7th Annual Science and Engineering Technology Conference/
DoD Technology Exposition

18 - 20 April 2006

Lake Buena Vista, Florida

Agenda

Tuesday, 18 April 2006

Preliminary Session: *Opportunities for Collaboration*
• FY 2007 President's Budget Request for DoD S&T Program
Mr. Robert W. Baker, Deputy Director, Plans & Programs, DDR&E

• Advanced Concept Technology Demonstration (ACTD) Program
Mr. Mark Peterson, Head, Program Resources & Integration, ODUSD (Advanced Systems & Concepts)

• T&E/S&T Program
Mr. Mark Brown, Principal Scientist, Defense Test Resource Management Center, Test & Evaluation/Science & Technology Program

• DoD Basic Research Program with a Focus on Academia
Dr. William Berry, Acting Deputy Under Secretary of Defense for Laboratories and Basic Sciences

• International Collaboration
Dr. Tony Sinden, Counselor for Defence Science & Technology at the British Embassy

CONFERENCE OPENING:
• NDIA Welcome - Major General Barry D. Bates, USA (Ret), Vice President, Operations, NDIA

Session I: *Navy Future S&T Challenges*

• Naval Future S&T Challenges Overview: S&T Program Influences, Priorities and Program Rationale
Dr. Joseph Lawrence, Director of Transition, Office of Naval Research

• Future Naval Capability: FORCEnet
Dr. Bobby Junker, IPT Lead, C4ISR Department Head, Office of Naval Research

• Maritime Defense Awareness: Overview
Dr. Gary Toth, Maritime Domain Awareness Program Officer, Office of Naval Research

• Comprehensive Maritime Awareness ACTD
Mr. Ken Bruner, USPACOM J-00618

• Advanced Capability Electric Systems
Mr. Scott Littlefield, PEO Ships Science & Technology Director, Office of Naval Research

Wednesday, April 19, 2006

Session II: *Air Force Future S&T Challenges*
• Air Force Future S&T Challenges Overview, Mr. Les McFawn, Executive Director, Air Force Research Laboratory

• AF S&T Challenges for ISR
Dr. Paul McManamon, Chief Scientist, AFRL Sensors Directorate

• AF S&T Challenges for Directed Energy
Dr. Bruce Simpson, Director, AFRL Directed Energy Directorate

• AF S&T Challenges for Responsive Space
Colonel Rex R. Kiziah, Materiel Wing Director, Space Vehicles, Air Force Research Laboratory

• AF Opportunities for Basic Research
Colonel Jeffrey Turcotte, USAF, Deputy Director and Commander, Air Force Office of Scientific Research

• A DoD Perspective on S&T Areas of Emphasis
Honorable John Young, Director, Defense Research & Engineering

Session III: *Army Future S&T Challenges*

• Army S&T Challenges for Current and Future Forces
Ms. Mary Miller, Director for Technology, Office of Assistant Secretary of the Army Futures S&T Challenges Overview

• Network Enabled Capabilities
Mr. Gary Martin, Director, CERDEC, RDECOM

• Force Protection
Dr. Marilyn Freeman, Executive Director for Research and Technical Director, TARDEC

• Unmanned Systems with Net Centric Operations
Colonel Cindy Bedell, USA, Director Technology Integration Assessment and Futures, Army RDECOM

• Next Generation Capabilities: Army Basic Research
Dr. John Parmentola, Director for Research, OASA (ALT)

Thursday, April 20, 2006

Session IV: Transitioning Disruptive Technologies
• Army Approach to Disruptive Technologies and Transition
Mr. Dennis Schmidt, Director, Science & Technology Integration, Office of the Assistant Secretary of the Army for Research and Technology

• Navy Approach to Disruptive Technologies and Transition
Mr. Lewis DeSandre, Program Manager, ONR 351

• Air Force Approach to Disruptive Technologies and Transition
Colonel Mark Stephen, Associate Deputy Assistant Secretary (Science, Technology & Engineering), HQ USAF

• A New Paradigm for Technology Transfer
Dr. Greg Raupp, Director, Center for Flexible Displays, Arizona State University

• Technology Transition from an Industry Program Manager's Perspective
Dr. Malcom R. O'Neill, former Vice President & Chief Technical Officer, Lockheed Martin

Tuesday, April 18, 2006

7:00 am — Conference Registration & Continental Breakfast

Preliminary Session: Opportunities for Collaboration

In this session we will present the Fiscal Year 2007 President's Budget Request for the DoD S&T program. We will also highlight specific programs that will provide conference attendees opportunities to engage in collaborative efforts with the DoD and international S&T community. Presentations will provide information on technology areas of high interest to the DoD, time lines, and points of contact for the submission of proposals. Opportunities for both industry and academia will be covered. A wide range of programs, from the larger technology demonstrations funded by the Advanced Concept Technology Demonstration program, that lead to the evaluation of military utility of advanced technology by a Combatant Commander; to the more focused technology development efforts that are funded by the Test & Evaluation/Science & Technology (T&E/S&T) program will be covered. Opportunities for proposing commercial off-the-shelf technology to meet current military needs will be addressed by the Quick Reaction Fund/Rapid Reaction Fund program presentation. Specific scientific research areas having high interest to the DoD will be highlighted along with information on the process universities should use to submit proposals. The session will be rounded out with a presentation on opportunities for collaborative international research and technology development.

Preliminary Session Chairman - Mr. Robert W. Baker, Deputy Director, Plans & Programs, DDR&E

8:15 am — **FY 2007 President's Budget Request for DoD S&T Program**
Mr. Robert W. Baker, Deputy Director, Plans & Programs, DDR&E

8:45 am — **Advanced Concept Technology Demonstration (ACTD) Program**
Mr. Mark Peterson, Head, Program Resources & Integration, ODUSD (Advanced Systems & Concepts)

9:15 am — **T&E/S&T Program**
Mr. Mark Brown, Principal Scientist, Defense Test Resource Management Center, Test & Evaluation/Science &Technology Program

9:45 am — BREAK

10:30 am — **Quick Reaction Fund/Rapid Reaction Fund**
Mr. Ben Riley, Director, Rapid Reaction Technology Office/Chairman Combating Terrorism Technology Task Force

11:00 am — **DoD Basic Research Program with a Focus on Academia**
Dr. William Berry, Acting Deputy Under Secretary of Defense for Laboratories and Basic Sciences

11:30 am — **International Collaboration**
Dr. Tony Sinden, Counselor for Defence Science & Technology at the British Embassy

12:00 pm — LUNCHEON & EXHIBITS OPEN

CONFERENCE OPENING

1:00 pm — **Call to Order** - Dr. A. Louis Medin, Chairman, NDIA S&ET Division
NDIA Welcome - Major General Barry D. Bates, USA (Ret), Vice President, Operations, NDIA

1:15 pm — **Keynote Address**
Admiral Edmund P. Giambastiani, Jr., USN, Vice Chairman, Joint Chiefs of Staff

Session I: Navy Future S&T Challenges

This session will address the Department of the Navy's S&T Investment Strategies with specific focus on upcoming BAAs and opportunities for alternative solutions from industry and academia. Following an overview of the Navy's S&T program, speakers will address key S&T areas, including basic research that will support the development and transition of technologies to enable the Navy to meet the uncertain and dynamic global security environment. Discussions will include overviews of the Navy's S&T efforts related to FORCEnet, the Navy's vision of Network Centric Operations, with specific emphasis on Maritime Domain Awareness and a related ACTD, and an overview of the Advanced Capability Electric Systems Program. University and DARPA involvement in these S&T initiatives will be highlighted by the speakers.

Co-Chairs:
Dr. Kenneth A. Potocki, APL LWS Program Manager, Space Department, John Hopkins University
Mr. E. Terrence Dailey, Deputy Director, Program Integration, Software Engineering Institute
Ms. Cathy Nodgaard, Associate Director, SBIR, ONR

2:00 pm	**Naval Future S&T Challenges Overview: S&T Program Influences, Priorities and Program Rationale** Dr. Joseph Lawrence, Director of Transition, Office of Naval Research
2:30 pm	**Future Naval Capability: FORCEnet** Dr. Bobby Junker, IPT Lead, C4ISR Department Head, Office of Naval Research
3:00 pm	BREAK
3:45 pm	**Maritime Defense Awareness: Overview** Dr. Gary Toth, Maritime Domain Awareness Program Officer, Office of Naval Research
4:15 pm	**Comprehensive Maritime Awareness ACTD** Dr. Chris Dwyer, Maritime Domain Awareness Program Manager, Naval Research Laboratory
4:45 pm	**Advanced Capability Electric Systems** Mr. Scott Littlefield, PEO Ships Science & Technology Director, Office of Naval Research
5:30 pm - 7:30 pm	RECEPTION in Exhibit Hall

Wednesday, April 19, 2006

7:30 am	Conference Registration & Continental Breakfast

Session II: Air Force Future S&T Challenges

The Air Force is developing capabilities that are key components of DoD's joint capabilities. The Air Force future is focused on achieving persistent C4ISR, global mobility, and rapid strike. The Air Force Research Laboratory (AFRL) is the single organization within the Air Force that focuses on science and technology (S&T) to help the Air Force realize this future. The AFRL is "leading the discovery, development, and integration of affordable war fighting technologies for our air and responsive space force." This session provides a perspective on the key S&T investments the Air Force is counting on to meet the current and future mission challenges. This perspective is followed by more detailed presentations on key areas of AFRL's S&T investments: Intelligence, Reconnaissance and Surveillance (ISR), directed energy weapons, space and basic research.

Co-Chairs:	Dr. James McCormack, Technical Director (Technology Integration & Applications), Northrop Grumman Information Technology Mr. Edward Palo, Chief Engineer, Center for Air Force C2 Systems, MITRE Corporation Colonel Mark Stephen, Associate Deputy Assistant Secretary (Science, Technology & Engieering), HQ USAF
8:30 am	**AF Future S&T Challenges Overview** **AF S&T Program Influences, Priorities, and Program Rationale** Mr. Les McFawn, Executive Director, Air Force Research Laboratory (AFRL)
9:00 am	**AF S&T Challenges for ISR** Dr. Paul McManamon, Chief Scientist, AFRL Sensors Directorate
9:30 am	**AF S&T Challenges for Directed Energy** Dr. Bruce Simpson, Director, AFRL Directed Energy Directorate
10:00 am	BREAK
10:45 am	**AF S&T Challenges for Responsive Space** Colonel Mike Leahy, USAF, Director, AFRL Air Vehicles Directorate
11:15 am	**AF Opportunities for Basic Research** Colonel Jeffrey Turcotte, USAF, Deputy Director and Commander, Air Force Office of Scientific Research
12:00 pm	LUNCHEON/EXHIBITS **Luncheon Speaker:** Dr. Fred Ambrose, Intelligence Technology Innovation Center
1:30 pm	**A DoD Perspective on S&T Areas of Emphasis** Honorable John Young, Director, Defense Research & Engineering

Session III: Army Future S&T Challenges

Our Army is at war…it is engaged in a Global War on Terrorism against an enemy unlike any previously faced. Success requires the enhancement of our current forces while continuing to transform the Army. The Army's Science and Technology program strategy is to develop the technology options that will ensure that the Army is relevant and ready today and remains relevant tomorrow. In this portion of the conference, an overview will be provided of the Army S&T Program challenge to develop technologies that will enhance the Current Force while concurrently enabling the Future Force. Battle Command capabilities are paramount in order to enable the Future Force. In addition, the session emphasizes the importance of networked systems, force protection and unmanned systems. In these discussions the speakers will emphasize their work with DARPA to provide the best technology to meet our soldier's needs. The final important area to be discussed is the role of the Army's basic research program…expanding and stimulating the human imagination to extend the boundaries of the possible. Creating future Army technological advances will be discussed and the role of academia and industry will be emphasized.

Co-Chairs: Dr. A. Michael Andrews II, VP & CTO, L-3 Communications
Brigadier General R. Mark Brown, RDECOM DCG, SOSI
Dr. John P. Solomond, Program Manager C4ISR, Booz Allen Hamilton

2:00 pm **Army S&T Challenges for Current and Future Forces**
Ms. Mary Miller, Director for Technology, Office of Assistant Secretary of the Army Futures S&T Challenges Overview

2:30 pm **Network Enabled Capabilities**
Mr. Gary Martin, Director, CERDEC, RDECOM

3:00 pm BREAK / LAST CHANCE TO VIEW EXHIBITS

3:45 pm **Force Protection**
Dr. Marilyn Freeman, Executive Director for Research and Technical Director, TARDEC

4:15 pm **Unmanned Systems with Net Centric Operations**
Colonel Cindy Bedell, USA, Director Technology Integration Assessment and Futures, Army RDECOM

4:45 pm **Next Generation Capabilities: Army Basic Research**
Dr. John Parmentola, Director for Research, OASA (ALT)

Thursday, April 20, 2006

Session IV: Transitioning Disruptive Technologies

In this session, representatives from the scientific and engineering communities will provide their perspectives on which technologies possess the greatest potential to produce significant increases in military capability. However, transitioning these technologies into advanced war fighting capabilities continues to be a challenge and has long been a concern in both the DoD and industry. Technology transition is a complex undertaking with competing pressures on the system developer and government program manager to control program cost and schedule, while meeting system performance objectives that often depend upon successful application of the latest technologies. The incentives to transition the latest technology have become more intense because of rapid growth and globalization of technology developments. Potential adversaries may have access to these technologies to achieve their own disruptive capabilities. This session will also examine how the DoD and industry can work together to improve the technology transition process.

Co-Chairs: Dr. James McCormack, Technical Director (Technology Integration and Applications), Northrop Grumman Information Technology
Mr. Herb Finkelstein, Industry/Government Research Liaison Officer, Arizona State University
Mr. Robert Baker, Deputy Director, Plans & Programs, DDR&E

8:15 am **Army Approach to Disruptive Technologies and Transition**
Mr. Dennis Schmidt, Director, Science & Technology Integration,
Office of the Assistant Secretary of the Army for Research and Technology

8:45 am **Navy Approach to Disruptive Technologies and Transition**
Mr. Quentin Saulter, Directed Energy Project Officer, Office of Naval Research (Invited)

9:15 am **Air Force Approach to Disruptive Technologies and Transition**
Colonel Mark Stephen, Associate Deputy Assistant Secretary (Science, Technology & Engineering), HQ USAF

9:45 am BREAK

10:30 am **A New Paradigm for Technology Transfer**
Dr. Greg Raupp, Director, Center for Flexible Displays, Arizona State University

11:00 am **Overall DoD Perspective on Disruptive Technologies**
Mr. Alan Shaffer, Director, Plans & Programs, Office of the Director, Defense Research and Engineering

11:30 am **Technology Transition from an Industry Program Manager's Perspective**
Dr. Malcom R. O'Neill, former Vice President & Chief Technical Officer, Lockheed Martin

Wrap Up & Adjourn Dr. Raj K. Aggarwal, Vice President, Global Technology and Special Projects, Rockwell Collins
Dr. A. Louis Medin, Chairman, NDIA S&ET Divsion

12:00 pm **BUFFET LUNCHEON**

Research, Development & Engineering Command

Challenges of Developing Unmanned Systems To Operate in a NetCentric Environment

Director
Technology Integration
Assessment and Futures

COL Cindy Bedell

Discussion Points

- Congressional Guidance
- Industrial and Military Standards
- The Challenge of Communications
- Mapping the Technology to Warfigher Needs
- Current Research Efforts

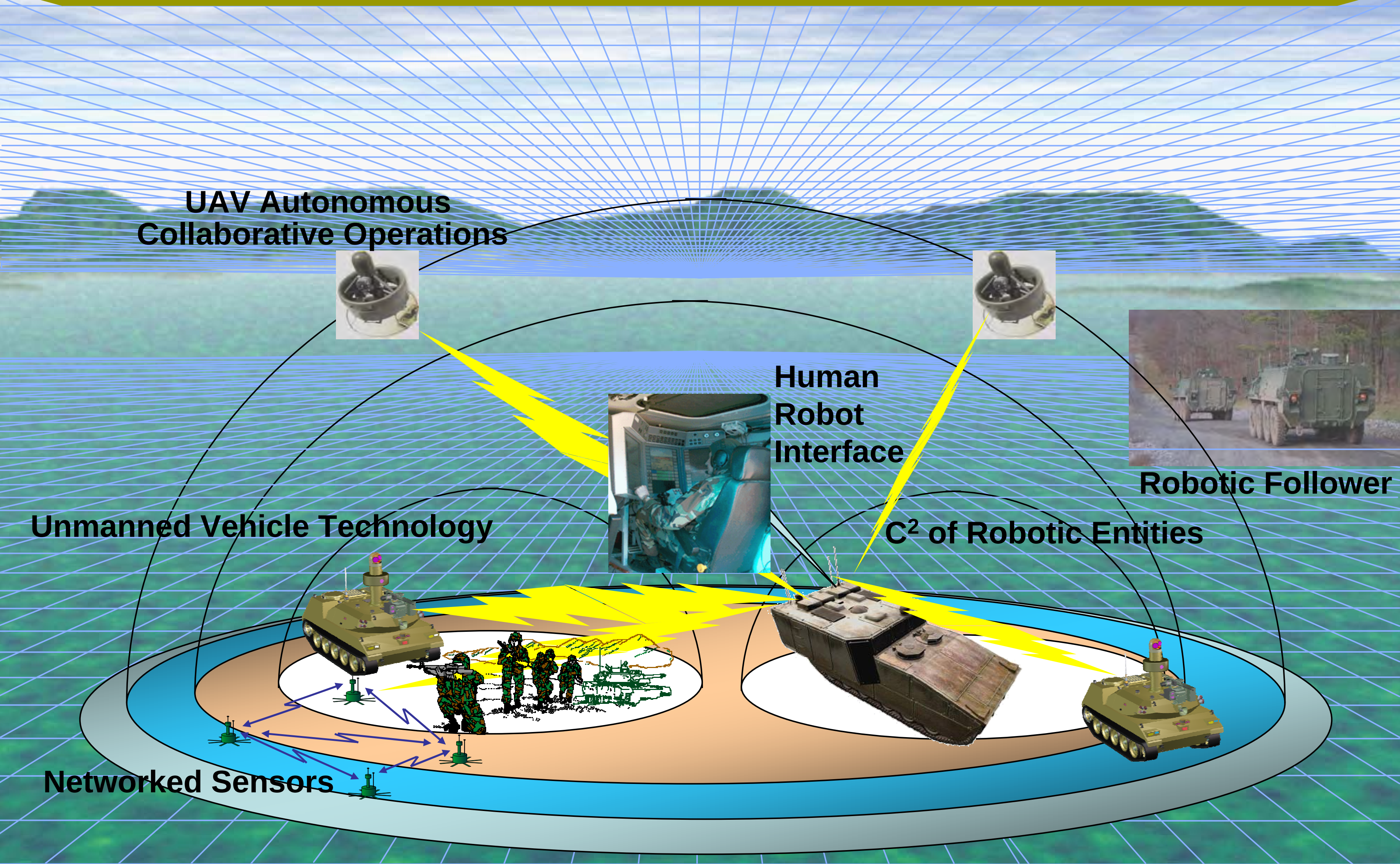
Call for Transformation with Robotics

It shall be a goal of the Armed Forces to achieve the fielding of unmanned, remotely controlled technology such that—by 2010, one-third of the operational deep strike aircraft of the Armed Forces are unmanned; and by 2015, one-third of the operational ground combat vehicles of the Armed Forces are unmanned.

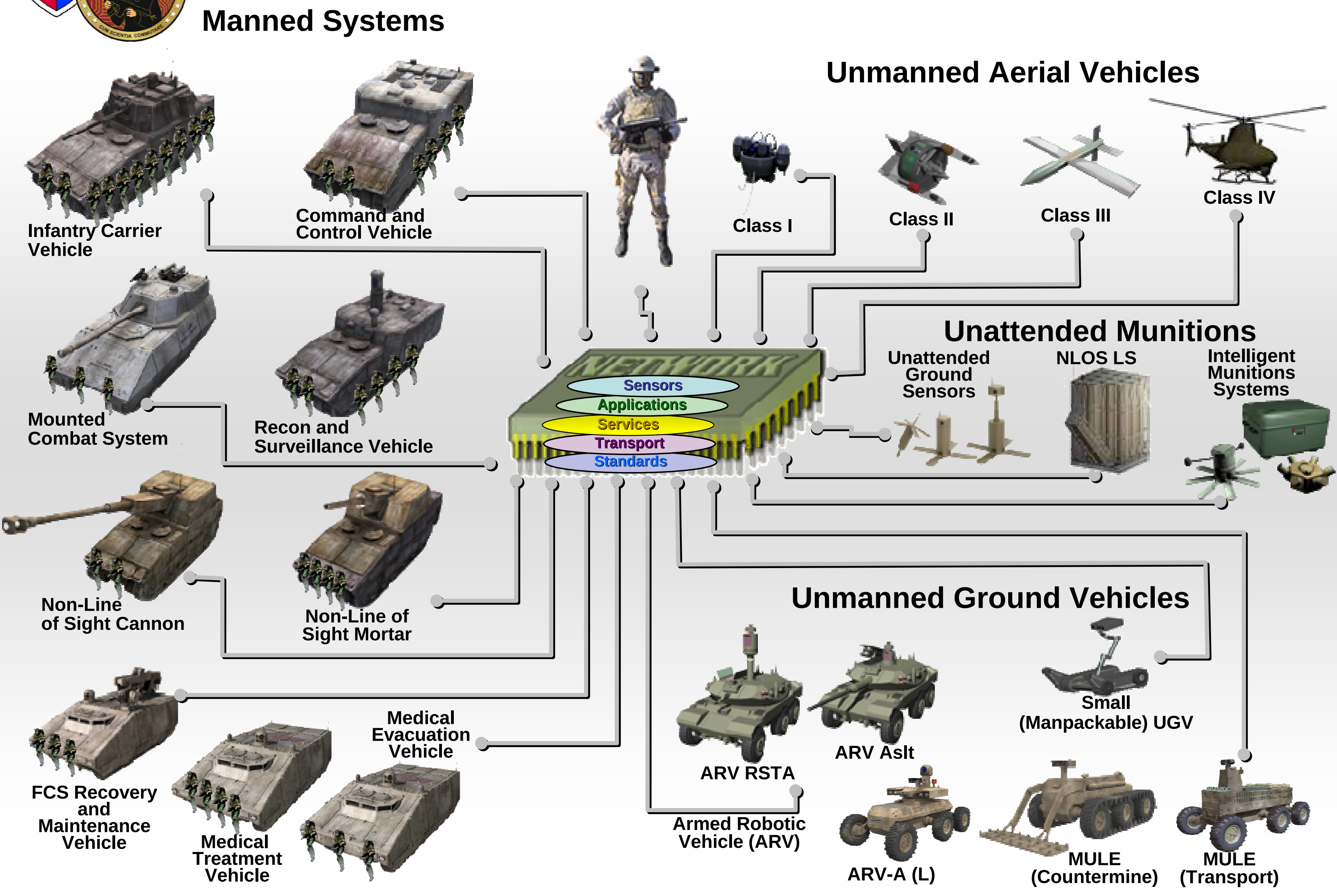
National Defense Authorization
Act for Fiscal Year 2001
H.R.4205, Sec. 220

Robotics Research & Development

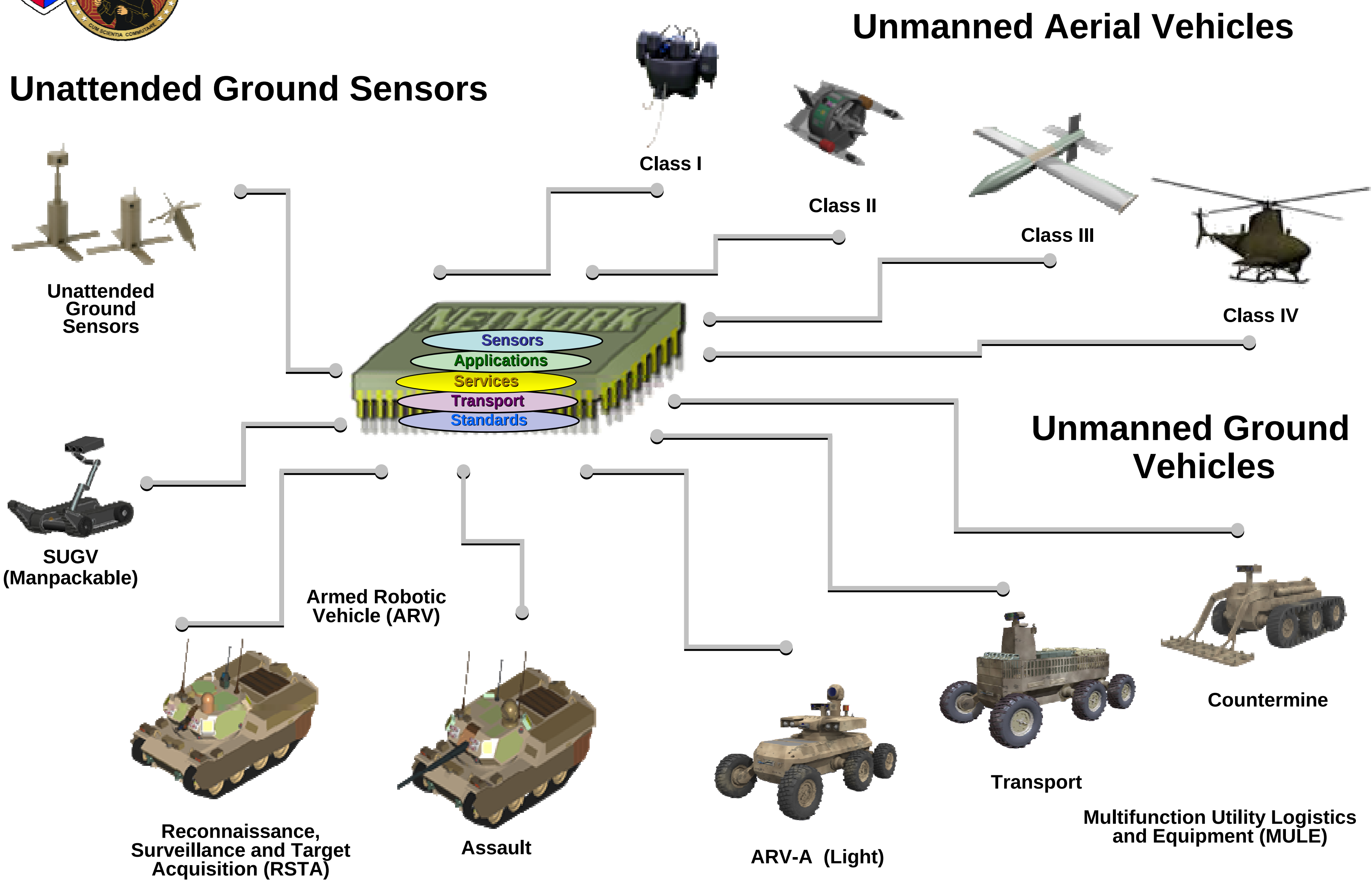
Technology for the Future Force



Future Combat System a System-of-Systems



Unmanned Systems – Key Part of FCS



The Joint Architecture for Unmanned Systems addresses interoperability with an emphasis on the logical communications between heterogeneous computing systems used for Unmanned Systems command and control.

JAUS

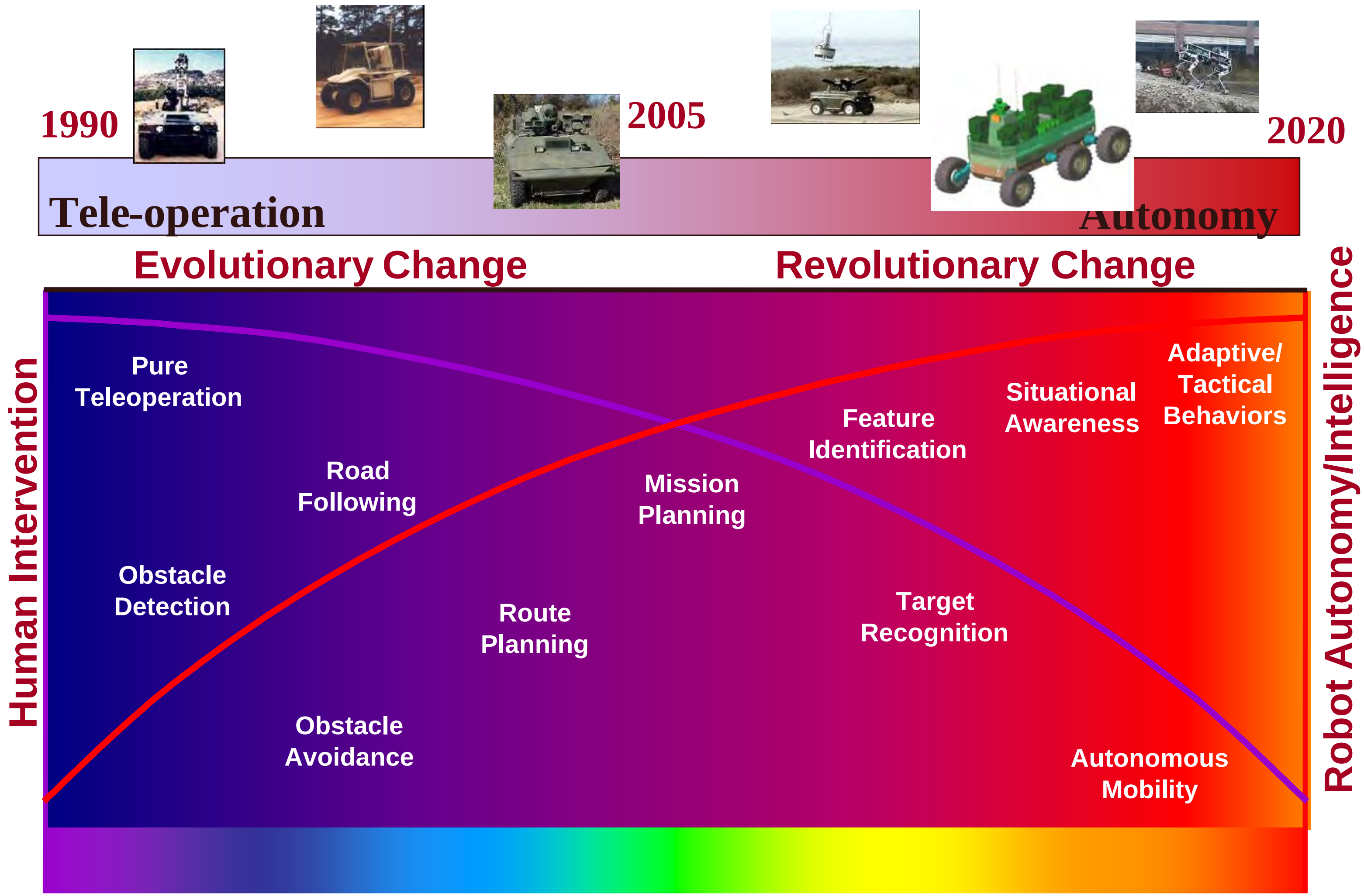
WWW.JAUSWG.ORG

JAUS MIGRATING TO SAE

The Aerospace Council of the Society of Automotive Engineers (SAE) has voted to establish AS-4, an Unmanned Systems Standards Committee. JAUS will become an Aerospace Standard within the next twelve months.

JAUS is a requirement for all FCS unmanned systems.

Robotic Technologies Development



Mapping the Challenges

Critical Technologies

- *Machine Perception*
- *Control System Architectures*
- *Tactical Behaviors*
- *Collaborative Engagement*
- *Communication/ Beyond Line of Sight Connectivity/ Bandwidth*
- *Command and Control*

Operational Capabilities

- *Battle Command*
- *Mounted/Dismounted Maneuver*
- *Air Maneuver*
- *LOS/BLOS Lethality*
- *Maneuver Support*
- *Human Engineering*

Other Operational Considerations

- *Unknown TTPS*
- *Soldier workload*
- *Control of heterogeneous systems*
- *OPTEMPO*
- *Reconstitution*
- *Bandwidth/ network operations*
- *Safety of unmanned vehicles near humans*
- *Fratricide*
- *Survivability*
- *Impact on Tactical/ Strategic decision making*

Current Unmanned Ground Systems Missions

- Explosive Ordnance Disposal
  - Combating Terrorism
  - UXO/IED Defeat
- Remediation
- Combat Engineering
  - Mine Clearing
  - Obstacle Breaching
  - Emplacing Charges
- Reconnaissance
  - Persistent EO/IR Surveillance
  - CBRN
  - BDA
- Direct Fire Weapons
- Obscuration
- Physical Security
- Force Protection
- Casualty/Medical Evacuation

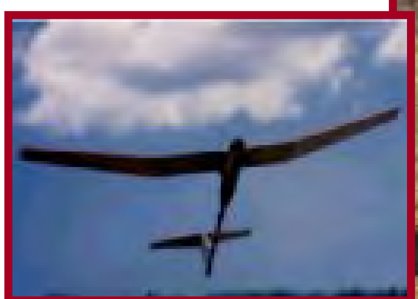
Current Capabilities

- **Remote Controlled**
- **Obstacle Detection and Avoidance**
- **Pattern Recognition**
- **Lane Detection**
- **Road Following**
- **GPS Way Point Navigation**
- **Rudimentary Terrain Recognition and Following**
- **Semi-Autonomous Behavior**







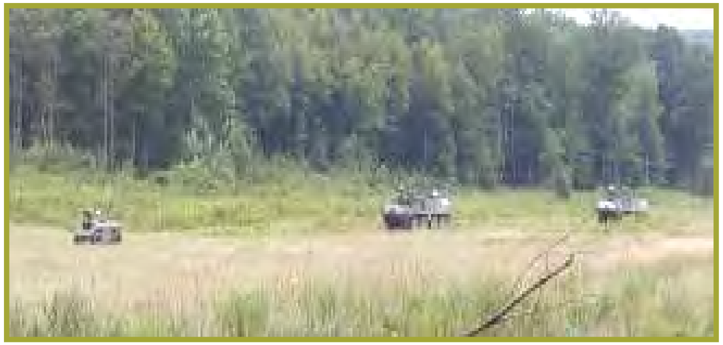


Critical Robotic Technology Gaps

- Power and Energy
  - Battery Life
  - Short burst of Power
  - All Weather Conditions
- Survivability
  - Anti-Tamper Security
  - Destroying or Blocking Sensors
  - Electronic Jamming
- Reliance on GPS for Navigation
  - Military Operations in Urban Terrain
  - Tunnel and Cave Operations
- Communications and Control
  - Range and Bandwidth
  - Human-Robot Interface
  - Autonomous Tactical Behaviors
  - Security
- Negative Obstacle Navigation
  - Water
  - Holes
  - Foliage
- Auto Target Recognition
  - Determining Friend from Foe
  - Spoof Prevention

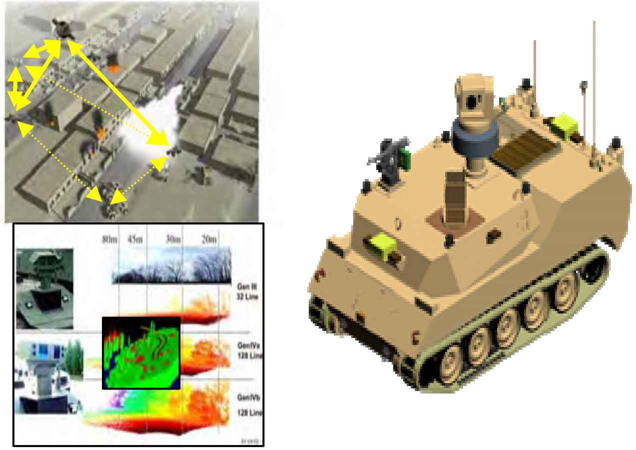
Army Technology Objectives for Unmanned Systems

Technologies for the Future & Current Force



Leader/Follower

Robotics Collaboration



Near Autonomous Unmanned Systems

Unmanned Aerial Vehicle Systems Technologies

Leader/Follower

Mature & Demonstrate Robotics Technology Required for Early Insertion into FCS

Autonomous Mobility Sensor Suite

Robotic Follower ATD

Technologies:
- *Decision Aids*
- *Advanced Warfighter Interfaces (AWI)*
- *Unmanned Asset Controls*
- *Multi-mission FCS Crew stations*
- *Embedded Simulation System*
- *Advanced System Architecture*
- *HFE (MANPRINT)*

Demonstrate the crew interfaces, automation, and integration technologies required to operate and support Future Combat Systems

Crew Integration and Automation Testbed ATD

Robotic Follower ATD

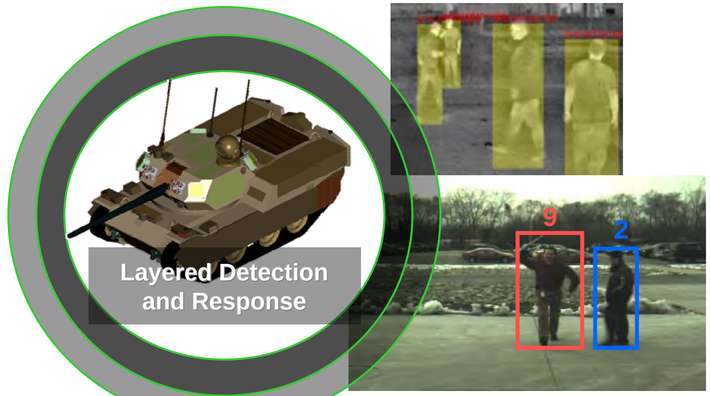
- **Robotic Follower develops, matures, and transitions to PM UA and the LSI the following capabilities:**
  - MMW Radar for vehicle tracking and collision avoidance.
  - Road and trail following.
  - High speed autonomous convoy on narrow roads.
  - Baseline convoy in live traffic.
  - Terrain/obstacle registration for leader-follower operations in GPS denied areas.
  - Human odometry dismounted follower.
  - Baseline safety procedures.
  - Robotic follower procedures, safety procedures, and TTP development.
  - Robotic Follower Testbed

Crew Integration and Automation Testbed (CAT) ATD

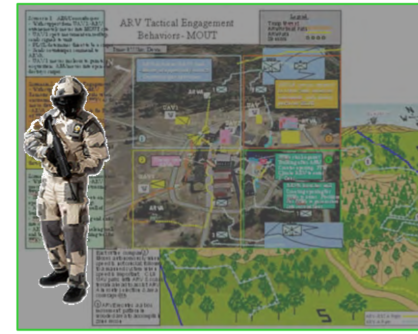
- **CAT develops, matures, and transitions to PM UA and the LSI the following capabilities:**
  - Advanced Warfighter Interfaces (AWI) for efficient multi-task execution.
  - Unmanned asset controls for UGVs, UAVs, and UGSs.
  - Multi-mission crew stations that provide the capability to perform all the tasks of a fight, scout, or carrier mission.
  - Embedded simulation system for in vehicle mission rehearsal, mission planning, and embedded training.
  - Crew aiding behaviors for assistance with manned and unmanned mission planning and execution.
  - Advanced system architecture provides that an order of magnitude performance increase over currently fielded systems.

Near Autonomous Unmanned Systems

UAV-UGV Collaborative Reconnaissance Missions



Platform Self Security



Tactical Behavior Development (Increase Platform Intelligence)

FCS Risk Areas Program Is Addressing

- Distributed Collaboration of Manned/Unmanned Platforms (FCS Risk 68)
- Safe UGV Mobile Operations in FCS UA (FCS Risk 213)
- Safe UGV Weapons Operations in FCS UA (FCS Risk 214)
- Transfer of Technology to Skid Steer Vehicles (UGV Risk 0032)
- UGV Situational Awareness (ARV Risk 0006)
- UGV Tactical Behaviors (ARV Risk 0007)
- UGV Self Security (ARV Risk 0008)

HRI for air and ground assets

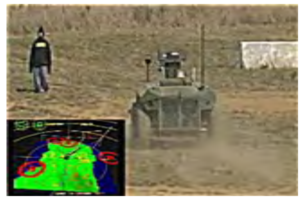
Point A to Point B Autonomous Mobility

Advanced Remote Armament System (ARDEC)

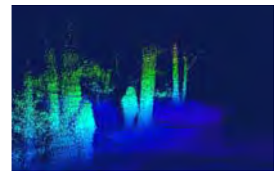
Near Autonomous Unmanned Systems

2005	2006	2007	2008	2009

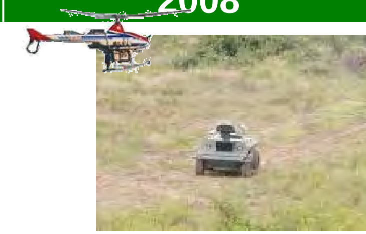
Delivery of GEN V LADAR (under IV.GC.2000.03)



Initial demonstration of detection & avoidance of moving vehicles & people



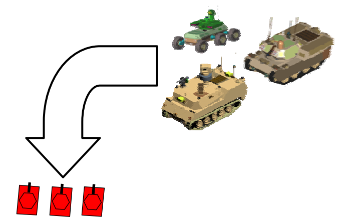
Perception Algorithms



Autonomous Cooperative Behaviors

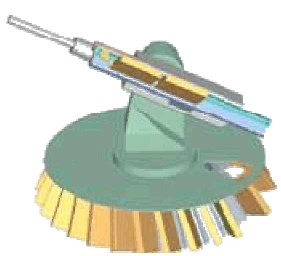
ART testbed development

Platform Self Security System
(pedestrian detection/tracking/intent system)

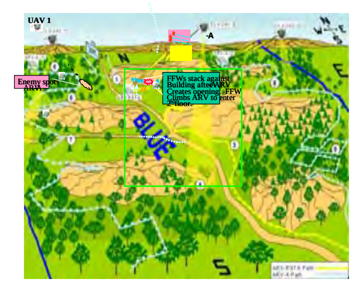


Platform Level Tactical Behaviors

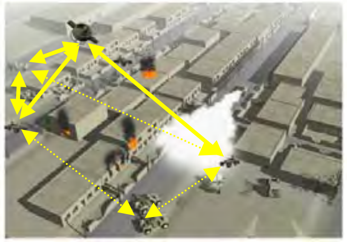
Advanced Remote Armament System Demonstration



Advanced Remote Armament System Development

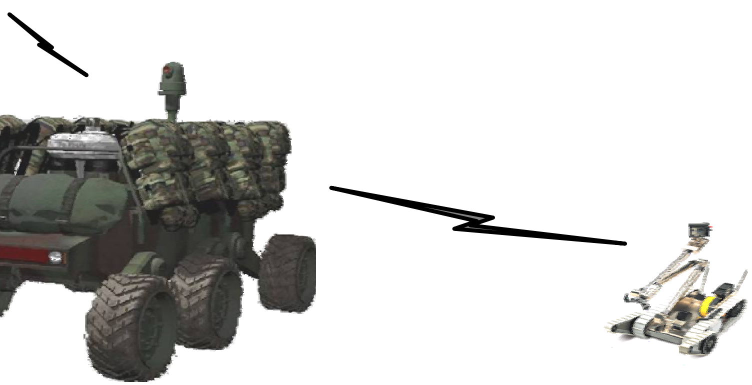


Initial Integrated Experiment



Final Integrated Experiment

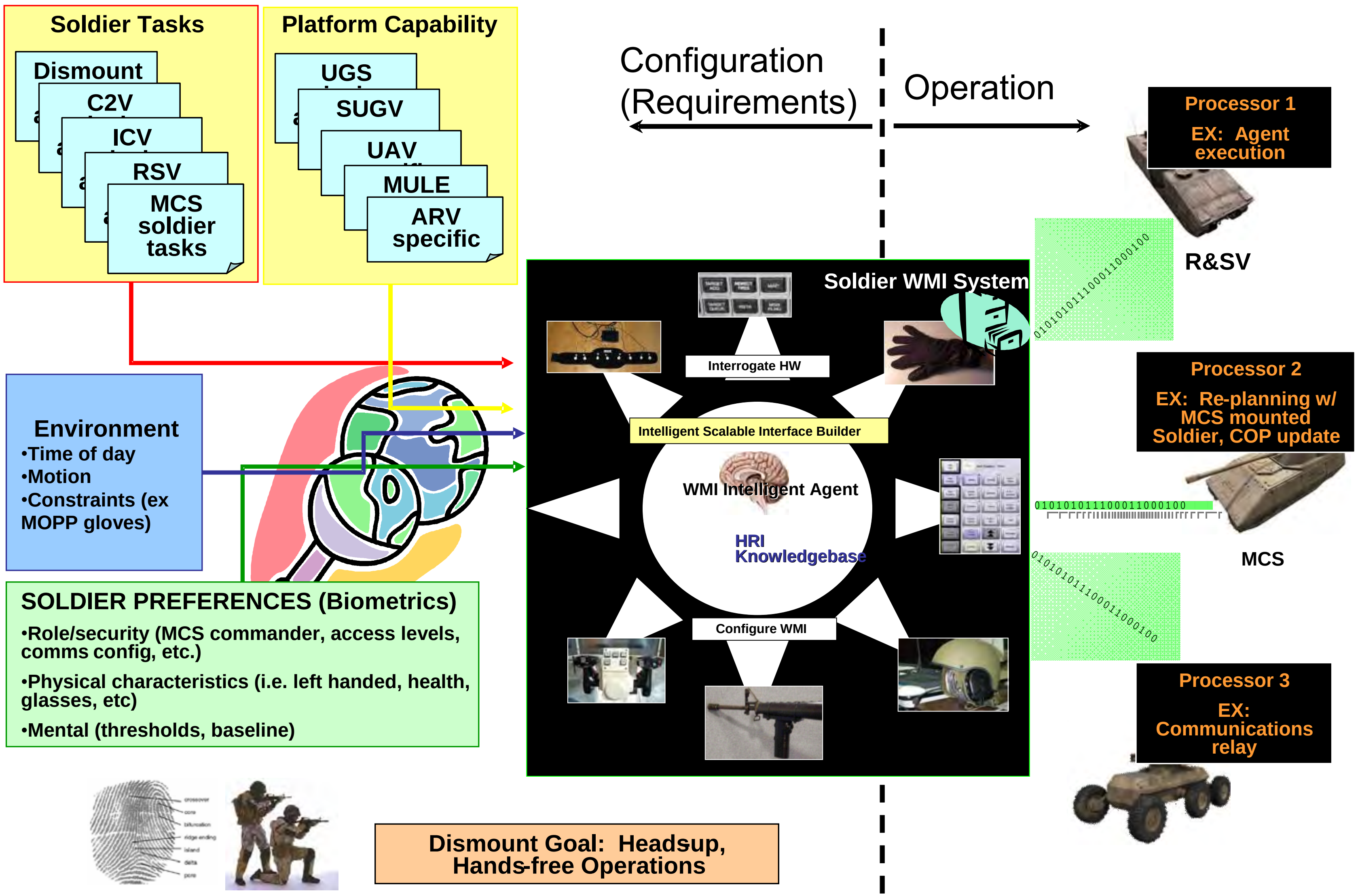
Robotics Collaboration



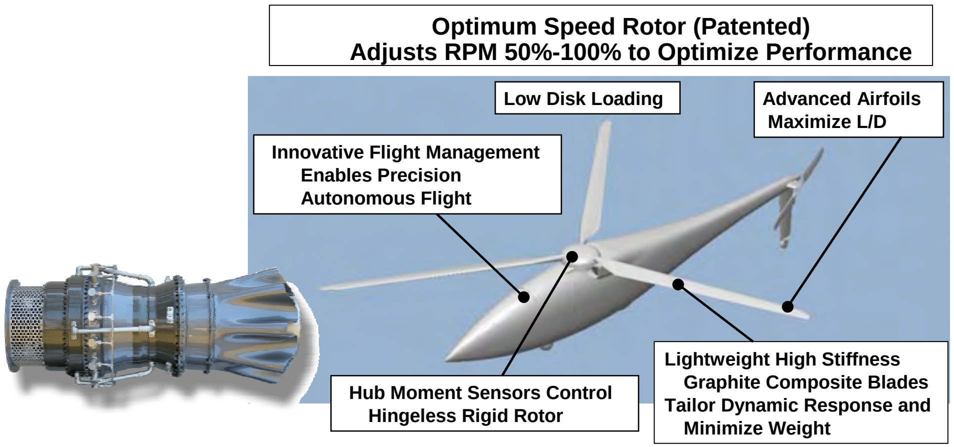
- Intelligent agent software to adaptively automate/adjust Soldier control tasks
- Common scalable interfaces that provide same look/feel across spectrum of control devices
- Unmanned Vehicles safety operational behavioral algorithms and recommendations for TTP development
- Software for UAV/UGV collaboration
- UAV autonomy and cooperative engagement capability

Robotics Collaboration

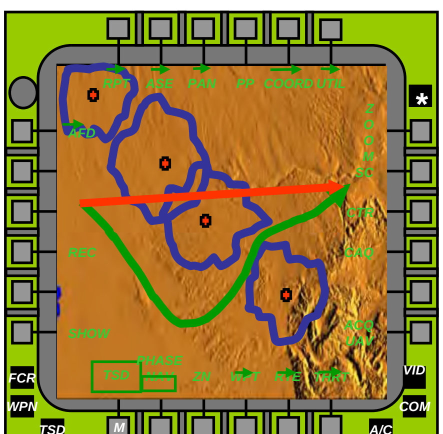
Scalable Interface Configuration & Implementation



Unmanned Aerial Vehicle Systems Technologies



- Five Phase I air vehicles with various engines
- Two full-size and one man-portable ground control stations
- Demonstration of a small, reliable, turbine engine for application to A-160 Hummingbird / ARH and other future force rotorcraft with:
  - -20% fuel consumption rate
  - +50% HP to weight ratio
  - -35% cost
- SHFE provides efficient operation at part power and variable power turbine speeds (50-100%) which is needed for A160 optimum speed rotor



Manned-Unmanned Rotorcraft Enhanced Survivability

Real-time Survivability Associate Re-Router software

Cooperative Manned-Unmanned Team Survivability

Summary

- Unmanned Systems Needed for Transformation
  - Congressional Directive
  - Future Combat System
- Defining Standards for Communications and Control
- Assisting Current Fight
  - Need to Capture Lessons Learned
  - Need to Refine Concept of Operations
- Current R&D Efforts to Fill Some Technology Gaps
- Will Require New Technology and New Means of Employment to Achieve Transformation

Research, Development & Engineering Command

Challenges of Developing Unmanned Systems To Operate in a NetCentric Environment

Director
Technology Integration
Assessment and Futures

COL Cindy Bedell

Discussion Points

- Congressional Guidance
- Industrial and Military Standards
- The Challenge of Communications
- Mapping the Technology to Warfigher Needs
- Current Research Efforts

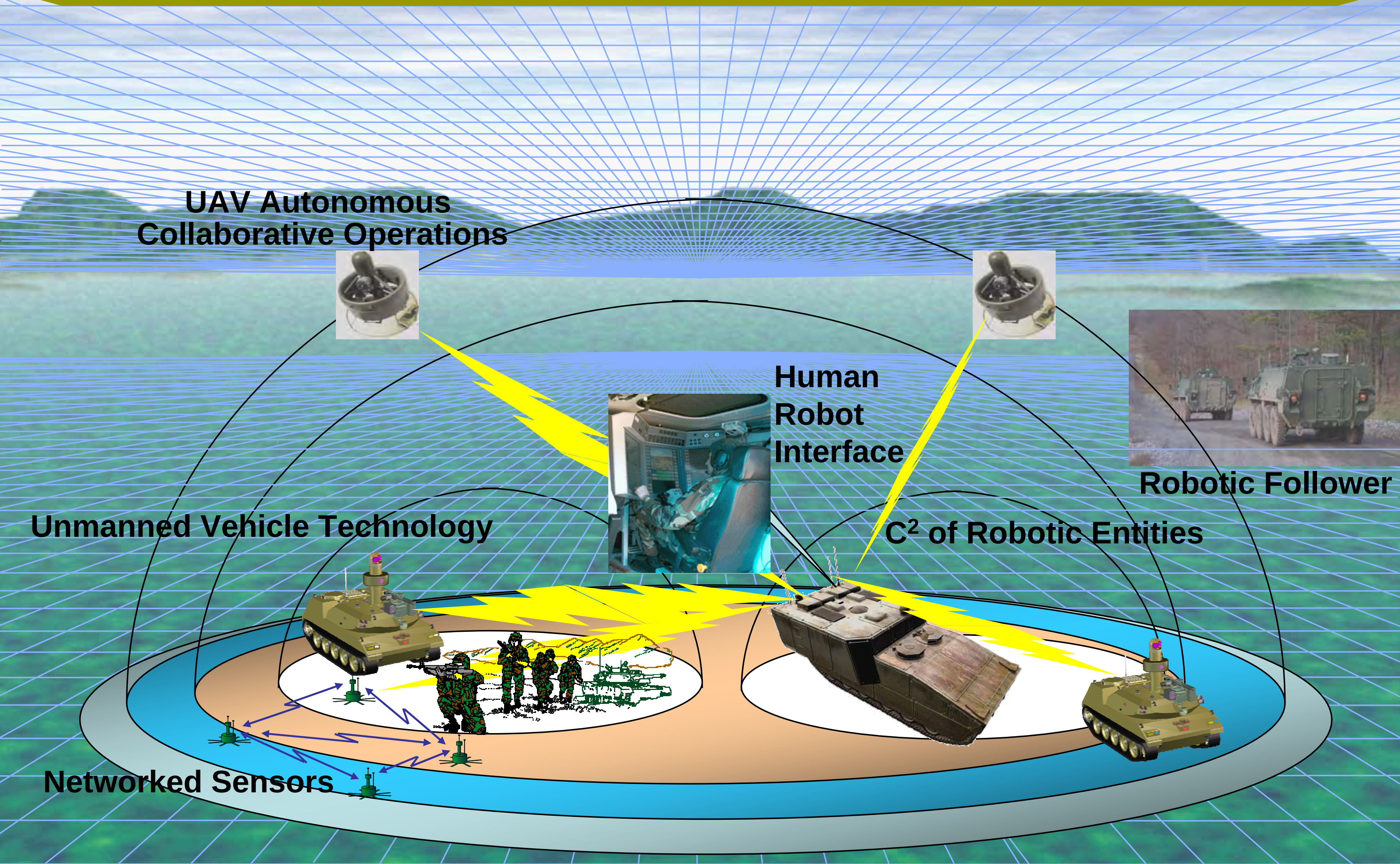
Call for Transformation with Robotics

It shall be a goal of the Armed Forces to achieve the fielding of unmanned, remotely controlled technology such that—by 2010, one-third of the operational deep strike aircraft of the Armed Forces are unmanned; and by 2015, one-third of the operational ground combat vehicles of the Armed Forces are unmanned.

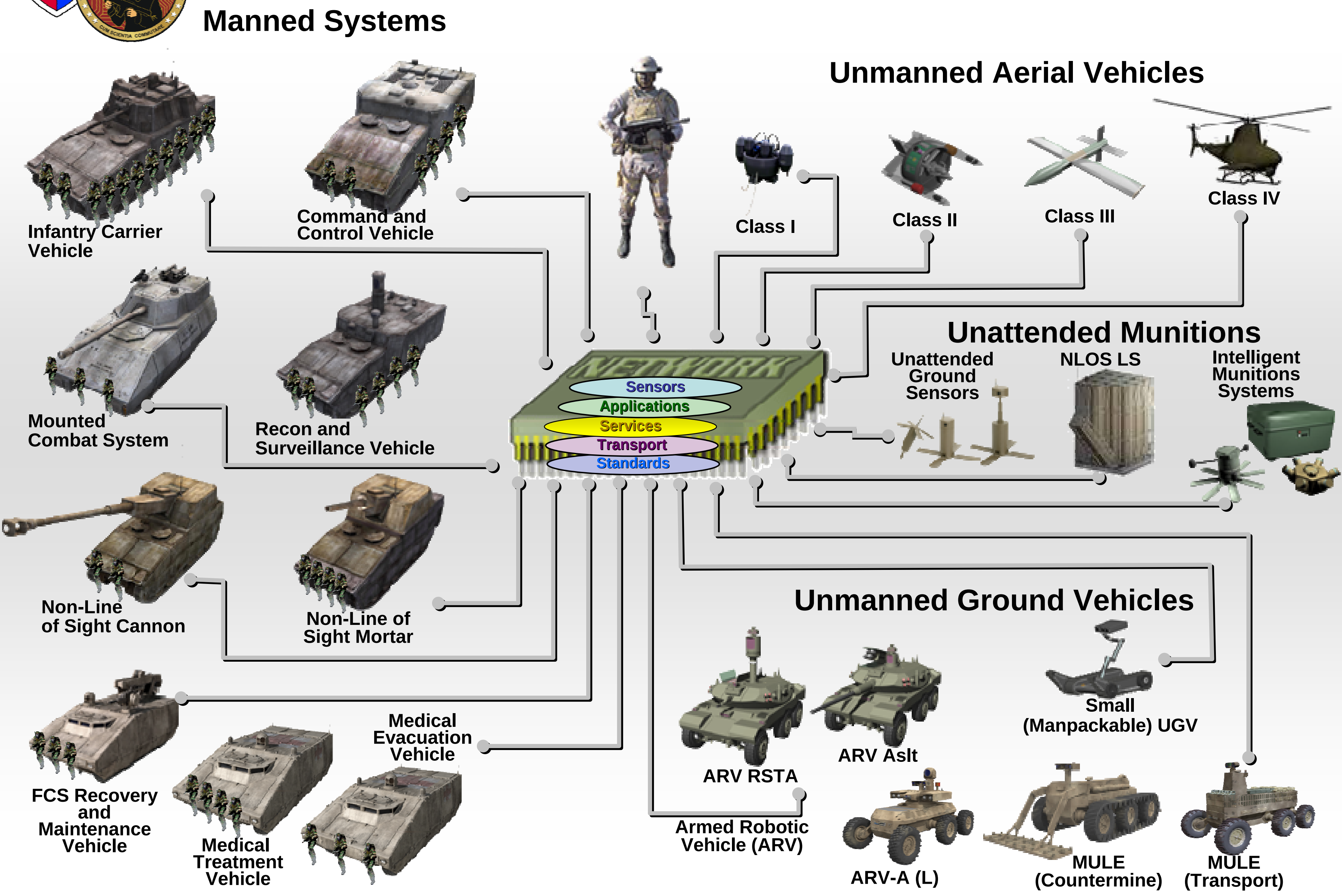
National Defense Authorization
Act for Fiscal Year 2001
H.R.4205, Sec. 220

Robotics Research & Development

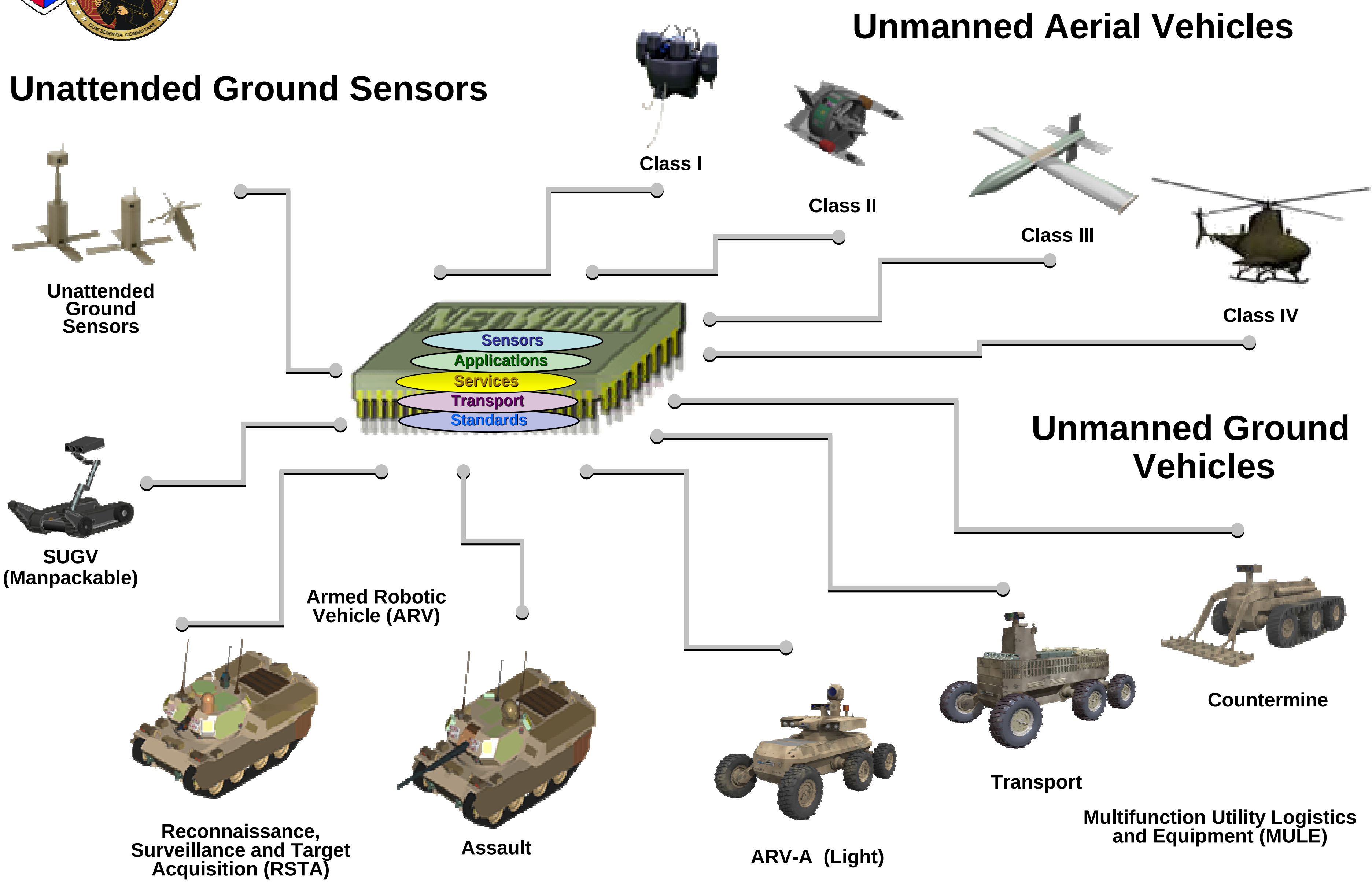
Technology for the Future Force



Future Combat System a System-of-Systems



Unmanned Systems – Key Part of FCS



The Joint Architecture for Unmanned Systems addresses interoperability with an emphasis on the logical communications between heterogeneous computing systems used for Unmanned Systems command and control.

JAUS

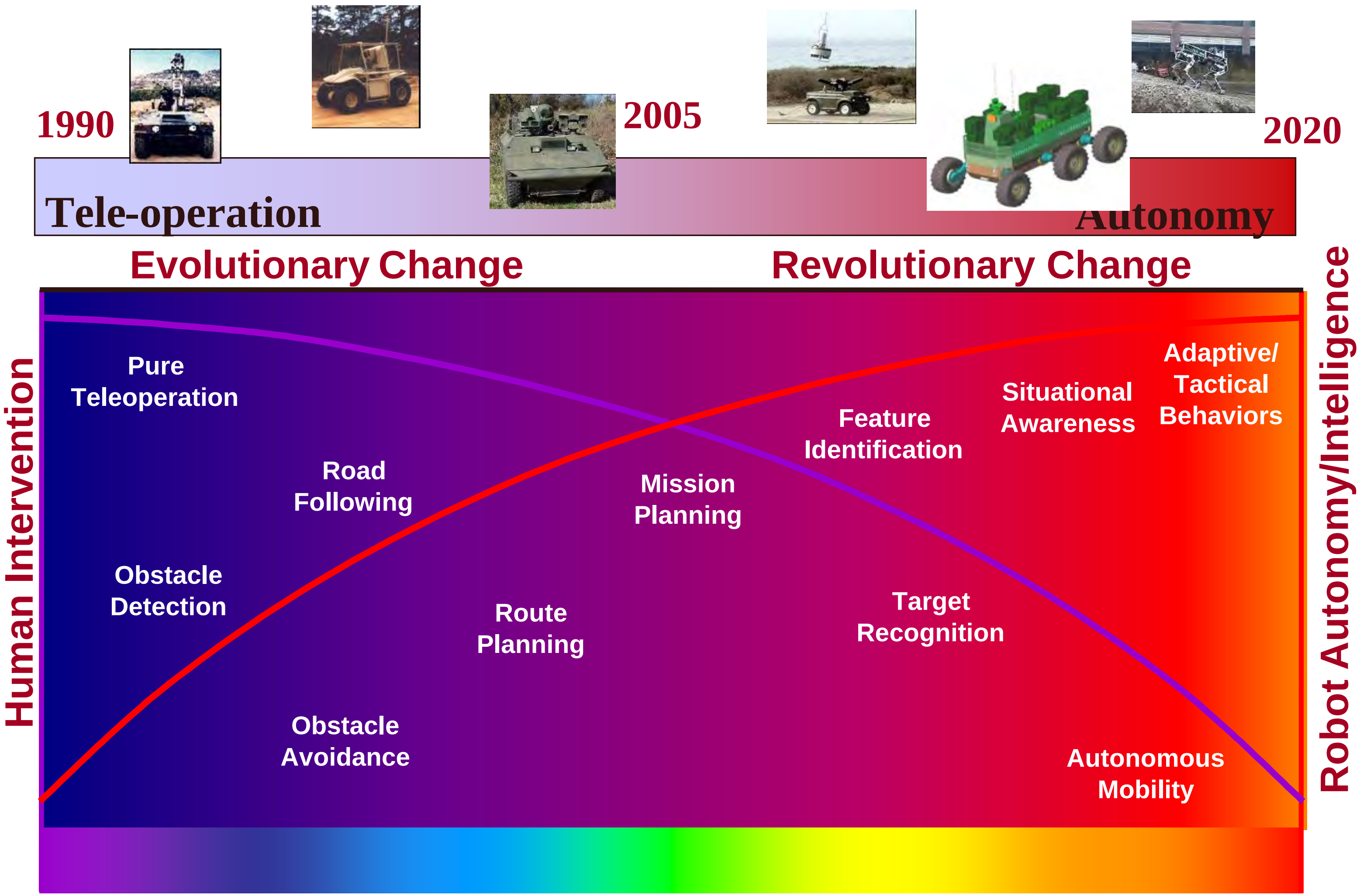
WWW.JAUSWG.ORG

JAUS MIGRATING TO SAE

The Aerospace Council of the Society of Automotive Engineers (SAE) has voted to establish AS-4, an Unmanned Systems Standards Committee. JAUS will become an Aerospace Standard within the next twelve months.

JAUS is a requirement for all FCS unmanned systems.

Robotic Technologies Development



Mapping the Challenges

Critical Technologies

- *Machine Perception*
- *Control System Architectures*
- *Tactical Behaviors*
- *Collaborative Engagement*
- *Communication/ Beyond Line of Sight Connectivity/ Bandwidth*
- *Command and Control*

Operational Capabilities

- *Battle Command*
- *Mounted/Dismounted Maneuver*
- *Air Maneuver*
- *LOS/BLOS Lethality*
- *Maneuver Support*
- *Human Engineering*

Other Operational Considerations

- *Unknown TTPS*
- *Soldier workload*
- *Control of heterogeneous systems*
- *OPTEMPO*
- *Reconstitution*
- *Bandwidth/ network operations*
- *Safety of unmanned vehicles near humans*
- *Fratricide*
- *Survivability*
- *Impact on Tactical/ Strategic decision making*

Current Unmanned Ground Systems Missions

- Explosive Ordnance Disposal
  - Combating Terrorism
  - UXO/IED Defeat
- Remediation
- Combat Engineering
  - Mine Clearing
  - Obstacle Breaching
  - Emplacing Charges
- Reconnaissance
  - Persistent EO/IR Surveillance
  - CBRN
  - BDA
- Direct Fire Weapons
- Obscuration
- Physical Security
- Force Protection
- Casualty/Medical Evacuation

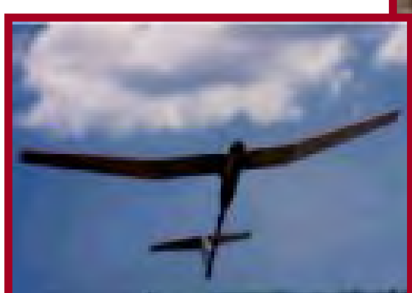
Current Capabilities

- Remote Controlled
- Obstacle Detection and Avoidance
- Pattern Recognition
- Lane Detection
- Road Following
- GPS Way Point Navigation
- Rudimentary Terrain Recognition and Following
- Semi-Autonomous Behavior







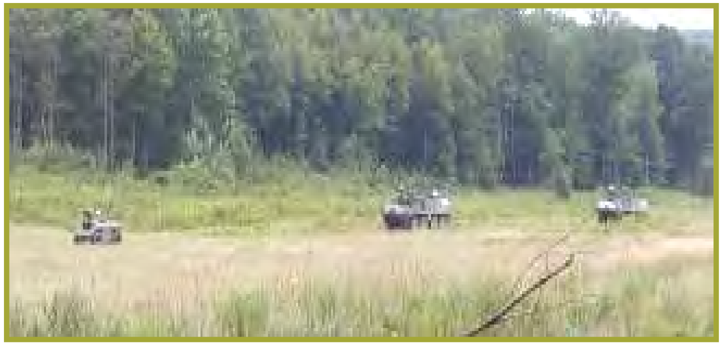


Critical Robotic Technology Gaps

- Power and Energy
  - Battery Life
  - Short burst of Power
  - All Weather Conditions
- Survivability
  - Anti-Tamper Security
  - Destroying or Blocking Sensors
  - Electronic Jamming
- Reliance on GPS for Navigation
  - Military Operations in Urban Terrain
  - Tunnel and Cave Operations
- Communications and Control
  - Range and Bandwidth
  - Human-Robot Interface
  - Autonomous Tactical Behaviors
  - Security
- Negative Obstacle Navigation
  - Water
  - Holes
  - Foliage
- Auto Target Recognition
  - Determining Friend from Foe
  - Spoof Prevention

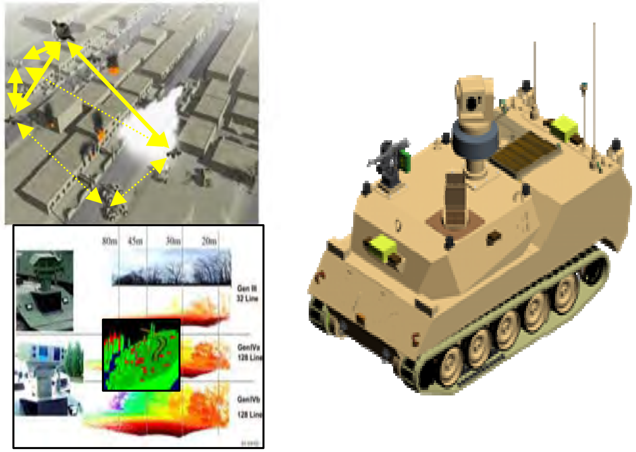
Army Technology Objectives for Unmanned Systems

Technologies for the Future & Current Force



Leader/Follower

Robotics Collaboration



Near Autonomous Unmanned Systems

Unmanned Aerial Vehicle Systems Technologies

Leader/Follower

Mature & Demonstrate Robotics Technology Required for Early Insertion into FCS

Autonomous Mobility Sensor Suite

Robotic Follower ATD

Technologies:
- Decision Aids
- Advanced Warfighter Interfaces (AWI)
- Unmanned Asset Controls
- Multi-mission FCS Crew stations
- Embedded Simulation System
- Advanced System Architecture
- HFE (MANPRINT)

Demonstrate the crew interfaces, automation, and integration technologies required to operate and support Future Combat Systems

Crew Integration and Automation Testbed ATD

Robotic Follower ATD

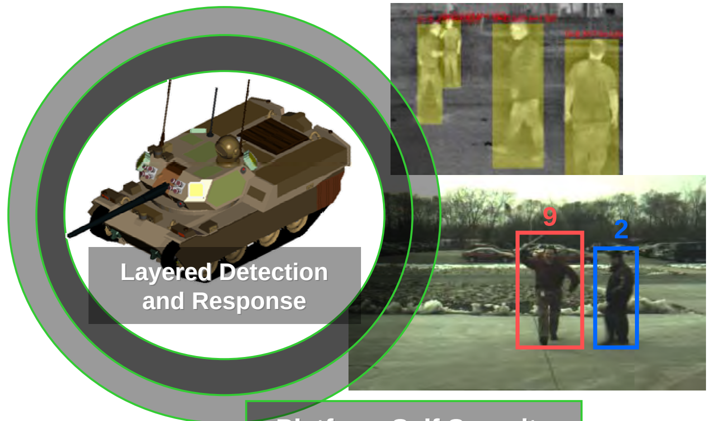
- **Robotic Follower develops, matures, and transitions to PM UA and the LSI the following capabilities:**
  - MMW Radar for vehicle tracking and collision avoidance.
  - Road and trail following.
  - High speed autonomous convoy on narrow roads.
  - Baseline convoy in live traffic.
  - Terrain/obstacle registration for leader-follower operations in GPS denied areas.
  - Human odometry dismounted follower.
  - Baseline safety procedures.
  - Robotic follower procedures, safety procedures, and TTP development.
  - Robotic Follower Testbed

Crew Integration and Automation Testbed (CAT) ATD

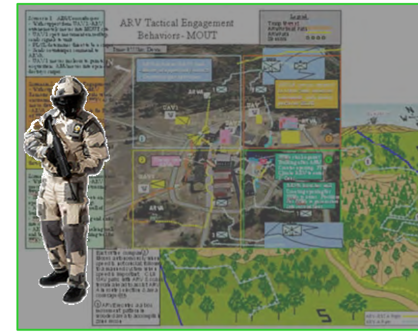
- **CAT develops, matures, and transitions to PM UA and the LSI the following capabilities:**
  - Advanced Warfighter Interfaces (AWI) for efficient multi-task execution.
  - Unmanned asset controls for UGVs, UAVs, and UGSs.
  - Multi-mission crew stations that provide the capability to perform all the tasks of a fight, scout, or carrier mission.
  - Embedded simulation system for in vehicle mission rehearsal, mission planning, and embedded training.
  - Crew aiding behaviors for assistance with manned and unmanned mission planning and execution.
  - Advanced system architecture provides that an order of magnitude performance increase over currently fielded systems.

