9th Annual Science and Engineering Technology Conference / DoD Technology Expo

15 - 17 April 2008

North Charleston, South Carolina

Agenda

<u>Tuesday, 15 April 2008</u>

Preliminary Session: *Opportunities for Collaboration*

- FY 2008 PB Request for DoD S&T Program, *Mr.Robert Baker,* Deputy Director, Plans and Programs Office of the Director, Defense Research and Engineering
- The Advanced Systems & Concepts Portfolio of Opportunities, *Mr. John Kubricky,* DUSD(AS&C)
- The DoD T&E / S&T Program, *Mr. Gerald Christeson,* Defense Test Resource Management Center Deputy Program Manager Test & Evaluation/Science & Technology Program
- DoD Basic Research Program with a Focus on Academia, *Dr. William S. Rees, Jr.*, Deputy Under Secretary of Defense (Laboratories and Basic Sciences) Office of the Director Defense Research and Engineering
- Strategic Initiative on Innovation & Technology Transition, *Ms. Kathleen Harger*, Assistant Deputy Under Secretary of Defense Innovation and Technology Transition

CONFERENCE OPENING:

Keynote Address: *Mr. Alan Shaffer,* Principal Deputy Defense Research and Engineering

Session I: *Development and Insertion of Innovative Technologies into Army Systems*

- Recent Trends in the Army's Common Test Support Facility, *Mr. Terry Edwards*, Chief Information Officer (CIO), Chief Technology Officer (CTO), HQ Army Materiel Command, CIO-G6
- The Army Science and Technology Program, *Dr. Thomas Killion*, Deputy Assistant Secretary for Research and Technology/Chief Scientist
- CERDEC Contributions to Army Battle Command Networking Efforts, *Mr. David Jimenez*, Director, Space & Terrestrial Communications Directorate
- Software Certification and Battle Command Interoperability Issues, *BG Nick Justice,* Program Executive Officer, PEO Command, Control, Communications Tactical
- Technology Transition and Insertion Evaluation, *Mr. Brian Simmons,* Director, US Army Evaluation Center

Assault Breaching System Technologies, *Mr. Brian Almquist*, Ocean Engineering & Marine Systems, Office of Naval Research

Wednesday, 16 April 2008

Session II: *Development and Insertion of Innovative Technologies into Air Force Systems*

- Overview of Air Force Science & Technology Program, *Mr. Terry Jaggers*, Deputy Assistant Secretary (Science, Technology and Engineering)
- Development and Insertion of Innovative Technologies Across the Lifecycle of a Weapon System, *Brig Gen Janet Wolfenbarger*, Brigadier General, USAF Director, Intelligence and Requirements Director, D&SWS AFSO21 Office
- Rapid Prototyping-Leapfrogging into Military Utility, *Mr. Randall Walden*, Air Force Rapid Capabilities Office (SAF/RCO)
- Industry Perspectives on Technology Insertion, *Dr. David Whelen*, Vice President & Deputy GM, Advanced Systems& Chief Scientist, Integrated Defense Systems, The Boeing Company
- Cyberspace: New Frontiers in Technology Insertion, *Dr. John Bay*, Chief Scientist, Air Force Research Laboratory, Information Directorate

Luncheon Speaker– *The Challenge of Transitioning Innovative Technology, Dr. Malcom O'Neill, PhD, NAE LTG USA/CTO LMC (ret)*

Session III: *Development and Insertion of Innovative Technologies into Naval Systems*

- Technology Insertion: Fleet / Operating Forces, *Ms. Charlene Rusnak*, ONR Science Advisor to US Fleet Forces Command

Innovative Technology Insertion: *Systems Command Panel*

Panelists:
- *Mr. James Sheehy*, Chief Scientist / Technology Officer Human Systems, AIR-4.6T
- *Mr. Brian Persons,* Executive Director Naval Systems Engineering Directorate (SEA 05) & Corporate Chief Technology Officer
- Mr. Gary Wang, Code 73, SPAWAR Command Overview, SPAWAR S&T OPPORTUNITIES
- *Mr. David Ungar,* Director Program Engineering & Technology

Thursday, 17 April 2008

Session IV: *Manufacturing and Affordability of Innovative Technology*

- The Need for Manufacturing Innovation and Readiness, *Mr. Mark Gordon*, Director, Defense Programs National Center For Advanced Technologies
- The Navy's Mantech and Affordability Program, *Mr. John Carney*, Director, Navy ManTech
- The Air Force S&T Manufacturing Readiness Assessment, *Mr. Jim Morgan*, Manufacturing Technology Division
- Inserting Technology Incrementally, *Mr. Daniel Zanini*, LSI Deputy Program Manager, Future Combat Systems Senior Vice President, SAIC

Manufacturing Technology Industry Panel

Moderator: *Mr. Gary Powell*, OUSD(AT&L)
Panelists:
- *Mr. Ed Morris,* Director, Hardware and Manufacturing, Lockheed Martin Corporate Engineering and Technology

- *Mr. Dale Iverson*, Raytheon Missile Systems
- Mr. Jim Lorenz, Manager, Advanced Industrial Engineering

9th Annual Science & Engineering Technology Conference / DoD Tech Exposition

April 15-17, 2008

Charleston Convention Center

North Charleston, SC

9th Annual S&E Technology Conf.

Tuesday, April 15, 2008

Opportunities for Collaboration

8:15am	FY 2008 PB Request for DoD S&T Program – Robert Baker
8:45am	The Advanced Systems & Concepts Portfolio of Opportunities – John Kubricky
9:15am	The DoD T&E / S&T Program – Gerald Christeson
9:45am	BREAK
10:30am	Quick Reaction Fund/Rapid Reaction Fund & JIEDDO Capability Needs – Ben Riley
11:00am	DoD Basic Research Program with a Focus on Academia – Dr. William S. Rees, Jr.
11:30am	Strategic Initiative on Innovation & Technology Transition – Kathleen Harger
12:00pm	LUNCHEON

9th Annual S&E Technology Conf.

Tuesday, April 15, 2008

Conference Opening

- 1:00pm Call to Order / Conference Opening – Dr. Raj Aggarwal
  NDIA Welcome – MG Barry D. Bates, USA (Ret)
- 1:15pm Keynote Address – Alan Shaffer

Session I: Development and Insertion of Innovative Technologies into Army Systems

Session II: Development and Insertion of Innovative Technologies into Air Force Systems

Session III: Development and Insertion of Innovative Technologies into Naval Systems

Session IV: Manufacturing and Affordability of Innovative Technology

9th Annual S&E Technology Conf.

Tuesday, April 15, 2008

Session I: Development and Insertion of Innovative Technologies into Army Systems

- 2:00pm Recent Trends in the Army's Common Test Support Facility… – Terry Edwards
- 2:30pm The Army Science and Technology Program – Dr. Thomas Killion
- 3:00pm BREAK
- 3:30pm CERDEC Contributions to Army Battle Command Networking… – David Jimenez
- 4:00pm Software Certification and Battle Command Interoperability Issues – BG Nick Justice
- 4:30pm Army Comm. Technologies, Incl. JTRS – Tim Snodgrass
- 5:00pm Technology Transition and Insertion Evaluation – Brian Simmons
- 5:30-7:30pm RECEPTION (In exhibit hall)

9th Annual S&E Technology Conf.

Wednesday, April 16, 2008

Session II: Development and Insertion of Innovative Technologies into Air Force Systems

- 8:30am Overview of Air Force Science & Technology Program – Terry Jaggers
- 9:00am Development and Insertion of Innovative Technologies Across… – Brig Gen Janet Wolfenbarger
- 9:30am Rapid Prototyping-Leapfrogging into Military Utility – Randall Walden
- 10:00am BREAK
- 10:45am Industry Perspectives on Technology Insertion – Dr. David Whalen
- 11:15am Cyberspace: New Frontiers in Technology Insertion – Dr. John Bay
- 12:00pm LUNCHEON w/Speaker – Dr. Malcom O’Neill

Wednesday, April 16, 2008

Session III: Development and Insertion of Innovative Technologies into Naval Systems

- 1:30pm Technology Insertion: Naval Science & Technology – RADM William Landay
- 2:00pm Technology Insertion: Fleet / Operating Forces – Charlene Rusnak
- 2:45pm BREAK
- 3:30pm Technology Insertion: The Anti-Torpedo Torpedo (ATT) Program – Brian Almquist & LtCol Tim Mclaughlin
- 4:15pm Innovative Technology Insertion: Systems Command Panel
  – Chair: Dr. John Sommerer
  – Panelists: James Sheehy, Brian Persons, Gary Wang, David Ungar
- 5:15pm Session Adjourned

9th Annual S&E Technology Conf.

Thursday, April 17, 2008

Session IV: Manufacturing and Affordability of Innovative Technology

- 8:00am — Session Introduction – James Chew
- 8:10am — The Need for Manufacturing Innovation and Readiness – Mark Gordon
- 8:35am — The Navy's Mantech and Affordability Program – John Carney
- 9:00am — The Air Force S&T Manufacturing Readiness Assessment – Jim Morgan
- 9:25am — Inserting Technology Incrementally – Daniel Zanini
- 9:50am — BREAK
- 10:25am — Best Poster Paper Winner Announcement
- 10:30am — Manufacturing Technology Industry Panel
  – Moderator: Gary Powell
  – Panelists: Ed Morris, Bob Schafrik, Al Sanders, Dale Iverson, Jim Lorenz
- 12:00pm — Wrap-Up & Adjournment – Alan McLaughlin
- 12:15pm — Box Luncheon

SUMMARY

- Attendees will be sent a link to the proceedings within two weeks

Join us next year!
The 10th Annual S&E Technology Conference / DoD Tech Exposition will be held April 20-23, 2009 in the North Charleston Convention Center

Fiscal Year 2009 President's Budget Request for DoD Science & Technology

Mr. Bob Baker
Deputy Director, Plans and Programs
Office of the Director,
Defense Research and Engineering

The Bottom Line

PBR09 is a continuation of the transition of S&T investment to enable growth of "non-kinetic", non-platform specific capabilities

Shifting away from an emphasis on ships, tanks, and planes—to focus on protection, information, knowledge, and timely, actionable intelligence

DDR&E Vision

Develop technology to defeat any adversary on any battlefield.

DDR&E Priorities for CY 2008

- Support Global War on Terrorism
- Support Urban Operations Capabilities
- Support WMD Detection & Response Capabilities
- Develop Transformational Power & Energy Technologies
- Develop Manufacturing Technologies
- Enhance Technology Transition
- Enhance National Security S&E Workforce
- Increase funding for Basic Research, plus $270M

White House Guidance

- **President Bush acknowledged the importance of science and engineering development in his January 2008 State of the Union address**

"To keep America competitive into the future, we must trust in the skill of our scientists and engineers and empower them to pursue the breakthroughs of tomorrow… I ask Congress to double federal support for critical basic research in the physical sciences and ensure America remains the most dynamic nation on Earth.."

President George W. Bush, State of the Union address, January 28, 2008

Overview

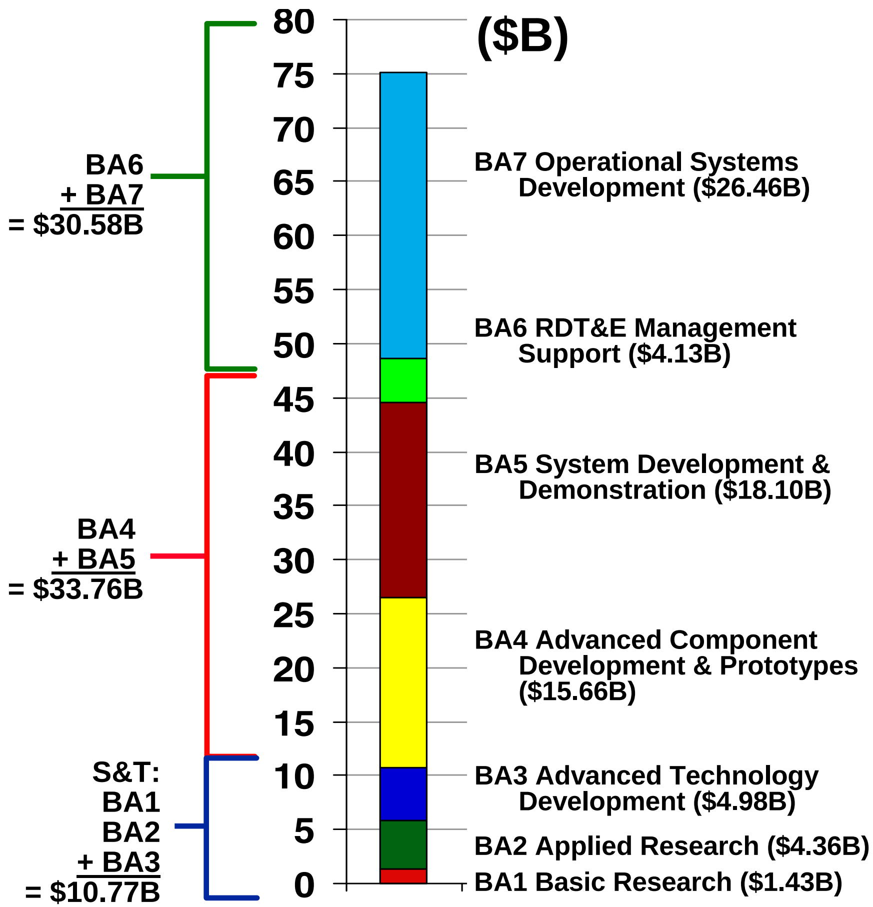
- PBR 2009 S&T Budget
- Budget Changes and Historical Context
- Strategic foundation and Investment Focus
- Reliance 21 and the R&E Portal

PBR 2009 S&T Budget

FY08 and FY09 RDT&E Budget Request Comparison

- in Then Year Dollars -

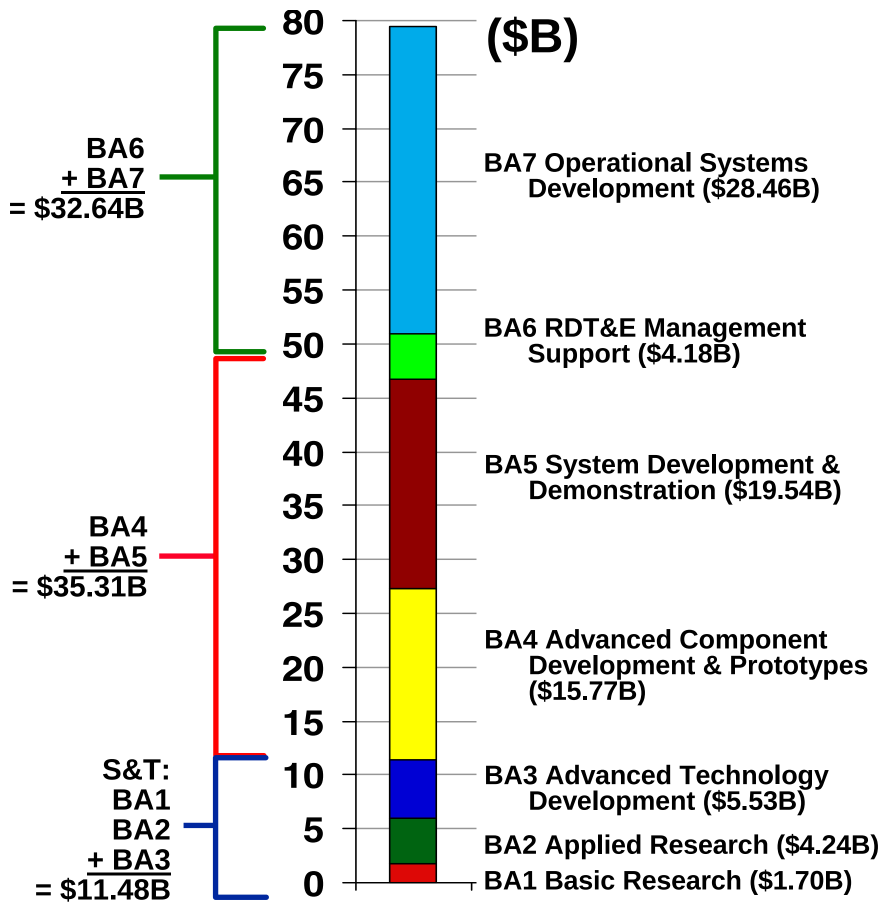
FY08 RDT&E request = $75.12B
(Budget Activities 1-7)



Technology Base (BA1 +BA2) = $5.78B

PBR08 S&T is 14.3% of RDT&E

FY09 RDT&E request = $79.43B
(Budget Activities 1-7)



Technology Base (BA1 + BA2) = $5.94B

PBR09 S&T is 14.5% of RDT&E

FY09 DoD R&E Budget Request Comparison

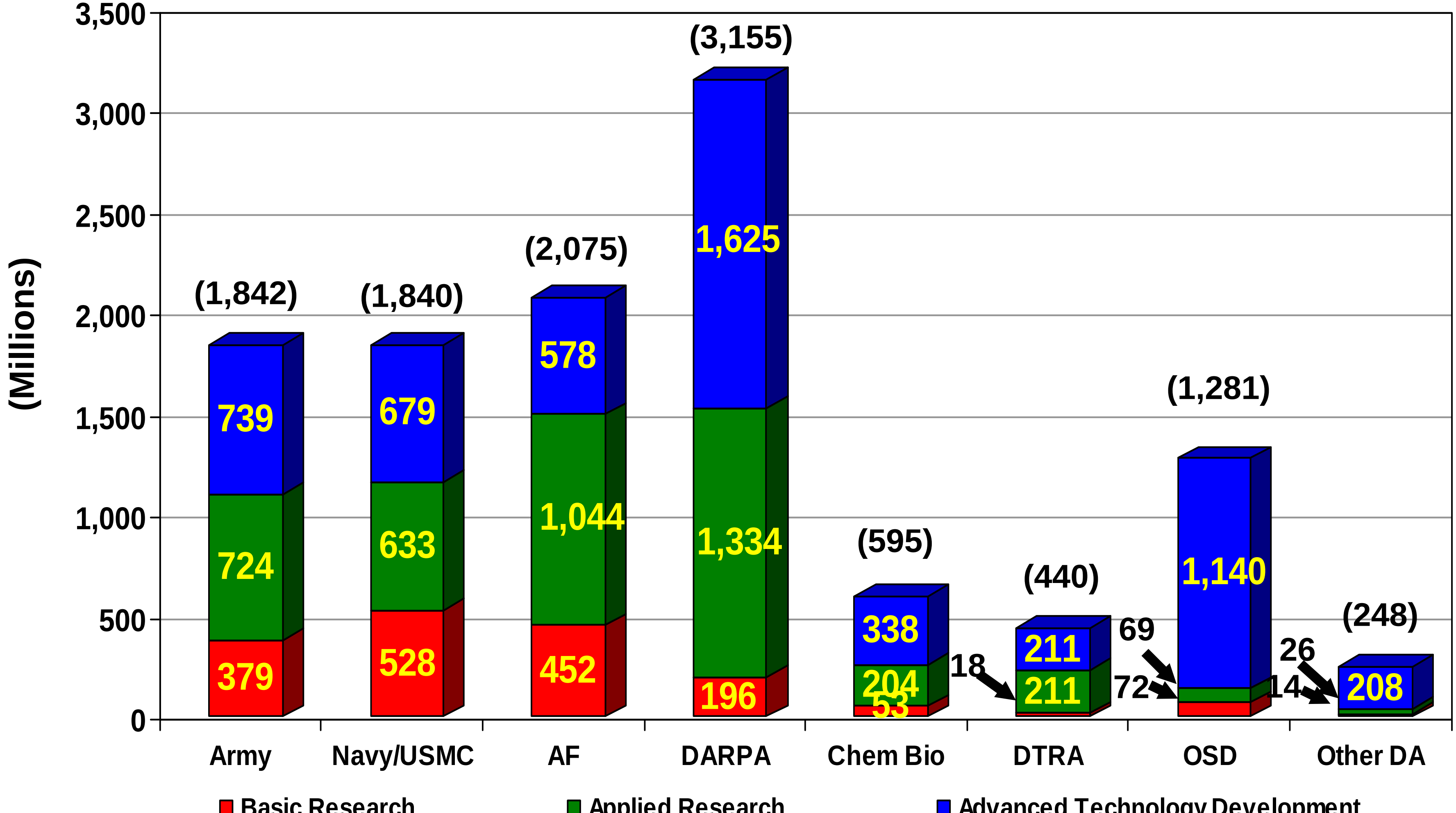
	FY08 PBR	FY08 Approp	FY09 PBR *(Constant Year FY08)*	Real Change from PBR (In CY $)
Basic Research (BA 1)	1,428	1,634**	1,699 *(1,662)*	+16.4%
Applied Research (BA 2)	4,357	5,092	4,245 *(4,153)*	-4.7%
Advanced Technology Development (BA 3)	4,987	6,043	5,532 *(5,412)*	+8.5%
DoD S&T	**10,772**	**12,768**	**11,475 *(11,227)***	**+4.2%**
Advanced Component Development and Prototypes (BA 4)	15,662	15,947	15,774 *(15,431)*	-1.5%
DoD R&E (BAs 1 – 4)	**26,434**	**28,716**	**27,249 *(26,657)***	**+0.9%**
DoD Topline	**481,554**	**569,000**	**515,400 *(502,486)***	**+4.3%**

FY09 DoD S&T Budget Request

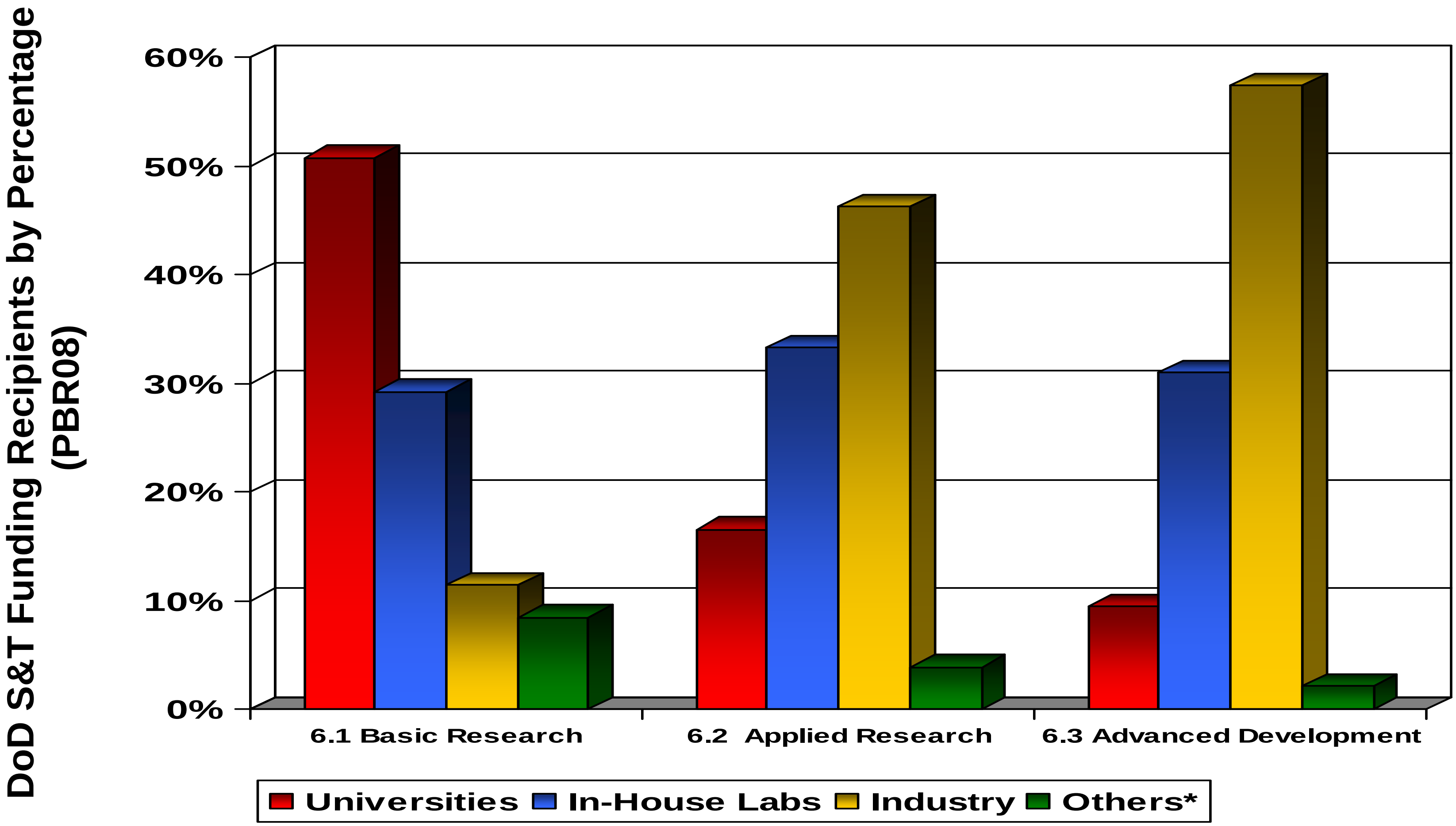
Total FY09 S&T request = $11.48B

Total FY08 S&T Request = 10.77B

Army = 1,728 Navy = 1,667 AF = 1,964 DARPA = 3,033 ChemBio = 610 DTRA = 401 OSD = 1,166 Other DA = 201



Recipients of DoD S&T Funds



***Includes non-profit institutions, State & local govt., & foreign institutions**

Source: National Science Foundation Report (PBR08)

Budget Changes and Historical Context

PBR09 S&T Request Addresses Capability Gaps

- **PBR09 S&T Request continues the realignment initiated in FY08 to address capability gaps identified in the 2006 QDR**
  - **Special (“non-kinetic”/enabling) technologies:**
    - **Clandestine Tagging, Tracking and Locating**
    - **Biometrics**
    - **Human, Cultural, Social Behavior Modeling**

      $183M
    - **Networks**
    - **Persistent Surveillance**

      $611M
  - **Technologies to decrease energy consumption and increase alternative sources of energy ($513M)**
  - **Active and conventional armor technology for protection against a range of threats ($68M)**
  - **Accelerating technology transition to fielded systems**

Investment is shifting away from platform-specific technologies

PBR09 S&T Request Addresses Capability Gaps *(Cont'd)*

- **New technology/emphasis areas**
  - **$270M increase to Basic Research**
    - **Enhance the science and engineering personnel base**
    - **Emphasis will be on research to address Grand Capability Challenges, e.g.,**
      - **Cyber protection and information assurance**
      - **Network sciences**
      - **Science of autonomy**
      - **Information fusion and decision sciences**
      - **Biosensors and biometrics**
      - **Human sciences (cultural, cognitive, behavioral, neural)**
      - **Software sciences and materials**
      - **Immersive sciences for training and mission rehearsal**
      - **Power and energy management**
      - **Counter directed energy weapons**
    - **Anticipate about 500 focused research efforts**

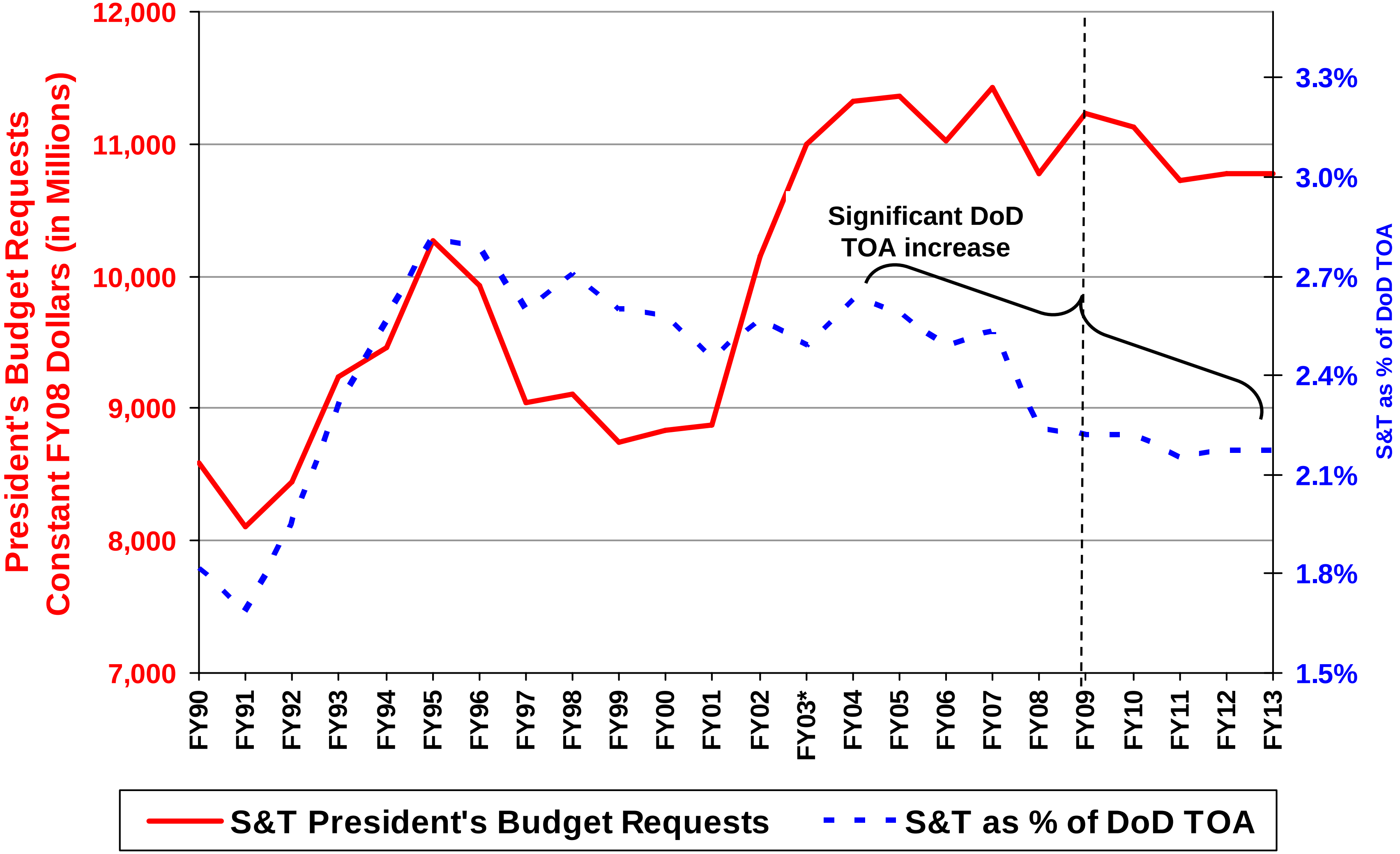
PBR09 S&T Request Addresses Capability Gaps *(Cont'd)*

- **New technology/emphasis areas *(Cont'd)***
  - **Increased protection for dismounted troops and ground forces ($60M)**
  - **Research in plasma and meta-materials to address emerging threats ($35M)**
  - **Cyber protection **($50M)**
  - **Hypersonics/Prompt Global Strike (Blackswift) – New technology prototype **($750M Total)**

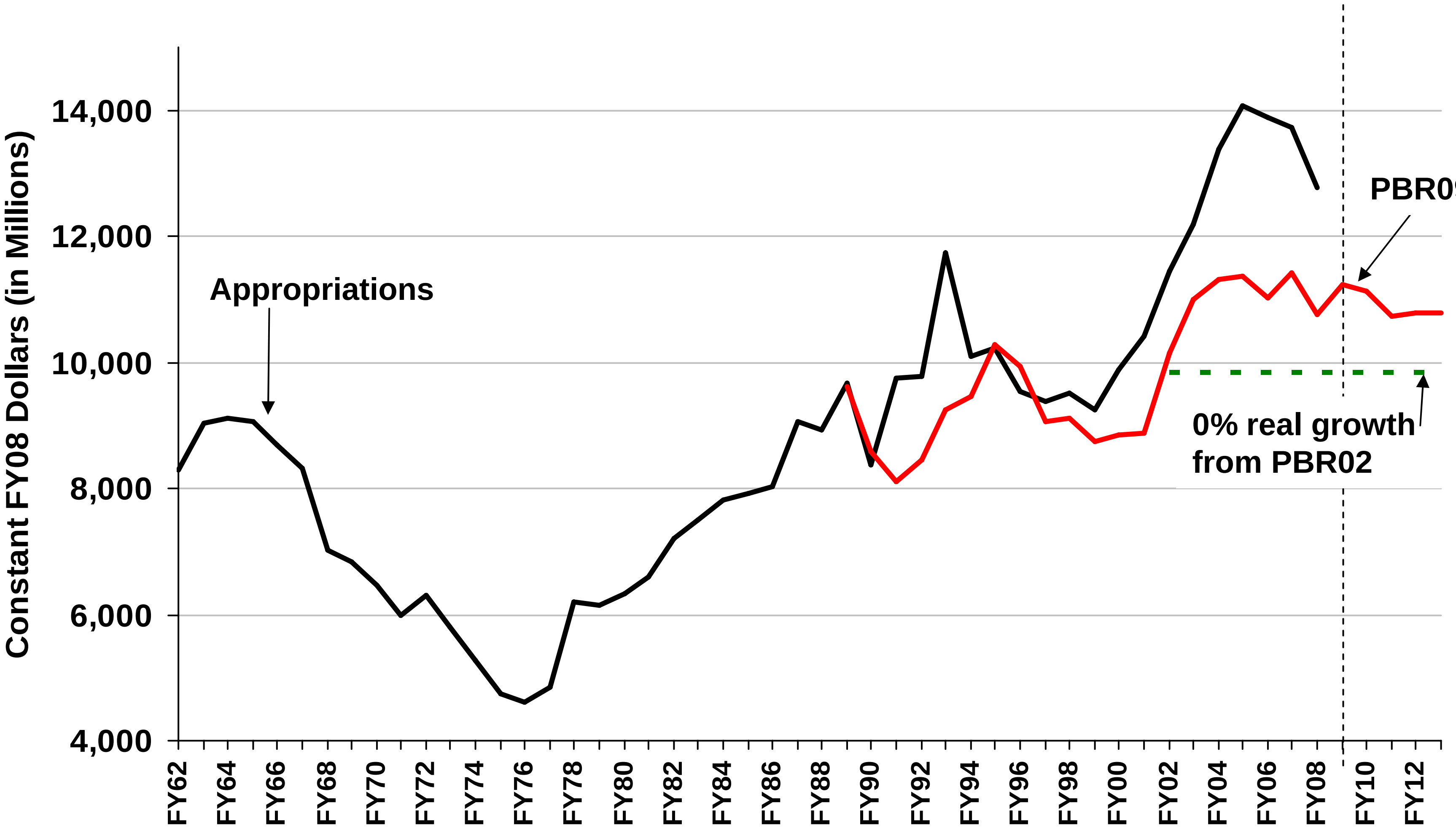
** ***Note***: *Cyber protection is funded in DARPA BA 6*
Air Force funding for Blackswift is in BA 7

DoD S&T - Macro Scale

- S&T Investment and % of DoD Total Obligation Authority (TOA) -

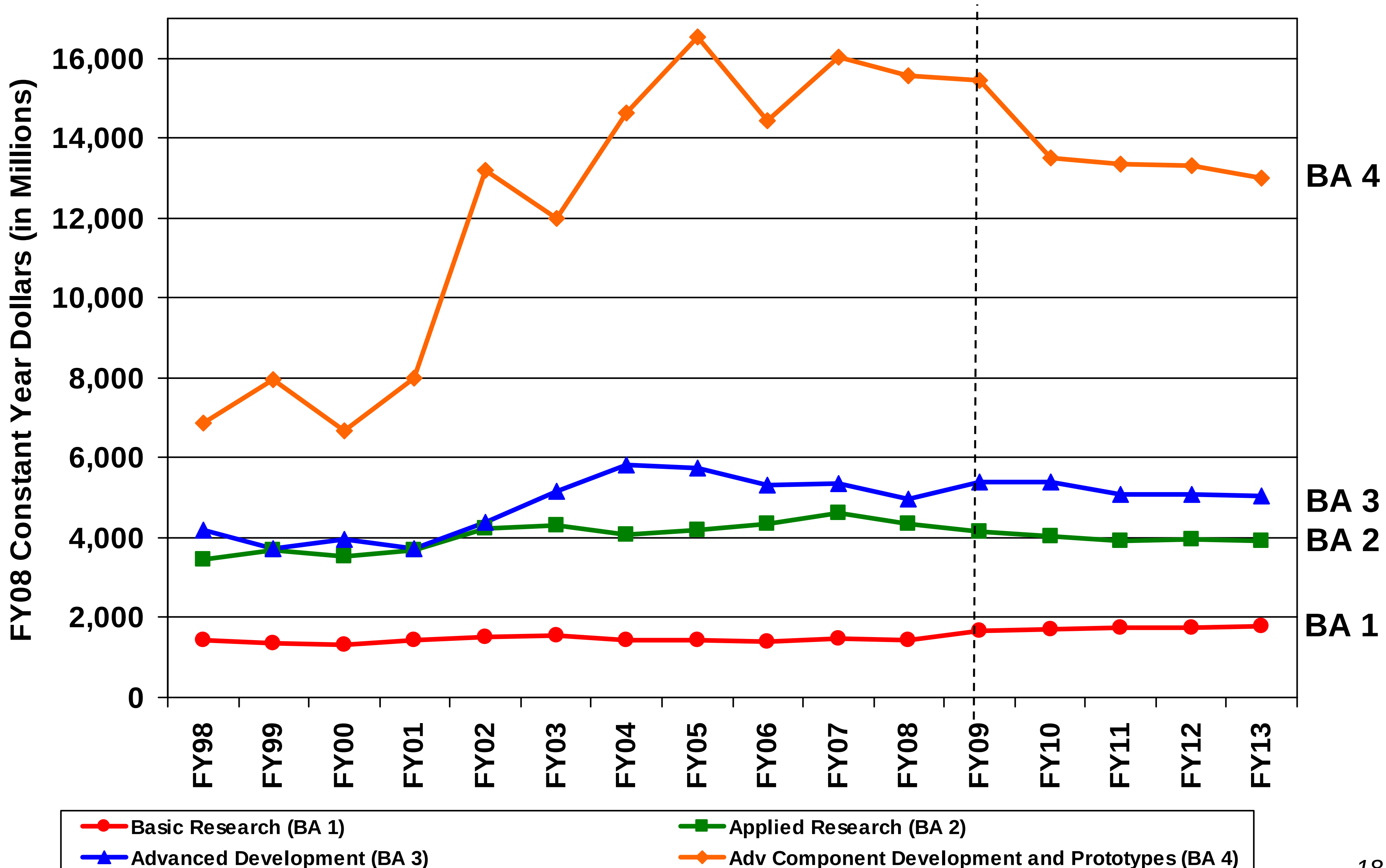


DoD S&T – Historical Context
- In FY08 Constant Dollars -



FY09 S&T request is among the highest

DoD R&E Funding By Budget Activity
- President's Budget Requests (in FY08 Constant Dollars) -



