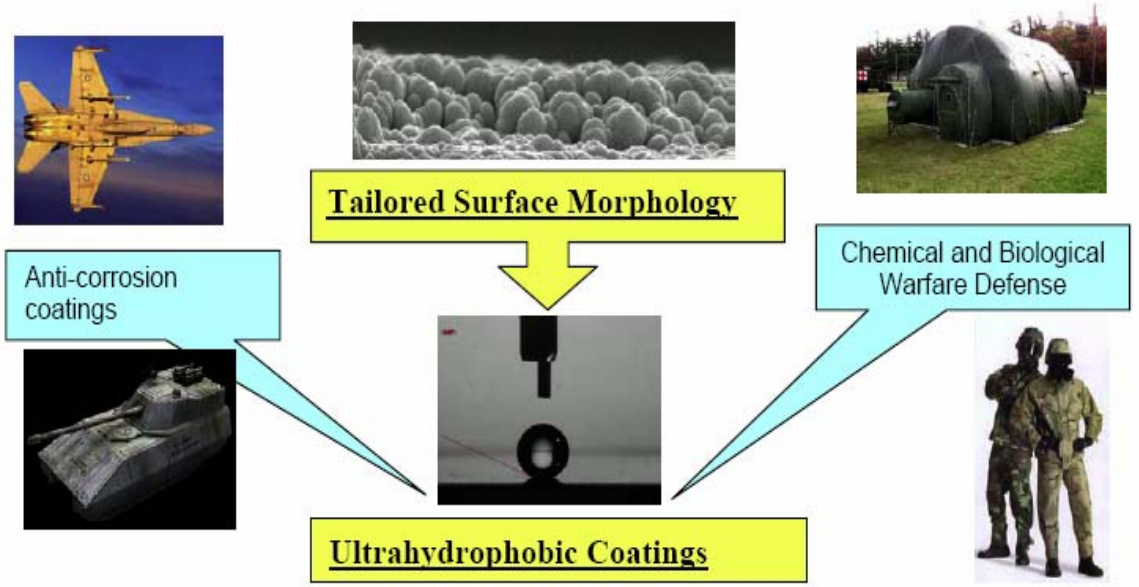
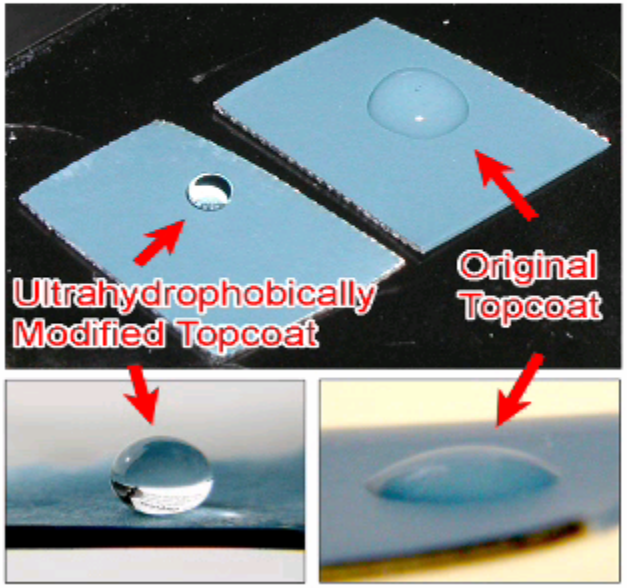
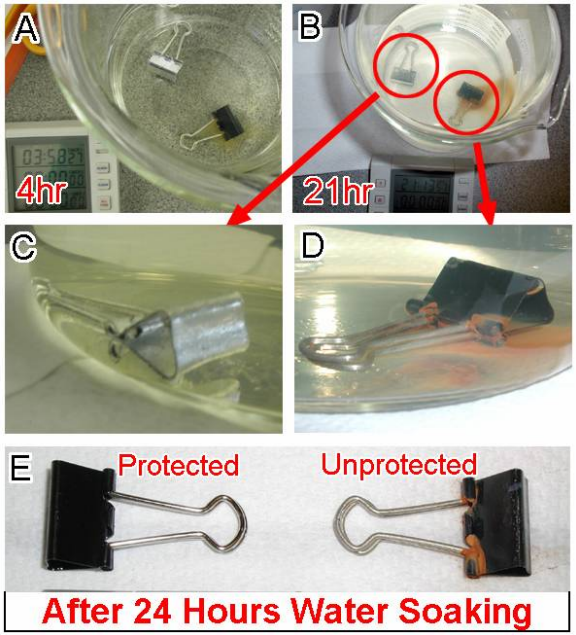


Figure 1. Tailored coating surfaces result in ultrahydrophobic coatings for water repellency supporting many military and commercial applications