Near Autonomous Unmanned Systems

UAV-UGV Collaborative Reconnaissance Missions



Platform Self Security



Tactical Behavior Development (Increase Platform Intelligence)

FCS Risk Areas Program Is Addressing

- Distributed Collaboration of Manned/Unmanned Platforms (FCS Risk 68)
- Safe UGV Mobile Operations in FCS UA (FCS Risk 213)
- Safe UGV Weapons Operations in FCS UA (FCS Risk 214)
- Transfer of Technology to Skid Steer Vehicles (UGV Risk 0032)
- UGV Situational Awareness (ARV Risk 0006)
- UGV Tactical Behaviors (ARV Risk 0007)
- UGV Self Security (ARV Risk 0008)

HRI for air and ground assets

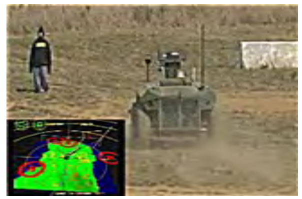
Point A to Point B Autonomous Mobility

Advanced Remote Armament System (ARDEC)

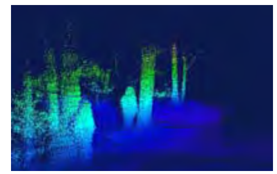
Near Autonomous Unmanned Systems

2005	2006	2007	2008	2009

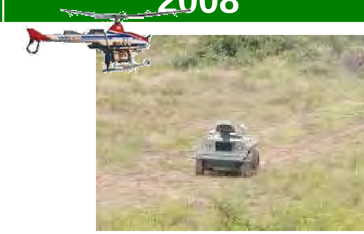
Delivery of GEN V LADAR (under IV.GC.2000.03)



Initial demonstration of detection & avoidance of moving vehicles & people



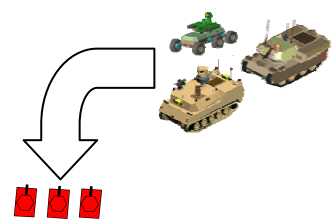
Perception Algorithms



Autonomous Cooperative Behaviors

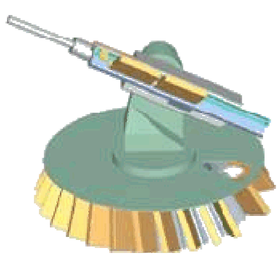
ART testbed development

Platform Self Security System
(pedestrian detection/tracking/intent system)



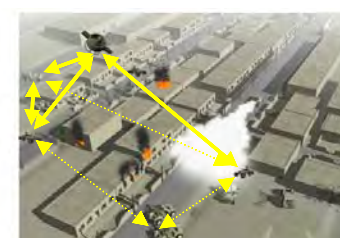
Platform Level Tactical Behaviors

Advanced Remote Armament System Demonstration



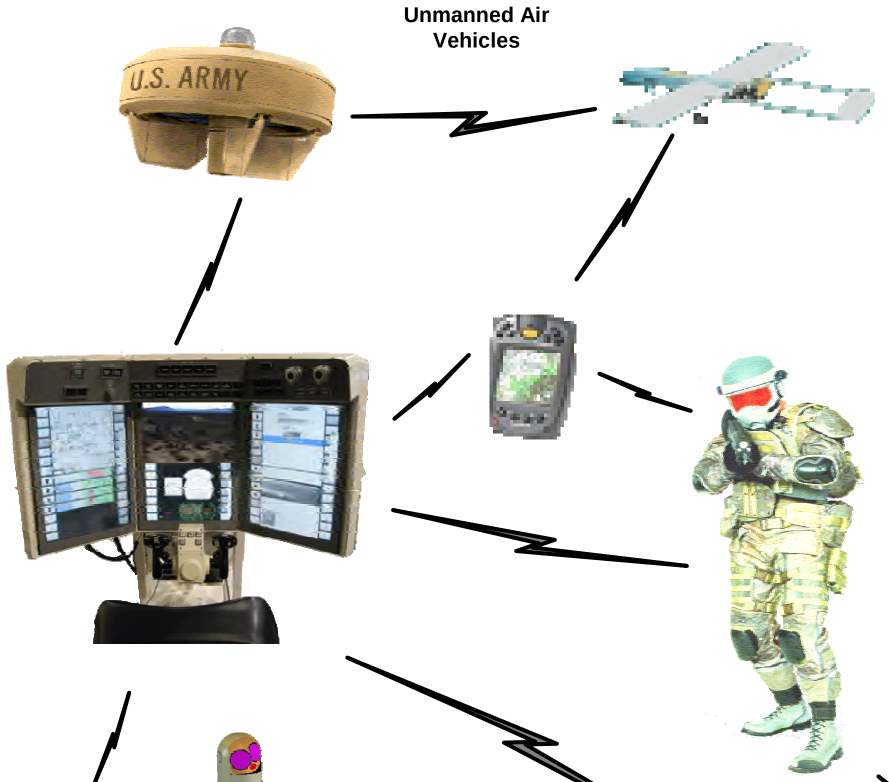
Advanced Remote Armament System Development

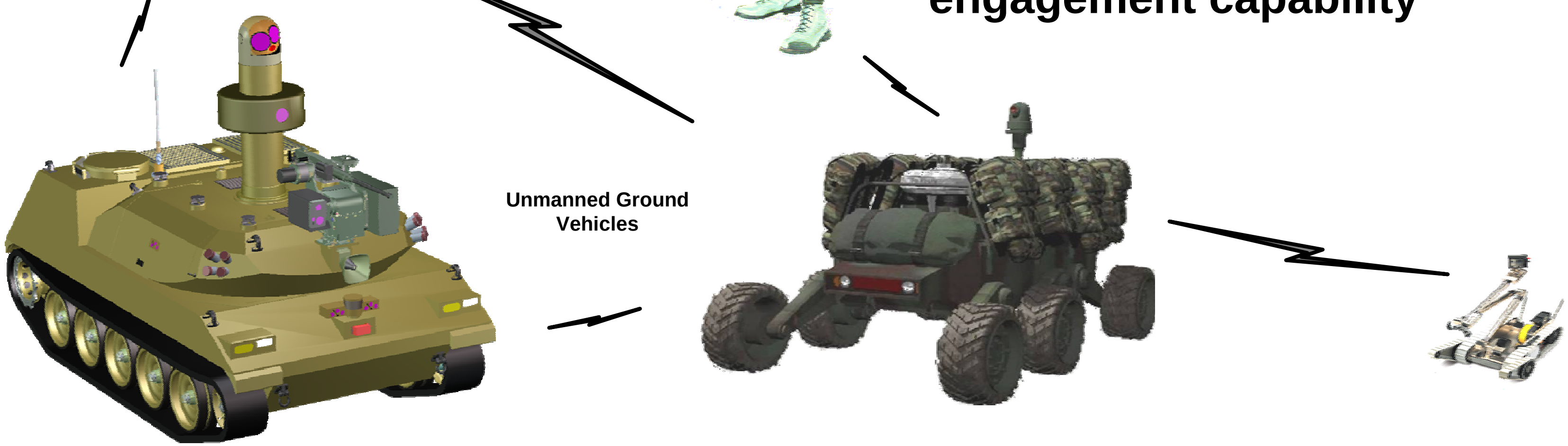
Initial Integrated Experiment



Final Integrated Experiment

Robotics Collaboration

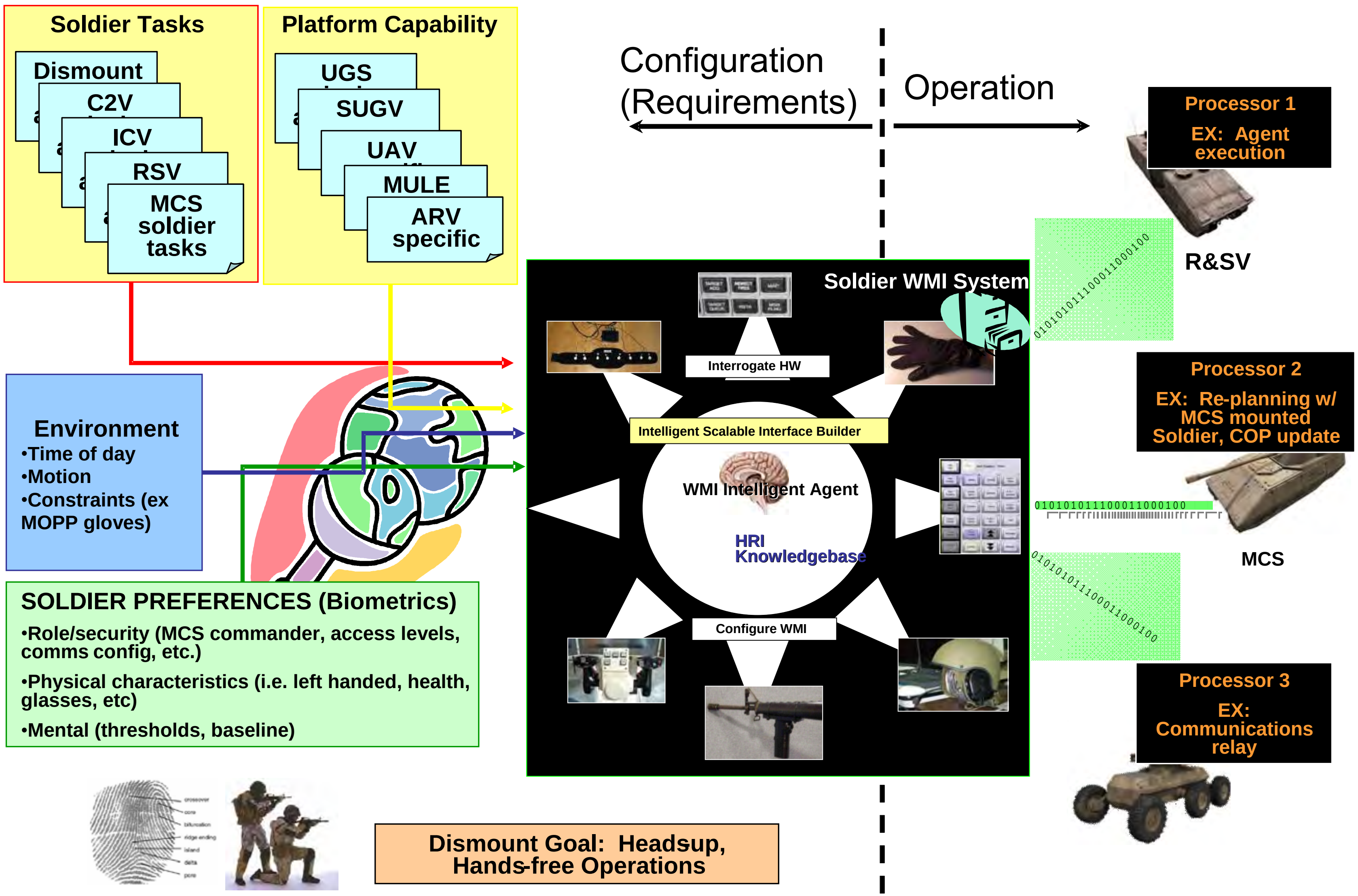




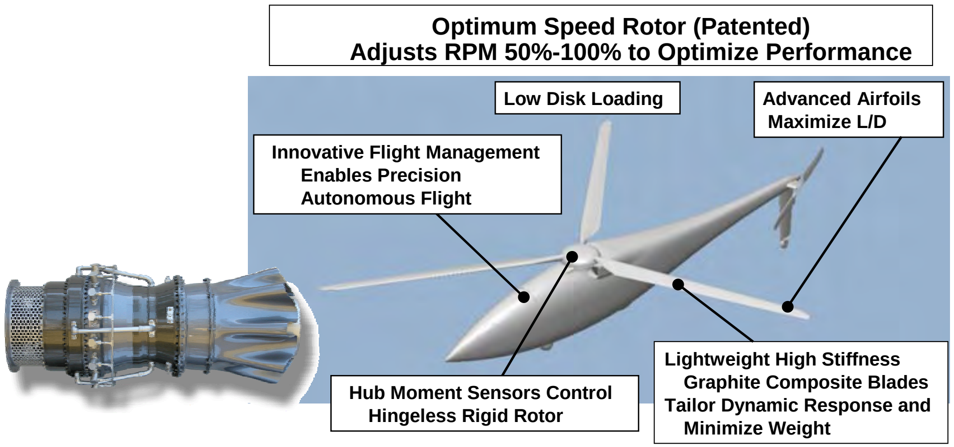
- Intelligent agent software to adaptively automate/adjust Soldier control tasks
- Common scalable interfaces that provide same look/feel across spectrum of control devices
- Unmanned Vehicles safety operational behavioral algorithms and recommendations for TTP development
- Software for UAV/UGV collaboration
- UAV autonomy and cooperative engagement capability

Robotics Collaboration

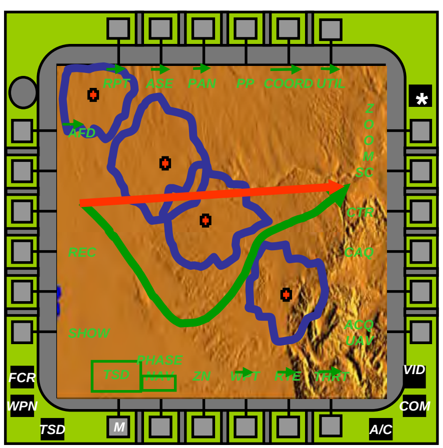
Scalable Interface Configuration & Implementation



Unmanned Aerial Vehicle Systems Technologies



- Five Phase I air vehicles with various engines
- Two full-size and one man-portable ground control stations
- Demonstration of a small, reliable, turbine engine for application to A-160 Hummingbird / ARH and other future force rotorcraft with:
  - -20% fuel consumption rate
  - +50% HP to weight ratio
  - -35% cost
- SHFE provides efficient operation at part power and variable power turbine speeds (50-100%) which is needed for A160 optimum speed rotor



Manned-Unmanned Rotorcraft Enhanced Survivability

Real-time Survivability Associate Re-Router software

Cooperative Manned-Unmanned Team Survivability

Summary

- Unmanned Systems Needed for Transformation
  - Congressional Directive
  - Future Combat System
- Defining Standards for Communications and Control
- Assisting Current Fight
  - Need to Capture Lessons Learned
  - Need to Refine Concept of Operations
- Current R&D Efforts to Fill Some Technology Gaps
- Will Require New Technology and New Means of Employment to Achieve Transformation

Relevant Research and Results . . . Yesterday, Today, and Tomorrow

7th Annual
Science & Engineering Technology Symposium

Spring 2006

Session IV: Transitioning Disruptive Technologies

Naval Approach to Disruptive Technologies and Transition

20 April 2006
Lewis DeSandre
Program Manager
ONR 351

Overview

- Organization and Responsibilities
- Relationship of Transformational Projects and Disruptive Technologies
- Current Programs
- Future Plans
- Summary

ONR Organization

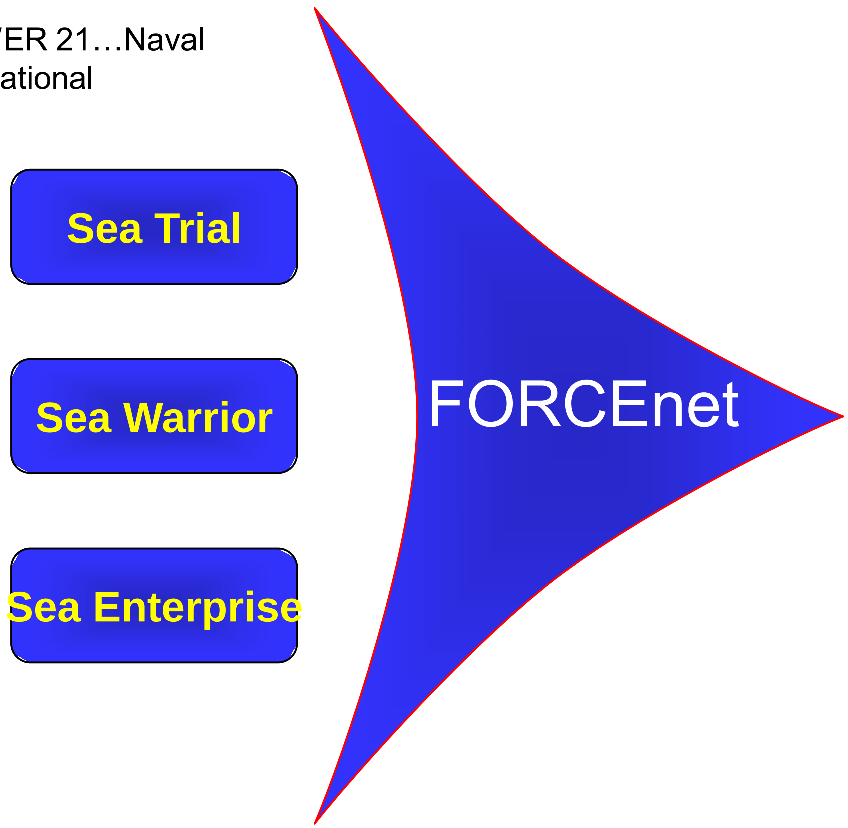
S&T for Naval Transformation

Relevant Research and Results . . . Yesterday, Today, and Tomorrow

Selected transformational projects funded in FNCs and elsewhere in DoN S&T

Sea Shield Directed Energy

SEA POWER 21…Naval Transformational Roadmap



Sea Strike EM Gun

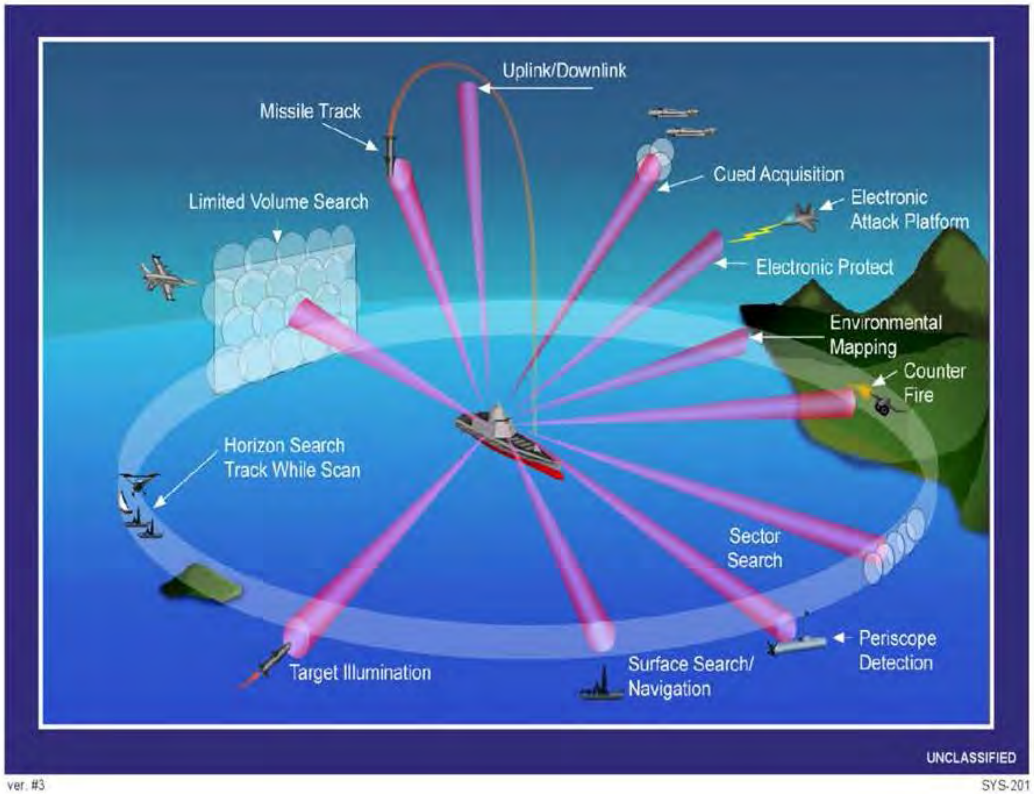
Sea Basing Electric Ship

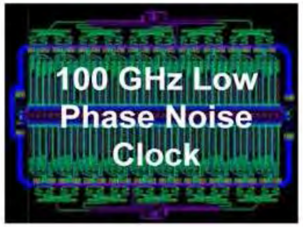
Information, Electronics and Surveillance (Code 31)

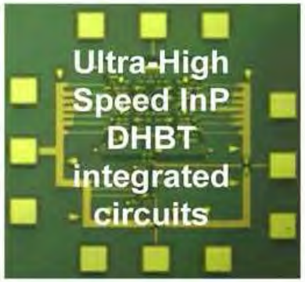
ONR
Relevant Research and Results . . . Yesterday, Today, and Tomorrow

- Surveillance capabilities, communications, command and control
- New concepts for electronic devices
- Application of information sciences to complex problems including human-computer interaction
- Electronic warfare

Advanced Multi-Function RF







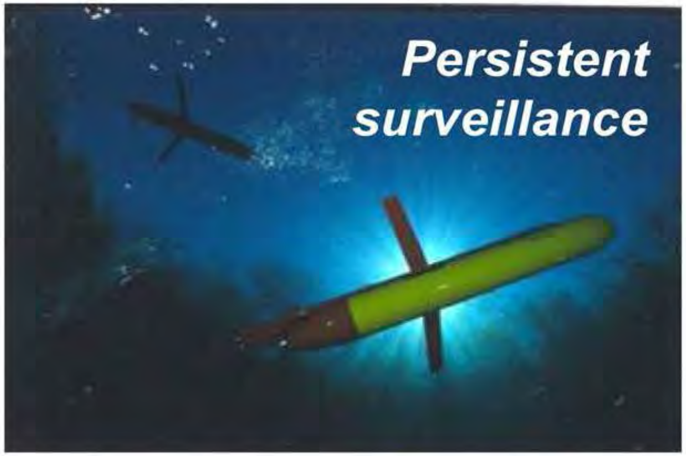
technologies to meet future radar requirements

Ocean, Atmosphere, and Space (Code 32)

- Battlespace Environments - (BSE)
- Anti-Submarine Warfare - (ASW)
- Mine Warfare - (MIW)
- Naval Special Warfare/Explosive Ordnance Disposal
- Advanced Force Operations

Autonomous Vehnicles

Letting robots do the dangerous work



Engineering, Materials, and Physical Sciences (Code 33)

- Chemistry
- Physics
- Structural & functional materials
- Structural, solid, & fluid mechanics
- Propulsion
- Energetics
- And hull, mechanical,
- & electrical systems

Virtual At Sea Training (VAST)

Realistic fire support training for the Navy-Marine Corps Team

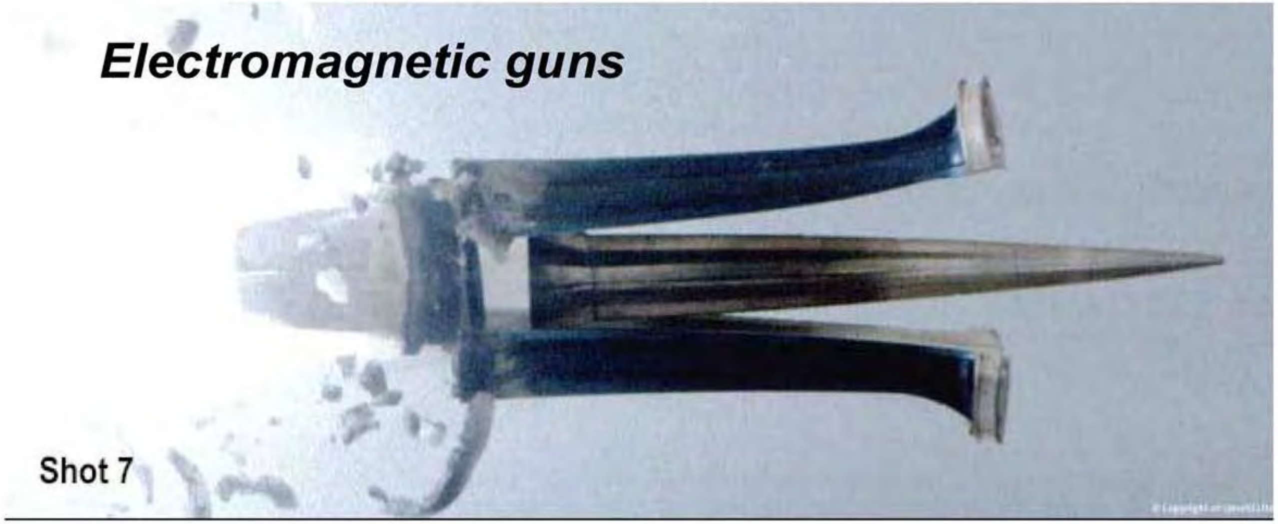
Naval Expeditionary Warfare (Code 35)

- Aeronautics, avionics
- Propulsion, ballistics, warheads
- Missile guidance, seekers
- Parallel distributed processing
- Technology programs particularly associated with Marine Corps/ground combat applications

Hypersonic Strike

Relevant Research and Results . . . Yesterday, Today, and Tomorrow

Speed kills



Human Systems (Code 34)

- Exploration programs at the leading edge of medical science
- Human performance
- Biotechnology
- Training and human factors
- Neural information processing
- Biorobotics

Navy Perspective for Disruptive Technologies

The Electric Warship enables Electric and Directed Energy weapons warfighting capabilities well beyond that currently available to US Navy.

Attainment of these capabilities continue to be a focal thrust for Disruptive Technology investments for the Navy.

Some Disruptive Technologies are:

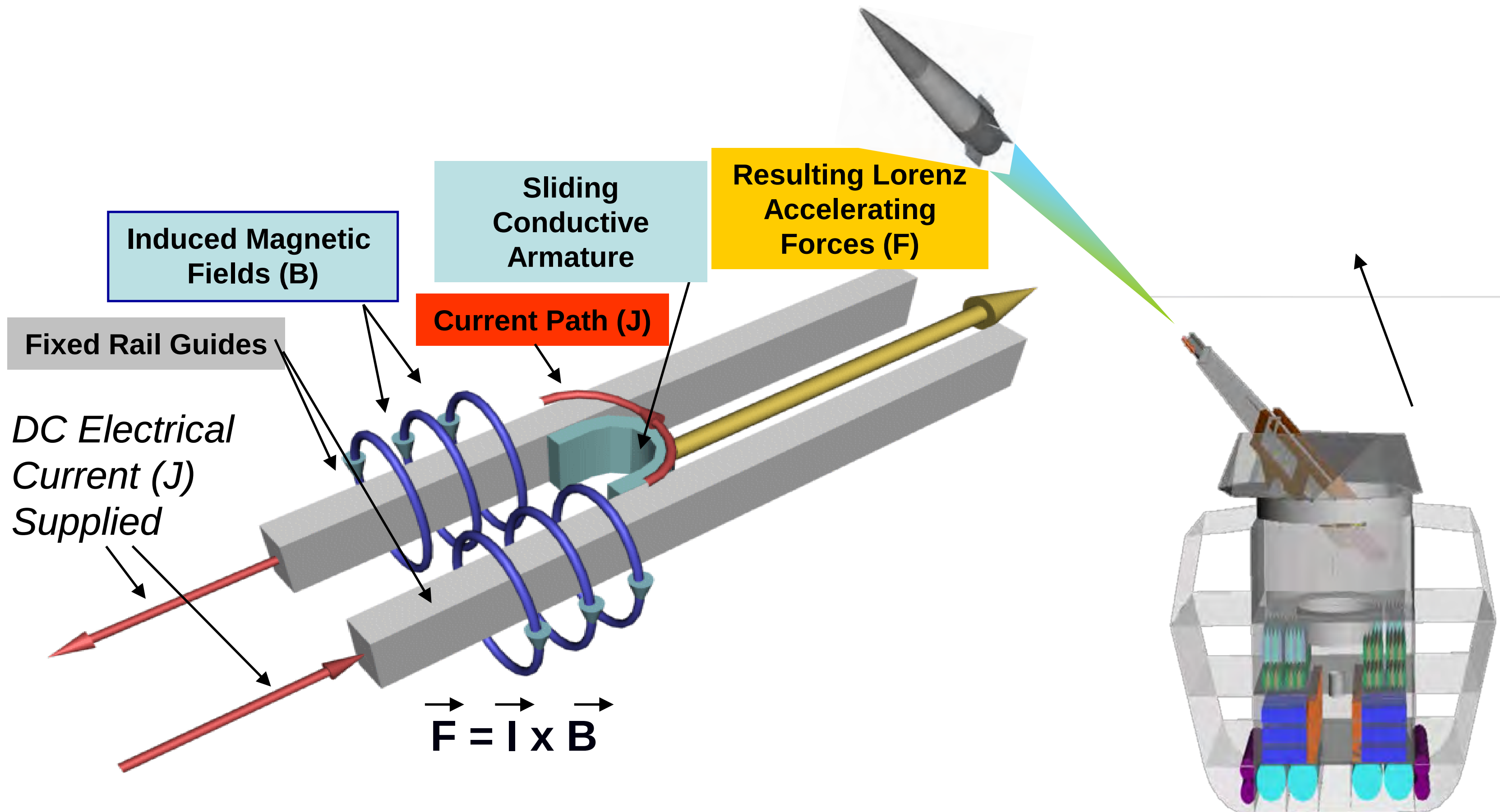
- Electric Weapons (Rail Gun)
- Directed Energy Applications
  - Free Electron Laser
  - Other Lasers
  - High Power Microwave

Electromagnetic Launcher

Long Range Gun Demonstration Prototype – FY12

Navy S&T Most Critical Issues:

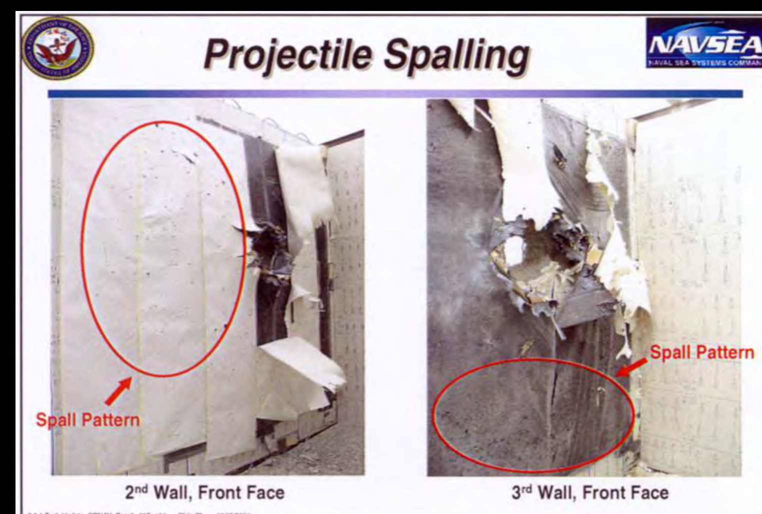
- Physics of Materials/Dynamics at High Energy State
- Factors for Electromagnetic Performance & Efficiency



$$\vec{F} = \vec{I} \times \vec{B}$$

Relevant Research and Results . . . Yesterday, Today, and Tomorrow

Rail Gun!!



NAVAL STRIKE FIGHTER HIGH ENERGY LASER (HEL)

Warfighting Payoff:

- Benefit to all programs considering HEL weapon by providing accurate analytic tools
- Address shortcomings in current HEL Engineering & Warfare Models and Simulations to sufficient level to support Acquisition Process
- Leverage currently accepted models and simulations by upgrading HEL modules, develop new simulation if no acceptable baseline exists
- Cross-service cooperation

Working Transitions :

- F/A-18 E/F
- DEW JUCAV
- JSF

High Power Microwave

- Specific Areas of Interest
  – Anti-missile Defense
  – Counter Munitions
  – Command and Control Warfare
  – Suppression of Enemy Air Defense (SEAD)
  – Ballistic Missile Defense
  – Air Craft Self Protect
- Approach
  – Apply High Power Microwave Technology to damage or upset electronics of systems so as to produce a mission kill

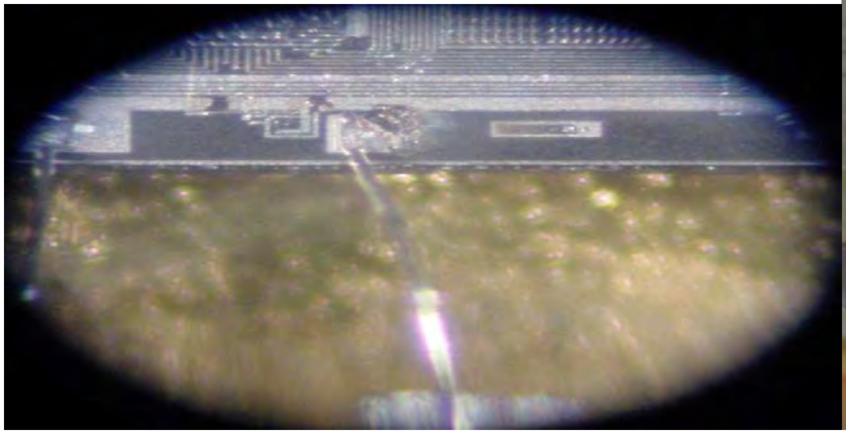
Research Underway

Susceptibility of Missiles
- RF induced deception (more desirable)
- RF Damage

Examined COTS systems to identify susceptibilities
- Carried out RF effects tests

RF Effects On Electronic Circuits

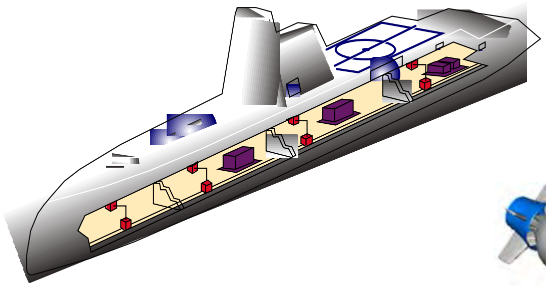
- Focused beams used to probe electronic susceptibilities of electronic modules and components to identify particularly vulnerable pathways
- Modeling and simulation is employed to verify effects and causes of susceptibilities
  - PSPICE
  - Finite Element Codes
  - Finite Difference Time Domain



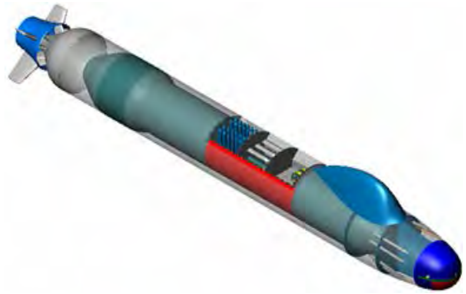
Engine Stopping

- Examining techniques for causing engines to stop running
  - Focusing on marine outboard engines
  - Part of a tri-service effort on engines
- System and Component
- Level Testing

The Future Is Electric



- Podded Propulsion
- Fuel Cells
- High Pulsed Power Sensors
- High Energy / Speed of Light Weapons



- Electric Propulsion
- Replace Diesel and Battery
- Control Surfaces
- Weapons Launch

- Aircraft Launch and Recovery
- Speed of Light Defensive Weapons
- Advanced Survivability Systems
- Advanced Storage and Distribution

- Hybrid Propulsion
- Enhanced Stealth
- Pulsed Power Weapons and Sensors

How Can Industry and Academia Help?

- The **Office of Naval Research** coordinates, executes, and promotes the science and technology programs of the United States Navy and Marine Corps through schools, universities, government laboratories, and nonprofit and for-profit organizations. It provides technical advice to the Chief of Naval Operations and the Secretary of the Navy and works with industry to improve technology manufacturing processes.

- ONR maintains a close relationship with the research and development community to support long-range research, fosters future discovery of technologies, and nurtures next generations of researchers for the future Navy and Marine Corps.

TARDEC Technical Director (Acting)

Dr. Marilyn Freeman

presentation on

Force Protection

to the

Science & Engineering Technology Conference

SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

TARDEC

U.S. ARMY TANK AUTOMOTIVE RESEARCH, DEVELOPMENT AND ENGINEERING CENTER

Approved for public release; distribution is unlimited

Outline

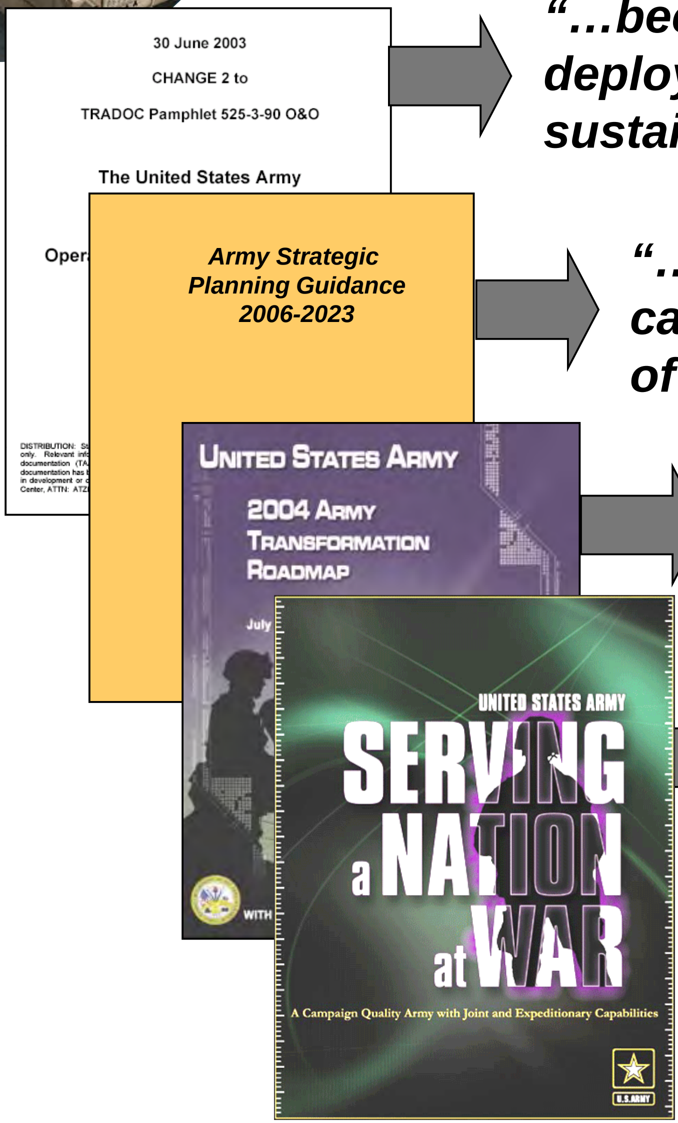
Perspectives:

- ***Science & Technology***
- ***Survivability***

Survivability:

- ***Recent Past***
- ***Present***
- ***Future***

Responding to Army Needs



"…become a more strategically responsive, deployable, agile, versatile, lethal, survivable, and sustainable force, effective in all situations …"

"…provide relevant and ready land power capability to the Combatant Commander as part of the Joint Team"

"…provide dominant land power to the Joint Force now and into the future."

"…change in time of war must deal simultaneously with both current and future needs"

Army S&T Vision: *Pursuing Transformational Capabilities for a Joint and Expeditionary Army*

Current Force

~100 lb. load

70+ tons

< 10 mph

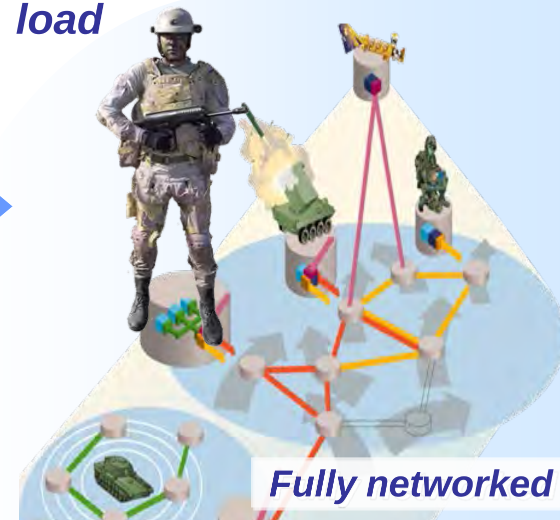
Enabling the Future Force

Science and Technology— develop and mature technology to enable transformational capabilities for the Future Modular Force while seeking opportunities to accelerate technology directly into the Current Modular Force

Enhancing the Current Force

Backpacked

< 40 lb. load



Fully networked

< 30 tons

> 40 mph

What is Survivability?

$$\text{Survivability} = \int_l^m \int_j^k \int_g^h \int_e^f \int_c^d \int_a^b f(\text{Armor})\,dxdt + f(\text{APS})\,dxdt + f(\text{Electronic Warfare})\,dxdt + \cdots$$

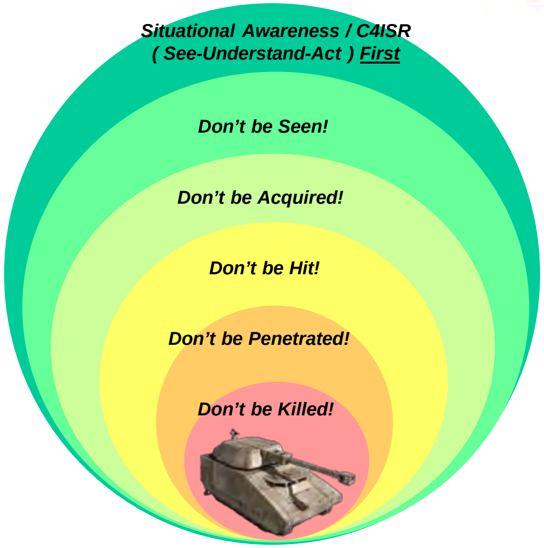
$$\cdots + f(\text{Signature Mgt})\,dxdt + f(\text{Countermine})\,dxdt + \cdots$$

$$\cdots + f(\text{Damage Mitigation})\,dxdt + f(\text{Lethality})\,dxdt + \cdots$$

$$\cdots + f(\text{Unmanned Platforms})\,dxdt + f(\text{TTPs})\,dx + \cdots$$

$$\cdots + f(\text{Platform Design})\,dx + f(\text{Mobility})\,dxdt + \cdots$$

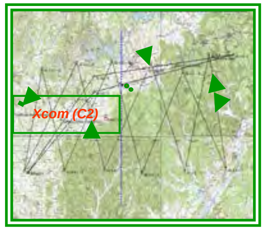
Survivability 'Onion'



Technologies: Recent Past & Present

Multi function OTM Secure Adaptive Integrated Comms

FCS C2



Networked Communications

Mid Range Munition

Compact KE Missile

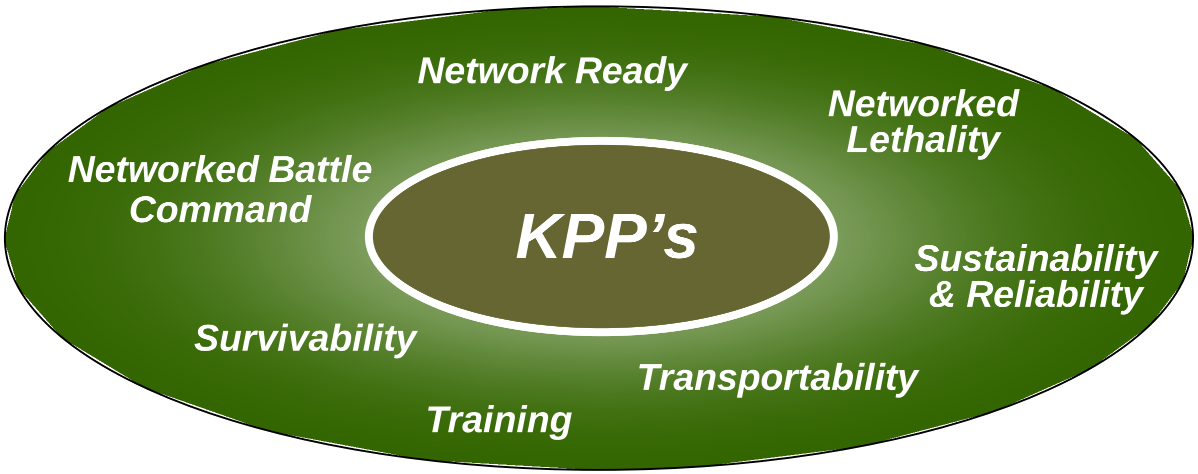
Precision Attack Msl

Loiter Attack Msl

CAT VTI Test bed

LtWt 120mm Gun

SATCOM On The Move



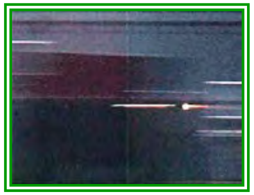
Auto Loader

Close-in Active Protection Sys (APS)

Hummingbird

On The Move APS

Adv Armor



KE APS

Change Detection

UGV

Spinner-Mobility

MAV

Technologies for the Current & Future Force

Soldier Protection Technologies
Individual Soldier Ballistic/Blast Protection

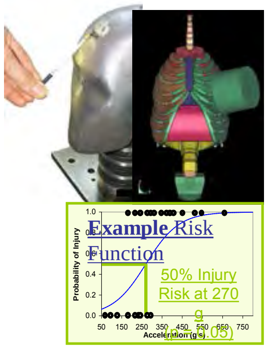
- The Warfighter continues to face a significant threat from multiple threats including ballistic and blast
- Personnel armor plays an important role in the survival of our Warfighters
- Soldier Protection Technologies are responding to capability requirements and address the need for:
  - Lightweight protective materials technology that improve the survivability of the individual warfighter against a full spectrum of ballistic and blast threats
  - Tools that provide "leap-ahead" capability to assess individual survivability and munitions lethality




Soldier Protection Technologies
Individual Soldier Ballistic/Blast Protection

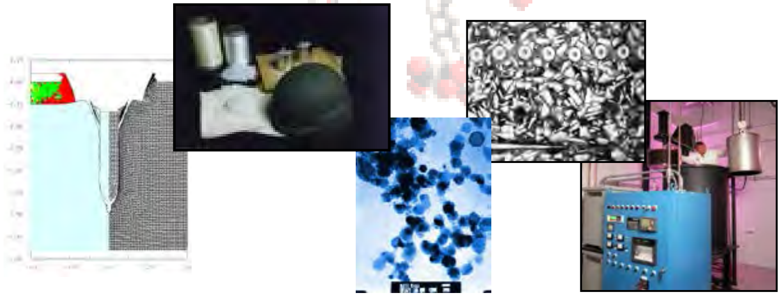
Key Focus Areas
for Research and Development

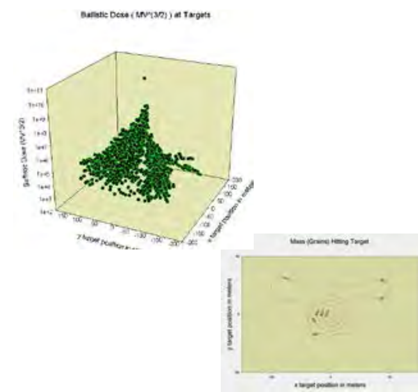
Behind Armor Effects Methodology	Advanced Technology Development	Casualty Reduction Analysis Model



Conduct experimental (tissue & test fixture), analytical and numerical assessments of non-penetrating impact on body armor/body

- New high performance polymers/ fibers/composites
- Nanotechnology
- Advanced ceramics & metals
- Enhanced predictive modeling
- Material systems integration



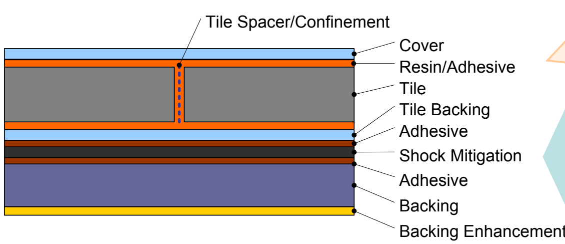


Develop/update models for armor system performance from threat definition to incapacitation effect

Survivability Technologies: Recent Past & Present

Army Science Board, 2001:
Active Protection Systems (APS) will not be able to achieve their objectives

Significant Strides:



IAAPS: Defeat On-the-move

EM Armor: Multiple defeats on single panel

EW: Defeat On-the-move

CIAPS: Defeat On-the-move

FCLAS: Threat defeat demonstrated

Ballistic Armor: 225 psf down to 64 psf

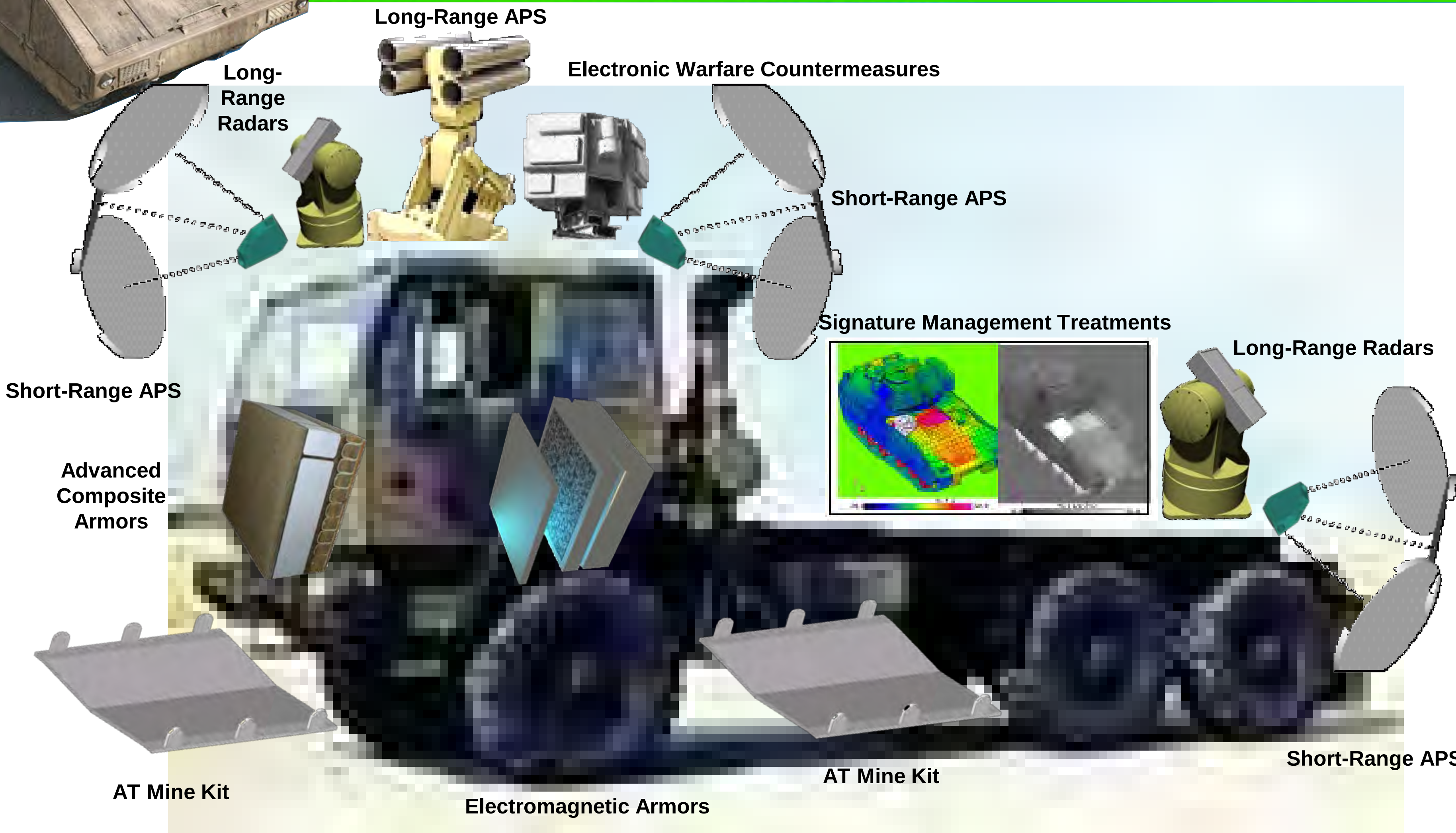
"Come a long way in a short time"

Influences that Drive Our Path Forward

- *As a result of today's world situation: There is not only technology push, now there is current demand - particularly for survivability*
- *Current Threats apply not only for Light, Medium & Heavy Combat Vehicles but for Light, Medium & Heavy Tactical Vehicles and unmanned systems*
- *Emerging Requirements*
- *Application of Survivability Technologies*
  - *Address IED protection*
  - *Address Safe & Arm issues*
  - *Address Fratricide issues*
  - *Integration onto Platforms*
  - *Right mix on Platform*
  - *Tactics, Techniques & Procedures*

Must Enable Continuous Improvement...
i.e. modularity, mission tailorability, commonality…

How Not to Make a Lightweight Vehicle Survivable



… Adding every survivability technology available without trade-off analysis and integration considerations

Path Forward

$$\text{Survivability} = \int_i^m\int_j^k\int_g^h\int_e^f\int_c^d\int_a^b f(\text{Armor})dx + f(\text{APS})dx + f(\text{Electronic Warfare})dx + \cdots$$
$$\cdots + f(\text{Signature mgt})dx + f(\text{Countermine})dx + \cdots$$
$$\cdots + f(\text{Damage Mitigation})dx + f(\text{Lethality})dx + \cdots$$
$$\cdots + f(\text{Unmanned platforms})dx + f(\text{TTPs})dx + \cdots$$
$$\cdots + f(\text{Platform Design})dx + f(\text{Mobility})dx + \cdots$$

CAUTION: All along the yellow brick road we should expect signs like: STEEP GRADE; SCHOOL ZONE; LIMITED SPEED ZONE; ROAD NARROWS; STOP; WINDING ROAD; GO; DETOUR; TRAFFIC LIGHTS AHEAD; NO EXIT; NO PASSING; WRONG WAY.

There is a huge challenge before us…our work has only begun… we must find the right path to deliver and implement suites enhancing current and future platform survivability

AFRL
THE AIR FORCE RESEARCH LABORATORY
LEAD | DISCOVER | DEVELOP | DELIVER

AF S&T Challenges for Responsive Space

Colonel Rex R. Kiziah

Materiel Wing Director, Space Vehicles

Air Force Research Laboratory

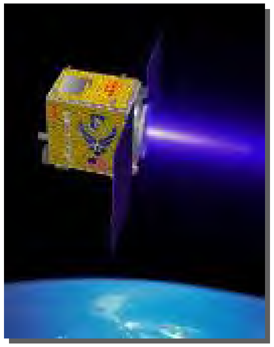
Overview

- AFRL Focused Long Term Challenges (FLTCs)
- Responsive spacecraft
- Responsive lift
- Responsive range
- Opportunities for industry collaboration

AF Technology Vision

CORONA Top, Jul 05

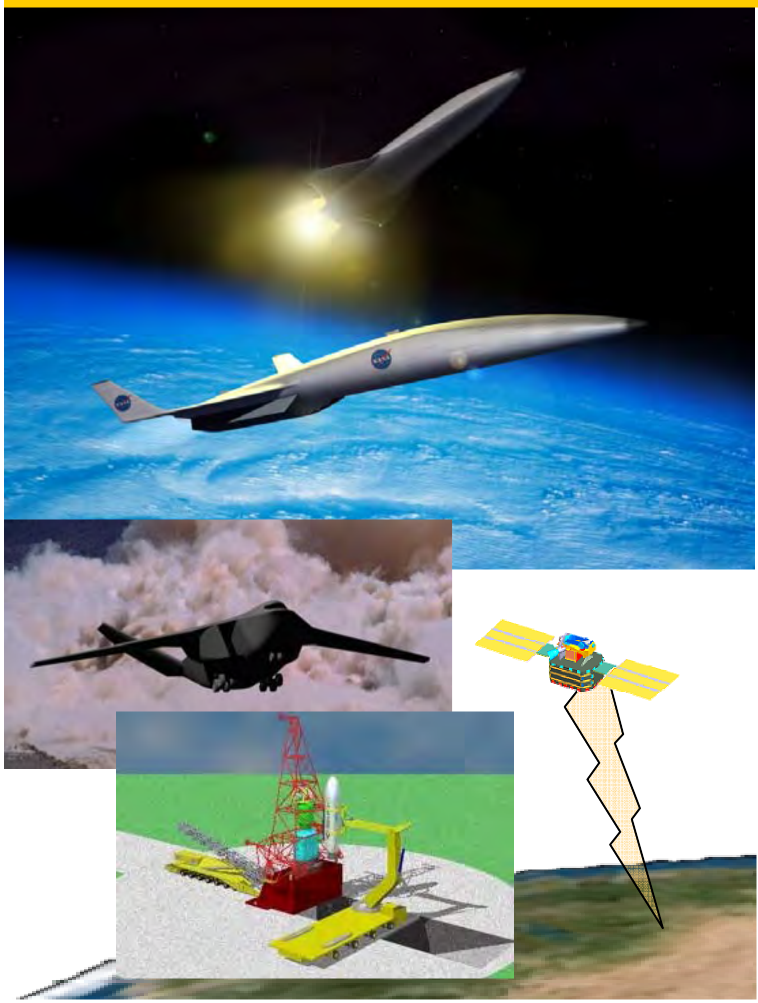
Anticipate, Find, Fix, Track, Target, Engage, Assess – Anything, Anytime, Anywhere



Energized By Focused Long Term Challenge (FLTC) Plans

FLTC #7

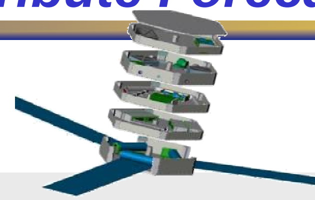
Timely Deployment of Flexible Ground & Space Capabilities for the AOR Commander



- Rapidly Constitute Multi-Mission, Affordable Tactical Satellites
- Rapidly Deploy Multi-Mission, Affordable Space Payloads
- Generate On-Demand, Reusable Affordable Space Access
- Rapidly Checkout Spacecraft
- Globally Project Ground Forces Anywhere in Any Weather
- Globally Move, Manage and Process Information in Real Time

FLTC 7–On-Demand Theatre Force Projection, Anywhere

Attribute Forecast



Rapidly Developed Tactical Satellites
- Modular s/c Bus
- Agile Orbit Transfer

Rapidly Developed Payloads
- Plug-n-Play Payloads
- Reconfigurable Components

Hybrid Responsive Space Access
- Rapid Turn 48 Hrs
- 3x Lower Ops Cost
- Vehicle Reliability .995

Rapid S/C Checkout & Autonomous Ops
- Autonomous Mission Operations

Rapidly Developed Tactical Satellites
- Enhanced Capability Microsats
- Rapid SC/LV Mate & Transport
- Collaborative Microsatellite Clusters

Rapidly Developed Payloads
- Reconfigurable Monolithic Sensor/Processor Subsystems

Fully Reusable Responsive Space Access
- Rapid Turn 24Hrs
- 10X Lower Ops Cost
- Vehicle Reliability .999

Rapid S/C Checkout & Autonomous Ops
- Autonomous Mission Management

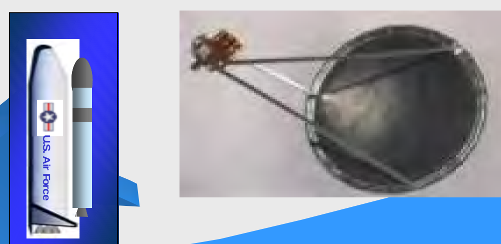
Rapidly Developed Tactical Satellites
- Flexible Printed Satellites
- Nanosatellites

Rapidly Developed Payloads
- "Morphable" RF & EO Sensor Systems
- Monolithic EO Sensor (Sensor, Laser Cooler, Readout, Processor, & Protection on a Chip)

Fully Reusable Responsive Space Access
- Rapid Turn 4hr
- 100X Lower Ops Cost
- Vehicle Reliability .9998

Rapid S/C Checkout & Autonomous Ops
- Anticipatory Mission Planning/Ops
- Automated On-Orbit Servicing

Baseline – long lead-time microsatellites, non-responsive launch

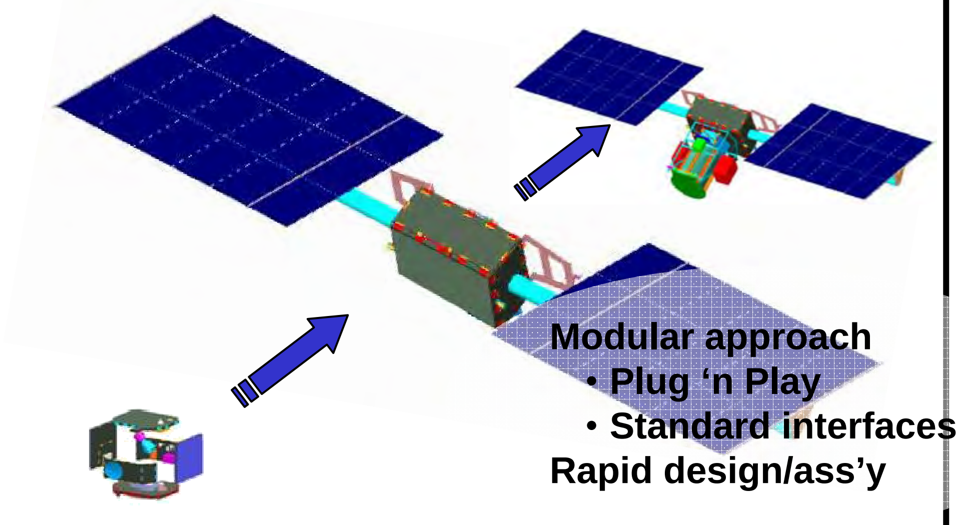


Near Term (thru 13)

Mid Term (14-18)

Far Term (19-25)

Multi-Mission, Low-Cost, Rapidly Developed Tactical Satellites



Far-Term Vision

- Rapid integration of new payloads & technologies using PnP architecture
- < $30M total mission cost
- < 12 month acquisition cycle
- Direct theater downlink and tasking
- Call up to operation < 6 days

Technology Challenges

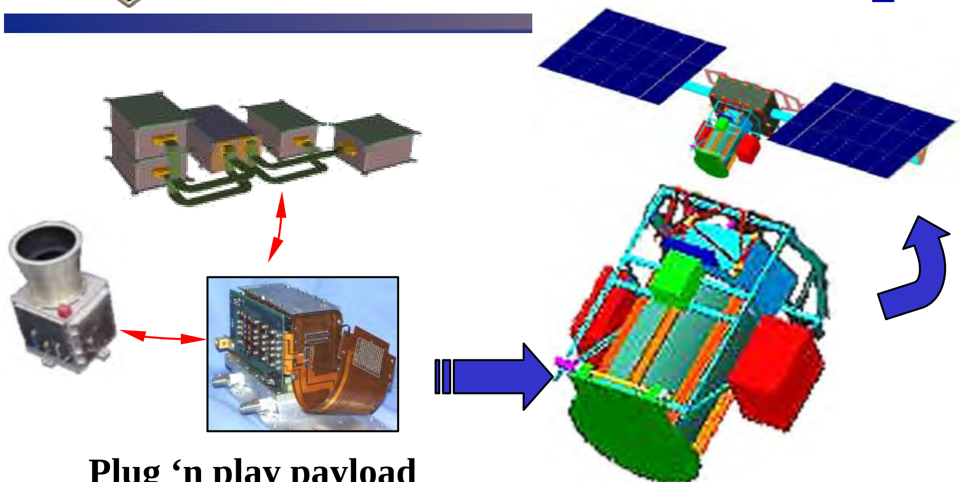
- Responsive avionics & software
  - Getting fast software faster
- Responsive/modular spacecraft bus
  - Driving responsiveness down the modular hierarchy
- Extreme miniaturization
  - Driving mass fraction of S/c bus down & performance up
- Reconfigurable communication
- Satellite system design & test tools

Mid-Term Demonstration (2013)

- Assemble TacSat bus and integrate with payload within one week
  - Structure
  - Power system
  - Propulsion
  - Avionics
  - Software

In Inventory…..Produced in Quantity……Employable in Hours

Multi-Mission, Low-Cost, Rapidly Developed Payloads



Plug 'n play payload components and subassemblies → Rapidly assembled spacecraft payload

Far-Term Vision

- The "real deal" PnP
- Ability to assemble payload within a day
- Eliminate custom interfaces, wiring harnesses, etc

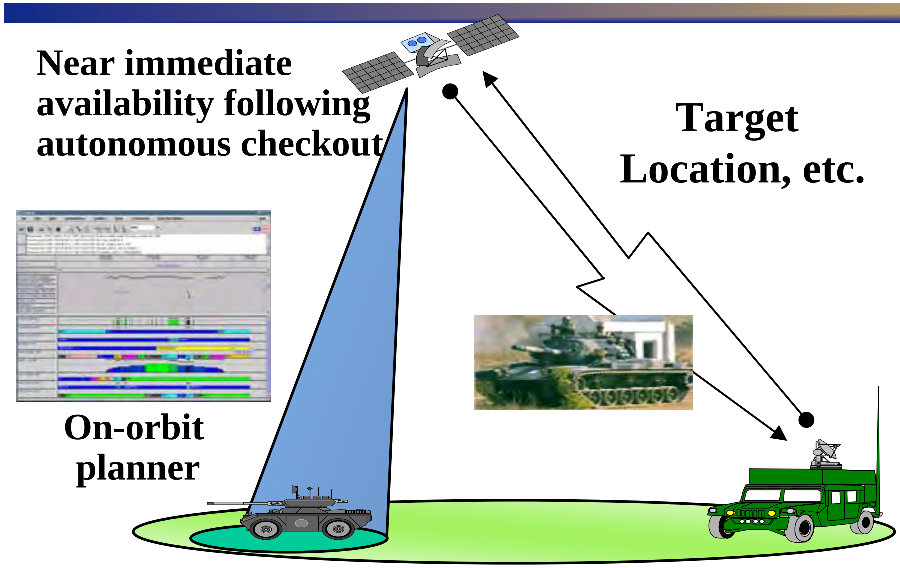
Technology Challenges

- Large, high-performance, light-weight RF apertures
- High-performance, light-weight mirrors and telescopes
- Advanced EO front-ends
- Advanced RF front-ends
- Miniature, high-performance signal/fusion processor
- Reconfigurable sensors/electronics

Mid-Term Demonstration (2013)

- Integrate TacSat payload within one week
  - Apertures
  - Front-end
  - Control and Processing
  - Bus Interface

Rapid S/C Checkout and Autonomous Operations



Far-Term Vision

- Autonomous on-board mission manager
  - Intelligent sensor control
  - Fault detection, isolation and resolution
  - Task decomposition and management
- Lights out ground operations
- Opportunistic real-time sensor control
  - Optimize data collection and downlink
- Collaborative decision making across multiple satellite bodies

Technology Challenges

- On-orbit checkout
  - Development of algorithms to support complex missions/vehicles
- On-board planning and reconfiguration
- Autonomous mission managers
- Inter-satellite/object collaboration
- On-orbit robotic refueling, reconfiguring, and repair

Mid-Term Demonstration (2012)

- On-orbit processing of sensor data
  - 80% percent of ISR data processed
- Autonomous re-tasking of satellite based on processed sensor data
- On-board cross-cueing between sensors
  - At least two sensors working cooperatively
- Autonomous TacSat two ship performing complex mission

Generate On-Demand, Reusable Affordable Space Access

Far-Term Vision

- Horizontal takeoff/landing fully reusable vehicle
  - Turbine Based Combined Cycle (TBCC) 1st stage
  - Rocket Based Combined Cycle (RBCC) 2nd stage
- Up to 40K lbs to LEO
- Rapid turn, 4 hrs or less
- 100X lower ops cost
- Vehicle reliability 0.9998
- All weather availability
- 1000 sortie airframe

Technology Challenges

- Reusable, long-life, operable propulsion, airframe, thermal protection systems (TPS) and seals repairable in hours with 100s mission life
- Low cost, reliable expendable upper stage
- Autonomous and adaptive GN&C for take-off, ops & landings
- 48 hour call-up mission planning
- Highly reliable Integrated System Health Monitoring for in-flight trajectory modification

Mid-Term Demonstration

- ARES hybrid launch vehicle (2017)
  - reusable 1st stage vertical takeoff
  - 10K lbs to LEO
- Reusable 2nd Stage (2025)
  - RBCC
  - 40% P/l increase
- Reusable horizontal takeoff 1st stage (2025)
  - TBCC
  - Flexible basing 10K lbs to LEO

Responsive Range

Technology Challenges

- Robust, low-cost flight termination system
  - Autonomous flight safety systems
  - Space-based communications
  - GPS/INS to eliminate need for ground-based tracking assets
  - Eliminate components that need to be recertified and tested on a regular basis
- Rapid trajectory analysis
  - Optimizing trajectories in real time
  - Rapid calculation of range safety corridors
- Unmanned surveillance tools for continuous observation of launch area
- Autonomous Flight Safety System
  - Rule-based logic to emulate human-in the-loop flight safety decision processes
  - Flight qualification and range safety certification
- Transportable/deployable range assets
  - Integrating assets with existing ranges
  - Maintaining assets in a state of readiness to support responsive missions

Opportunities for Industry

- **Broad Agency Announcement**

http://vsearch2.fbo.gov/servlet/SearchServlet

- **Small Business Innovative Research**

http://www.sbirsttrmall.com/Portal.aspx

- **Cooperative Research and Development Agreements**

http://www.vs.afrl.af.mil/TechOutreach/TT/CRADA.aspx

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Battle Command Requirements and Technical Challenges

Presented by
Gary P. Martin
Technical Director
Communications Electronics Research, Development and Engineering Center (CERDEC)
Research Development and Engineering Command (RDECOM)
gary.martin2@us.army.mil

19 Apr 2006

US ARMY – RDECOM

Outline

- Battle Command
- Network considerations
- Implications of the Future Network
- Challenges
- Summary

Definition of Battle Command

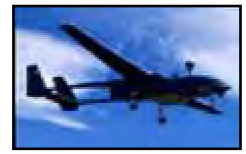
- Battle Command is the ability to envision the tactical military objectives, translate the vision into an intent, formulate courses of action, and provide the force of will to concentrate overwhelming combat power at the right time and place to win decisively with minimal casualties

- Battle Command competencies:
  - Seeing the enemy
  - Seeing yourself
  - Seeing the Terrain
  - Visualizing the battle
  - Seeing into the future

Commanders must not be prisoners of a static command post.
They must go where they can assess the risks and make adjustments by seeing, hearing, and understanding what is occurring.