Strategic Context and Investment Focus

Desert Storm

- **US dominance over Soviet-era systems "shocked" potential adversaries and combined to give US conventional superiority**
  - **Precision Weapons**
  - **Night Vision**
  - **Low Observability**
  - **Networked Systems**

- **The advent of information-based warfare feed the emergence of irregular warfare**

Strategic Framework

- **US National Security Strategy (March 2006) set national imperative to continue the war on terrorism**
- **2006 Quadrennial Defense Review also restated the need for DoD to balance its capabilities across four categories of challenges:**
  - Traditional
  - Irregular
  - Catastrophic
  - Disruptive

  Transformational
- **DDR&E S&T initiatives memorandum to SECDEF (24 Aug 07)**

National Defense Strategy—
Types of Programs Needing Technology

Higher

Irregular

- *Language Translation*
- *Cultural Awareness*
- *Combating Terrorism*
- *Small Unmanned Aerial Vehicles*
- *Rapid Terrain Mapping*
- *Constant Surveillance*
- *Active & Conventional Armor*

Catastrophic

- *Ballistic and Cruise Missile Defense*
- *Chemical Weapon Defense*
- *Bio Weapons Defense (includes research into state of genetic engineering*
- *Remote Detection of Weapons of Mass Destruction Materials and Components*

VULNERABILITY

Lower

Traditional

- *Conventional Ground, Sea, and Air Vehicles*
- *Standard Weapons*
- *Precision Weapons*
- *Stand Alone (Single Service) Command & Control Systems*

Disruptive

Higher

- *Nano, Bio, Information Techs.*
- *Hypersonics*
- *Directed Energy*
- *Networks on the Move*
- *Autonomous Systems*
- *Distributed Sensors*
- *Defeat of Speed of Light Weapons*
- *Metamaterials*
- *Plasma Research*

Lower

LIKELIHOOD

QDR Priority Formulation

- **Strategic Challenges**
  - **Traditional**
  - **Irregular Warfare**
  - **Catastrophic**
  - **Disruptive**

- **Strategic Outcomes**
  - **Defeat Terrorist Networks**
  - **Defend the Homeland in-Depth**
  - **Shape Choices of Countries at Strategic Crossroads**
  - **Prevent the Use and Proliferation of WMD**

Capabilities to Defeat Terrorist Networks

- Persistent surveillance
- Locate, tag, and track terrorists in denied areas
- Human intelligence
- Capabilities to fuse intelligence
- Language and cultural awareness
- Joint coordination, processes and systems

Non-kinetic effects

- Urban warfare capabilities
- Prompt global strike
- Riverine warfare capabilities

Kinetic effects

Capabilities to Defend the Homeland In Depth

- Interoperable, joint command and control
- Enhanced air and maritime awareness
- Consequence management
- Broad spectrum medical countermeasures

Non-kinetic effects

- Tailored deterrence, including prompt global strike
- Air and missile defense

Kinetic effects

Capabilities to Shape the Choices of Countries at Strategic Crossroads

- **Improved language and cultural awareness**
- **Persistent surveillance (penetrate and loiter)**
- **Cyberspace shaping / defense**
- **Secure broadband communications**

Non-kinetic effects

- **Prompt, high-value global strike**
- **Integrated defense against all missiles**
- **Air dominance**
- **Undersea stealth**

Kinetic effects

Capabilities to Prevent the use of Weapons of Mass Destruction

- Locate, tag, track, and characterize
- Stand off fissile material detection
- Wide area persistent surveillance
- Fusion of HUMINT, ISR, and open source information

Non-kinetic effects

- Capabilities to "render safe" WMD
- Non-lethal weapons

Kinetic effects

National Defense Strategy Drives S&T Investment

National Defense Strategy

Quadrennial Defense Review
- **Strategic Challenges**
- **Strategic Outcomes**

Desired Operational Capabilities

Enabling Technologies

Supporting Demonstrations

Progress: Capability Increase

S&T Enabling Technology Priorities
--Supporting the QDR Strategic Outcomes--

- **Technology focus areas:**
  - **Biometrics and Biological exploitation**
  - **Information Technology and applications**
  - **Persistent Surveillance Technologies**
  - **Networks and Communication**
  - **Human, Social, Cultural, and Behavioral Modeling**
  - **Language Translation Technologies**
  - **Manufacturing Technologies**
  - **Cognitive Enhancement**
  - **Directed Energy Technologies**
  - **Autonomous Systems Technologies**
  - **Hyperspectral Sensors**
  - **Nanotechnology**
  - **Advanced Materials**
  - **Energy and Power Technologies**
  - **Organization, Fusion, & Mining Data**
  - **Combating Weapons of Mass Destruction Technologies**
  - **Energetic Materials**

In Blue—Areas with Substantial Increases in FY08/09 President's Budget Request

S&T Enabling Technology Priorities
--Supporting DDR&E Investment Initiatives--

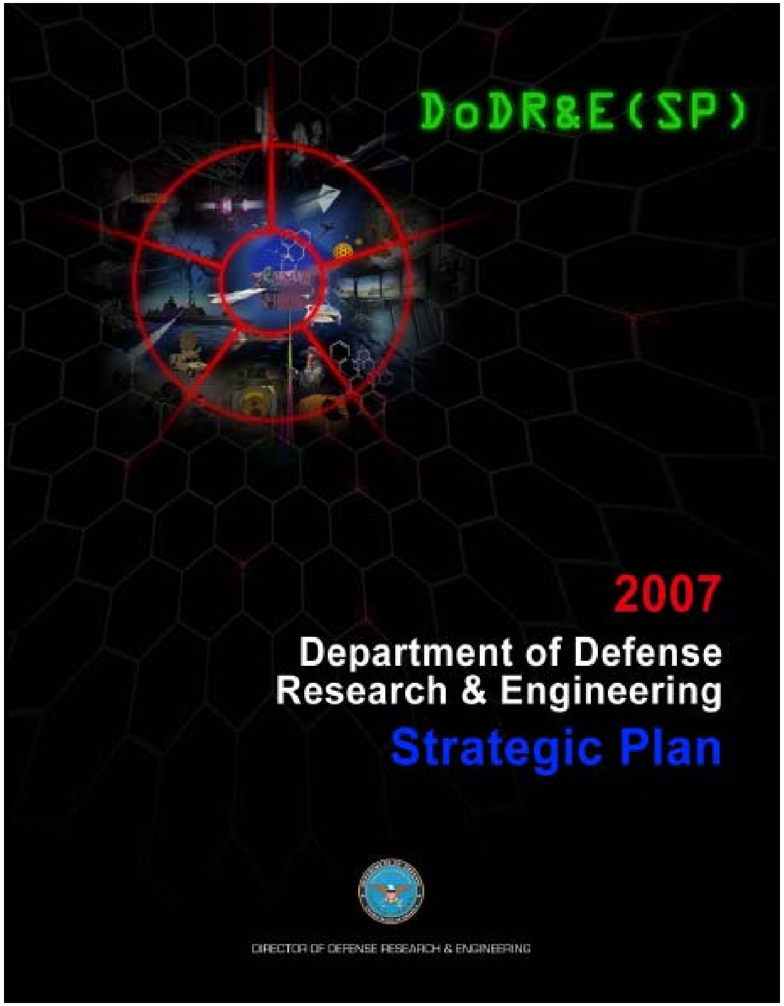
- **S&T Area Investment Initiatives from 24 Aug 07 memorandum to SECDEF:**
  - **Foundational Sciences**
  - **Active & Conventional Armor**
  - **Defeat of Speed of Light Weapons**
  - **Adaptive, Interactive, Full Immersion Training for Soldiers/Marines**
  - **Metamaterials**
  - **Information Warfare**
  - **Information Assurance**
  - **Networking Technologies**
  - **Manufacturing Science Technologies**
  - **Neuro-Ergonomics**
  - **Directed Energy Technologies**
  - **Autonomous Operation of Networks of Unmanned Vehicles in Complex Envir,**
  - **Advanced Medical Research**
  - **Software Development Technology**
  - **Energy and Power Technologies**
  - **Organization, Fusion, & Mining of Large Data Sets for Enhanced Decision Making**
  - **Combating Weapons of Mass Destruction Technologies**
  - **Energetic Materials**

Reliance 21 and the R&E Portal

Defense S&T Reliance

Defense S&T Reliance provides the <u>framework to enable the DoD S&T community to work together</u> to enhance the Defense S&T program and <u>eliminate unwarranted duplication</u>. It strengthens <u>cooperation</u> among the Services and Agencies thereby improving responsiveness to their warfighting and acquisition customers.

S&T Plans and Reliance 21



Defense Science and Technology Strategy and Plans

- ***Defense S&T Strategy (Replaced with DDR&E Strategic Plan)***
- ***Basic Research Plan (6.1) - BRP -(As necessary, new plan at printer)***
- ***Defense Technology Area Plan (6.2, 6.3) - DTAP - (Replaced with Technology Focus Teams)***
- ***Joint Warfighting Science and Technology Plan - JWSTP (Biennial, even years)***
- ***Defense Technology Objectives (DTO) Volume that supports JWSTP and DTAP (Replaced by Marquee Programs in JWSTP)***

Research & Engineering (R&E) Portal (https://rdte.osd.mil)

- **Provide DoD R&E community (civil service, military, approved contractors) with *single-point access* to all current R&E information:**
  - **Reliance 21 S&T planning documents**
  - **New E-Gov database**
  - **R&E Points of Contact**
  - **Congressional budget query**
  - **RDT&E budget data**
  - **DDR&E website**
  - **Dialog NewsEdge (24/7 breaking news on technology)**
  - **DoD In-House S&T Activities Report**
- **Be able to *intelligently search* all data**

R&E Portal Access
(https://rdte.osd.mil)

Welcome to the DoD Research & Engineering Portal

To view a video about the R&E Portal, click here!

The R&E Portal will be the focal point for obtaining information on research and engineering activities within DoD. It is sponsored by the o ffice of the Director of Defense Research & Engineering (DDR&E) and maintained by the Defense Technical Information Center (DTIC). Within th e R&E Portal, you will find:

- Data from systems that focus on the areas of Financial Management, Strategic Planning, and Congressional Reporting.
- Information on areas of strategic importance and current initiatives within DDR&E.
- Tools to facilitate collaboration, communication, and reuse of information and artifacts.
- Robust text searching tools to query the wealth of DoD ... and engineering information held by DTIC and other se... agencies.

Access to the R&E Portal is controlled by th... Registration Process. If you are not currently registered, click here to learn more.

Sign In

DoD CAC Card Sign In *

or sign in using your user name and password:

User Name:

Password:

Sign In | Cancel

Click here to change your password or update your profile.

Click here if you forgot your password or it has expired.

If you wish to bookmark the site, please wait until you have logged in successfully before adding it to your list of favorites.

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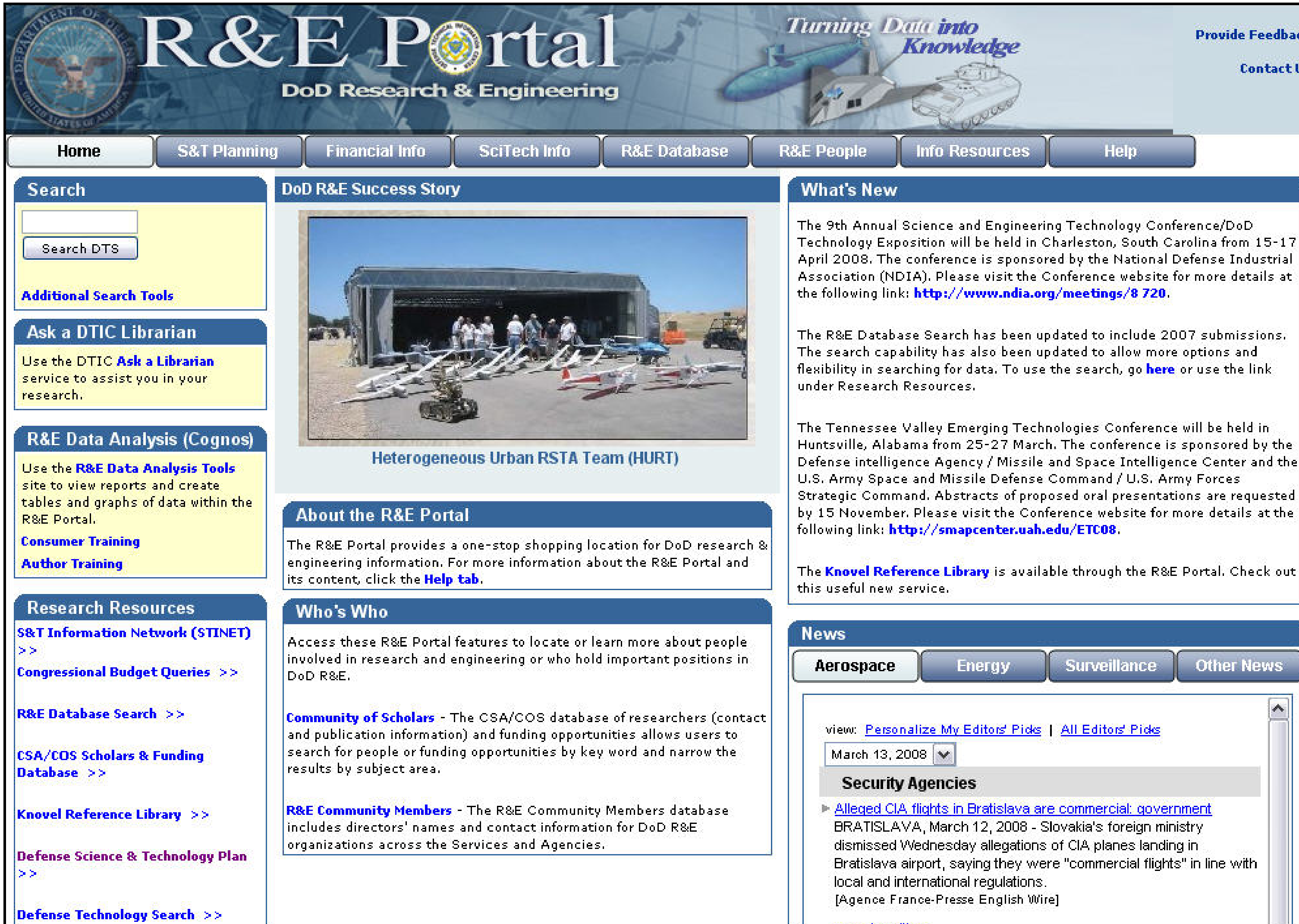
Use of this DoD computer system, authorized or unauthorized, constitutes consent to m onitoring of this system. Unauthorized use, including registering or attempting to register for access using personal identification other th an your own, may subject you to criminal prosecution. Evidence of unauthorized use collected during monitoring may be used for administrative , criminal, or other adverse action. Use of this system constitutes consent to monitoring for these purposes.

https://rdte.osd.mil

Research & Engineering (R&E) Portal

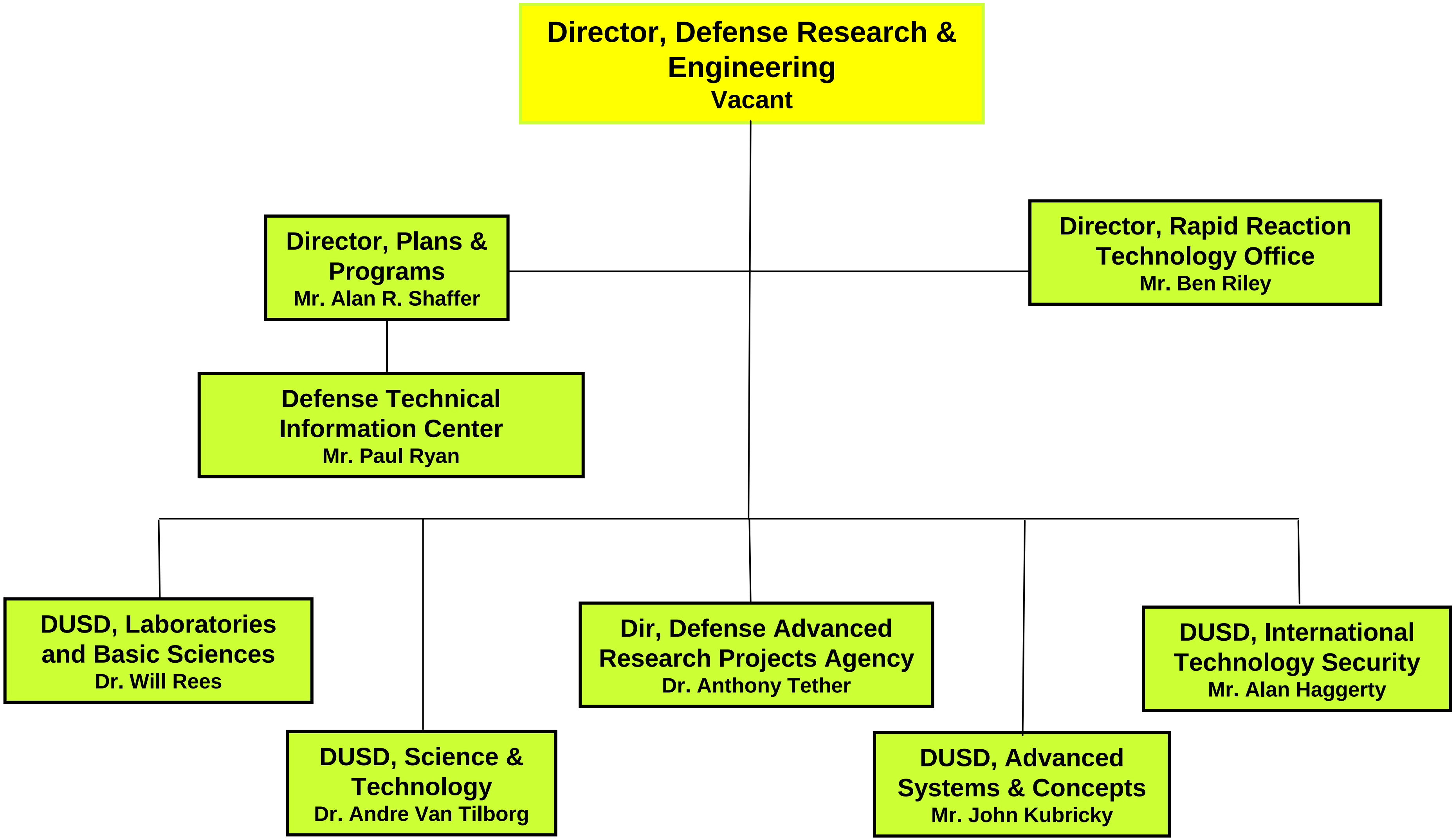


Summary

- **PBR09 S&T investment is driven by:**
  - ***DoD R&E Strategic Plan (guided by National Security Strategy and the QDR)***
  - **S&T Initiatives in 24 Aug 07 memorandum from DDR&E to SECDEF**
- **PBR09 shows SecDef's commitment to a strong S&T program – especially basic research**
  - **PBR09 is 4% higher than PBR08, in real terms**
  - **PBR09 is within $200M of highest request (PBR07), in real terms**
  - **SecDef directed increase in Basic Research is 16% higher than PBR08, in real terms**

Backup

DDR&E Organization

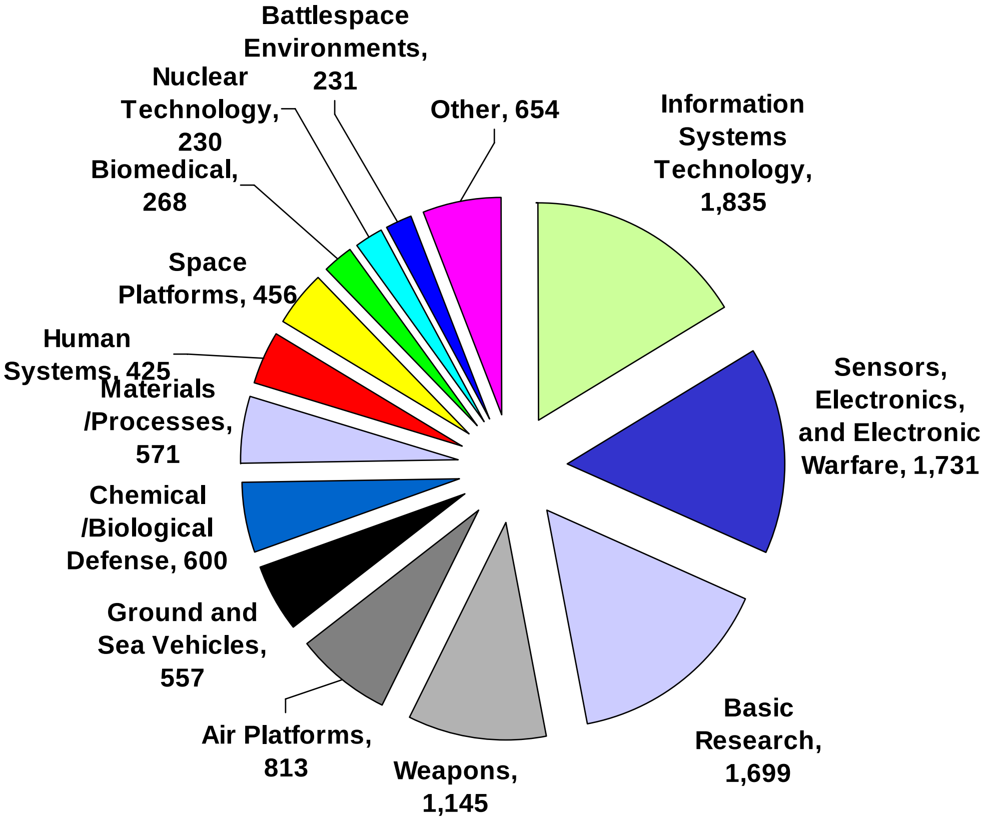


FY09 President's Budget Request

TY$M		FY08 Enacted	FY09	FY10	FY11	FY12	FY13
ARMY	Basic Research	379	379	367	383	395	424
	Applied Research	1,175	724	727	741	736	736
	Advanced Development	1,337	738	730	724	754	782
	Total S&T	**2, 891**	**1,842**	**1,824**	**1,848**	**1,885**	**1,943**
NAVY/	Basic Research	498	528	539	548	576	608
MARINE	Applied Research	801	633	612	660	732	787
CORPS	Advanced Development	722	679	649	663	6264	596
	Total S&T	**2,021**	**1,840**	**1,800**	**1,871**	**1,935**	**1, 991**
AIR	Basic Research	421	452	470	493	502	513
FORCE	Applied Research	1,170	1,044	1,103	1,059	1,096	1,112
	Advanced Development	664	578	669	632	642	659
	Total S&T	**2,255**	**2,075**	**2,242**	**2,184**	**2,240**	**2,284**
DEFENSE	Basic Research	336	339	392	417	440	445
-WIDE	Applied Research	1,912	1,844	1,770	1,700	1,720	1,721
	Advanced Development	3,264	3,536	3,594	3,408	3,498	3,563
	Total S&T	**5,512**	**5,718**	**5,756**	**5,525**	**5,659**	**5,730**
DoD	Basic Research	1,634	1,698	1,768	1,840	1,914	1,990
	Applied Research	5,058	4,245	4,213	4,160	4,284	4,357
	Advanced Development	5,987	5,532	5,642	5,427	5,520	5,600
	Total S&T	**12,679**	**11,475**	**11,623**	**11,428**	**11,718**	**11,947**

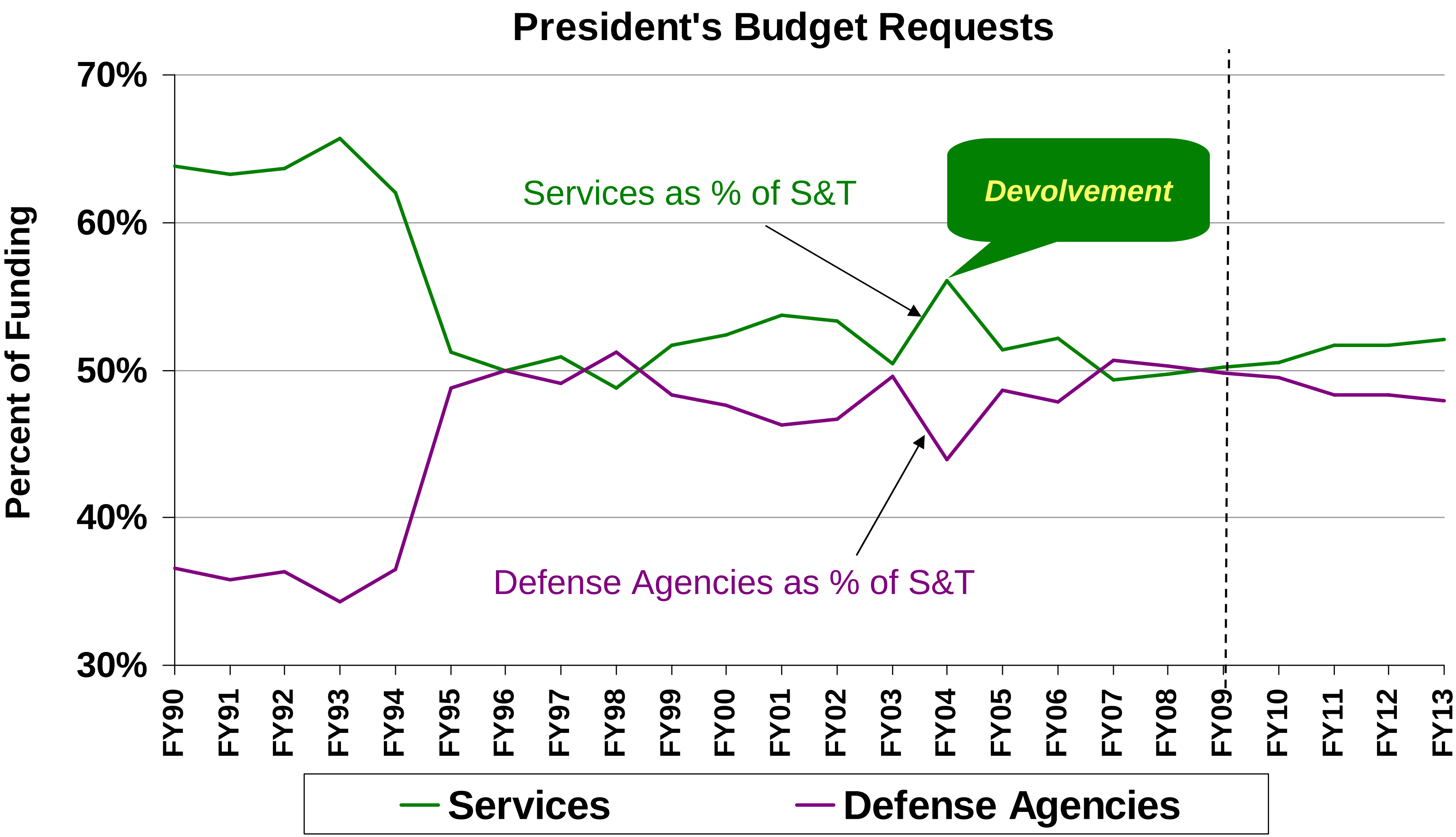
Characterization of the FY09 DoD S&T Program

- **Funding**
  - **Current year S&T dollars: $10.77B FY08 to $11.48B FY09**
  - **Percent of DoD funding: 2.24% FY08 to 2.22% FY09**
  - **Over 50% of total investment in 4 functional areas:**
    - Information Systems (1.8B)
    - Sensors, Electronics / EW (1.7B)
    - Basic Research (1.7B)
    - Weapons (1.1B)



DoD S&T program is focused on "sensing and shooting"

S&T Breakout
- Services and Defense Agencies as % of Total S&T -



Marquee Program Count

- Army – 25
- Navy – 65
- Air Force – 26
- DARPA – 44
- DTRA – 4
- MDA – 1
- AS&C – 28

Total = 193

The Need for Manufacturing Innovation and Readiness

Mark Gordon
Director, Defense Programs
National Center For Advanced Technologies

NDIA Science and Engineering Technology Conference
April 17, 2008

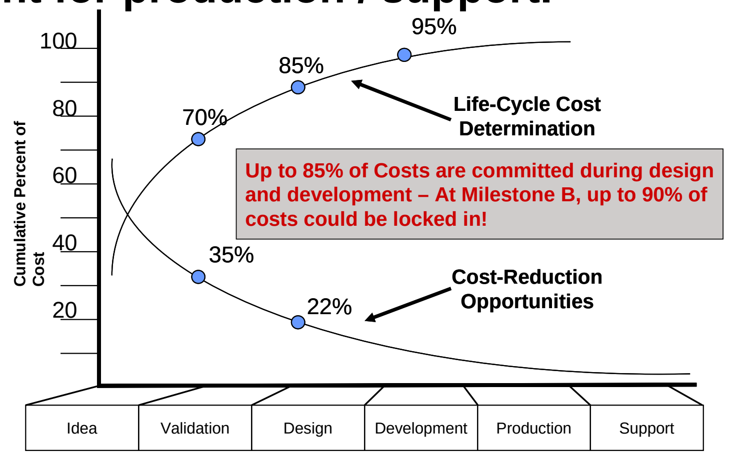
Topics

- Why Manufacturing is Key to Technology Transition
- The DoD Manufacturing Technology Program
- Current ManTech Priorities
  - Manufacturing Science and Technology
  - Manufacturing Readiness Levels
- MRL Implementation & Policy
- Questions

Why Consider Manufacturing In Transition?

- **The ability to manufacture a component:**
  - Is not subservient to technology development cycle, but central to it.
  - Determines a large percentage of the total cost and schedule.
  - Can in itself bring about innovative technologies (MEMS, LAM, Flexible Displays, Complex Dimensional Composites, CMCs)
- **The capability to produce a technology/material is often not seen as part of technology transition or innovation, and may be ignored by the Science and Technology community.**
  - However, it is a core focus in highly competitive commercial markets (Aerospace, Automotive, IT, & Transportation.)
  - System engineering models require the maturation of technology along with the ability to manufacture, support, and test.
- **In Defense, practice is often to demonstrate the performance of complex systems, then change the design late in development for production / support.**
  - Customer priorities requirements.
  - Contracting structure allows cost increases.

The foundation of affordable transition is the access for program manager to technology with demonstrated levels of performance, producibility and support. These attributes allow for effective design trades with knowledge about cost.



Source: DARPA Rapid Design Exploration and Optimization (RaDEO) Project

GAO: Knowledge Based Acquisition

- During GAO assessments of Acquisition Programs, a disturbing trend of growing cost and schedule overruns led to a conclusion that poorly performing DoD programs did not possess the knowledge required to achieve a successful design at key points during development.

- **$135B in Cost Growth (2004-2007)**

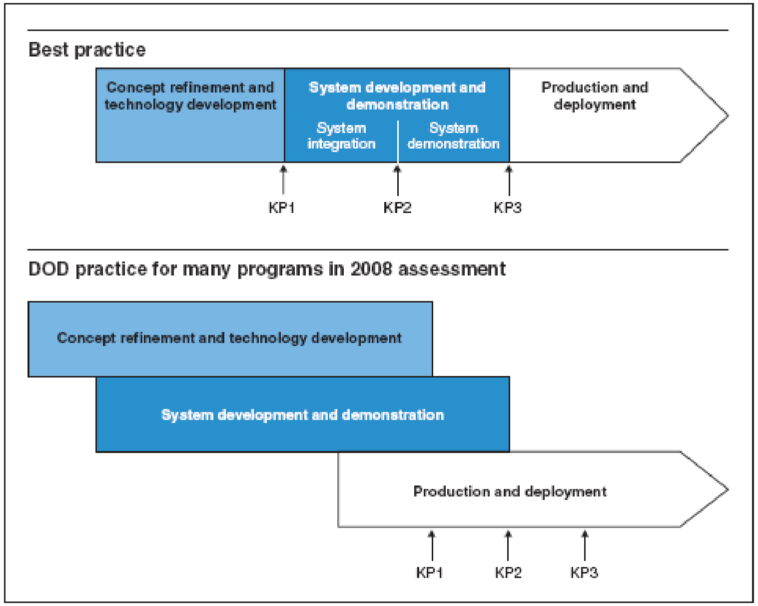
- They determined best practices in successful DoD and commercial development and defined three Knowledge Points:
  - **Knowledge point 1: Resources and needs match [Best practice: MS B]**
  - **Knowledge point 2: Product design is stable [Best practice: CDR]**
  - **Knowledge point 3: Production processes are mature [Best Practice: MS C]**

- In multiple assessments (2000-2008) of the DoD acquisition portfolio, there was found to be was a strong correlation between delayed knowledge points and poor performance.

- In typical defense program practices, these knowledge points were achieved significantly later in the development process, meaning that system design changes continued far into integration and production.

- Reversing this practices resulted in a strong policy requiring Technology Readiness at MS B, Configuration Control Boards and increasing use of Prototypes in competition.

Figure 6: Best Practices Compared to DOD Practices for Programs in 2008 Assessment



Source: GAO.

Finding: Most Programs Proceed With Low Levels of Knowledge Resulting in Cost/Schedule Increases

In a recent annual review of DoD programs (n=62), GAO found:

- Only 16% of programs achieved mature technology at MS B.
  - programs that demonstrated mature technologies averaged 2.6% cost growth and a 1 month schedule delay
  - programs that did not have mature technologies averaged 32% cost growth and a 20 month schedule delay
- At critical design review:
  - 44% of programs achieved technology maturity
  - 27% of programs demonstrated design stability (90% drawings releasable)
- At MS C, the start of Production:
  - Only 67% of programs achieved technology maturity
  - 33% of programs had still not achieved design stability
  - 10% of programs were collecting data on process control. (0% in control)
  - 47% reported they have already conducted or planned to conduct a developmental test of a production representative article (i.e., prototype)

Based on 62 programs	**Technology Status at Beginning of Development**	
	Mature	**Immature**
RDT&E Cost Increase	2.6%	32.3%
Acquisition Unit Cost Increase	<1%	>30%
Average Schedule Delay	1 month	20 months

Defense Acquisitions: Assessments of Selected Major Weapon Programs. GAO-07-406. Washington, DC.: March 2007.

The DoD Manufacturing Technology Program

- ManTech is critical for moving disruptive technologies into disruptive capabilities
- If you can't build it, build it affordably, reliably, and in a timely manner, you don't have IT.
- To have true capability, must be able to move beyond the prototype "One-Off"

  - Operates Under Title 10 (Section 2521)
    - Manufacturing process investments that provide product performance, operational, & affordability improvements
  - All About Affordable & Timely Equipping of the Warfighter
    - Defense essential needs beyond normal risk / interest of industry
    - Pervasive needs across systems, platforms, or components
  - Transition of Validated Technology
    - Scale-up of processes for S&T, ATDs, IR&D, & ACTD products
    - Focus: Manufacturing process investments

ManTech Addresses Major QDR Issues – Affordability, Sustainability, Decreased Logistical Footprint

Joint Defense ManTech Panel - (JDMTP)

ManTech Principals
(Army, Navy, AF, DLA, MDA)

Ex Officio:
- OSD, Army, Air Force Staff
- Agencies, Dept of Energy, Dept of Commerce (NIST)
- Industry

Metals Processing & Fabrication
- Specialty Materials
- Processing & Joining
- Inspection & Compliance

Composites Processing & Fabrication
- Performance Improvements
- Life Cycle Affordability

Electronics Processing & Fabrication
- Packaging & Assembly
- RF Electronics
- Electro-Optics

Sustainment

Focus – Joint Collaboration

Manufacturing Technology Program Examples

Warfighter Relevance

(U.S. Air Force)

Solved #1 B-2 Mission Capable MX Issue New capability will have the greatest impact on B-2 Fleet Availability

Developed new LO Magnetic Radar Absorbing Material (MagRAM) for B-2, reduced mx downtime for LO materials from 36 hrs to 7 hrs.