Ultrahydrophobic Coatings





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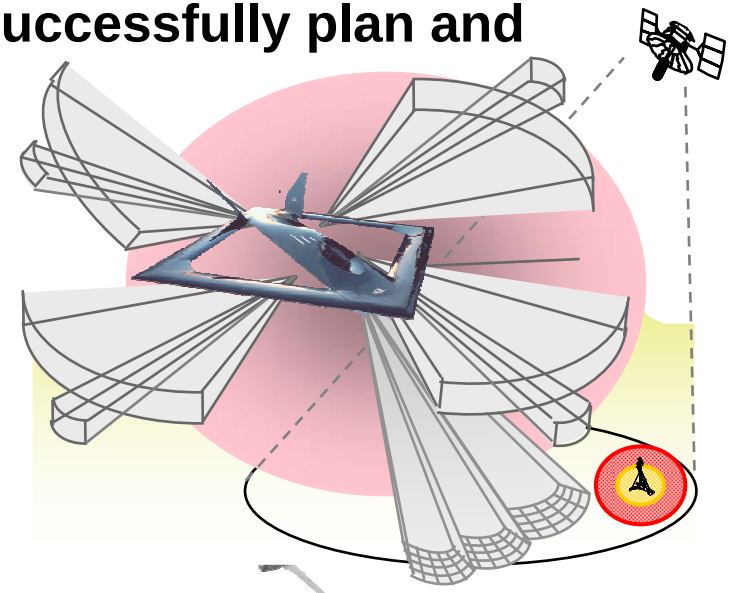
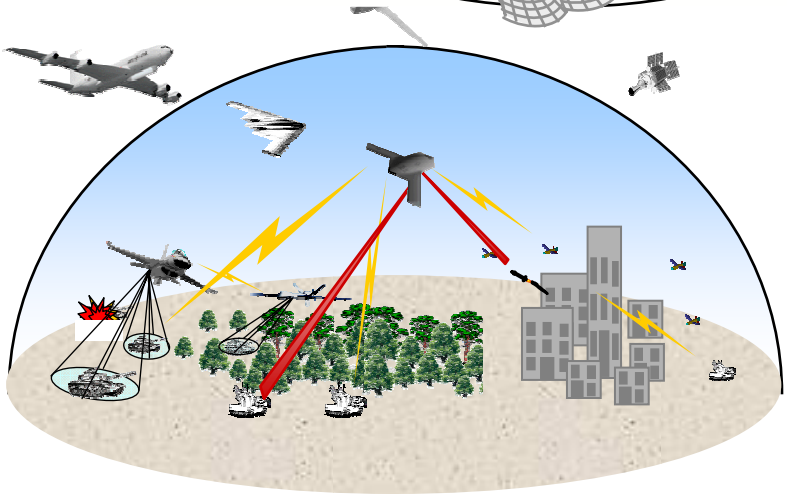
Computer Network Operations

- **Continuing Trend**
  - **Smaller, lighter, mobile and connected**
  - **Dramatic increase in: Cycles/Second/Watt/$**
  - **Results in CPU's becoming more personal and pervasive**
- **Military Opportunities**
  - **Gather intelligence**
  - **Alter perception**
  - **Impact decision making**
- **Changes the Way We Target**
  - **Old: Target organizations and equipment**
  - **New: Target individual personnel**
  - **Requires shift in way we plan ops and gather intelligence**

Persistent Intelligence, Surveillance and Reconnaissance (ISR)

- **Predictive battlespace awareness to successfully plan and conduct operations**
  - **Under challenging deployment conditions**
  - **Deny battlespace awareness to the adversary**
- **Sustained presence of integrated ISR capabilities**
  - **Collect, process, exploit, and disseminate accurate and timely information**
  - **Targeting quality accuracy in the right format at the right time to the right person**
- **Full spectral dominance**
  - **Dynamic network of databases to support a common operating picture**
  - **Rapid detection and attack authorization for time sensitive targets**