C4ISR Missions

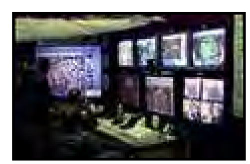

Intelligence Systems


Surveillance Systems


Reconnaissance Systems

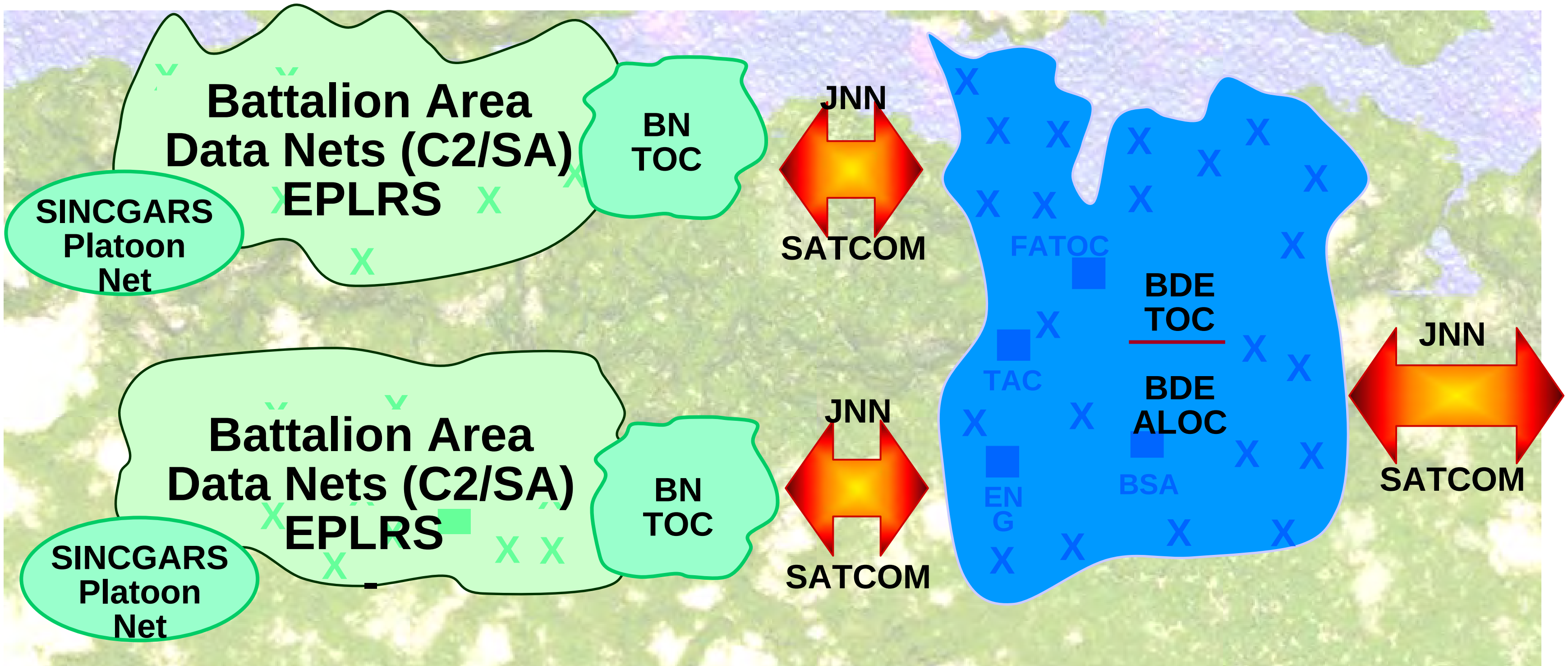

Communication Systems


Computers


Command and Control Systems

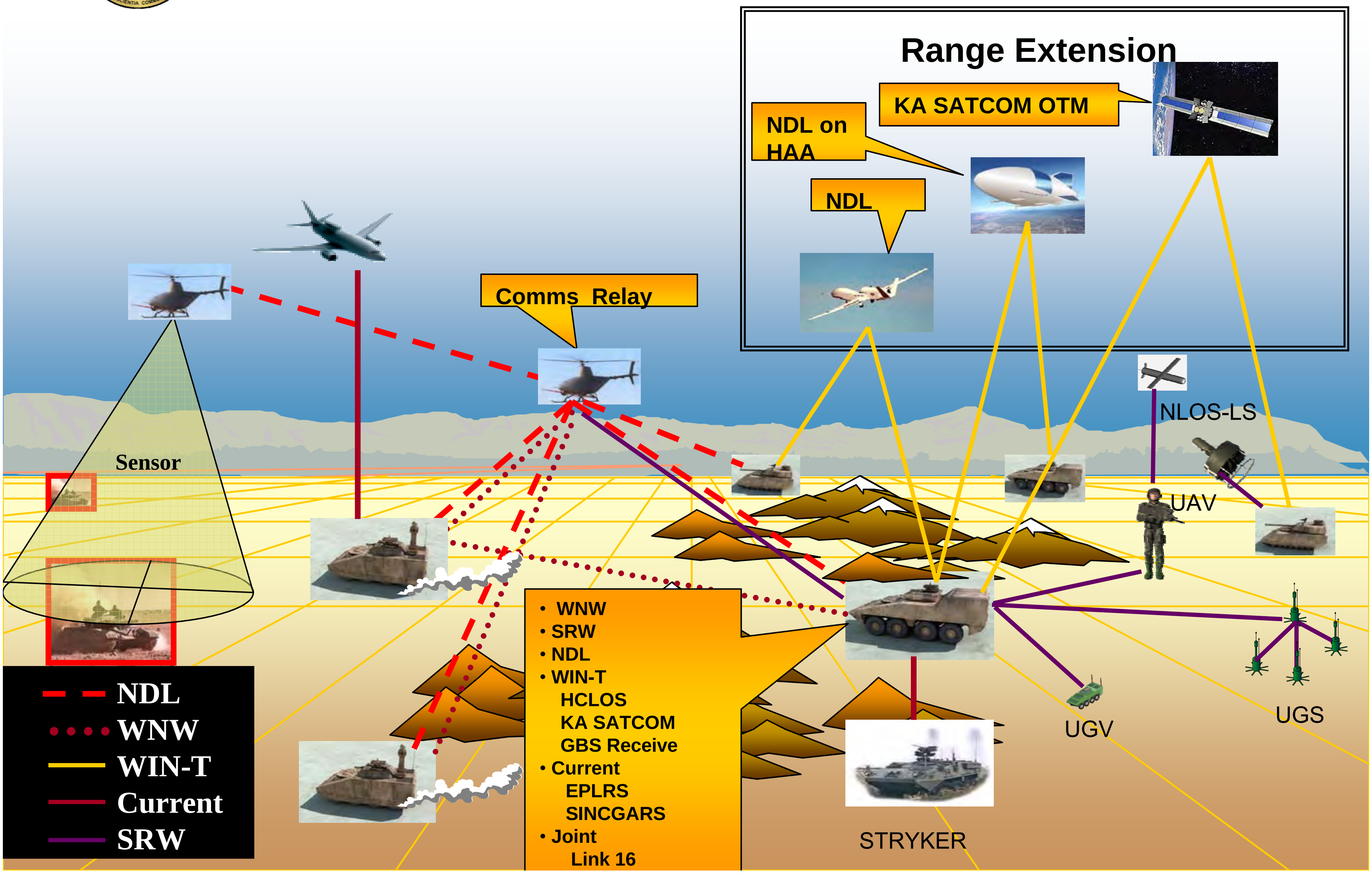
C4ISR

Network Challenges – Today's Network



- Limited bandwidth
- Line of sight communications
- Static TOCs (limited mobility)
- Difficult to initialize and manage

The Future Army Network



Technology Needs and Enablers

- Mobile Ad-HOC Networking Systems
- Affordable on-the-move satellite solutions
- Broad-band, multi-port, omni directional antennas
- Broadband, power efficient amplifiers
- Network aware Adaptive applications
- Sensor Management/tasking
  - Data Compression (especially for Sensor data)
  - Onboard Processing at the Sensor
- Automated decision aids

Operational Considerations

- Robotic and unmanned Systems
  - Management and tasking
  - Autonomous operation
  - Synchronization

- Sensor fidelity and adjustability to mission needs

- Fusion/Knowledge Management

- Tailorable COP

- Intelligent use of all communications systems

Future Considerations

- Better use of Available Frequency Spectrum
  - Move to more spectrally efficient technologies
  - Processing of data prior to transmission
- Connectivity
  - Network design Matters
  - Increased use of SATCOM or aerial relays for extending the range of terrestrial network
- Enhanced Interoperability
  - Gateways versus backward compatibility
- Simplification of Network Operation
  - Use of interoperable routing, network management, Information assurance, quality of service, and mobility protocols

Information Assurance

- Role Based Access & Control
- Identification, Authentication, Authorization, Accounting (IAAA)
  - PKI Certificate Services
  - Biometrics
- Database / Data Encryption
- Information Authentication
- Automated Intrusion Detection and Response
  - Antivirus sensor
  - Malicious code detection and intrusion correlation
  - Attack response
- Information Warfare Survivability

A Few Realities

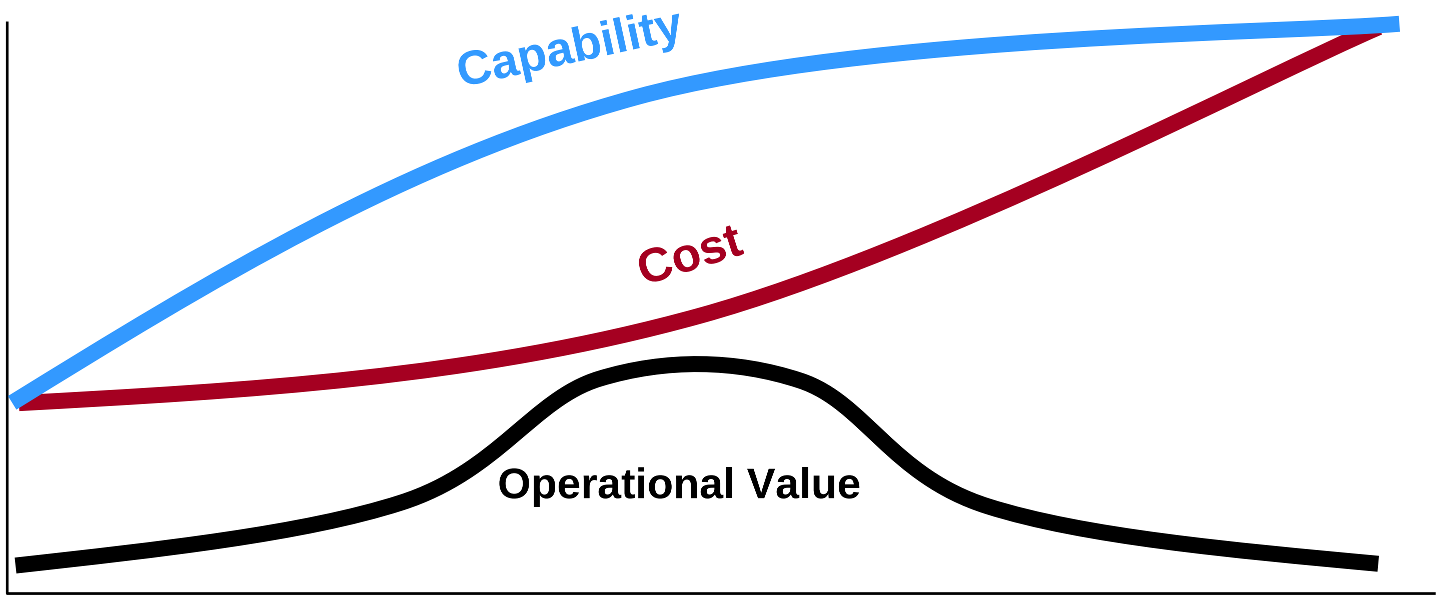
- Network designs need to optimize across dimensions of connectivity, robustness, and bandwidth
  - Trades required – we cannot maximize all three
  - Ad-hoc networking waveforms are required but insufficient to enable network centric operations

- There is significant trade space along dimensions of technical features, development costs, procurement costs, operating costs, and performance

- If the network is to provide protection equal to 20 tons of cold, hard, rolled steel, then the network must be “hard as steel”

- There is a dimension of “Art” in effective battle command. Technology alone will not achieve the objectives of Future Force Battle Command

Cost Versus Capability



Legacy Networks (NTDR, EPLRS, SINCGARS, …)

Appropriate mix of terrestrial, aerial and satcom networks (multi-tiered)

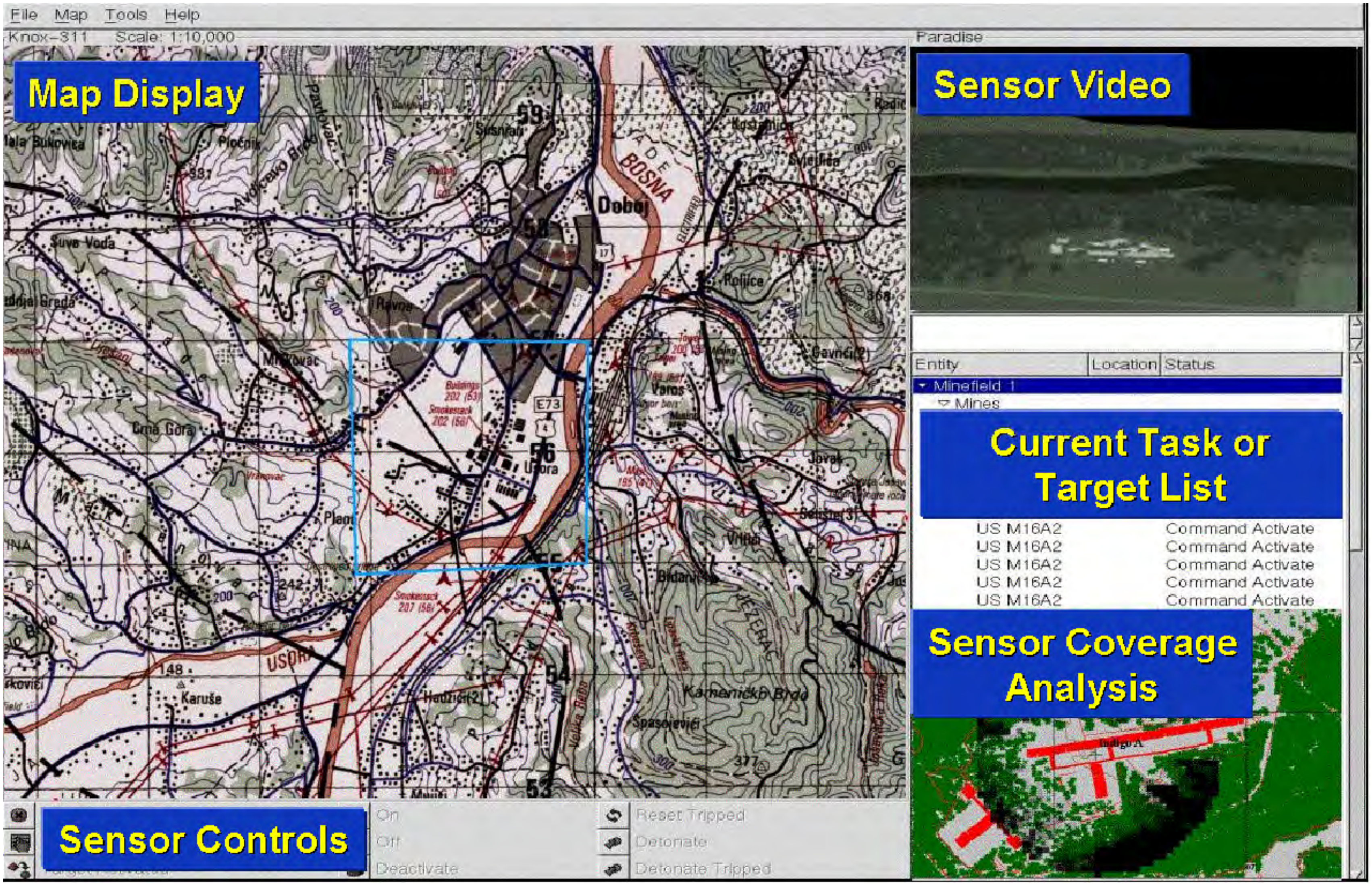
Large Terrestrial Nets with Ad-Hoc Networked Waveforms (WNW, SRW, …)

As the system becomes more complex, it reaches a point beyond which small increases in capability require very large increases in cost (development, procurement and operational).
Where is the maximum Value, which equals Capability / Cost?

The Urban Operations Challenge

★CERDEC
US ARMY – RDECOM

Situational Understanding



Tomorrow's Warfighter

Definition of Battle Command

- Battle Command is the ability to ***envision*** the tactical military objectives, ***translate the vision into an intent***, formulate ***courses of action***, and provide the force of will to concentrate overwhelming combat power at the right time and place to win decisively with minimal casualties

- Battle Command competencies:
  - Seeing the enemy
  - Seeing yourself
  - Seeing the Terrain
  - Visualizing the battle
  - Seeing into the future

This is Hard to do and it takes a seasoned Leader to do well!!

CERDEC
US ARMY – RDECOM

Summary

- Network Centricity is complex but essential to supporting mobile battle command.
- There are many dimension to solving the Battle Command Challenge (technical and operational)
- I contend that Network connectivity and Information security are the most critical challenges
- Trades are needed to ensure the right balance is achieved between technology, capability and “art”

THE AIR FORCE RESEARCH LABORATORY

LEAD | DISCOVER | DEVELOP | DELIVER

Air Force Future S&T Challenges Overview

Mr. Les McFawn
Executive Director
Air Force Research Laboratory

Outline

- **AFRL Overview**
- S&T Investment Development Challenges
- Focused Long Term Challenges (FLTCs)
- Strategic Technologies
- Industry Initiatives

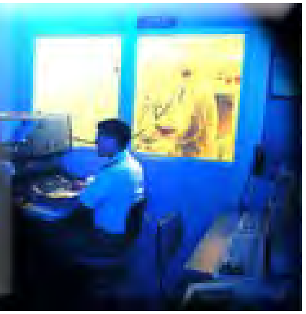
AFRL Mission

Lead **the discovery, development, and integration of affordable warfighting technologies for our air and space force.**

It's not just about the science…
…it's about *leadership* in S&T

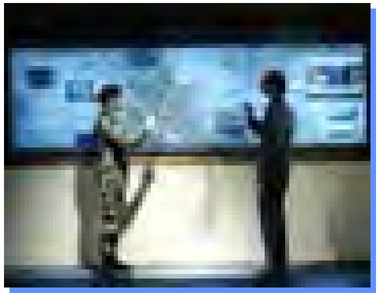
AFRL Organization

AFOSR



Human Effectiveness

Information



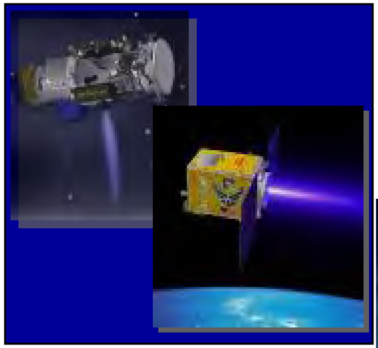
Air Vehicles

Sensors

Directed Energy

Materials & Manufacturing

Space Vehicles

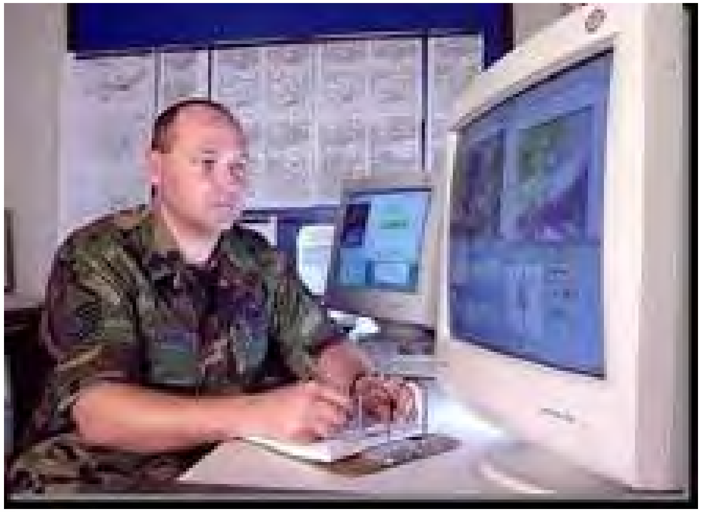


Propulsion & Power

Munitions

AFRL People & Facilities

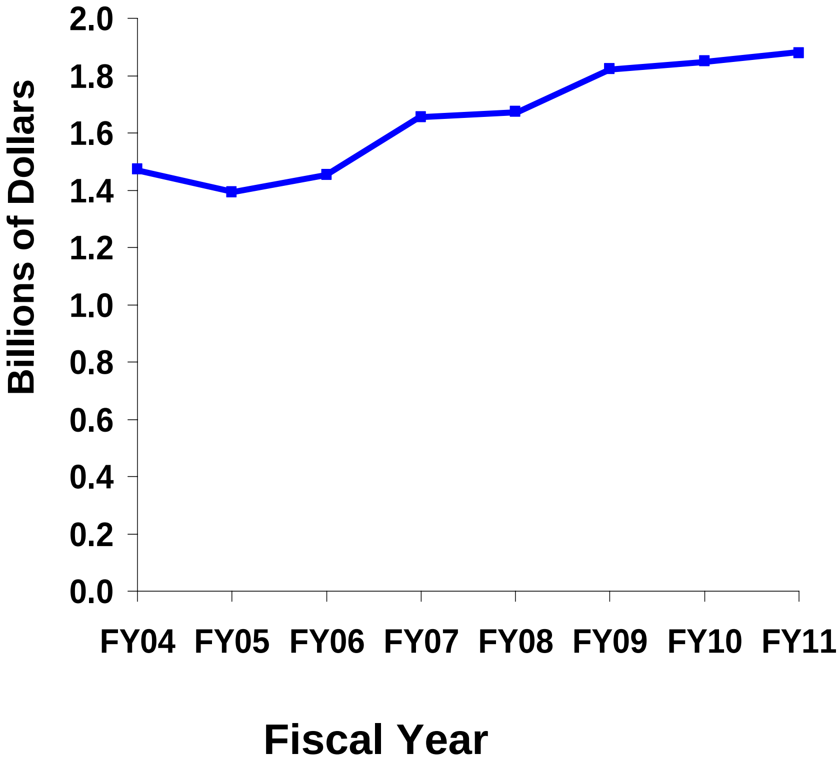
- **AFRL Workforce: 9608 Government / Contractor**



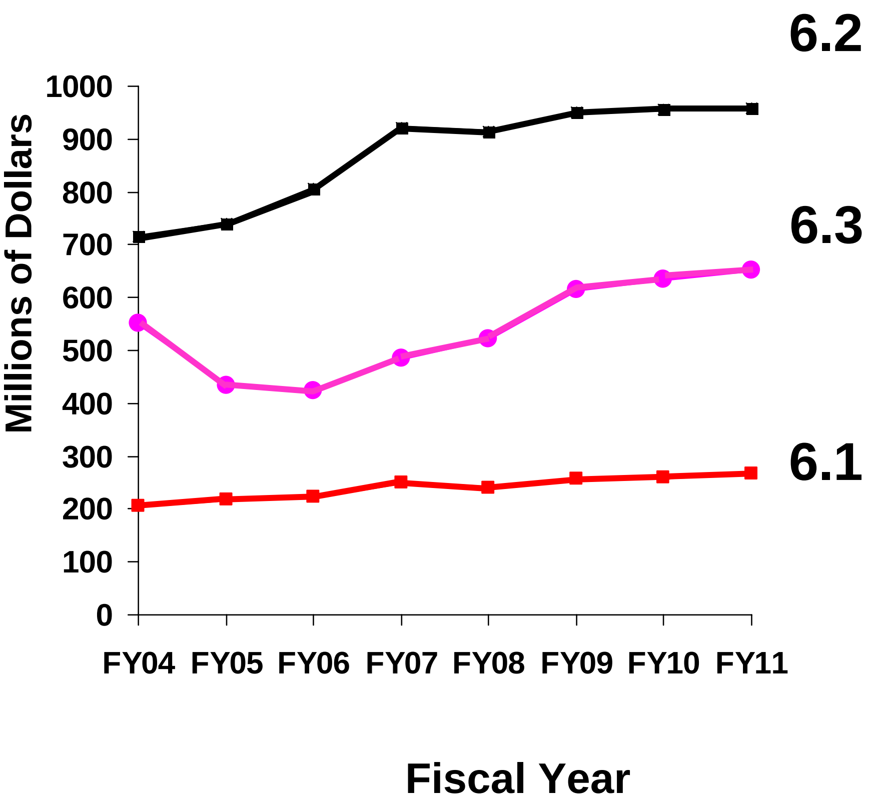
- **10 Major R&D Sites across US**
- **40 Sites World-Wide**

Funding Outlook
FY07 President's Budget

Core S&T Funds Total



Core S&T By Budget Authority



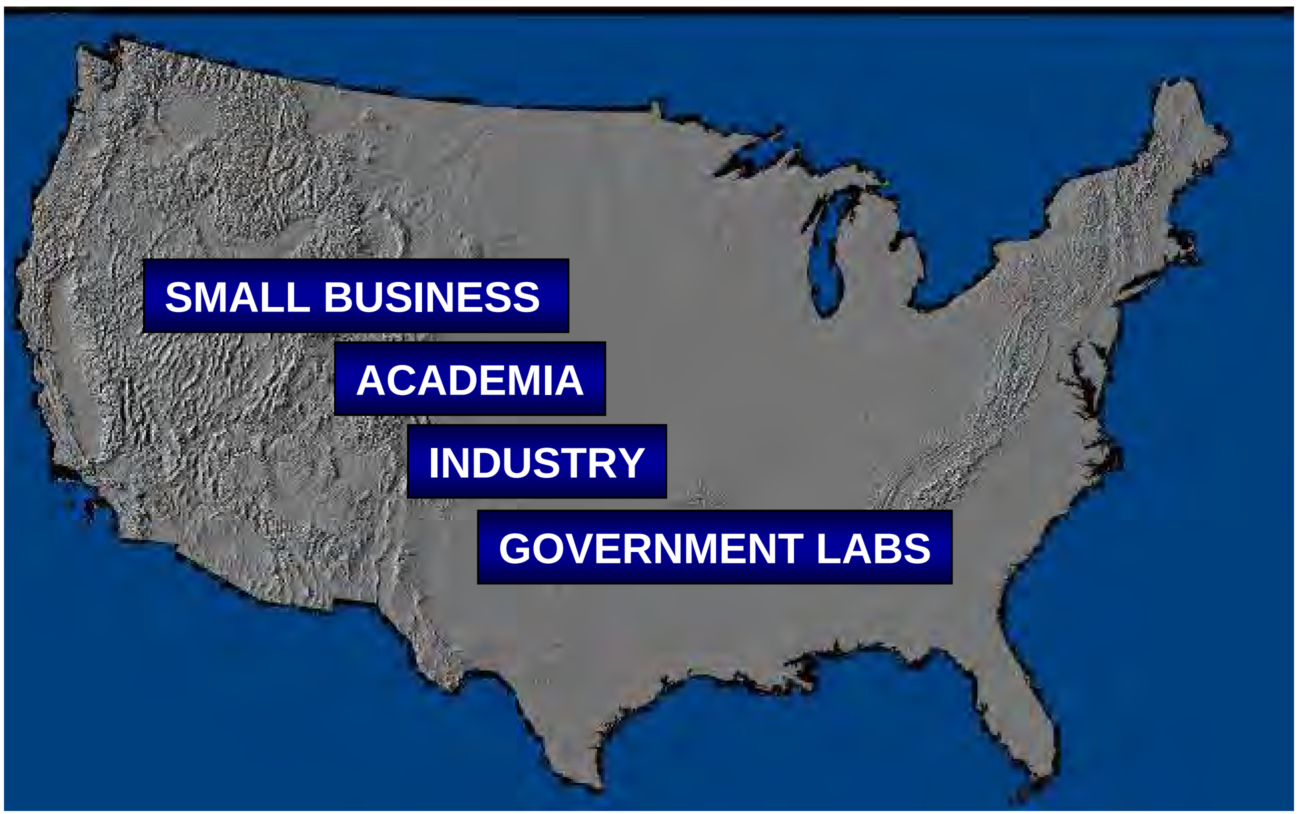
Funding Leverage

AFRL
$1.9 Billion
3,488 S&Es

+

DoD Funds
$1.7 Billion

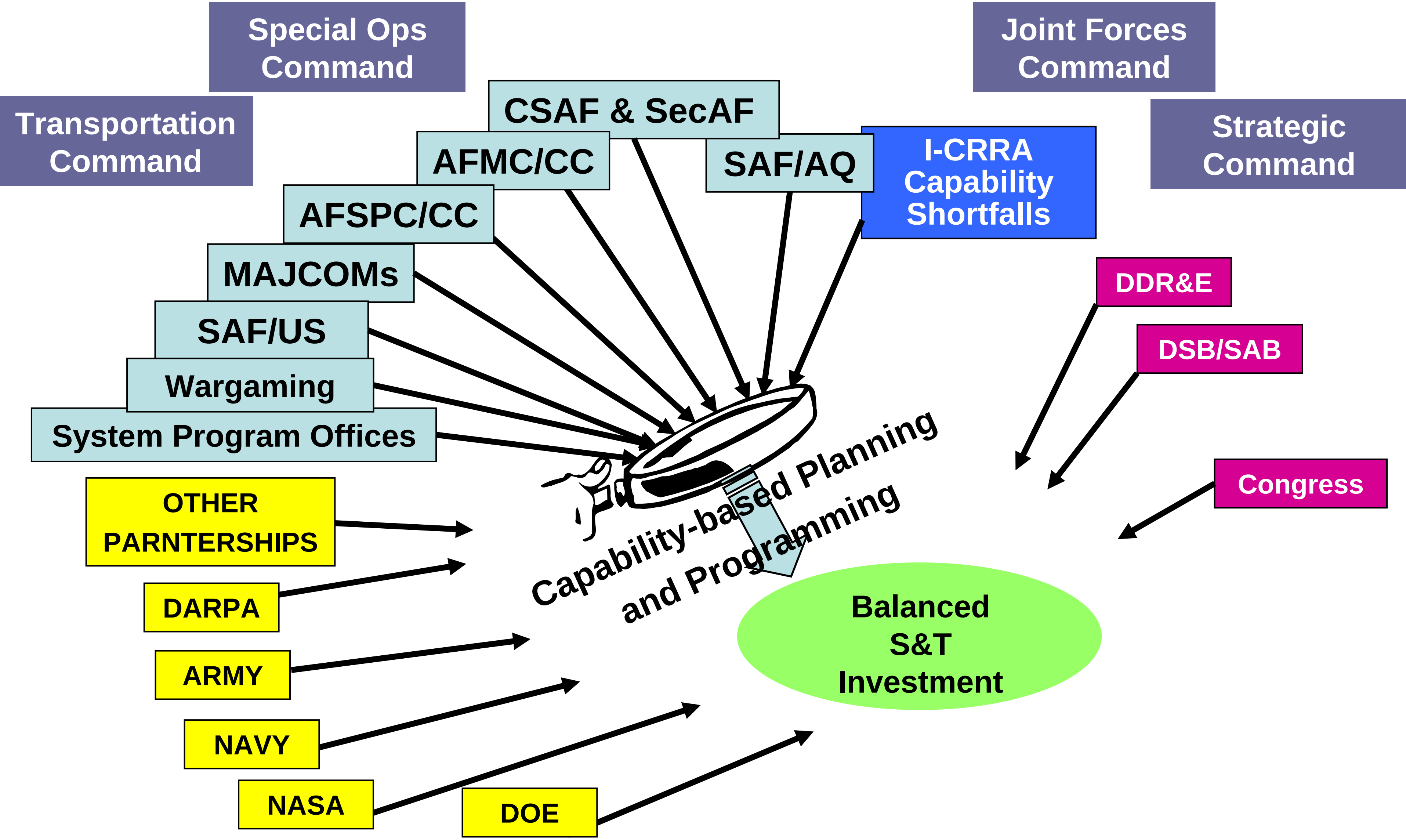
Thousands of Knowledge Providers



Outline

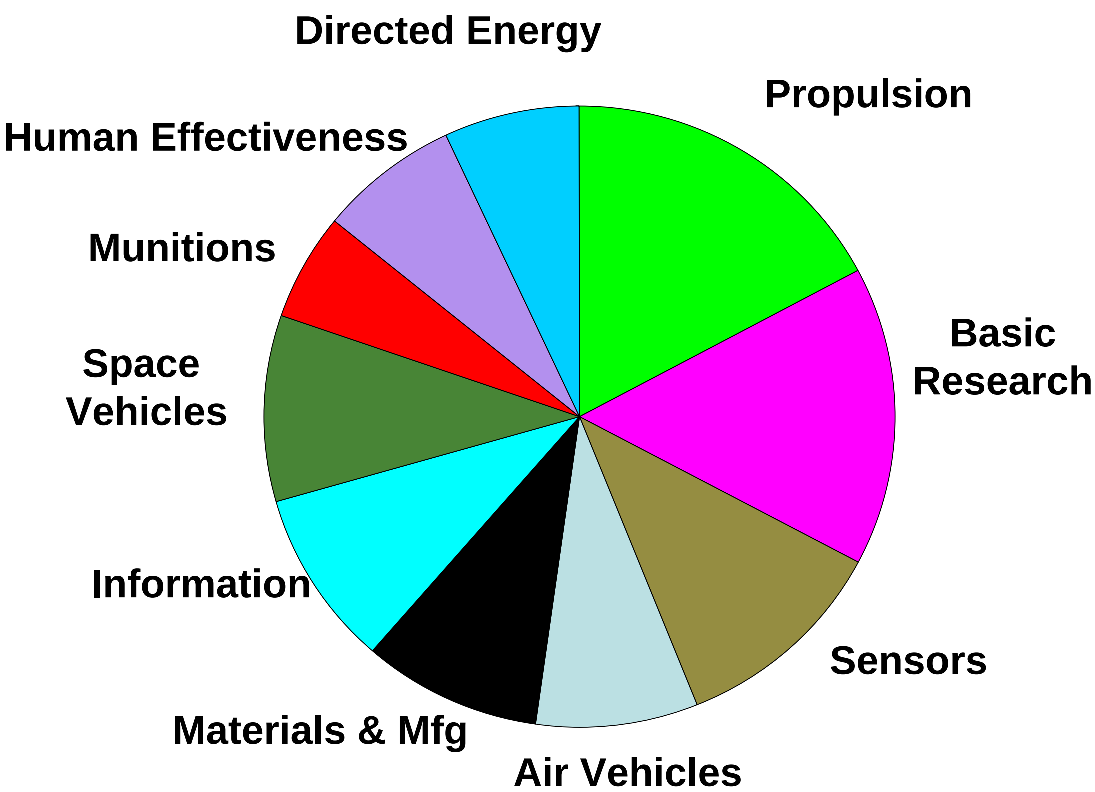
- AFRL Overview
- **S&T Investment Development Challenges**
- Focused Long Term Challenges (FLTCs)
- Strategic Technologies
- Industry Initiatives

S&T Investment Development is A Challenge!



Balanced S&T Investment

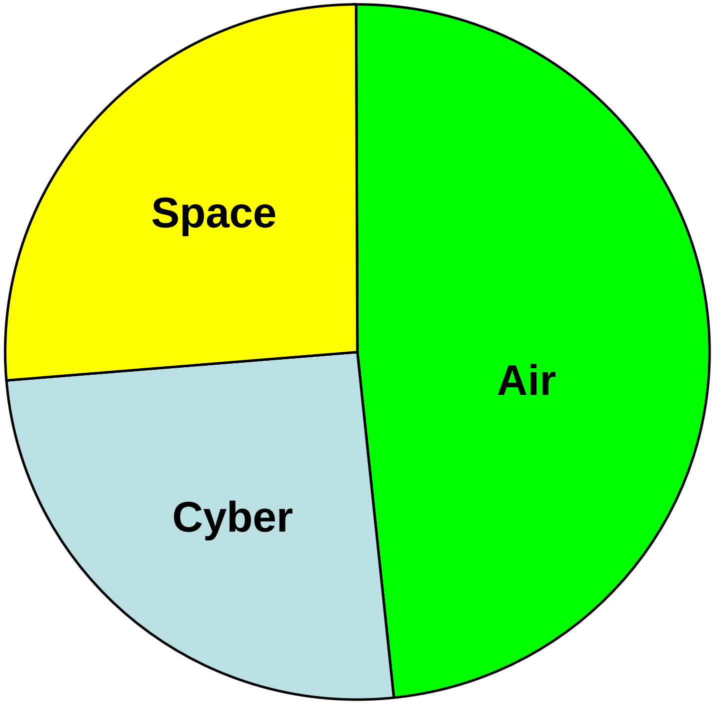
Technology View



TOTAL FY06: $1.454 Billion

Balanced S&T Investment

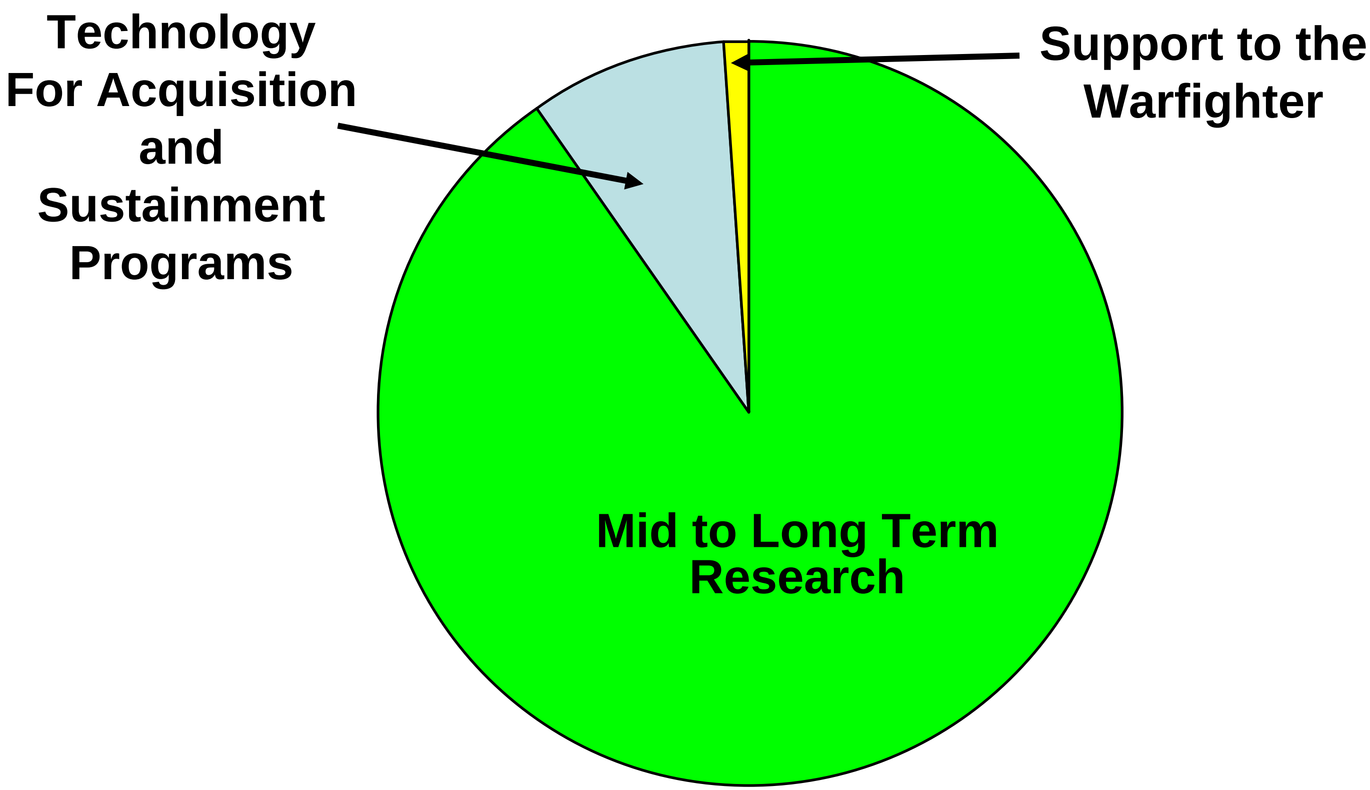
Domain View



TOTAL FY06: $1.454B

Balanced S&T Investment

Time Horizon View



TOTAL FY06: $1.454 Billion

8 NOV 05

AFRL Support to Warfighter

Driven by Urgent Needs…

AFRL Advanced Technology Development

Advanced Technology Demonstrations (ATD)

Advanced Concept Technology Demonstrations (ACTD)

External Customers

Direct Support

Manufacturing Technology

Driven by Acquisition and Sustainment Needs….

AFRL Basic & Applied Research

Long Range Strike

Sensor Craft
Persistent ISR

CAOC of the Future

Reusable Launch Vehicle
Rapid Access to Space

Enables Future Transformational Capabilities

Driven by Capability Planning & Technology Opportunities

Outline

- AFRL Overview
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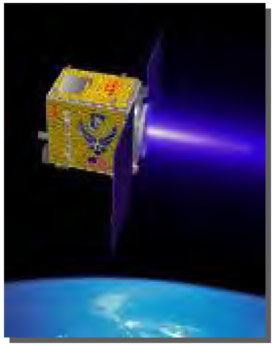
AF Technology Vision

CORONA Top, Jul 05

Anticipate, Find, Fix, Track, Target, Engage, Assess – Anything, Anytime, Anywhere

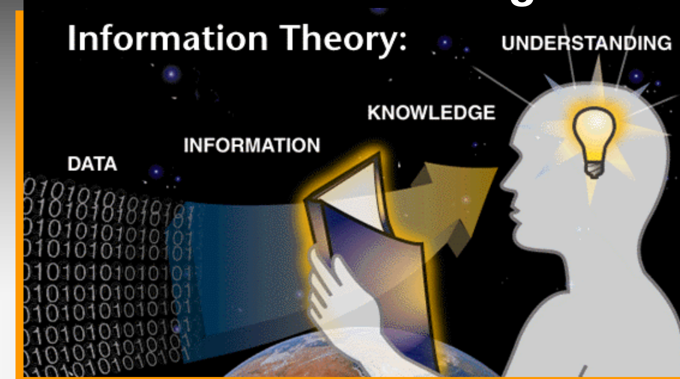


Energized By Focused Long Term Challenge (FLTC) Plans

FLTC #1

Anticipate Enemy Actions and Respond with Synchronized Management of Battlespace Effects

Understanding

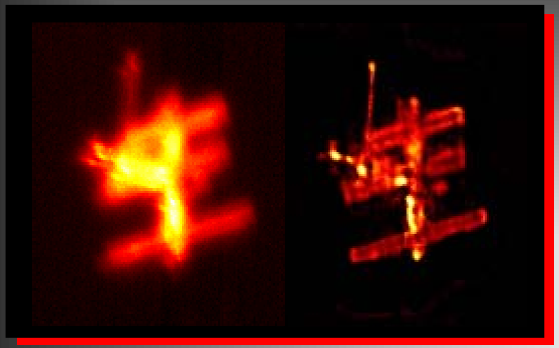


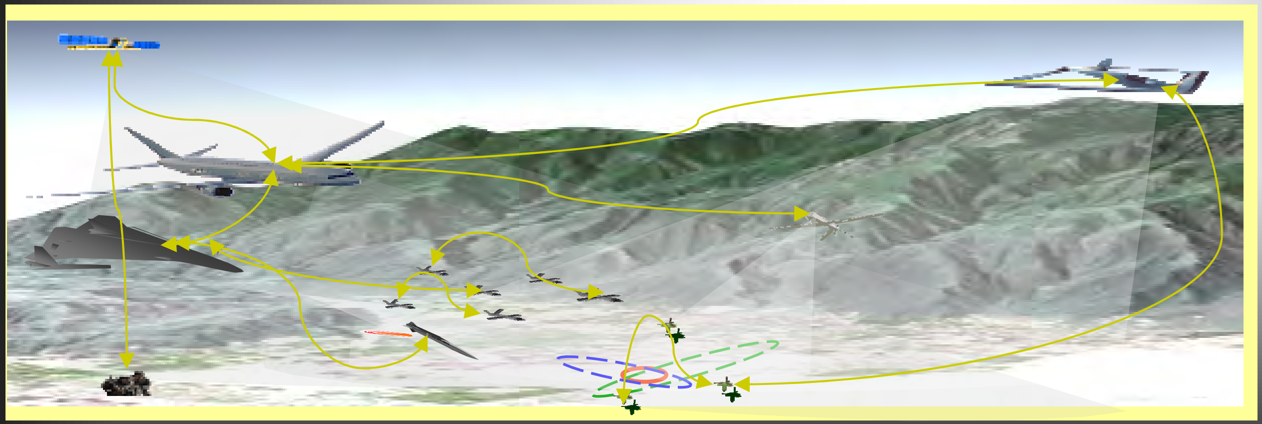
Building

Strategizing

FLTC #2

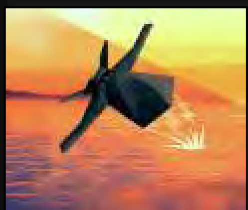
Proactively Find, Fix, and Track Anything, Anytime, Anywhere with Agile and Immediate C4ISR

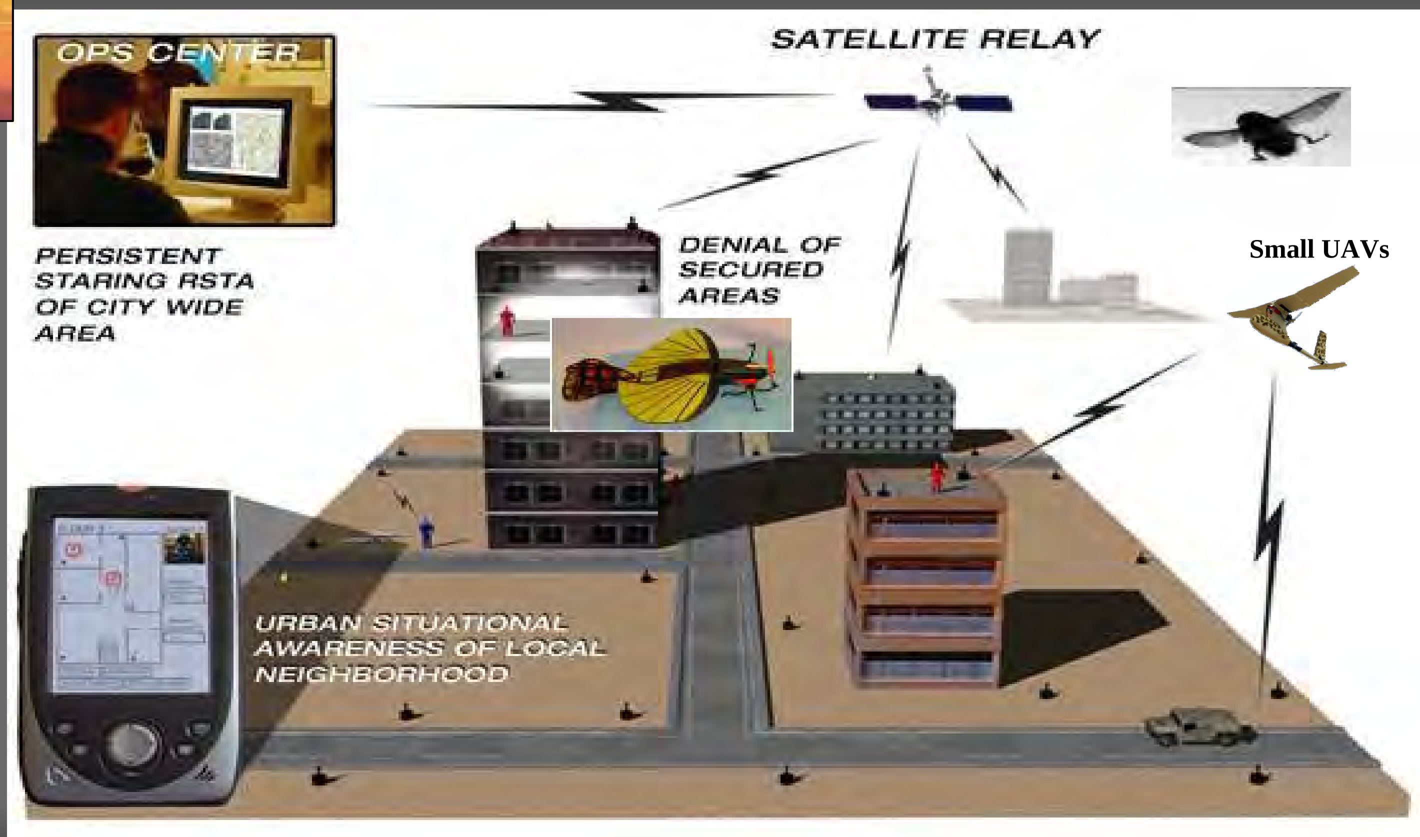




FLTC #3

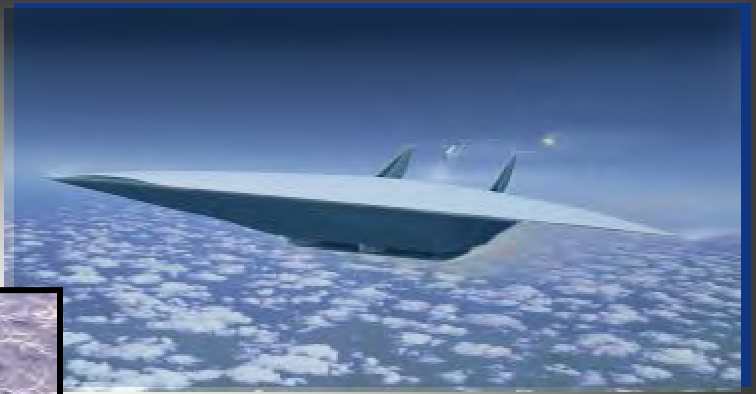
Detect, Tag, Track, Identify, Target Adversaries, IEDs, CBRNE in Congested or Concealed Environments and Create Desired Effects





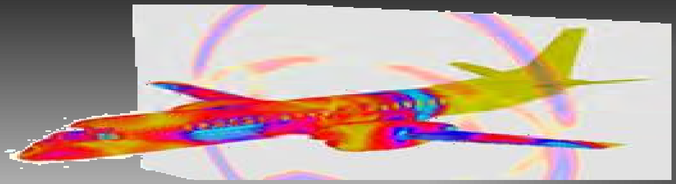
FLTC #4

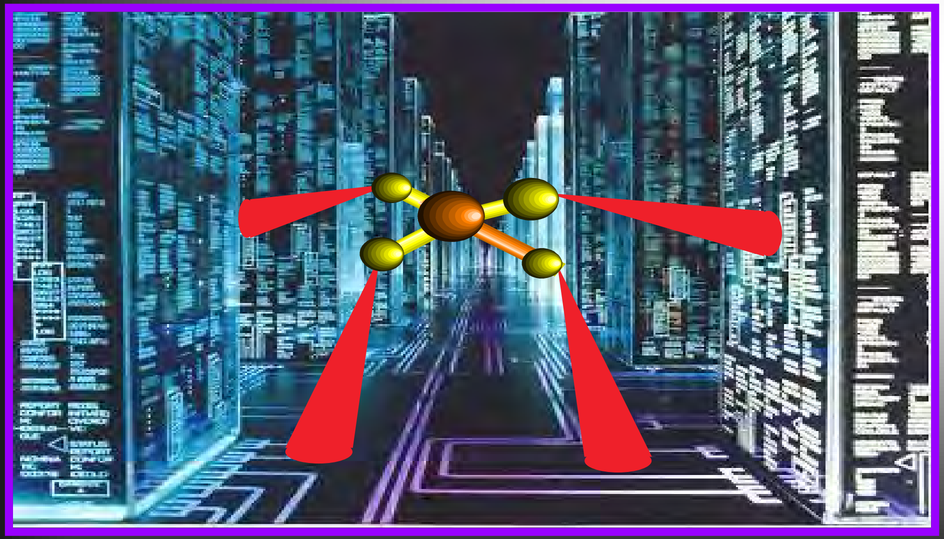
Maneuver Through Anti-Access/Area Denied Environments to Deliver Effects Rapidly and/or Persistently

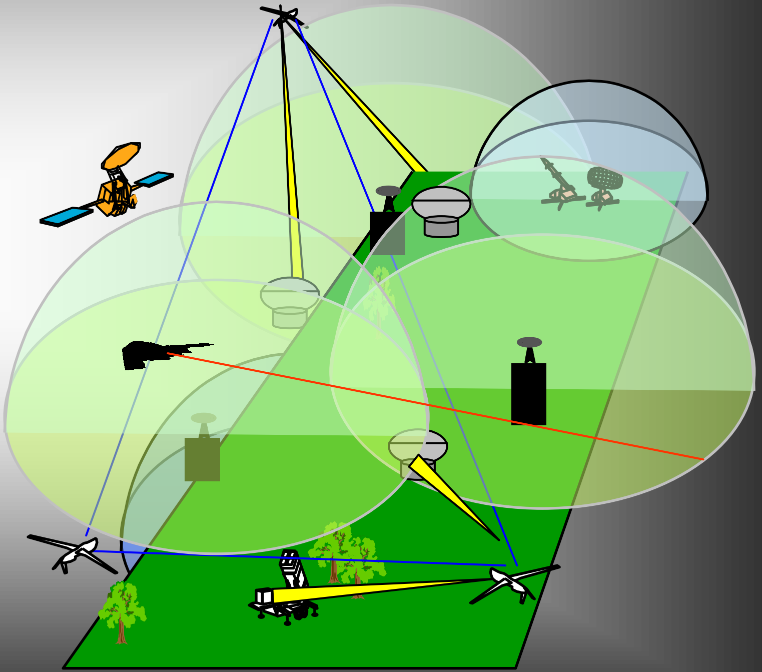


FLTC #5

Achieve Mission Objectives With Impunity Against Full Spectrum Threats, from Anti-Access IADS to Cyber

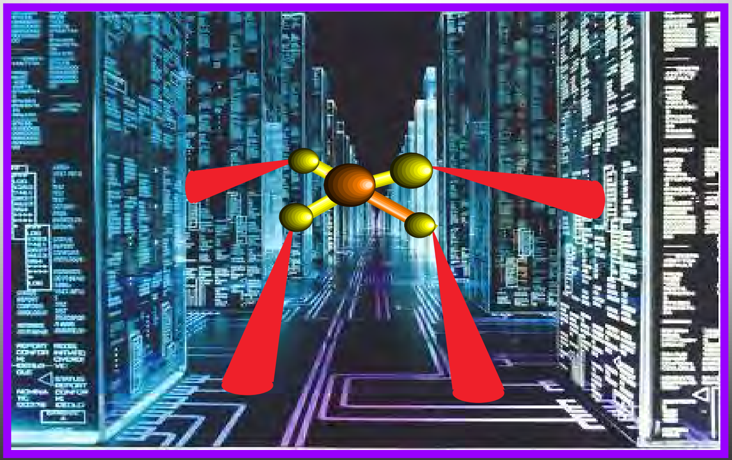






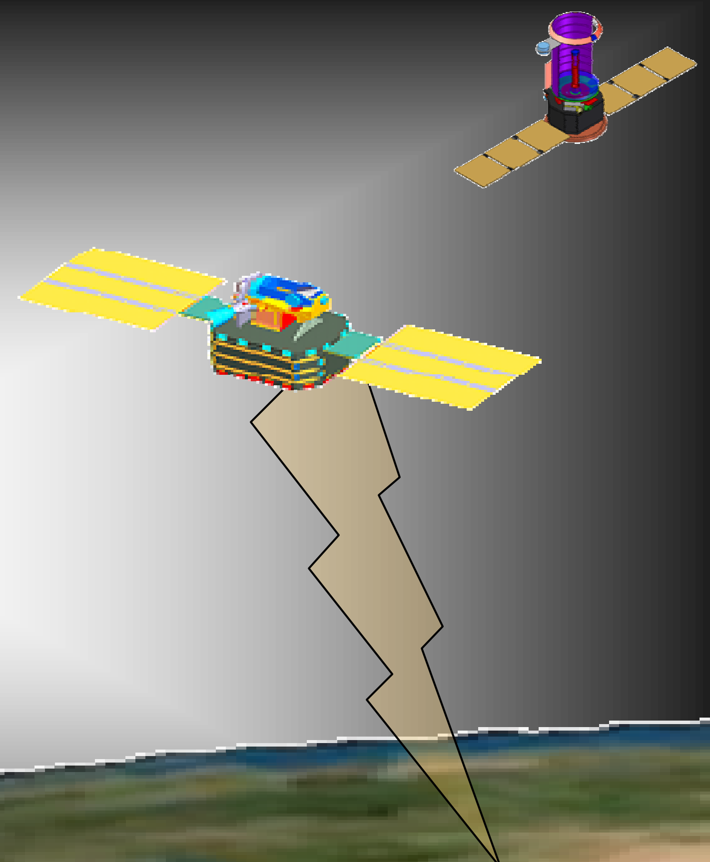
FLTC #6

Conduct Full Spectrum Offensive Cyber/Info Ops Against Military, Leadership, and Infrastructure



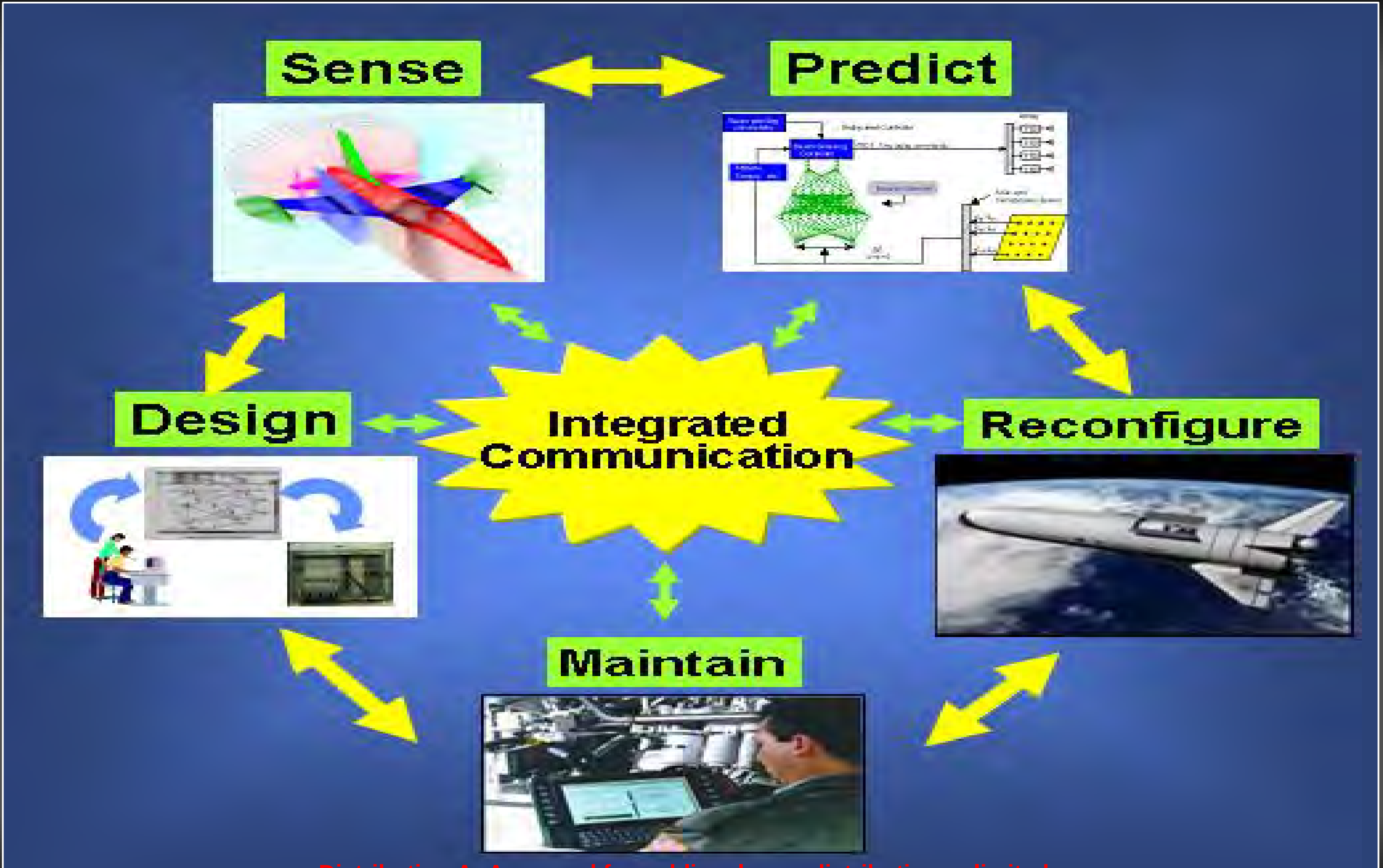
FLTC #7

Timely Deployment of Flexible Ground, Information & Space Capabilities for the Theater Commander



FLTC #8

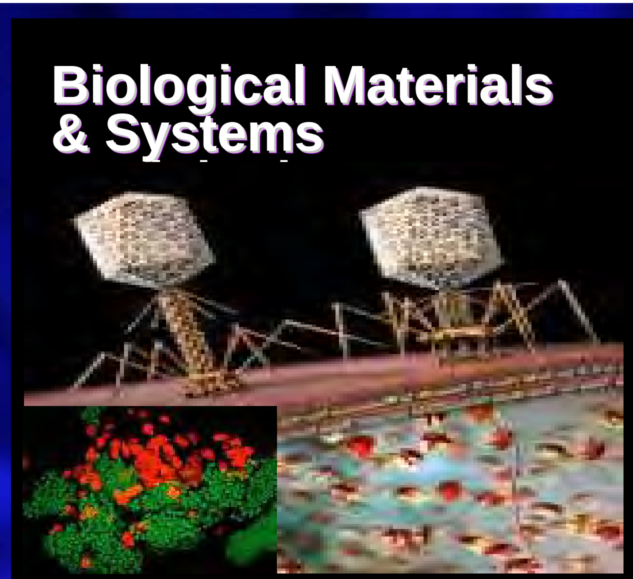
Maximize Mission Capability and Attack O&S Costs by Embedding Robust Reliability and Predictable Readiness



Outline

- AFRL Overview
- S&T Investment Development Challenges
- Focused Long Term Challenges (FLTCs)
- **Strategic Technologies**
- Industry Initiatives

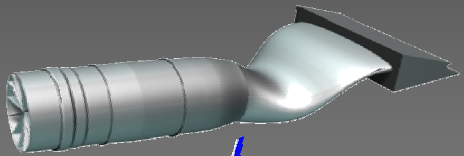
Strategic Technologies

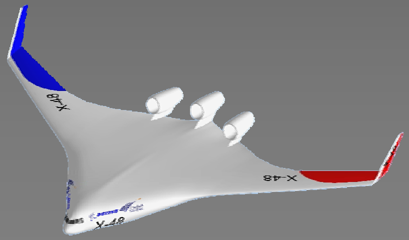


Fuel Initiatives
Current Investment Areas

Platform fuel efficiency

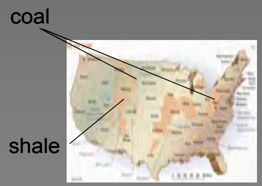
- Lightweight, efficient aero structures
- Advanced, fuel efficient turbine engine technology
- Lightweight, high temperature (engine applications) materials





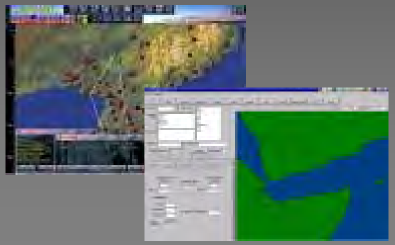
Alternative fuels

- Currently a small but critical effort in Fischer-Tropsch fuels



Conservation

- Improved simulator technology
- Improved mission/route planning



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- AFRL Overview
- S&T Investment Development Challenges
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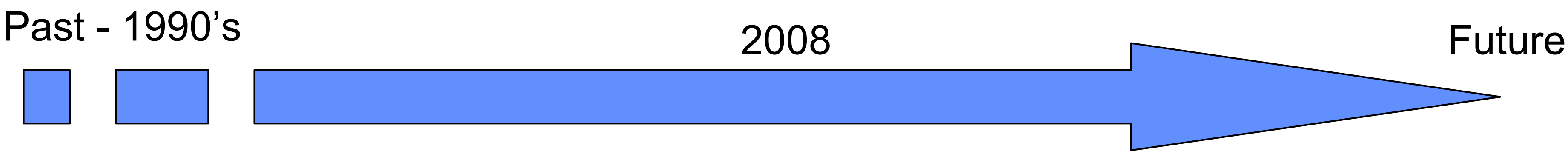
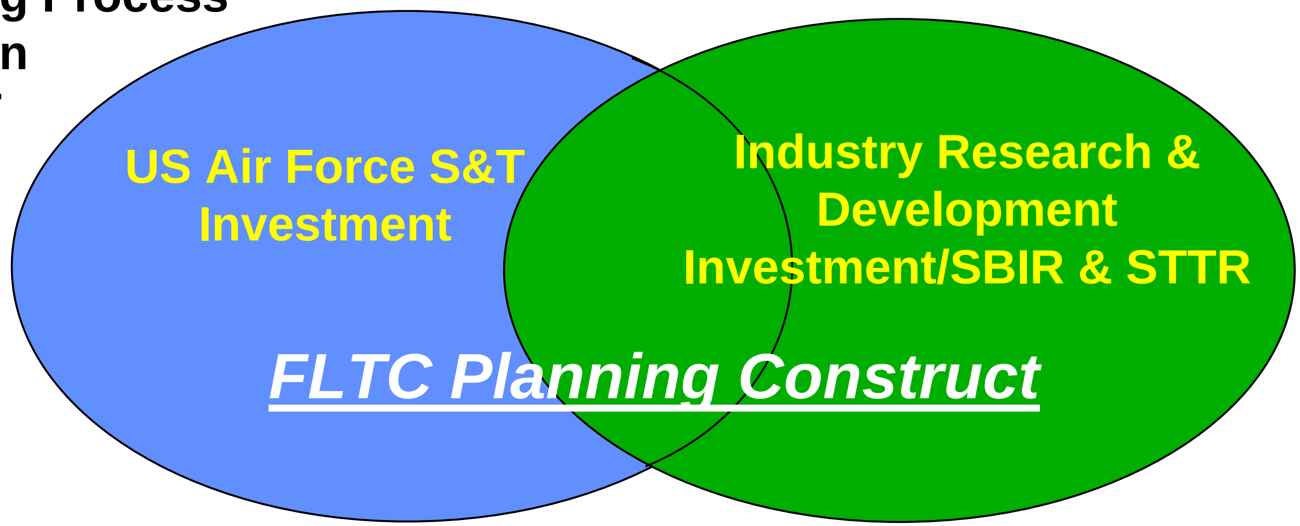
- Strategic Technologies
- **Industry Initiatives**

Linking to Industry IRAD Investments



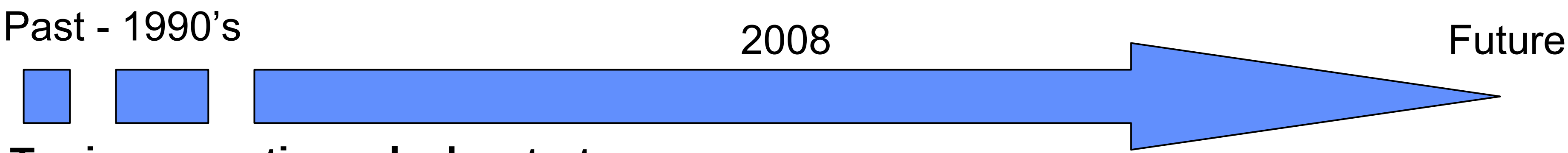
- IR&D Review Board
- Labor Intensive Scoring Process
- Limited Communication
- Limited Impact on S&T Investment



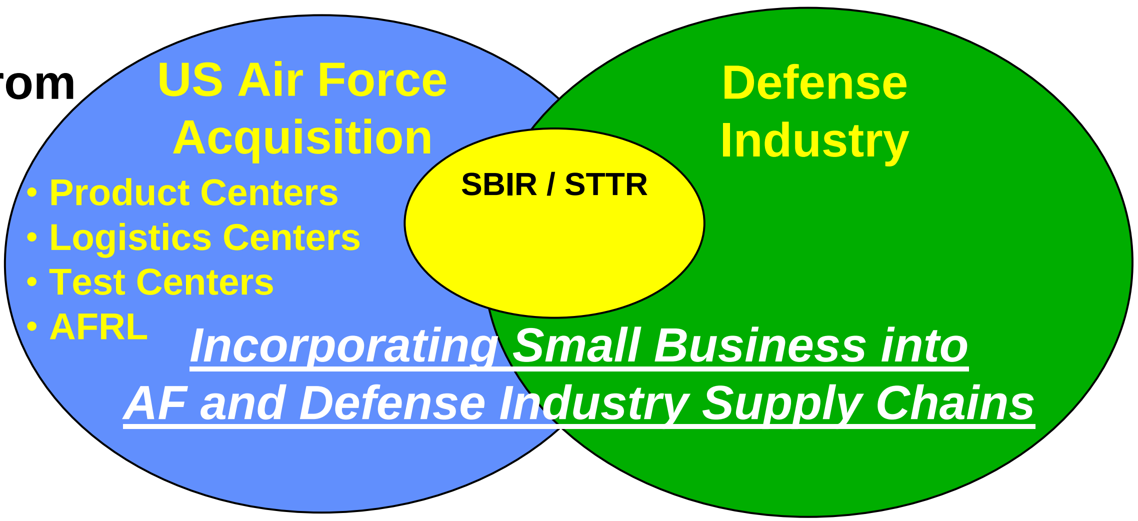
- ➢ Shared Vision & Roadmaps
- ➢ Single Voice To Industry
- ➢ Strategic IR&D Alignment
- ➢ Open and Active Lines of Communication
- ➢ Spanning Space, Air, Cyber and Weapons

SBIR/STTR

Infusing Small Business into the Acquisition Process



- **Topic generation -- lacks strategy**
- **Commercialization -- prime / SB connection weak**
- **Cycle time long -- ~540 days from topic call to award**



- ➢ **Lean- out plan under way**
- ➢ **Developing commercialization pilot to facilitate phase 2 to phase 3 transitions to acquisition**
- ➢ **Topics focused around Acquisition Focused Long Term Challenges and Strategic Technologies**

QUESTIONS?

Mr. Les McFawn
Executive Director
(937) 904-9100
www.afrl.af.mil

AFRL

THE AIR FORCE RESEARCH LABORATORY

LEAD | DISCOVER | DEVELOP | DELIVER

Sensor Challenges

19 April 2006

Dr. Paul McManamon
Chief Scientist, Sensors Directorate
Air Force Research Laboratory

Outline

- **AFRL Sensors Directorate Background**
- FLTCs and other Driving Forces for the Sensors Directorate
- Sensors Directorate Visions
- Summary

Sensors Directorate

Our Mission

To lead the discovery, development, and integration of affordable sensor and countermeasure technologies for our warfighters.