Solved #1 C-17 MX Issue – Structural Damage to Doors on undeveloped runways

AF – ManTech developed new stitched resin infusion process to prevent delamination.

Met Tank Tread Demand Surge for OIF

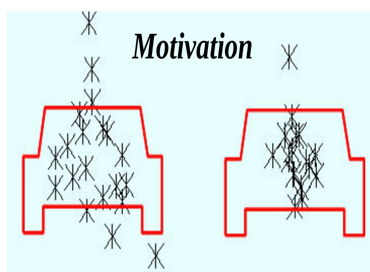
- Vital Track component experienced accelerated failures
- Advanced casting tooling method enabled industry to meet surge and demand

Created force multiplier for battle tanks

- Improved Accuracy through Cannon Tube Reshaping

- 20 fold tighter tolerance; 65% reduction of shot group dispersion;

- Resulted in greatest increase in “loss exchange ratio” in 20-plus years



Before After

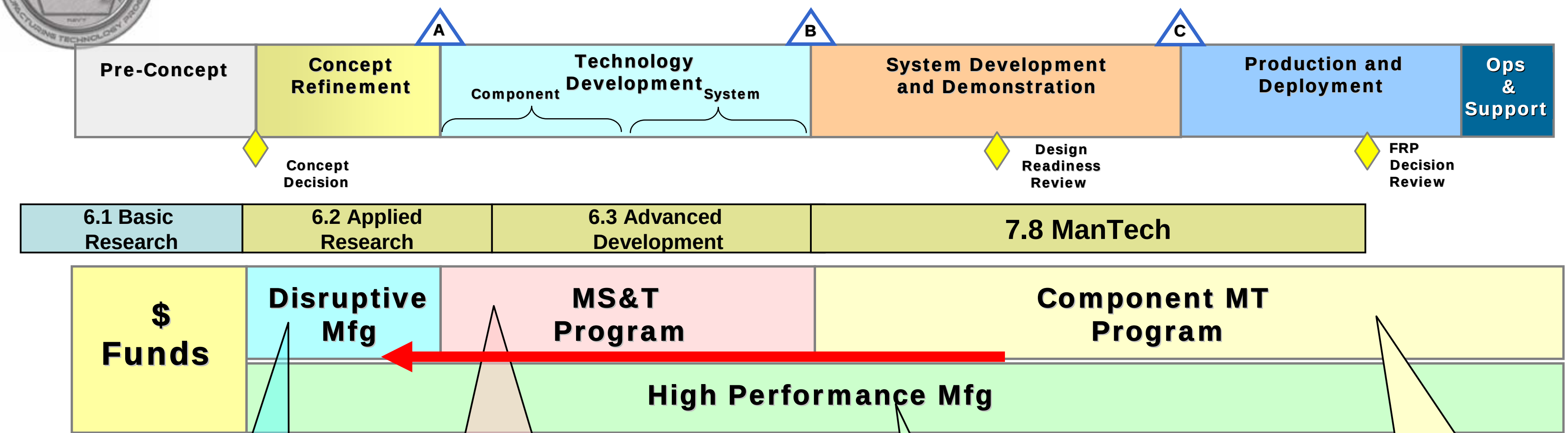
Developed New Capability - New Marine Composite-to-Steel Joining Capability - Reduces Logistics Footprint and enables DD(X) to meet Program Requirements

New Adhesive Joint replaces 5120 bolts that failed to meet technical req’ts of DD(X)

Manufacturing Technology Program
Top Priorities

- OSD Manufacturing S&T Program
- SBIR- Manufacturing
- MRL/MRA Implementation
- Strategic Planning

Pulling Manufacturing Back into S&T



<u>Manufacturing Science and Technology:</u>
Concurrently develop and mature cross-cutting manufacturing processes with new and emerging technologies.

- **Align R&D** investments
- **Accelerate** Transition

<u>Traditional ManTech:</u>
Develop and mature manufacturing processes for acquisition programs, and specifically for **affordable production and capacity**.

<u>Disruptive Manufacturing Technology:</u>
Radically alter the defense industrial base through development of “disruptive” manufacturing processes. Provide **faster and more affordable access** to low-volume production capabilities for **defense unique** technologies. Transition emerging, disruptive technologies

<u>High Performance Manufacturing:</u>
Identify and transition advanced manufacturing processes. Includes development of **test beds and prototypes**, and creation of **technology roadmaps**.

MRL: Background

- *Immature technology and unstable manufacturing processes are major acquisition drivers*

- *Manufacturing Readiness Levels (MRL) Developed*
  – In collaboration with industry
  – Common Standard and framework for identifying, communicating, and managing manufacturing risks
  – Reconciled with TRLs

- *Policy Required*
  – Establish and promote manufacturing risk management as basic principal of technology development and acquisition programs
  – Plan and budget for incorporating manufacturing readiness to support successful transition
  – Establish DoD standard for manufacturing readiness at key milestones
    - Milestone A – MRL4
    - Milestone B – MRL 6
    - Milestone C – MRL 8
    - FRP Decision – MRL 9
  – Support the development and maintenance of necessary knowledge and skills within the DoD workforce to support this best practice already used by key U.S. defense industries
  – Provide guidance for the new DoD standard

- *MRL Process Owner: DDR&E*

Equip the DoD Enterprise with Knowledge Based Approach to Manufacturing Risk Management - Standard, Policy, Tools, and Training

MRL Definitions & Descriptions

MRL	Definition
1	Manufacturing Feasibility Assessed
2	Manufacturing Concepts Defined
3	Manufacturing Concepts Developed
4	Capability to produce the technology in a laboratory environment.
5	Capability to produce prototype components in a production relevant environment.
6	Capability to produce a prototype system or subsystem in a production relevant environment.
7	Capability to produce systems, subsystems or components in a production representative environment.
8	Pilot line capability demonstrated. Ready to begin low rate production.
9	Low Rate Production demonstrated. Capability in place to begin Full Rate Production.
10	Full Rate Production demonstrated and lean production practices in place.

MRL	Definition	Description	Phase
	Production.	monitoring ongoing. LRIP cost goals met, learning curve validated. Actual cost model developed for FRP environment, with impact of Continuous improvement.	Production (FRP) decision
10	Full Rate Production demonstrated and lean production practices in place.	This is the highest level of production readiness. Engineering/design changes are few and generally limited to quality and cost improvements. System, components or items are in rate production and meet all engineering, performance, quality and reliability requirements. All materials, manufacturing processes and procedures, inspection and test equipment are in production and controlled to six-sigma or some other appropriate quality level. FRP unit cost meets goal, funding sufficient for production at required rates. Lean practices well established and continuous process improvements ongoing.	Full Rate Production/ Sustainment

MRL Criteria Matrix / Threads

MRL Criteria Matrix Threads

- Technology and Industrial base
- Design
- Cost and Funding
- Materials (Raw Materials, Components, Sub-assemblies and Sub-systems)

Producibility assessments of key technologies/components and producibility trade studies completed. Results used to shape System Development Strategy and plans for SDD or technology insertion.

Threads ↓

...ty	Evaluate product lifecycle requirements and product performance requirements.	Systems E... the Test a... recognize... establishm... manufactu... managem... risk for the... Initial Key... Paramete...			...ct ...is ...ta ... Major ...are ...hat key ...cesses ...those ...hange ...ntly ...cteristics ...n ...r ...gram.		Major product design features are stable and LRIP produced items are proven in product testing. Design change traffic is limited to minor configuration changes. All KC's are controlled in production to three sigma or other appropriate quality levels.	Product design is stable. Design changes are few and generally limited to those required for continuous improvement or in reaction to obsolescence. All KCs are controlled to six sigma or other appropriate quality levels.
...t ...st	Technology cost models developed for new process steps and materials based on engineering details at MRL 1-2. High-level process chart cost models with major production steps identified at MRL 3.	Detailed process chart cost models driven by key characteristics and process variables. Manufacturing, material and specialized reqt. cost drivers identified.	Detailed end-to-end value stream map cost model for major system components includes Materials, Labor, Equipment, Tooling/STE, setup, yield/scrap/rework, WIP, and capability/capacity constraints. Component simulations drive cost models.	Cost model inputs include design requirements, material specifications, tolerances, integrated master schedule, results of system/subsystem simulations and production relevant demonstrations.	Cost models updated with detailed designs and features, collected quality data, plant layouts and designs, obsolescence solutions.	Engineering cost model driven by detailed design and validated with data from relevant environment.	Actual cost model developed for FRP environment. Variability experiments conducted to show FRP impact, potential for continuous improvement.	Cost model validated against actual FRP cost.
	Sensitivity, Pareto analysis to find cost drivers and production representative scenario analysis to focus S&T initiatives and address scale-up issues.	Material, manufacturing, and specialized reqt. costs identified for design concepts. Producibility cost risks assessed and manufacturing technology initiatives identified to reduce costs.	Current state analysis of cost of design choices, make/buy, capacity, process capability, sources, quality, key characteristics, yield/rate, and variability.	Cost analysis of mfg future states, design trades, supply chain/yield/rate/SDD/technology insertion plans. Allocate cost targets. Cost reduction and avoidance contract incentives identified.	Costs rolled up to system level and tracked against targets. Detailed trade studies and engineering change requests supported by cost estimates. Cost reduction efforts underway, incentives in place.	Cost analysis of proposed changes to requirements or configuration.	LRIP cost goals met, learning curve validated.	FRP cost goals met. Cost reduction initiatives ongoing.
...ring ...t Budget	Program/ projects have budget estimates for reaching MRL 4.	Program has budget estimate for reaching MRL 5. All Risk Mitigation Plans required to raise deficient elements to MRL of 4 are fully funded.	Program has budget estimate for reaching MRL 6 by MS B. Estimate includes capital investment for Production-representative equipment. All Risk Mitigation Plans required to raise deficient elements to MRL of 5 are fully funded.	Program has budget estimate for reaching MRL 7 by CDR. All Risk Mitigation Plans required to raise deficient elements to MRL of 6 are fully funded.	Program has budget estimate for reaching MRL 8 by MS C. Estimate includes investment for Low Rate Initial Production. All Risk Mitigation Plans required to raise deficient sub systems to MRL of 7 are fully funded.	Program has budget estimate for reaching MRL 9 by the FRP decision point. Estimate includes investment for Full Rate Production. All Risk Mitigation Plans required to raise deficient sub systems to MRL of 8 are fully funded.	Program has budget estimate for lean implementation during FRP. All Risk Mitigation Plans required to improve deficient subsystems to MRL of 9 during FRP are fully funded.	Production budgets sufficient for production at required rates and schedule.

Cost & F...

Implementation: MRL/MRA Experience in Industry

- Industry Associations and companies are supportive of DoD Manufacturing Readiness efforts and support policy
  - Participated in Three DoD-Industry Workshops

- OEMs and Second Tier Suppliers are using the first or second generation definitions, published in the Technology Readiness Assessment Guide

- Many companies have developed their own manufacturing maturity measures.
  - Rockwell Collins Manufacturing Maturity Index
  - Sikorsky Production Readiness Index

- Other companies have adopted our MRLs, and are using them within the company's gated development process.
  - **Lockheed Martin Missiles and Fire Control**
  - **Raytheon (Tuscon)**
  - **Pratt & Whitney**
  - **General Electric Power Systems**
  - **Boeing (EMRLs for MDA, MRLs for FCS)**
  - **Goodrich**
  - **… and the list is growing**

Implementation: MRL/MRA Experience in DoD

- Air Force
  - MRAs completed on 21 Air Force Advanced Technology Demonstrations using the manufacturing readiness level (MRL) criteria; additional 12 are in process
  - Used MRL criteria to perform MRAs on two ACAT 1 Programs
- Army
  - Uses MRLs on all 6.3 Programs that have manufacturing or producibility issues tied to Army Technology Objectives- Manufacturing (ATO-M)
  - Army also uses MRLs and MRAs on selected SBIR Projects
  - Army to incorporate MRLs and MRAs into the management aspect of planned Commercialization Pilot Program.
- MDA
  - Applies related scale (EMRLs) to manage high risk prototype- production technologies.

Implementation – Statute and Policy

- **Manufacturing Readiness Levels**
  - Definitions and framework developed, socialized with industry, Services
  - Criteria Matrix developed, piloted, revised, and posted (Version 6.5, April 2008)
- **Developed AT&L Policy**
  - Coordinating with DAU on Defense Acquisition Guidebook Inputs
  - Signed Policy triggers 5000 updates
- **Manufacturing Readiness Guidebook** – "Why" posted 2006
- **Manufacturing Readiness Deskbook** - "How"
  - Piloted under AF
  - Lessons Captured
  - DoD MRA Deskbook Developed
  - DoD MRA Deskbook Red Teamed
    - SOO/SOW language
  - DoD MRA Deskbook – Post on DAU Website – April 2008
- **Coordination with TRA**
  - Incorporated MRL into TRA Deskbook Revision – Appendix I
  - Mapping MRA Deskbook to TRA Deskbook – Coordinating with OSD
  - De-conflicting existing policies

Summary

- **Manufacturing is a core attribute for transition of Innovative Technology, particularly for affordability!**
- **There is an obvious need for pacing development and demonstration of manufacturing processes concurrent with technology.**
  - **Targets $135B cost growth in Defense System Costs.**
- **DoD ManTech Program is shifting forward to include disruptive / high performance topics.**
- **Manufacturing Readiness Levels represent a stable, proven tool for tracking either a technology's or system's manufacturing maturity, and will be adopted by DoD Policy this year.**

Questions?

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Headquarters U.S. Air Force

Integrity - Service - Excellence

USAF Science, Technology & Transition

Presentation to
NDIA S&E Conference
16 April 2008

Mr. Terry Jaggers, SES
Deputy Assistant Secretary
(Science, Technology and Engineering)

Agenda

- AF S&T Overview
- National Imperatives
- The AF Transition Program
- AF Transition Policy
- Summary

AF S&T Overview

- AF executing $1.7B core in FY08 with 2,200 Scientists & Engineers in 10 core technical areas
- FY09 budget on Hill is $2.1B, increasing focus on:
  - AF Tech Vision
  - Basic Research
  - MANTECH
  - Cyber
  - Defensive Counterspace
  - Directed Energy
  - Revolutionary Propulsion
  - Thermal Management
  - Alternative Energy
  - Composites
  - Sense & Avoid for UAVs
- Improving Tech Transition is 1 of 5 guiding principles for AF S&T
  - SAE Commitment, OSD Initiatives, and JCTDs changes within AF
  - Organizing to align R&D development to 3 AF priorities, and tech transition efforts to 20-year AF roadmap
- Imperative for AF S&T tech transition to be synergized and leveraged with other tech transition efforts

Agenda

- AF S&T Overview
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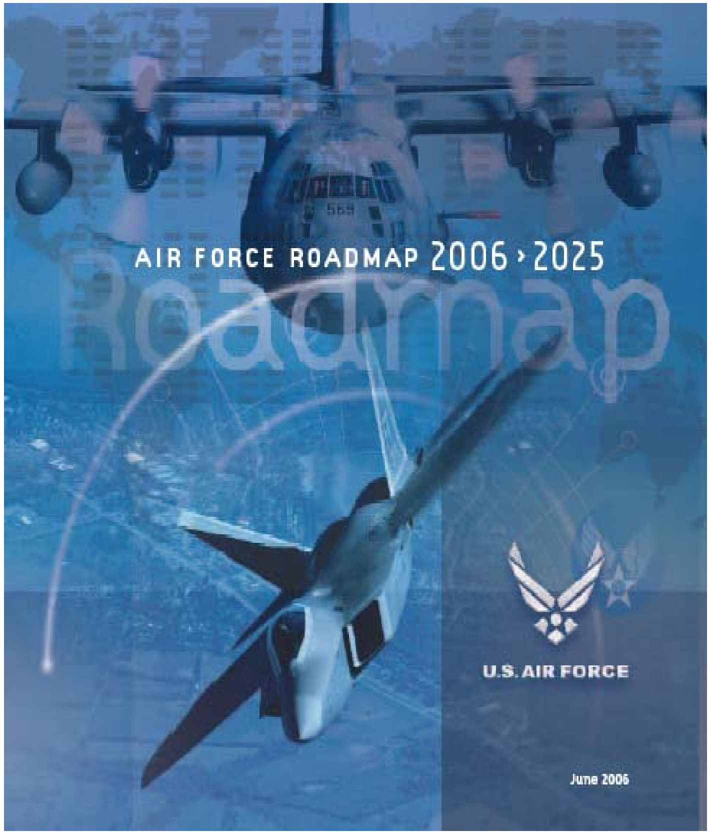
Winning the Current War

- The Nation must maintain technological superiority to win the GWOT
  - Winning the GWOT is the top priority of the AF
  - Terrorists exploit available technology faster than we can adapt and field ours
  - The AF leverages over $200M per year in transition assistance programs aimed at rapid technology transfer
  - *Effective* transition of technology is needed to maintain technology superiority and win the GWOT

Winning the Next War

- History has shown that Nations fail without modern militaries
  - Modernization is one of the top 3 priorities of the USAF, second only to GWOT and people
  - The AF has a 20-year modernization roadmap
  - The AF will spend over $15B in non-system specific managed 6.3/6.4 tech development over next 20 years
  - *Efficient* transition of this technology is a key enabler to AF modernization success and National Security



Agenda

- AF S&T Overview
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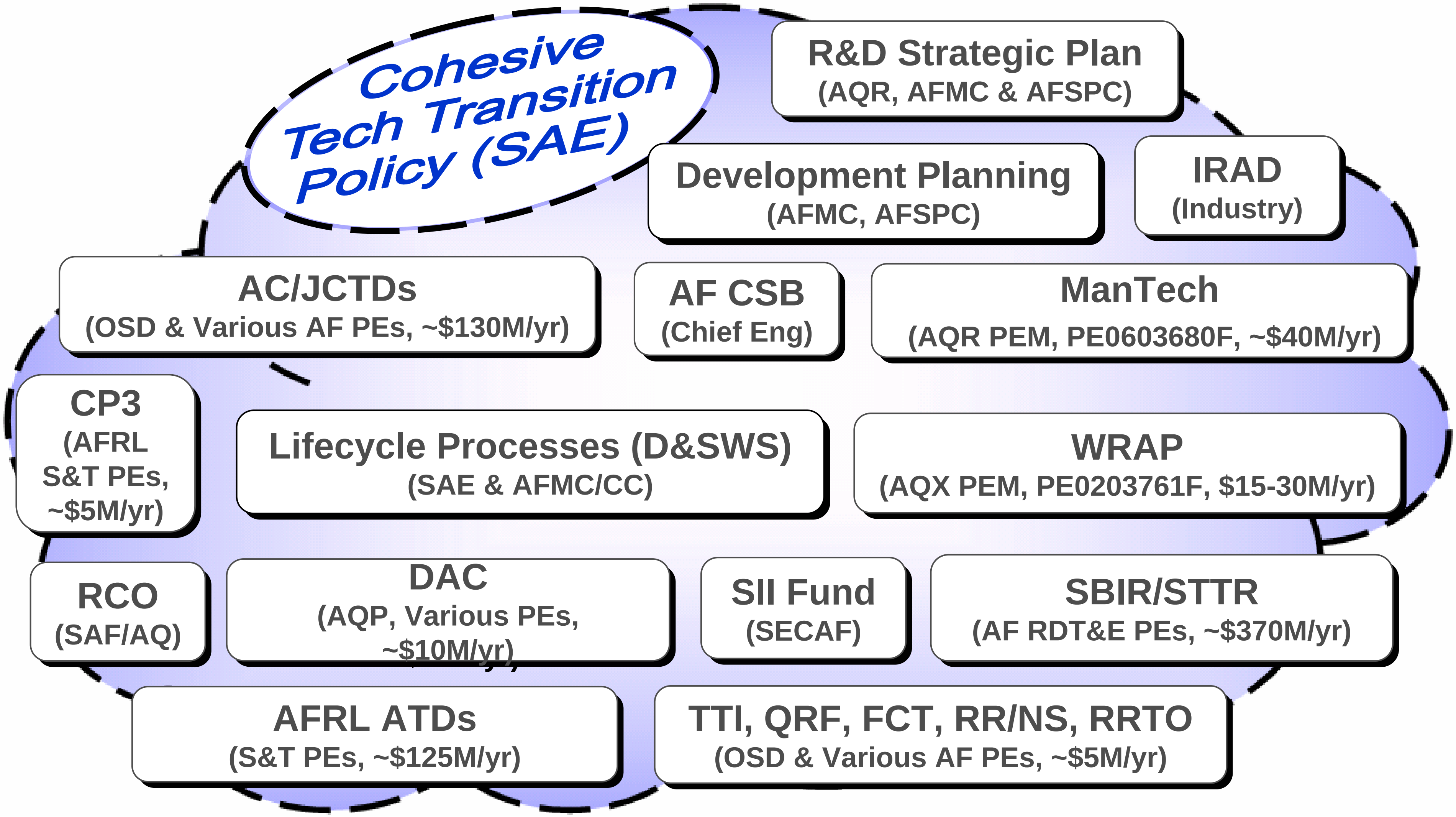
- Summary

AF Tech Transition Program



Agenda

- AF S&T Overview
- National Imperatives
- The AF Transition Program
- AF Transition Policy
- Summary

AF Transition Policy

- Tech transition office created on Air Staff to coordinate myriad of policy, processes & programs across AF
- Developing AF R&D policy for tech development *and* transition
- Key linkages to systems engineering policy for system developer insertion planning and corporate AF configuration control
- Policy recognizes differences in transition for air, space and cyber domains and adjusts for differences
- Tailored transition plans applied to achieve desired end-state for type of tech transition (to warfighter, to prime, to subtier) and life-cycle insertion point
- Tech transition requires risk identification, management, and acceptance by the customer and leadership

Full spectrum of tech transition across the life-cycle including policy, people and resources

Agenda

- AF S&T Overview
- National Imperatives
- The AF Transition Program
- AF Transition Policy
- Summary

Summary

- Technology transition is a key enabler to winning the GWOT, while preparing to fight and win the next war
- Technology transition program consists of multiple programs, processes and overarching policy
- Tech Transition office developing policy that aligns the right programs/processes to the right domain and end-state

Transition Technology

- Stand-up AF Technology Transition office
- Small Business Innovation Research (SBIR) Commercial Pilot Program (CPP) implementation
- Management/coordination of AF Joint Capability Technology Demonstrations (JCTDs)
- Policy for S&T Advanced Technology Demonstrations (ATDs)/ JCTD transition to acquisition
- Policy/coordination of lab urgent needs (Core Process 3) with AF Rapid Response Program
- Clearinghouse for Quick Reaction Funds, Technology Transition Initiatives, etc.
- Advanced development, prototyping, and risk reduction BA 4 initiative

Successful Transitions

- Certified 50/50 blend of Fischer-Tropsch alternative fuel on B-52
- Provided PNT support to SOCOM Joint Precision Air Drop System
- Demonstrated Automated Air Refueling for ACC
- Completed all TACSAT-2 S&T experimental objectives for USSTRATCOM
- Transitioned Angel Fire into a USMC Operational Assessment for IED detection
- Deployed Spiral 2 of PANACIA to NASIC and the 480th MASINT Cell
- Inserted adaptive optics technology at Starfire and began transition to MSSS for AFSPC
- Successfully tested Focused Lethality Munitions technologies and transitioned to Small Diameter Bomb Program

Navy Manufacturing Technology and Affordability Programs

John Carney
Director, Navy ManTech
ONR 03T MT
17 April 2008

Office of Naval Research
03T Organization

Director of Transition

Deputy Director of Transition

FNCs ★
Coordination of FNC Process and Execution Monitoring

JCTDs
Coordination of DON JCTD Process and JCTD Execution Monitoring

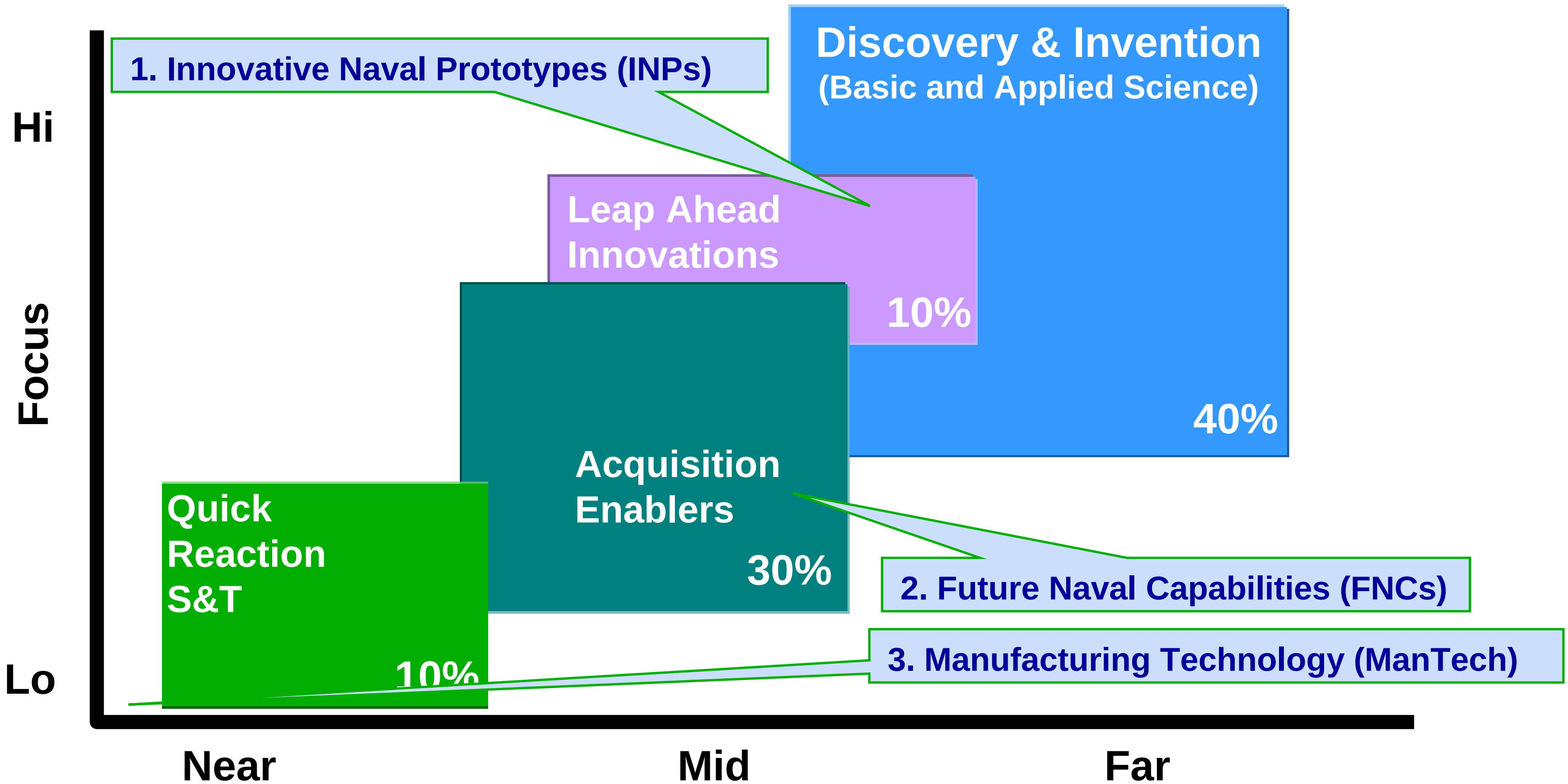
Transition Initiatives
Coordination of response to OSD and DON DAC/TTI/RTT/QRF/ TIPS, etc.

ManTech ★
Execution of Manufacturing Technology

SBIR
Mgmt control of DON SBIR and Execution Oversight of ONR SBIR / STTR

★ **Will be highlighted in brief**

Examples Addressing Manufacturing Early Cross ONR Spectrum



OSD Partnered / Quick Reaction S&T ($223M, 12%)

Acquisition Enablers ($655M, 36%)

Leap-ahead Innovations ($197M, 11%)

Discovery & Invention ($765M, 41%)

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6.1 – 6.3 Budget Chart

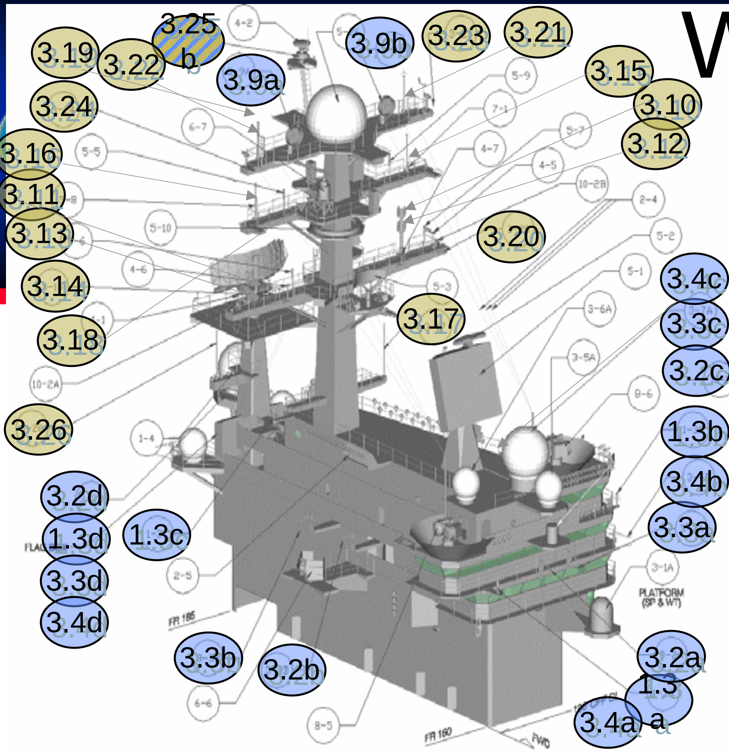
Innovative Naval Prototypes (INP) Overview

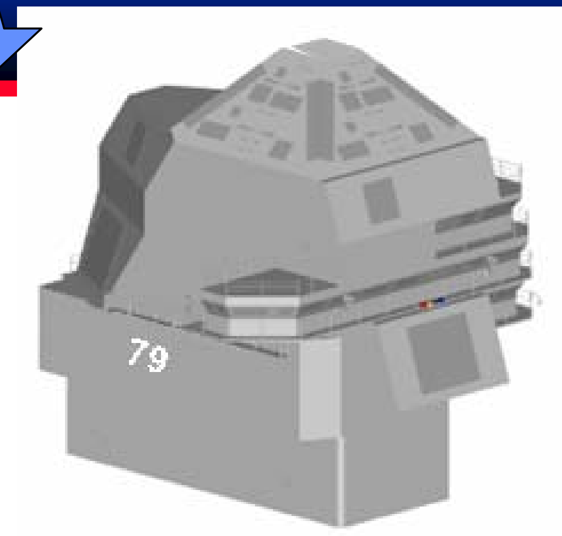
- **Investments planned with critical mass to achieve a level of maturity suitable for transition within 4-8 years**
- **Likely disruptive**
- **A primary goal is to move the risk from Acquisition (Billions of $$) back to S&T (Millions of $$)**
- **Higher technological risk than Future Naval Capabilities**
- **INPs are approved by the Navy Corporate Board (Assistant SecNav Research Development Acquisition, Vice Chief of Naval Operations, Assistant Commandant of the Marine Corps)**
  - **INPs with a technology focus:**
    - Electromagnetic Rail Gun
    - Free Electron Laser
    - Integrated Topside
  - **INPs with a capability focus:**
    - PLUS
    - Seabasing
    - Tactical Satellite

Integrated Topside Vision

- **Dominate the RF spectrum**
- **Enable innovation through a RF Open Architecture (hardware and software)**
- **Create affordable systems that are scalable across platforms**

What is Integrated Topside?