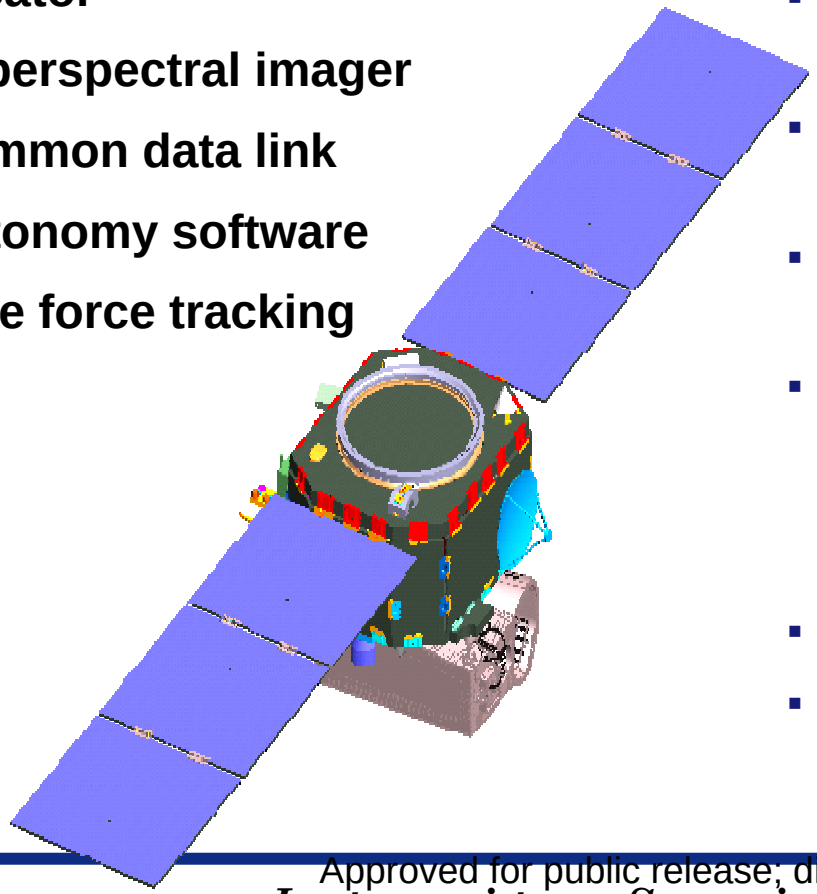




Responsive Space: TacSats and Launch

Possible Payloads

- Emitter detector/identification /locator
- Hyperspectral imager
- Common data link
- Autonomy software
- Blue force tracking



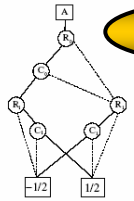
Objectives

- Standardized “plug-and-play” bus
- Miniature, modular spacecraft components
- Rapid design, development, and fabrication (1 year)
- On-demand deployment (6 days) to tailored orbits
- Intelligence, Surveillance, Reconnaissance and Communications augmentation (Theater node)
- Orbit change capability
- 1 year life

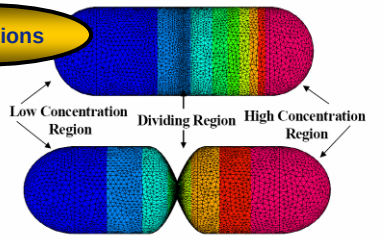
Persistent ISR of the Battlespace

Hybrid Information Systems

Simulations

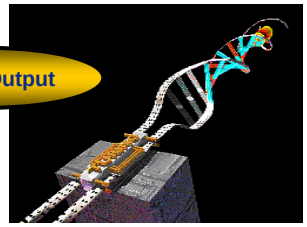


QUIDDs allow 40+ Qubit Simulation of Grover's Algorithm On Workstation



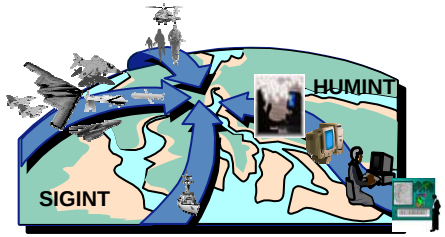
4D Constrained Diffusion Of Bacillus Silicus Division