Our Vision

Robust sensors and adaptive countermeasures that guarantee complete freedom of air and space operations for our forces, and deny these capabilities to our adversaries at times and places of our choosing

Sensors Directorate

DIRECTOR
MR. J. SCIABICA 937-255-2620

DEPUTY DIRECTOR
COL G. HOPPER 937-255-2620

CHIEF SCIENTIST
DR. P. MCMANAMON 937-255-2620

ORG. DEVELOPMENT
(SNN) DR. D. SASARAK 937-255-4415

CHIEF ENGINEER
MR. F. PAUL JOHNSON 937-255-6502

INTEGRATION & OPERATIONS
(SNO) MR. D. TOMLINSON 937-255-6180

FINANCIAL MANAGEMENT
(SNF) MS. C. VAN VOORHIS 937-904-9291

CONTRACTING
(PKS) MS. D. SUCHECKI 937-255-0350

SECURITY
(SNY) MS. K. CATALANO 937-255-7208

AEROSPACE COMPONENTS & SUBSYSTEMS TECHNOLOGY
(SND)
MR. T. KASTLE 937-255-2911

ELECTROMAGNETIC TECHNOLOGY
(SNH)
DR. R. PAYNE 781-377-5129

RF SENSOR TECHNOLOGY
(SNR)
MR. W. MOORE 937-255-5218

EO SENSOR TECHNOLOGY
(SNJ)
COL R. GAUDETTE 937-255-4039

AUTOMATIC TARGET RECOGNITION (ATR) TECHNOLOGY
(SNA)
DR. M. BRYANT 937-255-4949

SIGNATURE TECHNOLOGY OFFICE
(SNS)
MR. W. CUZICK 937-255-9175

SENSOR APPLICATIONS & DEMONSTRATIONS
(SNZ)
LT COL C. GILMOUR (Act'g)
937-255-5418

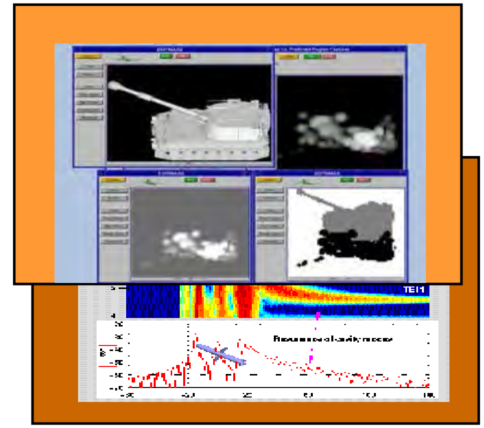
ANTI-TAMPER – SOFTWARE PROTECTION INITIATIVE OFFICE
(SNT)
MR. J. HUGHES 937-320-9068

Sensors Directorate Technology Thrusts

Radio Frequency Sensors & Countermeasures

Electro-Optical Sensors & Countermeasures

Automatic Target Recognition & Sensor Fusion



Application Sub-thrusts

- Battlespace Access
- Persistent ISR of the Battlespace
- Prosecution of Time Sensitive Targets

- Radio Frequency Apertures
- Algorithms & Phenomenology
- Digital Receivers & Exciters
- Reference Systems
- Components

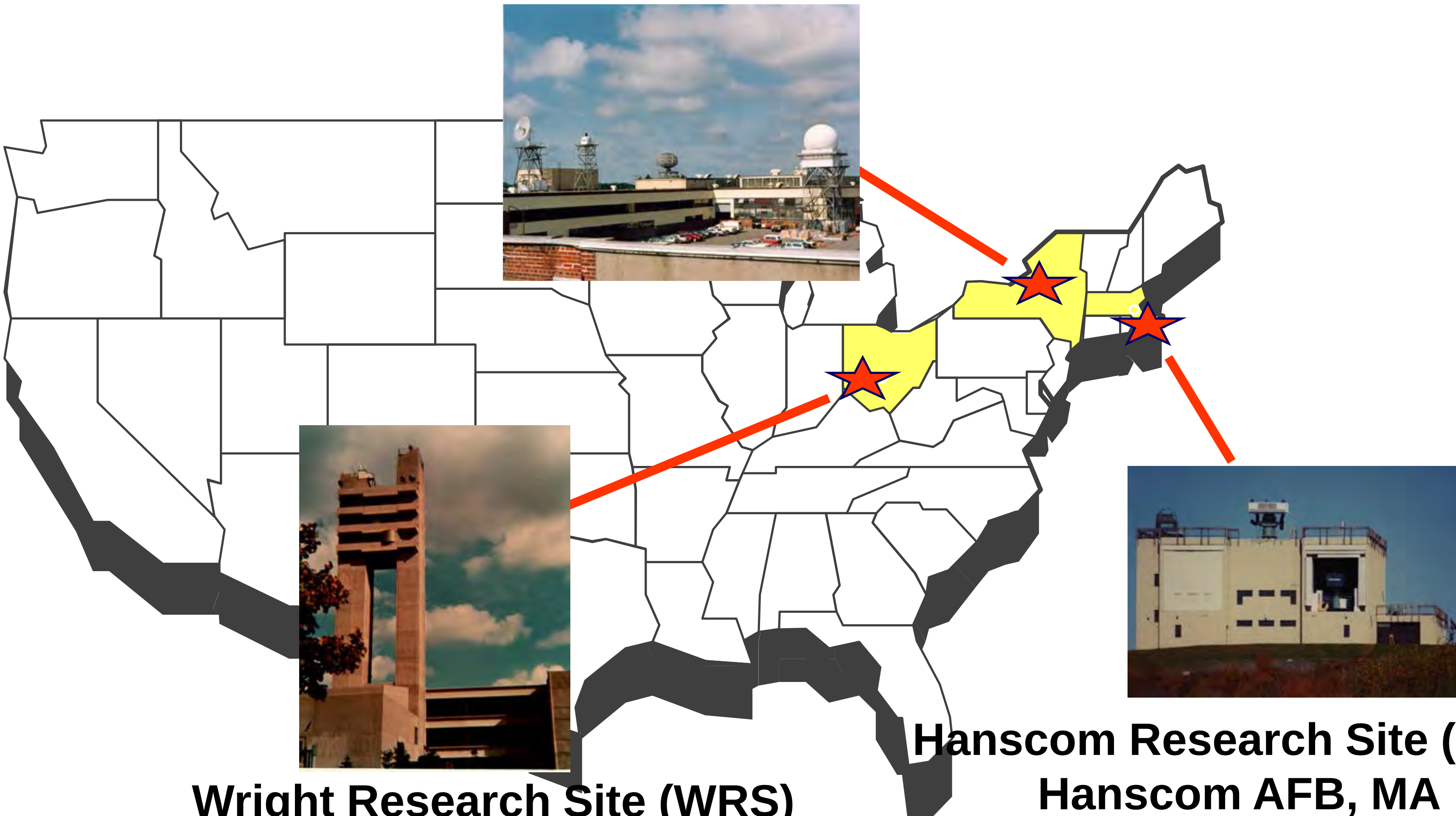
- Transmitters & Receivers
- Phenomenology & Algorithms
- Optical Apertures

- Signatures & Modeling
- Assessment & Foundation
- Innovative Algorithms

Enabling Sub-thrusts

Sensors Directorate Locations

Rome Research Site (RRS)
Rome,NY

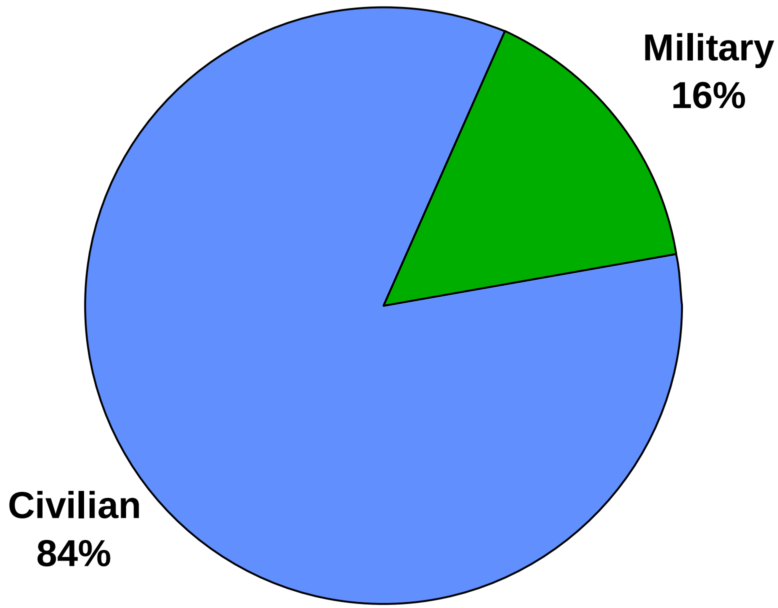


Wright Research Site (WRS)
Wright-Patterson AFB, OH

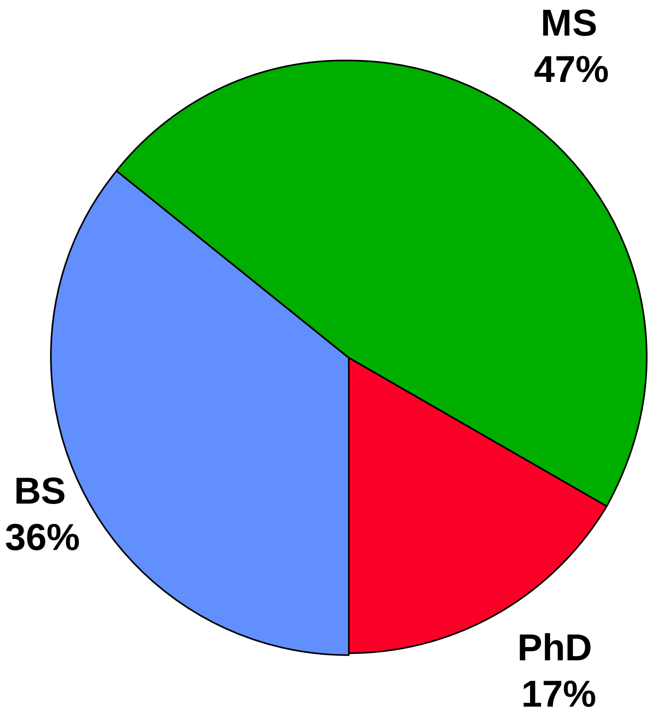
Hanscom Research Site (HRS)
Hanscom AFB, MA

Personnel – Total All Sites

Government	753
IPAs	3
On-Site Contractors	493
Total	1249



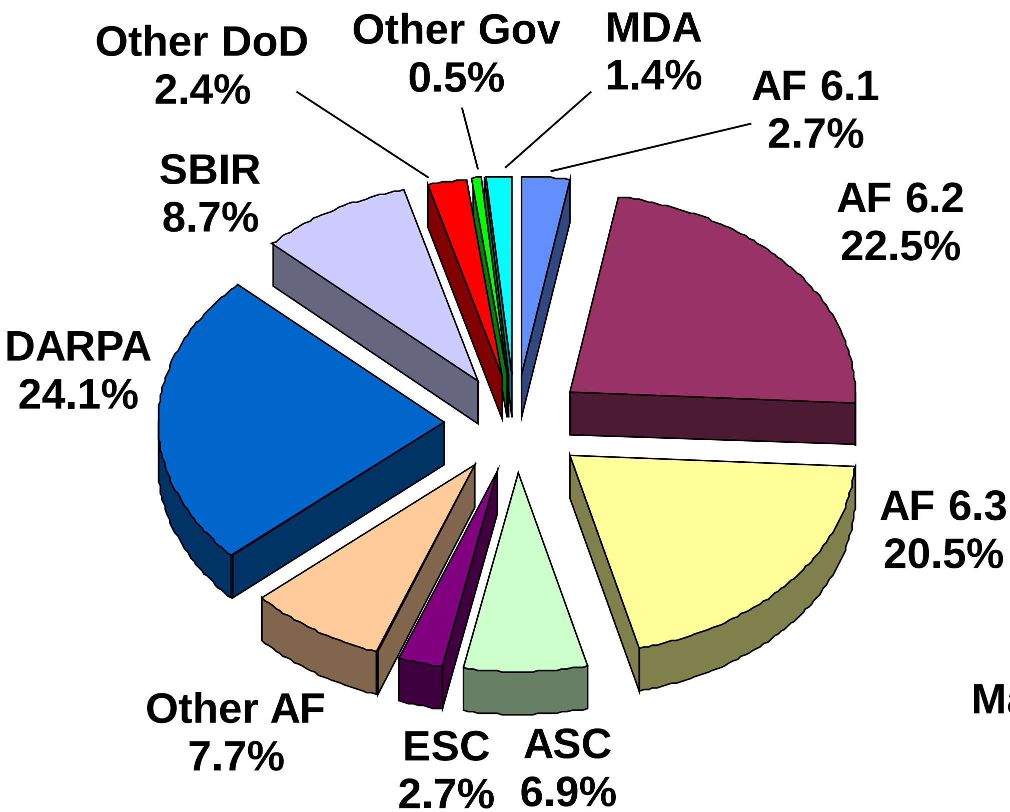
Government (753)



S&E (591)

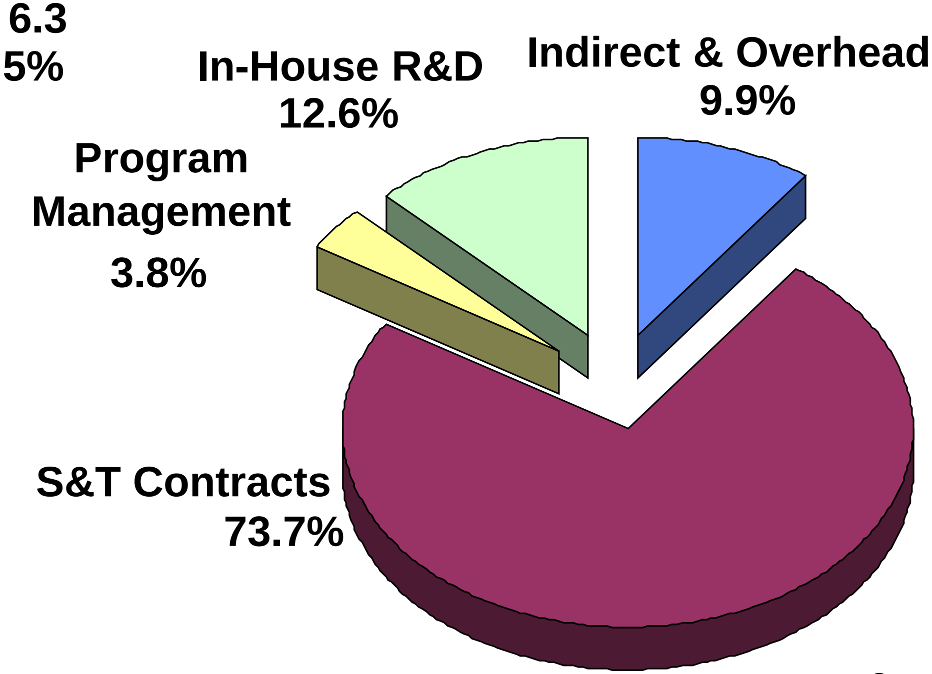
Sensors Directorate

FY05 Funding & Spending



Spending

S&T Contracts	$ 337 M
Program Management	17 M
In-House R&D	57 M
Indirect & Overhead	45 M
Sensors Total*	$ 456 M



Income

AF S&T	$ 196 M
Other Sources	260 M
Sensors Total*	$ 456 M

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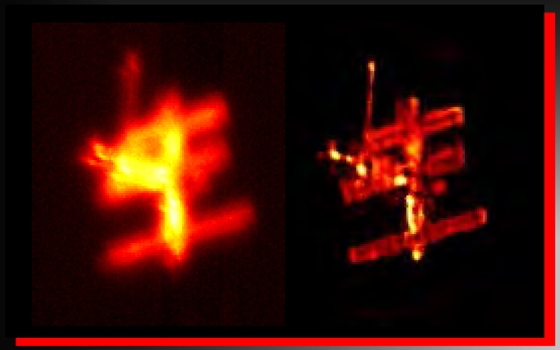

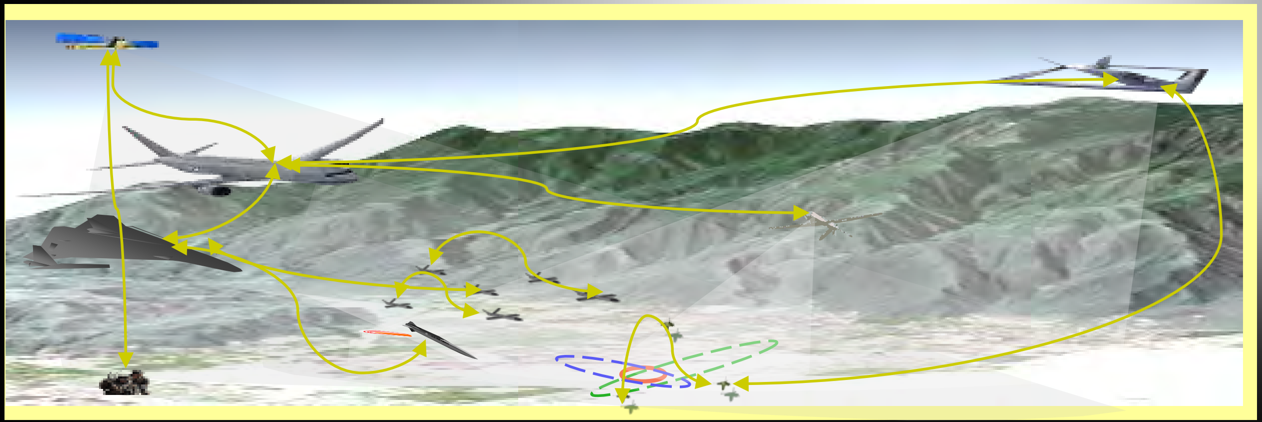

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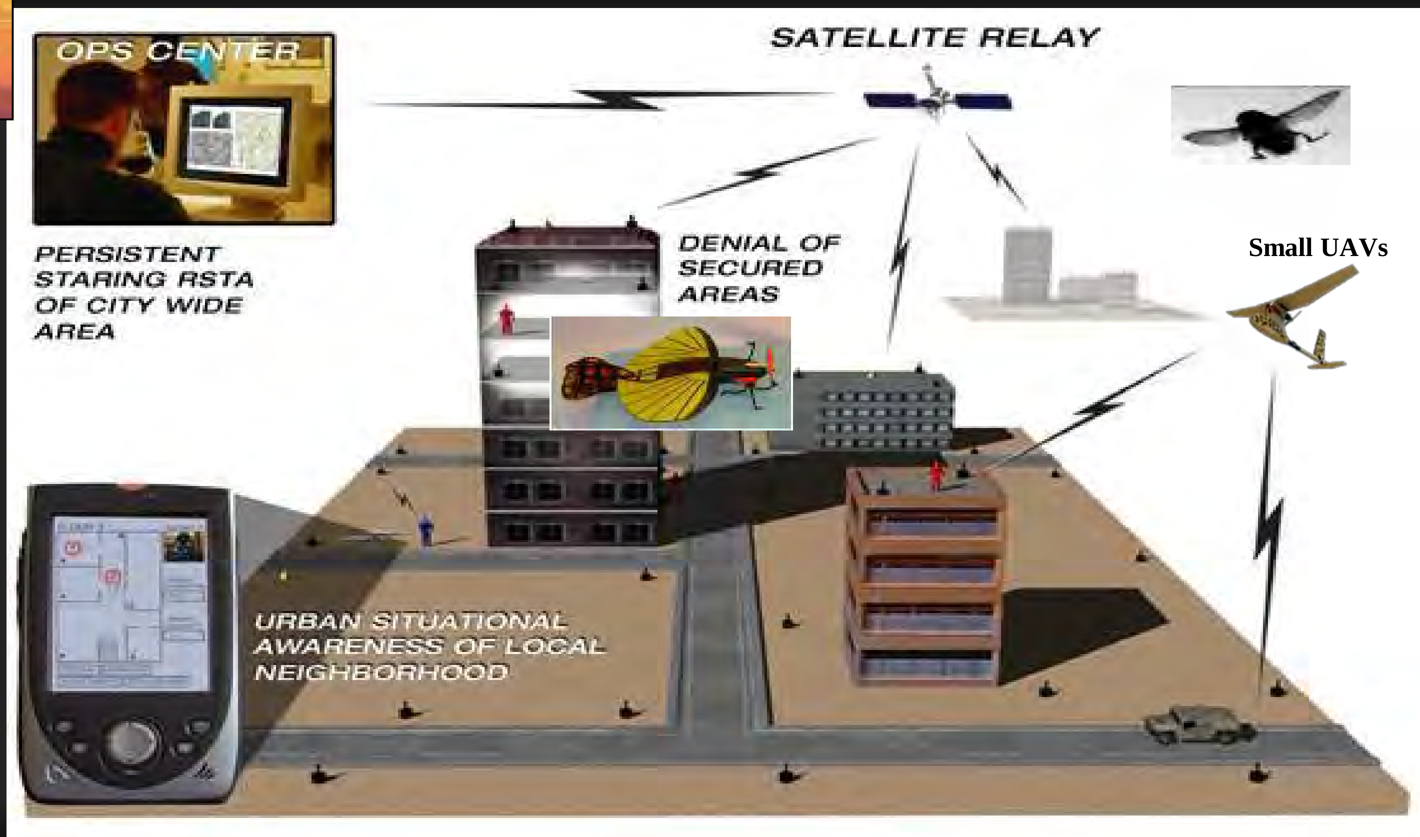

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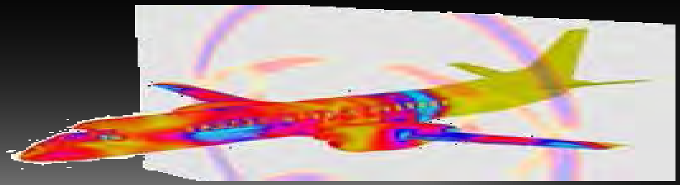
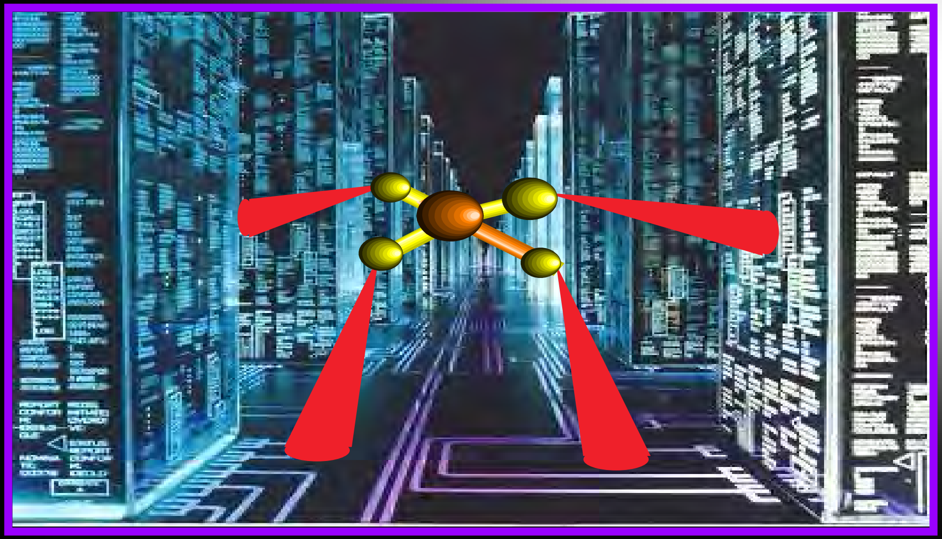
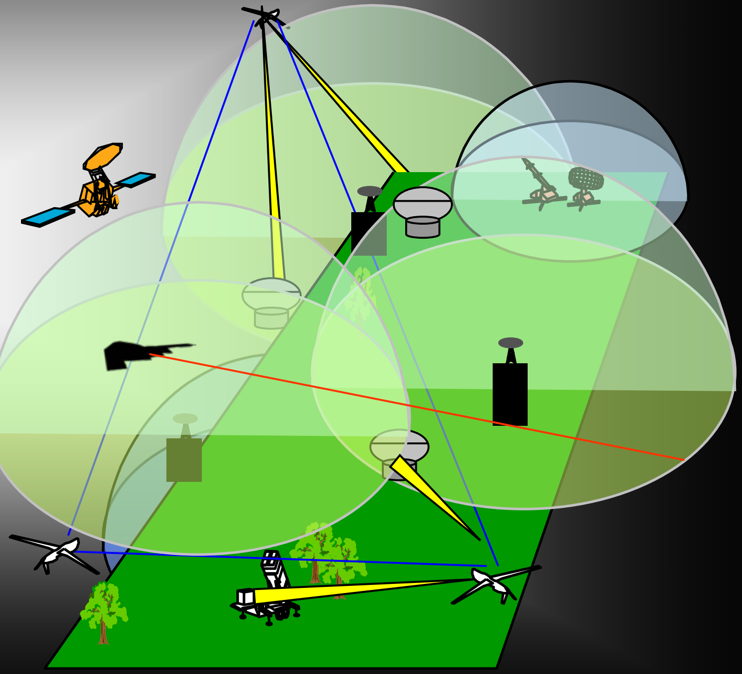
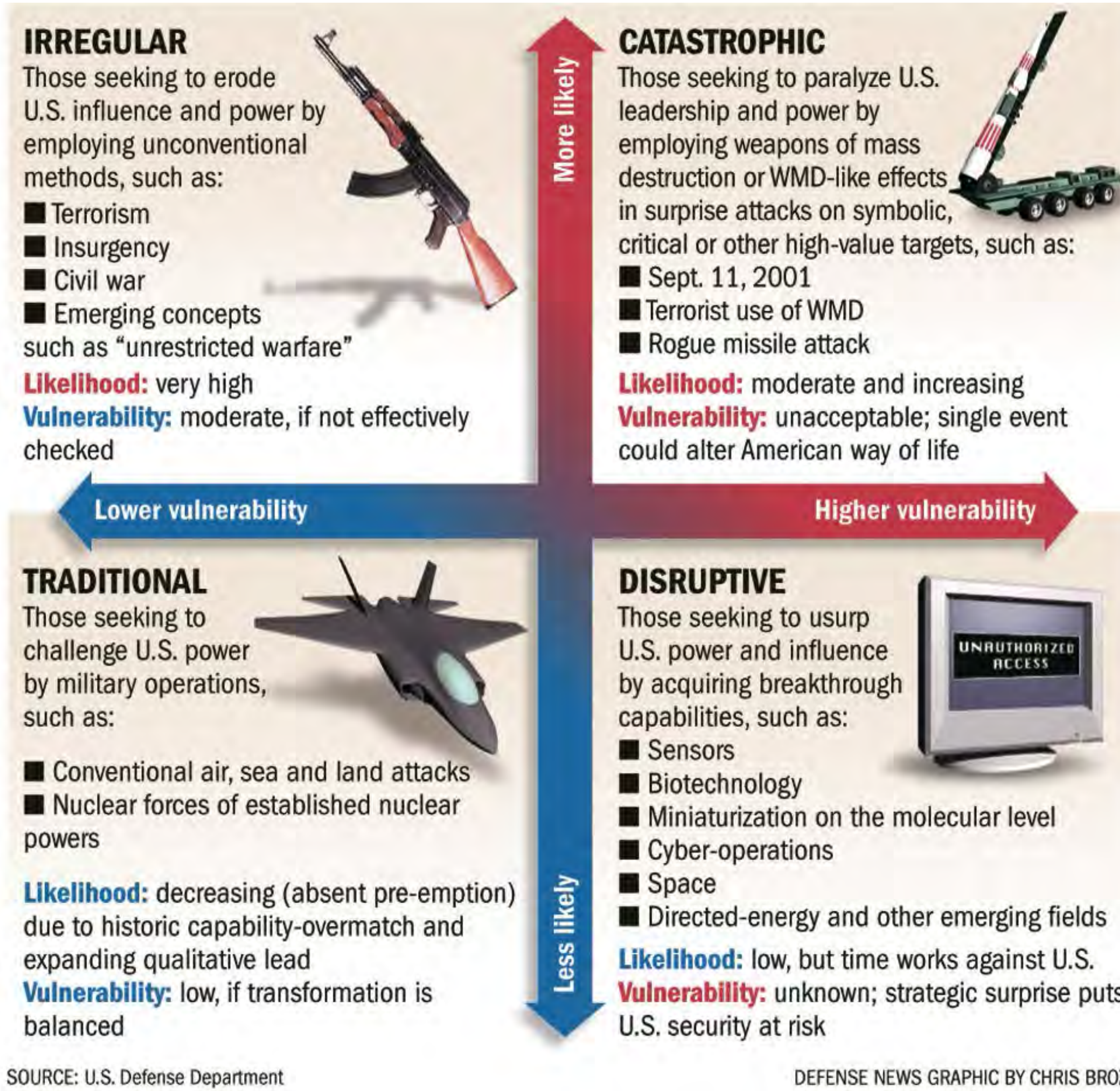






DOD Level - Changing the Plot

- **For decades the Pentagon's war plans focused on countering conventional military threats.**
- **New planning scenarios focus on preparing for a wider range of contingencies**



Some 2005 QDR ISR Visions

• Establish an "unblinking eye" over the battlespace

• Integrate global awareness with local precision

•Support operations against any target, day or night, in any weather, and in denied or contested areas

• Develop responsive space. Improve SSA

• Integrate Space and Air - featuring denied area ops. Investigate the use of high-altitude loitering capabilities

•Increase measurement and signature intelligence (MASINT) to ID enemy WMD

• Increase investment in unmanned aerial vehicles to provide more flexible capabilities to identify and track moving targets in denied areas

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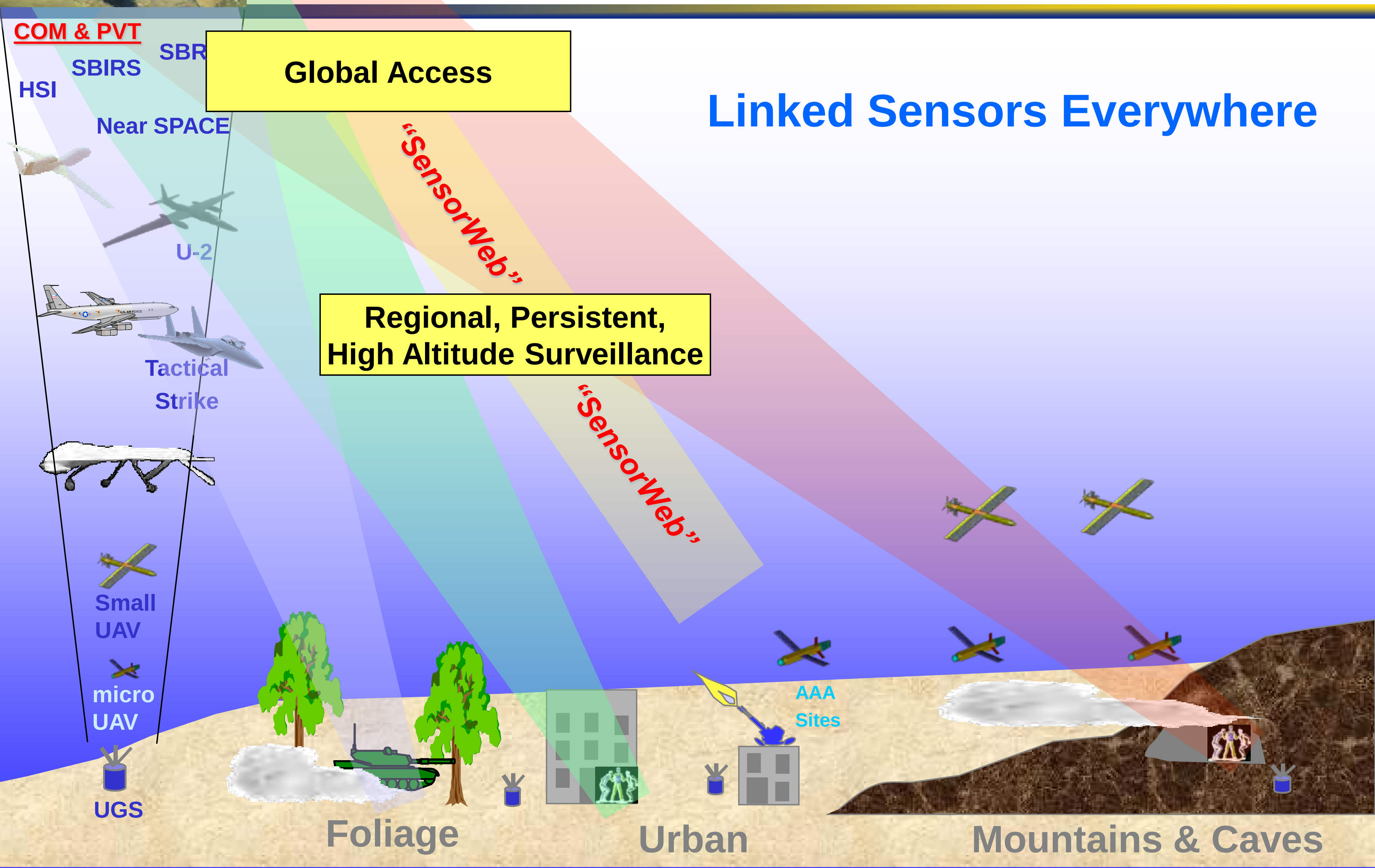
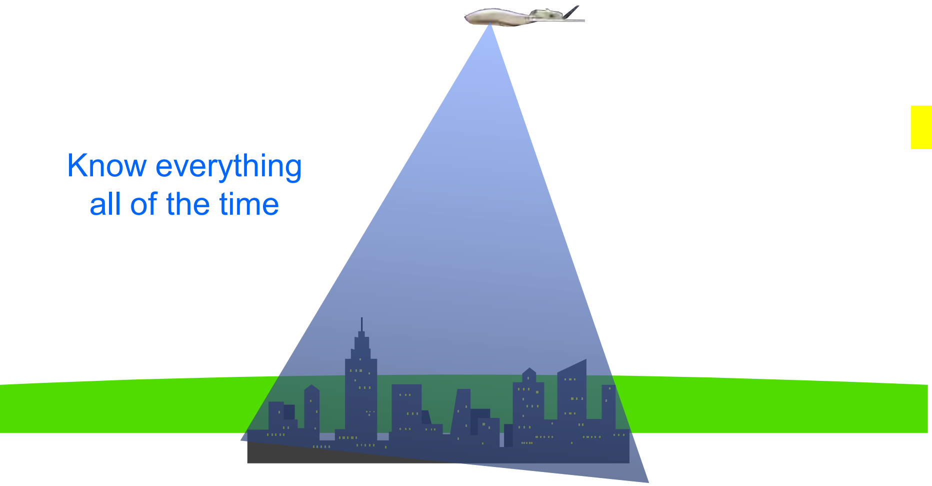
Layered Sensing

Vertically Integrated ISR Enterprise



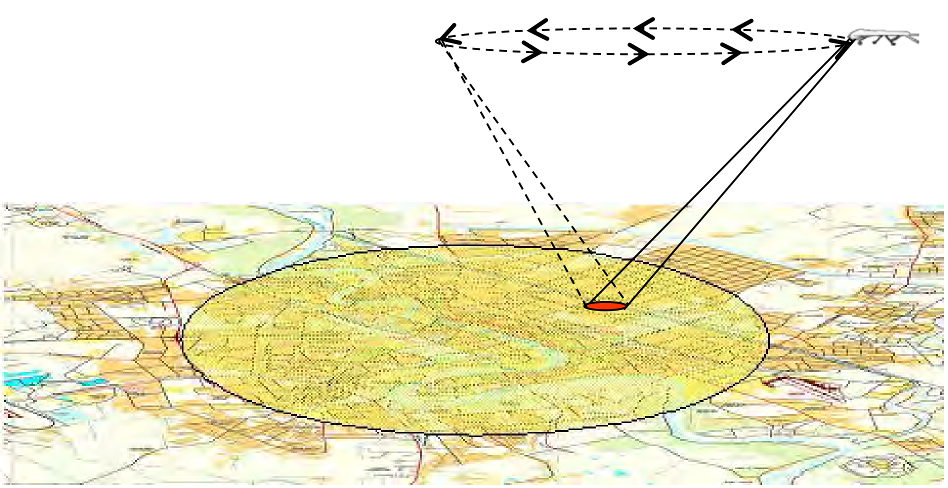
Continuous Surveillance

Know everything all of the time



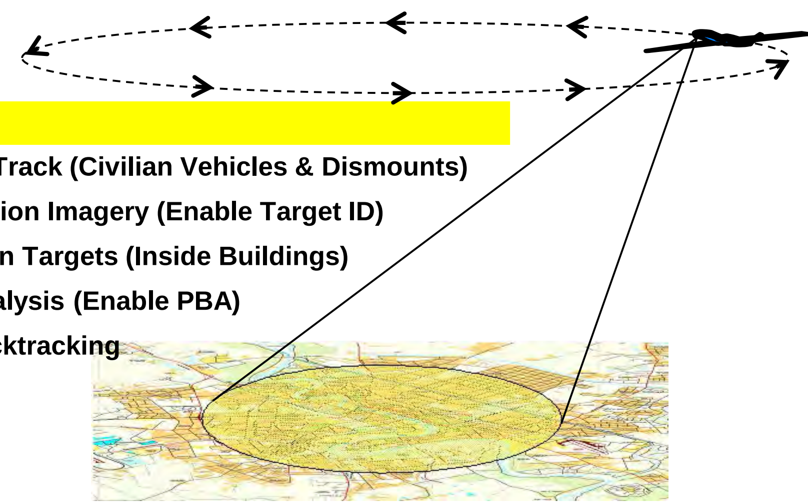
Multi-sensor EO and SAR System

3D Pixel Registered



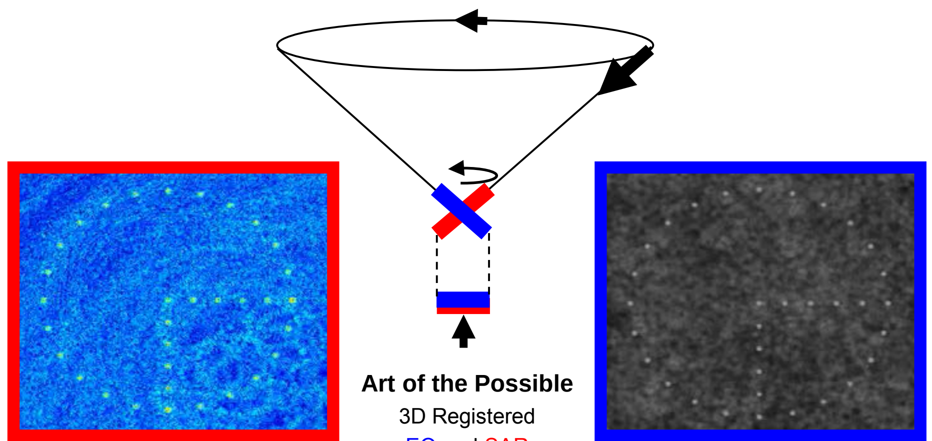
Gotcha Radar System

Persistent, High Altitude, All-Wx Surveillance



- Continuous Track (Civilian Vehicles & Dismounts)
- High Resolution Imagery (Enable Target ID)
- Detect Hidden Targets (Inside Buildings)
- Behavior Analysis (Enable PBA)
- Forensic Backtracking

SAR + EO



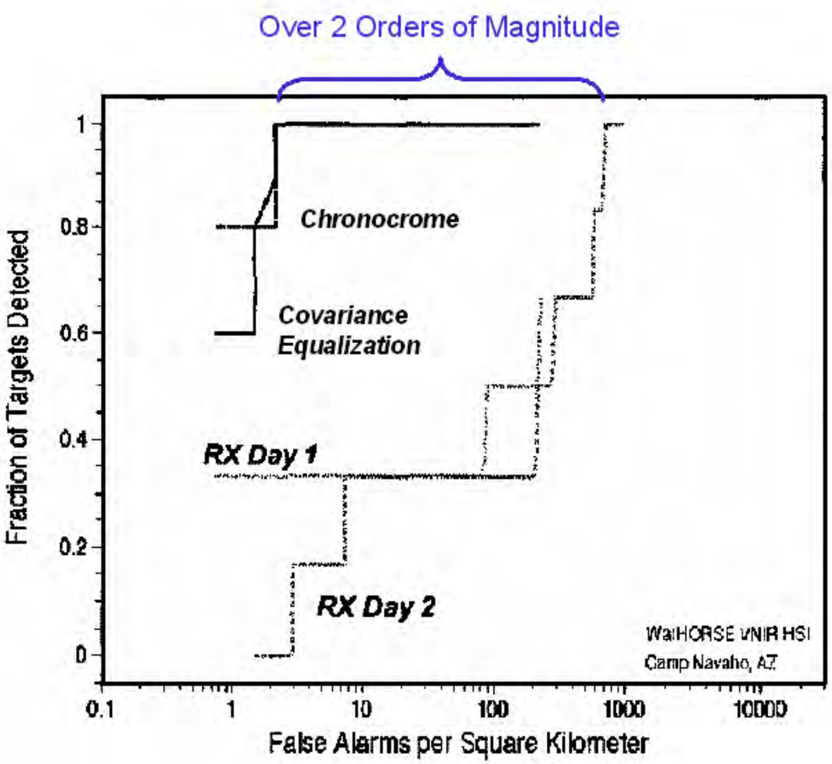
Art of the Possible

3D Registered
EO and SAR
From
Single EO and Single SAR
Aperture

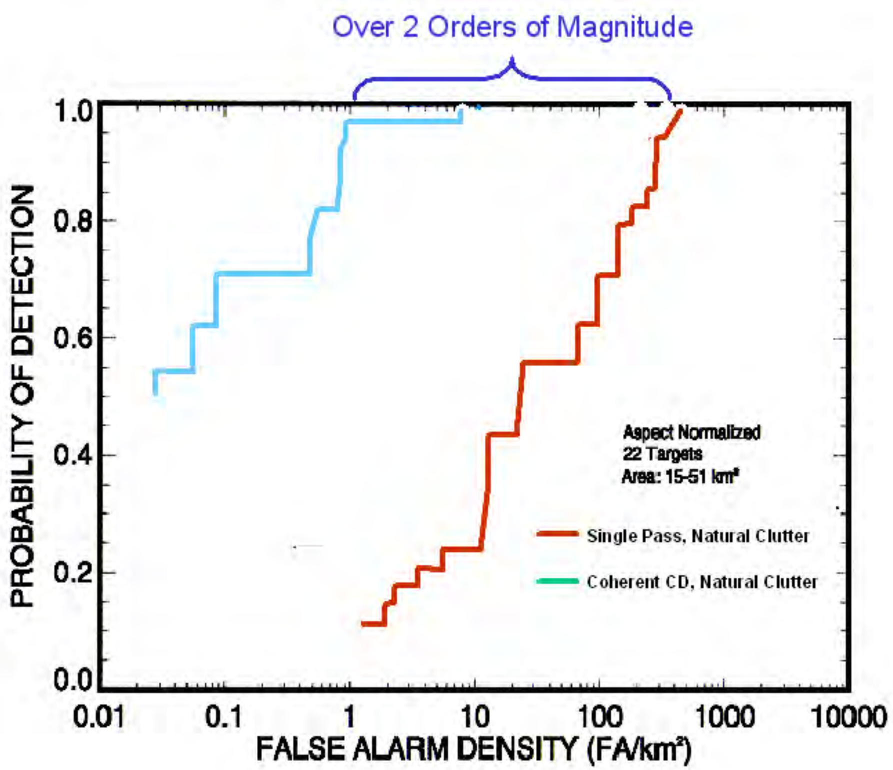
Multi-sensor Change Detection

Two Orders of Magnitude False Alarm Reduction With Change Detection

HSI

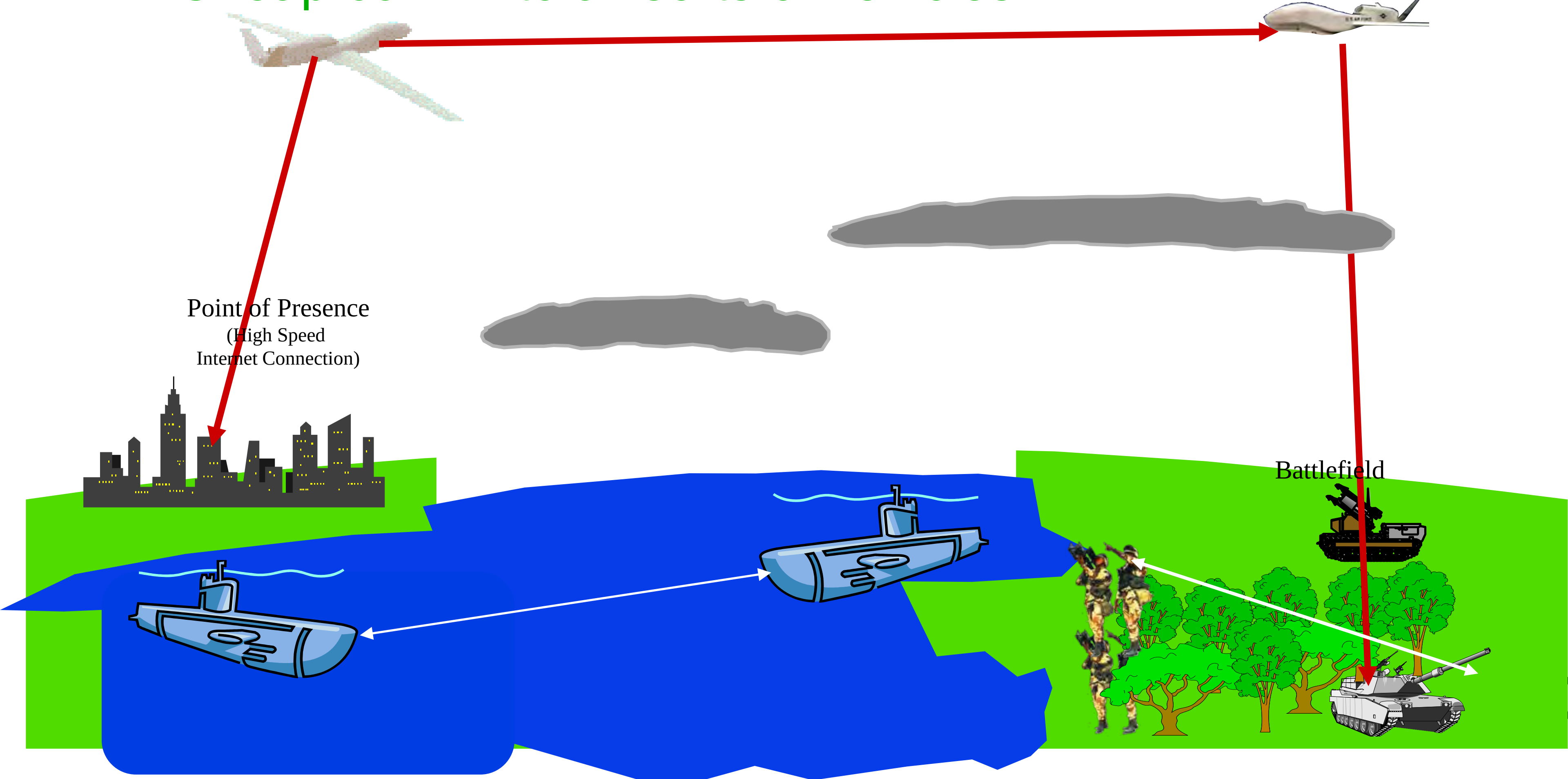


VHF SAR



Affordable High Bandwidth, Instant, Comm.

- High Bandwidth Lasercom through thick clouds
- Quantum communications through water and earth
- Cheap comm. to all sorts of vehicles



Pro-Active Countermeasures / Threat Suppression

- EO/RF Conformal, phased array Apertures

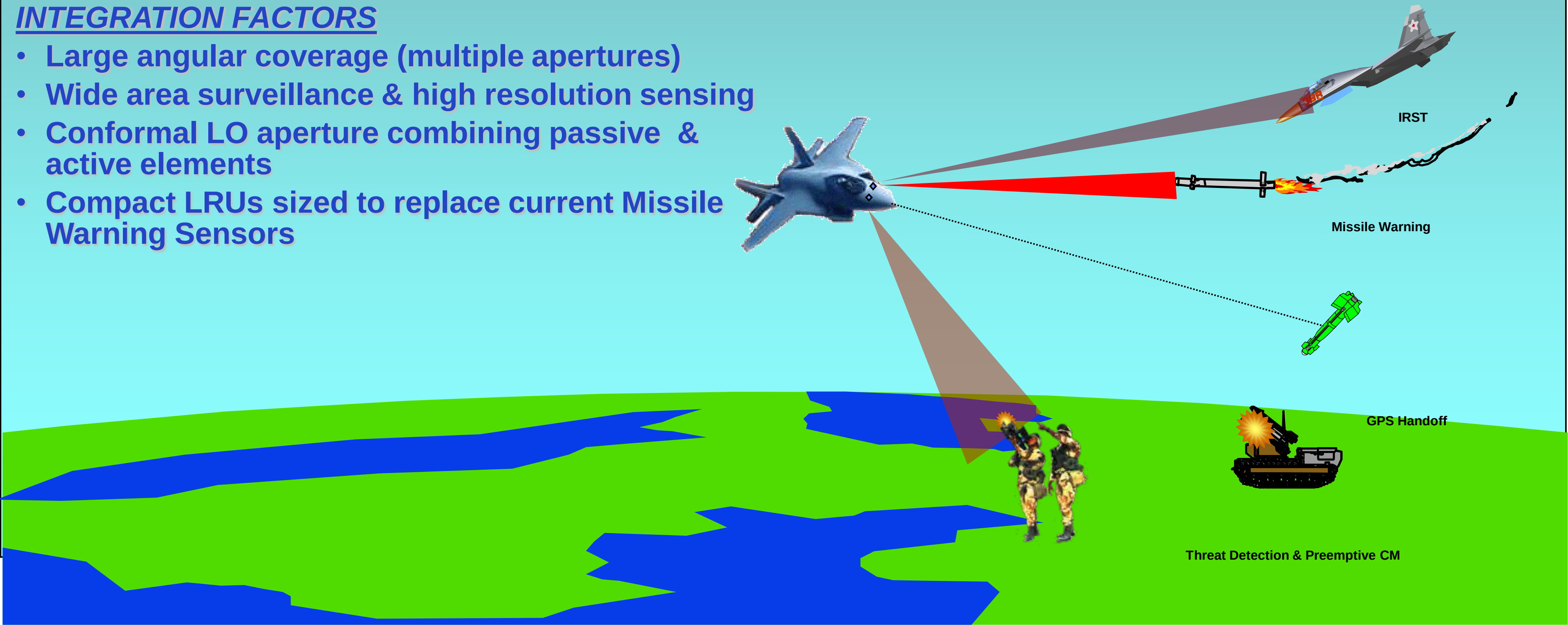
- Destroy all threats (the van - with the operators)

- Prefer speed of light, cheap, threat destruction

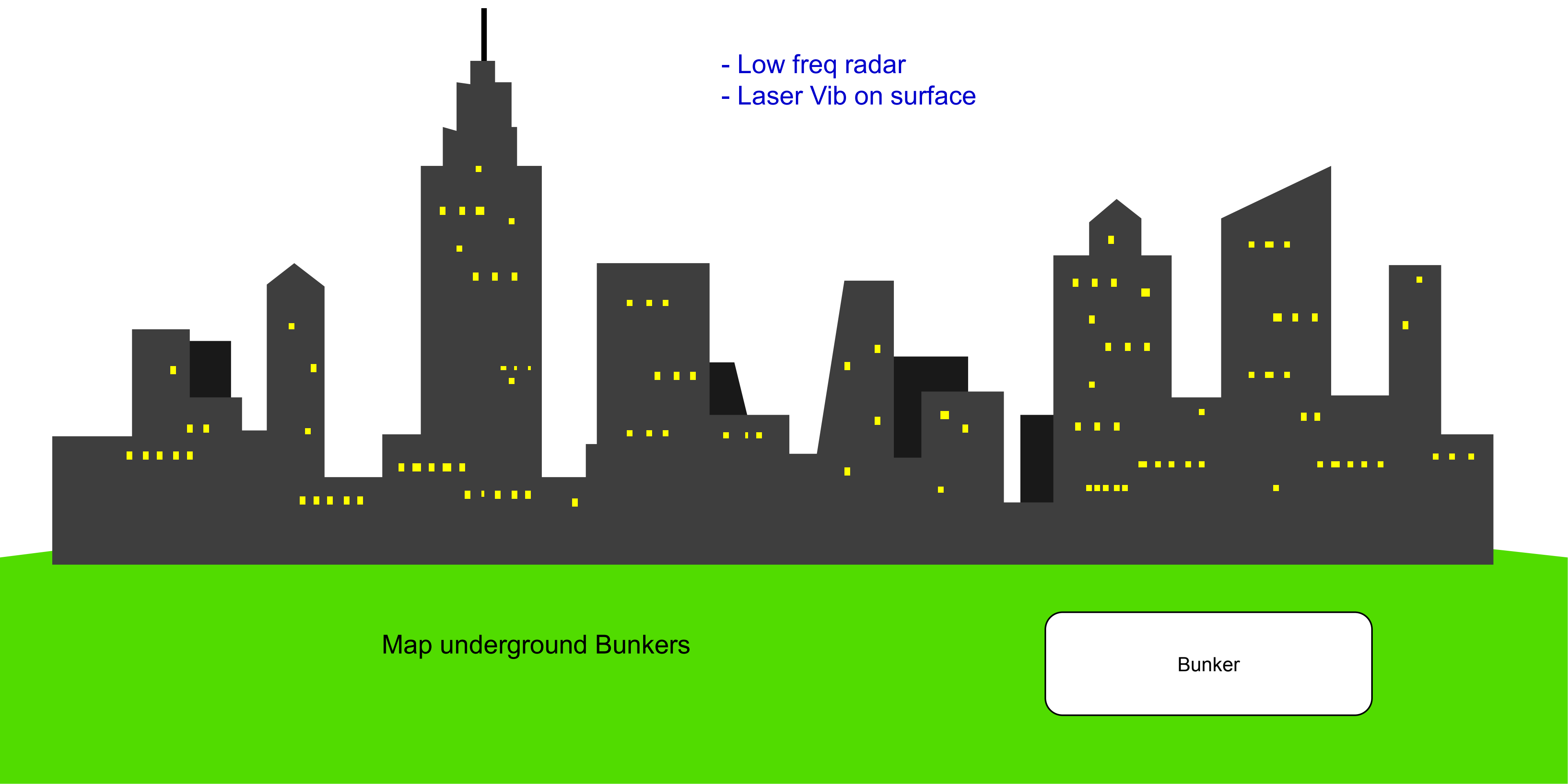
Impervious countermeasures

INTEGRATION FACTORS

- Large angular coverage (multiple apertures)
- Wide area surveillance & high resolution sensing
- Conformal LO aperture combining passive & active elements
- Compact LRUs sized to replace current Missile Warning Sensors



Sensing Inside of Buildings, & Underground



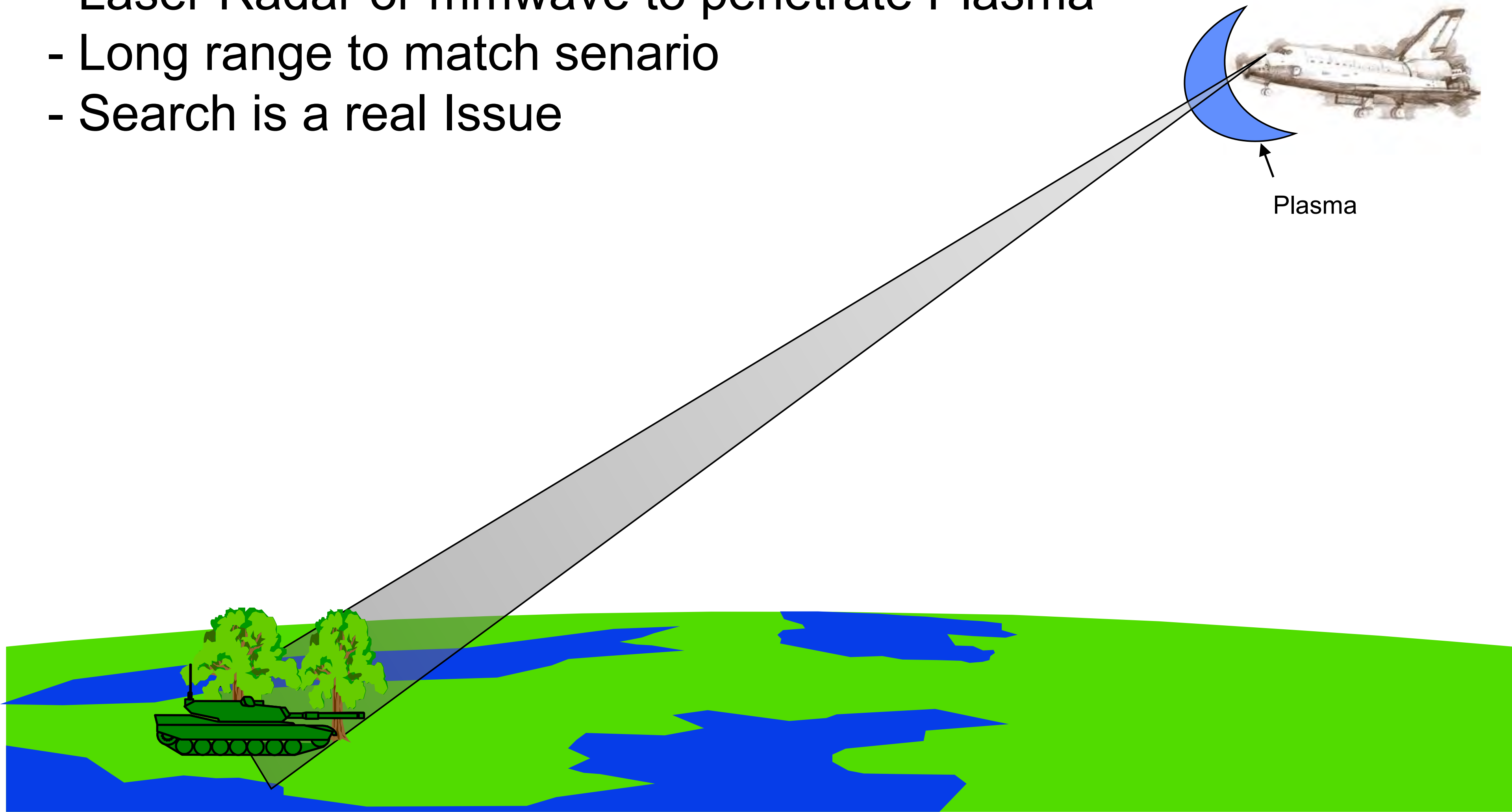
Long Range Chem / bio ID

- Hundreds of Kilometers
- Precise chemical and Bio ID
- Lasers in the Mid IR can do Chem - but
  Not at very long range
- Bio at long range is tough
  UV florescence short range &
  not very specific

Also want cheap and prolific
Chem & bio ID, especially in Urban areas

Precise Sensors for Hypersonic Vehicles

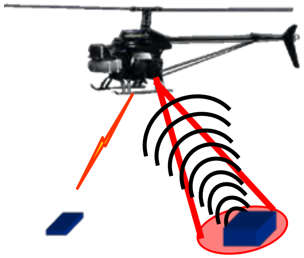
- Laser Radar or mmwave to penetrate Plasma
- Long range to match senario
- Search is a real Issue



Sensor / Component Vision

- Affordable Sensors – Near zero touch labor
- Scalable sensors for application reuse & scaled performance
- Software Programmable Sensors
- Ultra-Low power consumption components / Sensors
- Miniature multi-function sensors for mini & micro sized platforms
- Harsh Environment tolerant Sensors (Thermal, electromagnetic, radiation, EMP)
- Anti-tamper components
- Safe use of commercial devices made in China, India, or elsewhere
- Better "physics of Failure" knowledge

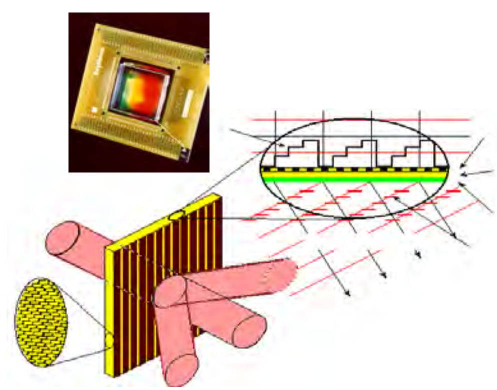
Small Close-In Sensors



Device Properties / Physics of failure

Affordable Conformal Apertures

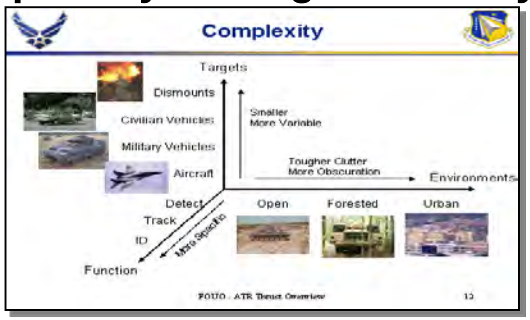
- Rapid Random Access
- Sensing, countermeasures, and communications - requiring wideband
- Integration with receivers and transmitters
- Wide angle coverage
- Thin and repairable



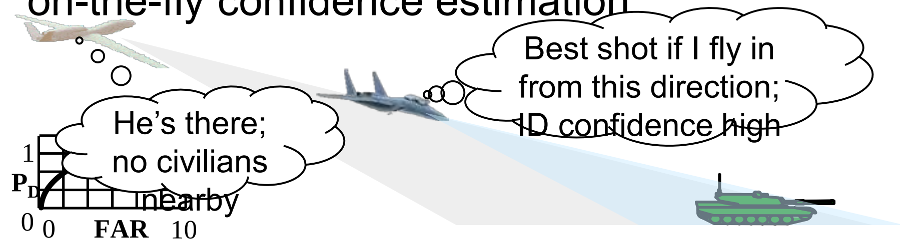
Anticipatory & Adaptable Automatic Target Recognition

Anticipate by driving the enemy options

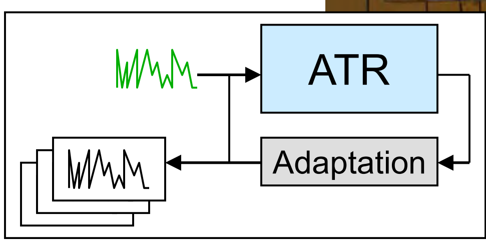
Detection, tracking, geolocation, and identification, and fingerprinting across targets and environments



A priori performance prediction and on-the-fly confidence estimation



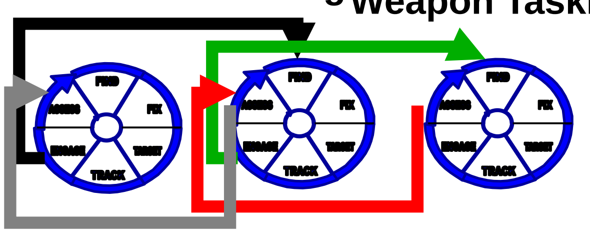
Rapid target acquisition and on-the-fly adaptation to targets and environments



Forward and backward tracking for anticipation and analysis

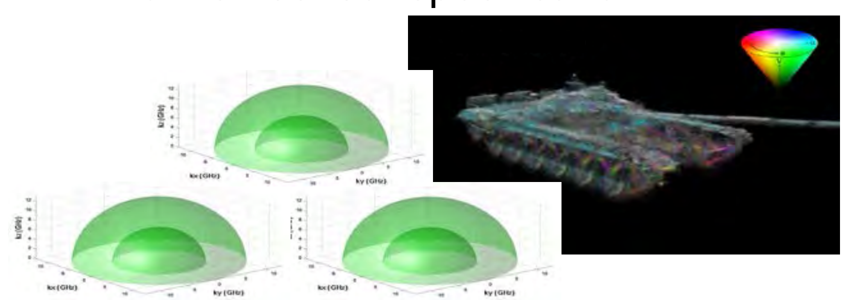
Machine-to-machine horizontal and vertical integration

Strike Tasking **Weapon Tasking**



Strike Feedback **Weapon Feedback**

ATR-driven sensor specification



Outline

- AFRL Sensors Directorate background
- FLTCs and other Driving Forces for the Sensors Directorate
- Sensors Directorate Visions
- **Summary**

Summary Remarks

- Layer Sensing is the way of the future
  - High level, wide area search
  - Small, cheap vehicles and Sensors for close in.
  - Sensors web – Connected sensors everywhere
- We are moving toward continuous sensing
  - Change detection is powerful
    - Orders of magnitude lower false alarms
- AFRL is moving to cross directorate planning
  - Focused Long term Challenges will be a significant future part of AFRL
- We need near zero touch labor for defense systems in the “World is Flat” World
  - Required for us to afford the most technically advanced military in the world
- Expect AFRL, to intensify their activity associated with counter-terrorism, counter-CBRNE and the GWOT


Measure of Success:
No Sanctuary for the Enemy

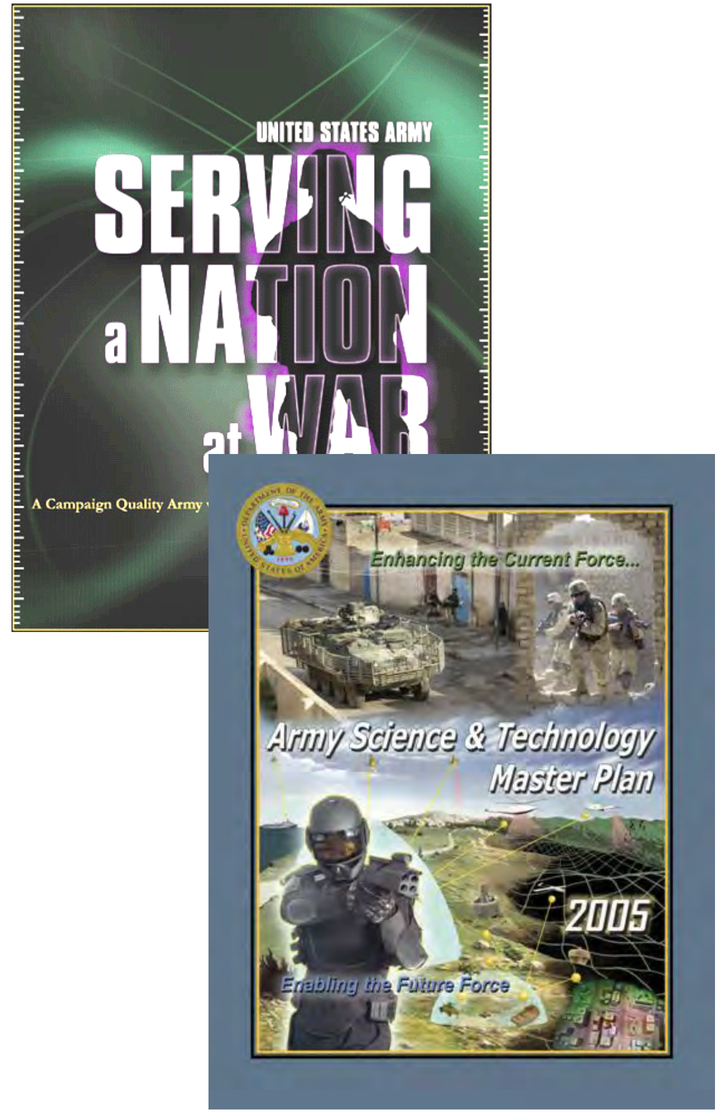
Dr. Paul McManamon

Chief Scientist

AFRL Sensors Directorate

937-255-3627

Paul.McManamon@wpafb.af.mil



Army
Science & Technology

NDIA
Army S&T Challenges for Current and Future Forces
April 19, 2006

Mary J. Miller
Director for Technology
Office of the Assistant Secretary for Research & Technology

Purpose

Provide an overview of the Army's S&T program challenge to develop technologies that will enhance the Current Force while concurrently enabling the Future Force

Outline

- *Army S&T Overview*
  - *Vision*
  - *Strategy*
  - *Warfighter is our Customer*
- *Army Investment*
- *Support to Future Force*
- *Basic Research*
- *Manufacturing Technologies*

Capabilities for a Joint and Expeditionary Army

Current Force

~100 lb. load

70+ tons

< 10 mph

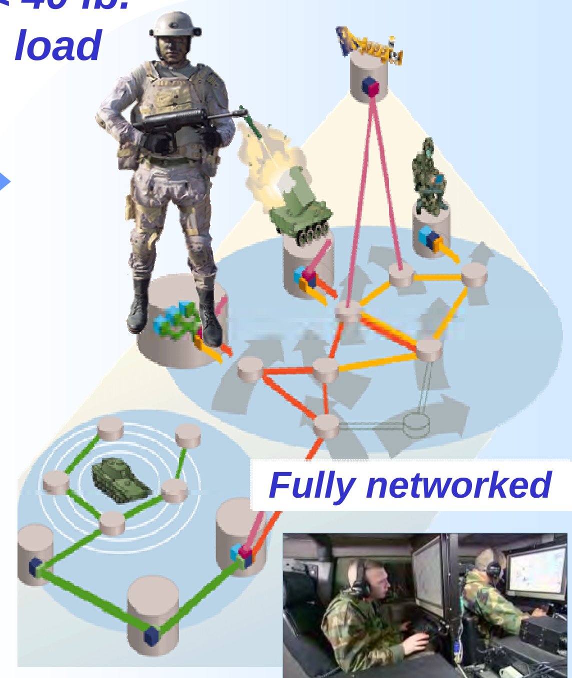
Enabling the Future Force

Science and Technology—<u>develop and mature technology to enable transformational capabilities</u> for the Future Modular Force while <u>seeking opportunities to accelerate technology</u> directly into the Current Modular Force

Enhancing the Current Force

Future Force

< 40 lb. load

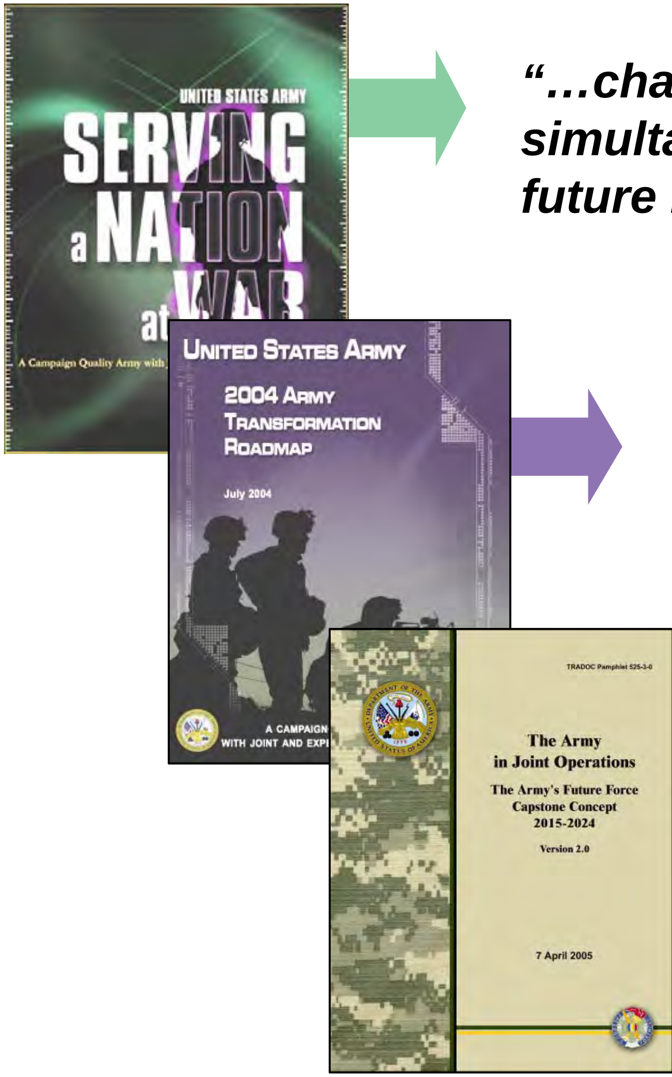


Fully networked

< 30 tons

> 40 mph

Army Strategies

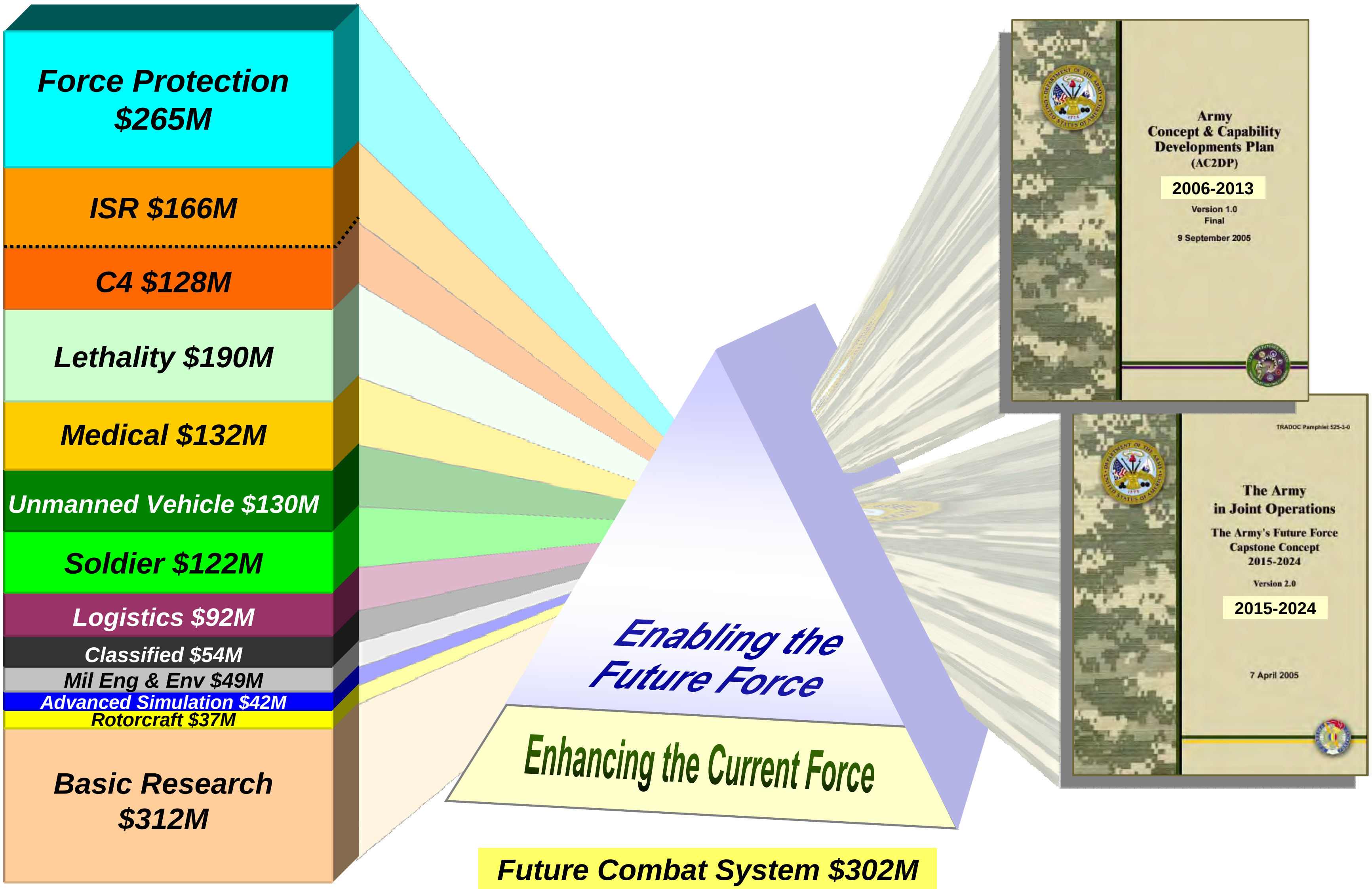


"…change in time of war must deal simultaneously with both current and future needs"

"…provide dominant land power to the Joint Force now and into the future."

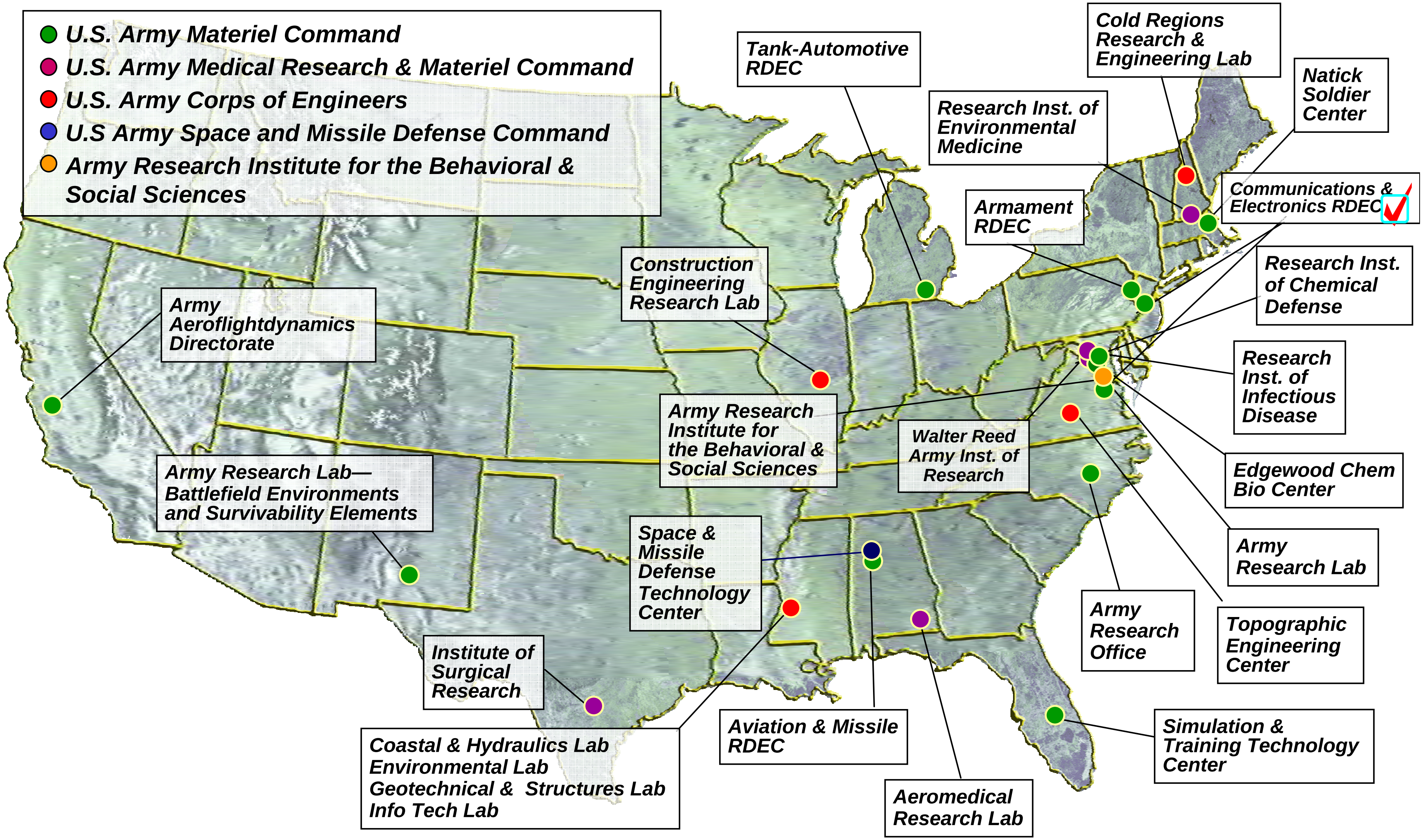
"The FCS further encompasses a set of technologies and capabilities that will spiral into the entire Army as they mature. Networked C4ISR, precision munitions, and advanced fire control will also be key enablers."