Current State of The Art	Integrated Topside
Overcrowded	**Combined apertures (multi-function, multi- beam)**
Poor performance due to blockage and EMI	**Optimally placed apertures, integration of RF functions to control EMI**
Expensive to acquire and maintain	**Reduced acquisition and total ownership cost**
Significant Size, Weight and Power requirements (SWaP)	**Significantly reduced SWaP**

RF functions simultaneously share apertures and signal processing
Topside continually optimized to meet highest priority needs

Integrated Topside (INTOP) Objective

- **Develop and demonstrate an integrated, multi-function, multi-beam top-side aperture construct that has:**
  - **A scalable family of EW, RADAR (not high power) & communications capability to support multiple classes of ships**
  - **Modular open RF design (apertures and electronics) to facilitate best of breed technology and cost effective upgrades**
  - **Shared apertures for multiple functions**
  - **Software defined functionality**
  - **Cost effectiveness up front and over the life cycle**
  - **Increased operational capability**
  - **Spiral development to reduce risk and costs and have high probability for transition of technology to the fleet**

Future Naval Capabilities (FNCs) Overview

- **The FNC Program:**
  - Composed of Enabling Capabilities (ECs) which develop and deliver quantifiable products (i.e., prototype systems, knowledge products, and technology improvements)
  - In response to validated requirements
  - For insertion into acquisition programs after meeting agreed upon exit criteria within five years

- **ECs**
  - Currently aligned with four of the pillars of Naval Power 21 (Sea Shield, Sea Strike, Sea Base, and FORCEnet)
  - Additional group for crosscutting technology improvements (Enterprise and Platform Enablers) for operations and maintenance cost savings

Aligns requirements, acquisition, Fleet, and S&T Communities to increase impact of S&T investment

FNC Overview (cont)
Keys to Transition

- **S&T passes mature technology to acquisition into development and production programs**
- **Agreement must exist on the maturity and readiness at the stage this happens (Technology Transition Agreement or TTA)**
- **Key components agreed upon in a TTA:**
  - -- Description of Product
  - -- Completion/Transition Year
  - -- Level of Risk (Technology Readiness Level)
  - -- Demonstration of TRL
  - -- Exit Criteria

Transition Commitment Level (TCL)

Strength of Transition Commitment \ Years remaining in approved S&T development program	1	2	3	4	5+
A — TTA Level A - Committed. Fully executed final TTA. Including integration strategy. Transition funding programmed.	A1	A2	A3	A4	A5
B — TTA Level B - Working. Detailed Exit Criteria. Acquisition Program interested. Transition TRL established. Proposed Transition Budget, PE Line identified/targeted	B1	B2	B3	B4	B5
C — TTA Level C - Initial. Initial Exit Criteria. Target Acquisition Program identified and Program Manager is watching with interest as technology is developed. PE Line identified/targeted. Key stakeholders identified	C1	C2	C3	C4	C5
D — No TTA. IPT and TOG commitment.	D1	D2	D3	D4	D5

Annual Transition Assessment


FNC Product: K/Ka/Q-Band Phased Array

Assessment*
Cost G
Schedule Y
Technical R
Transition R

*S&T Cost/Schedule/Technical
Green: S&T On-Track for Delivery
Yellow: Identified Delivery Issues/Risk but Manageable
**Red: S&T Delivery Unlikely or at High Risk

*Transition
Green: Adequate Funds Programmed
Yellow: Funds Planned/IPT Committed
**Red: No Funding Plan

** Requires recommendation on continuation in comments box

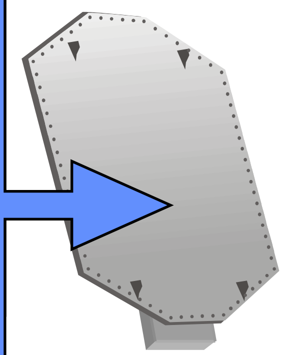
Transition is the responsibility of all stakeholders

Affordable Common Radar Architecture

FNC Project Highlight
Affordable Common Radar Architecture

Objectives

- Common scalable architecture for:
  - USMC HELRASR/USAF KMDS
  - Integrated SPN-43, SPS-48, SPS-49 retrofit.
- Emphasize scalability and open architecture for procurement and life cycle affordability



S&T Design Issues

- Affordable OA core relevant to afloat & expeditionary systems
- Extended reliability by design
- Address permanent and near-land use prohibitions from spectrum loss
- Address mid-latitude ducting limitations
- Fixed or rotator TBD depending upon procurement and life-cycle costs
  - If rotator, address Doppler resolution limitations
- ECCM
- High resolution for NCID and closely spaced objects
- Affordable scalable architecture meeting joint needs

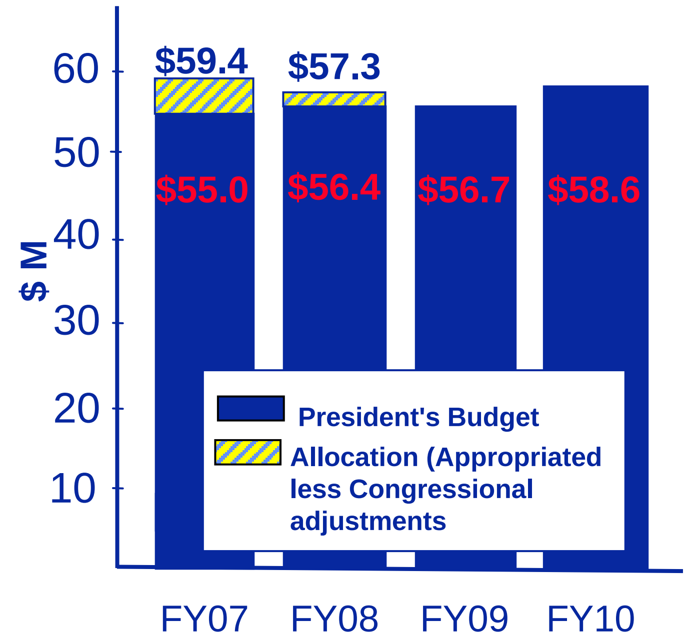
Budget ($M)

	FY09	FY10	FY11	FY12	FY13	Total
ACRA	2.75	7.26	8.25	5.39	3.3	26.95

AFFORDABLE, RELIABLE, MOBILE

Manufacturing Technology (ManTech) Overview

- **Mission:**
  - **Develop enabling manufacturing technology -- new processes and equipment -- for implementation on DoD weapon system production lines**
  - **DoD 4200.15 states investments should:**
    - Transition emerging S&T results to acquisition programs
    - Improve industrial capabilities in production, maintenance, repair and industrial base responsiveness
    - Advance manufacturing technology to reduce cost, improve performance, and responsiveness



- **Budget:**
  - **Stable at approx. $60M**

- **Execution:**
  - **Nine Centers of Excellence (COEs)**
    - 8 Contracted, 1 Government

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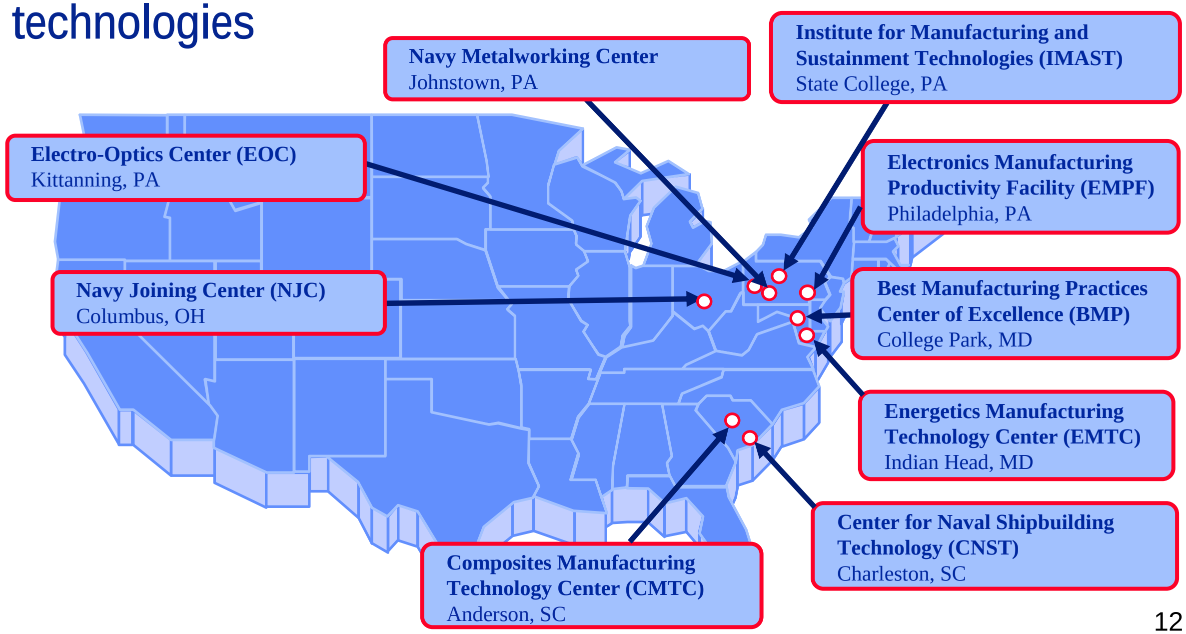
ManTech Overview (cont)
Execution

Navy ManTech is executed through nine Centers of Excellence (COEs):

- Execute projects; manage project teams
- Serve as corporate expertise in technological areas
- Collaborate with acquisition program offices / industry to identify and resolve mfg issues
- Develop and demo mfg technology solutions for identified Navy requirements
- Provide consulting services to Naval industrial activities and industry
- Facilitate transfer of developed technologies



ManTech Overview (cont)
FY09 Investment Strategy

- **Focused Shipbuilding Affordability Initiatives**
  - Concentrate resources on few high priority naval platforms for maximum benefit
  - Working with Program Offices and industry to select and execute projects to reduce acquisition cost
  - Acquisition Program Office prioritizes projects for platform portfolio
  - Platform IPTs oversee platform portfolios (ONR, COEs, Program Office, industry)

Primary Emphasis - Affordability

PEO (Ships)
DDG 1000

PEO (Carriers)
CVN 21

PEO (Ships)
LCS

PEO (Subs)
SSN

PEO (Ships)
LPD 17
DDG 51

PEO (T)
F-18 Family
EA-18G

PEO (IWS)
Missiles
Weapons
Munitions

PEO (W)
N-UCAS

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LCS Build Strategy (LCS)

- **LCS Program Office asked ManTech for suggestions for improving acquisition process for Littoral Combat Ships**
  - Recommendation - LCS bidders be required to include a Build Strategy in proposal

- **LCS Program Office agreed and requested that ManTech develop -**
  1. Draft build strategy requirements that could be included in the LCS solicitation and
  2. Evaluation criteria that the Navy could use to assess strategies submitted

- **CNST teamed with First Marine International (internationally recognized leader in providing specialist services to marine industry) to develop requested documents**
  - Delivered to ONR and **forwarded to LCS Program Office on 10 Jan 08**

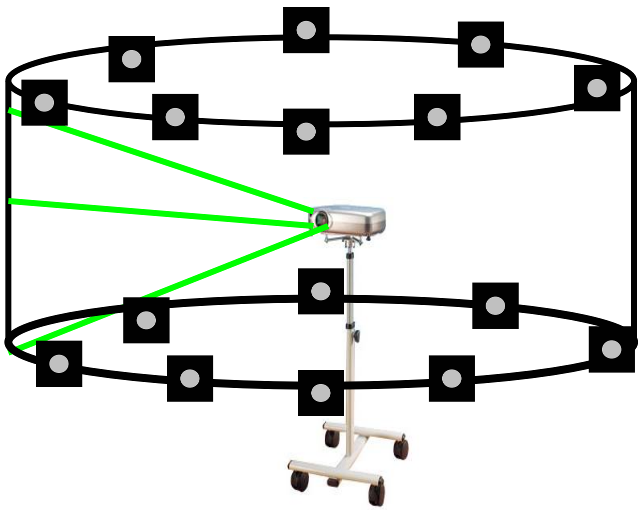
Build Strategy should:

- **Describe how the ship is going to be built:**
  - Block and unit definition
  - Outfit module definition
  - Interim product definition
  - Assembly methods and processes
- **Demonstrate that there are sufficient resources to the build the vessel as described:**
  - Labor, facilities and infrastructure
- **Demonstrate that the shipyard has the capability to carry out project as proposed:**
  - Realistic schedule
  - Alignment of resources to schedule
  - Material acquisition plan
- **Describe overall plan:**
  - From principal product breakdown and supply chain plans to test and commissioning plans

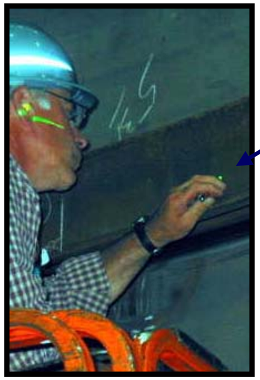
Done properly, build strategies will reduce cost by matching the production approach to the shipyard process capabilities and will reduce risk to Navy and industry

ManTech Project Highlight Laser Image Projection (VCS)

- **Goal:** Automate the layout of attachments during early outfitting
- **Benefits:**
  - Automate layout process
  - Eliminate paper templates and string measurements wherever possible
- **Background:**
  - Technology made possible by EB's One-Stop tool, developed under CNST's Product Centric project
  - One-Stop enables extraction of attachment data from EB's 3-D Product Model
- **Impact**
  - Partially implemented on Hull 781 (8 cylinders)
    - ~2000 hangers (~4000 studs) for Electrical & HVAC attachments
    - 2,910 hours saved **(~84% savings)** on partial use
    - $650,000 saved per hull (conservatively estimated at $65/hour)
    - **Project cost ($622K) re-couped in one hull**
    - Additional application being evaluated



Retro-reflective targets placed on already marked ship's grid system points can be used to position projection system.



Projector marks center-point location of stud (green laser light dot). Technician punch-marks & labels attachment point on face of frame flange.

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ManTech Project Highlight
HSLA-115 Eval / Implementation (CVN)

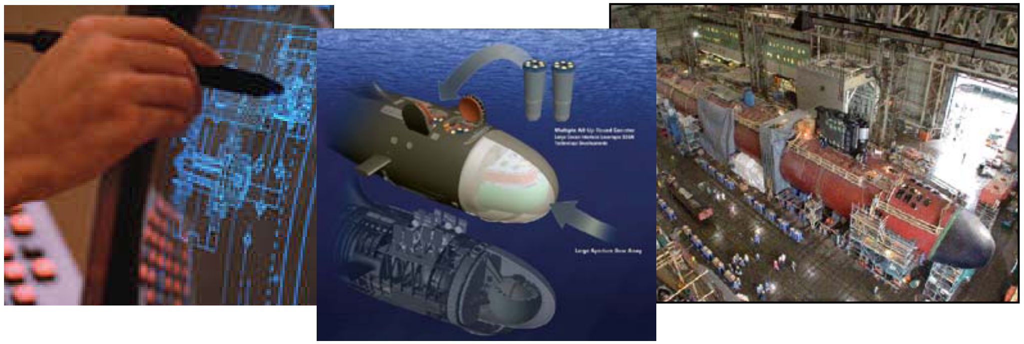
- **Background:**
  - CVN 78 requires improved performance and higher strength for reducing weight and to meet application requirements
  - Implement HSLA-115 at higher strength level and acceptable protection, toughness, welding and structural performance for weight reduction and increased factors of safety
- **Payoff:**
  - Potential weight savings of 100 - 200 long tons per hull for one application
  - Cost neutral to $1M savings impact anticipated
  - Reduced top-side weight, lower center of gravity 0.2-ft
  - Potential for additional future applications that require high strength and toughness
- **Achievements:**
  - NAVSEA / PMS 378 issued official letter to NGNN approving the use of HSLA-115 in baseline design and requiring successful completion of this project
  - NNS Management and Technical Review Board (TRB) officially approved incorporation of HSLA-115 into CVN 78 design (2 Nov 2007)

ManTech Project Highlight
Design for Production (DfP) Projects (VCS)

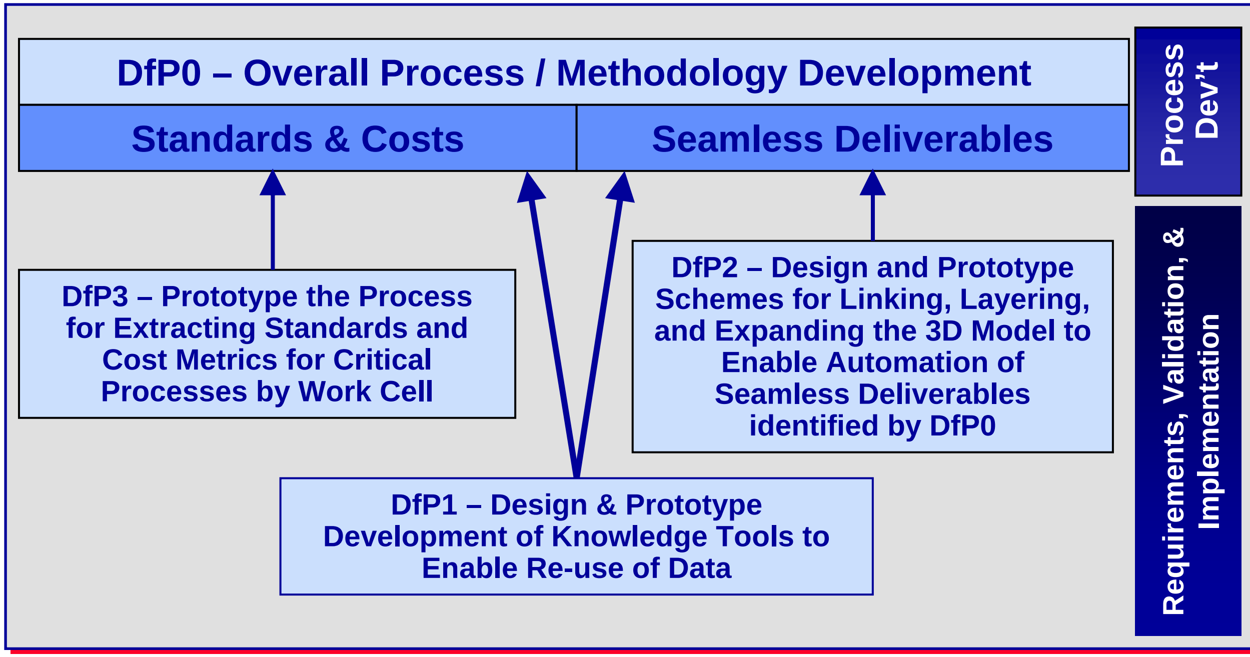
- **Goal:** Develop and implement Design for Production (DfP) techniques for VIRGINIA Class submarine construction cost reduction

- **Background:**
  - 4 inter-related DfP projects at Electric Boat

- **Payoff:**
  - Reduced design costs
  - Improved configuration management
  - Ability to consider design alternatives based on mfg costs
  - Standardized best mfg practices for re-use in design
  - Improved build sequencing
  - Reduced construction costs
  - Total est. cost savings of $4.8M/hull



Identifying design / process drivers to reduce construction costs



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Summary

- **Affordability is a key Navy theme**
- **Navy Science and Technology programs starting to address affordability and manufacturability**
- **Affordability needs to be addressed while developing next generation capability**
  - Affordability as part of the technology development concept (open systems, modular)
  - Difficult to insert affordability once technology has been developed
- **Navy ManTech addressing shipbuilding affordability**
  - High return on investment from areas such as Design for Production and Outfitting Process Improvement

Deputy Under Secretary of Defense

Advanced Systems & Concepts

~

9th Annual Science & Engineering Conference

~

The Advanced Systems and Concepts Portfolio of Opportunities

~

OSD/AT&L/DDR&E/AS&C

UNCLASSIFIED

John J. Kubricky

DUSD(AS&C)

15 April 2008

UNCLASSIFIED

OSD/AT&L/DDR&E/AS&C Mission

OSD / Advanced Systems & Concepts

- **<u>Find, Integrate, Demonstrate, and Transition</u>** operational concepts and technologies for **<u>multi-Service, Joint</u>** & **<u>Coalition Warfare Needs</u>**
- Leverage RDT&E Defense-wide resources through partnerships with Services and Agencies to meet the **<u>Most Critical Needs</u>** of the joint warfighter as defined by **<u>Combatant Commanders</u> (COCOMs)**
- **<u>Induct Innovative Technologies</u>** inside the traditional Planning, Programming, Budgeting, and Execution (PPBE) process that result in an enduring **<u>Capabilities-based Portfolio</u>** to defeat asymmetric threats

Thrusts: Agile, Adaptive, Affordable, Relevant, Urgent, Enduring, Transition

How Advanced Systems & Concepts Functions

- **Multi-Service Needs-Driven**
  - Monthly meetings with COCOMs - Progress on Deliverables
  - Frequent meetings with Intel Community
  - Participation in JCIDS and in JS/StratCom/DDR&E-sponsored studies
- **Technological Awareness**
  - Formal searches, pursuits and harvests of specified critical technologies
  - Briefings from industry (Domestic and International)
  - Intimate with technology development and assessment organizations
    - Services, Agencies, Intel Community, DHS, DOE, etc.
- **Program Oversight**
  - Organize, vet, select, and defend programs and projects
  - Validated Service and CoCom Priorities; IPLs and Most Pressing Needs
  - Wholly or partially funding projects – a core function
  - Closely monitor program and project execution
- **Transitioning Capabilities and Transferring Technologies**
  - Identify transfer and transition partners, pathways, PORs and POMs
  - Oversee transition process and progress; stimulate as necessary
  - Fund select game-changing technology enablers and transformation

Advanced Systems & Concepts Portfolio

OSD / Advanced Systems & Concepts

6.1	6.2	6.3	6.4	6.5	6.7	Proc	O&M

Science & Technology — Research & Engineering

TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6	TRL 7	TRL 8	TRL 9

Concept & Technology Development — System Development & Demonstration — Production & Deployment — O&M

A: Initial Product/ Process Capability

Product/Process Development

B: Product/Process Insertion

C: Product/Process Improvement & Sustainment

MRL	1	2	3	MRL 4 Lab or Modeling Environment	MRL 5 Prototypical Environment	MRL 6 Pre-production Representative Environment	MRL 7 Transition into LRIP	MRL 8 Low Rate Initial Production	MRL 9 Full Rate Production	MRL 10 Lean Production

COCOM /Joint/Coalition focused — ***Joint Capability Technology Demonstrations*** — *Demo 1-3 yrs*

AC/JCTDs Transition Enabler – "joint peculiar" capabilities — ***JCTD Transition & DAE Pilot Program***

Industry "On" Ramp – Test to Procure Tech Refresh — ***Defense Acquisition Challenge***

Service, SOCOM Nominated - Test to Procure — ***Foreign Comparative Testing***

DOD S&T Push — ***Tech Transition Initiative***

DoD Technology Transfer — ***Formerly TechLink*** — *to Private Sector*

Domestic Technologies Critical to National Security — ***Defense Production Act (Title III)***

ManTech Joint Investments — ***Defense Manufacturing Technology – Next-Gen Multi-Service Enablers***

MRLs - - a Technology Transition Risk Reducer

OSD / Advanced Systems & Concepts

Manufacturing Readiness Levels

5000	Pre-Concept	Concept Refinement	Technology Development (Component)	Technology Development (System)	System Development and Demonstration		Production and Deployment		Ops & Support
Milestones / Decisions	Concept Decision	A		B	Design Readiness Review	C	FRP Decision Review		

Technology Readiness Levels

Manufacturing Readiness Levels

	1 · 2 · 3	MRL 4 Lab or Modeling Environment	MRL 5 Prototypical Environment	MRL 6 Pre-production Representative Environment	MRL 7 Transition into LRIP	MRL 8 Low Rate Initial Production	MRL 9 Full Rate Production	MRL 10 Lean Production
TRL		TRL 4	TRL 5	TRL 6	TRL 7	TRL 7	TRL 8	TRL 9
Considerations	Manufacturing Concepts Identified	Mfg. Processes Identified Key Processes Identified Producibility Assessments Initiated	Mfg. Processes Developed Producibility Assessments On-going Mfg. Cost Drivers Identified	Critical Processes Demonstrated Cost Drivers Analyzed Long Lead Items Identified Equipment in a Relevant Environ	Mfg. Processes in Validation Producibility Improvement Underway Trade Studies Applied Supply Chain Validated	Process Maturity Demonstrated All Materials Ready for LRIP Mfg. Processes Proven Supply Chain Established	Mfg. Processes Operating at Target Quality, Cost and Performance Supply Chain Stabilized to Meet Production Lead Time Requirements	Lean/Six Sigma Production in Place Meeting or Exceeding Cost, Schedule and Performance Goals
Exit Criteria	✓ Meeting TRL 1 – 3 ✓ Identify Industrial Base (IB) Sources ✓ Characterize Basic Materials for Mfg. ✓ Identify Material Concerns ✓ Identify Funding ✓ Identify Advanced ManTech Initiatives ✓ Coordinate with Technology Plan	✓ Meeting TRL 4 ✓ Identify IB Gaps ✓ Assess Design for X ✓ Baseline Materials and Issues ✓ Funding/Budgeting for Trade Studies ✓ Identify ManTech or Other Initiatives ✓ Quality Strategy ✓ Mfg. Strategy ✓ Material and Tooling Planning	✓ Meeting TRL 5 ✓ IB Analysis Finished ✓ KPPs Allocated ✓ Material Development Begun ✓ Funding to Meet Next Level ✓ ManTech Initiatives Initiated ✓ Key Characteristics Identified ✓ Make/Buy Evaluations Begun	✓ Meeting TRL 6 ✓ IB Capability Est. ✓ Initial Trade Studies ✓ Materials Matured on Similar Lines ✓ Funding to Meet Next Level ✓ ManTech Solutions Developed ✓ Quality Thresholds Established ✓ Make/Buy Evaluations Done	✓ Meeting TRL 7 ✓ IB Monitored ✓ PEP Completed ✓ Materials Being Proven ✓ Funding to Meet Next Level ✓ ManTech Solutions Demonstrated ✓ Collecting Quality Data ✓ BOM Suppliers Identified	✓ Meeting TRL 8 ✓ Multiple Sources Established ✓ Pilot Line Builds Validated ✓ Materials Proven ✓ Funding to Meet Next Level ✓ ManTech Solutions Applied/Validated ✓ Validated Quality Characteristics ✓ BOM Supports LRIP	✓ Meeting TRL 9 ✓ IB Supports Sched ✓ Continuous Process Improvement is Ongoing ✓ Materials in Control ✓ Funding to Meet Next Level ✓ Quality Validated with LRIP Articles ✓ Make/Buy Supports FRP	✓ Meeting TRL 9 ✓ Monitor and Manage ✓ Key Characteristics at Six Sigma Level ✓ Funding Meets Six Sigma Goals ✓ No Changes to Make/Buy Decision ✓ All Key Suppliers Meet Six Sigma Goals

for the latest on MRLs, see http://www.ml.afrl.af.mil/mlm/about_manufacturing_readiness_levels.html

FY08 Emerging Defense-Wide ManTech Initiatives

OSD / Advanced Systems & Concepts

Current D-ManTech Program Drives 6 New Initiatives (examples):

- **Ceramic Matrix Composites Manufacturing Initiative**: to reduce cost and establish manufacturing technologies needed to develop and sustain advanced turbine engines
- **System-on-Chip Manufacturing Initiative**: advance manufacturing processes for packaging of system-on-chip systems; initial applications in communication and precision guided weapons
- **Prosthetics and Orthotics Manufacturing Initiative**: to integrate advanced manufacturing processes and materials that result in custom composite orthotics and prosthetics for wounded warrior amputees

Out-year and Potential FY08 D-wide ManTech Rolling Starts:

- **Identify/transition advanced manufacturing processes/technologies** to create significant productivity/efficiency in defense manufacturing base
- Radically alter defense industrial base through “disruptive” manufacturing
- Examples: solder-free electronics, advanced fixed and rotary wing aircraft structures, ballistic protection, conformal load bearing antennas

Defense Acquisition Challenge (DAC)…
…DoD's On-Ramp to Industry

OSD / Advanced Systems & Concepts

- **Scope:**
  - ➢ Allows anyone to propose innovations that could quickly improve -
    - ✓ Affordability, manufacturability, performance, or capabilities at a system, subsystem or component level
  - ➢ Competitive: Annual BAA in Federal Business opportunities and unsolicited proposals
  - ➢ Proposals "challenge" existing technology
    - ✓ Evaluated for merit & feasibility
    - ✓ If testing successful, innovations inserted into a program of record
    - ✓ Provides industry entry into DoD acquisition
- **Metrics & Measures**
  - ➢ Over 1200 proposals submitted
  - ➢ 68 projects awarded & ongoing
  - ➢ 70 companies from 26 states
  - ➢ 70% are small / medium enterprise technology providers
  - ➢ ROI (14 completed projects) is > 9:1

Spray Cool Technology: Electronics Sprayed with Non-Corrosive Coolant in a Hermetically Sealed Housing

Before SprayCool: 482 Pounds & 17 Cubic feet

Employed in Counter Targeting System - Part of OVERWATCH ACTD

4 units deployed to Iraq

After SprayCool: 100 Pounds & 2.6 Cubic feet

Mini Combat Trauma Patient Simulation System: Training medics at Camp Pendleton

Casualty simulator improves skills of medical personnel in mass casualty & triage - over 3500 medics trained & deployed to Iraq; attrition rate of trainees reduced from over 20% to 6%

Enhanced Performance Location Report System Tactical Data Network: Replaces manual network planning with automated system

Reduces complexity and need for manpower redundancy, deployed to 900 users (MEF II) in Iraq, enabling rapid and accurate information flow and data priority on the joint/coalition battlefield

CTO* FY08 Emerging Opportunities

Defense Acquisition Challenge (DAC) Program

OSD / Advanced Systems & Concepts

Current DAC (Examples) - - Supports 13 continuing projects ($13M)

- ***Omni-directional Antenna for M156 Magneto-Inductive Remote Activation Munition System (MI-RAMS)...*****Test 3-Axis Antenna for Army/SOF MI-RAMS allows placement of demolition charges and their initiator in any attitude (vice vertical only)**
- ***Mobile IP Interface to Tactical Data Links (TDL)..*****Test TDL to enable uninterrupted and real-time coordination/re-tasking of combat missions, challenging current system that requires manual reconfiguration**
- ***Sinuous Spiral Antenna for AN/ALQ211 EW System*** **...Test antenna candidate that may enable warfighter to better identify enemy transmission signals, improving threat geo-location and threat detection and defeat in all aircraft attitudes**

Out-year / Potential DACs: Estimate 8 to 12 new start FY09 projects ($15M)

- **Address warfighter operational issues / functional capabilities (effectiveness, employment, survivability, force protection, and/or sustainability)**
  - How: 'Challenge' existing legacy systems/equipment by testing mature technology for use in acquisition programs-of-record
  - Examples: Improved medical trauma simulation equipment; rapid armor or composites repair kits at unit level; better chemical / biological protective clothing; improved, lighter-weight, longer-lasting sources of power

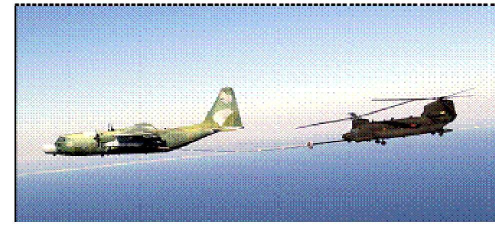
***Comparative Testing Office**

Foreign Comparative Testing (FCT)…

…the search for world-class technologies

OSD / Advanced Systems & Concepts

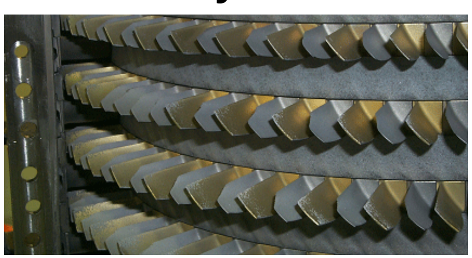
- ***Scope:***
  - ➢ Seeks international technologies for US warfighting needs
  - ➢ Leverages mature technologies for economic/speedy buys
  - ➢ Provides US Forces with new capabilities
  - ➢ Technologies assessed for use, bought from foreign source or manufactured under license in US



UK system can refuel two aircraft at once, avoiding $40 million in R&D

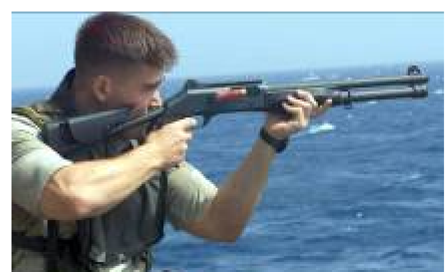
- ***Program Measures & Metrics (1980-2007)***
  - ➢ OSD investment of $1.1B has avoided $7B in costs
  - ➢ 567 projects started, 488 completed, 266 met test req's
  - ➢ 184 projects resulted in procurements worth about $8B
  - ➢ Accelerated fielding averaging 5–7 years
  - ➢ Participation from 27 allied and coalition partners
  - ➢ Vendor partnerships in 33 U.S. states
  - ➢ Past 5 years: Transition rate from test-to-procure > 80%

South-African developed Buffalo mine clearing vehicle probing & clearing mines & IEDs in Iraq



Russian erosion-resistant coating triples life of compressor blades in MH-53 helicopter, avoiding $1.6 million annually

Korean fiber optic mesh detects breaks and enhances perimeter security



Italian venture, the Joint Service Combat Shotgun, used in Iraq as a "door-buster"

Swedish bunker buster system fired from confined spaces, used in Afghanistan and Iraq

CTO* FY08 Emerging Opportunities

Foreign Comparative Testing (FCT) Program

Current FCTs (Examples) - - Supports 12 continuing projects ($17M)

- ***Fire Control System for SOF Combat Assault Rifle (SCAR) Grenade Launcher*** **- Test fire control and ammunition programming systems for enhanced grenade launch module for SCAR, improving range and suppressing hostile fire and other threats**
- ***A/C Arresting System for F-22 and JSF*** **- Test computer-controlled caliper-disk aircraft arresting system that increases functionality and capability to arrest both heavy aircraft and lightweight fighters**
- ***Advanced Airborne Expendable Infrared Countermeasures (IRCM)*** **- Test the effectiveness of expendable IR countermeasures to counter emerging advanced infrared Man-Portable Air Defense Systems**

Out-year / Potential FCTs - - Support 8 to 12 new start FY09 projects ($16M)

- **Address warfighter operational issues / functional capabilities (effectiveness, employment, survivability, force protection, and/or sustainability)**
  - **How: Test mature, non-development allied equipment and technology for use in acquisition programs-of-record**
  - **Examples: Light-weight, high-energy density batteries; health monitoring systems; improved active and passive armor protection; real-time, persistent surveillance**

***Comparative Testing Office**

The Technology Transition Initiative (TTI)

OSD / Advanced Systems & Concepts

➢ Objectives

- Accelerate transition of new technologies from DoD S&T programs into acquisition for production and deployment to US Armed Forces
- Demonstrate new technologies in relevant environments

➢ Partners and Processes

- Technology Transition Council
- Technology Transition Working Group

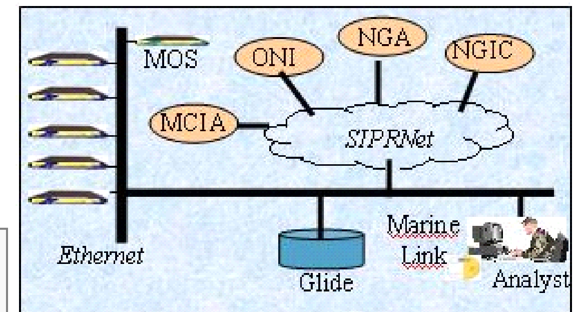
Countermeasures Protection System

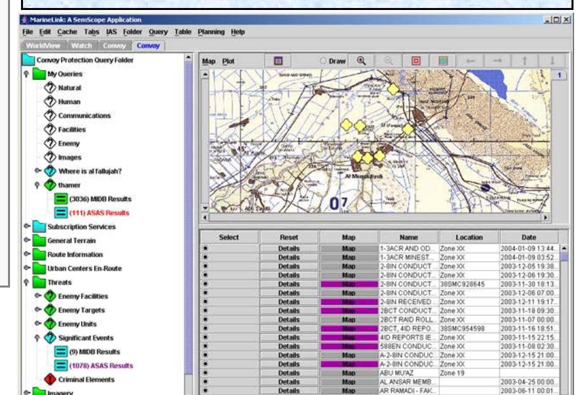
- Improves force protection against radio-controlled IEDs
- Deployed in GWOT

Water Purification Pen

- Eliminates risk of exposure to diseases and bio-chemical pollutants
- Deployed in IRAQ with each of the Services
- Sent as part of Tsunami relief effort in S.E. Asia

Semantic Web Network





- Incorporated into Marine Link
- Deployed w/1st and 2d MEF in Iraq
- Saves Analyst 4-5 hours per manual query

Technology Transfer Programs

OSD / Advanced Systems & Concepts

- Objectives
  - Ensure full use of the Nation’s investment in R&D (15 USC 3710)
  - Rapidly enhance warfighter capabilities via technology exploitation
- Benefits
  - Clear path from DoD S&T to application of technology
  - Commercial source for DoD items using DoD-developed technologies
  - Speed to deployment and cost-saving advantages
- Partners
  - US Industry (as opposed to contractual relationship)
  - Funds to support joint R&D efforts (funds from CRADAs)
  - Royalties on licensed inventions to reward inventors and perform R&D




FY08 Technology Transfer & Transition Initiatives

Current TTI Projects (Examples): 12 continuing projects ($20M)

- ***Accelerate Extremely Insensitive Detonating Substances (EIDS) and Insensitive Munitions (IM) Solution in 155mm Artillery Ammunition:*** Greater soldier survivability and reduced ammo storage/relocation detonation risk while retaining weapon lethality
- ***Improved Heating Technology (IHT) for the Unitized Group Ration:*** Self-heating group ration that sustains warfighters in remote, austere locations
- ***Joint Service General Purpose Mask (JSGPM) Filter End-of-Service-Life Indicator:*** $10M/yr savings in reducing unnecessary filter exchanges
- ***Solid State Laser Igniter for Artillery Applications:*** Safer, cheaper, more reliable means of firing 155mm artillery
- ***Tactical Idle Reduction Equipment for Heavy Tactical Vehicles:*** Saves 15M gallons/year in fuel with associated reduced fuel convoy personnel risks

Out-year/Potential TTI Projects: 6 to 8 new start FY09 projects ($10M)

Focus on TTI projects that enable affordable and decisive military superiority

- Address the following high-level mission areas: Battlespace Awareness; Stability of Operations; Cultural Awareness; Force Management; Command, Control and Information Management; Net-Centric Operations; Protection; Joint Training; Tailored Force Application

FY08 Defense Production Act Title III Initiatives

OSD / Advanced Systems & Concepts

Current DPA/T3s:

Atomic Layer Deposition Hermetic Coatings: ...domestic ALD for electronic components; transition to fabrication process for DDG-1000.

ALON/ Spinel:...domestic source of durable ceramics for transparent armor and apertures used in IR equipment and ballistic windows.

Beryllium Production: :...domestic source of high purity beryllium for defense sensors, missiles and satellites, avionics, weapon applications.

Boron Fiber: ...modernizing manufacturing processes of sole domestic source of boron fiber.

Coal-based Carbon Foam: ...establishing high-volume production for carbon foam materials in light weight tooling & non-structural components.

Reactive Plastic CO2 Absorbent: ...expanding production of reactive plastic CO2 absorbent to reduce hazards/increase diver mission duration.

Lithium Ion Batteries for Space:...long-life cells for space systems using assured domestically produced materials.
Military Lens Systems: ...advanced optics for multi-spectral fused imagery.

FY08 Defense Production Act Title III Initiatives

OSD / Advanced Systems & Concepts

Emerging/Imminent DPA/T3s:

Armstrong Titanium Production ...project aims to develop capabilities that lead to domestic production of low-cost titanium (**RFP in-process**).

Methanol Fuel Cells: ...components for soldier-portable equipment power.

SWORDS Safety Confirmation Testing and Production ...establish capability to produce a modified robotic system for confirmation testing.

Life Cycle Support Center for Unmanned Systems ...expanded capacity to support unmanned systems upgrade and repair for DoD and first responders.

Light-Weight Ammunition & Armor...establish production capacity for rigid polymer ammo cartridges to reduce weight for warfighters and transportation.

Out-year/Potential DPA/T3s:

Gallium Nitride (GaN) Radar Monolithic Microwave Integrated Circuits

S-Band radar: affordable production capability for GaN MMICs on SiC (fy09)

X-Band radar: affordable production capability for GaN MMICs on SiC (fy10)

Joint Capability Technology Demonstrations

OSD / Advanced Systems & Concepts

- **Enable Combatant Commanders to fill seams and gaps in core warfighting capabilities…particularly multi-Service operations**
- **Deliver new and *relevant* technology to warfighters *quickly***
  - ***The JCT <u>Demonstration</u> Program is not a procurement program***
  - ***JCTDs provide options that can lead to accelerated procurement***
- **Overcome resistance to transformational concepts (eg, tech risk)**
- **Integrate technology, joint doctrine and coalition operations**
- **Chartered to bypass delays in fielding innovative capabilities… …requires Transition Planning upfront.**

A Deliberate Technology Transition Strategy is Required to Begin a JCTD

JCTDs are not developmental projects...