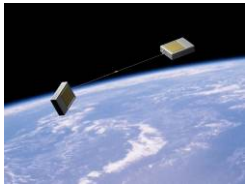
Input/Output



High Throughput Computer Interface

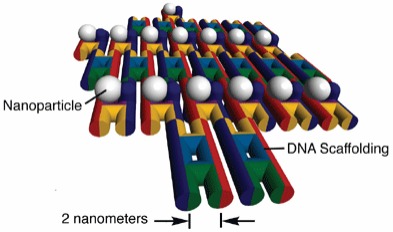
Asymmetric NanoSensor Threat Detection

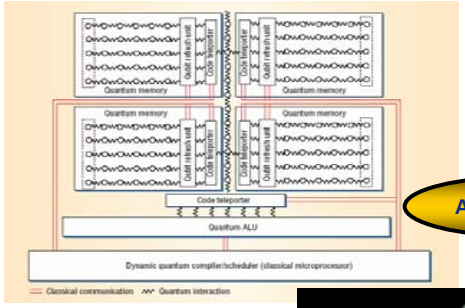




Infobot Proof of Concept

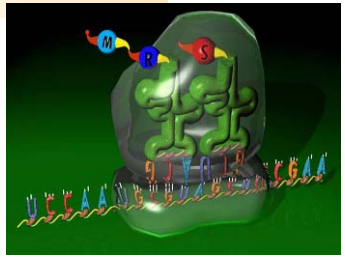
Self Assembled Nanoscale Fabrication



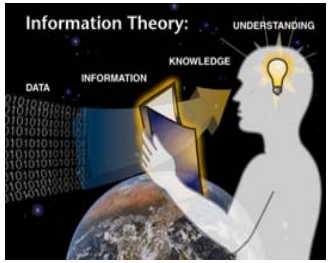


Architectures

Fault Tolerant Quantum Computer Architecture

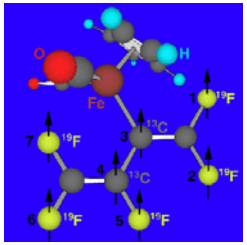


BioMolecular Signal Pathway

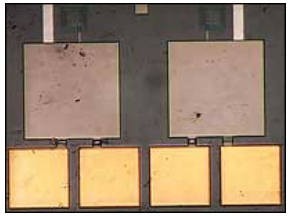


Self Assembling/Reconfigurable Nanoscale Information Processing Systems

Demonstrations



First 7-qubit NMR computer demonstrates Shor's algorithm to factor the number 15



Quantum Entanglement Demonstrated on a Chip

Data Storage

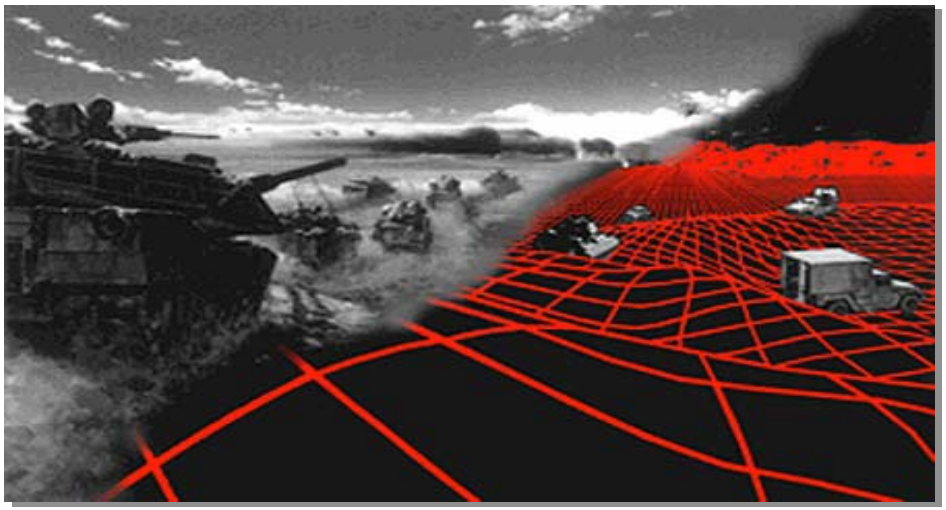
Molecular Memory Commercially Available

2001 2005 2010

Commander's Predictive Environment

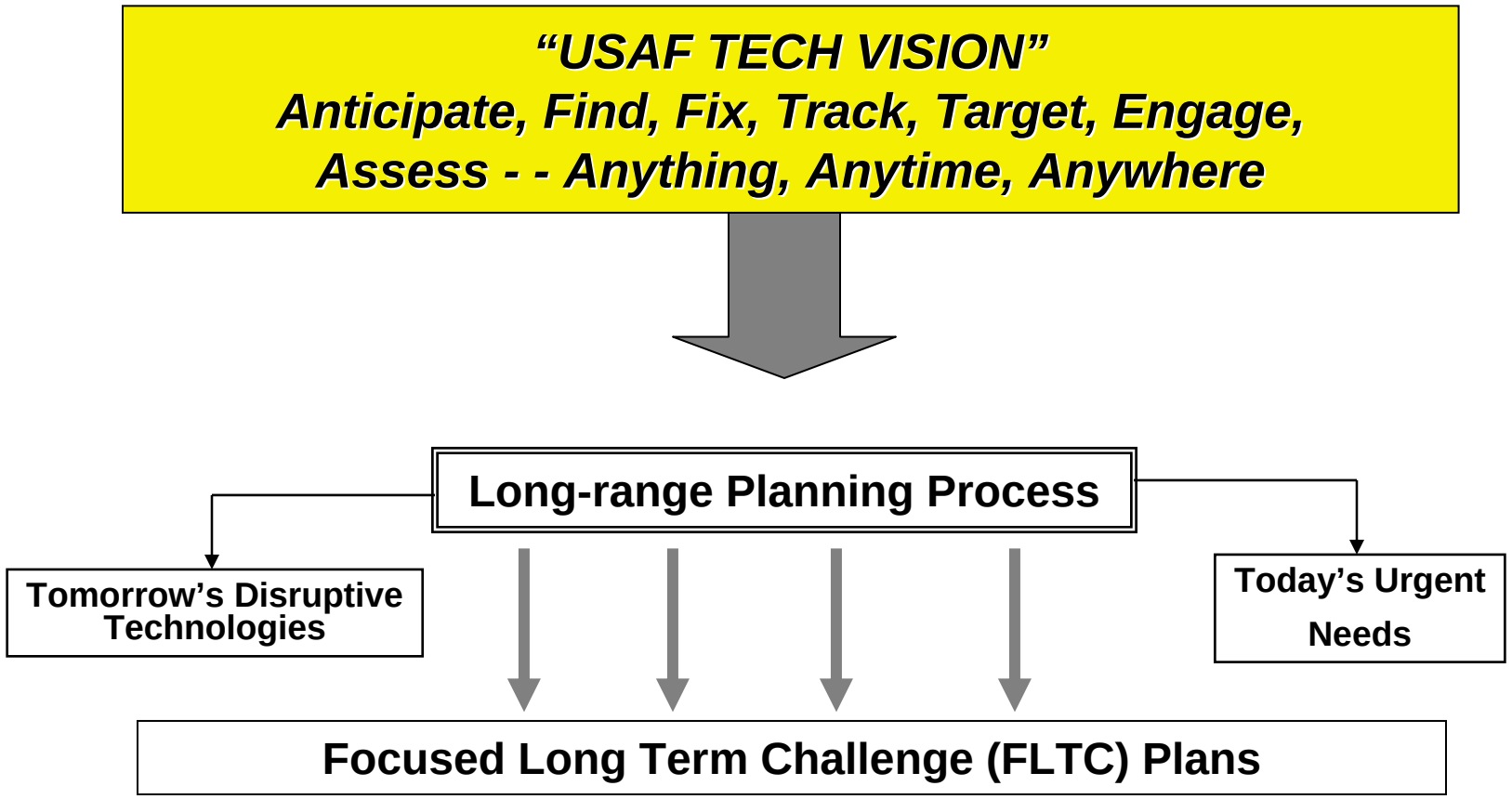
Visualization

Predictive Battlespace Awareness



Decision support environment for the Joint Force Air Component Commander and staff to better understand the mission space (past, present, and future) and predict enemy intent, actions, and emerging threats in Joint Operations

Technology Vision – What We Work On ...approved at AF 4-Star Summit, Corona, July 2005



Advanced Course in Engineering Cyber Security Boot Camp

Problem: ***Shortage of cyber security leaders in DoD and USAF***

Objective: Full spectrum cyber security education for high school students, ROTC cadets, post-graduate S&E and mid-career officers