Technology Area Investment
FY07 $1.7B



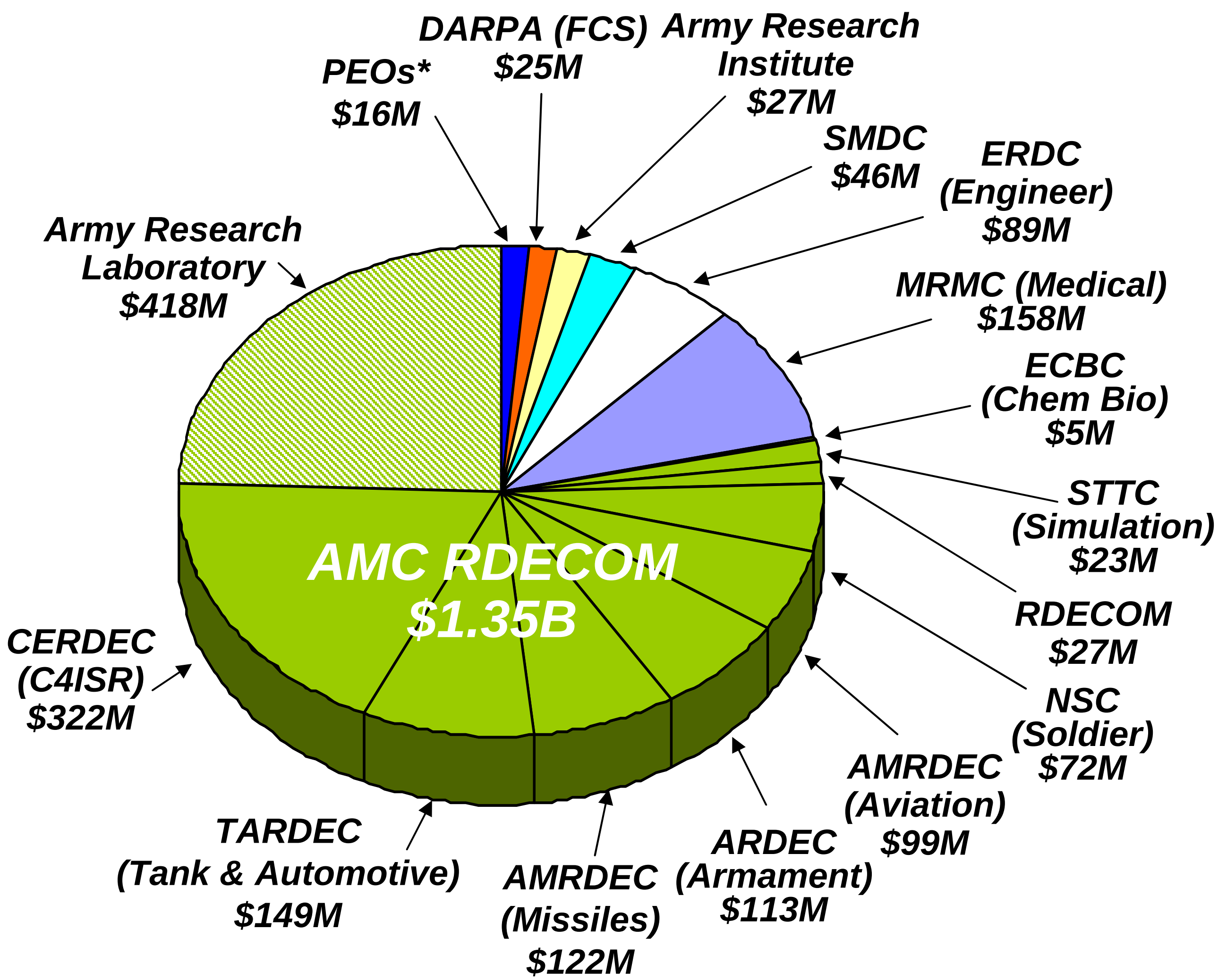
Future Combat System $302M

Army Research, Development & Engineering Centers and Laboratories



FY07 Army S&T Investment Perspective

Lab	*FY07*
Army Research Lab	*$418M*
CERDEC (C4ISR)	*$322M*
MRMC (Medical)	*$158M*
TARDEC (Tank & Automotive)	*$149M*
AMRDEC (Missiles)	*$122M*
ARDEC (Armament)	*$113M*
AMRDEC (Aviation)	*$99M*
ERDC (Engineer)	*$89M*
NSC (Soldier)	*$72M*
SMDC	*$46M*
Army Research Institute	*$27M*
RDECOM	*$27M*
DARPA (FCS)	*$25M*
STTC	*$23M*
*PEOs**	*$23M*
ECBC	*$5M*
FY07 S&T Total	*$1.7B*



***PEO-Ammo ($10M, OSD devolved)**
PEO-IEW (2 ACTDs)

3 Different Types of S&T Investments

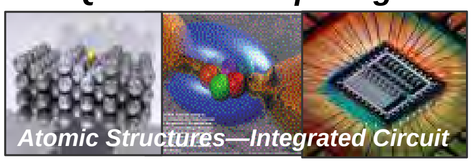
Basic Research, Applied Research, Advanced Technology Development

S&T FY07 $1.7B — **Development** → **Acquisition**

6.1: Basic Research
$312M (18% of S&T—5% OSD Directed)

Physics-Based Modeling

Quantum Computing

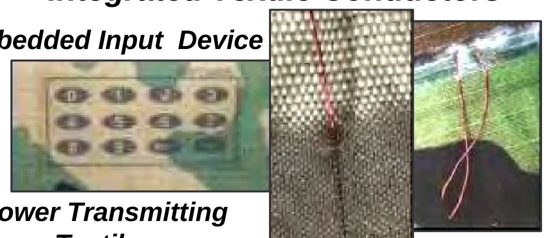


- Understanding to solve Army-unique problems
- Knowledge for an uncertain future

6.2: Applied Research
$685M (40% of S&T)

Integrated Textile Conductors

Embedded Input Device



Power Transmitting Textiles

Embedded Circuits

- Applications research for specific military problems
- Components, subsystems, models, new concepts

6.3: Advanced Technology Development
$722M (42% of S&T)

Flight Demonstration

- Demonstrate technical feasibility at the system and subsystem level
- Assess military utility
- Path for technology spirals to acquisition—rapid insertion of new technology

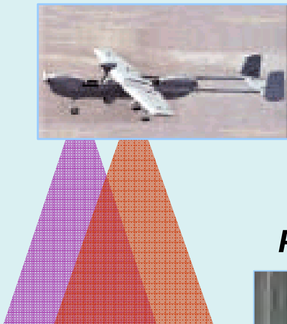
ATO-Rs—Army Technology Objectives—ATO-Ds

Far Term — **Mid Term** — **Near Term**

Future Force—Force Protection

Counter IED

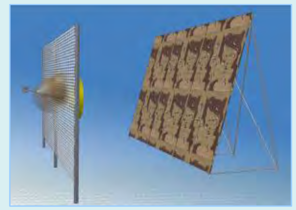
Sensors for Explosive Detection



Airborne IED Detection

Ground Penetrating Radar

Counter Rocket Artillery Mortar



Modular Protective Systems for structures

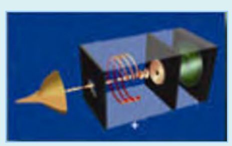
Solid State Laser (SSL) Technology

Platform Protection

Kinetic Energy Active Protection

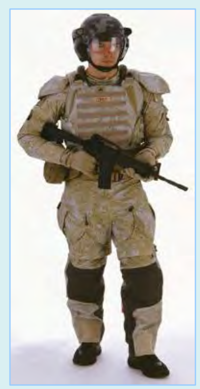
Integrated Rotorcraft Protection

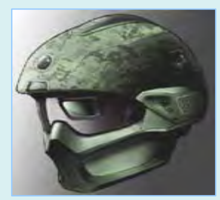
Structural Armor



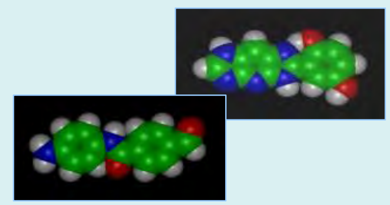
Electromagnetic Armor

Soldier Protection

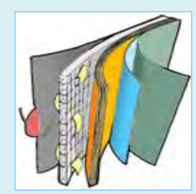




Protect (Integrated Suit & Helmet)



Advanced Fiber Technology for Ballistic Protection



Nanomaterials for Ballistic Protection

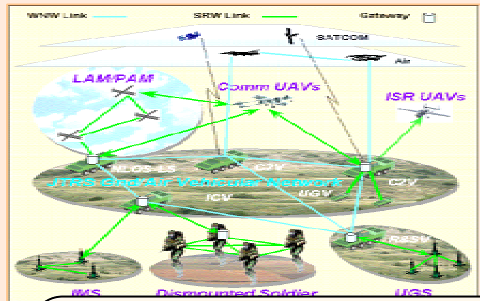
Future Force—ISR and C4

Command & Control

Flexible Displays

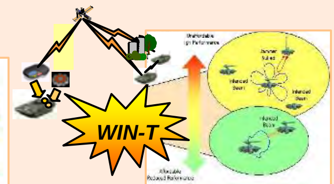
Knowledge Fusion

Tactical Mobile Networks



Advanced Antennas

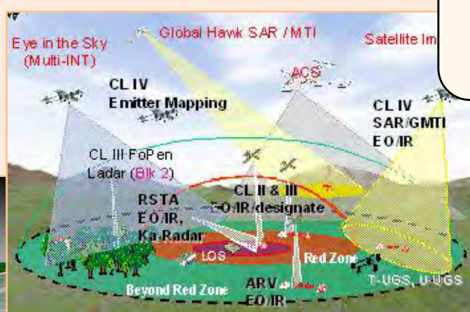
Tactical Network & Communications Antennas



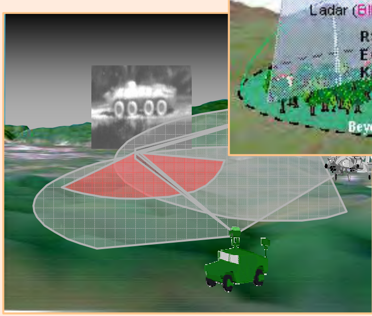
Directional Antennas

- Find the Enemy
- Assured Comms
- Battle Command

Persistent Sensor Coverage



Unblinking "Eye"



3rd Gen Infrared Sensors

MOUT Situational Awareness

C2 in Complex & Urban Terrain

Through Wall Sensing

Unmanned Aerial Vehicle (UAV) Sensor Mission Equipment Packages

Future Force—Lethality

Missiles

Future Missile Technology

Smaller, Lighter, Cheaper (SLC) Missiles

- Precision/ Maneuverable Urban Weapons
- Lighter/ Cheaper Manportable

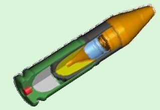
Next Gen NLOS-LS and C3

Loitering Attack Missile (30-60 min)

Precision Attack Missile (>40km)

Joint Small Arms

Armor Piercing Munitions

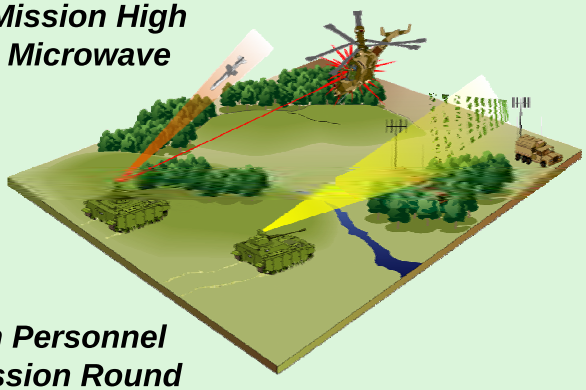


Lightweight Machine Gun

Caseless Ammo

Non Lethal

Multi-Mission High Power Microwave



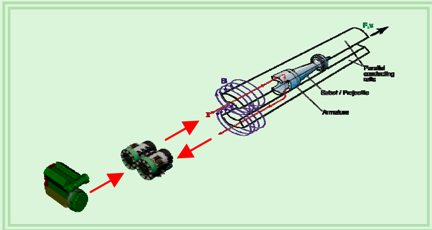
155mm Personnel Suppression Round (Malodorants)

Ultra-short Pulsed Lasers

Guns and Munitions

Multi-mission Capability from a Single Platform

Electromagnetic Gun… paradigm shift in propulsion



Future Force—Medical

Combat Casualty Care

Advanced Combat Casualty Litter System

- Self Contained Life Support System for Stabilization & Transport
- Optimal use of Resuscitation Fluids

Fluid Resuscitation Technology

Operational Medicine

Remote Health Monitoring & Assessment

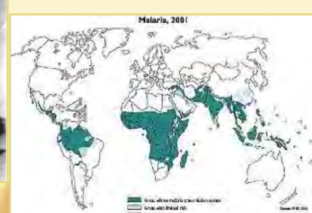
Physiological Status Monitoring

Diagnostics to Determine Soldier Exposure to Industrial Chemicals/ Materials

Indicators of Toxic Exposure

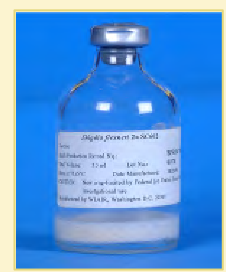
Drug/Vaccine Development

Infectious Disease



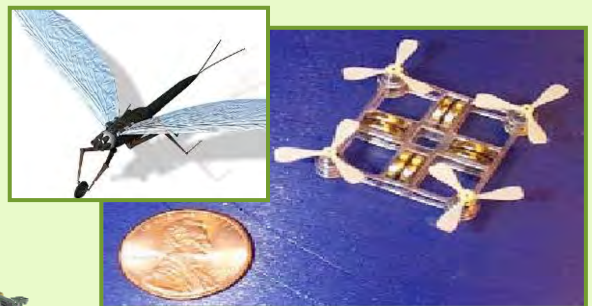
Prevention & Treatment of Malaria

- Vaccines to Prevent Diarrhea due to Campylobacter & Shigellosis
- Scrub Typhus Vaccine
- Sand Fly Control Preventive Medicine System
- Research into Hantaviruses & Hemorrhagic Fever



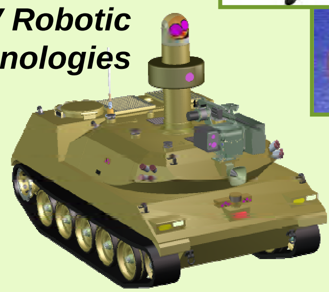
Future Force—Unmanned Systems

Near Autonomous Unmanned Technologies

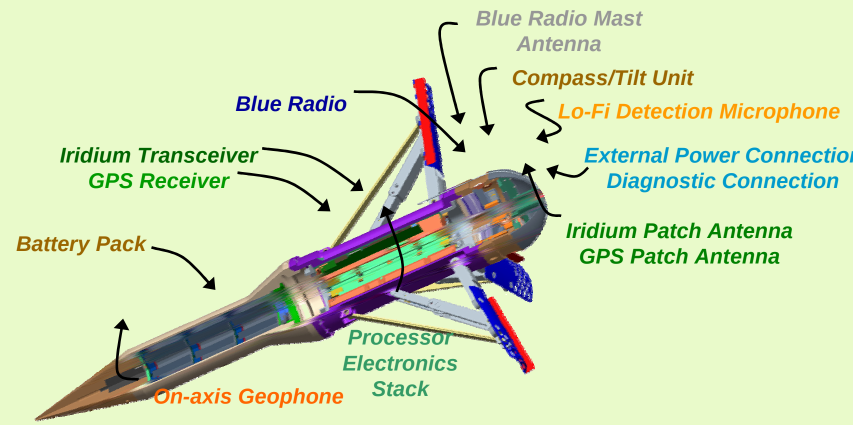


Micro Air Vehicles

ARV Robotic Technologies



Unattended Sensors



Sensor Dart

Unmanned Air Vehicles

A-160 Hummingbird

Extended Range & Increased Payload

Organic Air Vehicle (OAV)

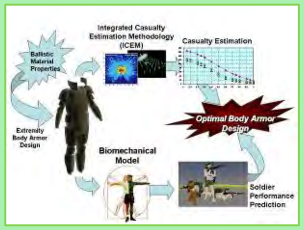
Extended Range & Endurance

Micro Air Vehicle (MAV)

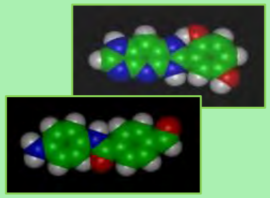
Extended Loiter "Perch & Stare"

Soldier Systems

Survivability

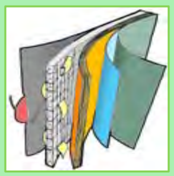


Modeling & Simulation



Advanced Fiber Technology for Ballistic Protection

Nanomaterials for Ballistic, Laser, Environmental Protection



Rations

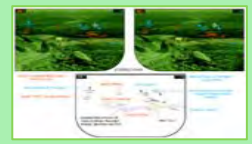
Biosensor Technology for Food Safety

First Strike Compact Ration

Future Force Warrior

Fused Thermal/ I2 Imagery

Protect (Integrated Suit & Helmet)



Collaborative Networked Situational Awareness

Robotics Interface

Strike (Exploit FCS Netted Fires)

Embedded Training

Advanced Power Sources

Power

Fuel Cell Battery Hybrid

Stirling Engine

Photovoltaics & Electro-textiles

Sensors

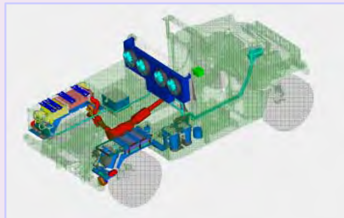
Physiological Status Monitoring

Uncooled IR Sensors for UAVs

Pointer

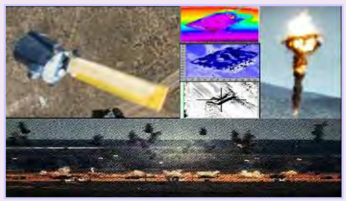
Future Force—Logistics

Sustainment



Water Generation & Recovery

EM Gun Munitions



Common Smart Submunitions

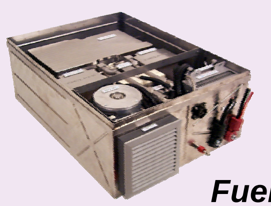
Deployability

Joint Rapid Airfield Construction

Joint Heavy Lift

Power & Energy

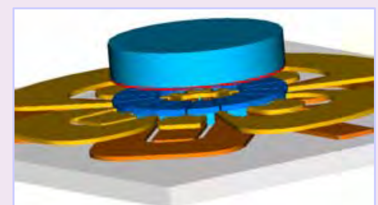
Hybrid Electric Drive



Fuel Reformation

Heavy Fuel Engine

Battery State of Charge Indicator

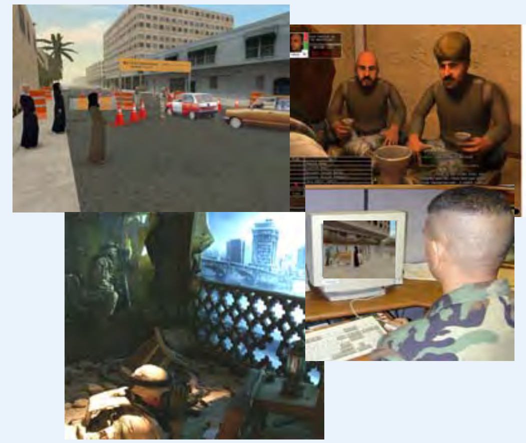


Portable Compact Power

Future Force—
Advanced Simulation/Personnel Technology

Training Simulation

Training Methods & Measures for Better Decision-making & Information Use



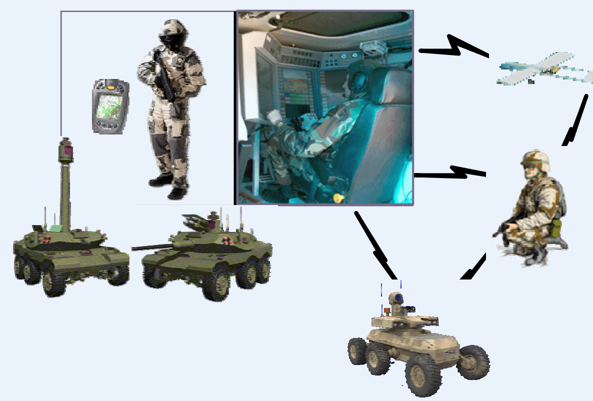
Training Future Force Small Unit Leaders & Teams

Embedded Combined Arms Team Training & Mission Rehearsal

Adaptive Learning Environments

Personnel Technology

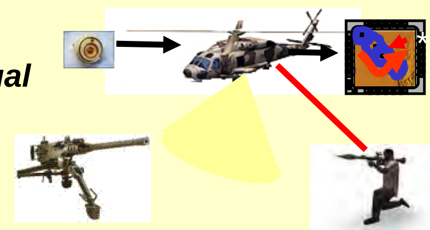
Strategies to Enhance Retention



Human-robotic Interfaces

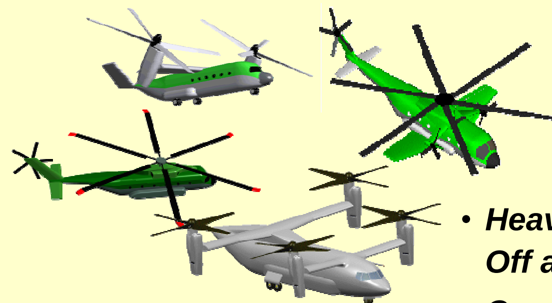
Future Force—Rotorcraft

Survivability



- Materials & Structures for Reduced IR Signature
- Adaptive Engine IR Suppression
- Super-lightweight Thermal Insulation
- EO/IR Countermeasures
- Hostile Fire Warning & Visual Cueing
- Affordable Directional IR Jamming

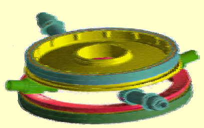
Joint Heavy Lift

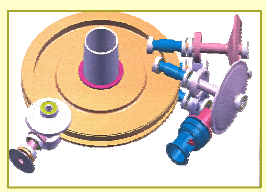


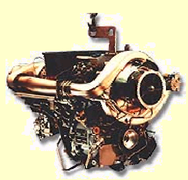
Technical Feasibility

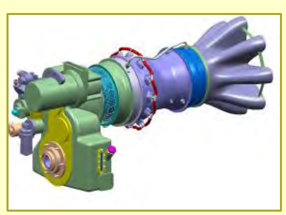
- Heavy Lift Vertical Take Off and Landing
- Concept Refinement
- 5 Contractor Teams
- Requirements Generation and Analysis

Engines & Drive Trains



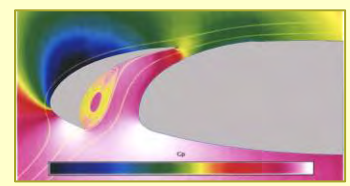






- Lighter Weight Components
- Increased Reliability
- Increased Fuel Efficiency
- Reduced Cost
- Reduced Vibration

Rotors & Flight Controls



- Hybrid Rotor
- Optimum Speed Rotor Evaluation
- Reduced Weight/ Vibration
- Reduced O&S
- Intelligent & Active Controls
- Improved Reliability and Durability

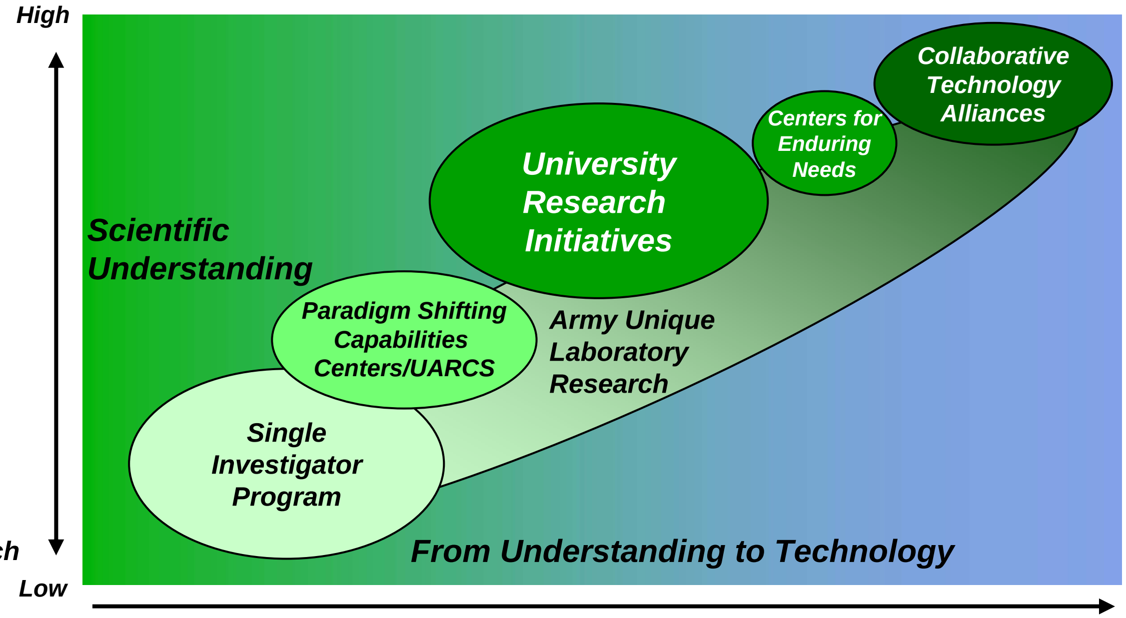
Basic Research

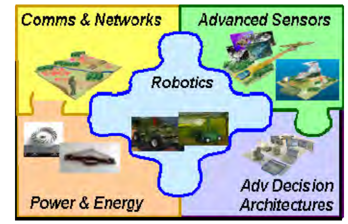
University Single Investigator Program

- Solid State Physics
- Structural Mechanics
- Electro-magnetics
- Materials Science
- Innovative Countermine

University Research Initiative (Devolved)

- Multidisciplinary Research
- DURIP

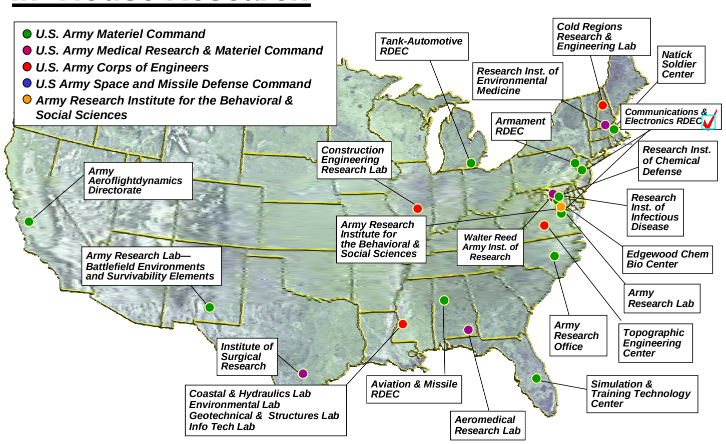




Collaborative Technology Alliances

- Comms & Networks
- Robotics
- Advanced Sensors
- Power & Energy
- Advanced Decision Arch
- Network & Info Science ITA

In- House Research



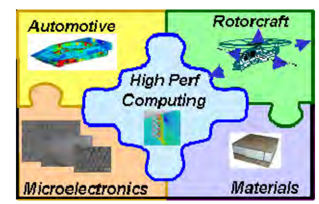
Paradigm Shifting Capabilities Centers/ UARCs

Institute for Advanced Technologies

Institute for Soldier Nanotechnologies

Institute for Collaborative Biotechnologies

Institute for Creative Technologies



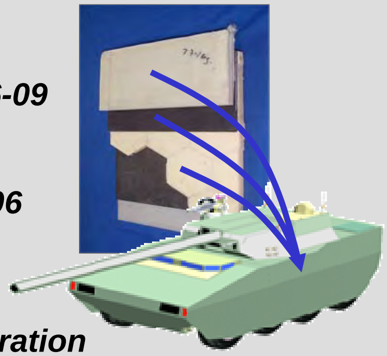
University Centers for Enduring Needs

- Microelectronics Center
- Vertical Lift Center of Excellence
- Materials Center
- Automotive Research Center
- High Perf Computing
- HBCU/MIs with Battle Labs

Manufacturing Technology

Armor

- Low-cost Composites FY06-09
- Appliqué Armor FY07-09
- Low Cost Titanium Mfg FY06



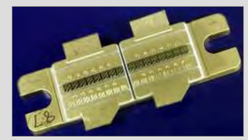
Composite Structural
& Appliqué Armor Integration

Electronics/Power Systems

- S/W Radios FY06-09
- Silicon Carbide Switches FY06-09
- Phase Shifter FY06-08
- Power Storage Systems FY06-09

Common SDR Core Transceiver

Li-Ion Cell

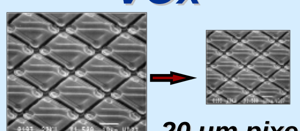


SiC Gate-drive Module

Sensors

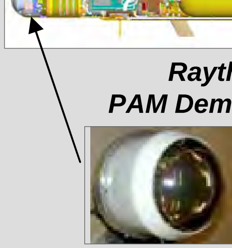
- Dual Band FPA Cooled FY06
- Flexible Display FY06-09
- Uncooled FPA FY06

VOx



25 um pixel 20 um pixel

Raytheon
PAM Demonstrator

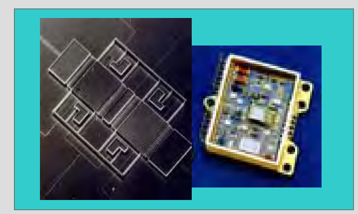


Uncooled Infrared

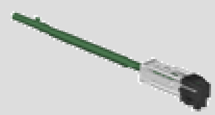
Flexible Display Initiative

Munitions

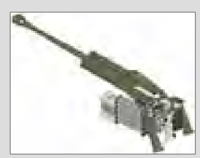
- MEMS-IMU/GPS FY06-07
- MEMS Safe & Arm FY06-07
- Durable Gun Barrels & Armaments FY06-06



MEMS-IMU

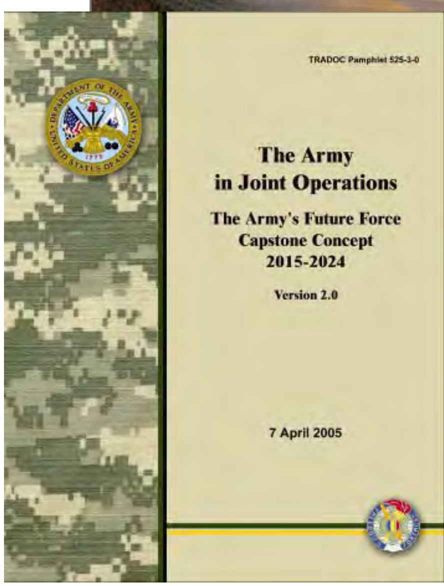


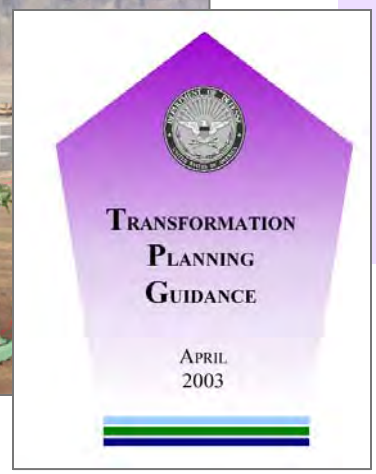
Lightweight 120mm Gun



155mm NLOS Cannon

The Army…
Transforming while at War





"…this may mean making the difficult decision of foregoing currently planned systems and investing instead in capabilities that we believe will reduce future risk."

Secretary Rumsfeld

"The FCS further encompasses a set of technologies and capabilities that will spiral into the entire Army as they mature. Networked C4ISR, precision munitions, and advanced fire control will also be key enablers."

Industry's Challenge in Transitioning Disruptive Technology

Mal O'Neill
CTO (ret.)
Lockheed Martin
mal.o'neill@lmco.com

Agenda:

- What is it?
- Why so hard?
- Success stories
- How should we do it?

Disruptive Modernization in 3-D

- Transitions can be disruptive in three areas:
  - New customer – new way to use existing or slightly modified product (Hellfire on Predator)
  - New process – new way to conduct operations (Performance Based Logistics Contracts)
  - New product – significant improvement of performance and cost or totally new capability

Disruptive Technology:

1. Promises major long term improvements in performance, cost, quality, and/or new capabilities
2. Isn't yet part of a successful product – largely unproven in a practical application
3. Faces competition from existing systems and adversaries inside and outside industry
4. Lacks advocates, especially with customer
5. Forces change in a system which resists change
6. Can't transition without perceptible risk for industry developer and user, potentially
    1. Significant development issues, missed IOC
    2. Poor performance, warranty-profit losses
    3. Damaged industry reputation

Difficulty of Transitioning

- Must educate large decisionmaker group
- Possible new customers – no history w/them
- Acceptably performing systems must be replaced. Are new capabilities good or bad?
- Monies must be found (difficult in any case)
  - Valley of Death (large investment to prove)
  - Unknown unknowns (survivability, environment, vulnerability, reliability, etc.)
- Doctrine and Force structure may be threatened/displaced/obsoleted
- Community of practice may be damaged

Leading Transition

Industry line of business mgt prefers incremental modernization:

- Wants low risk, predictable customer, known volume, costs, and profits
- Can’t differentiate its “commodities” from competitors unless the “process” is improved (Lean, 6-sigma)
- Won’t support disruptive modernization without:
  - Independent leadership
  - External resources (corporate or government)
  - Customer knowledge/buy-in

Success – Nano in Sports

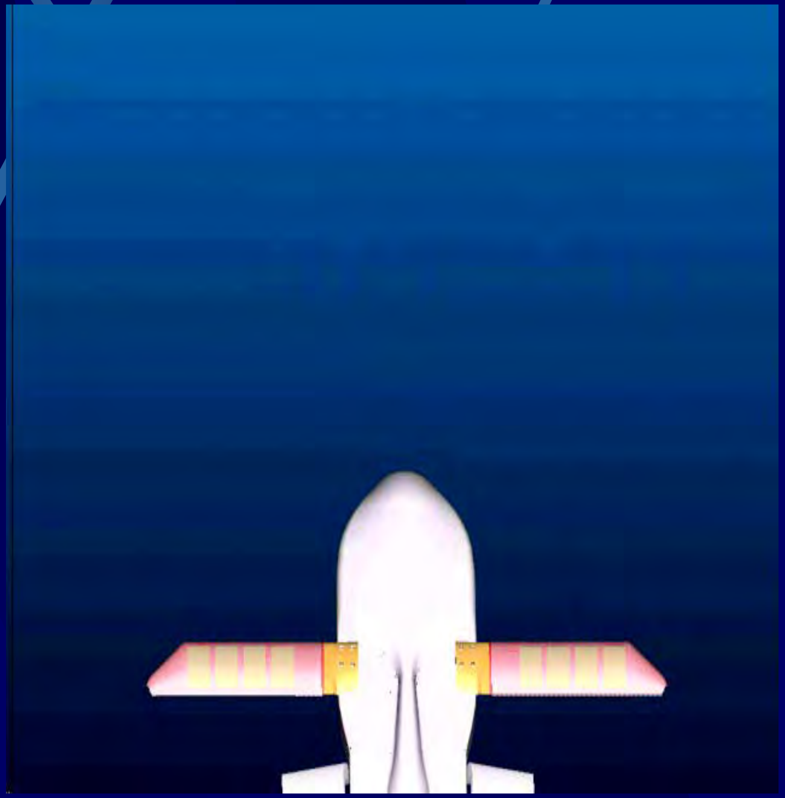
- Who said it's "disruptive" – avoid frontal assault
  - Don't hype nanotechnology
  - Existing products work okay – this is just better
  - If it's disruptive, let that be proven in future
- Engage suppliers in modernization strategy
  - Sell as better performance/quality at lower cost.
  - Use positive aspects of new technology vice risks – acquire/show real data
  - Worst vice is overselling!!! Credibility is Key!!

Interview, Dr. Tom Cellucci, Pres/COO, Zyvex Corp.

Nanomaterials Hit the Field

Nanomaterials Transition to DOD

- **Multifunctional Nano-Structures**
  - **- Ultra Light Weight**
  - **- Strength, rigidity**
  - **- Producibility**
  - **- Mission Adaptability**



Extended Wing LOCAAS

Courtesy of Dr. Les Kramer, LMMFC

Success – JSF Lift Fan

- Hit press in ’01 but lean team began in ‘87: USMC, DARPA and Lockheed
- USMC knew its objectives – stayed in-charge
- DARPA supported before PM had IRAD $
- Skunks had 50 concepts – PM picked “lift fan”
- Company liked “lift engine”; team/competitor influenced final “lift fan” decision
- Sold concept to engine teams thru AF code
- AF added strong staff/tech support (AQR)

Interview, Dr.P. Bevilaqua, NAE
Skunk-PM, Invented Lift Fan

FIRST: STO-SSDash-VL

Courtesy of LMAero

DOD Developer is Key

- Engage the internal R&D community
  - Access to all information (SAP, proprietary)
  - Low cost to sponsor
  - Aids planning and avoids tech surprise
  - Quick response capability
  - Inherently governmental tasks
  - Corporate Memory
  - Continuity Throughout System Life Cycle
- Refresh RDECs to ensure in-house capabilities across new tech domains

Reference: Mike Marshall, "From Science to Seapower"

Industry Needs DOD Developer to:

- Fund tech base for set of designated disruptive technologies – enliven "Reliance"
- Hire/support new S&Es to ensure knowledge of and access to disruptive tech domains (best/brightest)
- Engage Industry/DOE/HSARPA/NSF to ensure input on new system options (w/DARPA)
  - Assess all information (SAP, proprietary)
  - Assign joint monitor (Service lab, other)
  - Coordinate on budgets, goals, performance.
  - Co-develop transition strategies
  - Perform inherently governmental tasks
  - Act as corporate Memory
  - Support Product Across System Life Cycle

Warfighter is Critical

- Provides insights on what capability is needed
- Identifies value/impact of potential improvements
- Envisions when such improvements would be needed
- Doesn't understand the technology – needs explanation
- Thinks he knows what he needs – but hasn't been exposed to disruptive potential of new technology/capability
- Might be wrong customer, so joint and multifunctional inputs needed (might be better suited to MP than SOF)
- Can't articulate all of his knowledge – simple user surveys are of little value – prototype test results may be too late

"If I'd asked my customers what they wanted – they would have asked for a faster horse"   Henry Ford

Industry Needs Warfighter to:

- Include industry in Combat Developments
  - Immediately allow access to Lessons Learned
  - Integrate mod/sim, prototyping as tools
- Train cadre to understand capability options
  - Make system OR/SA trades (CAIV, AOA, COEA)
  - Make hard-nosed decisions early in process – drop dumb stuff sooner-the-better
  - A-TRADOC and JFCOM have good approaches
- Use concept of “pilot” operations in field to evaluate new hardware
- Be willing to revise TOEs, Tactics, Techniques and Procedures to achieve improvements

Industry Must: (1)

- Develop accountability for Independent leadership of disruptive transitions (COO, CTO, other)
- Allocate resources to evaluate disruptive tech
- Shield disruptive technologies from internal trades
  - Don't assign tech to "disrupted" system organization
  - Hire/empower engineers with access to new ideas
  - Build a cadre of "skunks" for mission areas
- Develop credibility with government
  - Understand warfighter problem - communicate
  - Prove the evolution/revolution possibility
- Convince BOD/shareholders that long term survival requires disruptive tech transition

Industry Must: (2)

- Establish Skunkworks-like organizations at corporate level with charters like DARPA
- Develop world-class virtual collocation, simulation, continuously validated, to model disruptive features (scalability, etc.)
- Tie above activities to warfighter and DOD developers, including DOE/Others
- Fully explore the potential of new tech to improve capabilities in DOD mission areas
  - Whether profitable to industry or not
  - Include subcontractors/suppliers/innovators
- Allow failure – assessing evolution/termination

Summary/Conclusion

- Transition of disruptive technology is difficult and if not expedited could negatively affect modernization
- Industry can successfully catalyze valuable disruptive capability with the help of warfighter and developer
  - Warfighter to brainstorm and assess potential
  - Developer to provide tech/business interface
- Industry must realize that success is not guaranteed by only market share and volume growth

"I must work longer and harder each day to weave a world in which I can live. Survival is the play and I want the leading role",

Callahan, *Adrift – 76 Days Lost at Sea*

QUESTIONS

OR WRAP-UP AND

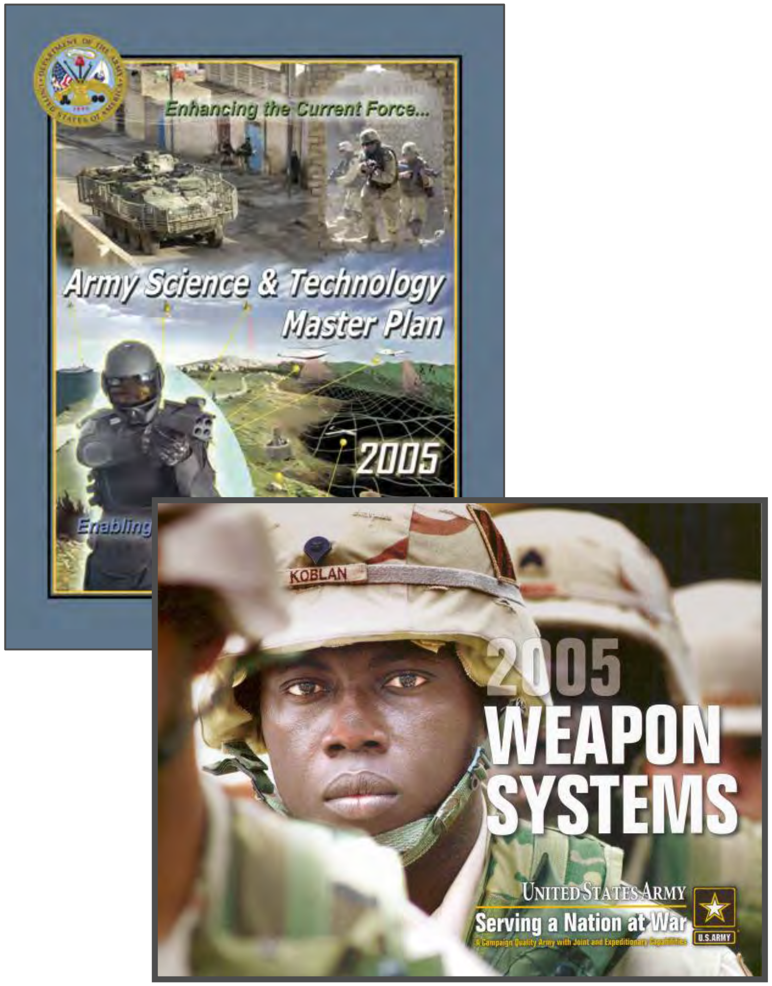
LUNCH, YOUR CALL?

BACKUP

Army
Science & Technology

NDIA
Next Generation Capabilities: Army Basic Research

19 April 2006



Mary J. Miller
Director for Technology
Office of the Assistant Secretary
for Research & Technology

Overview

- ***Basic Research Overview***
- ***Army Basic Research Program Components***
  - ***Single Investigator Program***
  - ***Paradigm Shifting Capability Centers/University Affiliated Research Centers (UARCs)***
  - ***University Research Initiatives***
  - ***In-House Research***
  - ***University Centers for Enduring Needs/Army Centers of Excellence***
  - ***Collaborative Technology Alliances***
- ***New Initiatives***
  - ***Network Science***
  - ***International Technology Alliance (ITA)***
  - ***Army Educational Outreach***

Capabilities for a Joint and Expeditionary Army

Current Force

~100 lb. load

70+ tons

< 10 mph

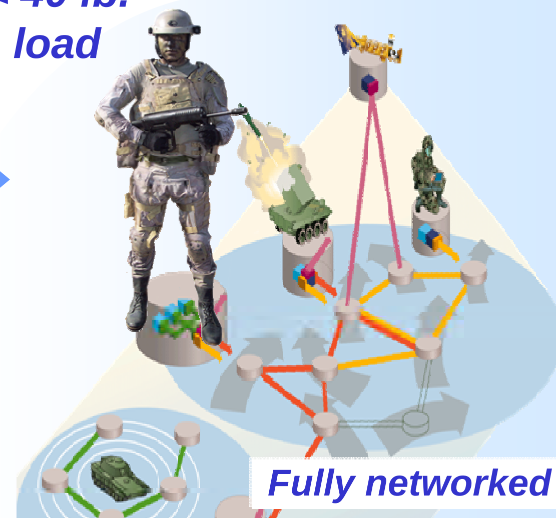
Enabling the Future Force

Science and Technology—
develop and mature technology to enable transformational capabilities for the Future Modular Force while seeking opportunities to accelerate technology directly into the Current Modular Force

Enhancing the Current Force

Future Force

< 40 lb. load



Fully networked

< 30 tons

> 40 mph

Army Enduring Need for Basic Research
- Maintain Land Warfare Technological Superiority -

- ***Sponsor Army-unique areas of research (e.g., penetration mechanics, insensitive energetic materials, pulse power, etc.)***

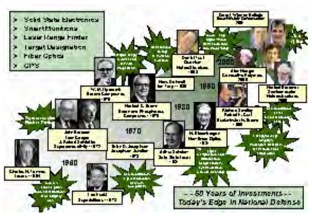
- ***Focus/tailor research and innovations in other areas to suit Army needs (e.g., compact power for the <u>soldier</u>, smart materials for <u>rotorcraft</u>, new materials for Soldier protection, high density <u>tactical</u> networks)***

- ***Purpose:***
  - ***Take advantage of new discoveries and mature knowledge to support Army future capabilities***
  - ***Enable breakthrough capabilities***
  - ***Exploit technological opportunities***
  - ***Interpret and tailor progress for Army benefit***

Basic Research

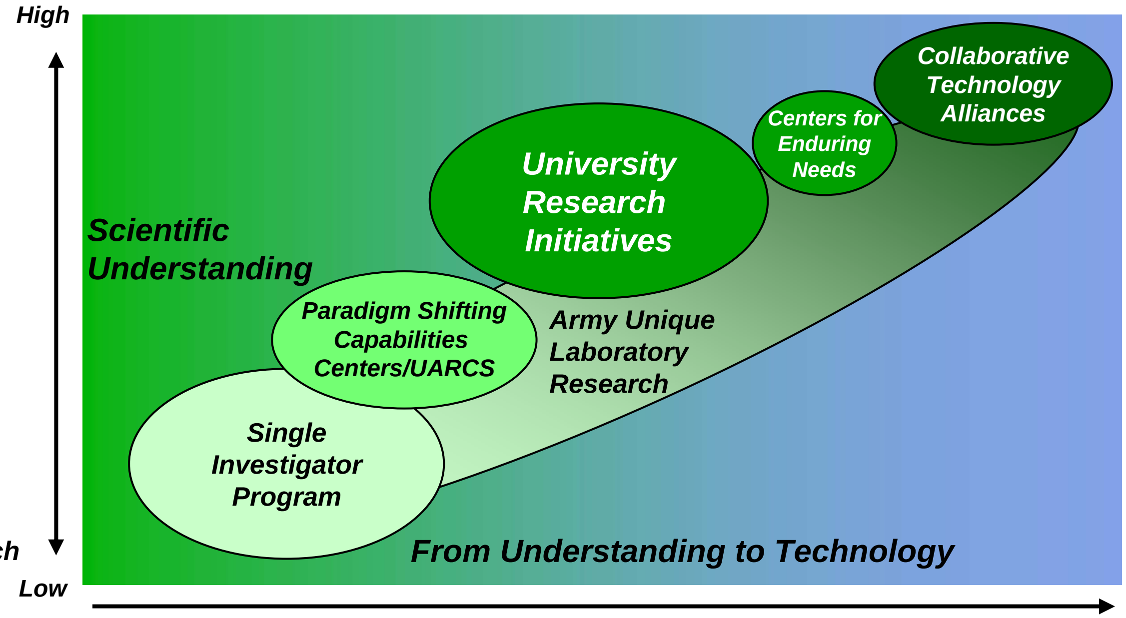
University Single Investor Program

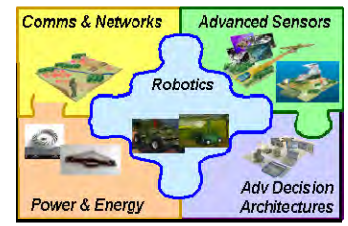
- Solid State Physics
- Structural Mechanics
- Electro-magnetics
- Materials Science
- Innovative Countermine



University Research Initiative (Devolved)

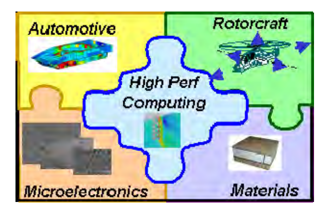
- Multidisciplinary Research
- DURIP





Collaborative Technology Alliances

- Comms & Networks
- Robotics
- Advanced Sensors
- Power & Energy
- Advanced Decision Arch
- Micro-Autonomous Systems & Technologies
- Network & Info Science ITA



University Centers for Enduring Needs

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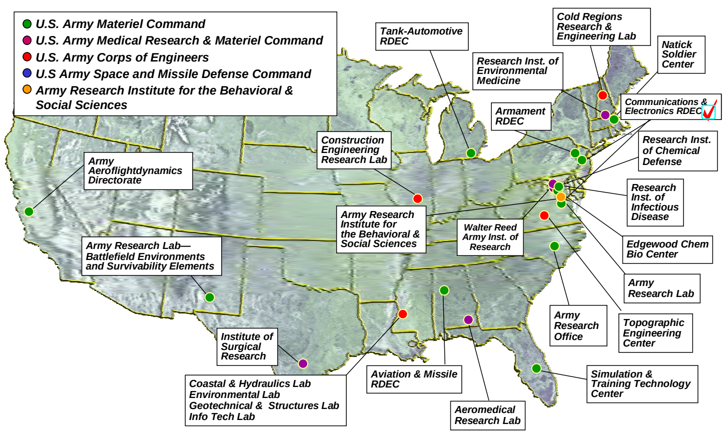
- Materials Center
- Automotive Research Center
- High Perf Computing
- HBCU/MIs with Battle Labs

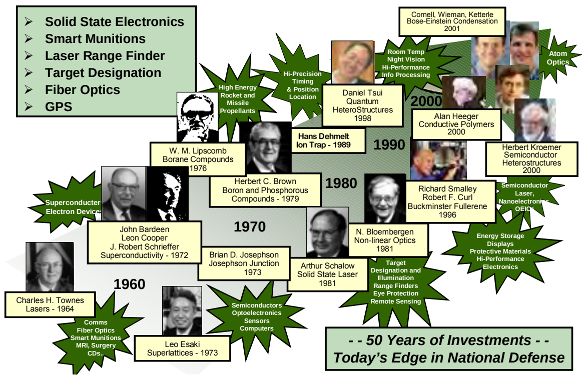
In- House Research



Paradigm Shifting Capabilities Centers/ UARCs

- Institute for Advanced Technologies
- Institute for Soldier Nanotechnologies
- Institute for Collaborative Biotechnologies
- Institute for Creative Technologies

Single Investigator Program

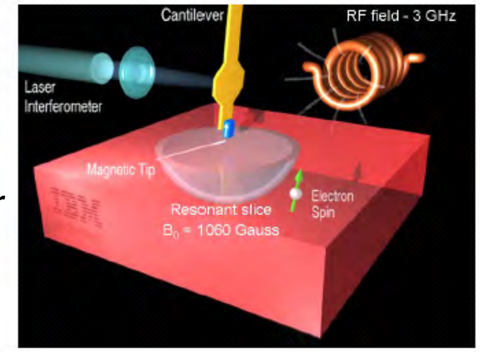


Exploit the innovation and flexibility of academia

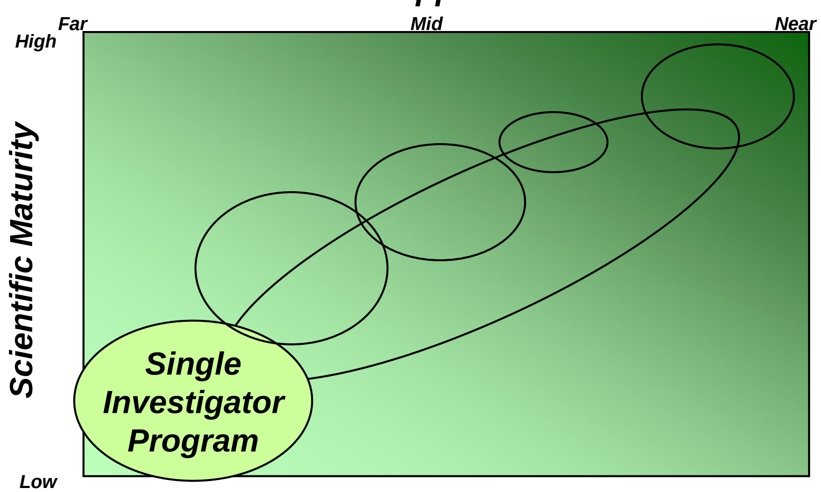
Single Electron Spin Detected

Ultra-high sensitivity coupling the magnetic resonance of atomic spins to the mechanical resonance of an Atomic Force Microsopy cantilever

Potential applications to
- *Quantum computing*
- *Chem/bio defense*



Transition to Applied Research



Discoveries and innovations often have unforeseen, widespread impact

- ***Rapid exploitation of novel science opportunities world-wide***
- ***45 states and DC***
- ***>200 institutions***
- ***Graduate students supported: ~1400***
- ***~ 900 university grants, $80k/yr grant***

Paradigm Shifting Capability Centers/ University Affiliated Research Centers (UARCs)

Electromechanics & Hypervelocity Physics

Immersive Environments

Soldier Survivability

Biotechnology

High intensity focus on emerging opportunities

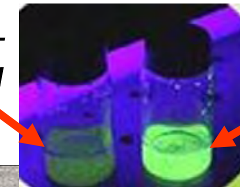
Institute for Soldier Nanotechnologies

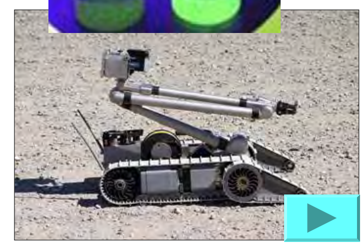
Objective:

Remote IED Detection

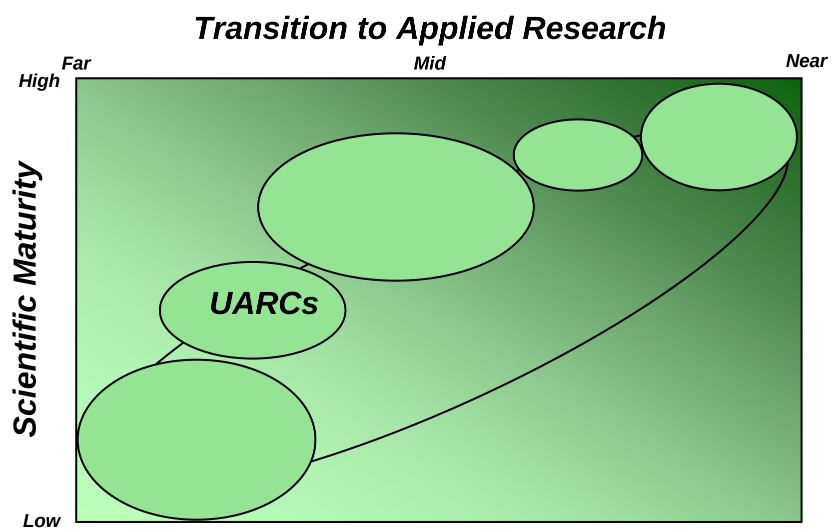
Approach:

Amplifying Fluorescent Polymer (AFP) developed by MIT ISN Associate Director Tim Swager normally glows green, but quenches when TNT is present



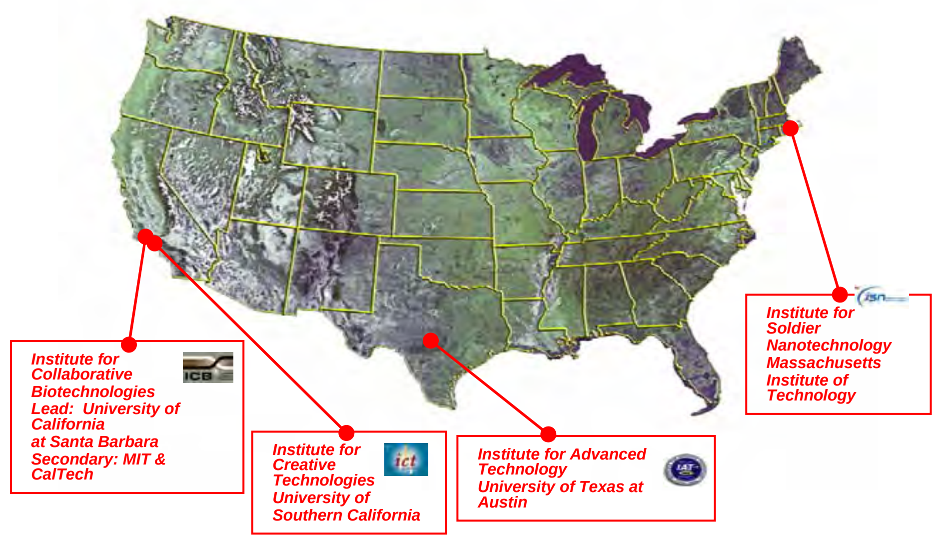


Fido/Pakbot



Leveraging breakthrough research for revolutionary capabilities

University Affiliated Research Centers



Paradigm Shifting Capability Centers/ University Affiliated Research Centers (UARCs)

Creating a Virtual Human

- ***Incorporate dynamics of human thought process, communication and response***
  - ***Speech recognition***
  - ***Natural language processing***
  - ***Dialogue management***
  - ***Cognition***
  - ***Perception***
  - ***Emotions***
  - ***Animation***
  - ***Cultural attributes***

Institute for Soldier Nanotechnologies

Grand Challenge:
Develop realistic human performance models

Multidisciplinary University Research Initiative (MURI)

- DDR&E provides oversight
- Collaboration with Army laboratories

Adaptive Coordinated Control in the Multi-Agent 3D Dynamic Battlefield

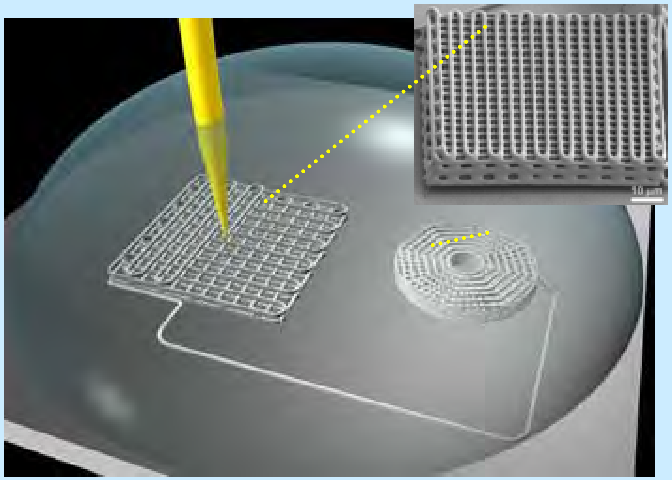
Development of scaleable control architecture and algorithms suitable for operation of multiple aerial vehicles in dynamic environments

- Examples of MURI Topics of high relevance to the Army
  - Cross-Disciplinary Approach to the Modeling, Analysis, and Control of Wireless Communication Networks
    - Develop analytical models and tools to describe, analyze, predict, and control the behavior of mobile ad hoc networks (MANETS)
    - Enhance the ability to analyze, design and predict performance of MANETS in a variety of challenging environments
  - Material Engineering of Lattice-Mismatched Semiconductor Systems
    - Establish the science base and infrastructure needed to commercialize lattice-mismatched electronics
    - Provide system designers with options to enable major performance gains in high-speed data processing, improved target detection/recognition, and improved battlefield communications

Multi-disciplinary research to enable Army transformation

Defense University Research Instrumentation Program (DURIP)

DURIP provided Research Instrumentation allows direct writing of polyelectrolyte ink



Robotically defined woodpile structure

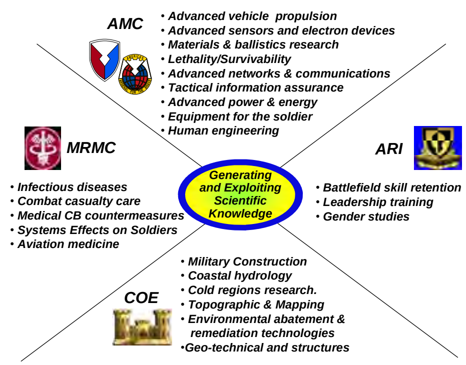
Research has applications for future photonic devices for Army communications and protection systems

- ***Competitive grants awarded for the acquisition of research instrumentation***
- ***Emphasis on instrumentation vital to the discovery of new science and the advancement of Army transformational technologies***
- ***Allows researchers to take immediate advantage of fast paced instrumentation innovation***

In one year, 210 professors and 920 post-docs and graduate students at top Universities in the U.S. perform research using Army sponsored DURIP equipment

Army Laboratory In-house Research

Army-Unique Facilities and Expertise



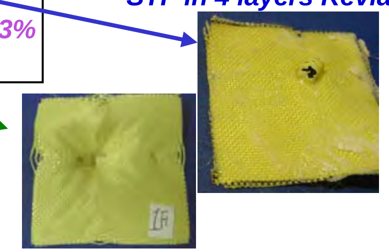
Insure against technological surprise

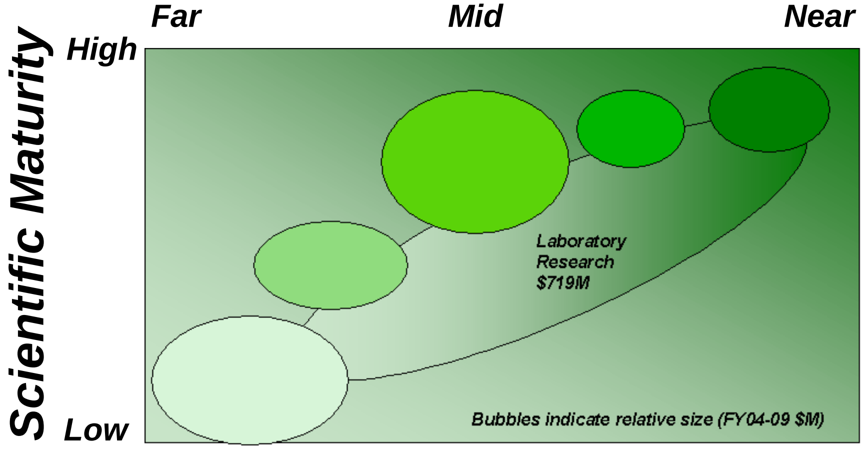
"Liquid Armor" Concept

Objective: Provide a compact, flexible armor material

- STF in 4 layers Kevlar
- STF in N layers Kevlar, v_f=83%
- Neat Kevlar

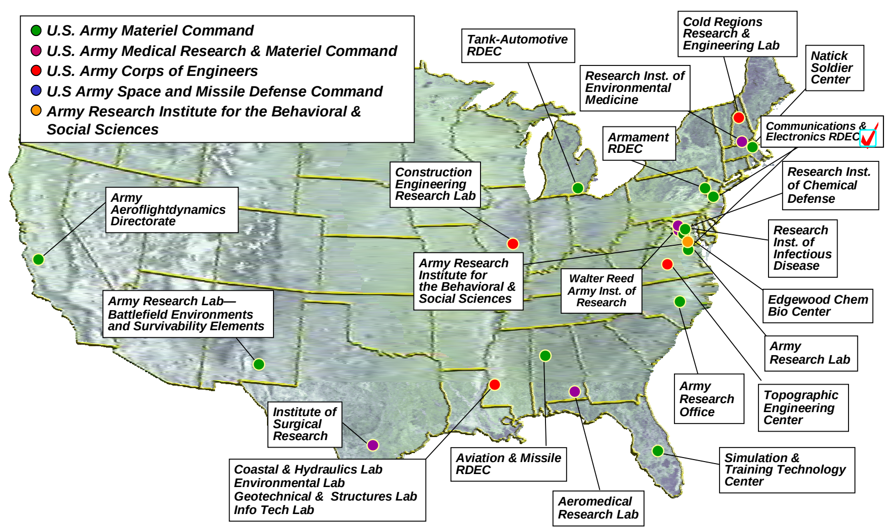
STF-Kevlar provides reduced area density (high fabric loading) or greatly reduced number of fabric layers (high STF loading) relative to Neat Kevlar



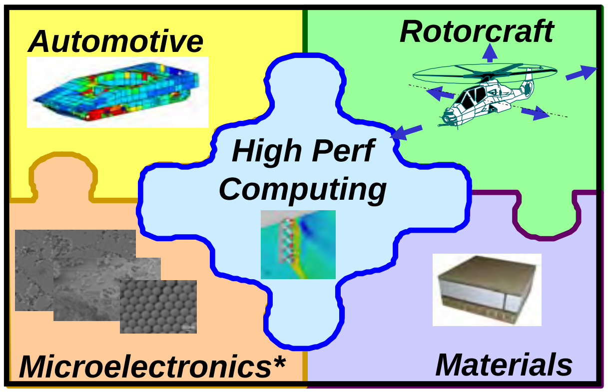


Discover & mature fundamental knowledge underlying Army applications

U.S. Army Laboratories



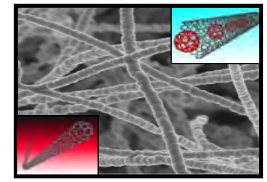
University Centers for Enduring Needs



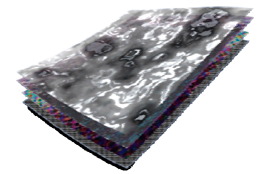
* Ends in FY07

Objective of this materials research is to protect, conceal, and provide lightweight sustainment for the soldier and equipment.

- *Indestructibility Integrated self-protection capabilities from weapons, puncture, and blunt trauma*
- *Undetectable by contact search or standard detection devices (metal detectors, radars, etc.).*

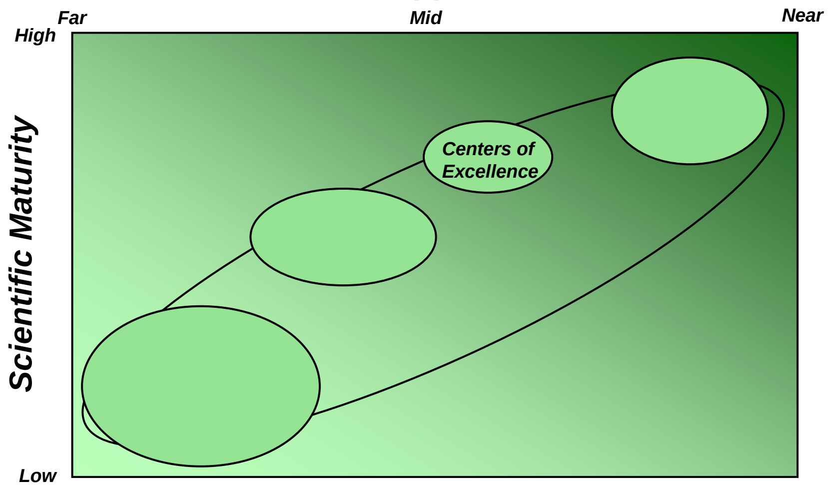


Carbon Nanotube Armor



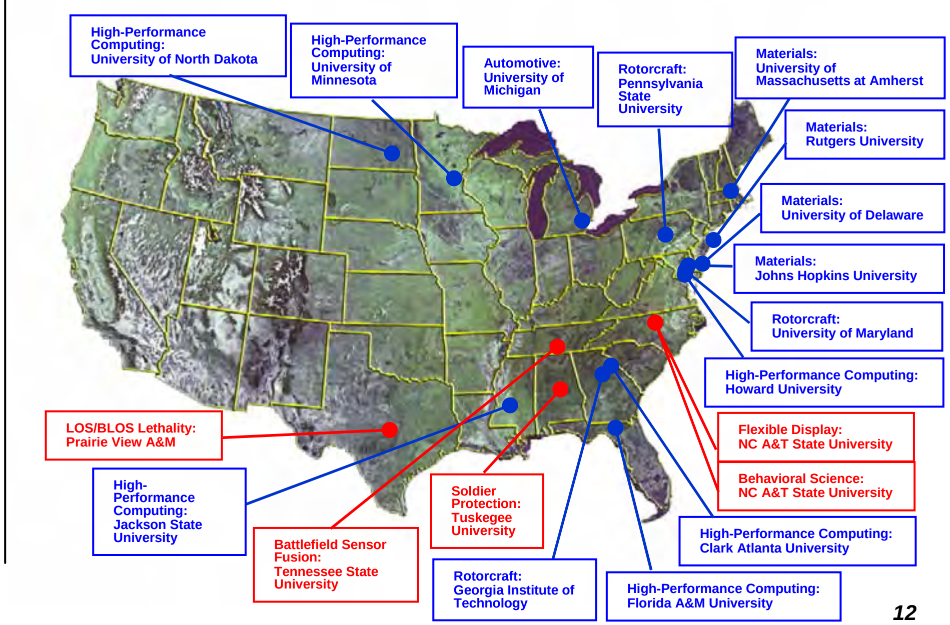
Adaptive Intelligent Laminates

Transition to Applied Research

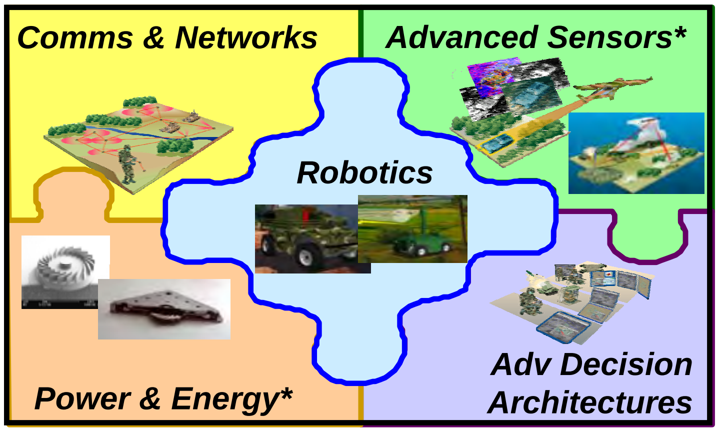


Advance the state-of-the-art for enduring Army needs

University Centers For Enduring Needs



Collaborative Technology Alliances



* Transitions to Micro Autonomous Systems & Tech CTA in FY07

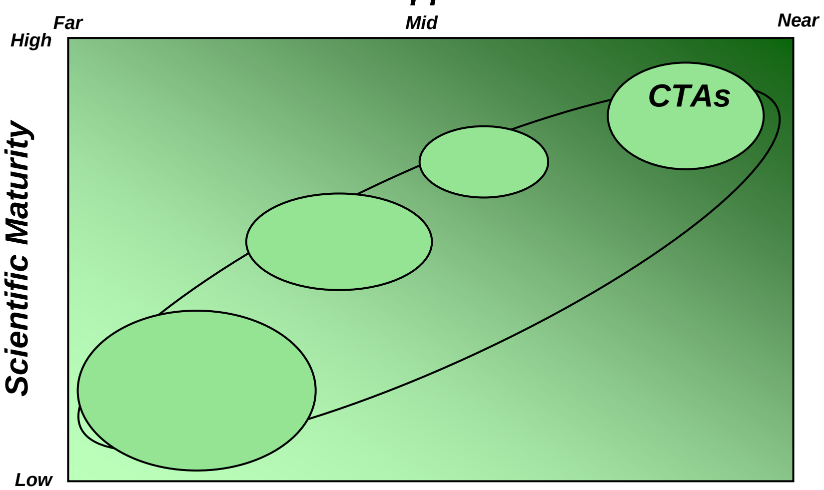
Micro Autonomous Systems and Technologies

Vision: Autonomous networked ensembles of multifunctional microsystems for enhanced battlefield situational awareness for the Soldier

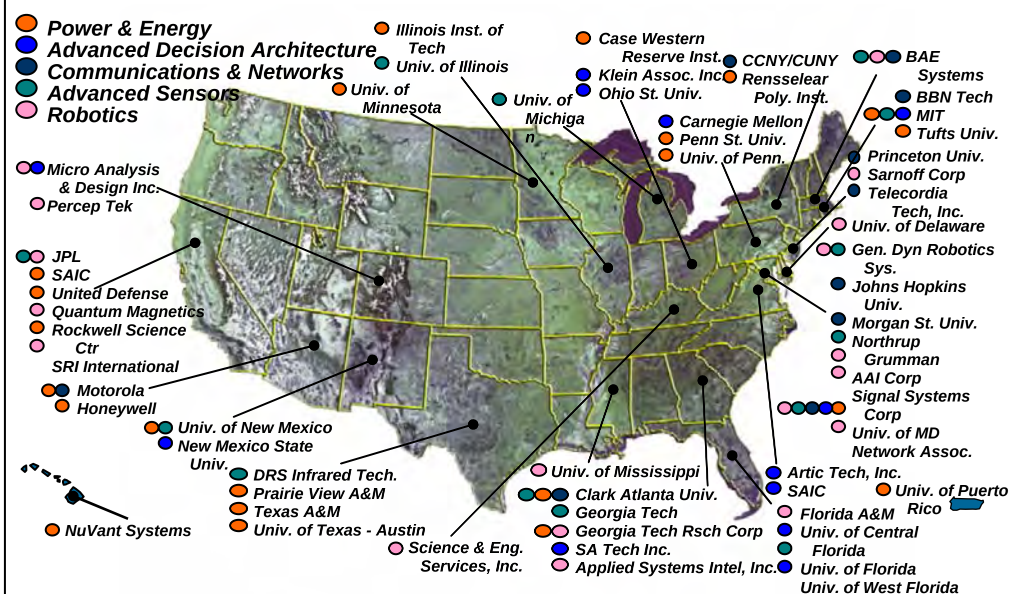
Technical Challenges:

- Sensing, processing, communication, navigation & control
- Materials, devices, integration, & packaging
- Microbionic ambulation & aeromechanics
- Miniature power & energy
- Mobile, Distributed Sentience
- Platform Integration

Transition to Applied Research



Access to world-class expertise & equipment



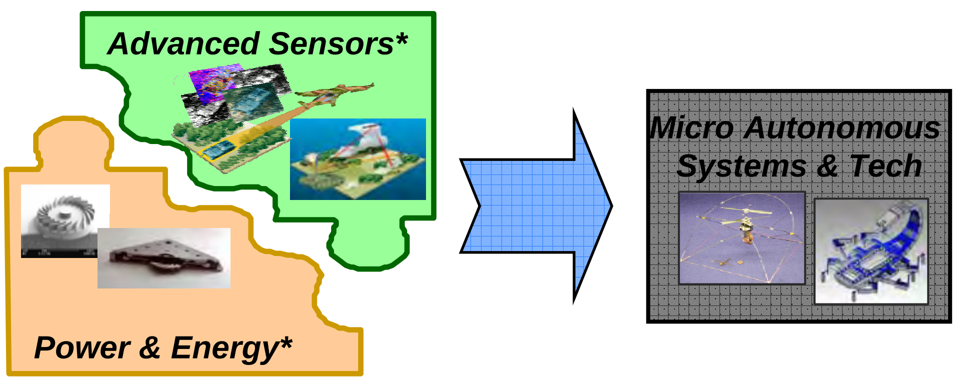
New Initiatives

Collaborative Technology Alliances

Industry Led Partnerships with Major Universities and the Army

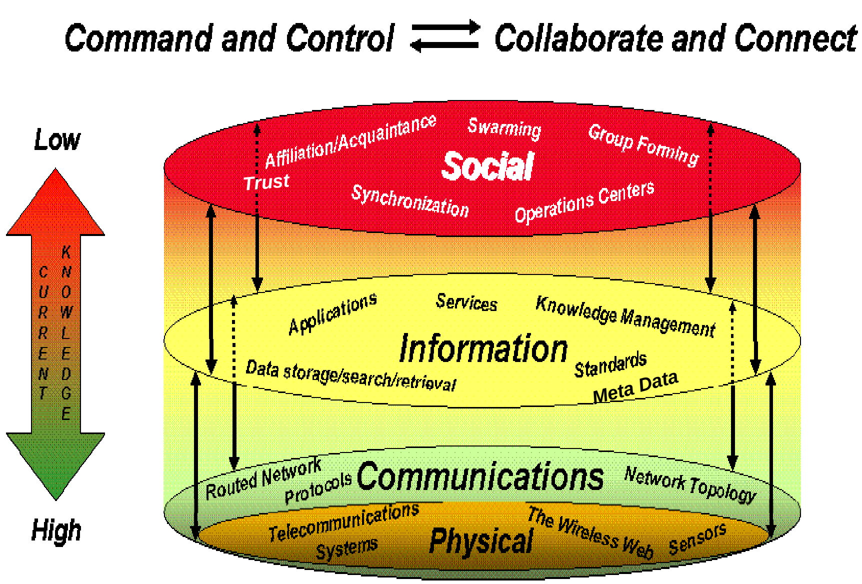
Micro Autonomous Systems & Technologies (MAST) CTA: ***Targeted refocusing of Advanced Sensors and Power & Energy CTAs on enabling technologies for next-generation robotic platforms***

- ***Payload power generation and management for palm-sized platforms***
  - ***Small size limits mission objective & duration***
- ***Power generation for mobile palm-sized platform***
  - ***Small size limits means for generating mobility***
- ***Bio-inspired and bio-mimetic sensing for navigation & control***
  - ***Small size requires simple sensors for navigation & control***
- ***Computational sensing***
  - ***Extracting information efficiently from data more important than improving sensor performance (e.g., dynamic range, resolution, frame rate)***



FY06 Initiatives
Network Science

- *Develop mobile ad-hoc networks (MANET) through an integrated research program in Network Science, including cognitive and social domains, comms, mathematical models, biomimetics, ecosystems, sensors, power and coalitions*



Project Provides:

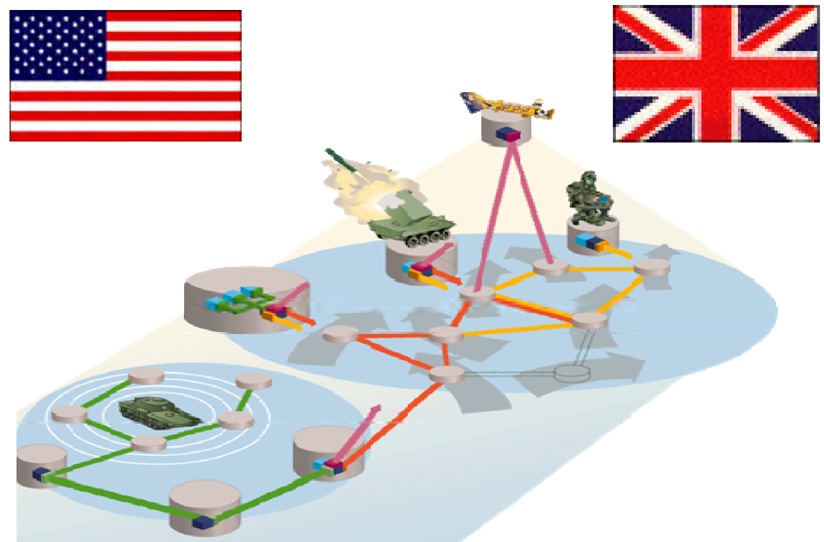
- *Mathematical models of network behavior to predict performance with network size, complexity and environment*
- *Optimized human performance in network-enabled warfare*
- *Networking within ecosystems*
- *Molecular networking of proteins in cells*