- ~~Development~~ (Integrate to Demonstrate)

...JCTDs integrate, demonstrate and deliver new capabilities for urgent COCOM needs within 1 - 3 years and become enduring warfighter resources.

- Adaptation, Modification, Refinement, Prototype, Tech Insertion, Improvement, Revision, etc. to enable Joint, Coalition or multi-Service operations

JCTDs apply, integrate, prototype, modify, adapt and deliver new capabilities to satisfy validated COCOM urgent needs.

FY08+ JCTD Initiatives & Emerging Opportunities

Current JCTDs:

Communications Air-Borne Layer Expansion (CABLE) (STRATCOM/USAF): **Airborne communications backbone network for IP-based, high capacity data transfer with secure gateways to interconnect data links and voice**

Joint Force Protection Advanced Security System (JFPASS) (STRATCOM / USN / USAF): **Integrated system protects expeditionary military installations**

Hard Target Void Sensing Fuze (HTVS) (STRATCOM / USAF): **Competitive prototype of survivable, void sensing fuze to destroy deeply buried targets**

Shadow Harvest (SOUTHCOM / USAF): **Demonstrate a rapidly configuarable non-traditional ISR pod on a C-130 aircraft to find obscured targets**

Out-year/Potential JCTDs:

Net Zero Plus (CENTCOM / USA): **Utilizes alternative energy technologies to reduce energy footprint at military facilities and forward operating bases**

Cross Domain Collaborative Information Environment (CD-CIE) (JFCOM / DISA): **Open standards, non-proprietary, secure, scalable, cross domain collaborative info environment for multinational information exchange**

Collaborative Security Environment (CSE) (SOUTHCOM / JFCOM): **Integrated decision and assessment tool to support coalition security**

Joint Recovery and Distribution System (JRADS) (TRANSCOM / Army): **Integrates joint cargo handling system for intermodal load and recovery ops**

Strategic Initiative on Innovation and Tech Transfer

- Technology access has changed throughout the world; proliferation of potentially disruptive technologies is the new way of global competition and economic success; DoD is no longer at tje forefront of most tech research; fewer sources for growing numbers of warfighter-relevant technologies with shorter threat/refresh/support cycles

- The Strategic Initiative for Innovation and Technology Transition is tasked to create an action plan that will accelerate the movement of technology to Warfighters
  – particular emphasis on global outreach, flexible contracting, and strategic linking of the Department's agile acquisition initiatives to set conditions for an "outward looking" culture ... a transformation!

References and Discussion

Advanced Systems & Concepts (AS&C)	www.acq.osd.mil/asc	**703-695-5036**
Joint Capability Tech Demo (JCTD)	www.acq.osd.mil/actd	**703-697-5558**
Comparative Test Office (FCTs)	www.acq.osd.mil/cto	**703-602-3740**
Office of Technology Transition	www.acq.osd.mil/ott/tti	**703-607-5316**

Considering Warfighter R&D Investments…

OSD/Advanced Systems & Concepts

…questions should be answered affirmatively:

1. Does the action address the COCOM's needs[1]?
2. Is a significant Joint capability or military advantage gained?
3. Do we have a clearly stated and attainable goal/outcome?
4. Have risks and costs been fully and frankly analyzed?
5. Have all other DOTMLPF[2] means been fully explored?
6. Is there an exit strategy to avoid endless development?
7. Have consequences of inaction been fully considered?
8. Can support be garnered from the Services[3] and Congress?
9. Are experienced people available to execute the effort?
10. Can results be demonstrated to project champions (<PCS[4])?

---

[1] Integrated Priority Lists and Most Pressing Military Issues – as validated by JCS J8
[2] DOTMLPF: Doctrine, Organization, Training, Materiel, Leadership, Personnel and Facilities
[3] Enduring outcomes are all about timely transition to an affordable and sustainable capability
[4] Demonstrate 80% capability before CoCom champion/sponsor moves to next assignment

Criteria proposed by John Kubricky for selecting project candidates to support CoCom needs.

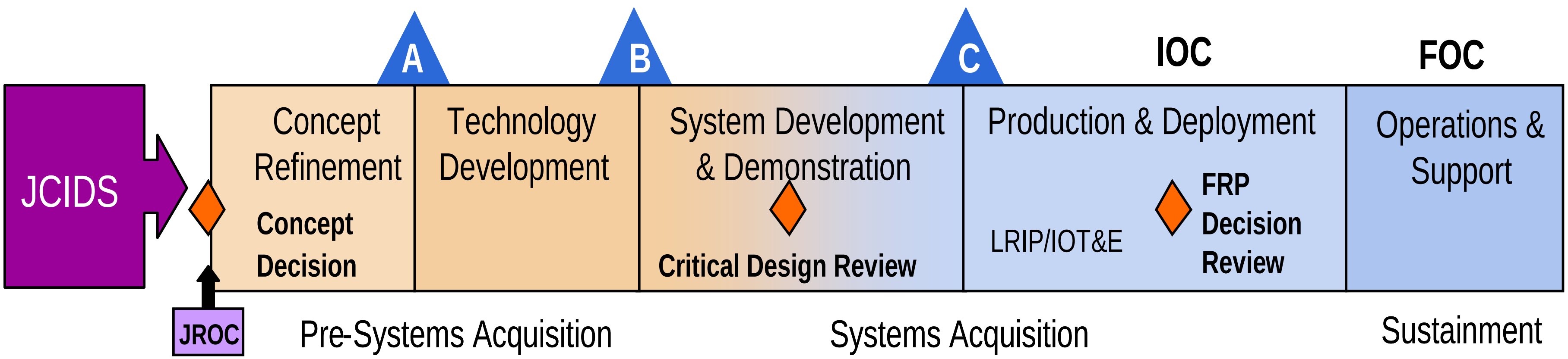
Development and Insertion of Innovative Technologies Across the Lifecycle of a Weapon System

Janet C. Wolfenbarger
Brigadier General, USAF
Director, Intelligence and Requirements
Director, D&SWS AFSO21 Office

Overview

- **Ongoing AF/AFMC initiatives to improve technology insertion:**
  - **Pre-MS B: AFSO21 Develop and Sustain Warfighting Systems (D&SWS) Technology Development (TD) Initiatives**
  - **Sustainment: Sustainment Technology Process (STP) to develop focused sustainment technology investments**

Integrated Life Cycle Management



Development and Sustainment of Warfighter Systems
“Technology Development Process”

TD 1-14 Tech Needs	TD 1-12 Tech Maturity	TD 1-13 Tech Transition

Sustainment Technology Process

Air Force Special Operations for the 21st Century (AFSO21)/D&SWS

Part of the Answer

Funding Our Priorities

"We will fund transformation through … organizational efficiencies, process efficiencies, reduction of legacy systems and manpower while sustaining GWOT and ongoing operations in support of the Joint Fight."

- Michael W. Wynne, SECAF

Integrity - Service - Excellence 1

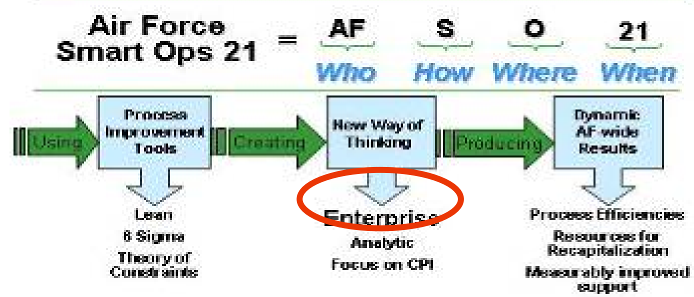
The Status Quo is Out

AFSO21

- ***-- The USAF will do less with less***
- ***-- Do what is valued by our customers***
- ***-- Employ tools and techniques smartly to reduce waste and non-value-added work, to maximize value to the warriors***

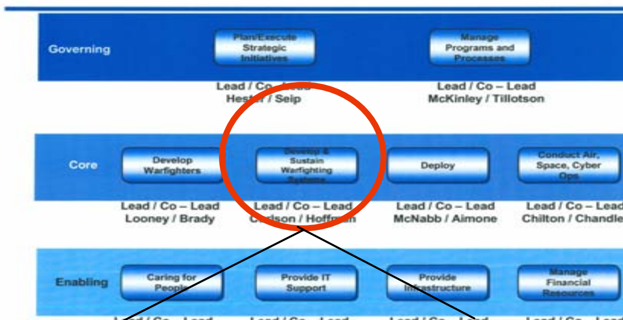
Integrity - Service - Excellence 4

AF Smart Ops 21



Integrity - Service - Excellence

CSAF Approved Process Owners



Develop and Sustain Warfighting Systems (D&SWS)

D&SWS Sub-Processes

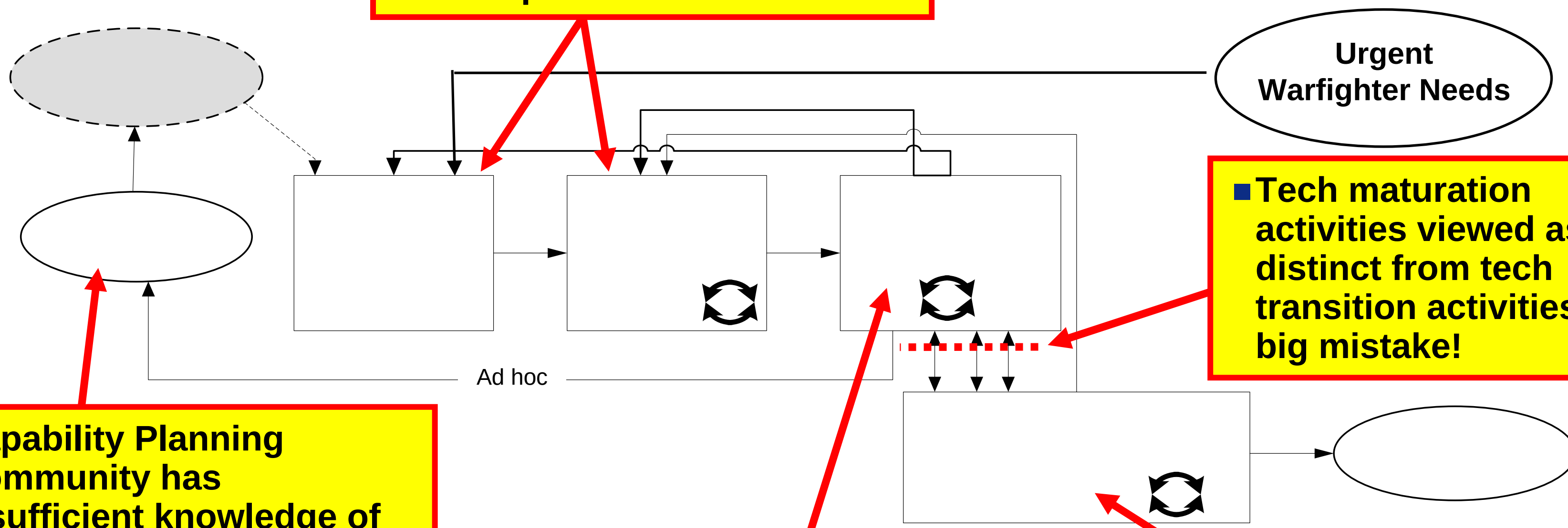
**Sub-Process Owners,* Co-Leads, Design Team Leads*

Process Owner/Co-Lead	**Gen Carlson/Lt Gen Hoffman**
Chief Process Officer	**Brig Gen Janet Wolfenbarger**

20080109

As-Is Technology Development Process

- Too many tactical (and adhoc) engagements with AF customers of S&T
- Local prioritization at best



- Tech maturation activities viewed as distinct from tech transition activities—big mistake!

- Capability Planning Community has insufficient knowledge of S&T breakthroughs
- Gov't has insufficient knowledge of industry IR&D

- Tech maturity assessed once at MS-B
- TRLs necesssary but not sufficient measure of tech maturity
- TRLs not universally understood & applied
- TDS (Tech Dev Strategy) often not created

- Tech Transition often an afterthought - too late to work the issues

D&SWS Technology Development Initiatives

TD-1-14 AF-wide process to identify and prioritize tech needs linked to capability gaps and program requirements

Benefits: Best technologies needed to achieve AF's highest priorities receive highest investment priority.

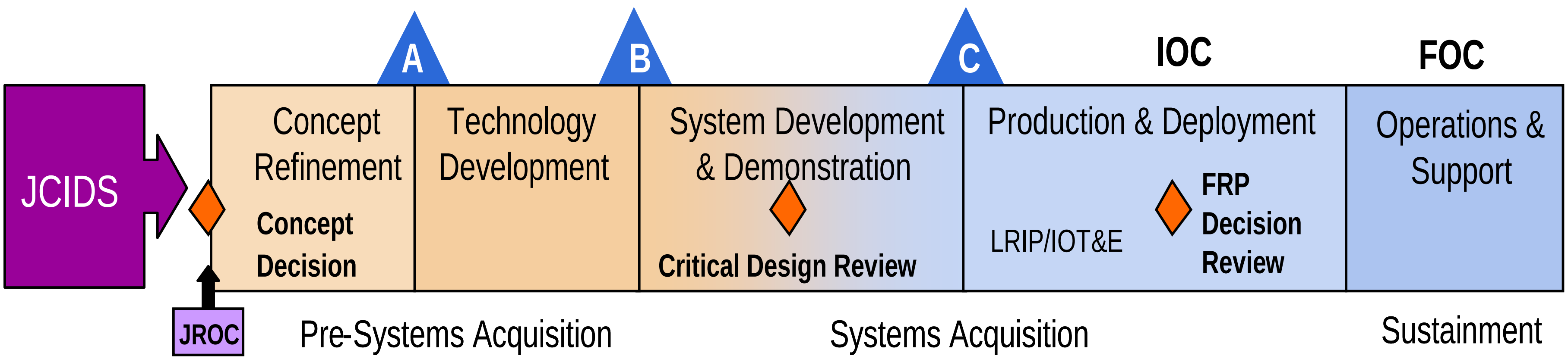
"Tech Push" better influences capability planning.

TD-1-12 Establish comprehensive "yardstick" to assess maturity of technologies (more than technology readiness levels: include testability, manufacturability, integratability, supportability, etc)

TD-1-13 Establish disciplined and collaborative "stage-gating" process to ensure highest confidence in successful technology transition

Benefits: Reverse the trend of starting SDD with immature technologies which cause RDT&E and production cost growth and schedule slips

Integrated Life Cycle Management



Development and Sustainment of Warfighter Systems
"Technology Development Process"

TD 1-14
Tech Needs

TD 1-12
Tech Maturity

TD 1-13
Tech Transition

Sustainment Technology Process

Strategy Development

Top Down Capability Driven Process to Support Strategic Sustainment Technology Investments

Strategic Drivers

E-Log21
- Reduced O&S Costs and increase system availability

AFMC Balance Scorecard
- Sustain Weapon Systems
- Improve equipment availability at reduced cost
- Enhance Sys Reliability

Customer Needs
- MAJCOMs
- AFMC

AFRL FLTC
- Affordable Mission Generation & Sust

Agile Combat Support
- Agile, Responsive & Effective Sustainment

Strategic Thrusts

- **Improve the sustainability of weapon systems, and influence the sustainability of new systems in development**
- **Improved Inspection, Fault Detection, Prognostics and Diagnostics Capability (Sense and Respond)**
- **Apply Advanced Practices for Maintenance, Repair & Overhaul, Production Processes, and Supply Chain management**

Focus Areas

- Crack & Corrosion Detection
- Coat/Decoat
- NDI
- LO Maintainability
- CBM + Integrity
- Maintenance Shop Improvements
- Aircraft Subsystem Diagnostics
- AGE, Test Equip & Avionics
- Obsolescence Management
- Supply Chain Enhancements

Technology Working Groups

- Airframe Sustainment - TWG
- Propulsion Sustainment - TWG
- MRO&P Sustainment - TWG
- Combat Sustainment - TWG

Governance Structure

Strategic Vision & Sustainment Thrust

Senior Sustainment Steering Committee (S3C)

GO & SES

Chair: AFMC/A4
Co-Chair: AFMC/A2/5

Members

AAC/CA	AFRL/CA	NWC/CC
ACC/A4/A8	AFSOC/A4	OC-ALC/CA
AEDC/CA	AFSPC/A4	OO-ALC/CA
AETC/A4	AMC/A4	SAF/AQR
AF/A4 M/A4RC	ASC/CA	SAF/IEL
AFMC/A3/A8/EN/FM	ESC/CA	WR-ALC/CA

Guidance

Internal Resources
- AFRL
- AFMC Centers
- AFMC Corporate Process
- AFMC CMPs

Advocacy

External Funding Sources
- MAJCOM, OSD
- Programs

Sustainment Review Group

O-6 & GS-15

Chair: AFMC/A4D
Deputy: AFMC/A5S

Members

SAF/AQRC, AQRT, IEL AF/A4MM, HQ AFMC/A2/5, A3, A4, A8, EN, FM, AFMC Centers EN, XR, XP AFRL/PR MAJCOMs A4, A8

AFMC CMPs

Technology Working Groups

AFMC Centers

MAJCOMS

Outputs
- High Priority Sustainment Tech Needs
- Planning Documents
- ID Funding Source

Requirements Generation/Transition Agents

Accomplishments

- **Expanded S3C membership to include MAJCOMs**
- **S3C approved sustainment technology needs:**
  - **Submitted for OSD transition/sustainment funding sources, i.e., Quick Reaction Funds, Reduction in Total Ownership Cost (RTOC)**
  - **Guided FY09 APOM and FY10 POM (Aging Aircraft and S&T supporting Affordable Mission Generation & Sustainment)**
    - Funded projects include: Condition Based Maintenance Plus, Non-destructive Inspections, LO Maintainability, and Improved Depot Processes

STP Next Steps

- Leverage Industry Research & Development (IR&D) and Small Business Innovation Research (SBIR) Commercialization Pilot Program (CPP)
- Technology Roadmap Development
  – Provides a WBS structured approach to acquire, test, and implement critical sustainment technology to meet a specified capability
  – Utilizing A2/5 modified Capability Based Roadmap Tool
- STP Performance measures being developed and implemented ECD: Jun 08
- Finalizing governance document: AFMCI 61-103; S&T and Technology Transition Planning

Summary

Objective is to develop and insert innovative technologies across the lifecycle of a weapon system

- **Pre-MS B: D&SWS initiatives focus on identifying highest priority needs, improved technology maturity assessments and establishing high confidence gated technology transition**
- **Sustainment: Strategy-to-task driven process to support cross-cutting sustainment technology investments**

AFMC and the AF are pressing forward with revolutionary initiatives to
Develop & Insert Innovative Technologies into AF Weapons Systems

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Approved for Public Release IAW AFI 35-101: AFMC 08-070

The DoD T&E / S&T Program

Gerry Christeson

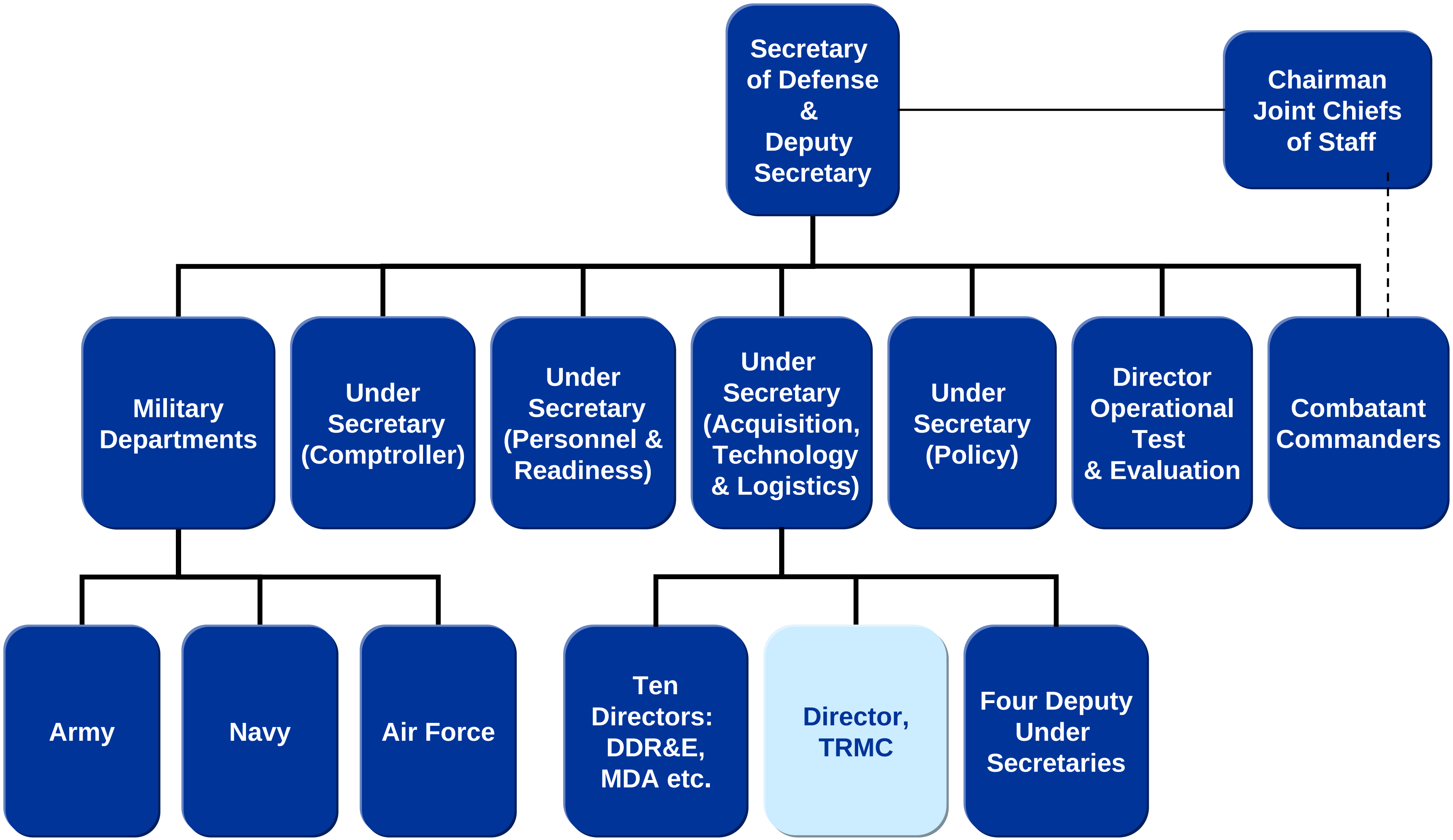
Defense Test Resource Management Center
Deputy Program Manager
Test & Evaluation / Science & Technology Program

NDIA 9TH Annual Science & Engineering Technology Conference

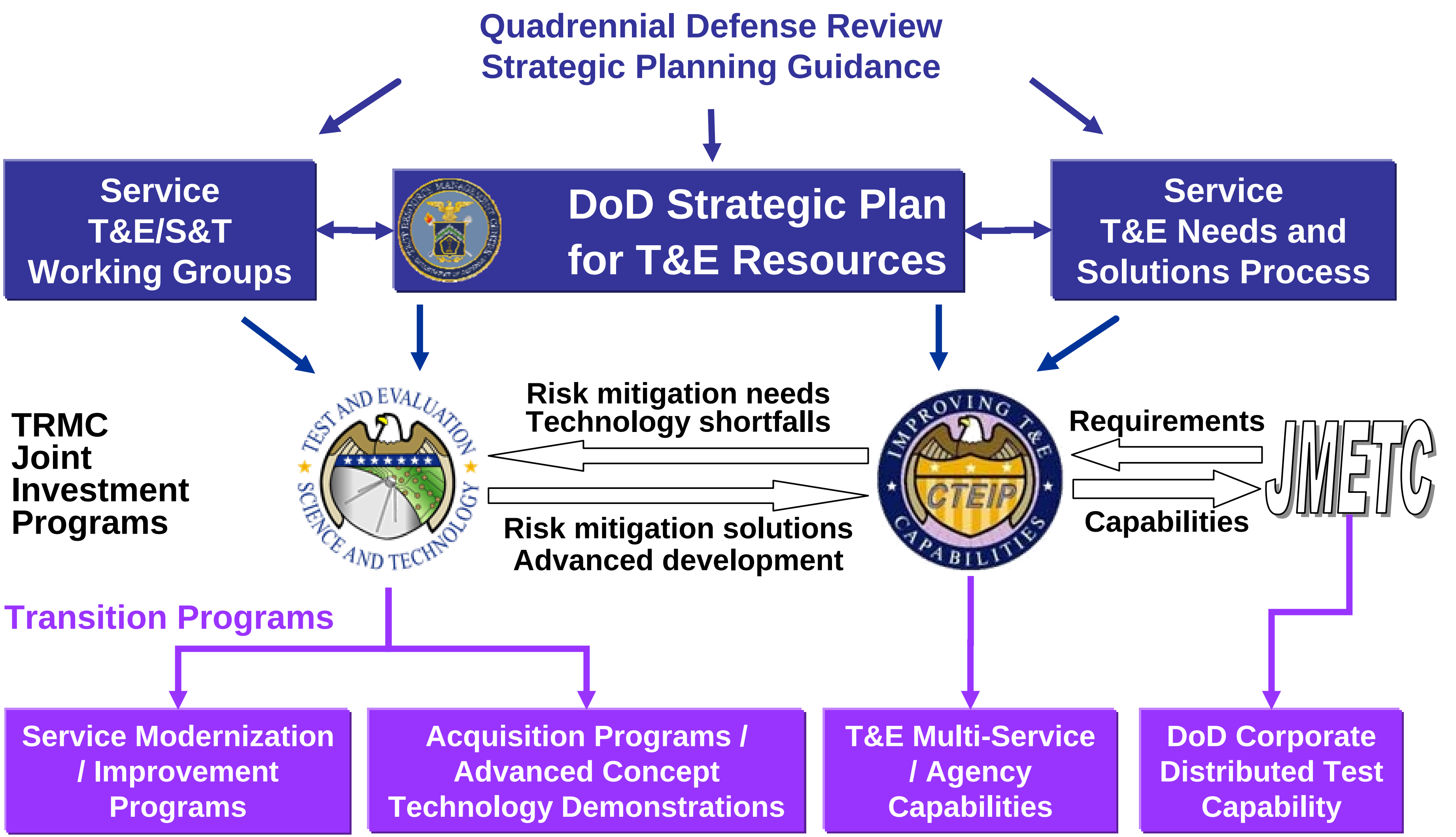
Test Resource Management Center (TRMC)
Sec. 231, FY 2003 National Defense Authorization Act
DoD Directive 5105.71, March 8, 2004

- DoD Field Activity
  - Established to ensure that the DoD T&E infrastructure is adequate to support the development and acquisition of defense systems
- Annually certify that the T&E budgets of the military departments and defense agencies are adequate
- Develop a biennial strategic plan that assesses T&E requirements for a period of ten years and identifies required T&E infrastructure investments
- Responsible for T&E infrastructure policy for DoD's Major Range and Test Facility Base (MRTFB)
- Administer three major T&E investment programs:
  - Joint Mission Environment Test Capability Program (JMETC)
  - Central Test and Evaluation Investment Program (CTEIP)
  - Test and Evaluation/Science and Technology (T&E/S&T) Program

TRMC T&E/S&T
Direct Report to USD(AT&L)



Synergy through Aligned Investment



T&E/S&T Program
Overview

- **Test & Evaluation / Science & Technology (T&E/S&T) Program started in FY 2002**
  - **Joint DDR&E / DOT&E initiative**
- **Mission**
  - **Investigate and develop new technologies required to test and evaluate our transforming military capabilities**
    - ➢ **Include any system that makes our warfighters more survivable and effective in combat**
    - ➢ **Mature test technologies from TRL 3 to 6**
- **Goal**
  - **Transition emerging technologies into test capabilities in time to verify warfighting performance**

Shaping Technology into Tomorrow's T&E Capabilities

Why a T&E/S&T Program?

- Nanotechnology
- Biometrics
- Genetic algorithms
- Microelectromechanical systems
- Adaptive optics
- High power microwaves
- High energy lasers
- Synthetic instrumentation
- Multispectral seekers
- Autonomous systems
- Hypersonics
- Intelligent agents

T&E/S&T Program Office

- **What We Do?**
  - Fund high risk / high pay-off T&E R&D projects
  - Foster technology transition to MRTFB and other DoD T&E field activities
- **How We Do It?**
  - Issue annual Broad Agency Announcement (BAA)
  - Tri-Service working groups draft BAAs and participate in proposal evaluation
  - Award T&E R&D projects starting at TRL3 and mature to TRL6
  - Executing Agents (EA) manage test technology Focus Areas
- **Who Do We Fund?**
  - Academia
  - Industry
  - Government laboratories
  - Teams of academia / industry / government labs

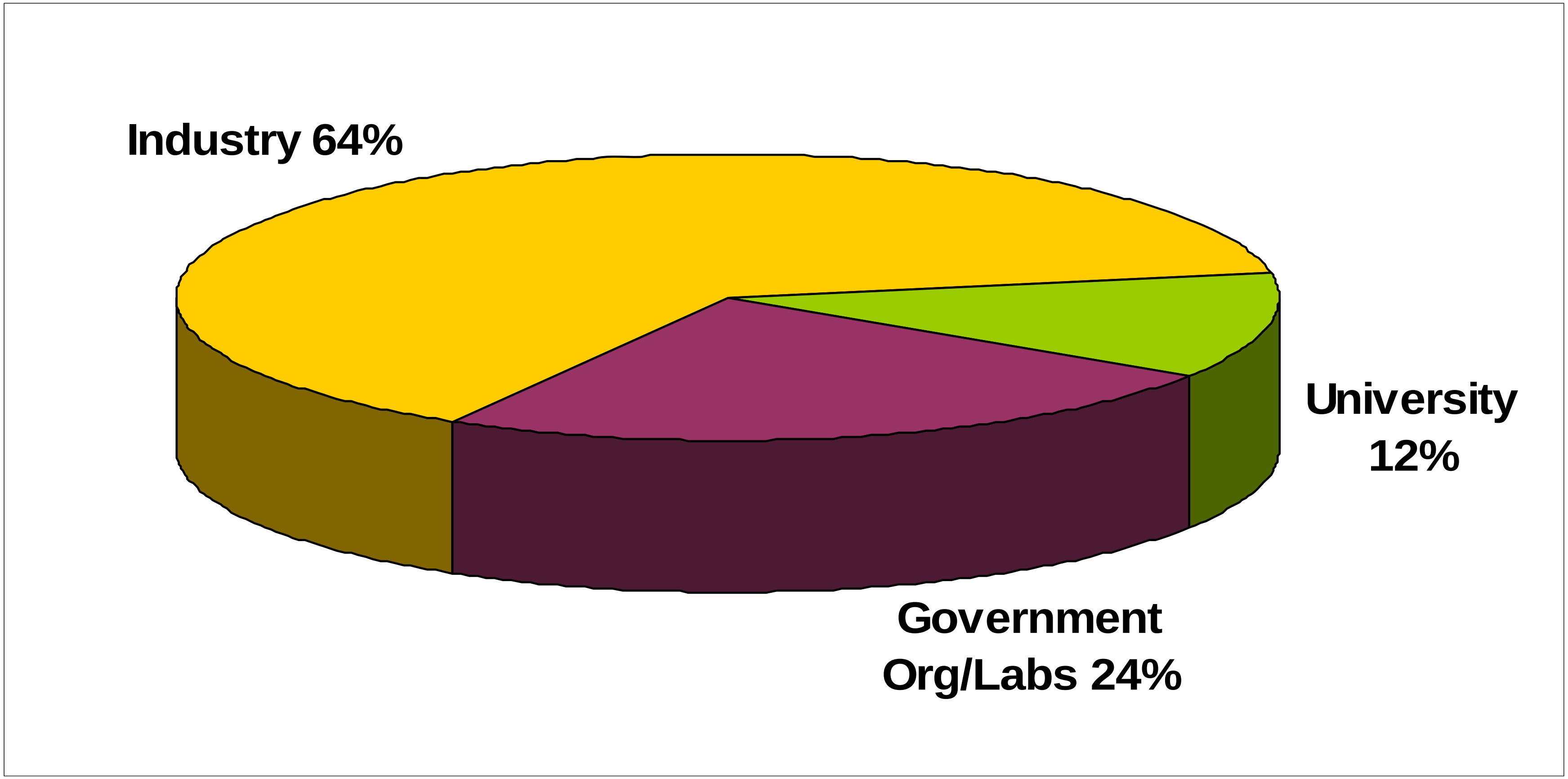
Technology Readiness Level

TRL 9	Actual system 'flight proven' through successful mission operations
TRL 8	Actual system completed and 'flight qualified' through test and demonstration
TRL 7	System prototype demonstration in an operational environment
TRL 6	System/subsystem model or prototype demonstration in a relevant environment
TRL 5	Component and/or breadboard validation in relevant environment
TRL 4	Component and/or breadboard validation in laboratory environment
TRL 3	Analytical and experimental critical function and/or characteristic proof of concept
TRL 2	Technology concept and/or application formulated
TRL 1	Basic principles observed and reported

T&E Technology Transition

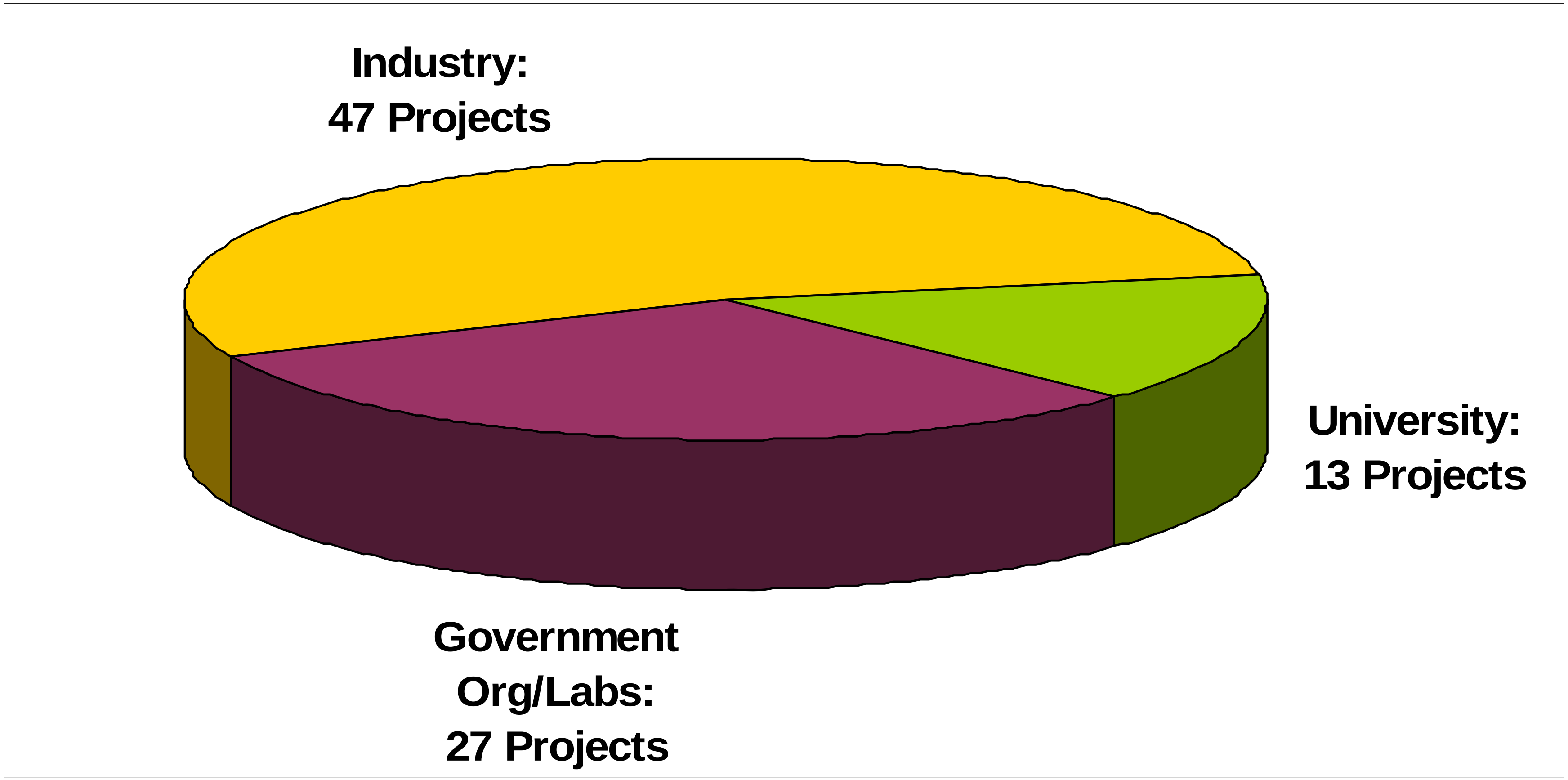
Cost to Achieve

FY 2008 Funding Distribution



Note: numbers apply only to FY08 funding profile

FY 2008 Project Distribution



Note: numbers apply only to FY08 funding profile

FY08 T&E/S&T Focus Areas

- **Directed Energy Test (DET) –** On-board and off-board technologies to assess performance of high energy laser and high power microwave weapon systems
- **Hypersonic Test (HST) –** Technologies to provide high fidelity environments, M&S and instrumentation for testing of air breathing hypersonic vehicle propulsion and flight systems
- **Multi-Spectral Test (MST) –** Technologies to enable real-time, realistic T&E of multi-spectral and hyperspectral seekers and sensors through scene injection and projection
- **Non-Intrusive Instrumentation (NII) –** Technologies for non intrusive sensors, data storage, and power sources to provide continuous, non-obtrusive T&E

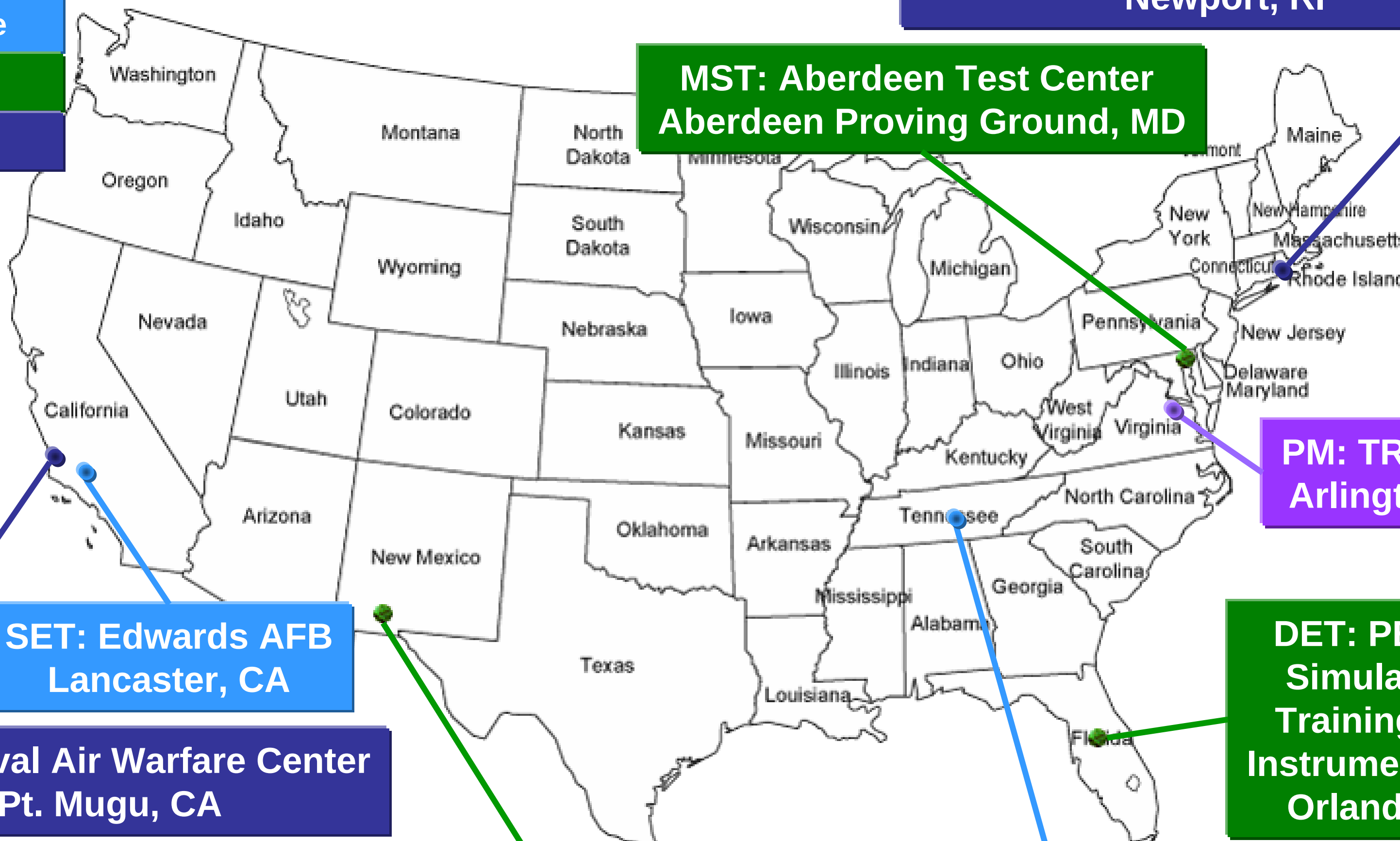
FY08 T&E/S&T Focus Areas (cont.)