Curriculum:

- **Information Warfare**
- **Policy and Legal Issues**
- **Access Control**
- **Network Attack**
- **Network Defense**
- **Digital Forensics**
- **Malicious Code**
- **Steganography**
- **Computer Security**
- **Wireless Security**
- **Capstone exercise ("Hackfest")**
- **8 Mile run and leadership classes**

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Precision Engagement

Unique capabilities

Provide scaleable effects from disrupt to destroy on a wide range of tactical targets with limited collateral damage

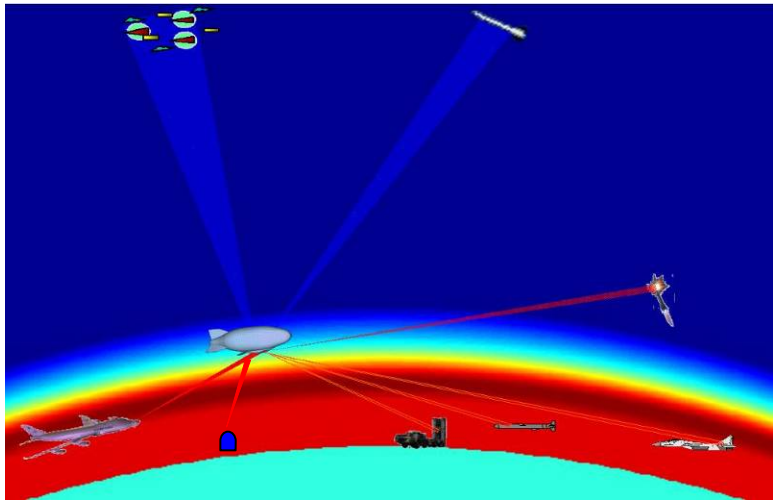
Potential missions

- **Surveillance**
- **Active tracking**
- **Boost phase intercept**
- **Deny, degrade, or destroy Time Critical Targets**
- **Destroy enemy high value air assets**
- **Protect friendly high value air assets**
- **Self-defense**
- **Destroy surface-to-air missiles**
- **Suppress enemy air defenses**
- **Kill cruise missiles**

Lasers Can Do It: Relays Can Enhance It!

Multiple Lasers

Identify, communicate and attack time critical targets anytime; anywhere



Multiple Missions

- Air Ground Attack
  - Battle Space Preparation
  - Area Defense
  - Asset Destruction
  - Urban Warfare
  - Target Designation
- Homeland Defense
  - Cruise Missile Defense
  - Hostile Aircraft Defense
- Ballistic Missile Defense Support
  - Theater Missile Defense and Nuclear Missile Defense
  - Discrimination
- Intelligence, Surveillance, and Reconnaissance
  - Active and Passive
  - Embedded Radar
- Laser Communications