Pacing Technologies:

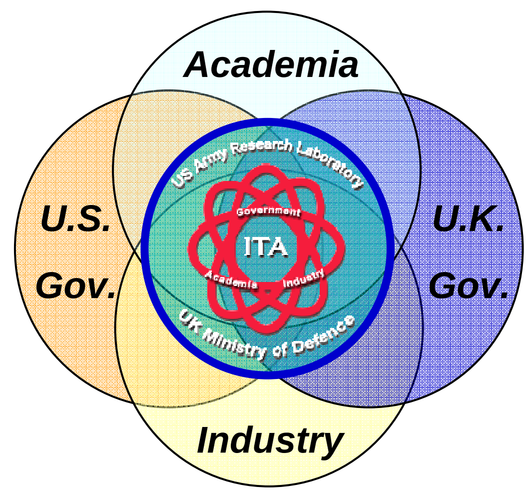
- *Statistical-based and analytic models for understanding MANET performance*
- *Cognitive and social models of individual and unit behavior in information-rich MANET environments*
- *Mathematical models of ecosystems as networks*
- *HPC exploitation of Interactomics*

Network & Information Sciences ITA

Jointly established research consortium formed from US and UK industrial and academic members for the purpose of conducting research to <u>develop underpinning technology applicable to network centric warfare</u> and to enhance US and UK capability to conduct coalition warfare



- ***Bi-lateral UK MOD—US Army collaboration***
- ***Integrated US/UK industrial/academic consortium***
- ***5-10 year program starting in Spring 2006***
- ***Builds on success of UK Defence Technology Centres and US Collaborative Technology Alliances***



Army Educational Outreach Program

Who	How	Outcome
Teachers	FREP & HSSMFP MWM	Research exposure and experience in the Army Labs and innovative SME teaching tools
K-6	Mentoring & Tutorial Programs	One on One academic support & career path guidance
6-9	eCYBERMISSION	Self Discovery of SME In every day life
8-12	GEMS, REAP, SEAP ECIP MWM, UNITE JSHS, IMO, ISEF	Challenging laboratory internships Enhances SME curricula & understanding of SME concepts Competition promoting conduct of original research
College	ROTC, EPA, STARS, CREST, CUWMA	Laboratory experiences promoting career opportunities

Army S&T is committed to identifying, growing, and developing future generations of the Army's Scientist & Engineering workforce

Summary

- ***Focused on accelerating the pace of Army Transformation to the Future Force while seeking opportunities to enhance the capabilities Current Modular Force***
- ***Exploits innovation through partnerships between Army labs, academia and industry***
- ***Seeks to strike balance between Army unique in-house research and extramural research at various levels of maturity***
- ***Continues to push the boundaries – initiatives in Network Science, Army Educational Outreach and Micro Autonomous Systems and Technologies***


ASC
25TH ARMY SCIENCE CONFERENCE
NOVEMBER 27-30, 2006 · ORLANDO, FL
CALL FOR PAPERS · EXHIBITS · INVITATION TO ATTEND
Transformational Army Science & Technology
— Charting the future of S&T for the Soldier
Sponsored by
The Assistant Secretary of the Army
(Acquisition, Logistics and Technology)
ASC 1957-2006
www.asc2006.com

A New Paradigm for Disruptive Technology Development and Transition

Gregory B. Raupp, Director
Flexible Display Center at Arizona State University
ASU Research Park
Tempe, Arizona 85224
raupp@asu.edu
http://flexdisplay.asu.edu

National Defense Industry Association
7th Annual Science & Engineering Technology Conference
Orlando, Florida
April 20, 2006

Information Displays are a Key Enabling Technology for Network Centric Operations

Source:
PEO Soldier

... and the Flexible Display Center is delivering the next generation displays

FDC

Flexible Displays Will Provide Unprecedented Performance

Next Generation Flexible Displays

- ✓ Rugged
- ✓ Lightweight
- ✓ Ultrathin / Compact
- ✓ Any shape
- ✓ Low power

Enabling the Revolution: *What was Missing in 2003?*

- Single organization with all the technology, know-how and resources required
- Driver to converge technology development on Army applications
- Strategic Plan to advance the technology to commercialization
- World Class Manufacturing Pilot Line incorporating unique toolsets required

The U.S. Army's Flexible Display Center
at Arizona State University
Est. February 10, 2004

Dual Mission:

- ✪ Accelerate commercialization of flexible displays
- ✪ Provide flexible display technology demonstrators for Army Systems and commercial partners

Flexible Display Center

Partnership Vehicle

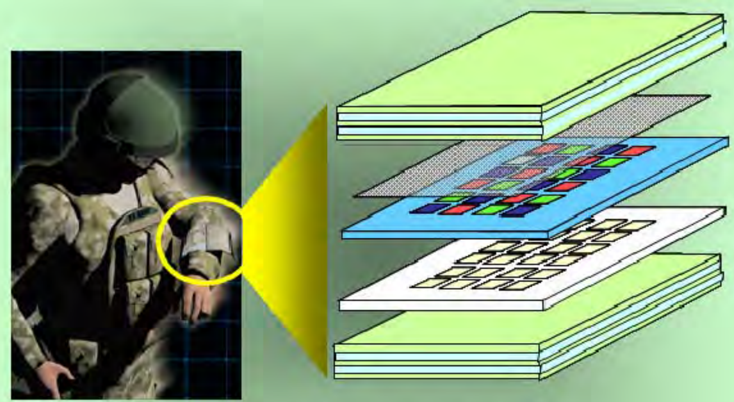
Rapid Innovation, Technology Development & Integration

Pilot Line Manufacturing

Shared Innovation Potential

Intellectual Capacity
Technology
Know-How
Infrastructure
Financial Resources

Flexible Display Center



Government
University
Industry

Technology Demonstrators

Lightweight
Compact
Rugged
Low Power
Manufacturable

FDC

Innovating Military Technology Development

Devices
Low TRL
Low MRL

Development Timeline

Demos
High TRL
High MRL

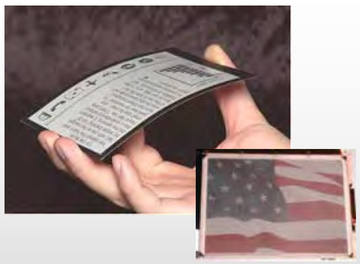
"6.2" Applied R&D Funding	New component technologies Technology integration
"6.7" ManTech Funding	New process technologies Pilot Line deployment and scale-up
FDC Members — Industry Funding	Materials, processes, tools IP, know-how, personnel
ASU — University Funding	Facility, core toolset Faculty, students

World Class Strategic Partnership

FDC Technology Focus

High Information Content
Low Power, Rugged, Lightweight, Flexible

Reflective
Bi-stable "zero power"



Electrophoretic Ink

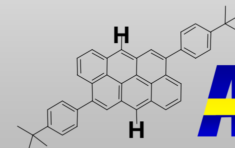
Cholesteric Liquid Crystal

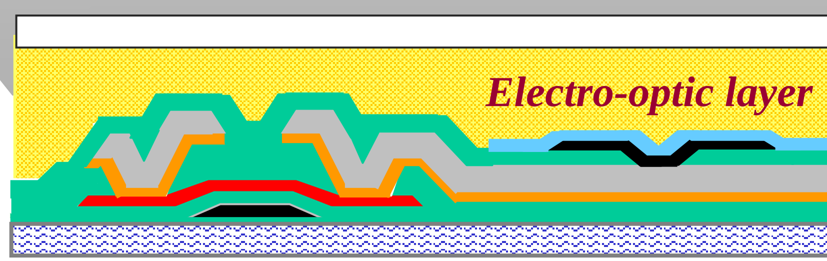
Emissive
Efficient low power

Phosphorescent OLED

OLED Integration

Novel Blue OLEDs





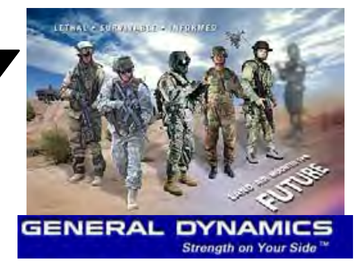
Thin Film Transistor (TFT) Pixel Cross Section on Flexible Substrate

Delivering First Technology Demonstrator to FFW in 2007

2005												2006												2007											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

Re-Plan	System Eng Synch	Design	Build, Integrate, Test	FFW Demo

Capstone Demo



Increment 0 → 1.1” 64x64 emissive and reflective on flex

Increment 1 → 4” QVGA reflective display on rigid

Increment 2 → 4” QVGA reflective display on flex June ’06

Increment 3 → 7.5” VGA reflective display on flex May ’07

Flexible reflective “plug-in ready” Sept ’07 Demo

Increment 0	Increment 1	Increment 2	Increment 3	FFW Demo
Concept Devices and Technology Demonstrators				Capstone Demo

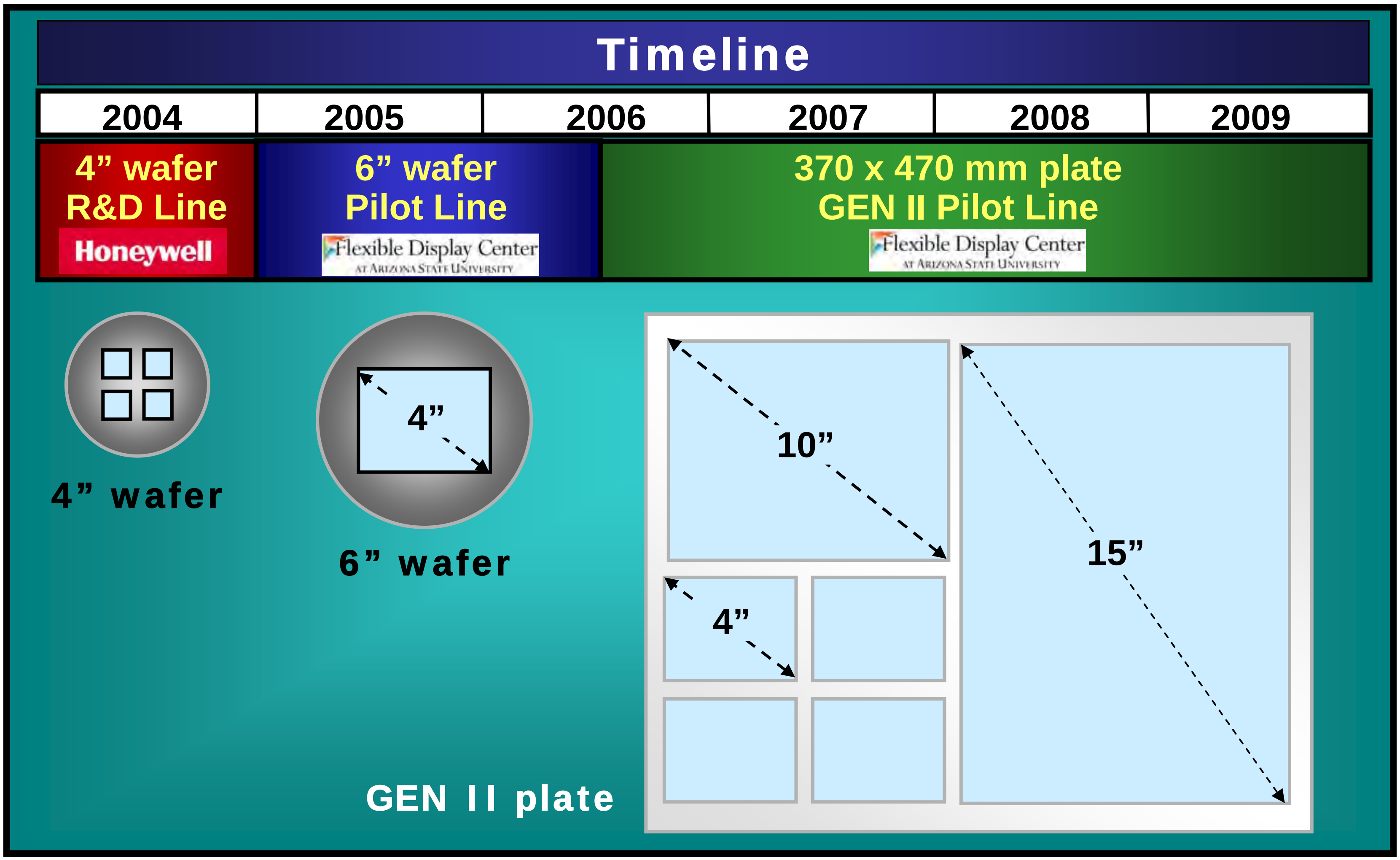
FFW Engaged to Set Capstone Objectives and Requirements

- Comprehend customer-desired display size, form factor, resolution
- Led by Andy Taylor, Chief FFW Architect

Follow-on studies and workshops culminating in formal requirements 3Q 2006

U.S. ARMY NATICK SOLDIER CENTER ARL GENERAL DYNAMICS Strength on Your Side™ Honeywell

Rapid Pilot Line Deployment:
Alignment with Army Programs
Commercialization Acceleration

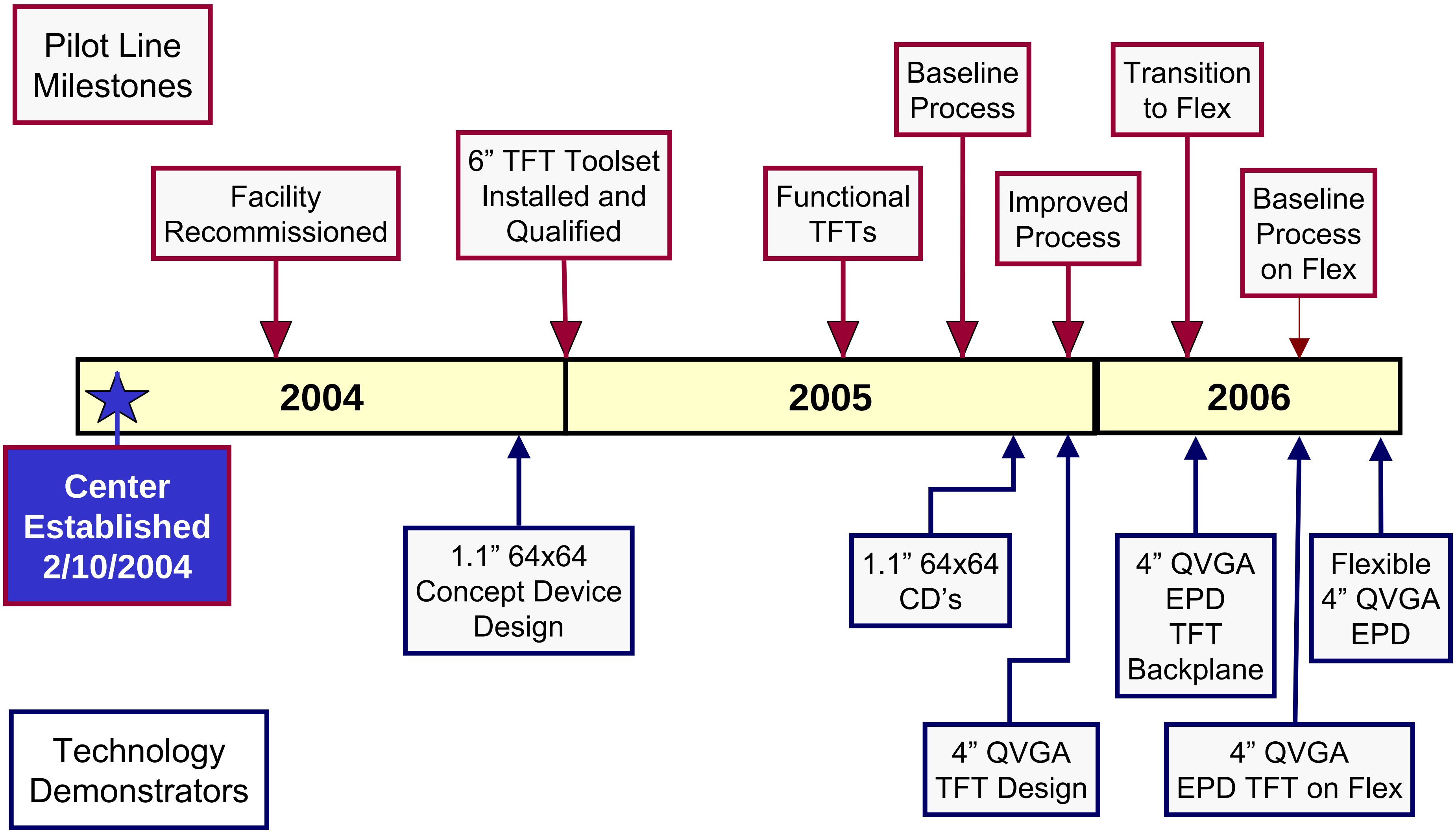


FDC Pilot Line Capability Compared to Typical R&D Line

- Dramatically higher productivity:
  - ✓ Throughput
  - ✓ Cycle time
- Higher quality at high yield
- Lower unit cost

Characteristic	Academic R&D Line	FDC Pilot Line
Throughput	4-5 starts/month	250-300
Cycle time	8-12 weeks	1-2 weeks
TFT Yield	Undefined	> 90%
Staffing	Students & Post-docs	Industry Professionals
Tool Operation	Manual	Automatic
Data Collection	Manual	Automatic (MES)
Substrate Scale	Chip → 4-6" Wafer	6" Wafer → GEN II
Display Unit Cost	High	Moderate

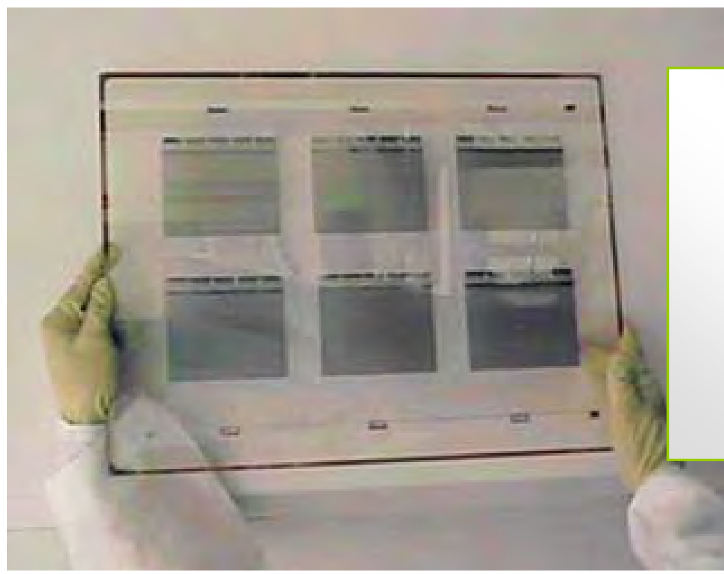
Technology Demonstrators linked to Pilot Line and Backplane Milestones

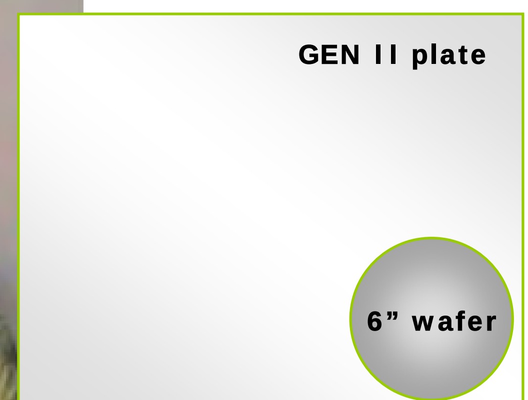


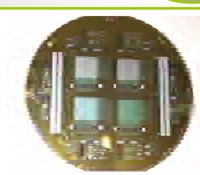
FDC

Manufacturing Scale-up to GEN II

- Only Pilot Line of this scale and sophistication dedicated to flexible display development
- Demonstrates manufacturability and scaleability
- Provides vehicle for producing large form factor (17”) custom displays for the Army and partners
- Requires custom designs and modifications of conventional process tools

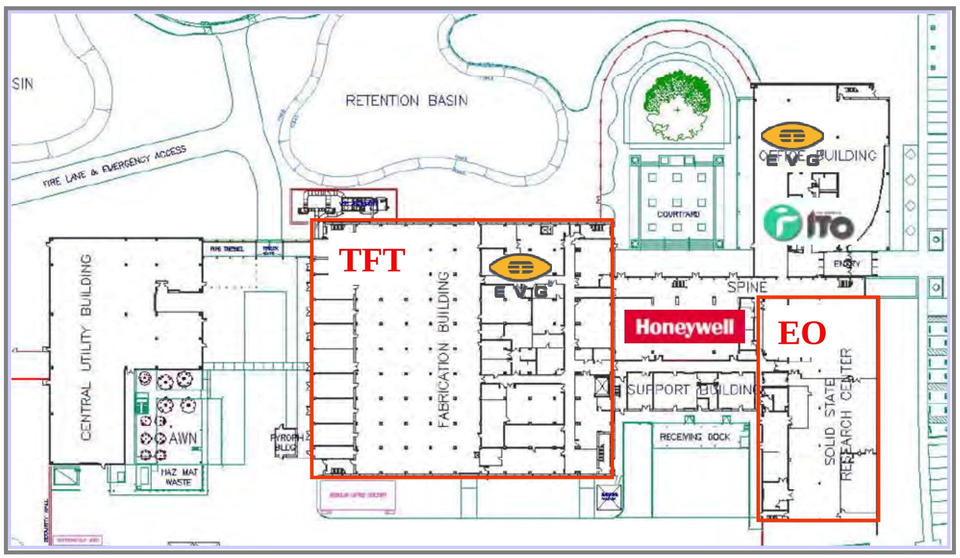






World Class Display R&D to Manufacturing Facility

- State-of-the-Art Infrastructure
- 250,000 SF total capacity
  - 43,500 SF Cleanroom
  - Pilot Line and Production capable
  - 22,000 SF Wet / Dry Labs
- Flexible subdivision for partner co-location



TFT Fab

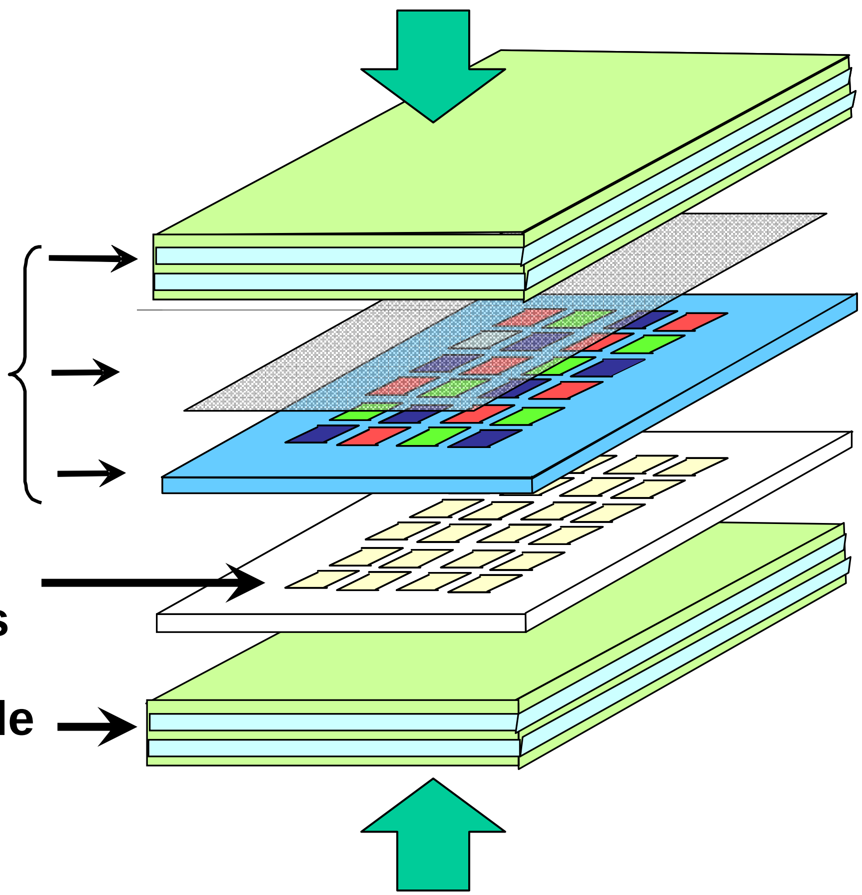
FDC

FDC is Attacking Key Technology Challenges

Encapsulated EO Materials and Devices

Backplane Electronics

Impermeable Flexible Substrates System



❸ Robust materials and manufacturable processes on flexible backplanes

❷ Low quality TFT materials

❶ No manufacturing-ready “drop-in” replacements for glass

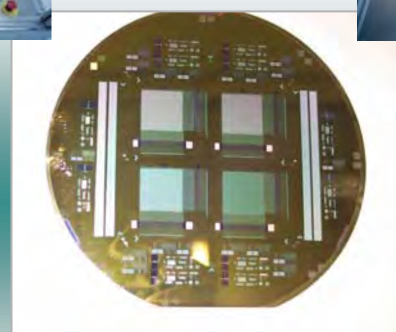
❹ Sub-system integration: material / process compatibility

FDC

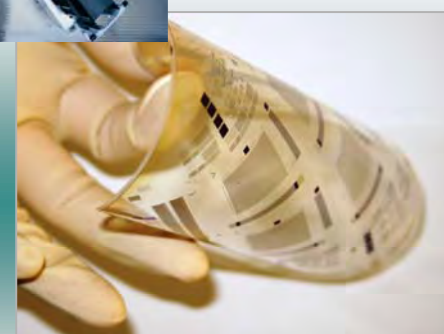
FDC Technology Solutions
Substrate Bond / De-Bond

- Pilot Line Tools
- Novel Adhesive Materials
- Manufacturable Processes

Bonded substrate



After TFT Fab

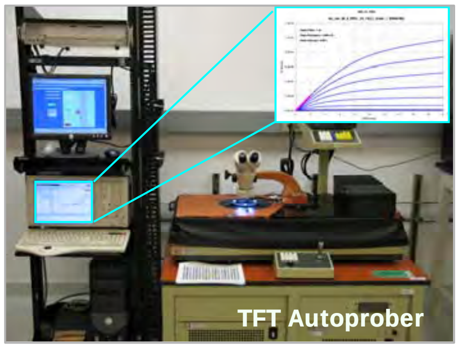


Debonded substrate

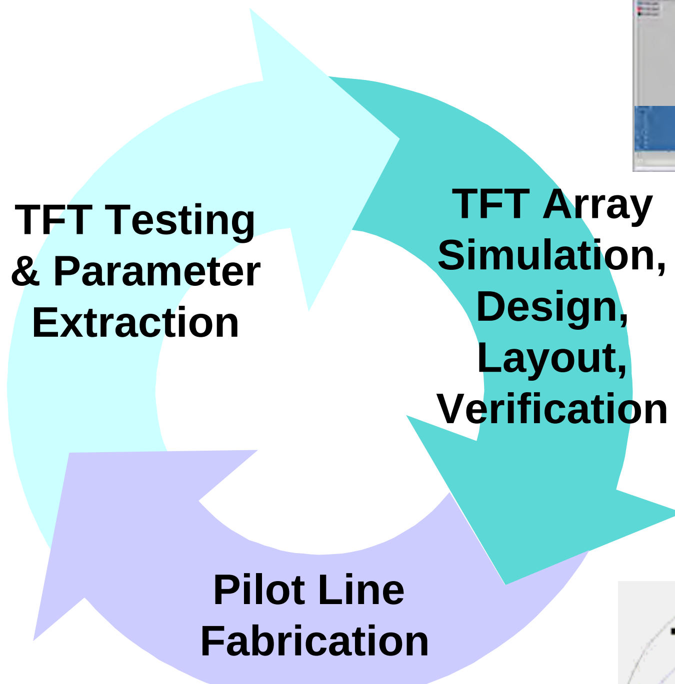
EVG DuPont Teijin Films NITTO DENKO National Starch & Chemical (A member of the ICI Group) USDC U.S. Display Consortium

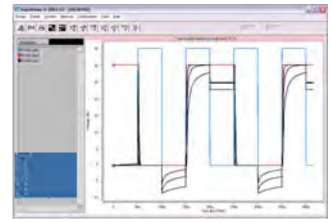
FDC Technology Solutions

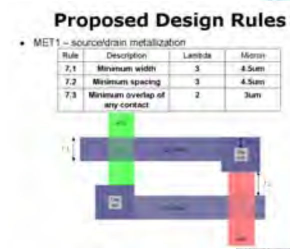
Rapid Cycles of Learning: TFT design, fabrication, testing



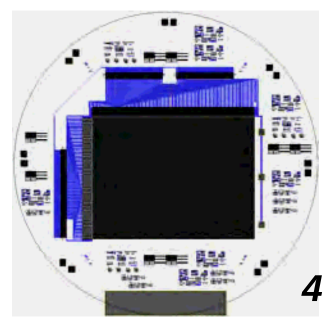
FDC custom auto-probe
24,150 TFTs CY 2005
5,840 TFTs 1Q 2006



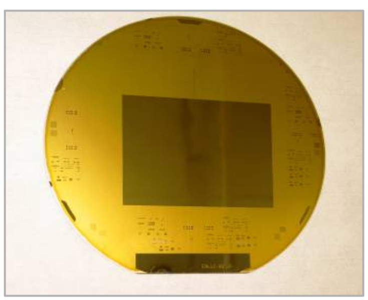




Design Rules for high manufacturing yield



4" QVGA Maskset

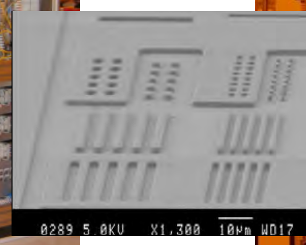


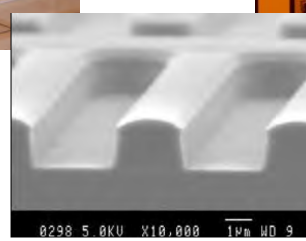
Fabricated array

FDC Technology Solutions

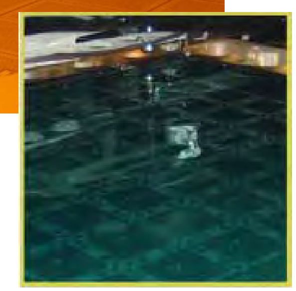
Unique GEN II Toolset
for patterning large area flexible substrates

EVG FDC Photoresist Coater





Azores 5200 gT Stepper



Alpha Tool
high uniformity with unprecedented material utilization efficiency (> 90%)

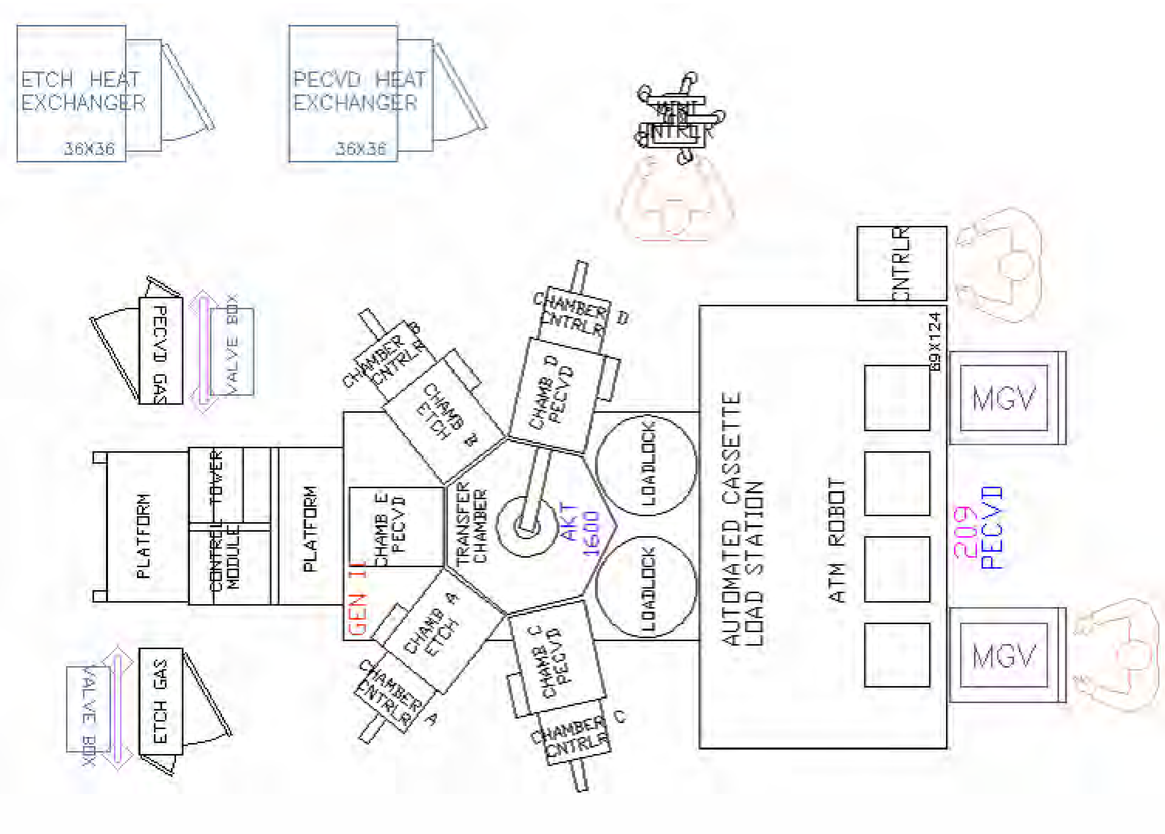
EVG

World's First
photolithography tool with flexible substrate distortion compensation

USDC
U.S. Display Consortium

FDC Technology Solutions:

Unique GEN II Tool for large area flexible substrate thin film dep/etch



AKT 1600

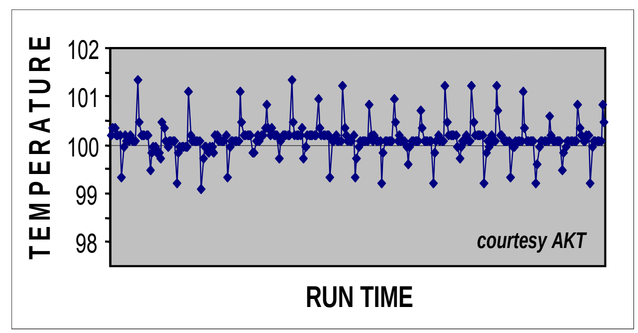
3 PECVD Chamber

2 Etch Chamber

Hybrid design by AKT to FDC specs

2nd AKT Pilot Scale tool dedicated to flex

New "active cooling" deposition chamber design for accurate T control



Summary

- **The FDC was established to accelerate commercialization of flexible displays and to provide new, early capability to the Army**
- **The FDC has created a <u>one-of-a-kind partnership</u> to enable rapid <u>development</u> of dual-use flexible display technology and <u>transition</u> to the military and commercial world**
- **Rapid deployment of Pilot Lines**
  - ✓ **6" wafer-scale Pilot Line for rapid technology development**
  - ✓ **Producing 4" QVGA backplanes and TDs**
  - ✓ **Tools, materials and processes developed to enable processing on flex**
  - ✓ **Unique GEN II Pilot Line to demonstrate manufacturability and scaleability**
- **The Strategic Plan is being executed on or ahead of schedule**

New Capability for the Soldier-- New Opportunities for Industry

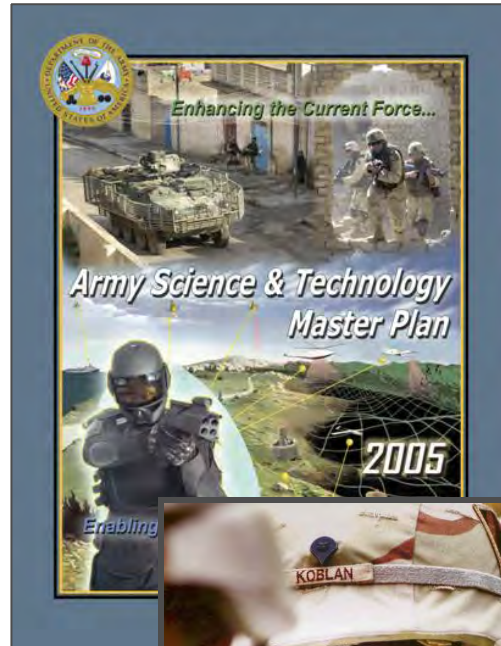
Acknowledgements

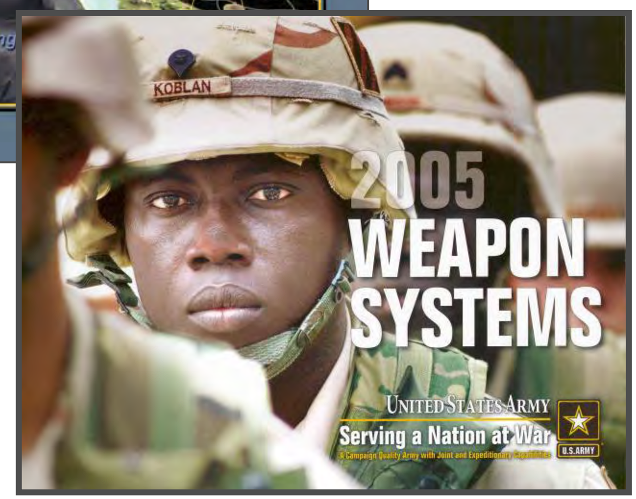
- ASU and The Flexible Display Center gratefully acknowledge the substantial financial support of the U.S. Army through Cooperative Agreement W911NF-04-2-0005
  - ✓ Dr. David A. Morton, ARL, Cooperative Agreement Manager
  - ✓ Mr. Henry Girolamo, U.S. Army NSC, Associate PM Integration
  - ✓ Dr. Eric Forsythe, ARL, Associate PM Technology
- FDC Principal Members: *EV Group, Honeywell, UDC, USDC*
- FDC Associate Members: *E Ink, Kent Displays, Corning, Ito America, Abbie Gregg, Inc., Surface Science Integration, Rockwell Collins, Nitto Denko, Litrex, DuPont Teijin Films*
- FDC Technology User Members: *General Dynamics, Raytheon, L-3 Communications*

Army
Science & Technology

NDIA
Army Approach to Disruptive Technologies and Transition

20 April 2006





Mary J. Miller
Director for Technology
Office of the Assistant Secretary
for Research & Technology

Purpose

- *Describe some Army Disruptive Technologies*
  - *Future Combat Systems*
  - *Solid State Laser Technology*
  - *Immersive Training*
- *Describe Technology Transition Issues*

Capabilities for a Joint and Expeditionary Army

Current Force

~100 lb. load

70+ tons

< 10 mph

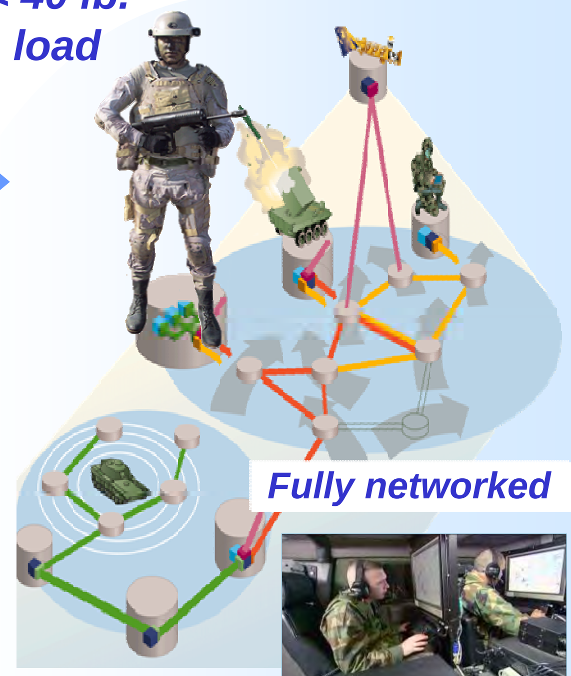
Enabling the Future Force

Science and Technology—
__develop and mature technology to enable transformational capabilities__ for the Future Modular Force while __seeking opportunities to accelerate technology__ directly into the Current Modular Force

Enhancing the Current Force

Future Force

< 40 lb. load

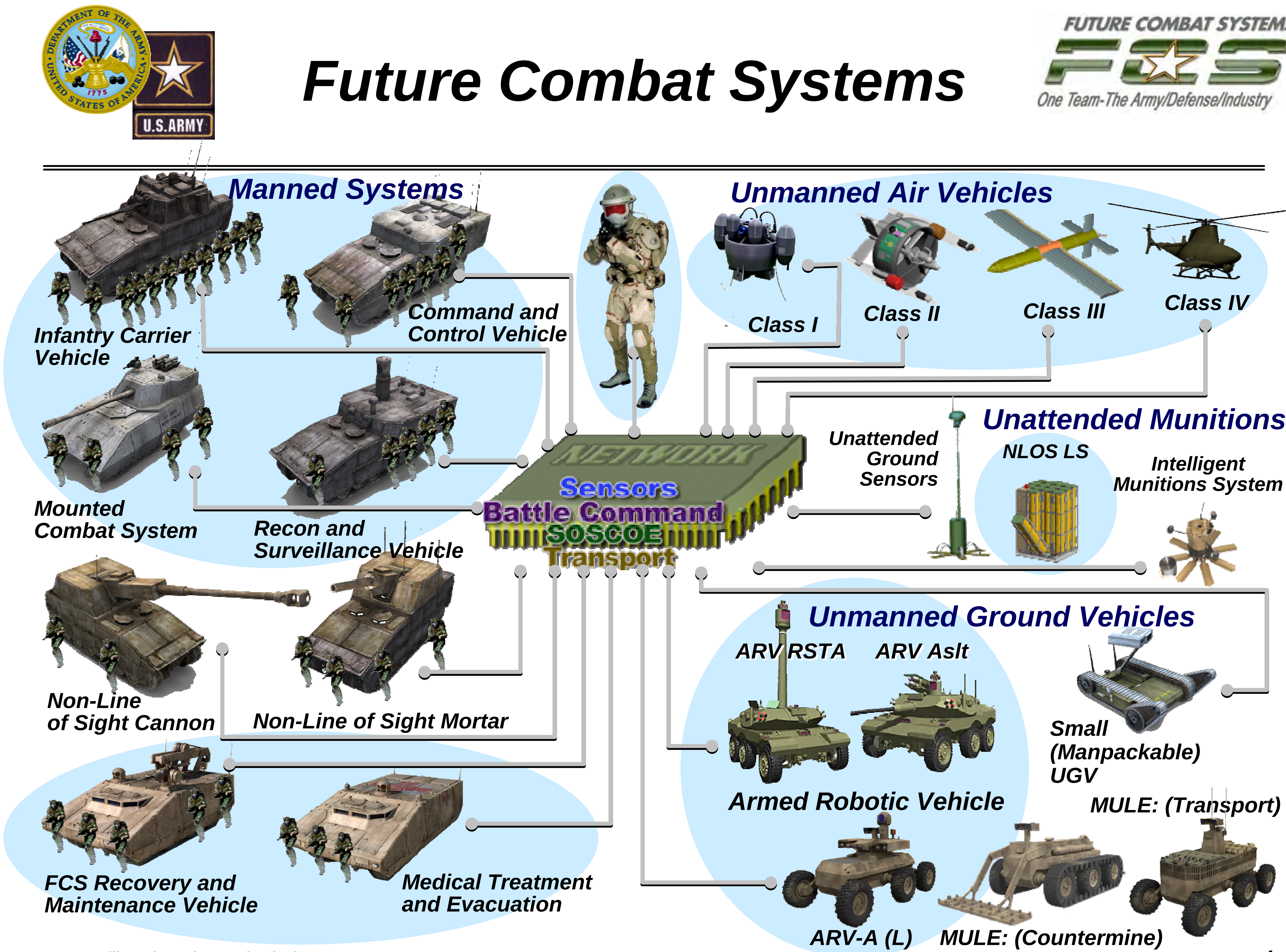


Fully networked

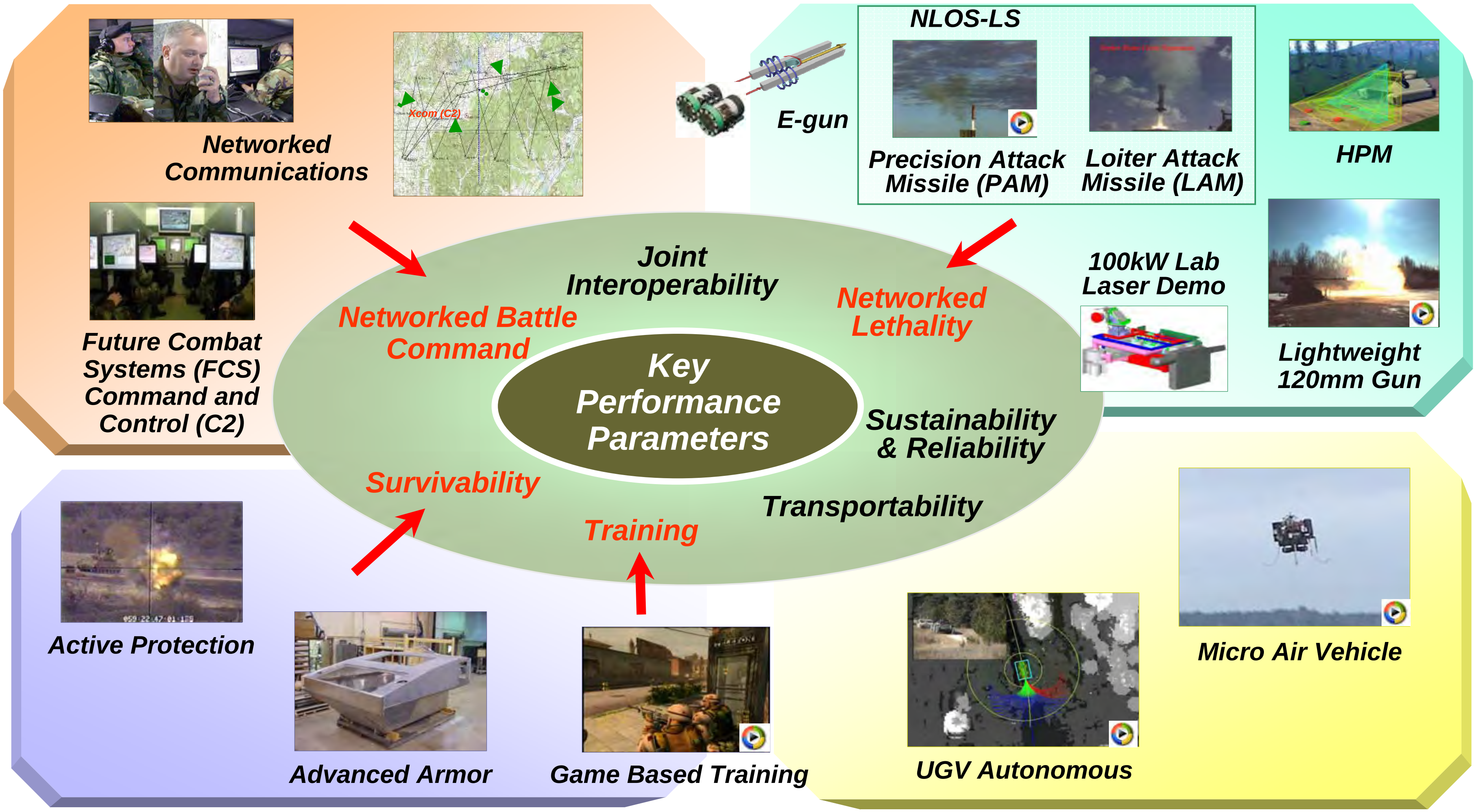
< 30 tons

> 40 mph

Future Combat Systems



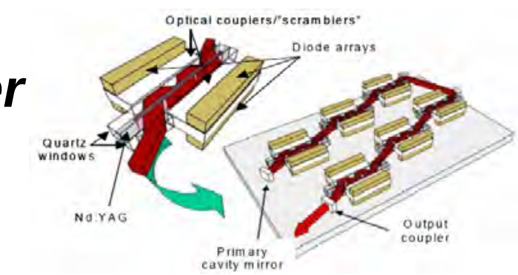
Disruptive Technologies for FCS



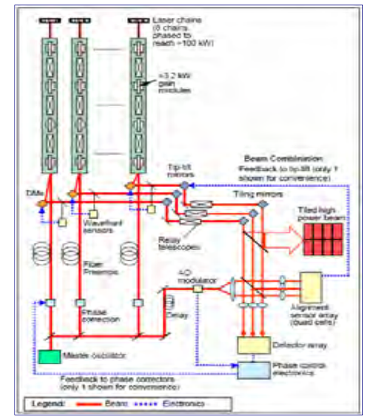
Why FCS? Providing Strategically Responsive Forces with Information Dominance and Paradigm Shifting Lethality & Survivability

Solid State Laser (SSL) Technology for Force Protection

Develop and demonstrate weapons-traceable Solid State Laser (SSL) technologies for future force



Textron 100kW Concept



Northrop Grumman 100kW Concept

Program Provides:

- ***Development of solid state high energy laser technologies to meet size, weight & efficiency needs of the future force***
- ***25kW lab laser demonstrated in FY05, 100kW laser scheduled for demo in FY09***
- ***Initial development of a 100kW laser for integration into SSL weapon demo in FY13***
- ***Assessment of SSL lethality against targets of interest***
- ***Exploration of novel laser concepts for high laser efficiency & low weight***

Notional Concept for Battlefield Employment of High Energy Lasers

Why Lasers?

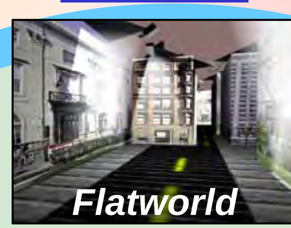
Ultra-Precision, Scaleable Effects, Speed of Light Target Closure

Immersive Training

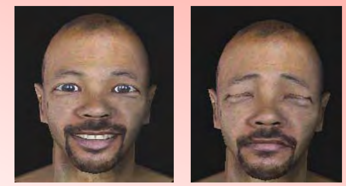
Embedded Training for FCS

OneSAF Objective System

Sound



Gaming and Animation



Computer Graphics

Artificial Intelligence

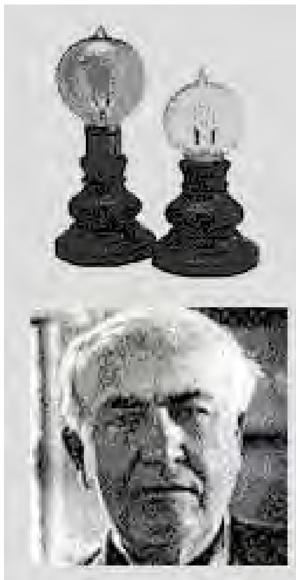
HOLODECK

"JFETS"—Joint Fires & Effects Trainer System at Fort Sill

Mission Rehearsal—Virtual Humans

Research in simulation environments for training, mission planning and rehearsal

Transitioning Technology
from Ideas to Capabilities



Technology Concepts
Whatever you're looking for
you can get it on eBay.
www.eBay.com

- ***Technology concept***
- ***Army Technology Objective***
- ***Technology Transition Agreement***
- ***Mature technology and transition to Program Manager***

Department of Defense

INSTRUCTION

NUMBER 5000.2
May 12, 2003

3.6 Technology Development

3.6.1 Purpose. The purpose of this phase is to reduce technology risk and to determine the appropriate set of technologies to be integrated into a full system. Technology Development is a continuous technology discovery and development process reflecting close collaboration between the S&T community, the user, and the system developer. It is an iterative process designed to assess the viability of technologies while simultaneously refining user requirements.

Technology Transition—
Technology Transition Agreements

Documents acquisition program needs for Critical Technologies from the S&T community

Key elements:

- Program requirements
- Maturation strategy
- Milestones & schedule
- Funding
- Deliverables
- Key personnel

FCS Technology Transition Agreements

- Security Systems and Algorithms (CT3B2)
- Dynamic Sensor-Shooter Pairing Algorithms & Fire Control (CT14)
- Recoil Management & Light Weight Cannon (CT17)
- Distributive Collaboration of Manned/Unmanned Platforms (CT18)
- Signature Management (CT26)

Signed 14

Being worked

- Water Generation and Purification (CT22A)
- Survivability (CTs 25A, 25B & 27)
- Power Distribution and Control (CT29)
- Manned Ground Vehicle High Density Packaged Power (CT31)

Draft 36

Partnering with PEOs to ensure maturity of Critical Techs

How do we get technology products to the warfighter faster?

- ***Mature technology and get it to the PMs***
  - ***Generate more options: "no single point of failure"***
  - ***Demonstrate technology in operational environments***
  - ***Defense Acquisition Guidebook:***

    "… the S&T Program is uniquely positioned to reduce the risk of promising technologies before they are assumed in the acquisition process."
- ***Use rapid acquisition initiatives***
- ***Shorten SDD time***
  - ***Technology matured and risk reduced in S&T***
  - ***More concurrent developmental and operational testing***
- ***Reduce time to production***
  - ***Early operational testing***
  - ***Manufacturing technology***

Lock requirements sooner

Technology Transition Issues—an S&T Perspective

- ***Increasing Technology Readiness Level (TRL) does not by itself speed transition—evidence of TRL becomes debatable***
- ***PMs use their own criteria to make technology maturity decisions—some want more tests, some want the final S&T demo to be in a form, fit, function equal to the final system, which is yet to be built***
- ***Need stronger partnerships—commitment—between technology development and acquisition communities***
- ***System Development & Demonstration (SDD) funding shortfalls***
- ***Limited procurement funding may make the technology unaffordable***

If there was a simple answer or solution we wouldn't have issues

Technology Transition is a Contact "Sport"

- ***PMs not convinced the technology is mature***
  - ***Labs may promise more than they can deliver***
- ***PMs want S&T to mature technology more—using S&T money***

OR

- ***PMs may want to control technology development***
  - ***Time and money is lost "rediscovering" the technology***
- ***PMs are concerned about too many integration unknowns***
  - ***PMs doubt the technology is producible***
  - ***S&T doesn't provide form, fit, function for the PM's system***
- ***PMs may want to use their own contractor—not the S&T demo contractor***
- ***PMs may find "acceptable" technology from non-S&T sources***

A Reasonable Way Ahead?

PEOs should require PMs to explain why they didn't use the technology available from the lab

- ***PMs need to fulfill their agreements with the Labs or be upfront and tell them 'No'***
- ***PMs need to commit resources to integrate the technology beyond that which is reasonable to expect from the Lab—the Labs don't integrate***

A Reasonable Way Ahead—more?

MACOMS/DASA(R&T) should require Lab Directors to show what they are doing to make the technology acceptable to the PM

- ***Lab Directors need to come forward with proposed changes to the technical program when customer needs change***
- ***Labs need to deliver what they say they are going to or inform the customer that they cannot do it***

Don't be absolutely program centric—
make technology decisions based upon what is best for the ARMY

Where do we go from here?

- Don't be limited by traditional solutions
- Seek technology insertion opportunities
- Take technology when its ready
  - Get an independent assessment

S&T Transitions—we can do it 2000-2005

S&T Complete	SDD Transition	Current Status
Hunter Sensor Suite-1997	1999	Currently in production as LRAS3, 700+ fielded
GLMRS-1999	2001	In production
OICW-1999	*Pub RFP for SDD on-hold pending JCIDS results and JROC review	SDD (OICW-1) funded
HSTAMIDS-2000	SDD 2000	In LRIP—AN/PSS-14
SAPI-2000	Specifications to PM-SEQ	Fielded as Interceptor Body Armor
Life Support for Trauma & Transport -2001	2001 (3rd Quarter)	In production
PGMM-2001	MS B Sep 2003 fully funded	SDD fully funded
Chitosan Bandage-2001	2002 fully funded	In production
One Handed Tourniquet (OHT)-2001	2002 fully funded	In production—improved & renamed Combat Application Tourniquet
SATCOM OTM - 2002	SATCOM Antenna—WIN-T	WIN-T in SDD
Tactical C2 Protect-2002	Network Security Software—WIN-T	In production 4ID IRAQ
ASTAMIDS-2003	SDD 2003	Fully funded through FY09
LCMR-2003		In production
Shortstop-2003	Modified to be counter-IED system; Core WARLOCK family of systems	Fielded
GSTAMIDS-2004	SDD 2004	Fully funded through FY12
Agile Commander-2004	C2 software for MCS	
MOSAIC-2004	Network Comms software for WIN-T	WIN-T in SDD
LSTAT-2004	In SDD	
NLOS LS-2004	2004	SDD fully funded for FCS
TWS-2004	2004	In production
Rechargeable Li-ion Battery-2004	NA	In production
Zinc Air Battery-2004	NA	In production
120mm Gun-2005	2006	PM FCS selected for manned gun system
DRAMA-2005	Network Comms software for WIN-T	WIN-T in SDD

The Army…
Transforming while at War

"Beware when any idea is promoted primarily because it is "bold, exciting, innovative, and new." There are many ideas that are "bold, exciting, innovative and new," but also foolish."

Secretary Rumsfeld

THE AIR FORCE RESEARCH LABORATORY

LEAD | DISCOVER | DEVELOP | DELIVER

Directed Energy S&T Challenges Overview

L. Bruce Simpson, SES

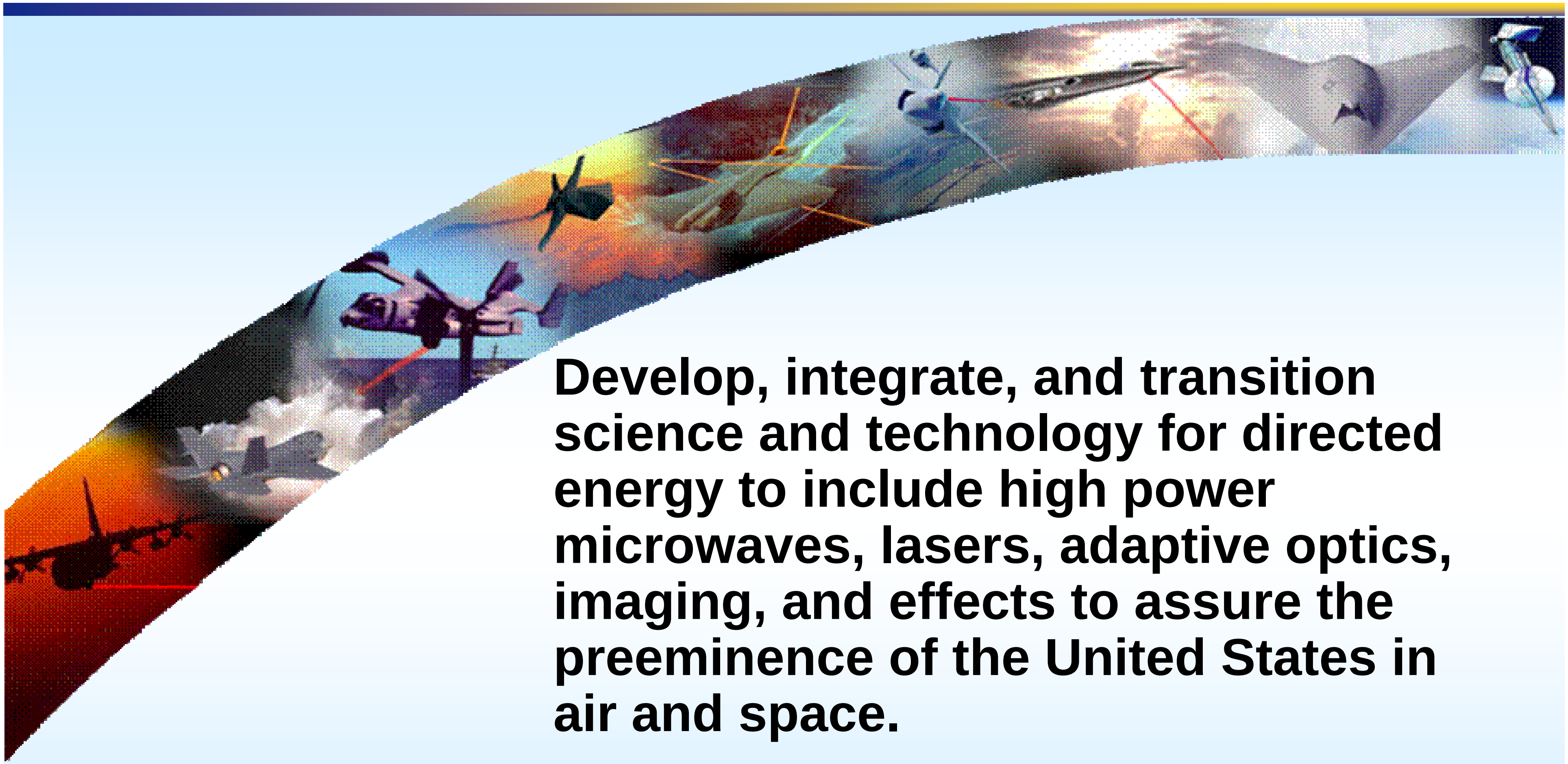
Director

Directed Energy Directorate

Kirtland AFB, New Mexico

Mission

AFRL/Directed Energy Directorate



Develop, integrate, and transition science and technology for directed energy to include high power microwaves, lasers, adaptive optics, imaging, and effects to assure the preeminence of the United States in air and space.

What is directed energy?

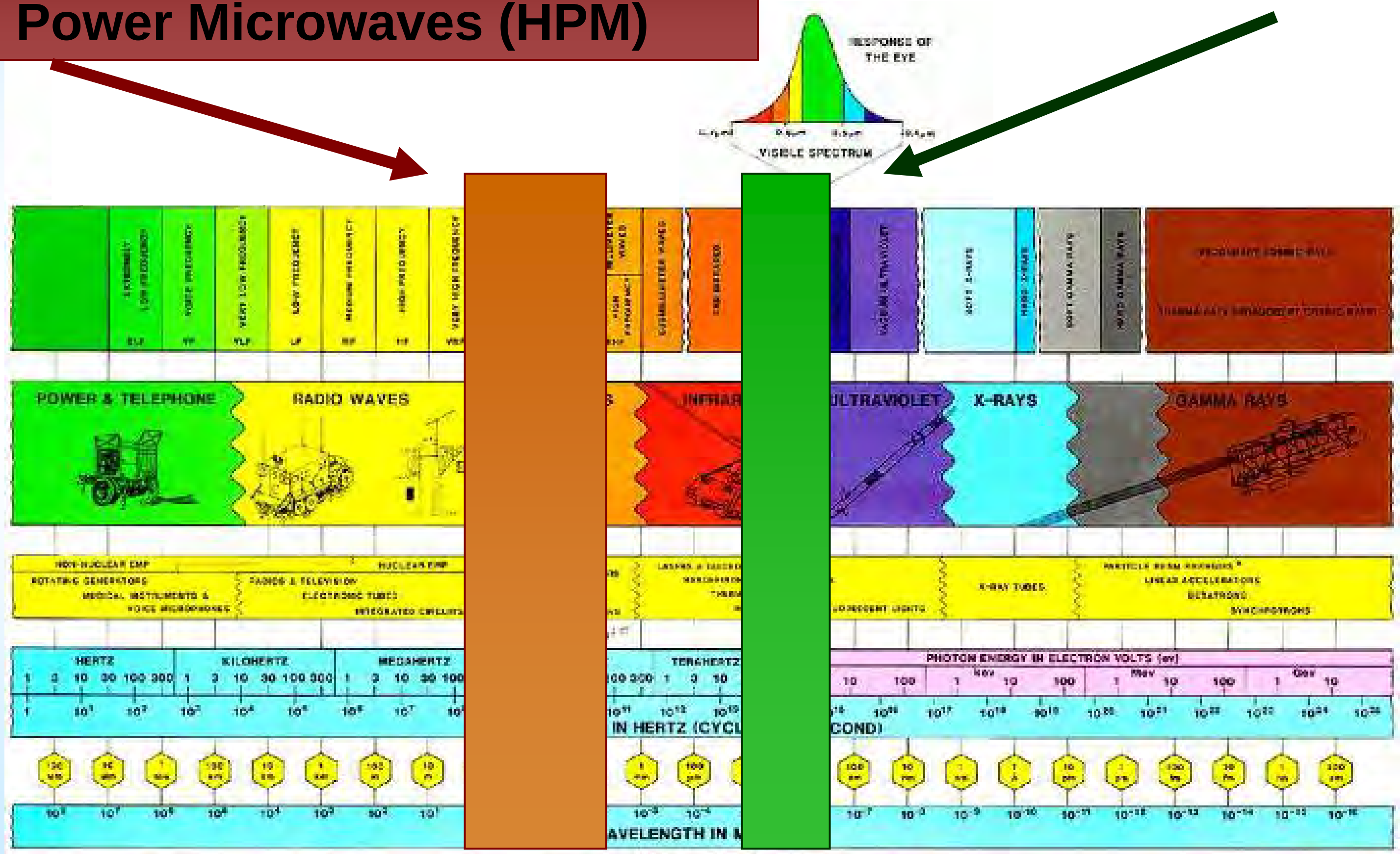
AFRL/Directed Energy Directorate

Electromagnetic Spectrum

High Power Radio Frequency (RF)

High Power Microwaves (HPM)

High Energy Lasers (HEL)



What is directed energy?
AFRL/Directed Energy Directorate

- ***Precision Engagement***
  - **Selective targeting measured by the inch**
  - **Rapid re-targeting in real time**
- ***Speed-of-Light Delivery***
  - **Immediate attack with global reach**
  - **Surprise element for enemy confusion**
- ***Controlled Effects***
  - **Minimum collateral damage**
  - **Graduated effects from deny to destroy**
- ***Logistical Advantage***
  - **Seamless awareness of battlefield and space**
  - **Deep magazine without shelf-life or stockpile issues**

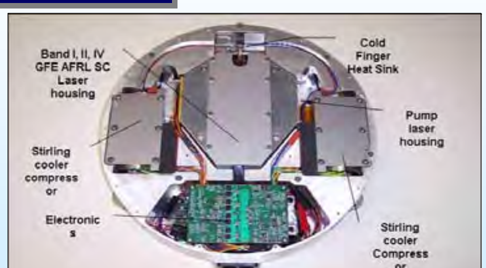
Customers and Products
AFRL/Directed Energy Directorate

Near Term: Transition to Acquisition Community and Industry

Today	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025

Rapid Prototyping

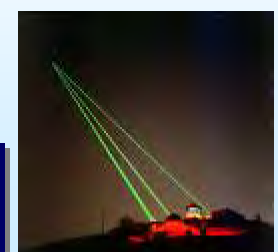
Active Denial



Aircraft Self-Protection

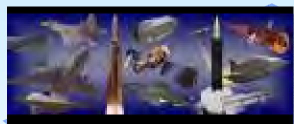
Aircraft Countermeasures

Non-Lethal Weapons

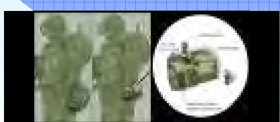


Adaptive Optics

Customers and Products
AFRL/Directed Energy Directorate

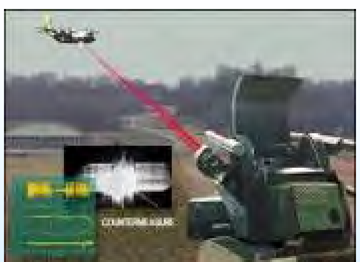


Mid Term: Existing Customers and Demonstration Partners
Advanced (Concept) Technology Demonstration (ACTD and ATD)



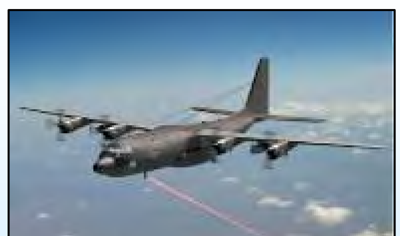
Near Term: Transition to Acquisition Community and Industry

Today	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025

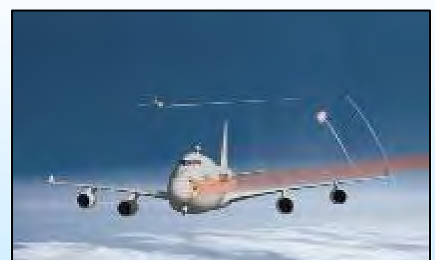


Laser Imaging

Advanced Beam Control



Tactical Lasers

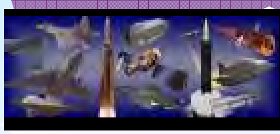


Ballistic Missile Defense

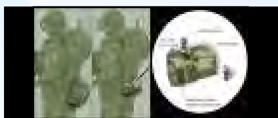
Counter IED

Customers and Products
AFRL/Directed Energy Directorate

Long Term: Strategic Planning of cross directorate integrated systems of systems development



Mid Term: Existing Customers and Demonstration Partners Advanced (Concept) Technology Demonstrations (ACTD and ATD)



Near Term: Transition to Acquisition Community and Industry

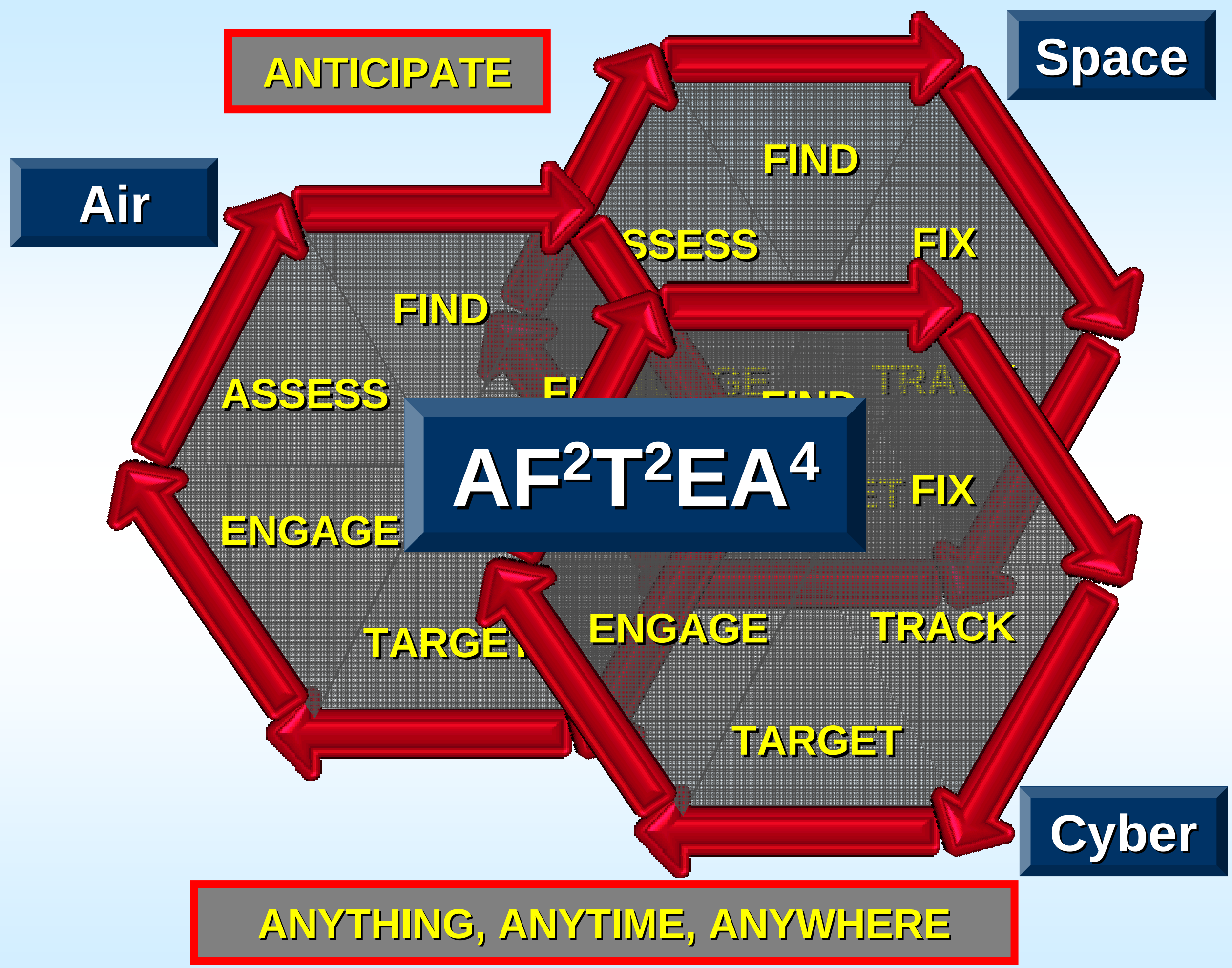
Today	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025

Game Changing Technologies

Space Control - Counter Electronics – Precision Engagement – Long Range Strike – Force Protection

Focused Long Term Challenges

(FLTCs derived from S&T Vision)



Focused Long Term Challenges

AFRL Investment Strategy

Delivering the Air Force S&T Vision through Leadership, Discovery, Innovation, and Integration.