- **Netcentric Systems Test (NST) –** Technologies to measure and assess the performance of the physical, information and cognitive domains of Joint, integrated architectures
- **Spectrum Efficient Technology (SET) –** Technologies to enable more efficient use of legacy telemetry bands and expand into non-traditional areas of the RF spectrum and the optical spectrum
- **Unmanned Autonomous Systems Test (UAST) –** Technologies for T&E of unmanned systems ranging from full tele-operation to totally autonomous, learning performance

111 active projects

T&E/S&T Program Management

- TRMC HQ
- Air Force
- Army
- Navy



NII: Naval Undersea Warfare Center
Newport, RI

MST: Aberdeen Test Center
Aberdeen Proving Ground, MD

PM: TRMC HQ
Arlington, VA

DET: PEO for Simulation, Training and Instrumentation
Orlando, FL

SET: Edwards AFB
Lancaster, CA

NST: Naval Air Warfare Center
Pt. Mugu, CA

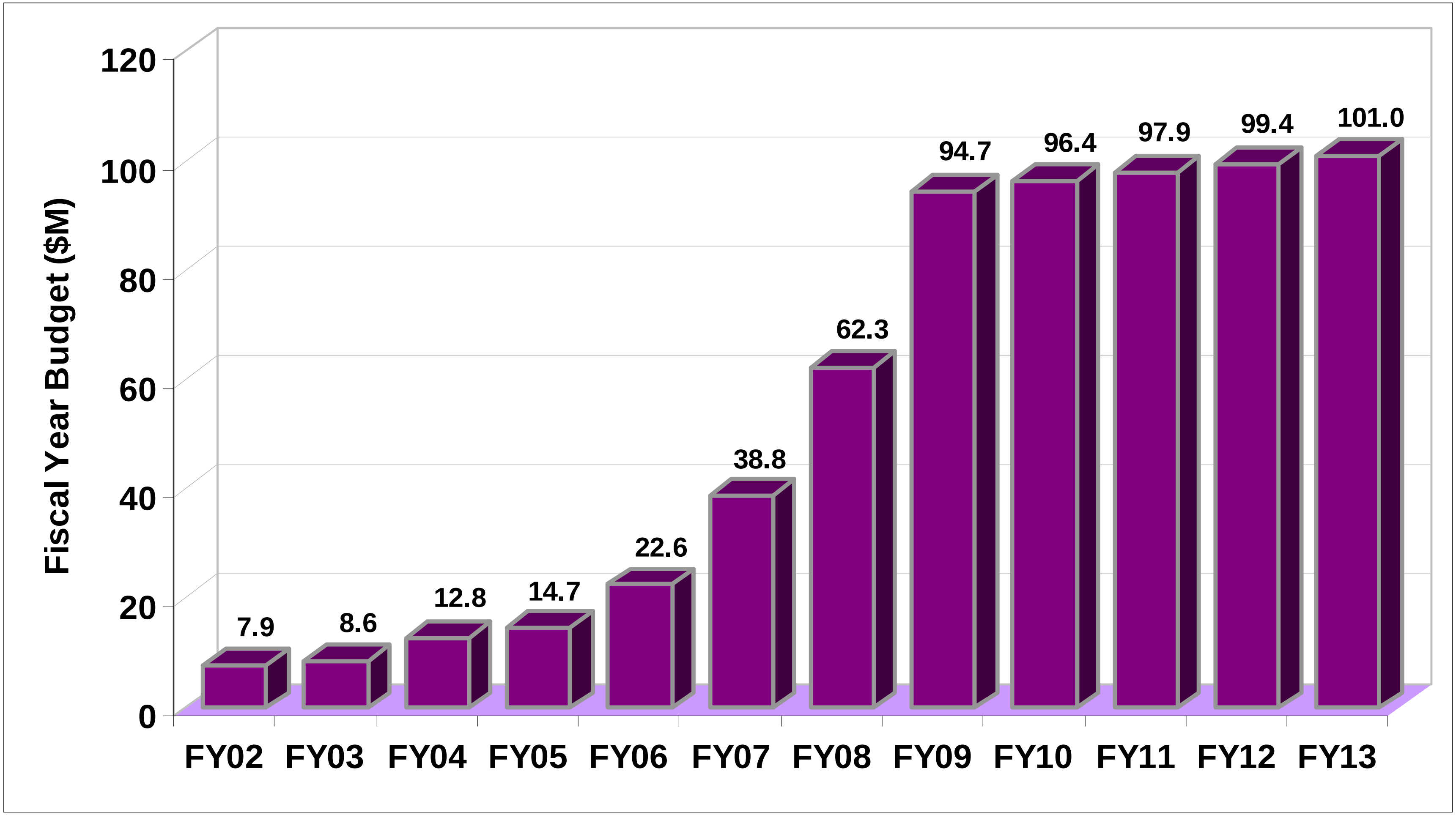
UAST: White Sands Missile Range
Las Cruces, NM

HSHT: Arnold Engineering and Development Center
Tullahoma, TN

Working Groups

Army	AMRDEC	IEW
	AMSAA	NVESD
	ARL	OTC
	ATC	PEO STRI
	ATEC	RDEC
	ATTC	RTTC
	HELSTF	TRADOC
Navy	NAVAIR	NAWC
	NAVSEA	NUWC
	NRL	SPAWAR
Air Force	AEDC	AFRL
	AFEWES	AFWDC
	AFFTC	46th TW
	AFOTEC	452nd FLTS
DoD	DDR&E	JCS
	DISA / JITC	JFCOM
	DOT&E	

T&E/S&T Program Annual Budget



T&E/S&T Program
Project Selection Process

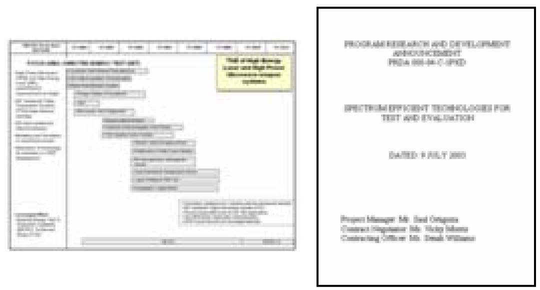
Drivers

Tri-Service Focus Area Working Group

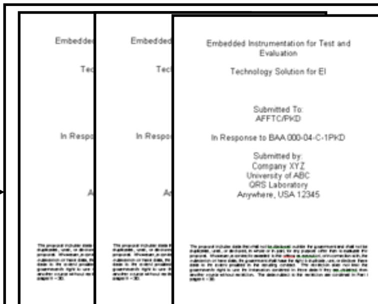
- Executing Agent
- T&E Community Reps
- S&T Community Reps
- Subject Matter Experts

Needs/Requirements

Solicitations are issued through http://www.fedbizopps.gov



Roadmaps and Solicitations



Proposals

Source Selection Evaluation Team

- Working Group
- Subject Matter Expert
- Contracting Reps

Recommendations

Executing Agent

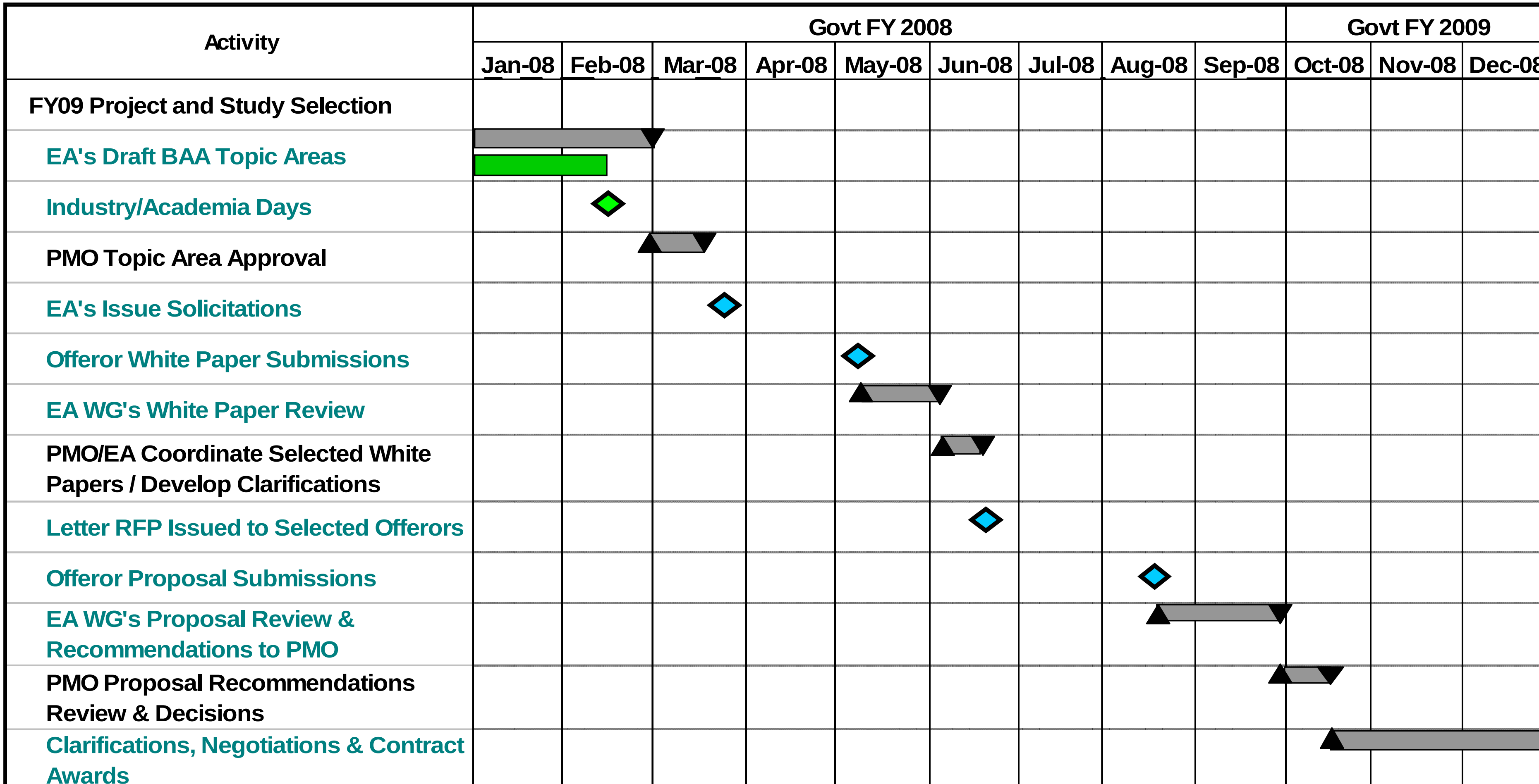
Final Selections

Program Manager

Funding Decision

Focus Area Execution

BAA Schedule



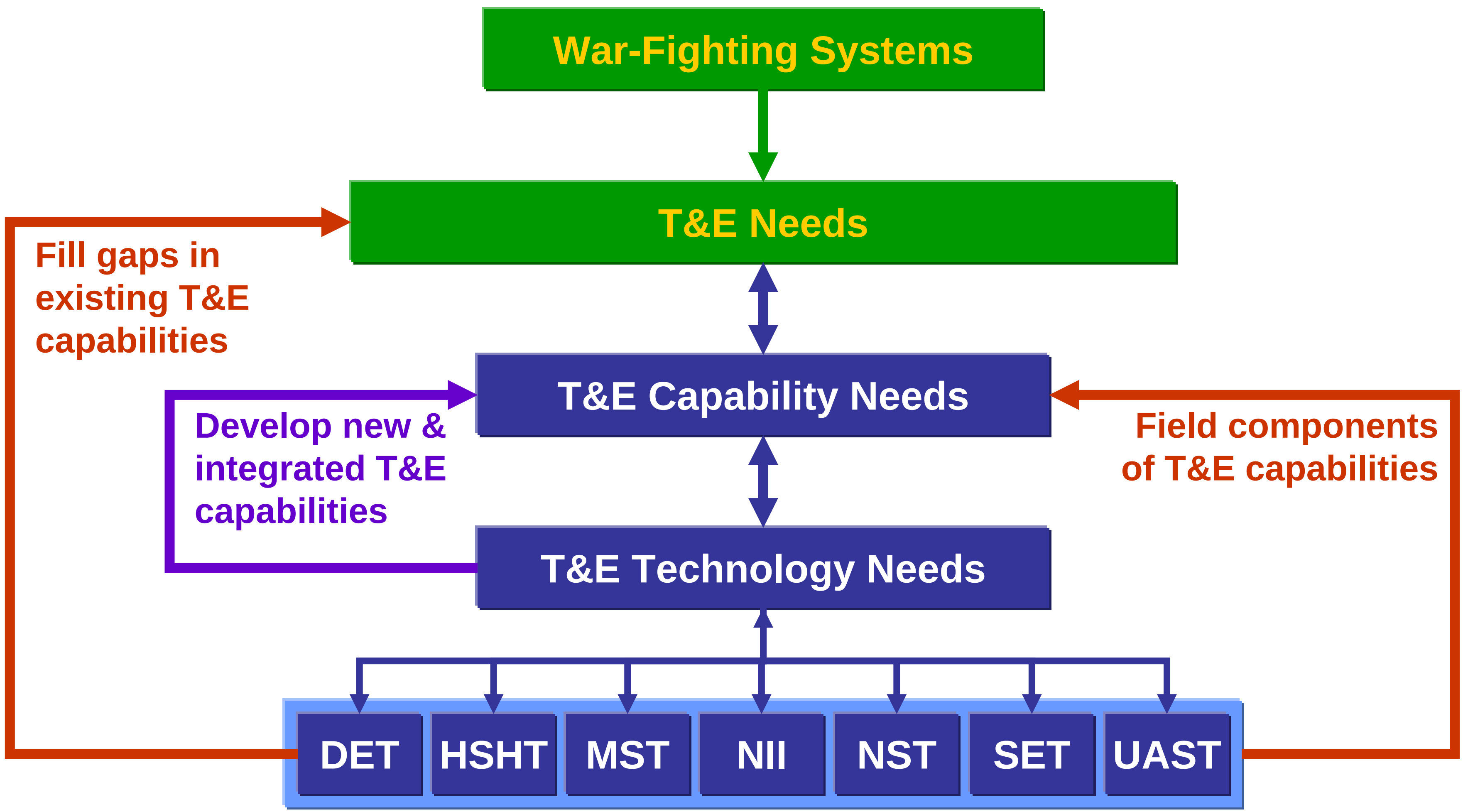
BAA – Broad Agency Announcement | **EA – Executing Agent** | **WG – Working Group**

PMO – Program Management Office | **RFP – Request for Proposal** | **FY – Fiscal Year**

The Proposal — Key Criteria

- **Meets a T&E Need**
- **Requires S&T work**
- **High Risk / High Payoff**
- **Broad application (more than one DoD test activity)**
- **High potential for transition to development of a test capability**

Technology Development Framework



Partnerships

- Partnerships between universities, industry & DoD laboratories
  - Form the best research teams possible
- Collaborate to pursue bigger opportunities
  - Leverage each others’ core competencies
  - Share resources
- Increase transition opportunities through increased involvement in the T&E/S&T Program

Success Stories

- **In-Situ Pressure Measurement**
  - <u>Transitioned</u> to the hypersonic HyFly program which is sponsored by the Office of Naval Research and the Defense Advanced Research Projects Agency
- **Tactical-Report Generation Test Bed**
  - <u>Transitioned</u> to the CTEIP Interoperability Test and Evaluation Capability (InterTEC) program and to Joint Forces Command for automated netcentric test planning and scenario development
- **Steerable Beam, Directional Antenna Concepts**
  - <u>Transitioned</u> technology to the CTEIP integrated Network Enhanced Telemetry (iNET)

Success Stories (cont.)

- **Heat Flux Sensor**
  - **Transitioned to Arnold Engineering Development Center for aerothermal measurements by miniaturized heat flux sensors at high temperatures—used in the Shuttle Return-to-Fly Program**
- **Directed Energy Data Acquisition Transformation**
  - **Transitioned to Naval Surface Warfare Center, Dahlgren for conducting T&E of High Power Microwave Systems**
- **Multi-Spectral Stimulator Injection Test Method**
  - **Transitioned to U.S. Army Redstone Technical Test Center Future Force/Future Combat Systems for hardware-in-the-loop testing of multispectral systems**

Summary

- Only DoD S&T program for T&E
- Tri-Service participations
- Focus on transition
- Partnerships
  - Government labs / ranges
  - Industry
  - academia

Questions?

Contact Information:

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Defense Test Resource Management Center
Deputy Program Manager
T&E / S&T Program
Gerald.Christeson@osd.mil

Back Up

T&E Needs

The R&D project:

- **Addresses the T&E requirements**
- **Fills known T&E gaps**
- **Articulates how the above are to be achieved**

Example: T&E Need

Ground test facilities generally use combustion processes to create representative flight conditions for hypersonic engine testing. The effects of vitiates on the engine performance is not well known. Ground test facilities need a clean air test capability to more realistically simulate actual flight conditions to accurately predict engine performance in flight.

S&T Challenges

The R&D project:

- **Develops new test & evaluation capabilities that do not currently exist**
- **Utilizes /develops beyond state-of-the-art technologies that can be high-risk**
- **Pushes technology to new limits**

Example: S&T Challenges

- Develop resistively heated elements to routinely operate between 2200 to 2400 Kelvin (4535 to 4927 deg F)
- Develop electrical interface materials that can maintain high current (60 Amp or greater) electrical and mechanical connection at extreme temperatures
- Develop element materials and shapes that can withstand temporal temperature cooling gradients of at least a thousand degrees a minute and maintain air seal to prevent internal cooling air from leaking into external airflow and cooling it

Manufacturing Readiness Levels (MRLs) Manufacturing Readiness Assessments (MRAs) In an S&T Environment

Air Force Research Laboratory | AFRL
Science and Technology for Tomorrow's Aerospace Force

AF ManTech
UNITED STATES AIR FORCE

U.S. AIR FORCE

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Manufacturing Technology Division
Phone # 937-904-4600
Jim.Morgan@wpafb.af.mil

Why MRLs?

***"Advanced weapon systems cost too much, take too long to field, and are too expensive to sustain"* -- Congress, OSD, CSAF, GAO**

- Production/manufacturing processes are major contributor
  - A GAO study of core set of 26 programs: RDT&E costs up by 42% and schedule slipped by 20%
    - $42.7B total cost growth
    - 2.5 years average schedule slip
  - Characteristics of successful programs:
    - *Mature technologies, stable designs, **production processes in control***
    - ***S&T organization responsible for maturing technologies**, rather than program or product development manager*
- Need way to mitigate impact of diminishing manufacturing infrastructure
  - People, policy, programs gutted
  - Lost recipe on how to manage manufacturing risk
  - Won't get infrastructure back but still need to manage manufacturing risk

Technology Readiness Levels
(TRLs)

Provide a common language and widely-understood standard for:

- Assessing the *performance maturity* of a technology and plans for its future maturation
- Understanding the level of performance risk in trying to transition the technology into a weapon system application

TRLs leave major transition questions unanswered:

- Is the technology producible? Reproducible?
- What will these cost in production?
- Can these be made in a production environment?
- Are key materials and components available?

Manufacturing Readiness Levels
(MRLs)

- Common language and standard for
  - Assessing the ***manufacturing maturity*** of a technology or product and plans for its future maturation
  - Understanding the level of manufacturing risk in trying to produce a weapon system or transition the technology into a weapon system application
- Designed to complement TRLs
- Designed to help set the agenda for manufacturing risk mitigation
- Usage
  - Army, for Future Combat Systems development efforts
  - Missile Defense Agency using EMRLs on all development programs
  - Several defense primes using on weapon system programs
  - ***Mandated by AFRL on all hardware CAT I ATDs***

MRL Relationships

Relationship to System Acquisition Milestones

Pre-Concept Refinement	Concept Refine-ment	Technology Development	System Development & Demonstration	Production & Deployment

A B C

MRL 3	MRL 4	MRL 5	MRL 6	MRL 7	MRL 8	MRL 9	MRL 10
Mfg Concepts Identified	Mfg Processes In lab Environment	Components In Production Relevant Environment	System or Subsystem In Production Relevant Environment	System or Subsystem In Production Representative Environment	Pilot Line Demonstrated Ready for LRIP	LRIP Demonstrated Ready for FRP	FRP Demonstrated Lean Production Practices in place

TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6	TRL 7	TRL 8	TRL 9
Basic Principles Observed	Concept Formulation	Proof of Concept	Breadboard in Lab	Breadboard in Rep Environment	Prototype in Rep Environment	Prototype in Ops Environment	System Qual	Mission Proven

Relationship to Technology Readiness Levels

MRL Evaluation Criteria (Threads)

- Technology and Industrial Base
- Design
- Materials
- Cost and Funding
- Process Capability and Control
- Quality Management
- Manufacturing Personnel
- Facilities
- Manufacturing Management

MRL Evaluation Criteria (Threads)

S&T Phase		6.2 / 6.3	6.3 / 6.4	6.3 / 6.4 / 7.8	6.4 / 6.8 / 7.8	7.8
Acq Phase		Pre CR		TD		SDD
Thread	Sub-Thread	MRL 3	MRL 4	MRL 5	MRL 6	MRL 7
Technology & Industrial Base	Technology Maturity	TRL 3	Should be assessed at TRL 4.	Should be assessed at TRL 5.	Should be assessed at TRL 6.	Should be assessed at TRL 7
	Technology Transition to Production	Potential manufacturing sources identified for technology needs. (Commercial/Government, Domestic/Foreign)	Industrial Base capabilities and gaps/risks identified for key technologies, components, and/or key processes.	Industrial Base assessed to identify potential manufacturing sources.	Industrial Capability Assessment (ICA) for MS B has been completed. Industrial capability in place to support mfg of development articles. Plans to minimize sole/foreign sources complete. Need for sole/foreign sources justified. Potential alternative sources identified.	Industrial capability to support production has been analyzed. Sole/foreign sources stability is assessed/monitored. Developing potential alternate sources as necessary.
	Manufacturing Technology Development	Initial demonstration of Mfg Science	Mfg Science & Advanced Mfg Technology requirements identified	Required manufacturing technology development efforts initiated.	Manufacturing technology efforts continuing. Required manufacturing technology development solutions demonstrated in a production relevant environment.	Manufacturing technology efforts continuing. Required manufacturing technology development solutions demonstrated in a production representative environment.
Design	Producibility Program	Evaluate relevant materials/processes for manufacturability & producibility	Producibility & Manufacturability assessment of design concepts completed. Results guide selection of design concepts and key components/technologies for Technology Development Strategy. Manufacturing Processes assessed for capability to test and verify in production, and influence on O&S.	Producibility & Manufacturability assessments of key technologies and components initiated. Systems Engineering Plan (SEP) requires validation of design choices against manufacturing process and industrial base capability constraints.	Producibility assessments of key technologies/components and producibility trade studies (performance vs. producibility) completed. Results used to shape System Development Strategy and plans for SDD or technology insertion programs phase.	Detailed producibility trade studies using knowledge of key design characteristics and related manufacturing process capability completed. Producibility enhancement efforts (e.g. DFMA) initiated.
	Design Maturity	Evaluate product lifecycle requirements and product performance requirements.	Systems Engineering Plans and the Test and Evaluation Strategy recognize the need for the establishment/validation of manufacturing capability and management of manufacturing risk for the product lifecycle. Initial Key Performance Parameters (KPPs) identified.	Identification of enabling/critical technologies and components is complete and includes the product lifecycle. Evaluation of design Key Characteristics (KC) initiated.	Basic system design requirements defined. All enabling/critical technologies/components have been tested and validated. Product data required for prototype manufacturing released. A preliminary performance as well as focused logistics specification is in place. Key Characteristics and tolerances have been established.	Product requirements and features are well enough defined to support detailed systems design. All product data essential for manufacturing of component design demonstration released. Potential KC risk issues have been identified and mitigation plan is in place. Design change traffic may be significant.

Air Force MRL Implementation Approach

In partnership with Joint Defense Manufacturing Technology Panel (JDMTP)

- Conduct pilot MRAs on various programs
  - Advanced Technology Demonstration programs
  - Weapon system acquisition programs
  - Demonstrate benefits of using MRLs
- Conduct training for key program personnel
  - What are MRLs, how to conduct an MRA
    - Air Force ManTech personnel
    - Category I ATD IPTs and ACAT pilot program personnel
  - Utilize various training materials that can be tailored
  - Transition to DAU once MRLs are in policy
- Put MRLs into policy documents
  - AFRL, AFMC, AF, DoD

MRL Incorporation into AFRL ATDs

- AFRL/RXM conducted ATD pilot assessments on five ATDs, Nov 04 – May 05
  - Identified gaps in manufacturing maturity that would delay technology transition upon ATD graduation
    - Highlighted what was required to turn technologies into products
  - Tasked by AFRL/CA to implement MRLs into all “hardware” intensive ATDs
    - Developed three year plan to reach steady state
    - Developed basic MRL implementation process
    - Developed training for ATD IPTs and ManTech personnel
- Identified core ManTech funding for MRAs and selected follow-on MRL maturation
- Now taking on all CAT I “hardware” intensive ATDs

Manufacturing Readiness Level Implementation
Approach (ATDs)

INTRODUCTION

- Meet with PM to get buy-in and gather program info
- Customize MRL approach for program

TRAIN

- Train program IPT on manufacturing tools to support manufacturing maturity efforts

OBJECTIVE STATEMENT DEFINED

- Define objective of program
- Define what is to be assessed and why

ASSESS

- Determine current MRL
- Develop plan, actions, and estimate costs to get to target MRL
- Schedule for implementation

INCORPORATE

- Incorporate MRL into program baseline

MANAGE

- Manage overall process
- Manage risk identification and reduction process
- Manage manufacturing maturity to target MRL
- Reassess as appropriate

- **Hardware-intensive**
- **Critical mass of time to complete**
- **Newly developed products**

MRA Deliverables

- Identification of ***current MRL***
- Identification of key factors where manufacturing readiness falls short of ***target MRL***
  - Define driving issues
  - Define high risk areas
- Identify programs and plans to reach target MRL
  - Generate the manufacturing maturation plan (MMP)
- Assess type and significance of risk to cost, schedule and/or performance

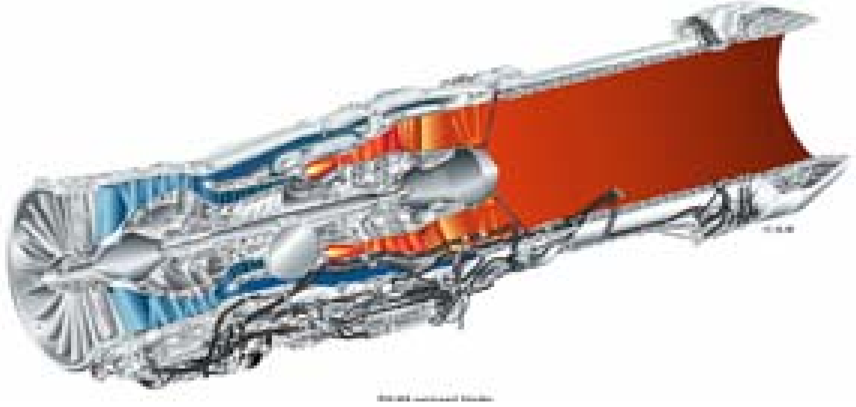
Emerging MRA Successes

High Durability Hot Exhaust Structures

- Provided identification of high risk processes and single point failures driving scale-up from MRL 3
- Maturation plan provides awareness of issues relating to move to new production facility
- Follow-on MRA at new facility will help ensure transition success

F135

- Enabling opportunity to accelerate transition for F135 thrust improvement by ~4 years
- Advanced feature high cost driver: must overcome producibility issues
- Developed plan to mature from MRL 3 to 5 leveraging commercial and military IR&D, F135 program, and ManTech funding



Emerging MRA Success

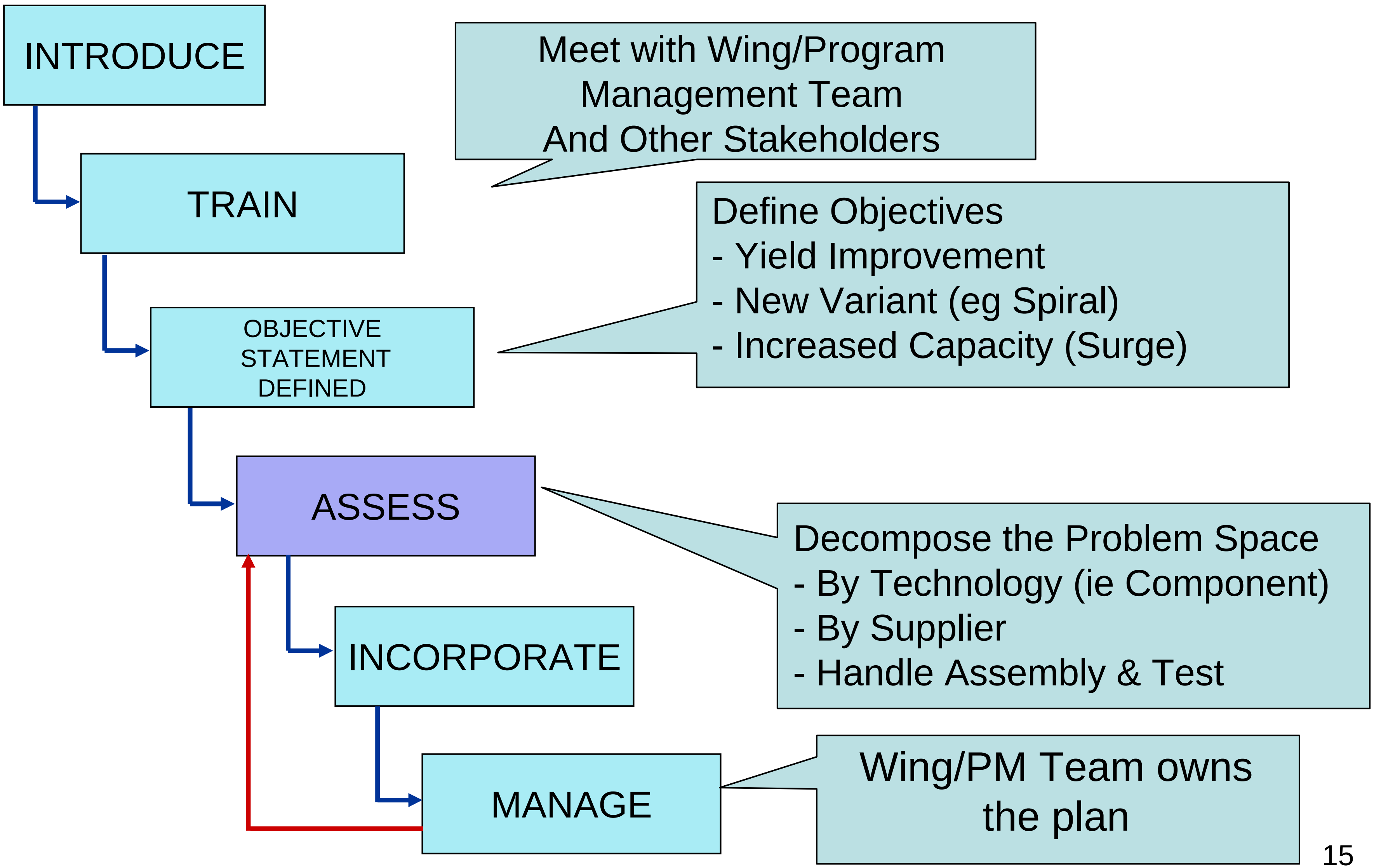
Sensor Hardening for Tactical Systems (Two contractors)

- Identified common manufacturing readiness driver among both contractors -- Optical Power Limiter (OPL) -- MRL 3
- Drilling down into OPL supplier processes to identify root issues -- OPL also likely driver on Sensor Hardening for UAS ATD
- MRA enabling identification of common manufacturing issues and ManTech investment opportunity