Electronic Attack/Defense

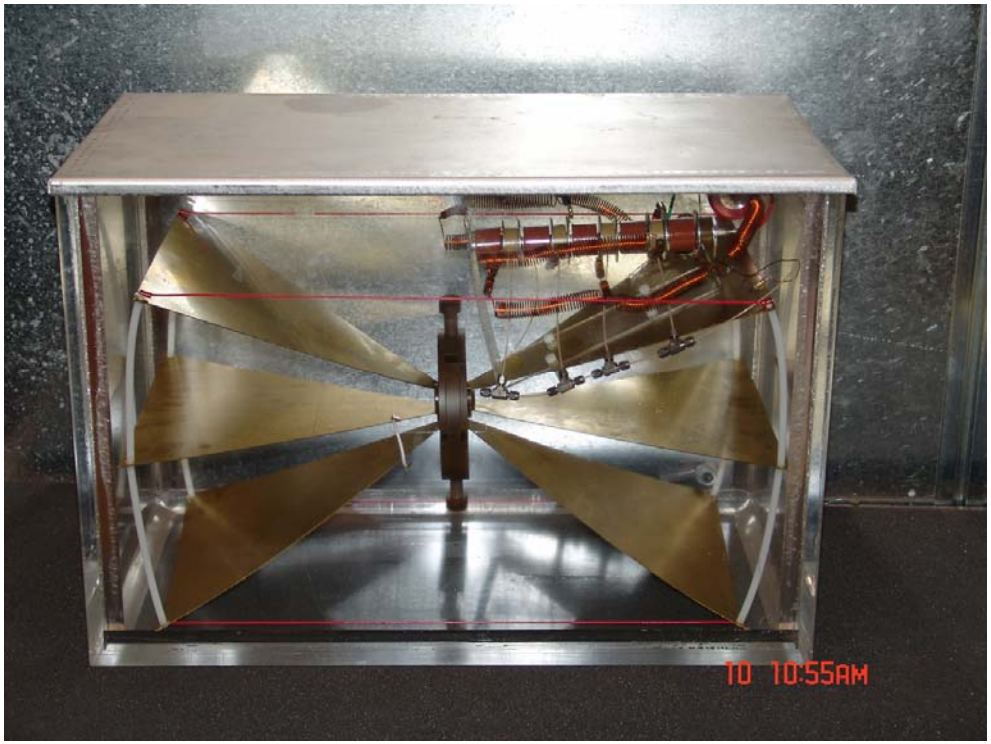
- **Directed energy shields and non-lethal weaponry:**
  - **Electronic infrastructure**
  - **Command and control**
  - **Covertness and plausible deniability**

Generally passes through "things"

- **Weather, plastics, boxes, glass, buildings**
- **Minimum collateral damage**
- **Effects electronics by creating stray currents and voltages that can disrupt to destroy**

RAPTR

(Resonant Antenna Pulsed Transient Radiator)



- Driven by 250-500 KV Compact Marx Generator
- 160 MHz Resonant Blumlein antenna
- 1 kHz PRF
- Total Weight – under 50 lb

Force Protection

Field Tested System

Concept

- Non-lethal, anti-personnel system
- Protect forces and areas
- Energy beam heats adversary's skin
  - Forces adversary to flee
- Outranges effective small arms fire
- Many potential platforms

Status

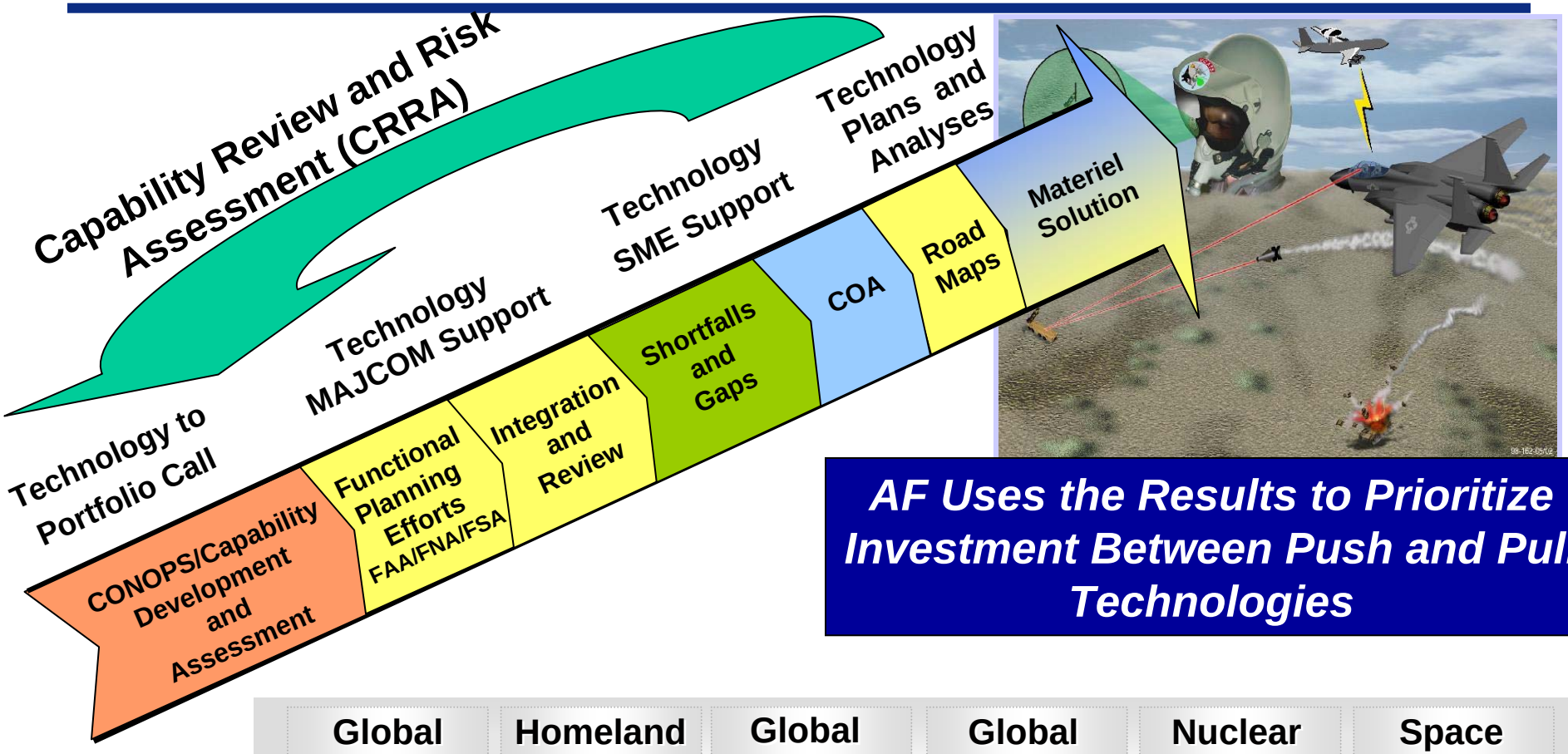
- Developed by Air Force
- Funded by the Joint Non-Lethal Weapons Directorate and the Air Force
- Safely demo'd on hundreds of volunteers at full range
- Passed preliminary legal review
- Technology under development future spirals