1. **Anticipatory Command, Control and Intelligence (C2I)**
2. **Unprecedented Proactive Surveillance and Reconnaissance (S&R)**
3. **Dominant Difficult Surface Target Engagement/Defeat**
4. **Persistent and Responsive Precision Engagement**
5. **Assured Operations in High Threat Environments**
6. **Dominant Offensive Cyber Engagement**
7. **On-demand Theater Force Projection, Anywhere**
8. **Affordable Mission Generation and Sustainment**

DE Problem Statements

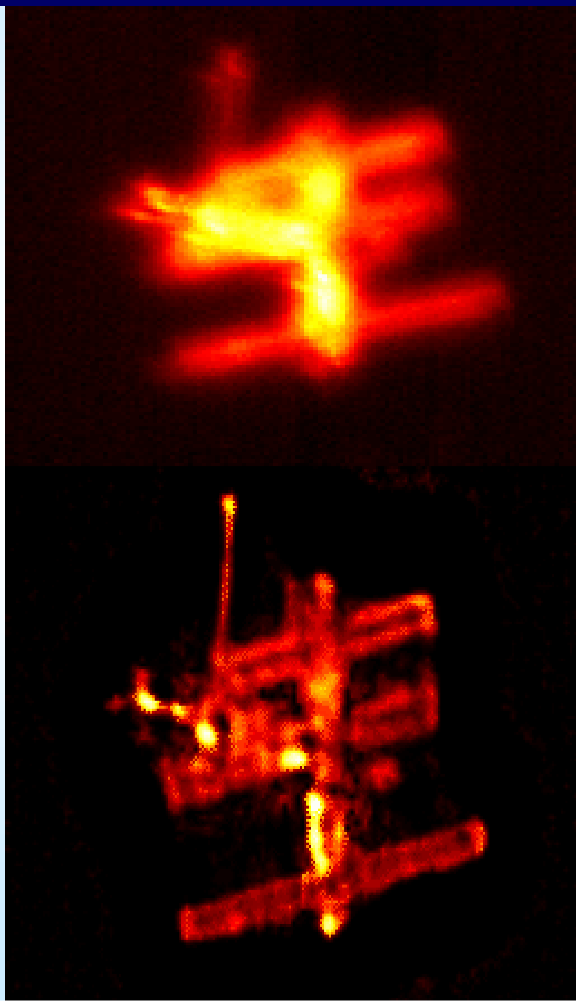
AFRL/Directed Energy Directorate

Problem Statement	Goal
FLTC-2 Unprecedented Proactive Surveillance & Reconnaissance	Assure All-Object Space Situational Awareness
FLTC-3 Dominant Difficult Surface Target Engagement/Defeat	Deliver On-demand, Lethal Effects to Difficult Targets with Ultra Precision
	Engage Adversaries with Non-Lethal Force
FLTC-4 Persistent & Responsive Precision Engagement	Globally Deliver DE and Non-Lethal Effects
FLTC-5 Assured Operations in High Threat Environments	Detect and Defeat Threats Through Active Defenses
FLTC-6 Dominant Offensive Cyber Engagement	Deliver Counter Electronics Effects

Vision | *Problem Statements* | *Tech Challenges* | *Approaches*

FLTC #2 Unprecedented Proactive Surveillance & Reconnaissance (S&R)

Proactively Find, Fix, and Track Anything, Anytime, Anywhere with Agile and Immediate C4ISR

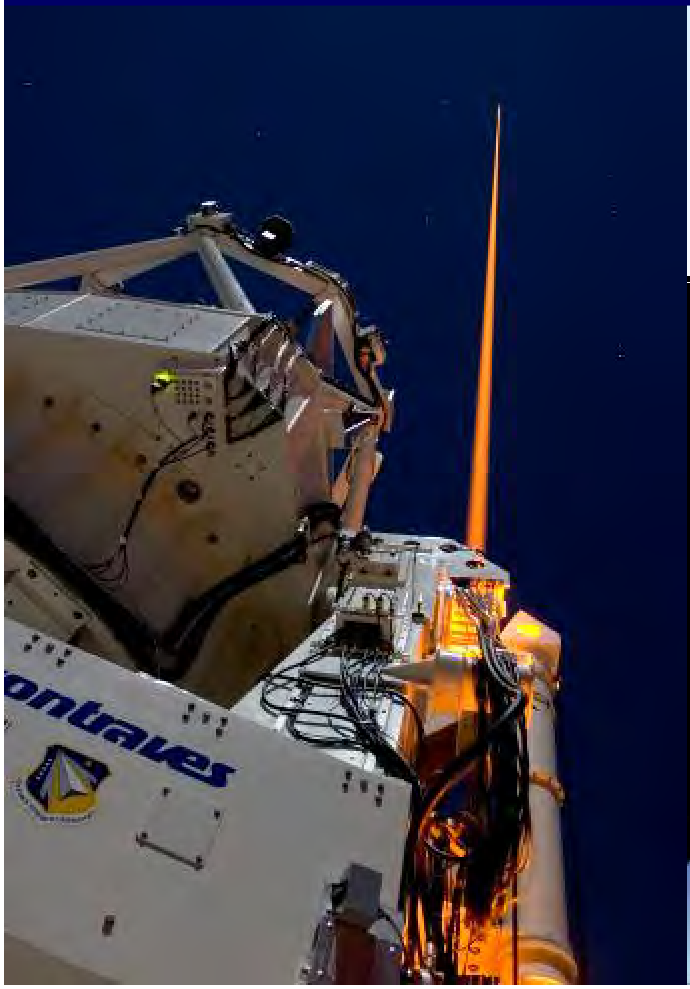


- Enable High Performance Networks for Assured C2 and Sensing
- Persistently Deliver Fused Multi-Source S&R for Total Battlespace Awareness
- Assure Closed-Loop C2ISR Sensing and Processing (anticipatory)
- Generate Wide-Area, Global Access, Detection and Tracking
- Deliver High-Volume, Super Resolution Imagery of Anywhere, Anytime
- Assure All-Object Space Situational Awareness

FLTC #2 Unprecedented Proactive Surveillance & Reconnaissance (S&R)

Assure All-Object Space Situational Awareness (SSA)

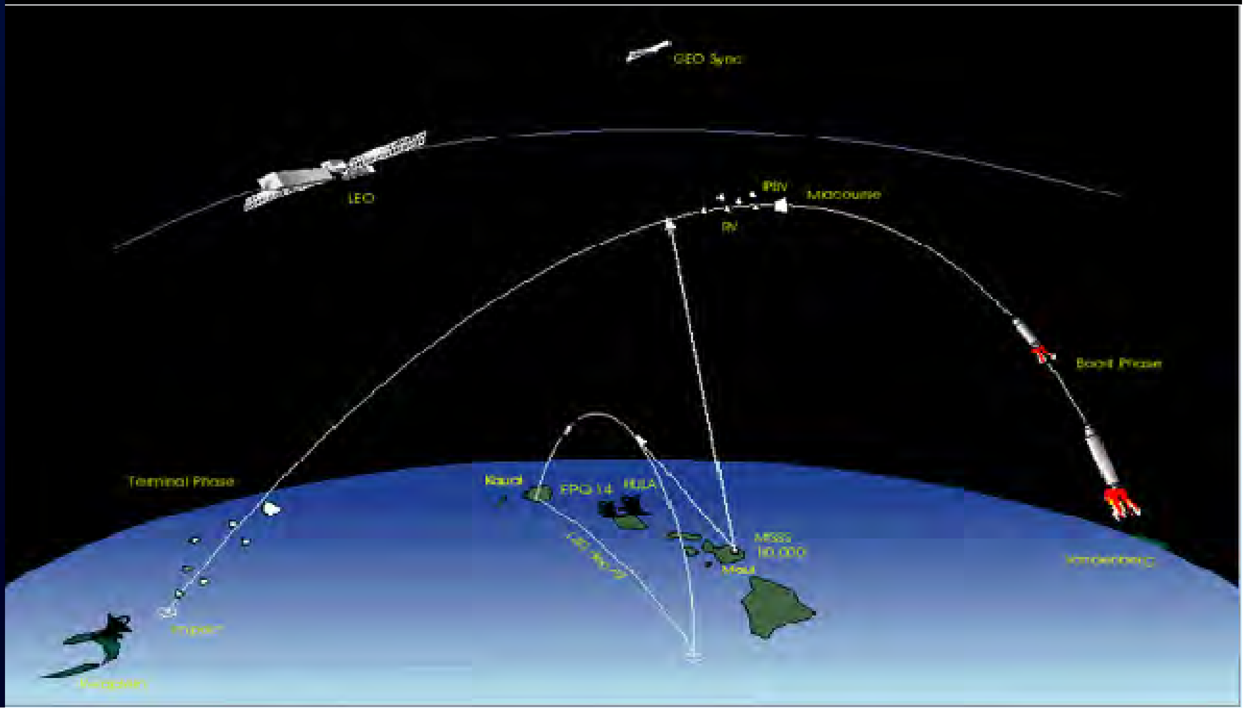
Objective: **Detect/track all space objects at various altitudes**



SSA Technology

Space Surveillance Metrics and Images

Optics for Atmospheric Compensation

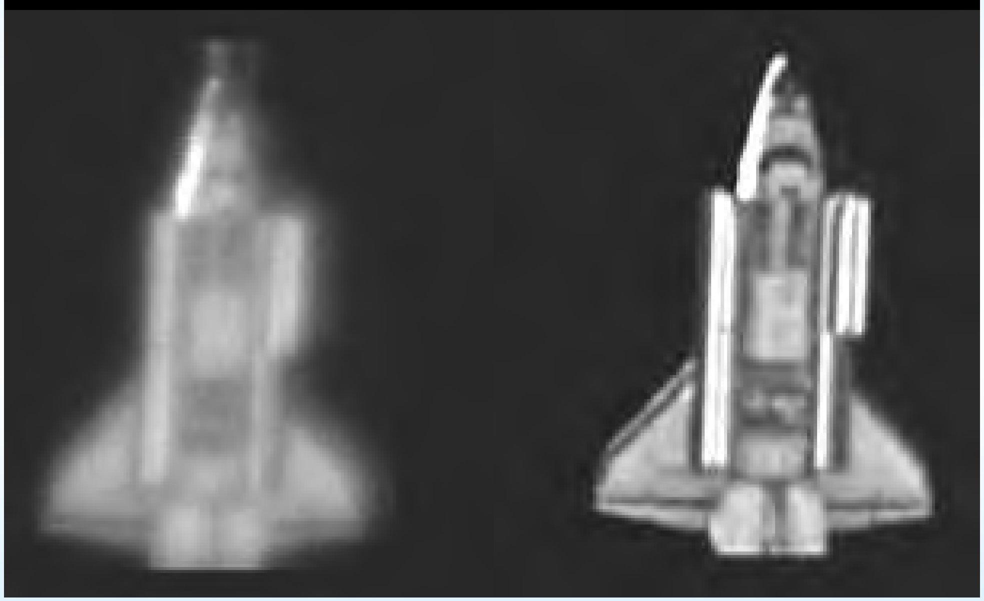


FLTC #2 Unprecedented Proactive Surveillance & Reconnaissance (S&R)

Assure All-Object Space Situational Awareness (SSA)

Objective: **Develop technology in resolvable and non-resolvable characterization**

Space Shuttle



Adaptive Optics Image…

…with Post Processing

Adaptive Optics and Image Post Processing **enables identification of deep space and dim objects**

FLTC #2 Unprecedented Proactive Surveillance & Reconnaissance (S&R)

Assure All-Object Space Situational Awareness

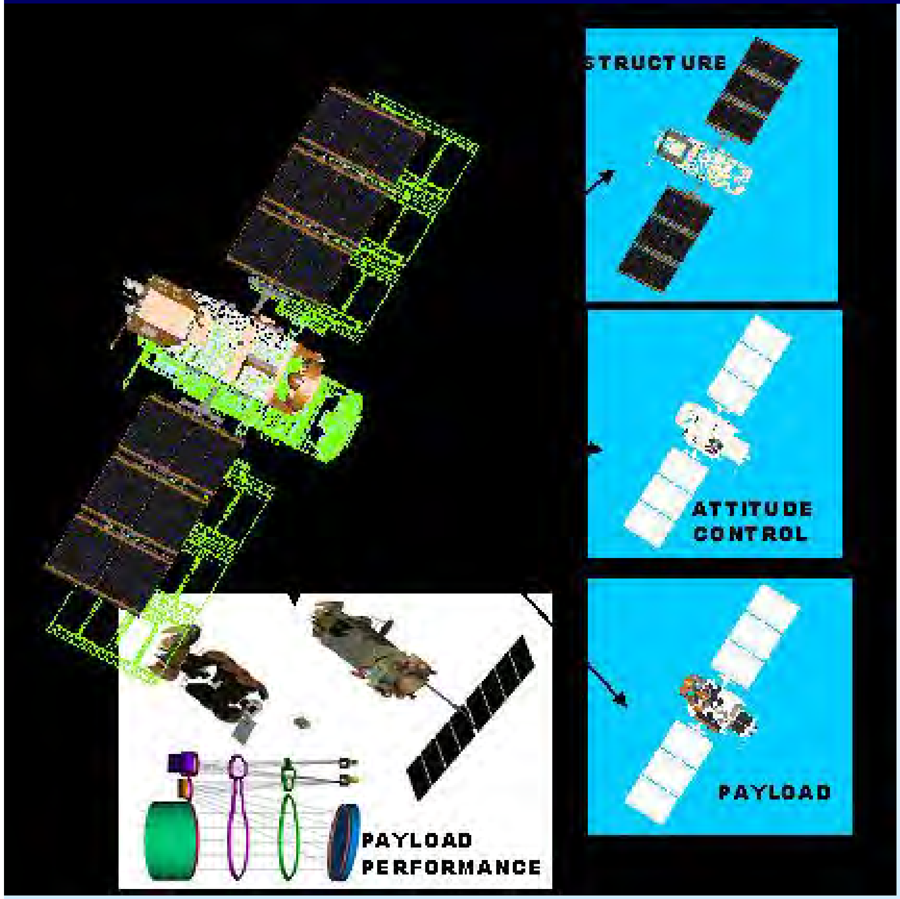
Objective: **Refine large aperture optical beam control technologies to provide improved tracking, imaging and dim object detection**

- Capture real time, exquisite characterizations of satellites
- Detect micro-satellites within narrow field to include detection and discrimination
- Extend hours and object list for high bandwidth tracking
- Improve beam control capabilities for laser propagation applications
- Develop more efficient signature analysis for satellite identification and states

FLTC #2 Unprecedented Proactive Surveillance & Reconnaissance (S&R)

Assure All-Object Space Situational Awareness

Objective: **Perform physical and functional analysis of satellites**



- Analyze phenomena effects on the function/operation of subsystems and the entire satellite
- Perform analysis for potential directed energy (DE) threats
- Integrate and automate engineering data, analysis process
- Provide support to military and space communities

FLTC #3 Dominant Difficult Surface Target Engagement/Defeat

Detect, Tag, Track, Identify, Target Adversaries, IEDs, CBRNE in Congested or Concealed Environments and Create Desired Effects

- Find, ID, Assure-Tracking and Engage Individuals & IEDs
- Locate, ID, Engage and Neutralize CBRNE
- F2T2 Difficult Targets Including Complex Urban and Difficult Terrains
- Rapidly Deliver Scalable Kinetic & Non-Kinetic Effects to Difficult Targets
- Deliver On-Demand, Lethal Effects to Difficult Targets with Ultra Precision
- Engage Adversaries with Non-Lethal Force

FLTC #3 Dominant Difficult Surface Target Engagement/Defeat

Deliver On-Demand, Lethal Effects to Difficult Targets with Ultra Precision

Objective: **Deliver lethal effects to a range of tactical targets in challenging environments and engagement scenarios**

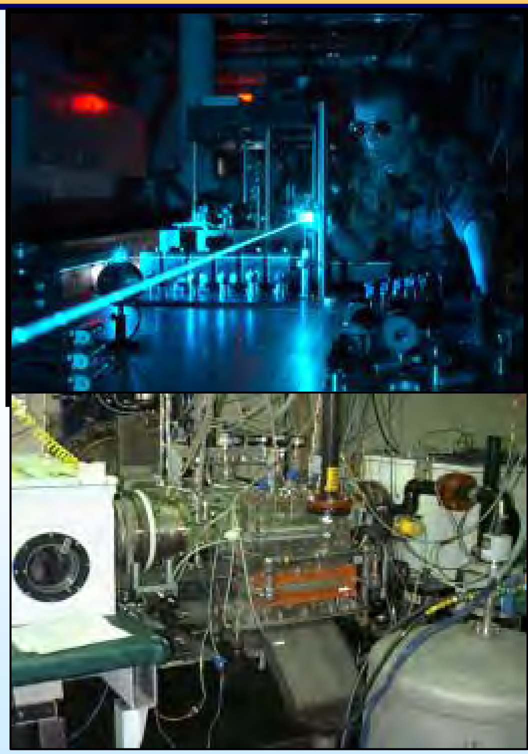
- Expand speed-of-light offensive and defensive capabilities
- Maintain precise aimpoint
- Obtain scaleable effects
- Supply deep magazine
- Provide minimal collateral damage

Representational Timeline

FLTC #3 Dominant Difficult Surface Target Engagement/Defeat

Deliver On-Demand, Lethal Effects to Difficult Targets with Ultra Precision

Objective: **Provide high energy laser systems to enable ultra-precise lethal attacks on tactical targets**



- Operate in highly dynamic environment
- Enable precision engagement at long distant ranges
- Minimize laser power requirements
- Meet stringent platform constraints
- Mitigate aero-optics distortion
- Provide system of systems laser testing

Representational Timeline

FLTC #3 Dominant Difficult Surface Target Engagement/Defeat

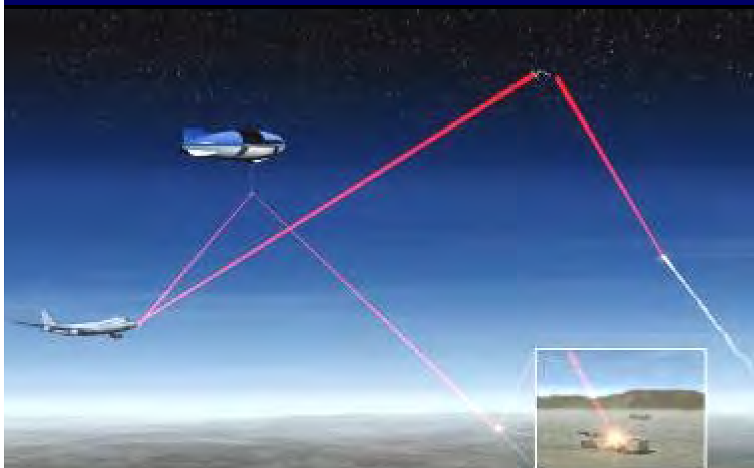
Engage Adversaries with Non-Lethal Force

Objective: **Advance millimeter wave source and antenna system technologies to enable robust non-lethal counter personnel options**

- Self-protect platform
- Clear lines of communication
- Deny access
- Provide urban air support
- Assist in personnel recovery
- Protect assets (troops, convoys, embassies, airfields, bases, etc)
- Support special operations' efforts

FLTC #4 Persistent & Responsive Precision Engagement

Maneuver Through Anti-Access/Area Denied Environments to Deliver Effects Rapidly and/or Persistently

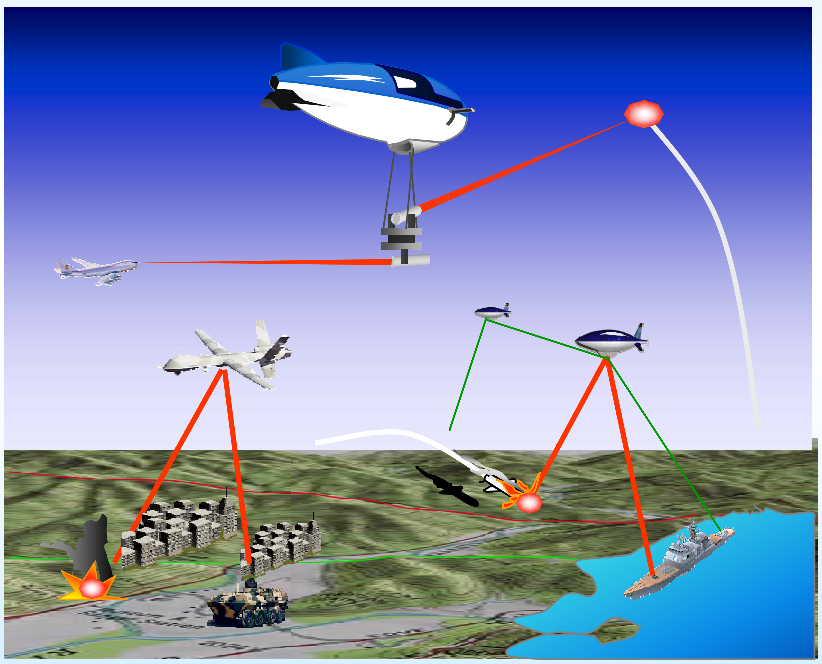


- Globally Deliver Directed Energy and Non-kinetic Effects
- Globally Deliver Full Spectrum of Kinetic Effects
- Globally Deliver Selected Effects for Time Sensitive Targets
- Covertly Globally Deliver Autonomous, Unattended Sensor Payloads

FLTC #4 Persistent & Responsive Precision Engagement

Globally Deliver Directed Energy and Non-Kinetic Effects

Objective: **Provide Speed-of-Light awareness, communications, engagements, and assessments of anything, anywhere, anytime**



- Look over the horizon
- Deliver scaleable force projection
- Uplink to a cooperative network
- Provide geostationary high energy laser in the sky
- Augment mission of forward fighting troops
- Increase stand-off range

FLTC #5 Assured Operations in High Threat Environments

Achieve Mission Objectives with Impunity Against Full Spectrum Threats, from Anti-Access IADS to Cyber

- Anticipate and Avoid Threats Through Stealth and Deception
- Detect and Defeat Threats Through Active Defenses
- Survive the Attack Through Passive and Adaptive Protection
- Recover from Threat Effects

FLTC #5 Assured Operations in High Threat Environments

Detect and Defeat Threats through Active Defenses

Objective: **Fuse directed energy capabilities to detect, avoid, repel and survive attacks on land, sea, air and space**

iMAGiNE

A Directed Energy Shield

FLTC #5 Assured Operations in High Threat Environments

Detect and Defeat Threats through Active Defenses

Objective: **Fuse directed energy capabilities to detect, avoid, repel and survive attacks on land, sea, air and space**

FLTC #5 Assured Operations in High Threat Environments

Detect and Defeat Threats through Active Defenses

Objective: **Fuse directed energy capabilities to detect, avoid, repel and survive attacks on land, sea, air and space**

Increase survivability of troops

- Layer a protection systems (fixed and mobile)
- Protect perimeters and high value assets
- Detect enemy activity beyond operational range thresholds
- Control crowds/separate insurgents
- Disrupt electronic systems
- Neutralize IEDs at safe distances
- Engage escort planes equipped with countermeasure weapons
- Defeat threats with conventional, HEL and HPM weaponry

FLTC #6 Dominant Offensive Cyber Engagement

Conduct full spectrum offensive cyber/info ops against military, leadership, and infrastructure

- Access Adversary's Cyber/Info Systems Anywhere, Anytime
- Operate with Stealth and Persistence in Cyber
- Generate Robust Cyber Intelligence (CYBINT)
- Deliver Integrated D5 Information Operations Effects
- Deliver Counter Electronics Effects

FLTC #6 Dominant Offensive Cyber Engagement

Deliver Counter Electronics Effects

Objective: **Disrupt adversaries' critical military and infrastructure electronic and communication equipment with little to no collateral damage**

- Disrupt communications
- Tailor for multiple attack paths
- Deliver to wide-area non-lethal coverage of urban areas with swarming UAVs
- Attack critical infrastructure, leadership, and CBRNE targets
- Identify electronic signatures to feed intelligence preparation of the battlespace (IPB) and battle damage assessments (BDA)
- Deliver low collateral damage through glide bomb fly-bys

Technology Challenges

AFRL/Directed Energy Directorate

- **High Energy Lasers**
- **High Power Microwaves**
- **Space Situational Awareness**
- **Adaptive Optics and Imaging**
- **Millimeter Waves**
- **Relay Mirrors**

Bridge to the Warfighter
AFRL/Directed Energy Directorate


Directed Energy
• Provides robust capabilities to the warfighter
• Offers integrated applications ready to field now
• Future DE paradigms
– Deliver global reach on demand
– Transform the way we engage our adversaries
DE has the Power to Change the face of military conflict.


Dr. Bruce Simpson
Director, Directed Energy
(505) 846-0860
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Headquarters U.S. Air Force

Integrity - Service - Excellence

Air Force Approach to Disruptive Technologies and Transition

April 20, 2006

Mark Stephen, Col, USAF

Associate Deputy Assistant Secretary (Science, Technology and Engineering)

Outline

- Introduction
- Disruptive Technologies
- Transition
- Summary

Air Force S&T Program

- Technology <u>Options</u> for Future Warfighting Capabilities
  - Upgrades for fielded systems
  - New systems
- <u>Broad</u> and <u>Balanced</u> Set of Technologies
  - Evolutionary improvements
  - Revolutionary capabilities
- Research Laboratory Provides <u>Technical Expertise</u>
  - 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

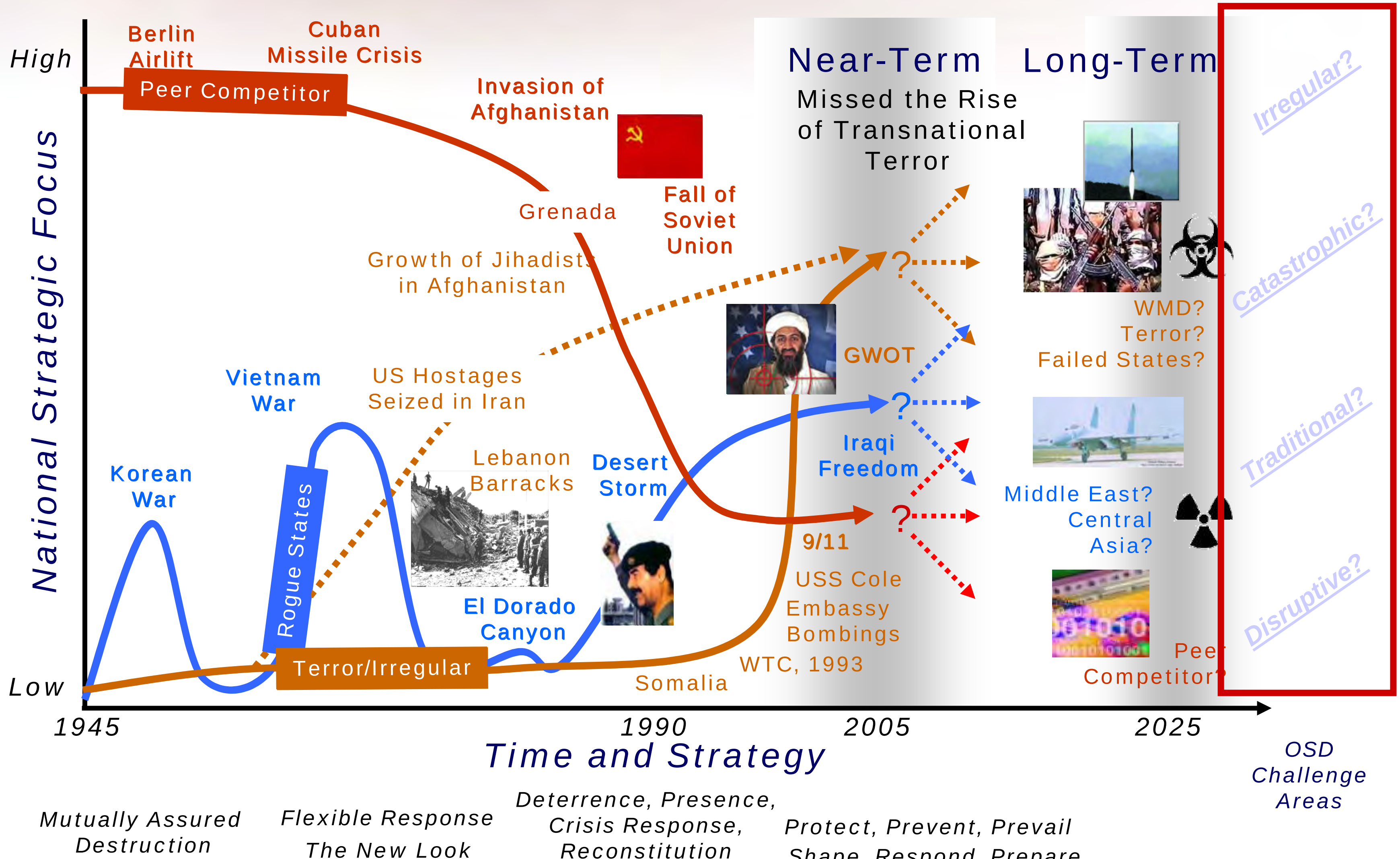
It’s an Uncertain World Out There

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



Outline

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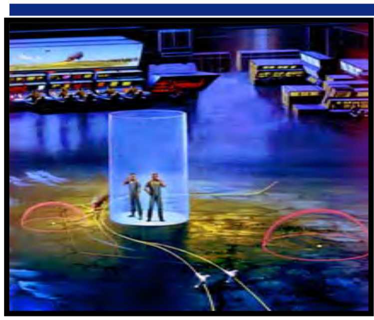
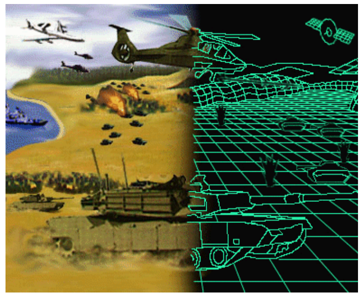
- Summary

The Changing Landscape of Research

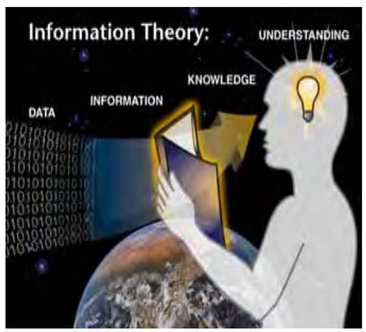


Virtual Worlds

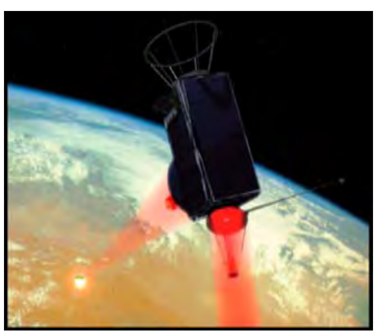


Virtual Presence

Advanced Computing



Cognitive Sciences



IT in Space

Cyber World

BioTechnology

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

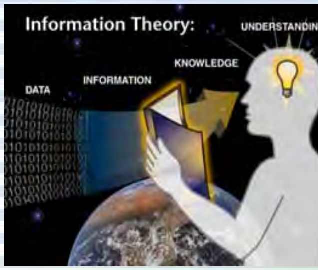
NanoTechnology

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

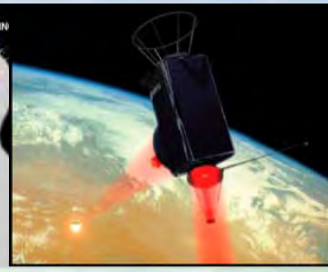
Quantum Technology

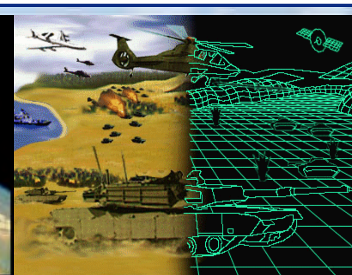
- Quantum Information Systems
- Quantum Communications

21st Century: Landscape of RESEARCH

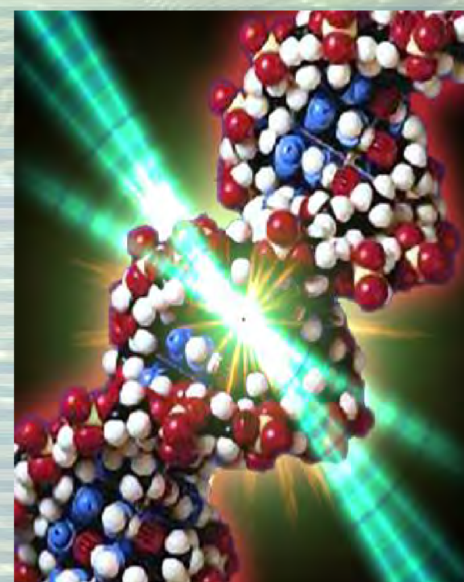


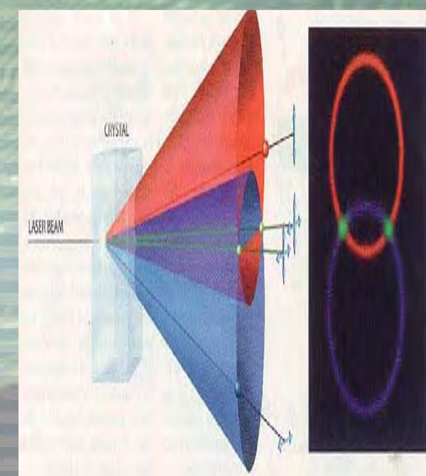
Advanced Computing


IT in Space


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

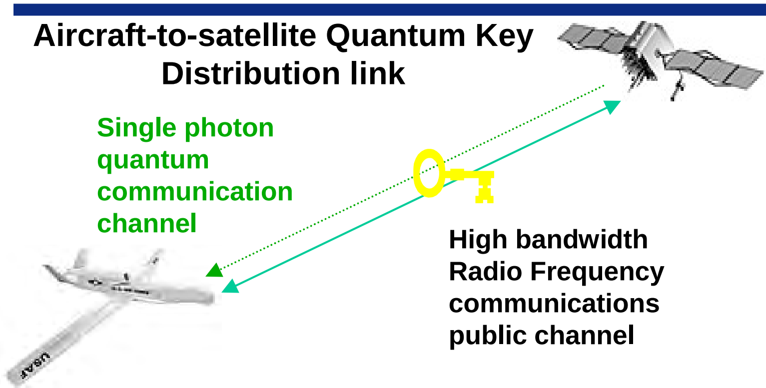
DNA Memory

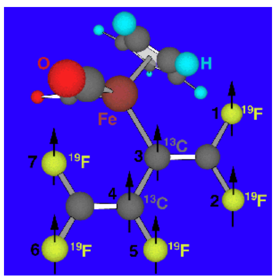
Started with **1600** Magnetic tapes and have reduced that to **10^{15} bits per cm^3**

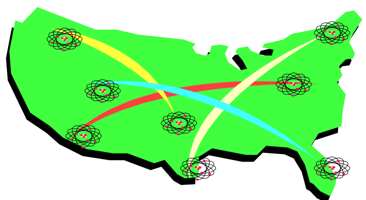
Quantum Technologies

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

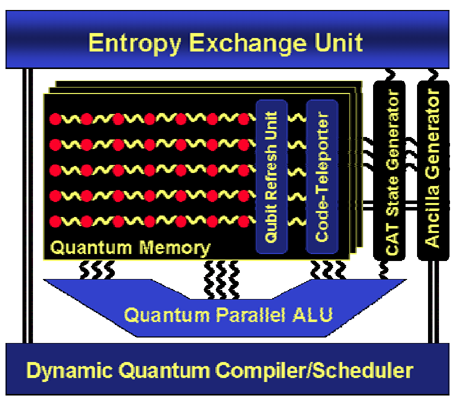
Quantum Information Science

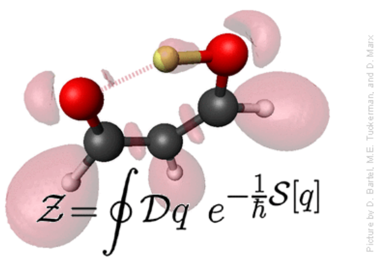






Quantum Internet

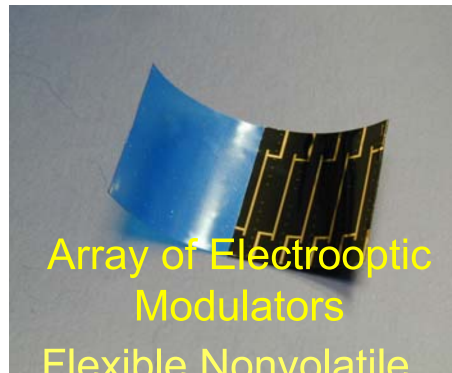


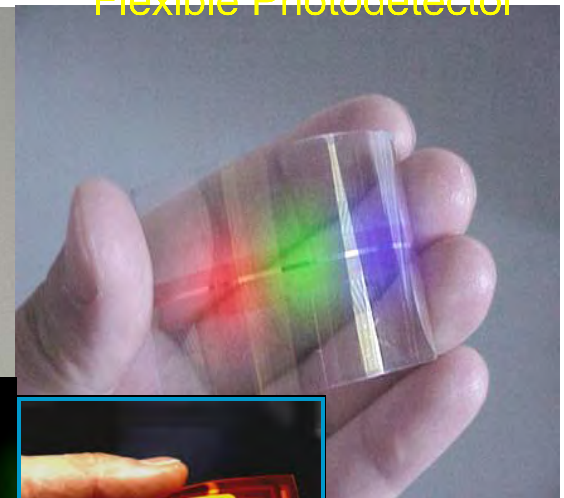


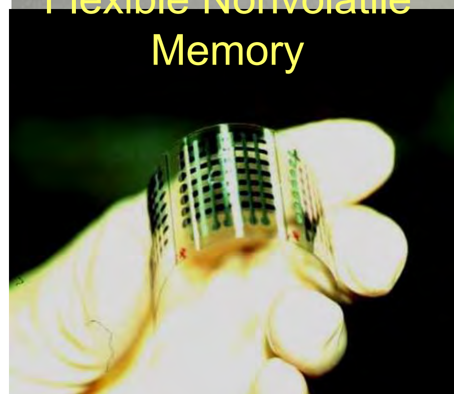
- **Ultra-secure communication**
  - **Virtually unlimited channel capacity**
- **Develop *revolutionary computing and communication* capabilities:**
  - **Calculate difficult/impossible tasks classically**
    - Factoring large numbers
    - Simulating large quantum systems
  - **Rapid sorting of large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

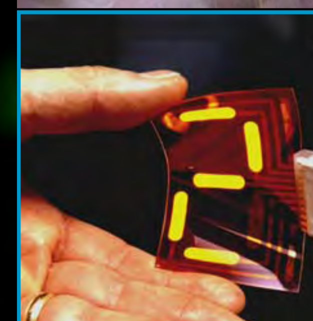
Flexible Multifunctional Structures

- 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

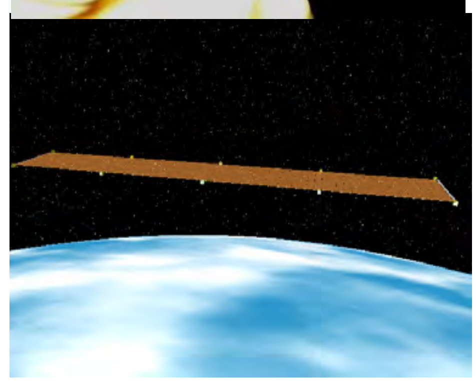






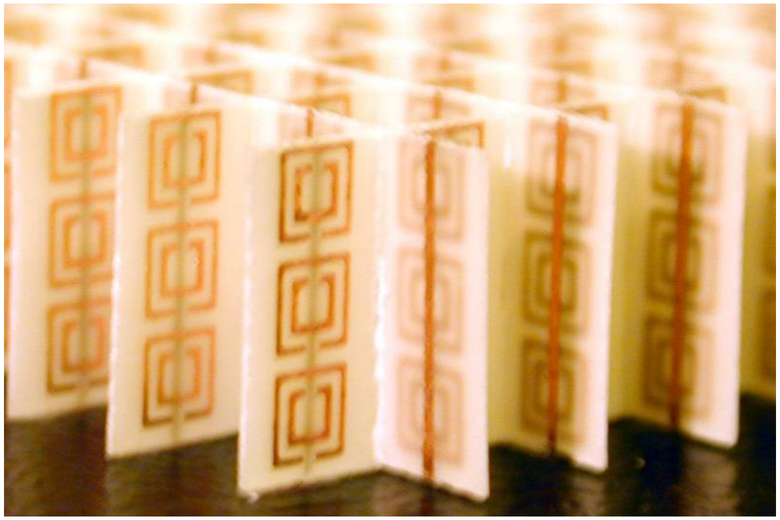


Flexible Light Emitting Diode

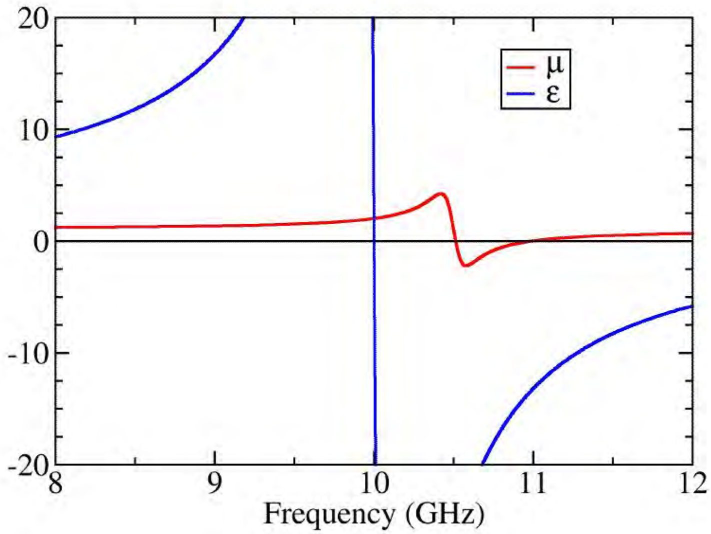


Plastic Sensor Carpet for Space Surveillance

Left-Handed Material (Metamaterial)

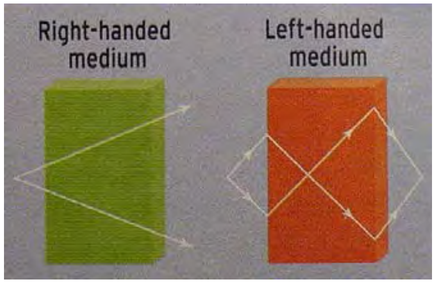


Index of refraction (n) is given by: $n = \sqrt{\frac{\varepsilon\mu}{\varepsilon_o\mu_o}}$



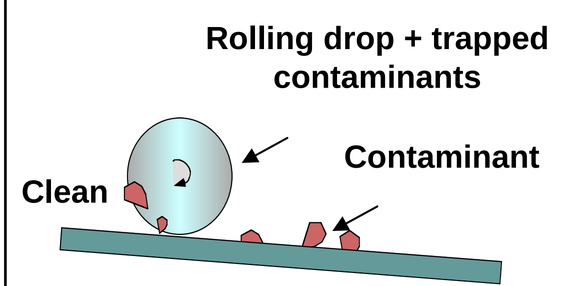
Both the permittivity (ε) and permeability (μ) are negative from about 10.4 GHz to 11 GHz.

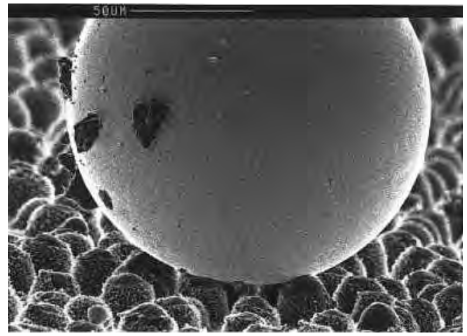
- **Negative index of refraction**
- **Focus radiation from a point source back to a point**
- **Smaller, lighter, more precise filters, communication, antennas, other electromagnetic devices**



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

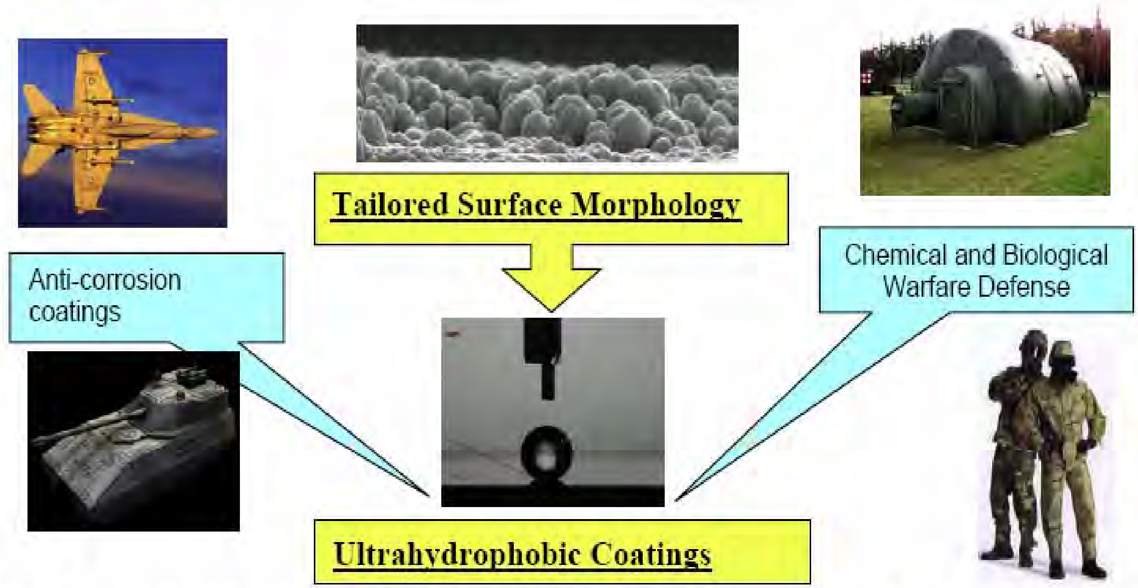
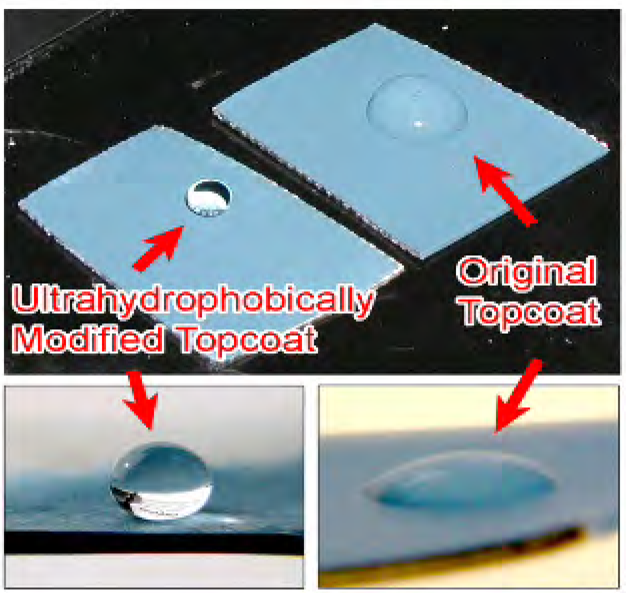
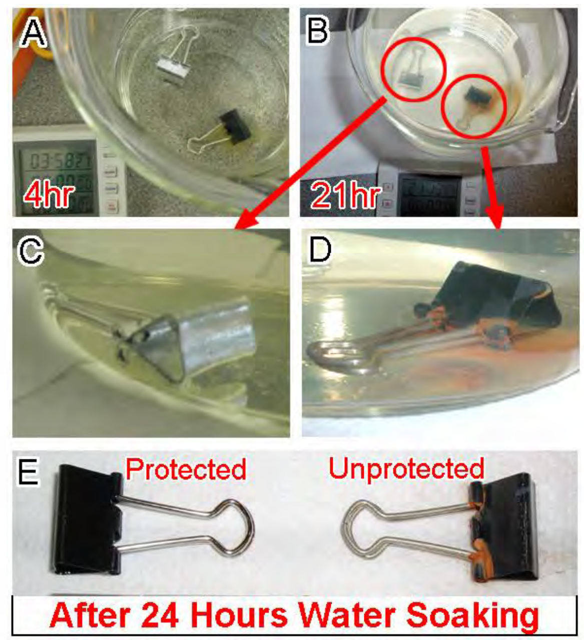


Figure 1. Tailored coating surfaces result in ultrahydrophobic coatings for water repellency supporting many military and commercial applications

Ultrahydrophobic Coatings

[redacted]





[redacted]

Outline

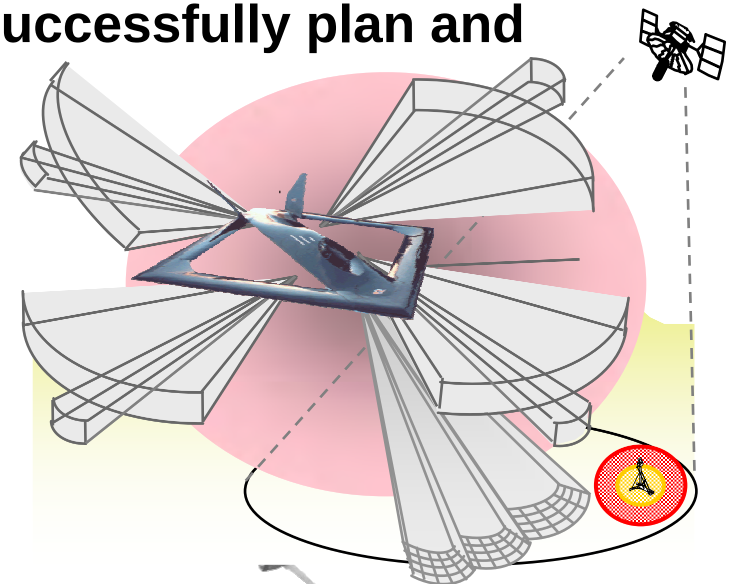
- Introduction
- Disruptive Technologies Definition
  - Smaller is Better
  - All Encompassing Battlefield
  - Directed Energy
- Transition
- Summary

Computer Network Operations

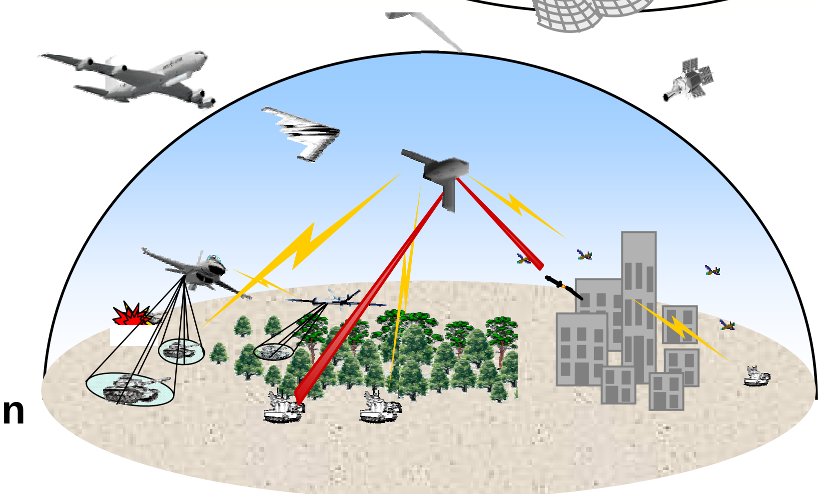
- **Continuing Trend**
  - **Smaller, lighter, mobile and connected**
  - **Dramatic increase in: Cycles/Second/Watt/$**
  - **Results in CPU's becoming more personal and pervasive**
- **Military Opportunities**
  - **Gather intelligence**
  - **Alter perception**
  - **Impact decision making**
- **Changes 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**

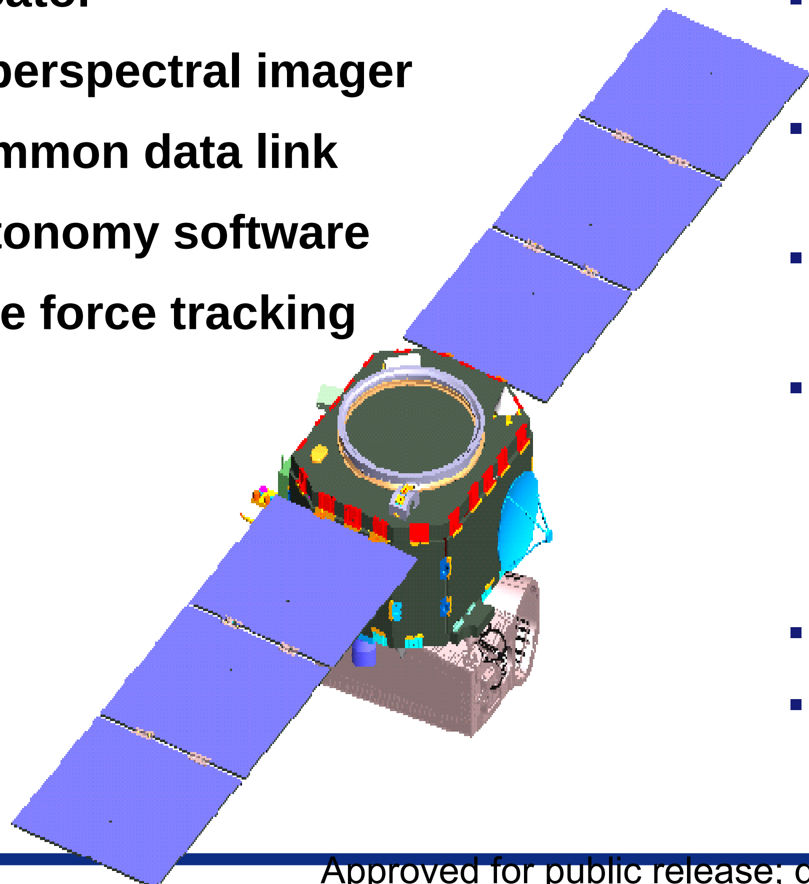


- **Full spectral dominance**
  - **Dynamic network of databases to support a common operating picture**
  - **Rapid detection and attack authorization for time sensitive targets**

Responsive Space: TacSats and Launch

Possible Payloads

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



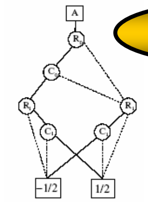
Objectives

- 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

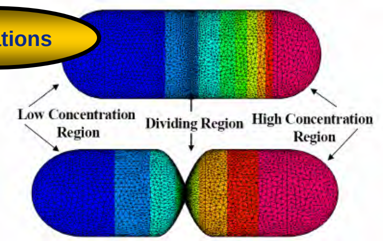
Persistent ISR of the Battlespace

Hybrid Information Systems

Simulations

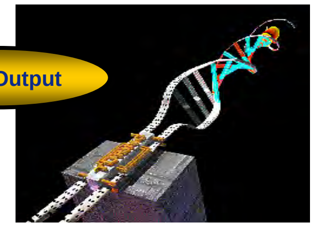


QUIDDs allow 40+ Qubit Simulation of Grover's Algorithm On Workstation



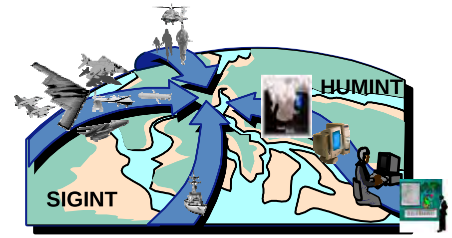
4D Constrained Diffusion Of Bacillus Silicus Division

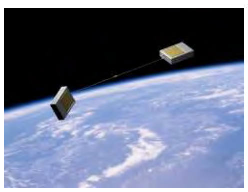
Input/Output



High Throughput Computer Interface

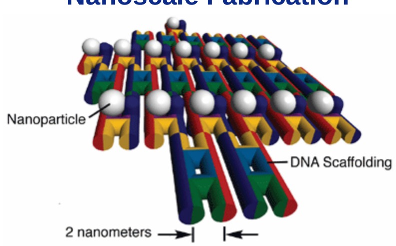
Asymmetric NanoSensor Threat Detection

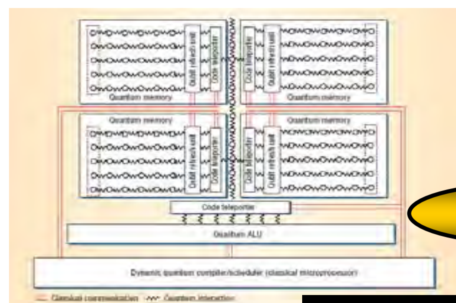




Infobot Proof of Concept

Self Assembled Nanoscale Fabrication



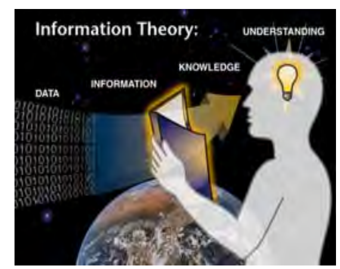


Fault Tolerant Quantum Computer Architecture

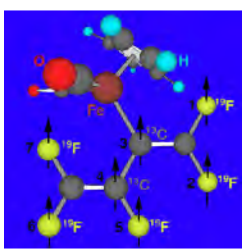
Architectures

Demonstrations

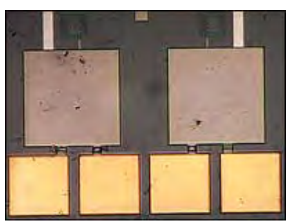
BioMolecular Signal Pathway



Self Assembling/Reconfigurable Nanoscale Information Processing Systems



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



Quantum Entanglement Demonstrated on a Chip

Data Storage

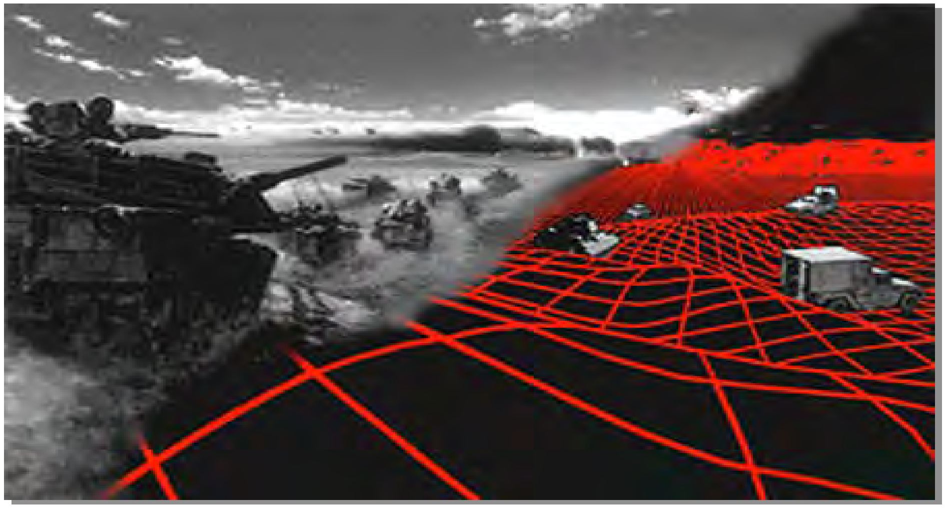
Molecular Memory Commercially Available

2001 2005 2010

Commander's Predictive Environment

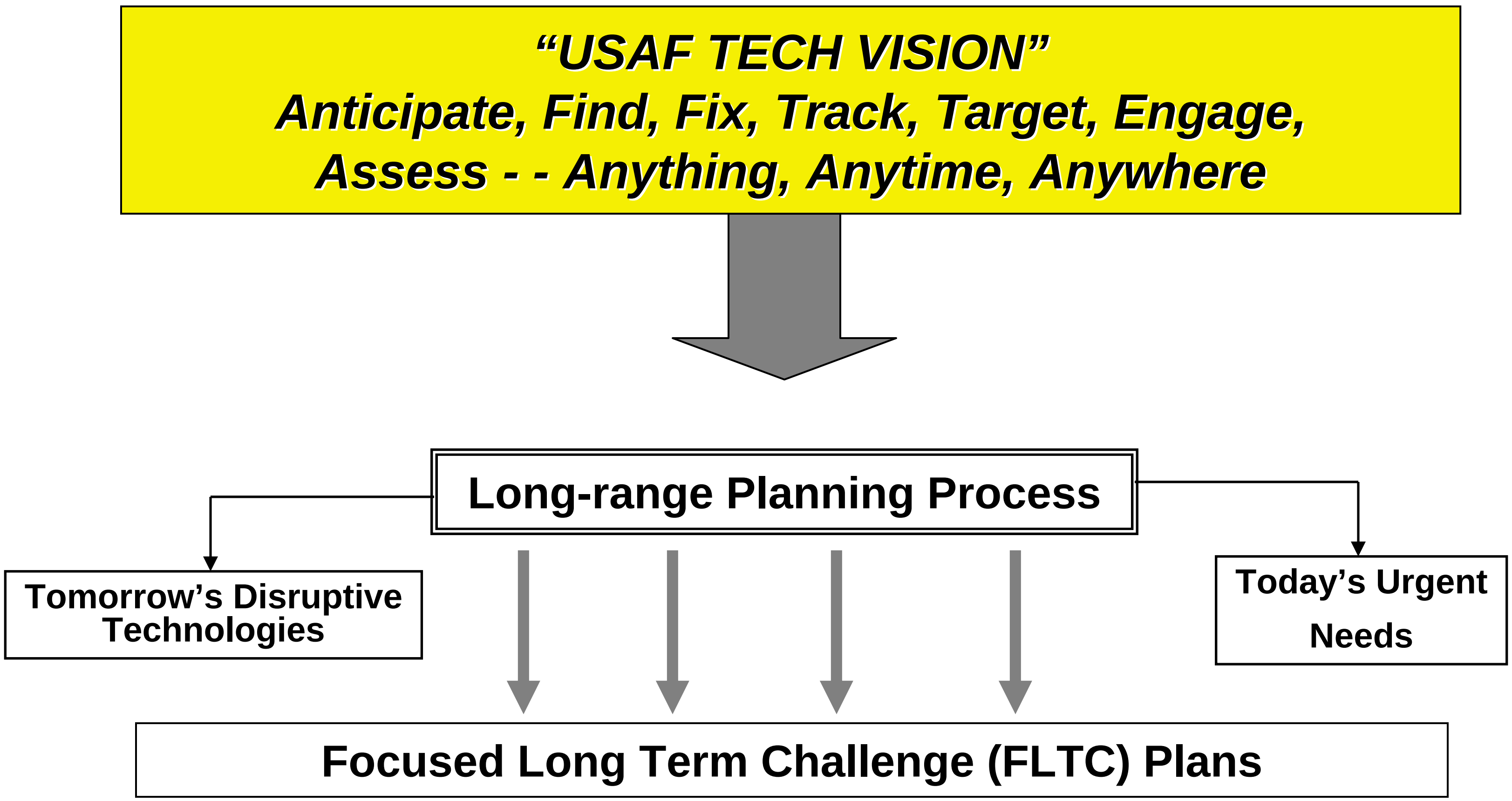
Visualization

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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- Introduction
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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

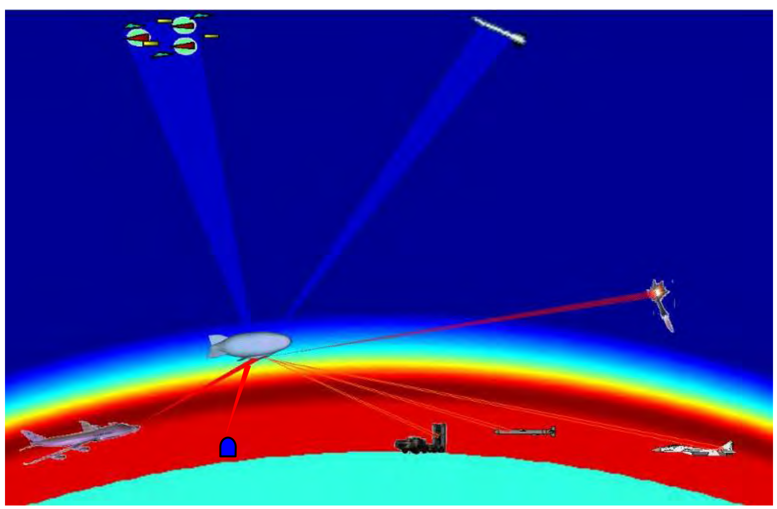
Potential missions

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

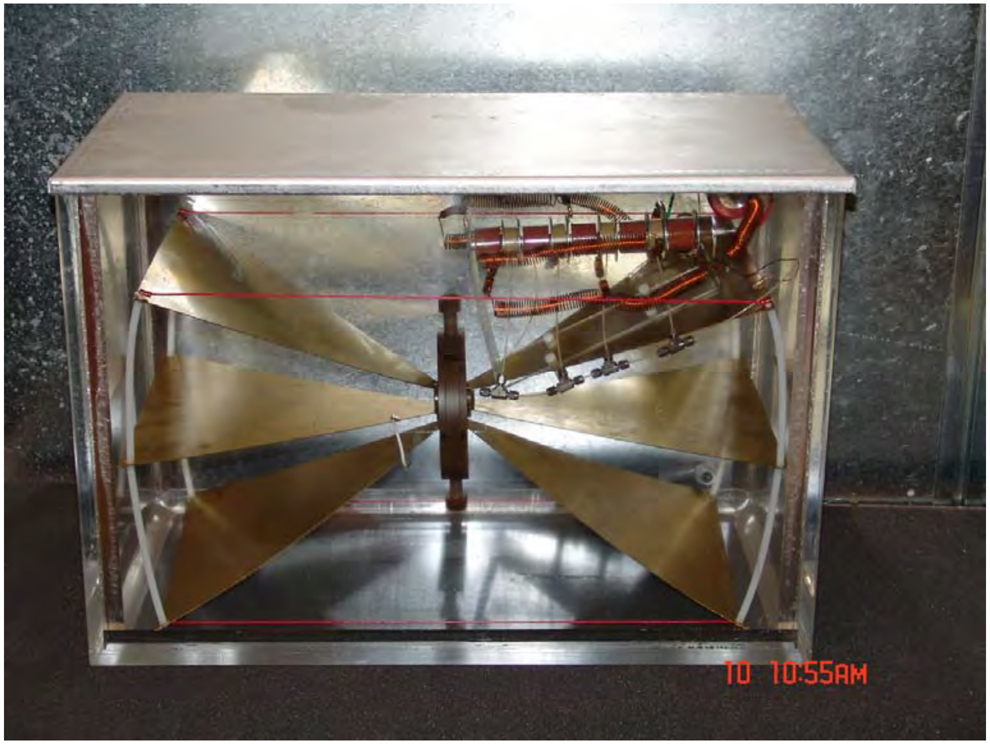
- **Directed energy shields and non-lethal weaponry:**
  - **Electronic infrastructure**
  - **Command and control**
  - **Covertness and plausible deniability**

Generally passes through "things"

- **Weather, plastics, boxes, glass, buildings**
- **<u>Minimum collateral damage</u>**
- **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

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

Concept

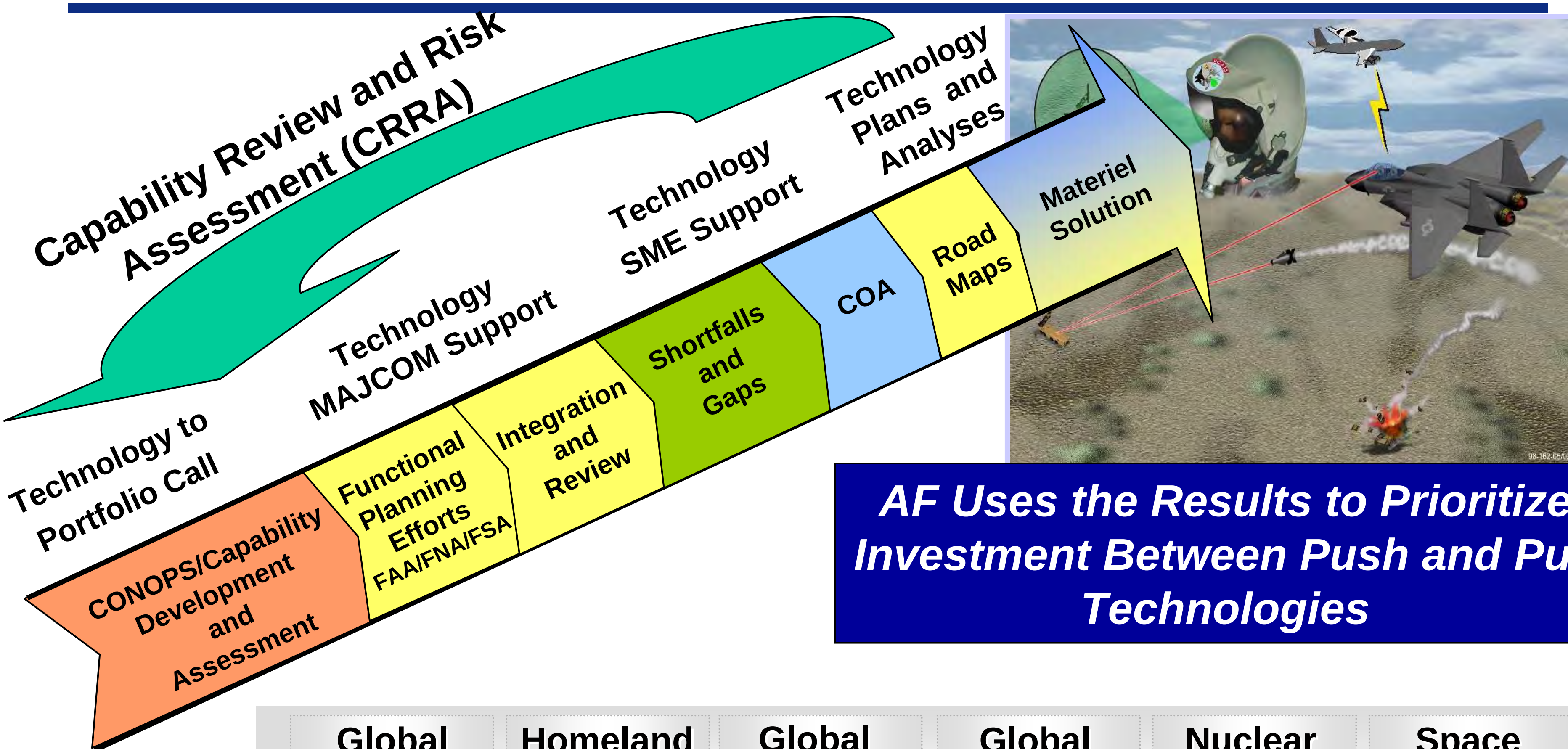
- Non-lethal, anti-personnel system
- Protect forces and areas
- Energy beam heats adversary's skin
  - Forces adversary to flee
- Outranges effective small arms fire
- Many potential platforms

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

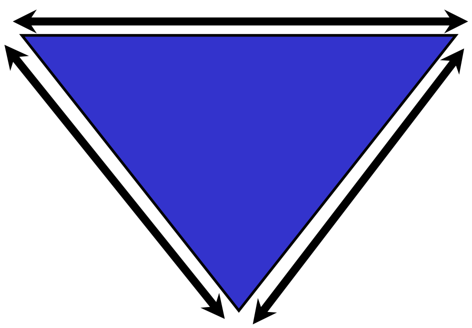
Global Strike CONOPS	Homeland Security CONOPS	Global Mobility CONOPS	Global Persistent Attack CONOPS	Nuclear Response CONOPS	Space and C4ISR CONOPS

Agile Combat Support CONOPS

Applied Technology Council

MAJCOM ★★★

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

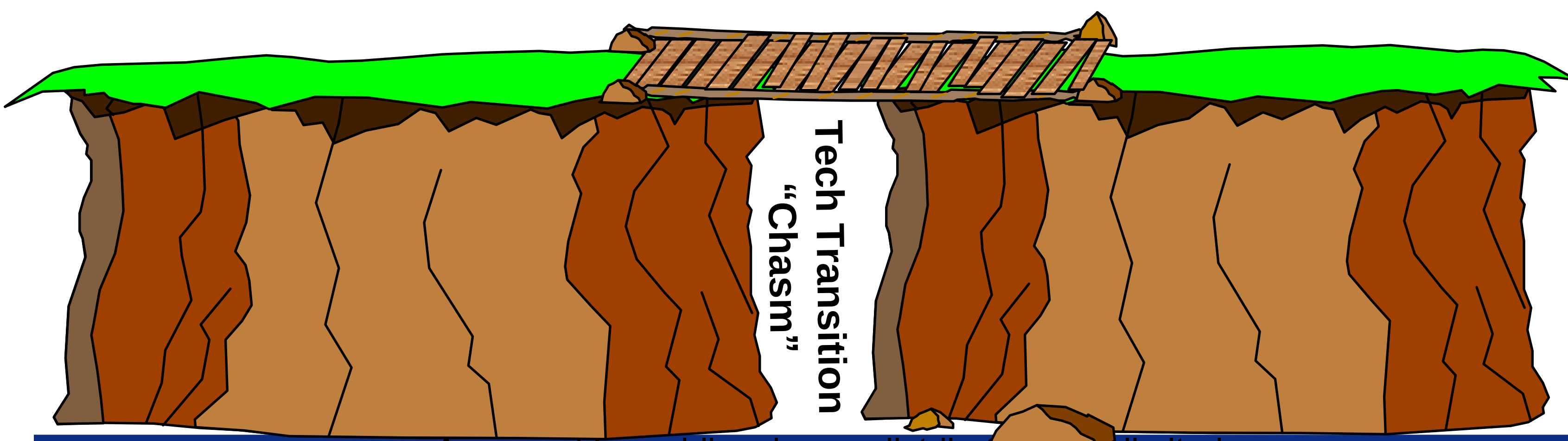


Product Centers ★★★

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

Air Force Research Laboratory ★★

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



Urgent Needs

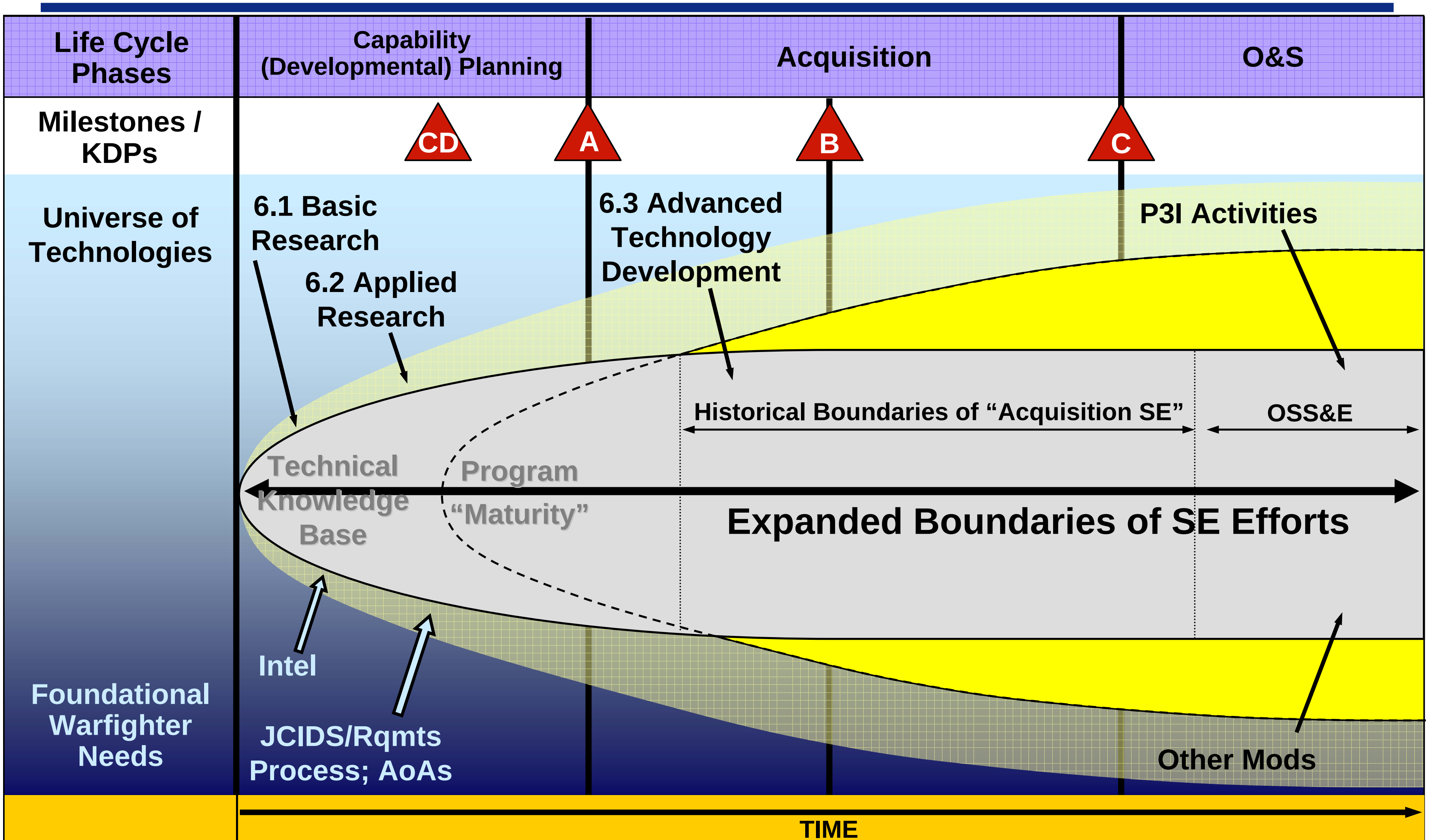
- Operator Urgent Request
- Quick Reaction Capability
- Warfighter Rapid Acquisition
- Advanced Concept Technology Demonstrations
- Technology Transition Initiative
- Leadership Vision