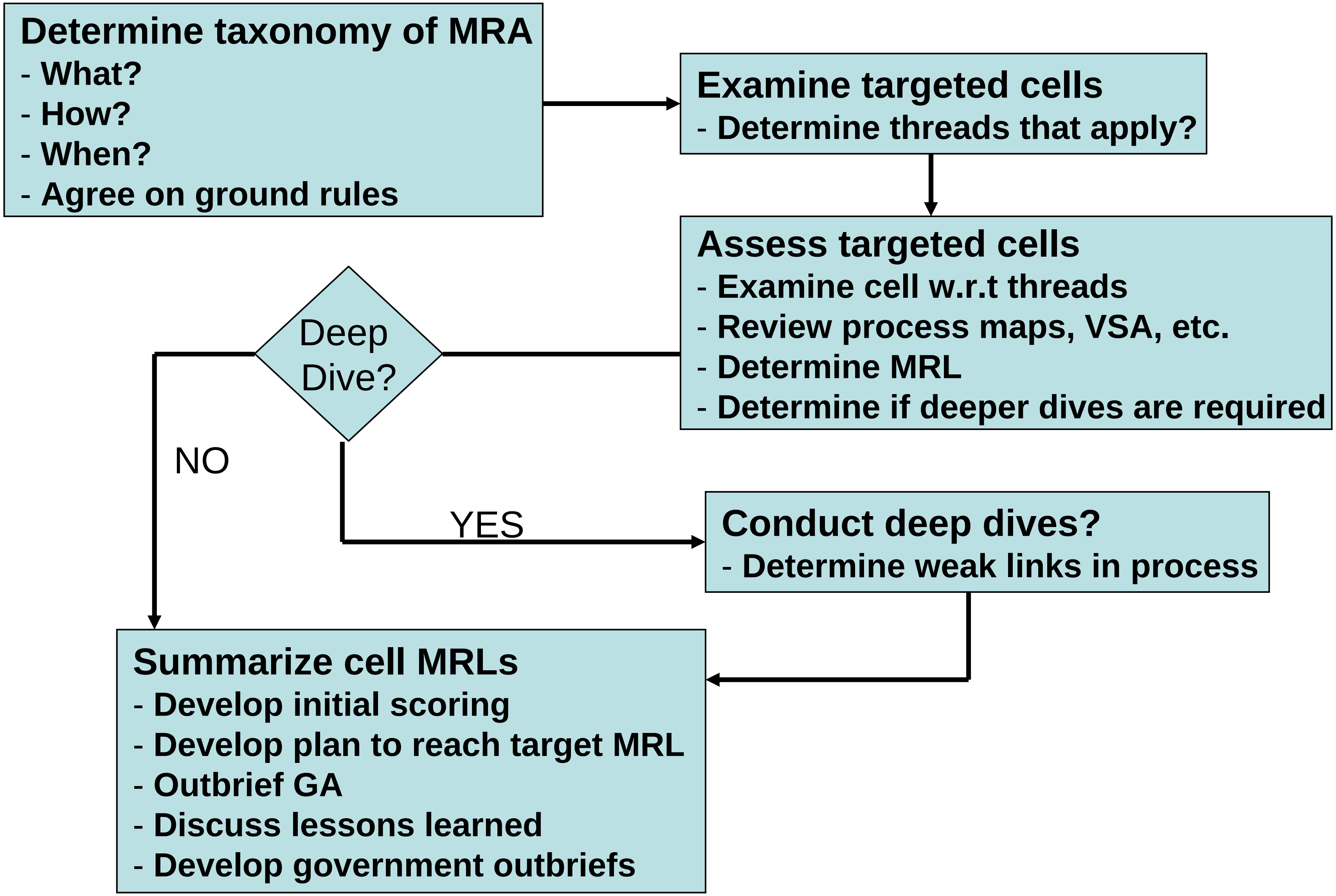
ACAT MRA Pilot

- **Translate the successful MRL ATD process to acquisition programs**
- **Common themes**
  - **Utilize approximately the same process**
  - **Utilize current MRL definitions to assess against**
  - **3-5 people per MRA**
- **What is different**
  - **ATDs focus on MRL 3 – MRL 6**
    - **Assess manufacturing maturity with a goal of transition/implementation**
  - **ACATs focus on MRL 4 – MRL 9**
    - **Schedule, cost, manning considerations**
    - **Milestone decisions**
    - **Production planning process**
    - **Will require a more rigorous approach**
- **Develop and document a structured ACAT assessment approach**
  - **MRA Deskbook**
    - **First draft completed Mar 07 based on ATD and limited ACAT experience**
    - **Drafted with SAF/AQRE, MRL Working Group, and ASC/EN**
  - **Test drive on acquisition programs**
    - **Update based on lessons learned**

Manufacturing Readiness Implementation Approach (ACATs)



ACAT MRA Process



AMRAAM

– <u>What:</u> Performed a system-level MRA on the AMRAAM C-7 variant
  - Looked at all test and assembly steps, including FACO
  - Fourteen key suppliers; over thirty-five technology areas examined
– <u>Impact:</u> Based on independent assessment, AMRAAM Group received go-ahead to proceed to next production lot for C-7 variant; reduced testing cycle time in particular cell by 90%

Some MRA Thoughts

- MRLs are not a report card
  - ***MRL 7 might not be good***
  - ***MRL 3 might not be bad***
- MRLs are a tool to manage and mitigate manufacturing risk
  - ***A common language used to assess manufacturing maturity***
  - ***Provide insight not <u>oversight</u>***

Some MRA Lessons Learned

- Process is more effective if company is actively engaged in the assessment
- System integration and test operations are often ripe for maturation efforts
- Resources required to conduct an MRA will vary significantly
  - Not all programs are equal
- Subject matter expertise is needed to “do it right”
- Templates and guidelines developed
  - Not a one size fits all solution
  - Engineering skills/judgment still need to be used
  - Avoid a checklist mentality

Future Steady State

- Programs utilizing MRLs
  - Funding MRL maturation
  - Understanding of manufacturing concepts
- Use of MRLs in policy
  - Program offices staffed/trained
  - Manufacturing a key component for milestone reviews
- Training
  - DAU acts as the primary DoD training agent
  - AFIT supports detailed manufacturing training

Additional Information

- MRL definitions can be found at DAU web site:
  - https://acc.dau.mil/CommunityBrowser.aspx?id=18231
    - Look for MR definitions
    - Look for MR matrix (threads)
    - Look for MRL tutorial
    - Look for MRA Deskbook
- Google – manufacturing readiness assessments

In Closing

- Using a three-pronged approach to implementation
  - Piloting and incorporating into various programs
  - Training
  - Policy insertion
- Overall implementation is progressing
  - Air Force
  - DoD
- We are still learning and applying lessons learned

Air Force is Leading DoD-wide Implementation

Integrity - Service - Excellence

Rapid Prototyping: Leapfrogging into Military Utility

Mr. Randy Walden

Air Force Rapid Capabilities Office (SAF/RCO)

9th Annual NDIA Science & Engineering Technology Conference

16 April 2008

Rapid Prototyping Needed

- Asymmetric threat has a very short timeline for change
  - COTS timeline available to threats
  - WWW used by threat
- DoD Acquisition has relatively long timeline
  - Limited access to COTS
  - Budget process is multi-year
- Complex systems stress definition of requirements/architecture
  - Requirement trade-offs delay system
  - Only as fast as slowest element

SAF/RCO Rapid Prototyping

Objectives

- Rapidly develop new capabilities to counter the increasing pace of threat evolution
- Improve acquisition process; facilitate faster transition of S&T to warfighter
- Realistic definition of requirements & architectures for complex problems; prototype to innovate

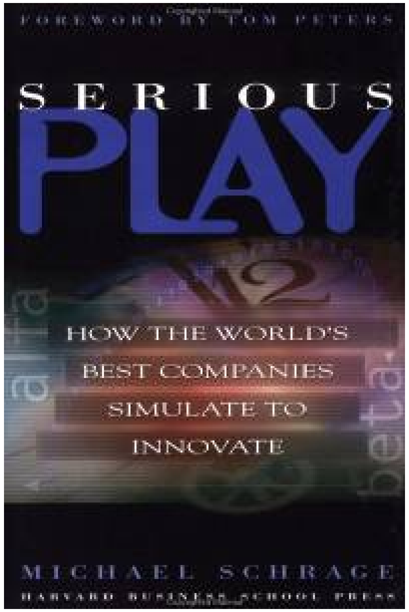
Enablers

- Mindset: acceptance of 80% solution
- Team: leadership support, warfighter involvement, "A-team" executing
- Investments for the future: open architectures, etc.
- Experience: practice to improve

“Rapid Prototyping” in Commercial Industry

A tool for rapid design & manufacturing …

A way to rapidly get products to market …



A way to innovate …

Not a new idea; approaches well established in commercial industry

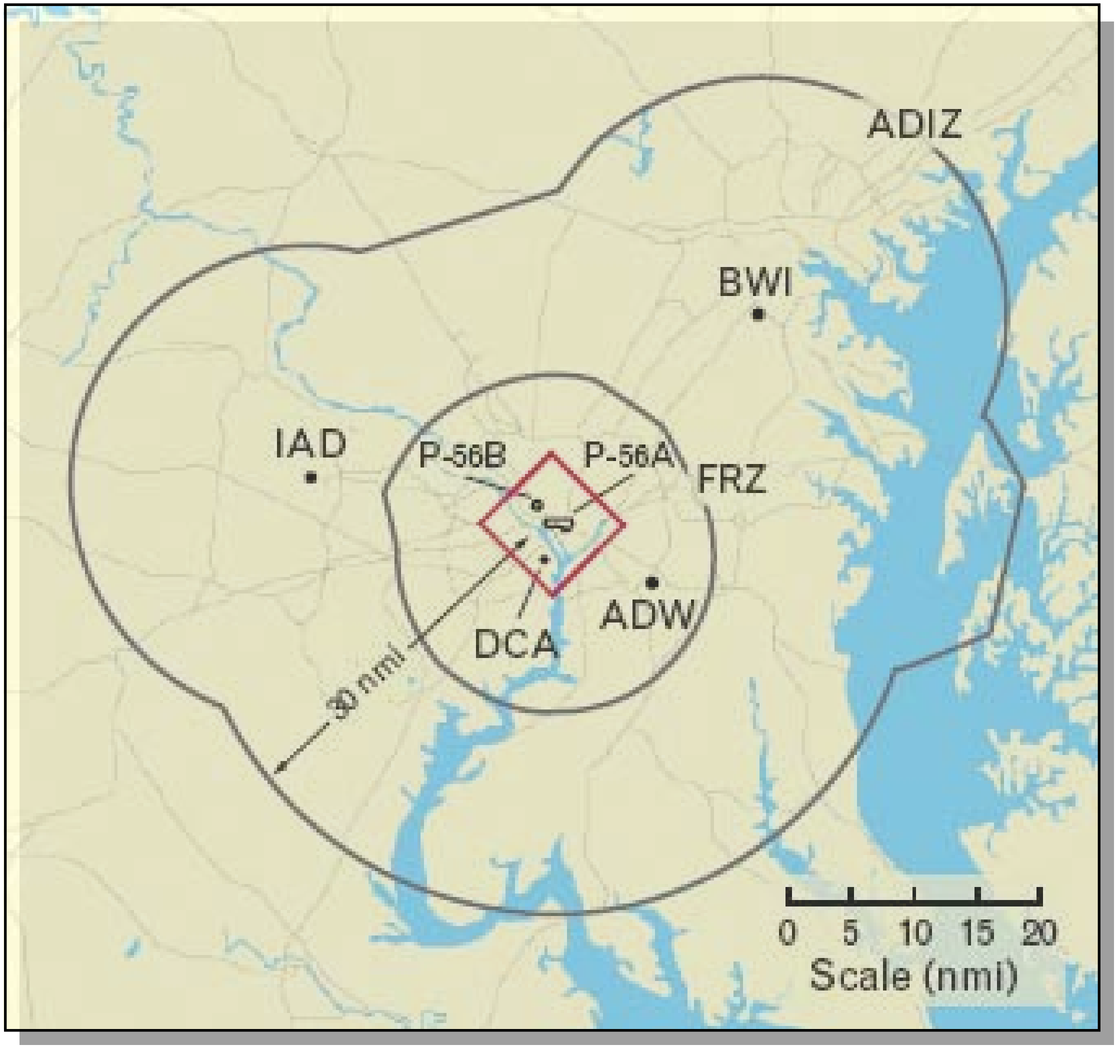
Outline

- Motivation / Objectives
- Air Force Rapid Capabilities Office
- Rapid Prototyping
  - Rapid capability development examples
  - Enablers to rapid development
  - Prototyping to innovate
- Summary

Air Force Rapid Capabilities Office

- Established April 2003
- Mission: Expedite development and fielding of select DoD systems
  - Leveraging defense wide technology development efforts and existing operational capabilities
- Reports directly to Board of Directors
  - SecAF, CSAF, SAF/AQ, and USD(AT&L) chairs
  - Responds to Combat Air Force (CAF) and Combatant Command (COCOM) requirements
- Rapid Prototyping Example: National Capital Region (NCR) IADS
  - Enhanced Regional Situational Awareness (ERSA)
  - Norwegian Advanced SAM System (NASAMS)

National Capital Region Airspace



ADIZ – Air Defense Identification Zone

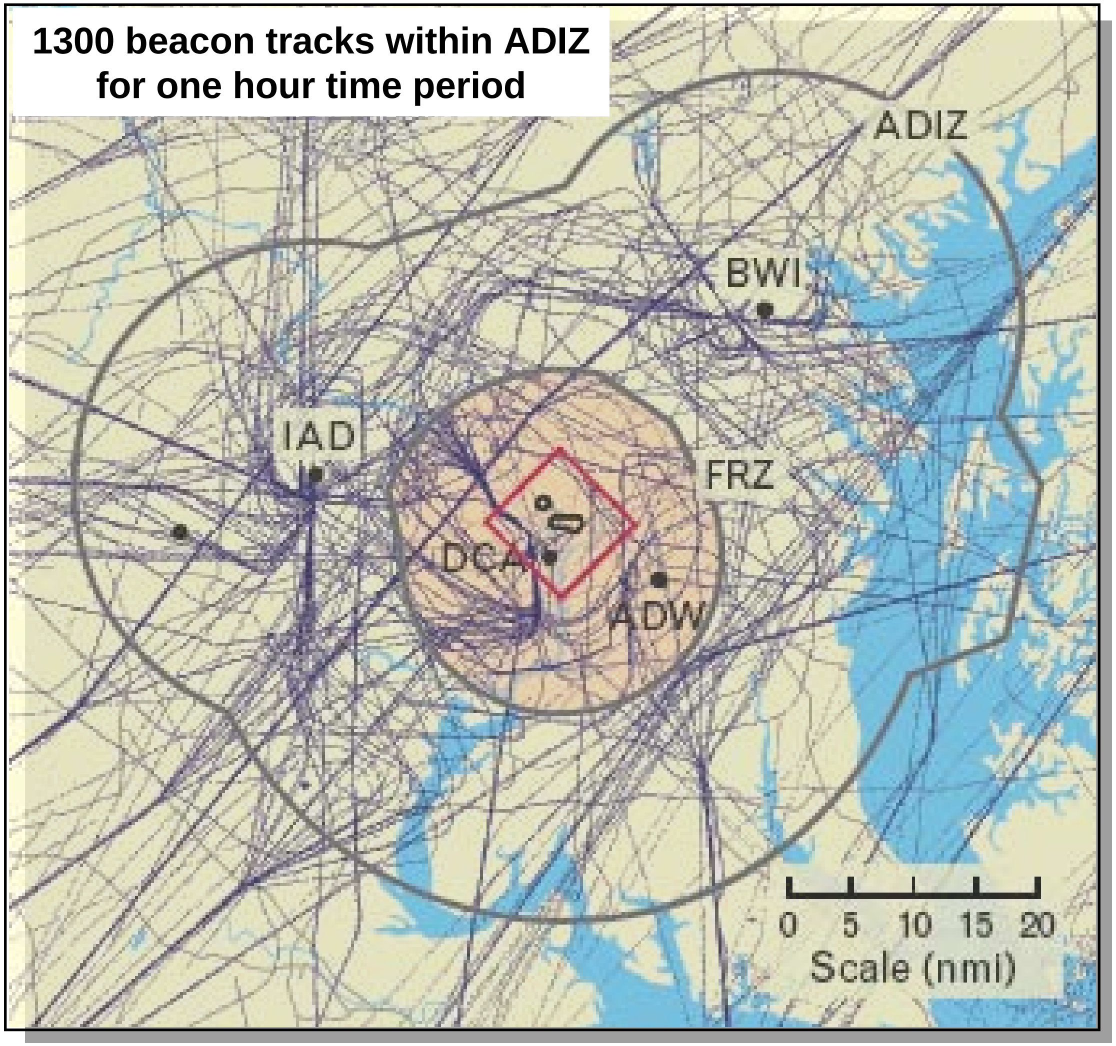
FRZ – Flight-Restricted Zone

IAD – Dulles International Airport

DCA – Reagan National Airport

ADW – Andrews Air Force Base

National Capital Region Airspace



ADIZ – Air Defense Identification Zone

FRZ – Flight-Restricted Zone

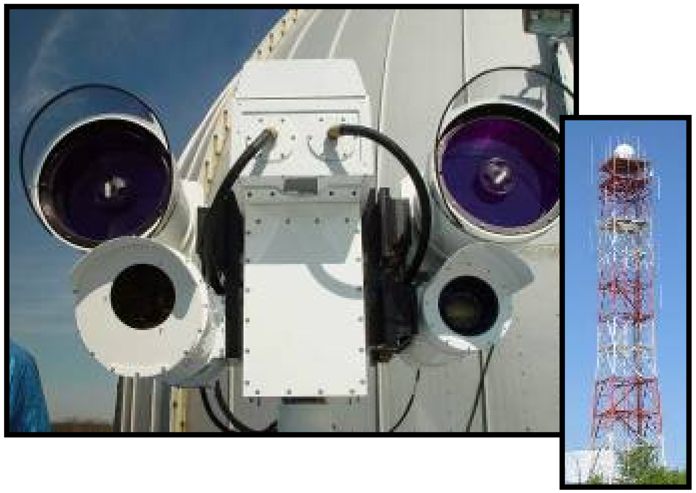
IAD – Dulles International Airport

DCA – Reagan National Airport

ADW – Andrews Air Force Base

RCO Rapid Developments

Enhanced Regional Situational Awareness (ERSA)



- Integrated air defense system for National Capital Region (NCR) in 2 years
- Operational for Jan 2005 Presidential Inauguration
- Developed and Fielded
  - Tower Mounted Radars
  - Aircraft ID
  - Visual Warning

Norwegian Advanced Surface to Air Missile System (NASAMS)

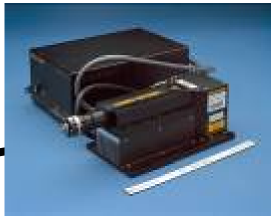
- Developed & integrated system into NCR IADS
- 9 months from Chairman JCS tasking to IOC

Rapid Prototyping

Visual Warning System (VWS)

HPD High Power Devices, Inc

Red Light

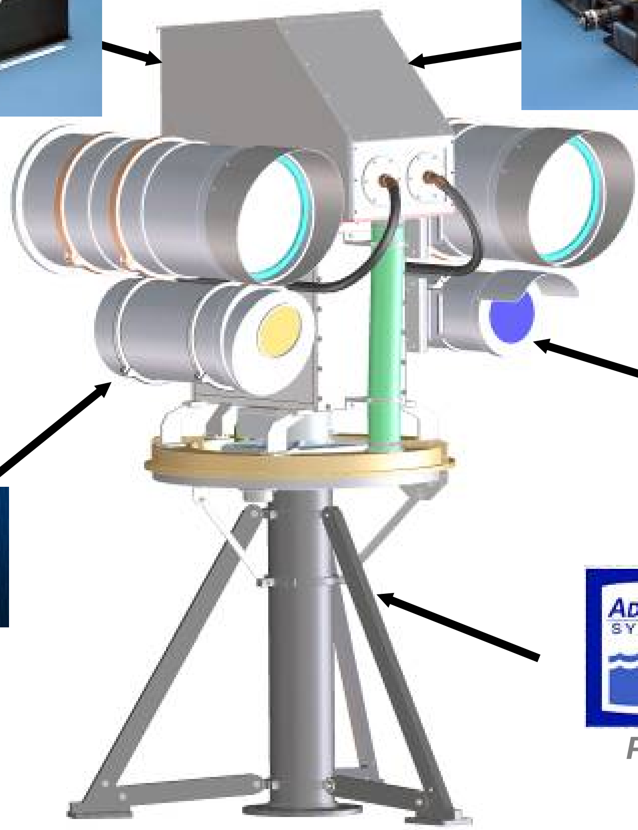


CVI Melles Griot

Green Light

CELESTRON

Telescope & Optics



HITACHI Inspire the Next

Visible Camera

L3 communications

Infrared Camera

Advanced EO Systems, Inc. PVP

Pedestal

Visual Warning System developed by rapidly integrating COTS to create a new capability

Visual Warning System (VWS)

- Provide visual warning to errant pilots entering NCR airspace
- Eye safe system at aperture and beyond
- Precision pointing at single aircraft
- Special Flight Advisory has been published on meaning of lights
- Operational on 21 May 2005

• Warning Sequence with translucent covers on

• Nighttime aircraft view from 3 nm, 28 Jan 05

NORAD uses the Visible Warning System

U. S. Capitol, 12 March 2008

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AIR SAFETY

Small Plane Enters Restricted Space

2nd Incident in a Week Prompts Calls to Refine Evacuation Process at Capitol

By Mary Beth Sheridan
Washington Post Staff Writer
Thursday, March 13, 2008; Page B06

A small plane penetrated restricted air space and flew within six miles of the U.S. Capitol yesterday before being intercepted without incident, officials said.

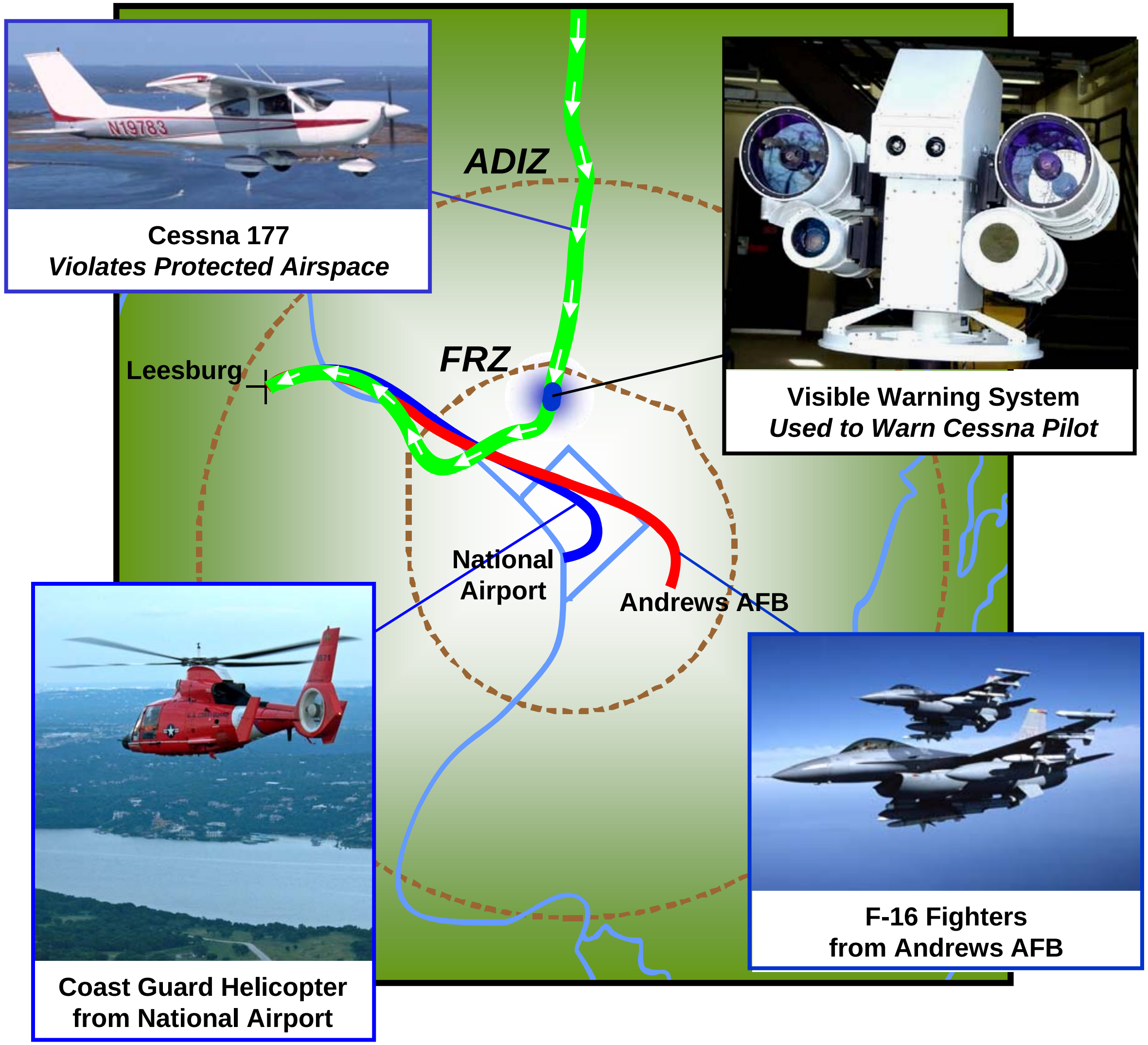
When air-traffic controllers couldn't reach the pilot by radio, military personnel on the ground aimed red and green warning lights at the cockpit, said Maj. Brian Martin, a spokesman for the North American Aerospace Defense Command, or NORAD. That prompted the pilot to veer west, Martin said.

Two F-16 jets from Andrews Air Force Base and a Coast Guard helicopter escorted the plane to Leesburg airport, where the pilot was questioned by the Secret Service and the FAA, officials said. He was not considered a threat, they said.

A NORAD spokesman cites the use of the Visible Warning System

12 March 2008 Events

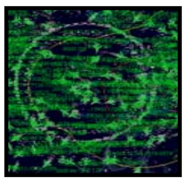
- A Cessna 177 crosses the Air Defense Identification Zone (ADIZ) in violation of airspace rules
- NORAD warns pilot using the Visible Warning System
- The Cessna is escorted to Leesburg Airport by F-16 interceptors



NASAMS Integration Timeline

FY04						FY05					
A	M	J	J	A	S	O	N	D	J	F	M

Chairman JCS Direction ▲



AT&L funding ▲

Fire Control Cue Developed ▲

Integration with fire control unit ▲

Fire Distribution Center

Live Fire Tests ▲ ▲

NORAD Validation and Acceptance Testing ▲ ▲

NASAMS IOC in NRC ▲

NASAMS developed, deployed and operational in nine months

NCR IADS

Key Attributes for Rapid Fielding

- Clear Charter with Clear Priorities
  - Schedule was #1; field ERSA by inauguration day 2005 (18 months)
- Senior DoD, Joint Staff, US Air Force, & US Army leadership buy-in
  - Short chain of command facilitated quick decisions
- Small, Focused, Empowered Team; 5 – Program Office, 7 Contractor, plus key external POC's
  - Experienced, solution oriented, A-team type personnel
  - QRC focus – Long hours, 6 & 7 days/week were routine
- Recognition of Need for After-Fielding Clean Up
  - Formalized needed leases and MOAs/MOUs
  - Minor safety adds to installed equipment
  - Long-term transition planning

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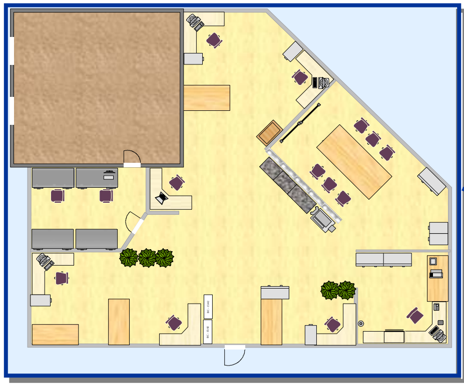
Enablers to Rapid Development

Facilities

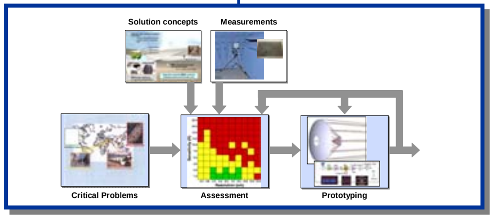


Hardware / Software Enablers

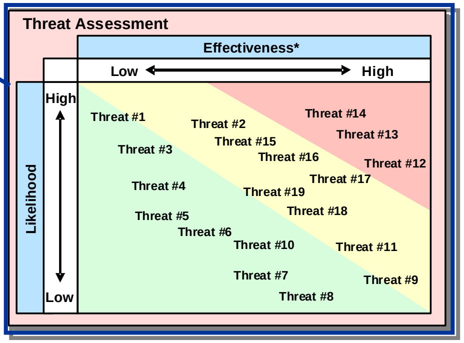
Rapid Innovation Cell

User Connection

Blue Team Process



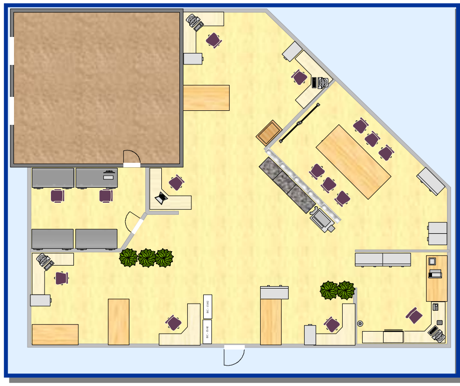
Red Teaming



- Series of elements key to enabling rapid innovation, demonstration, prototyping, and fielding of critical military capabilities

Enablers to Rapid Development

Facilities



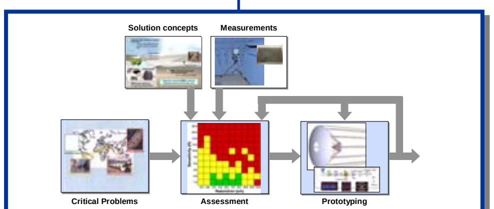
Hardware / Software Enablers

Open System Architectures

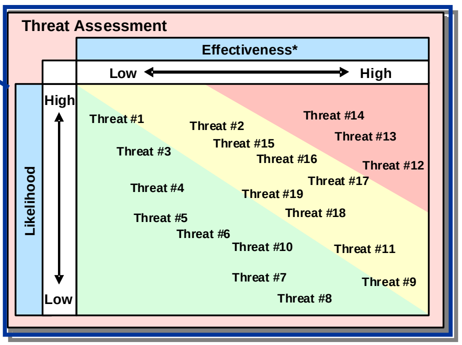
Rapid Innovation Cell

User Connection

Blue Team Process



Red Teaming

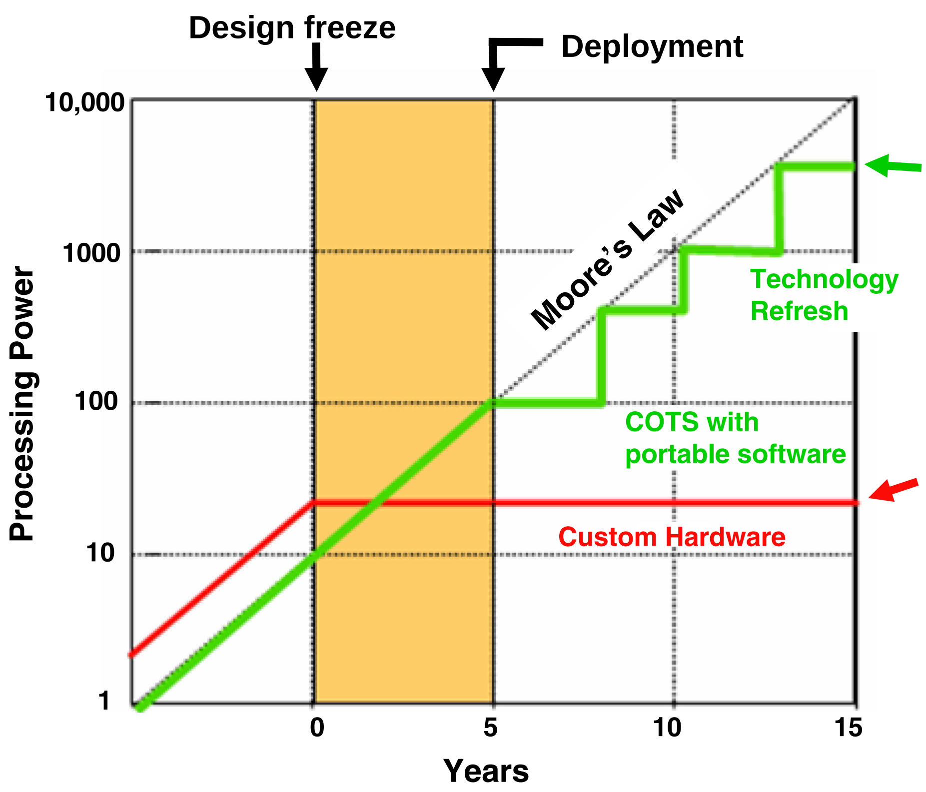


- **Series of elements key to enabling rapid innovation, demonstration, prototyping, and fielding of critical military capabilities**

Open System Architecture
Advantages

- *Commonality allows lower cost …*
  - **Plug and play pieces reusable from system to system**
- *Innovation enabler …*
  - **Allows entrance of “smaller” players, often with innovative ideas**
- *Rapid development & rapid upgrades …*
  - **Open design allows replacement of individual components**
  - **Allows isolation of components that evolve technically at differing rates (e.g., rapid Moore’s Law advance in computing)**
  - **Upgrades vs. replace; more responsive to agile threats**

Open Systems Support "Leverage Adapt" Strategy

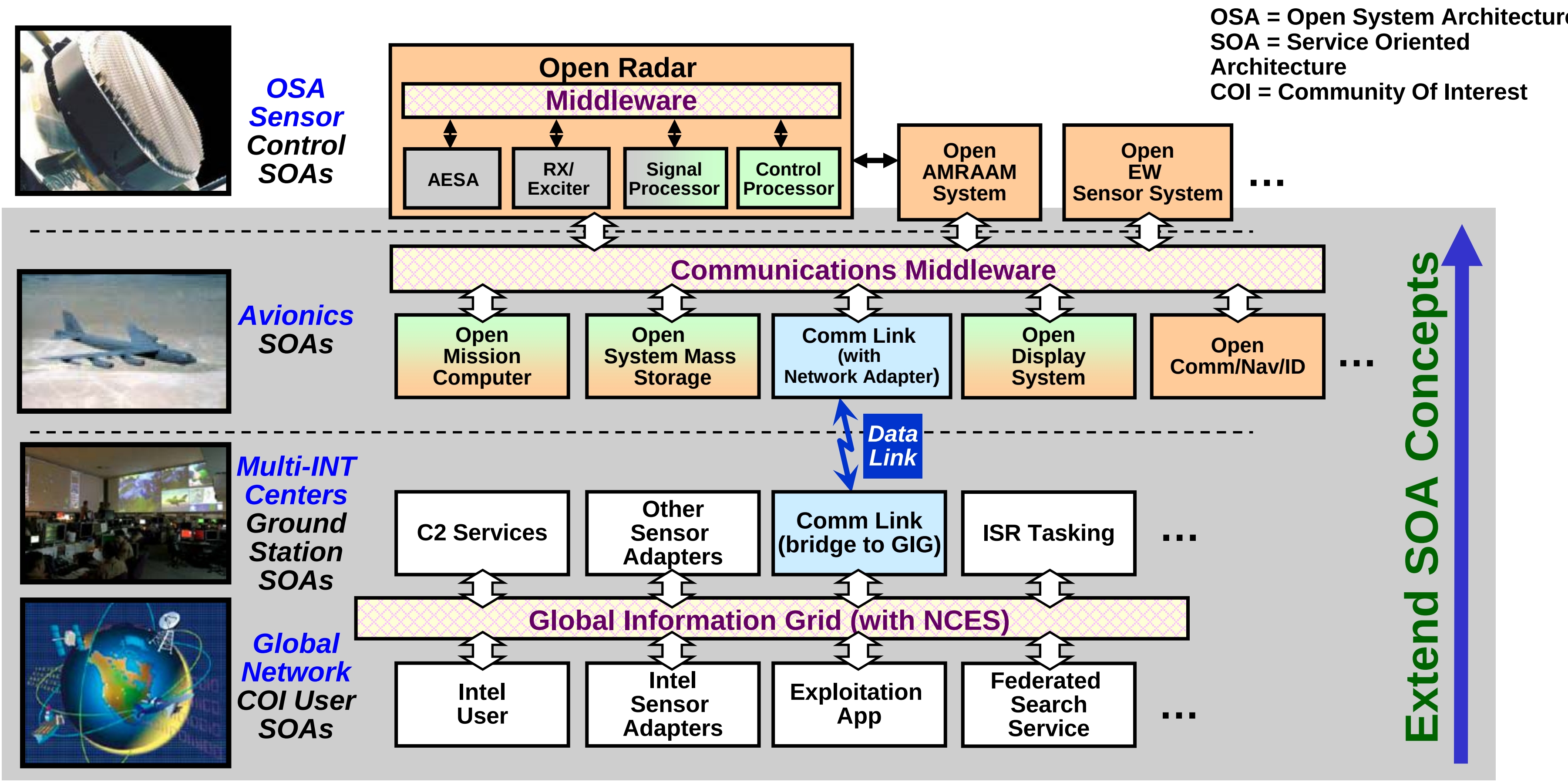


"Leverage & adapt"
- Good for rapidly changing technology
- Good for rapidly changing requirements
- Built-in refresh and improvements
- More difficult to manage