Airborne Active Denial System Concepts

Outline

- Introduction
- Disruptive Technologies Definition
- Transition
  - Deliberate Capability Planning
  - Applied Technology Councils
  - Urgent Needs
  - Industry
- Summary

AF S&T Linkage to Capabilities-Based Planning



AF Uses the Results to Prioritize Investment Between Push and Pull Technologies

Global Strike CONOPS	Homeland Security CONOPS	Global Mobility CONOPS	Global Persistent Attack CONOPS	Nuclear Response CONOPS	Space and C4ISR CONOPS

Agile Combat Support CONOPS

Applied Technology Council

MAJCOM ★★★

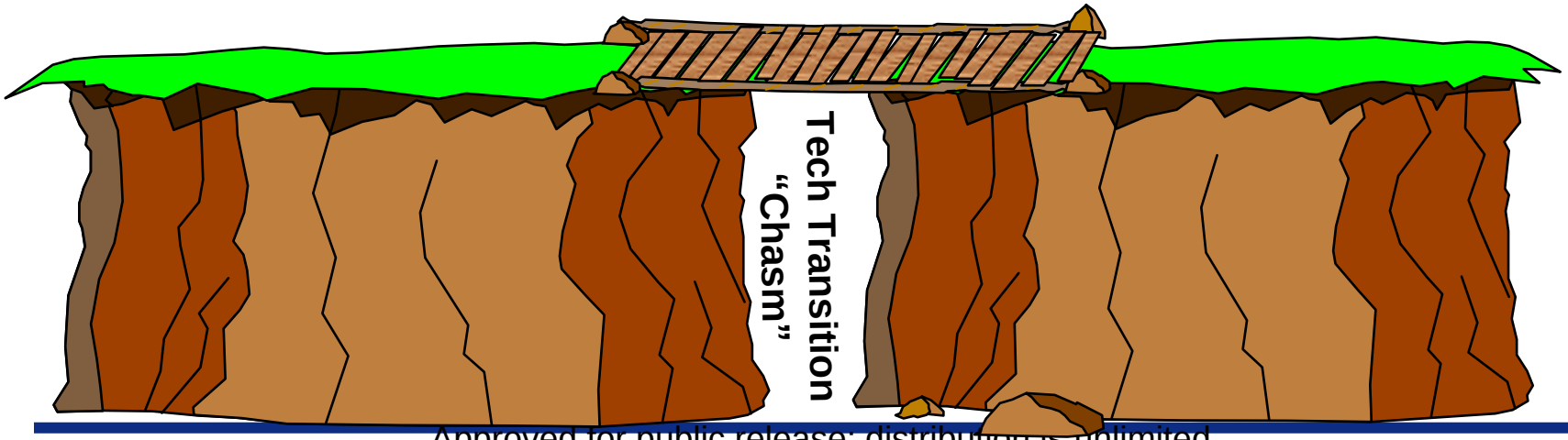
- **Define requirements**
- **Lead steering group**

Product Centers ★★★

- **Interpret requirements**
- **Establish transition plan**

Air Force Research Laboratory ★★

- **Develop/Demonstrate technologies for the future**
- **Identify Advanced Technology Demonstration (ATD) candidates**