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**

AFRL Inside

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



Outline

- **Introduction**
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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

AF OPPORTUNITIES FOR BASIC RESEARCH

19 April 2006

Col Jeff Turcotte

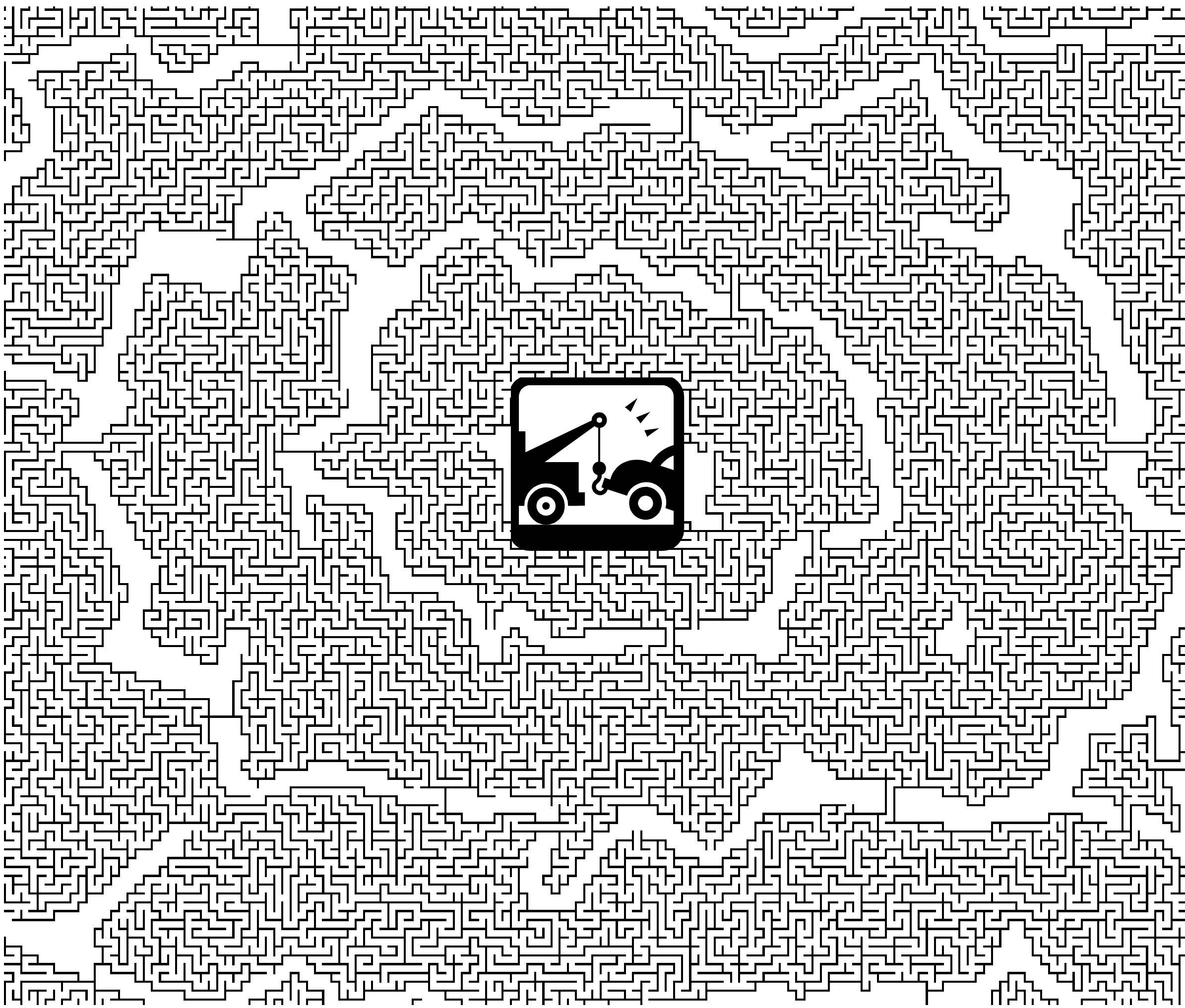
Deputy Director and Commander

Air Force Office of Scientific Research

BASIC RESEARCH INVESTMENT

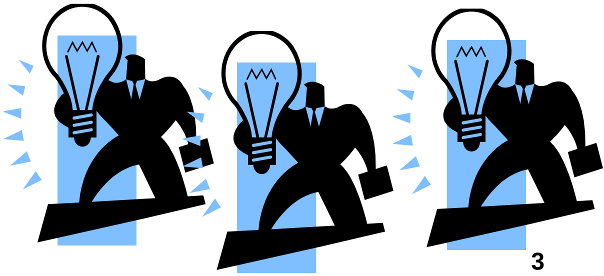
- Core budget can only be used for basic research
  - Definition: systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards process or products in mind
- Invest in all areas that might contribute to AF missions
- Example: We know Hydrazine is hypergolic but we don't know why
  - Who cares, it works?
  - Understanding how it works may lead to additional, perhaps friendlier, hypergolic fuels

Discovery & Innovation Process

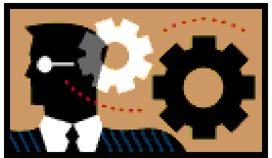


DISCOVERY

INNOVATIONS



START



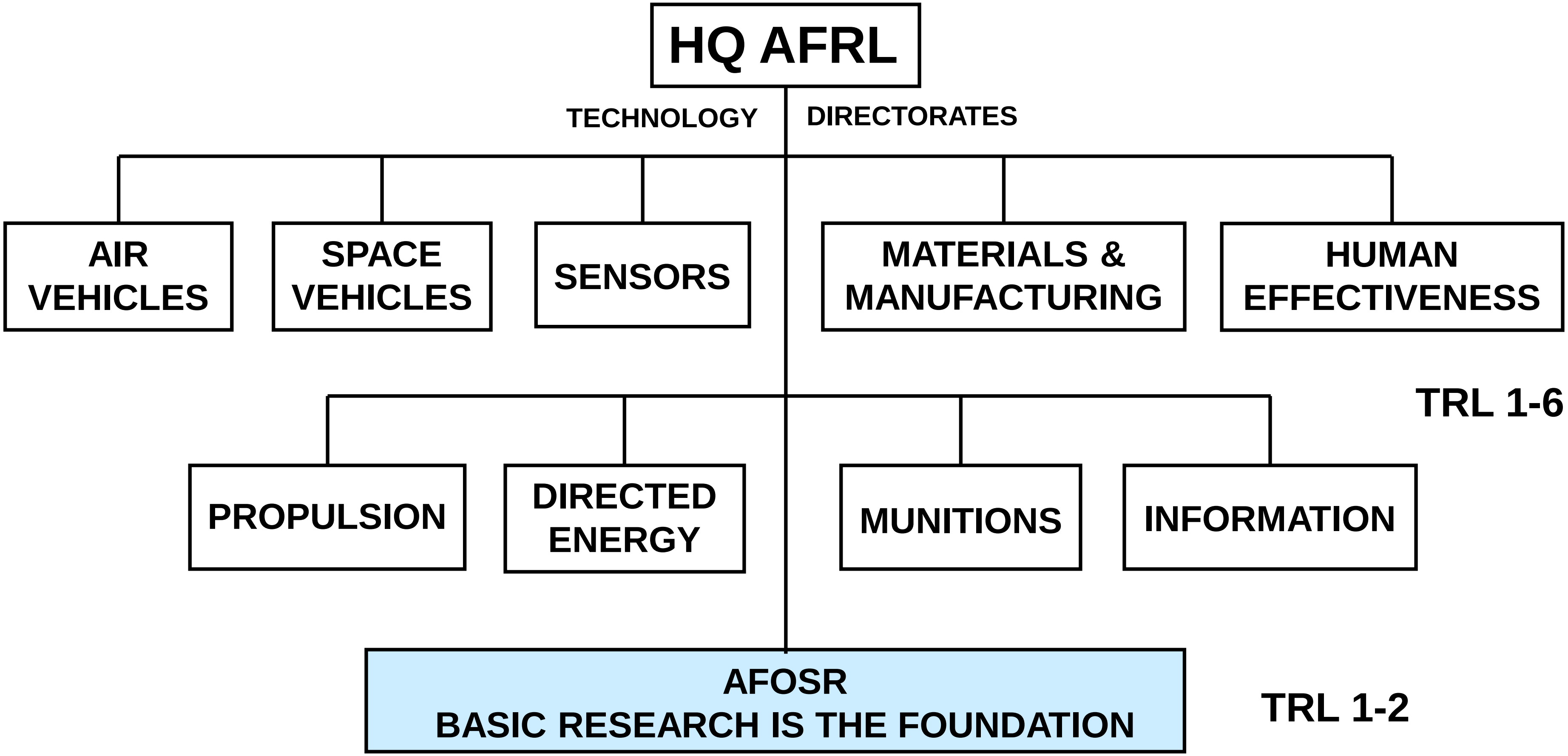
OUTLINE

- AFOSR Overview
- Current initiatives and examples
- Collaborations
- Programs and processes
- Summary

AFOSR Leadership Roles

- Foster Revolutionary Basic Research for Air Force Needs
  - 728 extramural research grants at 211 universities
  - 194 intramural research projects at Air Force laboratories
  - 133 STTR small business - university contracts
  - 368 transitions to DOD and industry
- Build Relationships with Leading Researchers – Here and Abroad
  - 79 summer faculty; 40 postdocs at AFRL
  - 264 short-term foreign visitors; 37 personnel exchanges
  - 58 technical workshops; 205 conferences sponsored
  - Liaison Offices in Europe and Asia
- Educate Tomorrow's Scientists and Engineers
  - About 2000 post-docs and grad students on research grants
  - 430 National Defense Science & Engineering Fellowships

AFOSR Within the AF Research Lab



AFOSR is the Sole Manager of AF Basic Research Funds

Organization

Air Force Office of Scientific Research


DIRECTOR
Dr. Brendan Godfrey

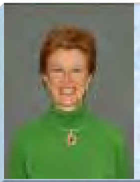

DEPUTY DIRECTOR
Col Jeff Turcotte

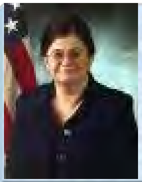

CHIEF SCIENTIST
Dr. Herb Carlson (ST)

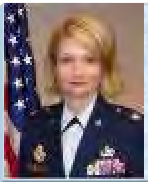

ASSOCIATE DIRECTOR
Col Thurmon Deloney


SENIOR RESERVIST
Lt Col Joe Fraundorfer


PHYSICS & ELECTRONICS
Dr. Jack Agee
Director


AEROSPACE & MATERIALS SCIENCES
Dr. Ozden Ochoa
Director


CHEMISTRY & LIFE SCIENCES
Dr. Genevieve Haddad
Director

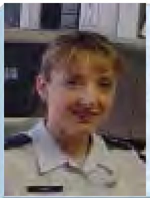

MATH & INFO SCIENCES
Lt Col Sharon Heise
Director


INTERNATIONAL OFFICE (IO)
Dr. Mark Maurice

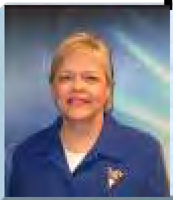

ASIAN OFFICE OF AEROSPACE RESEARCH & DEV
TOKYO
Dr. Terry Lyons


EUROPEAN OFFICE OF AEROSPACE RESEARCH & DEV
LONDON
Col Stephen Pluntze

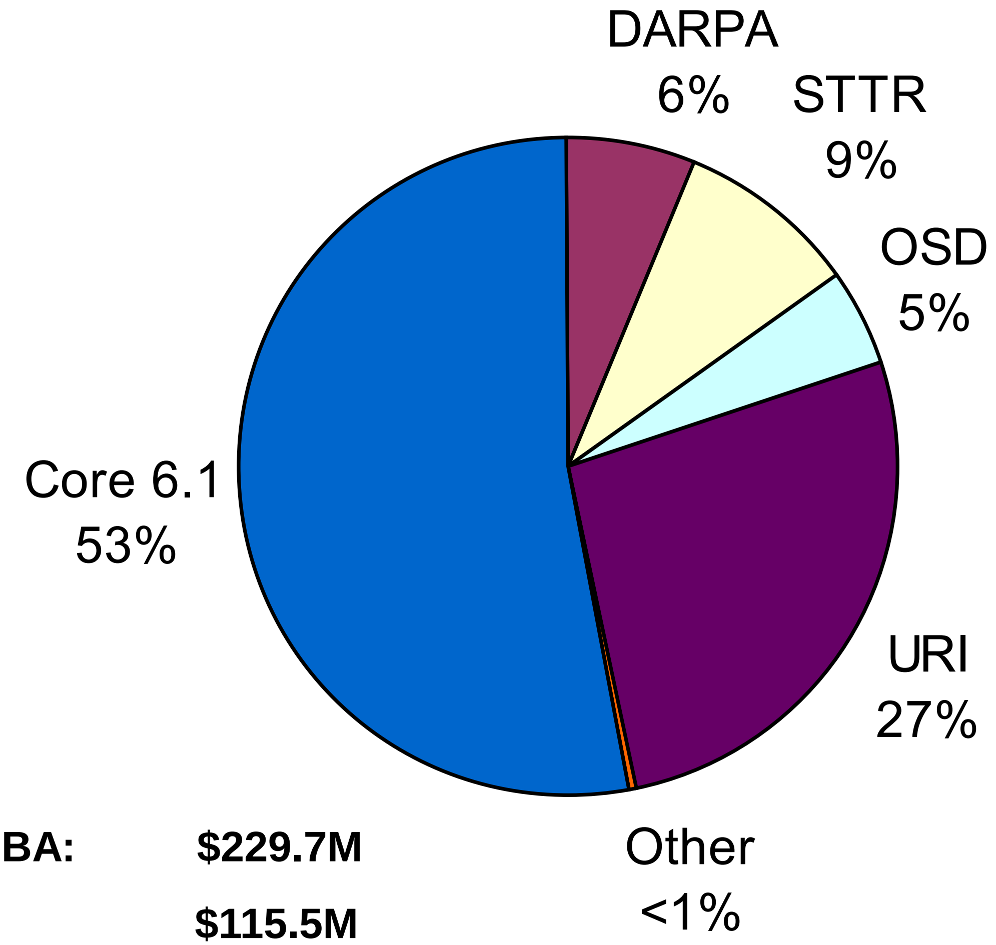

HUMAN RESOURCES
Ms Terry Hodges


STAFF JUDGE ADVOCATE
Maj Vicki Lund


DIRECTORATE OF POLICY & INTEGRATION
Lt Col John Kaplan


DIRECTORATE OF CONTRACTING
Ms Kathy Wetherell (Acting)

AFOSR
FY05 Budget Authority (BA)



FY05 Core 6.1 BA: $229.7M

FY05 URI BA: $115.5M

<u>FY05 External Funding: $88.1M</u>

Total AFOSR FY05: $433.3M

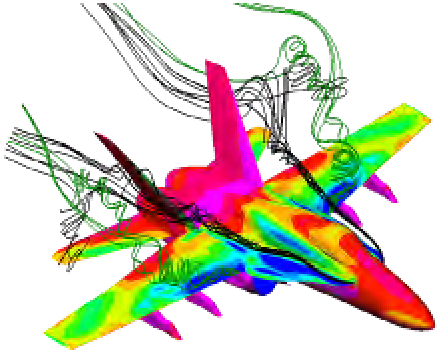
<u>Core funds after taxes</u>

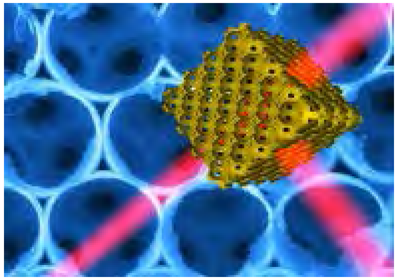
FY06 $201M

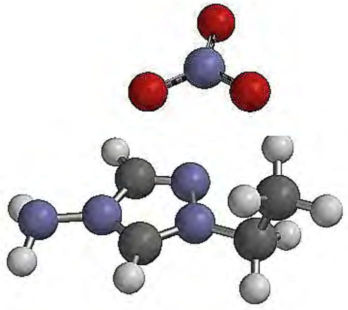
FY07 $224M

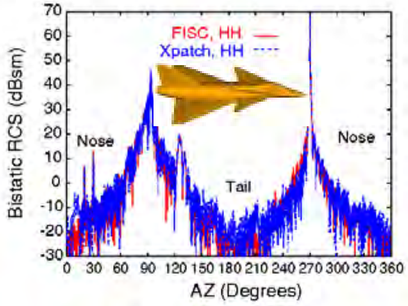
AFOSR Research Areas

Aerospace and Materials Sciences	Physics and Electronics	Chemistry and Life Sciences	Mathematics and Information Sciences









Sub-thrusts

Aerospace and Materials Sciences
- Solid Mechanics and Structures
- Materials
- Fluid Mechanics
- Propulsion

Physics and Electronics
- Physics
- Electronics
- Space Sciences

Chemistry and Life Sciences
- Chemistry
- Bio Sciences
- Human Performance

Mathematics and Information Sciences
- Info Sciences
- Computing Sciences
- Mathematics

Areas of enhanced emphasis:

- Information Sciences
- Mixed-Initiative Decision Making
- Adversarial Behavior Modeling
- Novel Energy Technology
- Nanotechnology

OUTLINE

- AFOSR Overview
- **Current initiatives and examples**
- Collaborations
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Vision for AF IS&T Research: Team-Focused Network-Enabled Systems

Human-system interactions

Goal: Mixed initiative reasoning and decision support

Information management and integration

Goal: Processing & managing of semi-structured content

Software

Goal: Understand what to build, ensure predictability, evolve in the field

Networks & communications

Goal: Assured connectivity

Distributed research & experimentation environments

Multi-UAV control

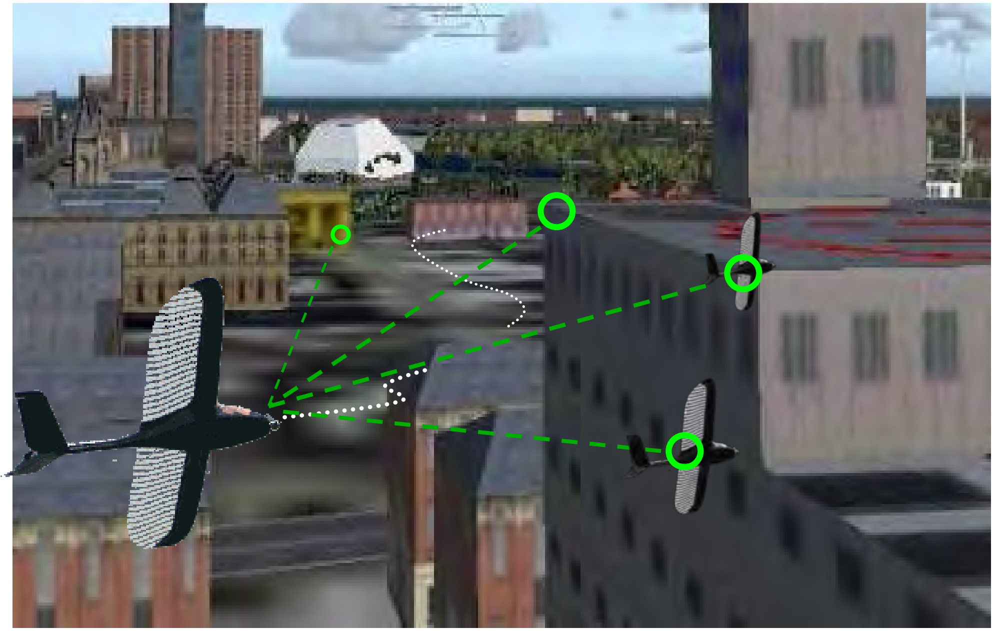
C2 for mixed manned & unmanned operations

Grand Challenge Problems

Mixed reality training environments

Beyond AOC automated assistant

Agile Autonomy for MAVs



Goal: Operation in Close Proximity to Terrain, Structures

Inspiration from Biology?

Motivation

- Hidden, Occluded Targets
- Target Uncertainty, Mobility
- Stealth, Covert Operation

➔ *Operation in Confined Airspace*
  - Collision Avoidance
  - Datalink Dropout
  - Situational Awareness

Technologies

Aerodynamic Agility
  - Exploit Unsteady Aerodynamics
  - Agile Airframe Control Concepts

Guidance Agility
  - Wide Field-of-Regard Sensing
  - Autonomous Imaging Guidance
    - Active vision control systems

- **Time-sensitive operation in confined airspace requires aerodynamic agility**
- **Aerodynamic agility in confined airspace requires guidance agility**
- **Multi-vehicle operations require cooperative system management**

Mixed-Initiative Decision Making

- Describe quantitatively how humans process information to learn, recognize, assess, and make decisions about events occurring in dynamic environments
- Develop quantitative models and methods to improve understanding of
  - Multisensory perceptual integration
  - Cognitive and perceptual factors in the acquisition of complex skills, including motor skills
  - Individual and team decision-making
  - Fundamental constraints of attention and memory on human performance
- Ability to identify and quantify the individual attributes that determine or constrain human performance, especially in complex information-processing environments

Adversarial Decision Modeling

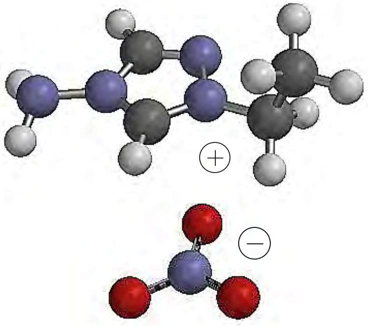
- Modeling cultural influences on attitudes and behaviors of regional factions
  - Determine critical dimensions of culture
  - Discover how cultures shape attitudes and behavior
  - Model factional dynamics under influence

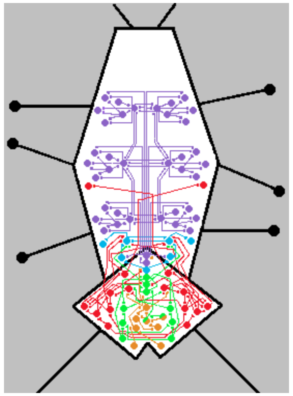
- Influence operations training aids
- Decision making in adversarial domains

Coordinated with informal multi-agency working group

Improved Fuel Efficiency and Alternative Energy

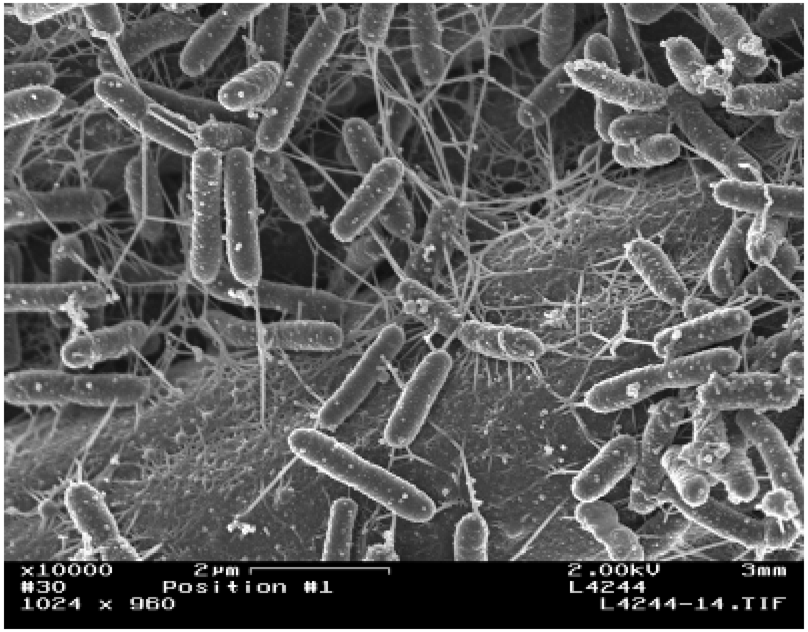
- **Alternative Fuels Combustion Simulation:** Tools to assess the effects of fuel properties on propulsion system performance
- **Plasma Enhanced Combustion**: Short duration corona discharges for improved ignition characteristics in hydrocarbon-air mixtures
- **Trapped Vortex/Ultra Compact Combustors:** Improved efficiencies and emission profiles compared to conventional combustors
- **Solar Cells:** Lighter, more-efficient solar cells for power generation in space
- **Drag Reduction:** Laminar flow control to reduce drag friction and active flow control for optimized aerodynamics
- **Novel Energetic Materials:** New materials (ionic liquids, strained-ring hydrocarbons, polynitrogen compounds) with higher-energy densities, lower volatilities, and other improved properties
- **High Temperature Materials:** New materials to allow engines to operate at higher temperatures
- **Biofuel Cells:** Utilization of enzyme/microbial fuel cells to power micro air vehicles with flexible fuels sources from the environment
- **Bio-hydrogen:** Production of hydrogen from photosynthetic microbes and sunlight
- **Fuels Toxicology:** Determination of biological effects and damage mechanisms to enable the development of safer fuels





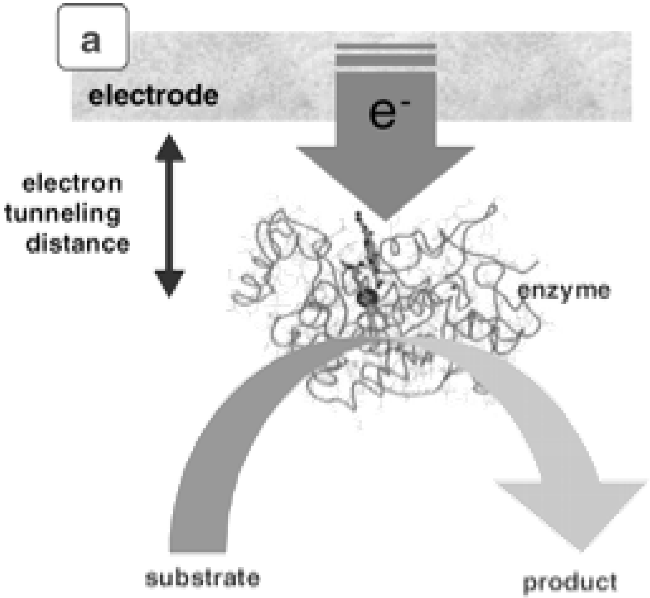
Bioengineering for Compact Power

GOAL: Understand & control electron transfer using biological systems



Shewanella oneidensis strain MR-1 cultivated on a graphite fiber electrode

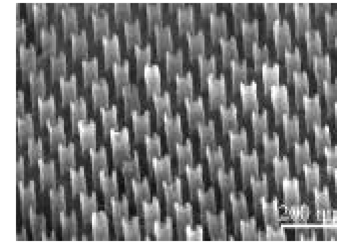
Microbial approach
Ken Nealson - USC



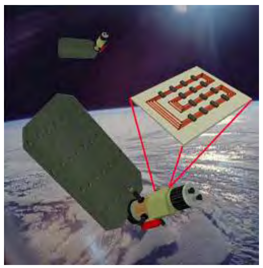
Understanding direct electron transfer to and from electrode surfaces

Enzymatic approach
Plamen Atanassov - UNM

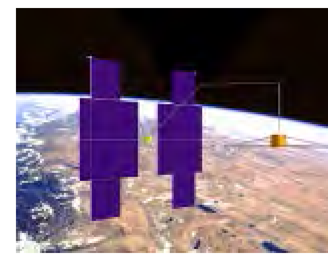
AFRL Nanotechnology Initiative
(Added in FY2006PB)



Nanoelectronics: Multispectral Detector Arrays: Explore techniques to control growth of self-assembled quantum structures, connections to the structures, and combinations of both, which will lead to detectors for multispectral and hyperspectral image processing.

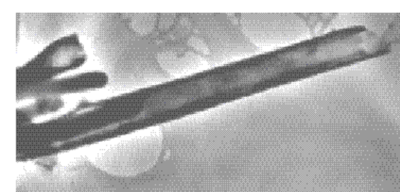


Nanoelectronics: Chip Scale Optical Networks: Forward-looking architectural effort that seeks to develop new concepts in the design, operation, employment, and overall functioning of military platform networks.



Nanoelectronics: Compact Power for Space: Increase specific power for solar arrays, fuel cells, and power storage systems for high power space platforms.

Nanoenergetics: Enable the development of higher performance, less-sensitive nanoscale energetic materials for applications in munitions and propulsion.



Nanomaterials for Structures: Establish nanomaterial and nanocomposite systems that will enable reduced system weight or size, increased operational lifetime, and multifunctional performance of load-bearing aerospace structures.

PHOTONICS and NANOTECHNOLOGY

(nano-optical circuits)

Microcavities EIT PBG/PC Quantum Dots Plasmonics
Nanocrystals/particles QC optical methods
Refractive Index Engineering Dispersion Engineering

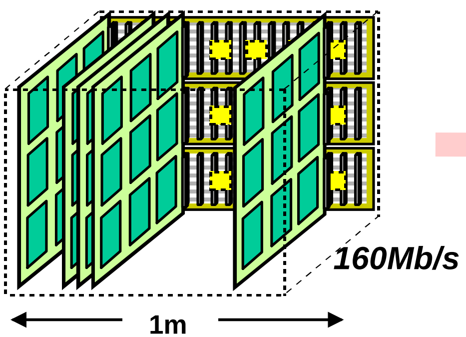
Nanophotonics:
Extending the power of optics to the nanometer scale... The control and manipulation of light on this scale offers new approaches to photonic devices, as well as microscopy and spectroscopy.

Nanophotonics:
Novel –
Materials
Devices
Phenomena
Tools

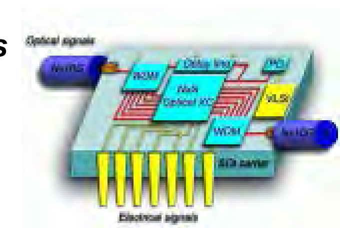
Silicon Photonics

The combination of Nanofabrication & Photonics:
Nanofabrication allows for the development of devices at the nanometer level.
Photonics allow for the controlling of photons, or light, for telecommunications.

Electrical power consumption & dissipation
Achieving greater speed (>10GHz)
Interconnects
Novel Computing

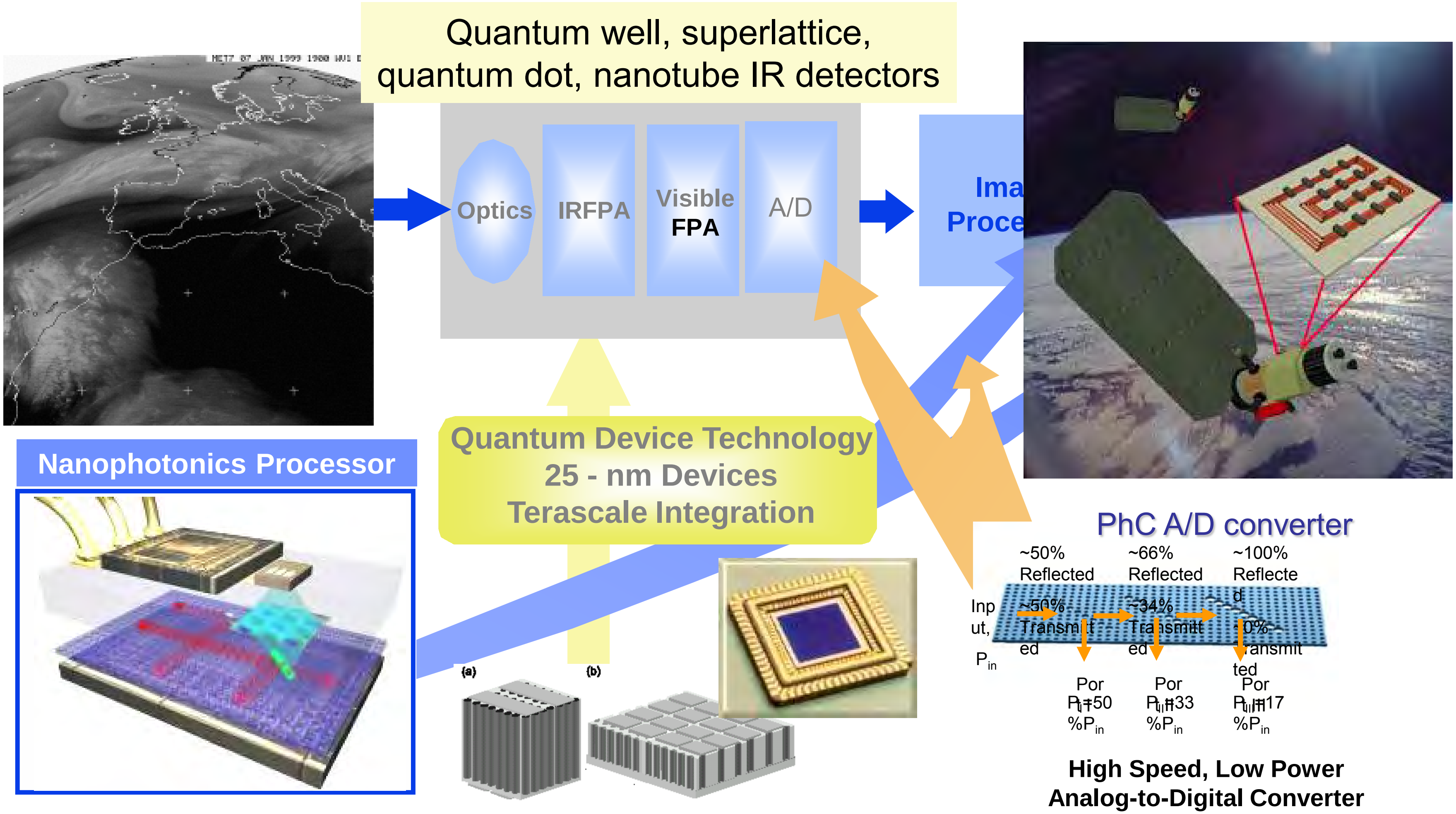


Terabits/s



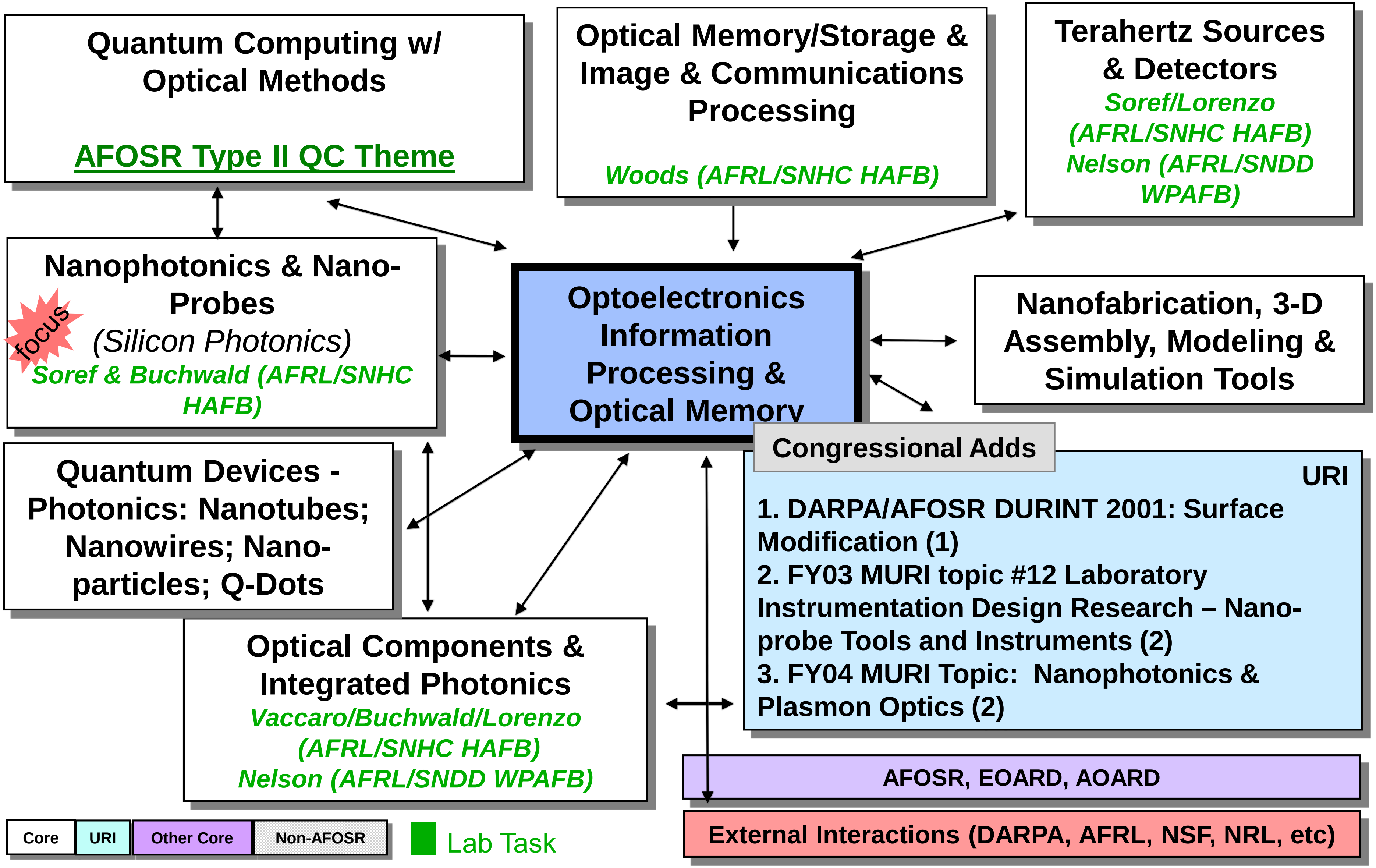
- Scalable; - High Integration
- Low power/small footprint

Impact: SENSING and HIGH SPEED IMAGE PROCESSING – Using Photonics



“Advanced signal processing components for infrared & THz imagery, smart munitions, target acquisition and satellite imagery .”

Optoelectronics Components, Information Processing, High Density Memory



3D Negative-index PhC Lens for Sub-wavelength Imaging Applications

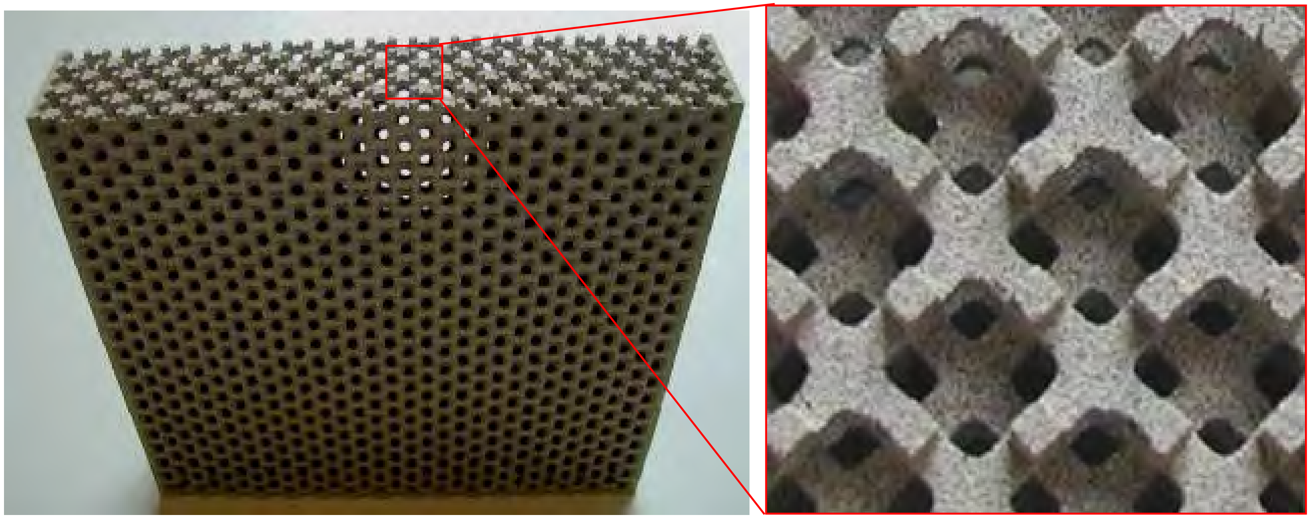


Fig. 1: 3D body-centered cubic photonic crystal for achieving negative refraction imaging.

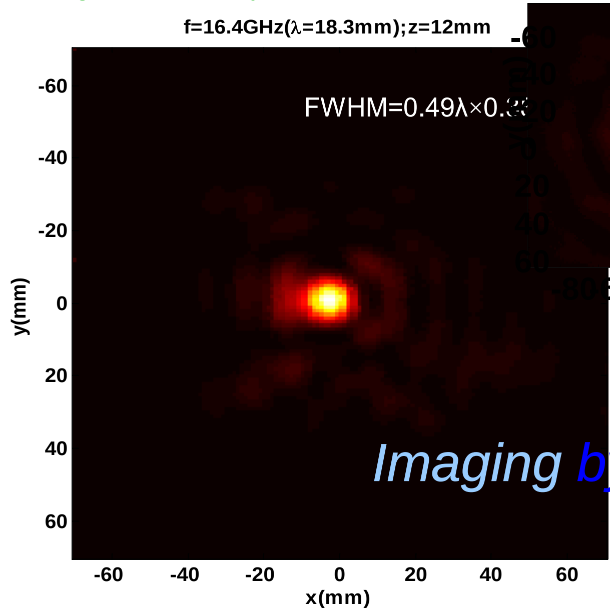
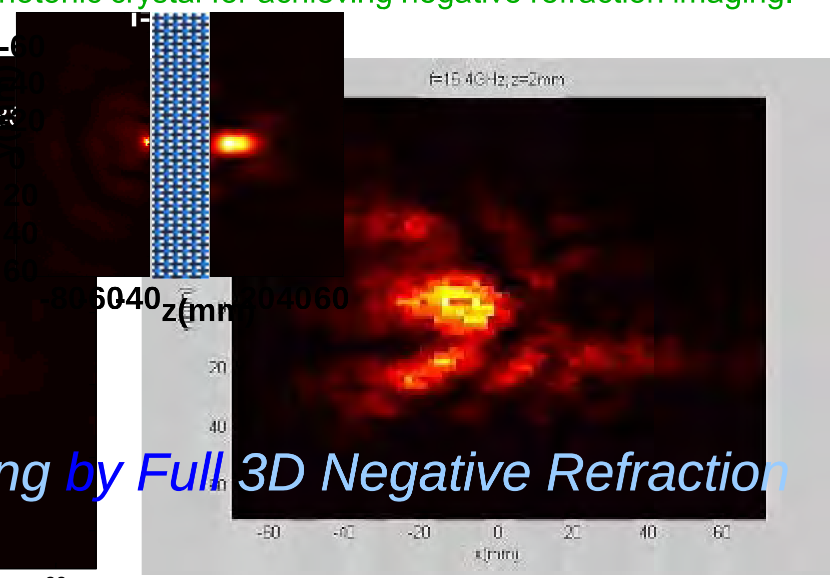


Fig. 2: Subwavelength image for a dipole is achieved.



Mov. 1: Image is formed at 12mm away from the lens.

Imaging by Full 3D Negative Refraction

Prof. Prather, UDL

First time ever demonstration of a spherical negative refraction lens in the millimeter-wave wavelength region.

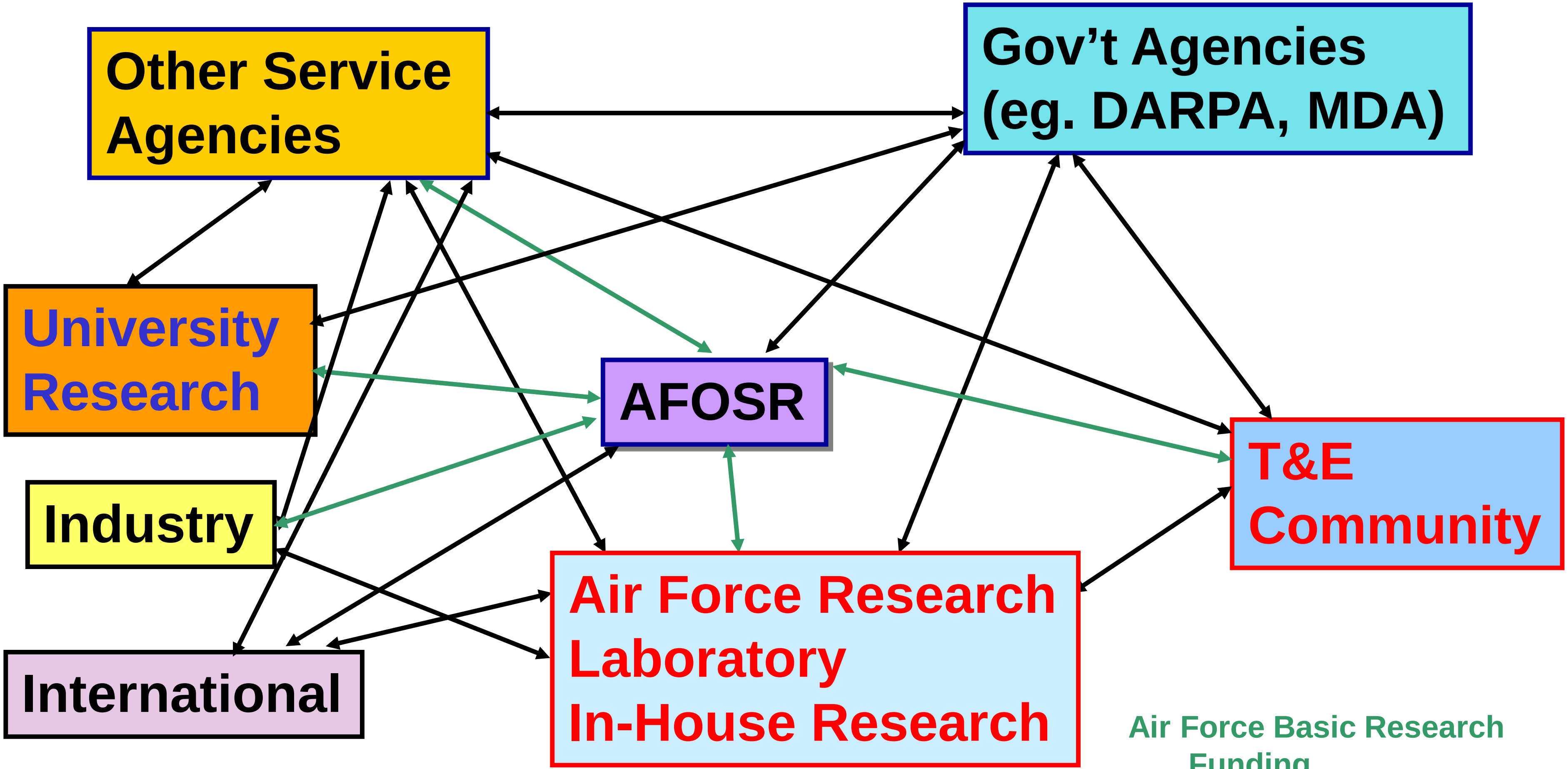
Recently fabricated a body-centered cubic lattice photonic crystal and used it to experimentally demonstrate imaging at millimeter-wave frequencies using full 3D negative refraction.

The realization of 3D photonic crystal lens is not only important for practical applications, but also significant for fundamental research since full 3D negative refraction, as a basic physical phenomenon, has never been experimentally achieved.

OUTLINE

- AFOSR Overview
- Current initiatives and examples
- **Collaborations**
- Programs and processes
- Summary

Research Collaboration



Air Force Basic Research Funding
Air Force In-House Research

Dynamics & Control External Collaborations

Army
Doligalski
Launer
Zachery

DARPA
ISAT
Kott
Schwartz

Navy
Buss
Kamgar-Parsi
McKenna
Steinberg
Szu

AFOSR hosts sole program 100% dedicated to basic research in dynamics and control

Tech Community
AIAA GNC TC
IEEE
SAE

AFOSR
Dynamics & Control

International
Innocenti
Maciejowski
NATO RTO
Sasiedek

Industry
Wise
Buffington
Huzemezan

NSF
Baheti
Foster
Freeman
Gill

NASA
Batterson
Sellers
Waszak
Whorton

NCO/ITR&D
Howe
Matzke

AFOSR basic research is the community foundation

Air Force Biological Sciences

Agency Interactions

DARPA — Biomimetics (stealthy sensors, camouflage); Biomaterials (biomagnetics, BMM); Biointerfacial Sciences (signaling pathways, MOLDICE)

- *Army* — Bioresponse Prediction (lasers); Biomimetics; Biomaterials (silk); Biointerfacial Sciences (bionanotechnology)
- *Navy* — Bioresponse Prediction (jet fuels, microwaves, lasers), Biomaterials (biomagnetics, biocomposites, silk, bionanotechnology)
- *DOE* — Bioresponse Prediction (nanomaterials); Bioenergy (biosolar hydrogen); Biointerfacial Sciences (biosensors)
- *DTRA* — Adaptive Bio-Mechanisms (hormesis); Biointerfacial Sciences (biosensors)
- *DIA & NASA* — Biointerfacial Sciences (biosensors)
- *EPA, NIOSH, Health Canada* — Bioresponse Prediction (nanomaterials)
- *VA* — Bioresponse Prediction (jet fuels)

Biology Program Coordination

- Program managers at ARO, AFOSR, ONR, and DARPA interact frequently with their DoD counterparts
  - to discuss new programs and transitions
  - to participate in proposal evaluations, kick-off meetings, program reviews (e.g. MURIs; Army's ICB; BRR; SERDP Working Group) and with other agencies
- Plan and implement interagency programs to share resources via OSTP/NSTC interagency work groups such as Metabolic Engineering (involving DoD, USDA, DOE, NIST, NSF, NIH, EPA< NASA, FDA, for example); Environmental Biotechnology; Microbe Project; Molecular Vaccines; Marine Biotechnology.
- Co-managing ~$65M of DARPA investment in FY06
- Transition OSR Core findings and MURI discoveries to DARPA
- ARO, AFOSR and ONR coordinate complementary research via BRR and BRP activities

Chemistry Program Coordination

- Joint Technical Meetings
  - Computational Chem. & Mat'ls Sci – DoD Coordination Mtg – March 05
  - Tri-Service Corrosion Meeting – November 2005
  - DoD Advanced Energetics Technology Interchange Meeting
  - Chem–Bio Defense Quarterly Tri-service Meeting
- Joint Programs/Working Groups
  - Joint Chem-Bio Defense Non-Medical Basic Research Program
  - Tri-service coordination on Power and Energy
  - MURI topic development, proposal evaluation
- Program Reviews
  - Participation in Division Reviews (e.g. – ARO Board of Visitors, NRL)
  - Attendance at Contractor's Meetings, MURI Reviews, etc.
- Reliance Meetings
  - Multiple reliance meetings each year for investment planning
- Collaboration

University Centers of Excellence

- Co-Funded by AFOSR, TD and University
- Extends the capabilities and scope of AFRL
- Opens up opportunity for continued focus on AF needs to a new generation of scientists
- Six Centers Funded:
  - Intelligent Information Systems Institute (IISI) - IF, Cornell U
  - Information Assurance Institute (IAI) - IF, Cornell U
  - Collaborative Center of Control Science, - VA, Ohio State U
  - Metals Engineering - ML - Ohio State U
  - Collaborative Center in Polymer Photonics - ML, U Akron
  - Center for Agile Autonomous Flight – MN, U Florida

OUTLINE

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Grant Proposal Selection Process

- **Core Broad Area Agency Announcement (BAA) is open at all times to good ideas**

http://www.afosr.af.mil/

- **General Process**
  - **Researchers submit white papers to AFOSR program managers (Fall time frame)**
  - **Promising white papers are suggested for full proposals**
  - **Proposals are merit reviewed for *excellence* and *relevance***
  - **Individual grants are typically for three years**

Portfolio Goals and Considerations

- **Goals**
  - Provide revolutionary scientific breakthroughs to maintain military air and space superiority
  - Avoid technological surprise
  - Build collaborations between AFRL and universities
  - Educate tomorrow's scientists and engineers
- **Primary Considerations for grant selection**
  - Technical excellence
  - Relevance to goals
  - Potential for revolutionary impact
  - Potential to influence scientific research priorities

Small Business Technology Transfer (STTR) Program

- **The STTR Program provides up to $850,000 in early-stage R&D funding directly to small companies working cooperatively with researchers at universities and other research institutions (http://www.acq.osd.mil/sadbu/sbir/solicitations/sttr06/preface06.htm)**
  - **Company must be a U.S. For-profit small business, 500 or less employees; No size limit on research institution**
  - **Research institution must be a U.S. college or university, FFRDC or non-profit research inst.**
  - **The principal investigator may be employed at the small business or research institution**
- **Air Force Has 35 STTR Topics in FY06 (see list at http://www.dodsbir.net/solicitation/sttr06/af06.htm)**
  - **February 1, 2006: Solicitation was issued for public release**
  - **March 15, 2006: DoD began accepting proposals**
  - **April 14, 2006: Deadline for receipt of proposals**
  - **August 15, 2006: Contracts Awarded (approximately)**

Impediments to Transition

- Intellectual Property Agreements required for STTR
- Lack of 6.2/6.3/6.4 funds
- STTR with Government partner requires commercial test agreement (Gov't agency must be paid directly by contractor)

Partnership for Research Excellence and Transitions (PRET)

- Up to five years duration
- Typically $0.5-1M/year (can be over $2M)
- Prime is one or more universities
- Must have at least one industrial partner to ensure transition of research; industry gets funding as subcontractor to university
- Current PRETs
  - Advanced Concepts in Space Situational Awareness
  - Information Fusion for Command and Control
  - Information Fusion for Image Analysis
  - Information Fusion Support for Natural and Man-made Disasters
  - Homeostatic & Circadian Regulation of Wakefulness

AF Young Investigator Program

(New for FY-07)

- Support young scientists/engineers in AF relevant areas
  - Enhance early career professional development
  - Promote innovative research
  - Increase opportunities to recognize AF challenges

- Awards and Submission features
  - 3-year renewable awards $100K/year (minimum)
  - 15 new awards each year (45 or more steady state)
  - Proposal due 4:00 p.m. EDT, Thursday, 20 July 2006
  - BAA can be found at http://www.afosr.af.mil/pages/oppts/afrfund.htm#Research

- Eligibility
  - Less than 5 years after Ph.D.
  - US citizens and permanent residents
  - Faculty, Post-Doc, Industry Researchers eligible

SUMMARY

- **Basic research generally cannot be roadmapped**
- **AFOSR is adapting to the GWOT with substantial initiatives**

- **Basic research leads to discovery**
- **Discovery requires innovation/application/further development to become useful**

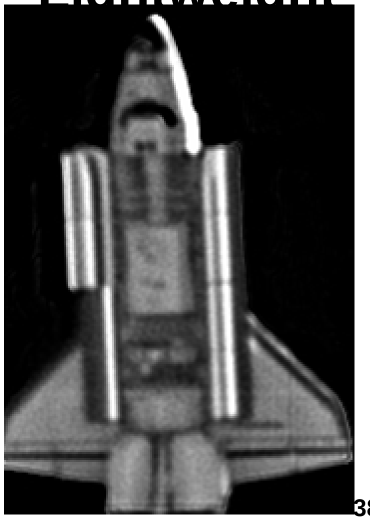
- **STTR is a common transition path**

- **Other AFRL TDs are another common path, when funds are available**
- **AFOSR is open to transition/transfer ideas— we need your help to identify paths to transition/transfer**

BACK-UPS

Recent Technology Transitions

- **Laminar Flow Control for Reduced Drag (university to AFRL/VA, DARPA, and industry) – reduced aircraft fuel consumption**
- **Fiber-Optic Sensor for Total Lifetime Monitoring of Polymer Matrix Composite Materials (university to industry, new company formed) – improved aircraft maintenance**
- **Real-time Scintillation Prediction Capability (AFRL/VS to Air Force Weather Agency) – more reliable satellite communications**
- **Nanowire Technology for Future High Performance, Lightweight Electronics (university to industry)**
- **Coatings Deposition Process for MEMS Devices to Prevent Friction and Wear (AFRL/ML to – reduced maintenance**
- **Self Healing Composites (university to industry) – greater reliability, reduced maintenance**



Recent Scientific Breakthroughs Supported by AFOSR

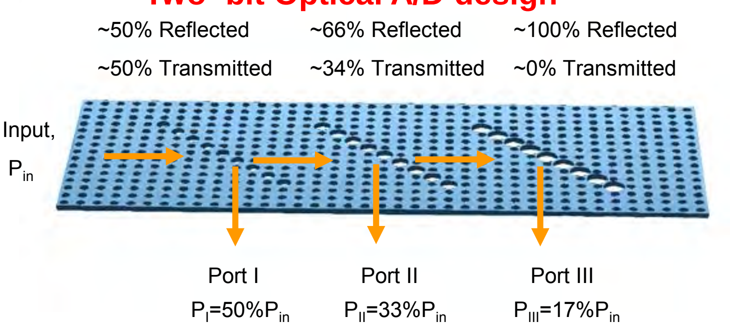
- **Spintronics:** Studying electron spin coherence, ultrafast electronic spin polarizers, and electronic spin manipulation • Implications for all aspects of information processing technology
- **Left-Handed Materials:** Developing magnetic composites negative indices of refraction • Wide range of potential applications (antenna, microwave devices, shielding)
- **Interference Suppression:** Developed conformal antenna circuitry for GPS interference suppression • Transitioned to UAV Special Projects Office (SPO)
- **Polynitrogen Chemistry:** Computational methods used to aid synthesis of new all-nitrogen compounds • First new all-nitrogen species, N_5^+, in over 100 years • Studying reactivity and compatibility of compounds
- **Electric Oxygen Iodine Laser (EOIL):** Developing a new class of electric hybrid lasers • Lasers retain benefits of Chemical Oxygen Iodine Laser (high power, good beam quality, etc) while eliminating reliance on potentially hazardous chemicals
- **Electromagnetics:** Developed Incremental Length Diffraction Coefficients method to predict radar cross sections • Transitioned to Industry

STTR Phase II : Photonic Bandgap Devices
First Experimental Demonstration of All optical A/D Converters Using Photonic Crystals

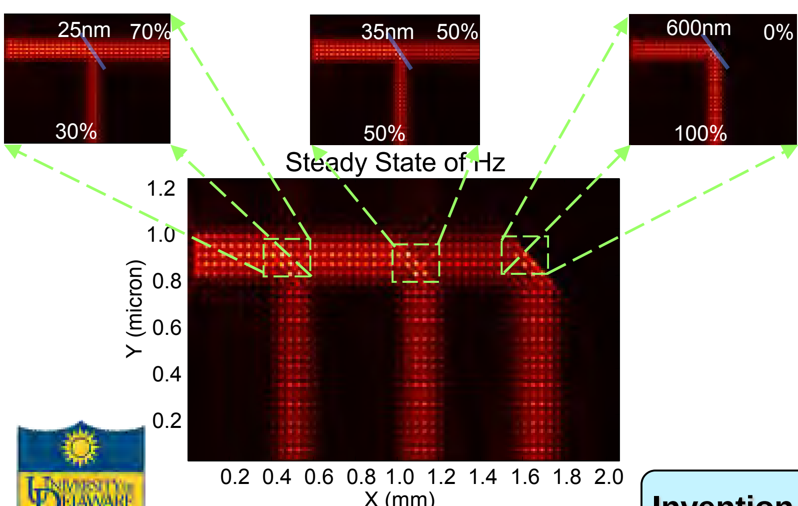
Goal: Define and develop a new paradigm for engineering global properties of photonic crystals that combines design, simulation, fabrication and characterization.

Impact:
- Photonic crystal (PhC) dispersion based devices including ADC will provide the basic building blocks to transfer PhC technology from research labs to commercial market.
- Develop PhC devices that are immune to fabrication tolerances.

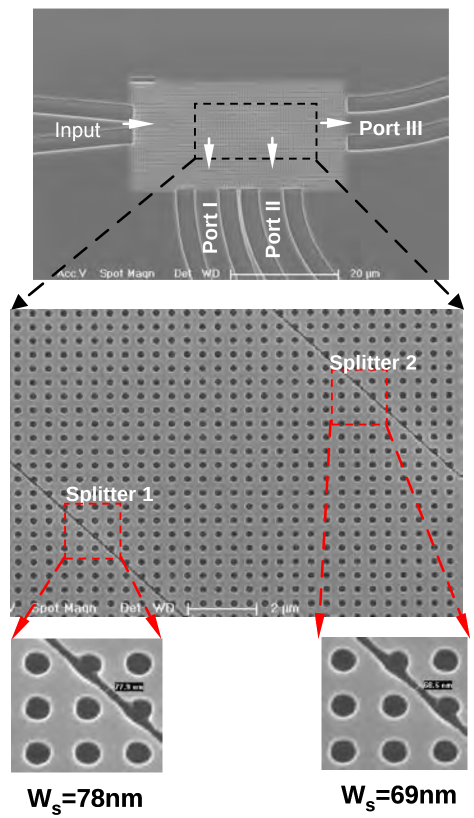
Two- bit Optical A/D design



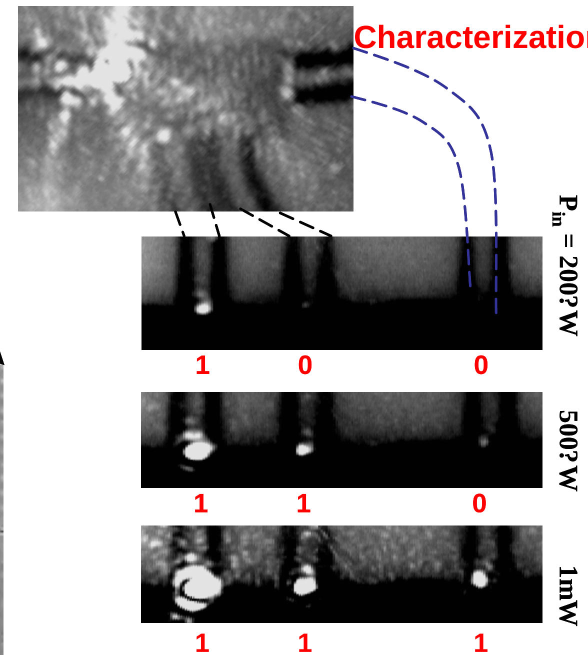
Simulation



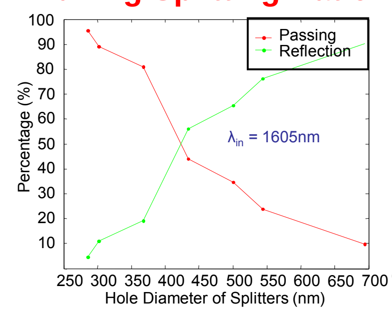
Fabricated Prototype



Characterization



Tuning Splitting Ratio



Invention Report is currently being processed

Co-PI: D. Prather

AFOSR Contract FA9550-04-C-0062 **Start Date**: Jul/04 - **End Date**: Jul/06

PI: A. Sharkawy

Example #1 STTR Topic

- TITLE: Quantitative Model of Human Dynamic Attention Allocation
- OBJECTIVE: Develop quantitative model(s) of attention allocation in dynamically complex multi-modal task environments
- Key model requirements are:
  - Model must capture the timing and spatial parameters of dynamic information structures produced by multiple information sources in complex task environments, and
  - Model must characterize attentional expenditure patterns related to the spatio-temporal characteristics of dynamic information flow
- PHASE I:
  - Develop an innovative approach to the problem
  - Provide a prototype(s) model based on this approach
  - Demonstrate that prototype meets the key model requirements

Example #2 STTR Topic

- TITLE: Nano-scale Optical Components
- OBJECTIVE: Fabricate optical components employing subwavelength structures exhibiting particular polarizing, reflecting, and transmitting properties in the ultra-violet to terahertz spectral regions
- PHASE I: Demonstrate feasibility of optical devices with nano-scale structures for the manipulation of light in UV to THz spectral regions that exhibit particular optical properties such as polarization, reflection, and transmission. Identify application, integration and performance parameters
- PHASE II: Build upon Phase I work and demonstrate a system of one or more variations of the components and implementation of a working prototype. Perform appropriate analysis and modeling, design the materials and other elements, fabricate the device and test its performance. Address the issues of integration into an optical system requiring the functionality provided by the prototype

International Highlights

EOARD

Hypersonics: Russia

- Leveraging Russian Expertise (Boundary Layer Control, Plasma Fuel Injection, Heat Flux Control, etc.)
- Technology is Transitioning

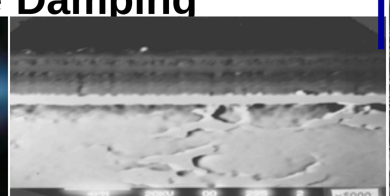
Hall Effect Thruster (HET): Russia, Spain

- HETs Provide Highly Efficient Spacecraft Propulsion (Increased Payload/Decreased Cost)
- Investigating How to Cluster Multiple HETs for Increased Power

Damping Coatings: Ukraine

- Seeking to Overcome High Cycle Fatigue Effects on Titanium in Air Force Fighter Engines
- Investigating Layering Materials on Titanium to Improve Damping





AOARD

Hyshot In-flight Scramjet Test – Australia

- Leveraged Data from First In-flight Supersonic Scramjet Com. Test – (Mach 7.5)

Ionospheric Scintillation Data – Taiwan

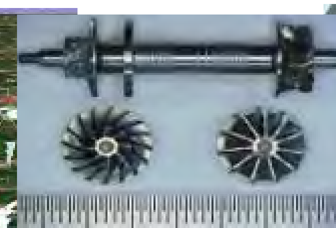
- Studying low-latitude events that interfere with Communications

MicroTubine Research – Japan

- Developing Lunch-Box size power sources (100W), 10 mm Rotors

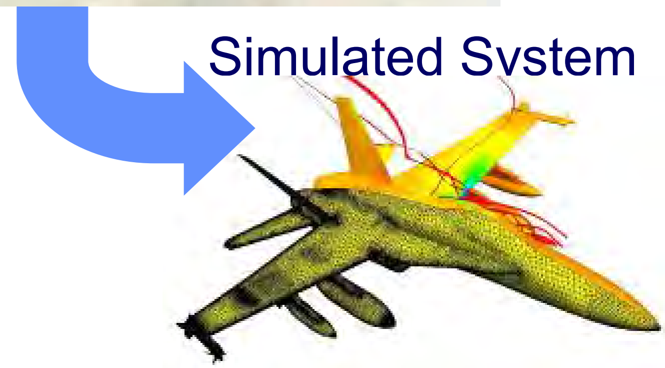
Nanoscience Initiatives – Taiwan & Korea

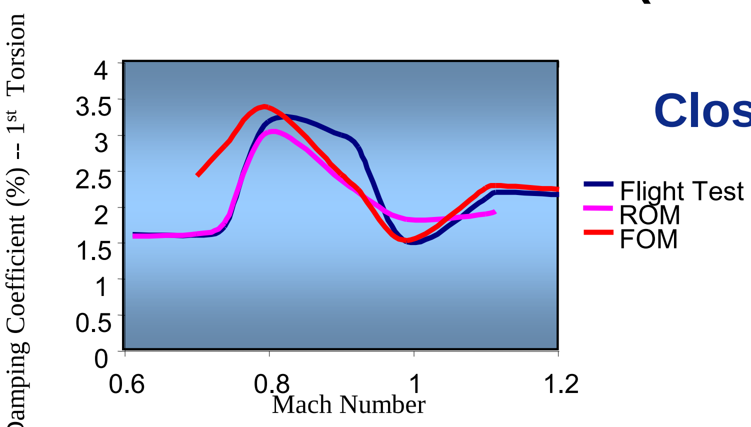
- Leveraging Asia’s $1B Nano-science investment
- Quantum Dots, Polymer Electronics, Photovoltaics


Test and Evaluation

- **$2.4M AFOSR program focuses top university and industry scientists on reducing costs and increasing effectiveness of $multi-billion AF T&E program**
- **Multiple AFOSR program managers involved**
- **Program identified and evaluated collaboratively with AF T&E Centers**
  - **Arnold Engineering Development Center (AEDC)**
  - **Air Force Flight Test Center (AFFTC)**
  - **Air Armament Center (AAC)**





Closing the Gap on Real Time Prediction of Flutter

Full-Order Model (FOM)

10 minutes CPU on a 160-processor Linux Cluster

Reduced-Order Model (ROM)

5 seconds CPU on the same 160-processor Linux Cluster

FResH
Fundamental Research in Hypersonics

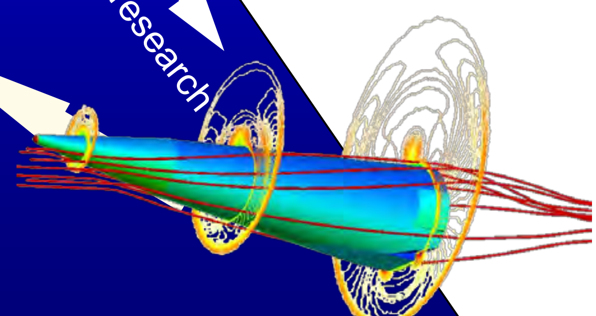
Flight Research Provides Focus

Affordable *Flight Research* exploring critical phenomena common to many systems

- AFRL-level effort: Aero, Propulsion, Material, Sensor and Instrumentation issues addressed
- All resources: Ground Test, Numerical Simulation and Flight Research employed

AFRL/Australian DSTO Collaborative Effort

- Received $1.8M in ICR&D funding for FY 07-09
- 6 AFRL TDs involved: VA, PR, ML, SN, VS, OSR
- NASA Aeronautics program is providing analysis and building a payload
  - Flight 1 (of 10) scheduled for Late FY07

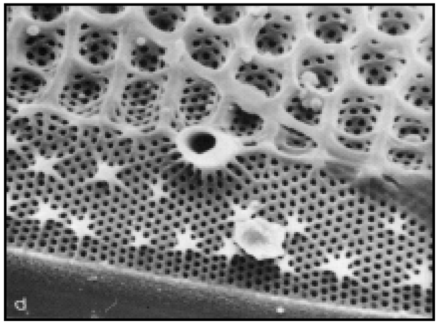


NRC Information Science and Technology Study

- **Networks & Communications:** Decision theory, communication theory and design principles that enable large scale, dynamic networks
- **Software & Security:** Capability to analyze the composability, evolvability, scalability, and security of large software intensive systems
- **Information Management & Process Integration:** Capability for active interrogation and instantaneous, synchronized exploitation of actionable information
- **Human-System Interactions:** Augmented human capability produced via training and hybrid systems and the formal models (computational and mathematical) for analyses in all phases of operation: anticipate, observe & orient, decide, and act

University Research Initiative Program (FY2005)

- Multidisciplinary University Research Initiative ($54.6M): 70 grants at 40 institutions
  - Grant size will increase in FY2007
- Defense University Research Instrumentation Program ($15.8M): 70 grants at 53 institutions
- Education ($34.3M)
  - National Defense Science and Engineering Graduate (NDSEG) Fellowships: 430 PhD-track students/year
  - Awards to Stimulate and Support Undergraduate Research Experience (ASSURE): ~500 students/year
  - PECASE: 2 per year



University Research Initiative (URI) Program Moved From OSD to AF in FY 2004

A DoD View on Defense Research & Engineering

Blueprint for the Future

John J. Young, Jr., DDR&E

19 April 2006

9/11 Changed Everything

From working to provide overmatching capability against any nation-state on the sea, in the air and on the land … to a global war on terrorism against an enemy who fights in the shadows…

"The concept of a virtual organization is essential to understanding how 21st Century business will work. Al Qaeda represents a new and dangerous kind of virtual organization and the rise of the virtual state. We are entering into an era in which a small number of people, operating without state sponsorship, but using the enormous power of modern computers, biogenetic pathogens, air transport, suitcase bombs, and even small nuclear weapons will be able to penetrate the tremendous vulnerabilities of contemporary open societies." - ***Time,* 9 Sept. 2002**

Background

"Today the Department of Defense again is in need of change and adjustment. Current arrangements pretty much designed for the Cold War must give way to the new demands of war against extremists and other evolving 21st century challenges" - Secretary Rumsfeld

The Research & Engineering community must develop and deliver systems which provide **strategic resilience.** Our systems must be flexible enough to respond to the many means terrorists or hostile forces might employ. We must also reinvent ourselves, our processes, and our thinking continuously-- not just when there is a new crisis or new foes threatening our national security.

Background

Today and Tomorrow

"On September 11, 2001, we found that problems originating in a failed and oppressive state 7,000 miles away could bring murder and destruction to our country."

"To keep America competitive, one commitment is necessary above all: We must lead the world in human talent and creativity. Our greatest advantage in the world has always been our educated, hardworking, ambitious people, and we are going to keep that edge."

President George W. Bush
2006 State of the Union

DDR&E Vision: *Develop Technology to Defeat Any Adversary on Any Battlefield.*

We recognize that to achieve this, we need to create an Inspired, High Performing, Boundary-less Organization that Delivers.

To achieve this vision, we need:

- An inspired, high-performing organization where each person makes a difference.
- To collaborate effectively across traditional boundaries.
- To see the value of an informal organization.
- To see ourselves as part of a community that comes together as stakeholders around joint projects.

Guiding Principles

The Defense Research & Engineering Team must use insight and collaboration to anticipate, develop and deliver the technologies necessary for the joint warfighter.

- Understand the warfighter's operational concepts and needs
- Invest in programs that can transition and meet critical warfighter needs
- Apply the unique skills and enterprise insights afforded Team Members to identify research investment areas
- Integrate combatant commander needs and Service requirements to define development priorities
- Coordinate and prioritize requirements, remaining constantly conscious of jointness and interoperability imperatives
- Lead the revitalization of technology intelligence to minimize the probability of technology surprise from adversaries



Guiding Principles

The Defense Research & Engineering Team must LEAD THE DEFENSE, RESEARCH & ENGINEERING ENTERPRISE TO STRATEGIC BUSINESS SUCCESS.

- Drive the DoD research and development program to be a coherent, coordinated investment in the future
- Use data to drive S&T investment levels
- Use management tools to run the business
- Manage programs with metrics and execute like a lean business
- Promote innovation and accept risk to attain results
- Instill a culture which is open-minded and constantly conscious of jointness and interoperability
- Ensure that value and competition are foremost considerations in every program

I ask you to be a difference maker.

My request to all members of the science and engineering team is . . .

- Understand warfighter operating concepts
- Prioritize efforts to fill CoCom gaps
- Make jointness and interoperability fundamental considerations in every program
- Challenge excessive requirements
- Evaluate openly all new technology opportunities
- Engage the programming and budgeting process fully
- Actively pursue collaboration and coordination across lanes
- We are at war – bring urgency to our daily efforts