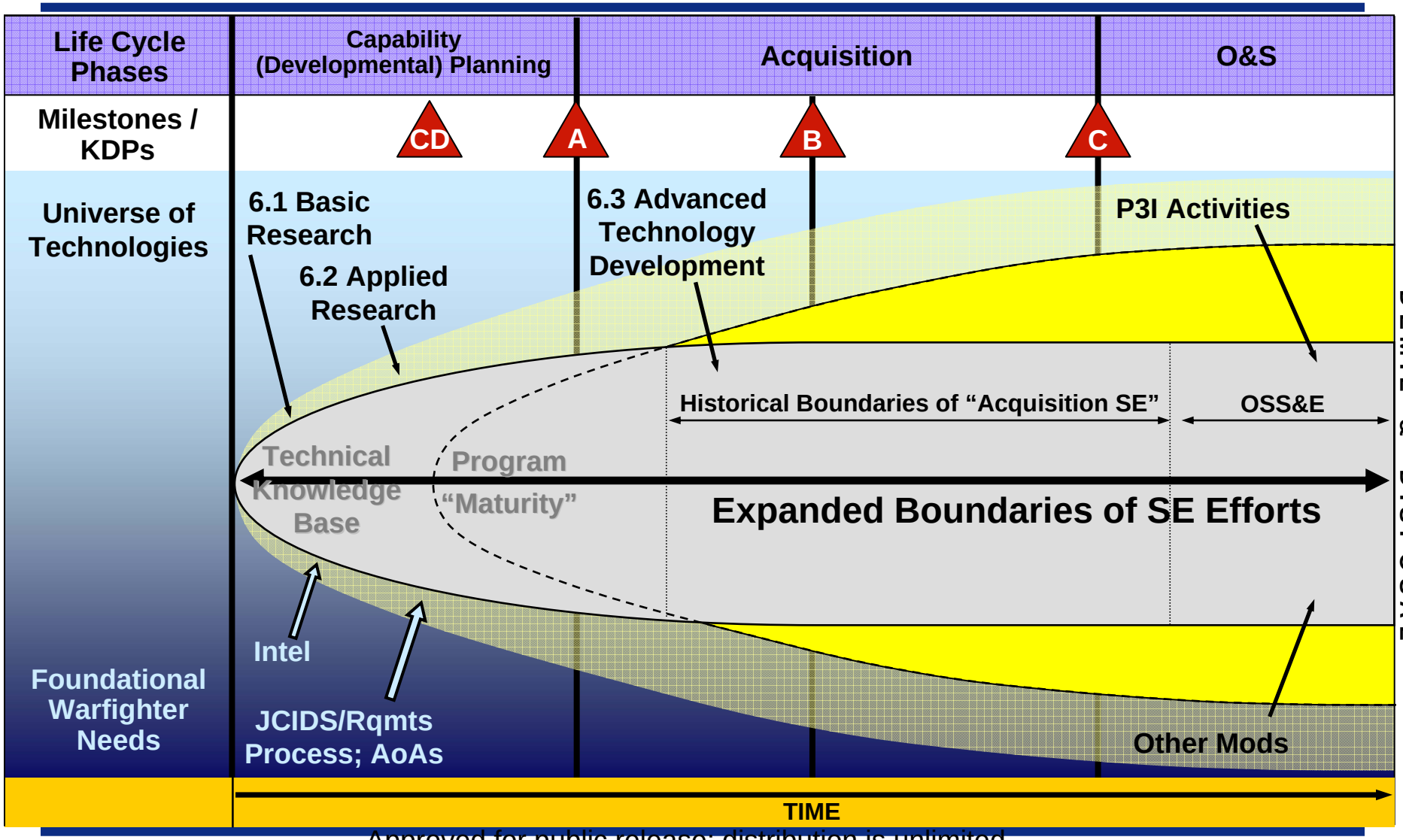
Urgent Needs

- Operator Urgent Request
- Quick Reaction Capability
- Warfighter Rapid Acquisition
- Advanced Concept Technology Demonstrations
- Technology Transition Initiative
- Leadership Vision

Independent Research & Development (IR&D)

- **Objectives:**
  - Increase Government awareness of Industry investment
  - Increase Industry awareness of Government capability needs
  - Maximize S&T investment
- **Approach: Two-way discussion with Industry**
  - Two IR&D conferences (Spring and Fall)
  - Consistent Government message to Industry
  - Companies get 1-on-1 time with Government team
  - Smaller expert Government team conducts targeted site visits
- **Expanding from test case in space**
- **Transition to industry**

VISION: Life Cycle SE -- Seamless Continuum of SE Efforts



Outline

- Introduction
- Disruptive Technologies Definition
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- Summary

Summary

- **Broad/balanced set of technology development**
- **Focus on current/future Warfighting capabilities**
- **Multiple paths to transition**

Moving the Pendulum

"None of the Most Important Weapons

Transforming Warfare in the 20th Century – the Airplane, Tank, Radar, Jet Engine, Helicopter, Electronic Computer, not Even the Atomic Bomb – Owed Its Initial Development to a Doctrinal Requirement or Request of the Military."

John Chambers, ed., *The Oxford Companion to American Military History* (New York: Oxford University Press, 1999) p. 791

We need to inspire and guide innovation that will provide technology-based options for future Air Force capabilities

…… and avoid technological surprise