"Freeze & build"
- Freezes technology and builds to fixed design
- Acceptable for slow moving technologies
- Requires stable requirements throughout lifecycle
- Easier to manage with current acquisition strategy

- Open Systems supports "leverage and adapt" strategy; allows DoD to leverage commercial industry's investment
- Continuous upgrade/refresh possible to meet evolving threats and obsolescence

Layered Open System Architecture Approach



- **Change with technology and readily add new capabilities**

Outline

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Prototyping Facilitates Innovation

"It is far easier for [users] to articulate what they want by playing with prototypes than by enumerating requirements."†

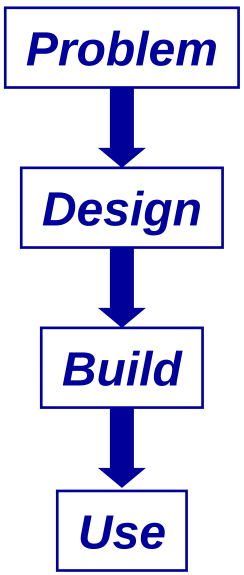
† **Schrage, Michael, *Serious Play: How the World's Best Companies Simulate to Innovate*, Harvard Business School Press, December 1999.**

- **Key additional use of rapid prototyping is for innovation; "simulate to innovate" concept**

Development Approaches

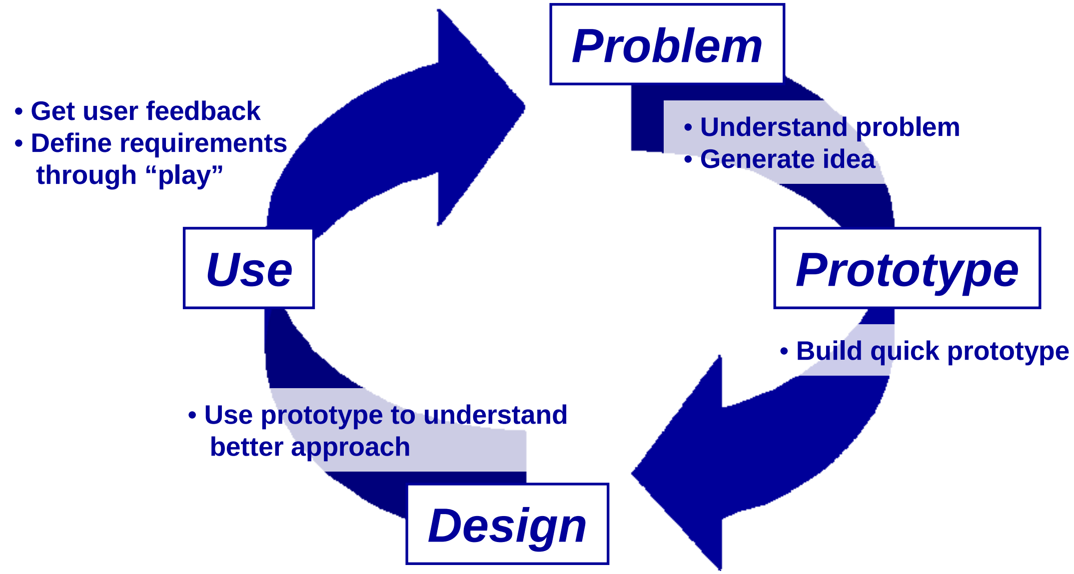
Linear / "Waterfall" Approach

Fixed Design



Rapid Prototype Approach

Inherent Feedback



- Assumes "design" can be accomplished apriori
- No developer / user co-design

- Build prototypes to explore "design" approach
- Iterate based on user feedback; design influenced by user response

Prototype to Innovate

National Capital Region IADS

- **Integrated Air Defense for protection of the National Capital Region**

Touch Table

- **Vehicle for novel data extraction / representation and action**

X-37B Orbital Test Vehicle

- **Unmanned reusable vehicle test platform for new space technologies**

Summary

- **Rapid prototyping permits timely, cost effective military capability development**
  - **Strongly motivated by increasing pace of threat cycle**
- **Air Force Rapid Capabilities Office (SAF/RCO) established to expedite development of selected DoD systems**
  - **Number of successful projects (e.g., ERSA, NASAMS)**
- **Success of rapid developments dependent on variety of factors**
  - **80% solution mindset, strong team, enabling investments (e.g., Open system architectures)**
- **Additional rapid prototyping role in innovating new military capabilities**
  - **Rapid prototyping cycle allows refinement of solution**

Challenge to S&T Community

- **Traditional “S&T Gap” still exists; greater warfighter interchange needed**

- **Apply rapid prototyping approach earlier in S&T development**

Early insertion of new technologies
Faster innovation
Discovery of new / advanced capabilities

Mr. Randy Walden / (703)696-2407 / safcroworkflow@pentagon.af.mil

BOEING

Boeing Technology

9th Annual Science & Engineering Technology Conference /
DoD Tech Exposition

Boeing's Approach to Innovation & Technology Integration

Dr. David Whelan
Vice President & Deputy GM, Advanced Systems
& Chief Scientist, Integrated Defense Systems
The Boeing Company

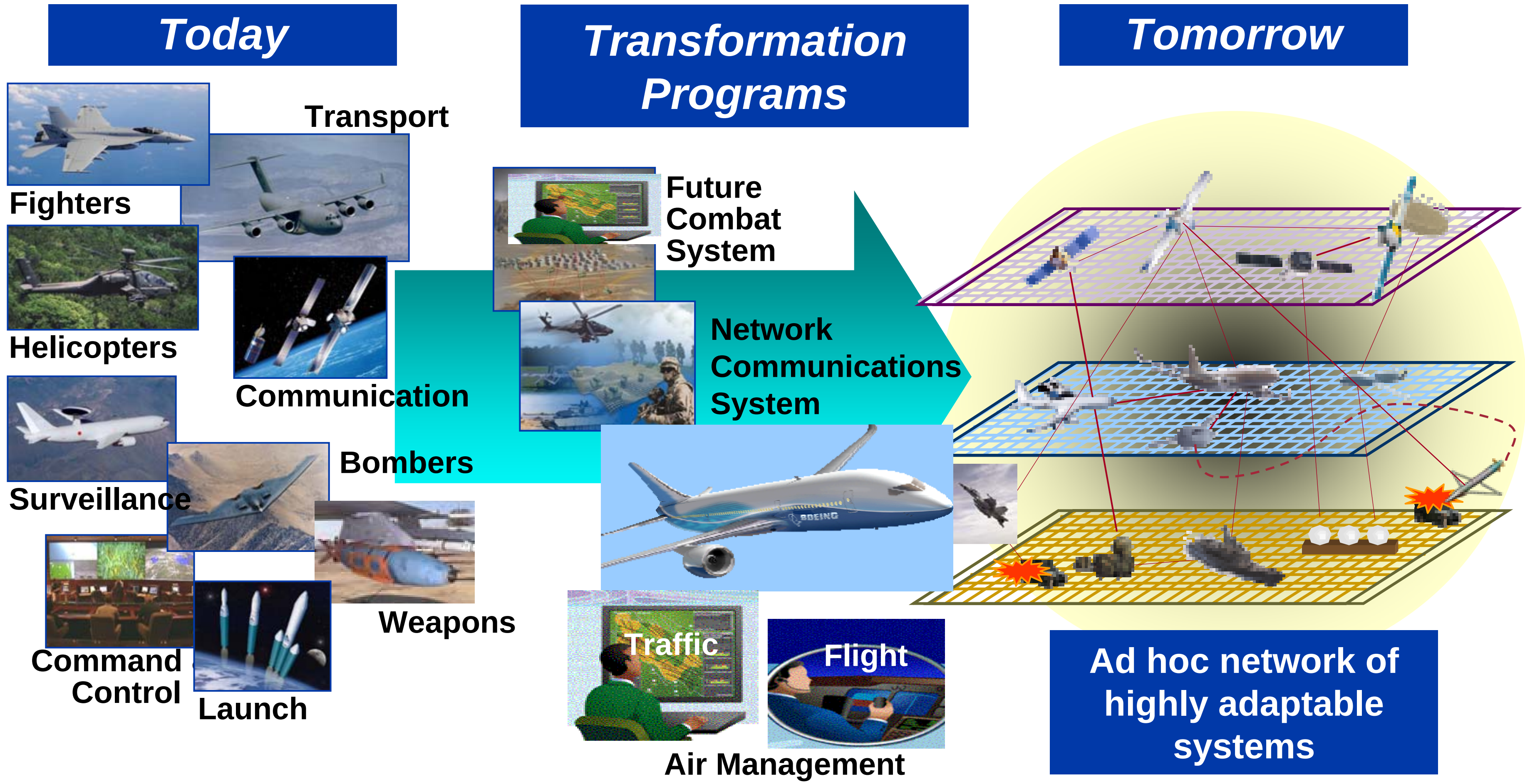
April 16, 2008

The Boeing Company Today

Boeing Commercial Airplanes

Integrated Defense Systems

Customers Demanding Connected, Integrated and Intelligent System of Systems

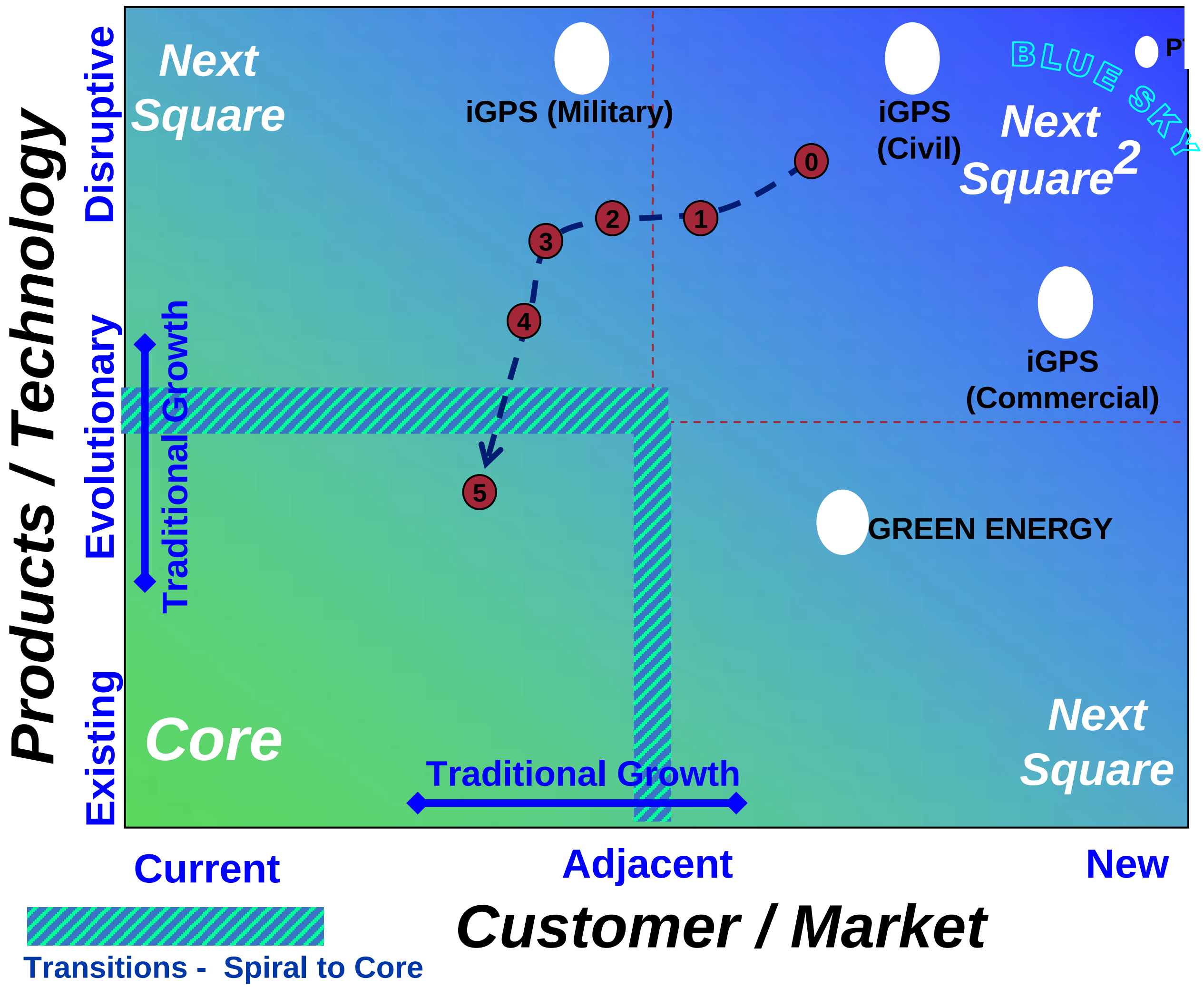


Boeing is balancing a customer pull for integrated systems with technology push for "Innovation"

Innovation Strategy

- **Leverage Boeing technology to find & develop growth platforms:**
  - **Markets & businesses that meet Boeing criteria**
- **Create competitive advantage in new markets and businesses**
  - **Leverage Boeing's differentiated assets**
  - **Focus on Breakthrough Technology**
  - **Create new verticals via development/acquire**
- **Leverage outside R&D resources (DARPA, military labs, universities,…)**
- **Efficient Stage/Gate Innovation Process**
  - **Migrating growth opportunities to comfort zone**

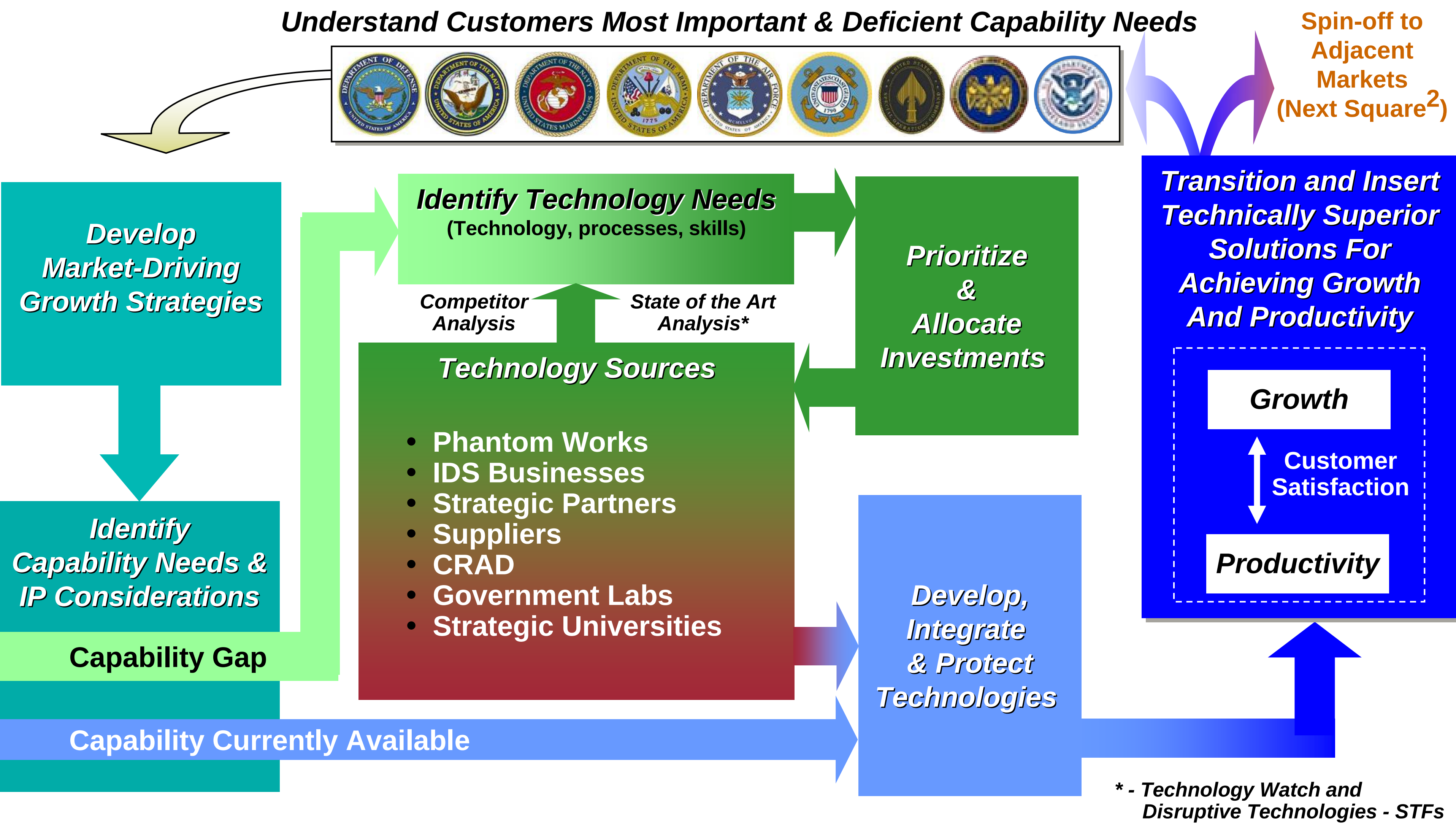
Strategy for Technology Integration – Spiral to Core



The Key was to move FCS toward the core by:

- ✓ **Partnering**
  - 1 ***Experimentation & Customer Feedback***
  - 2 ***Teamed with SAIC***
    - ***Army Land Combat domain knowledge***
  - 3 ***Army LSI for FCS***
    - ***UDLP & GD added***
- ✓ **Spiral Development**
  - 4 ***Phased Technology Increments***
- ✓ **Spiral Out**
  - 5 ***To Current Force***

Technology Integration Driven by Customer Requirements (Pull) and Innovation (Push)

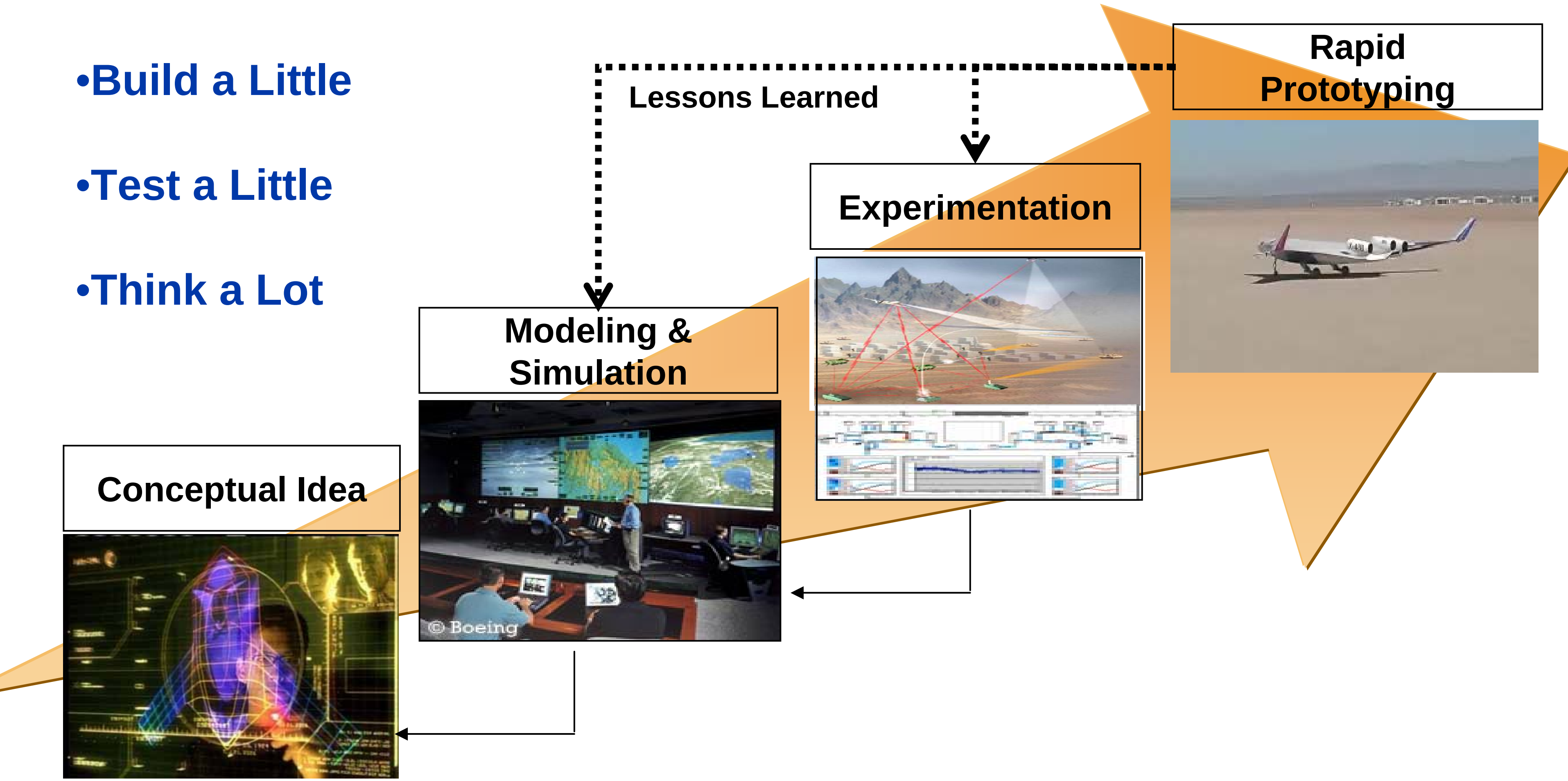


21st Century Defense Technology Vectors

Key Vectors	Boeing Perspective (Products → Development → Research / Ideas)	Imperatives
Precision Sensing, Navigation & Timing	ICBM-IMU, GPS-IIF, GPS-III, Very Small SDB JDAM, SDB, GMD, iGPS (Comm & Nav)	10 x improvement, Integrate Comms & Navigation
Integrated C4ISR	FCS SOSCOE, EP-X, Un-blinking Eye P-8A, TSAT, Foliage Penetration	No Stovepipes between ISR Systems Ad-Hoc Task/Exploit
Info Assurance	EA-18G, JTRS, High Integrity Knowledge Mgmt Railhead, Secure Network Server (SNS)	High Integrity Networks & Computer Systems
Nano-electronics & Nano Technology	G-bytes/sec Analog-Digital, RF & Digital Systems on Chip ASIC Processors, Mission Specific Processors, Carbon-X	Intelligence at the edge, 20 yrs till Silicon = Human
Laser & Photonics	ABL, Laser Comms ATL, Solid State HE Lasers	Communicate, Tag and Engage at the Speed of Light
Unmanned Systems & Robotics	ScanEagle, FCS Robotics, Variably Manned Systems A-160, Orbital Express	High Integrity Zero “Pilot” Operations
Energy & Environment	Space Solar Cells, Bio-Fuels Terrestrial Solar Cells, BWB, H^2 Powered UAVs	High Efficiency, Zero Emissions, Alternate Energy

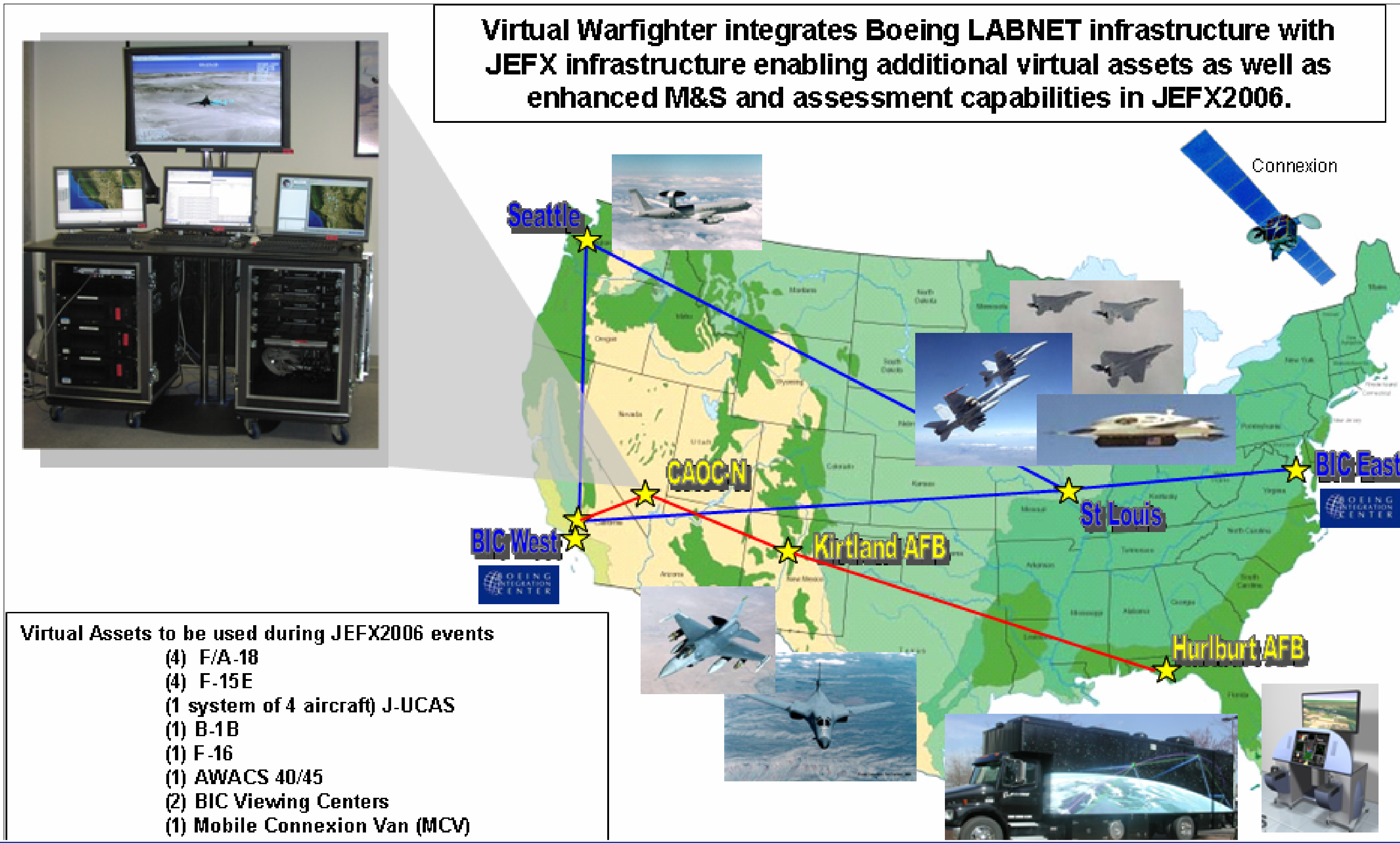
Successful Technology Integration Requires M&S, Experimentation, and Rapid Prototyping

- •Build a Little
- •Test a Little
- •Think a Lot



Key Components for Successful Technology Integration

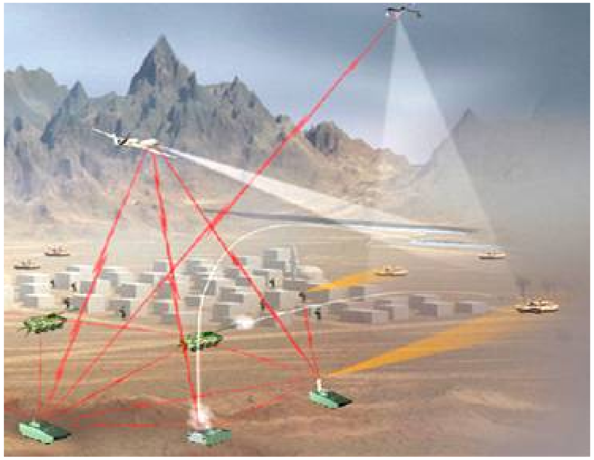
Modeling & Simulation Environment

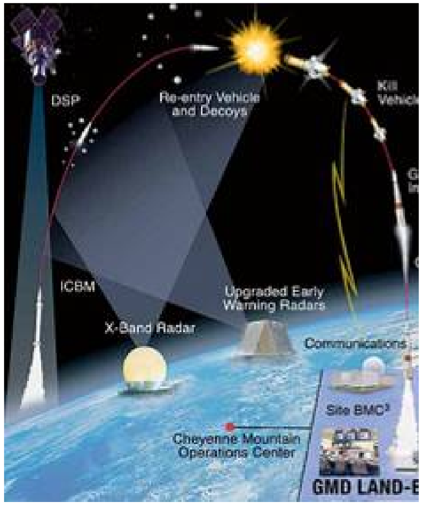


Live-Virtual-Constructive enables Pilots to fly real hardware in live events without live fly costs

Technology Evaluation through Experimentation

- **Experimentation, using M&S, enables exploring the impact of new technology at every level of insertion…before building or buying**
  - **For example, improved sensor and data link capability in A&M aircraft supporting BP counter drug operations (existing military or entirely new)**
  - **Or new counter cruise missile radar/sensor capabilities**
  - **Or better forest firefighting equipment**
  - **Or new WMD detection capabilities**
  - **Or direct hospital to first responder medical support technologies**
  - **Or …**

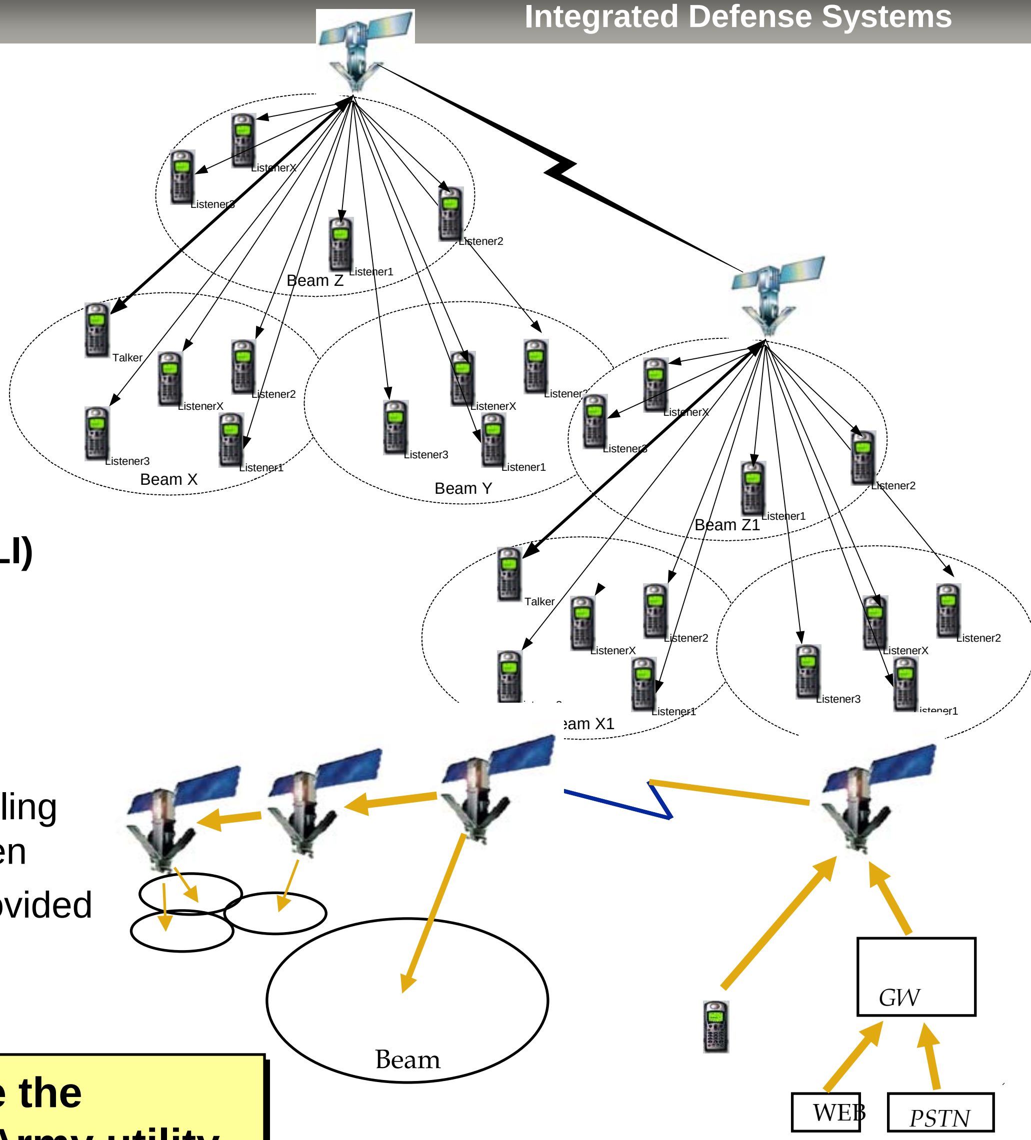




Boeing's & Iridium's "Group Call" On-Orbit Upgrade

Enables Iridium Cellular system to function a "UHF Satcom Radio"

- **Service(s)**
  - **Support DOD customers**
    - **Encrypted service, does not require call intercept**
  - **Three types of Services**
    - **Push to talk (PTT)**
    - **Broadcast**
    - **Position Location Information (PLI)**
  - **GC shall not impact the call performance of non-GC users**
- **Security**
  - All group calls shall be encrypted
  - System shall have the capability of disabling specific users if equipment is lost or stolen
  - Encryption key management shall be provided
  - All group members shall have the latest encryption update prior to joining a GC

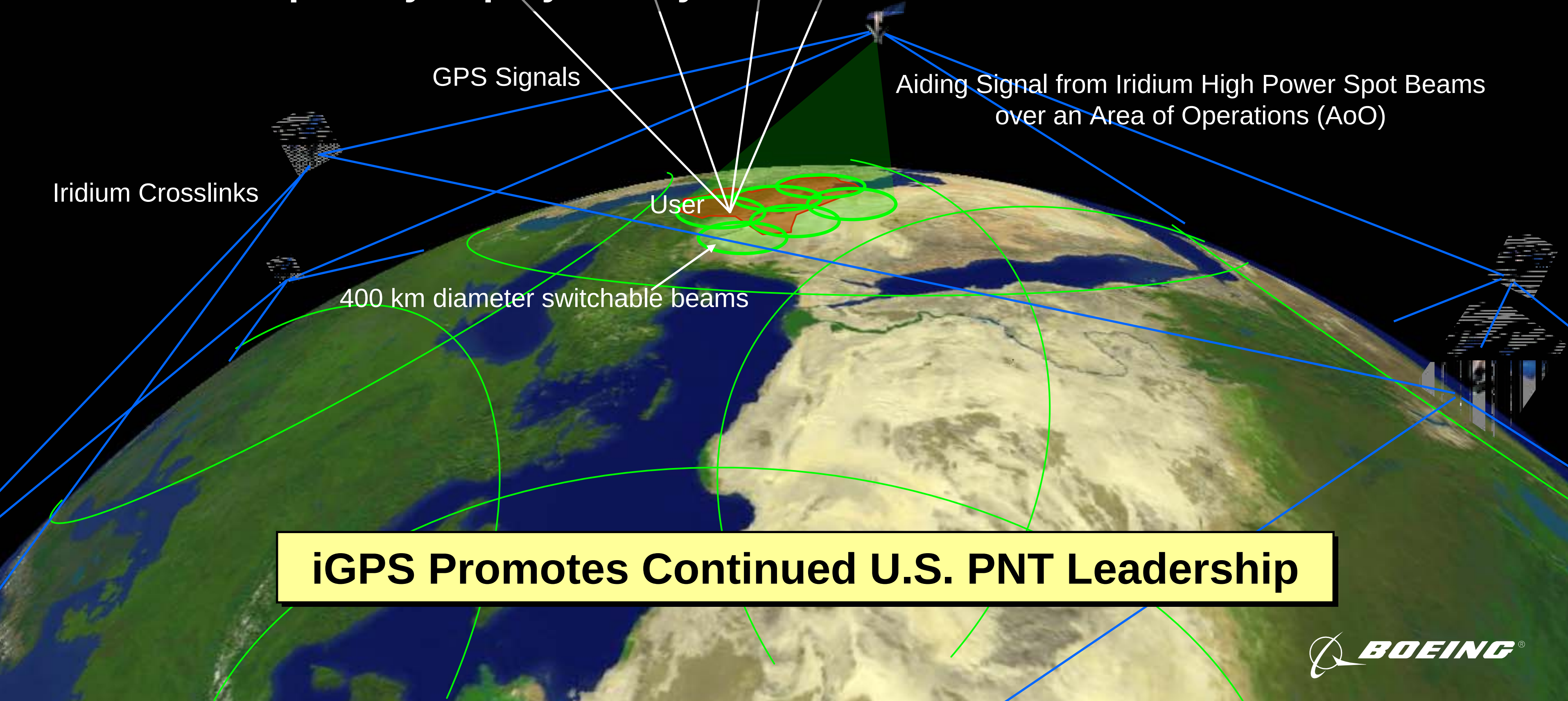


Boeing has already been able to upgrade the constellation to offer new services with Army utility

High Integrity GPS (iGPS Enhancement via Iridium)

Enabled by Horizontal (ground) Integration of Iridium Nav-Com System & GPS

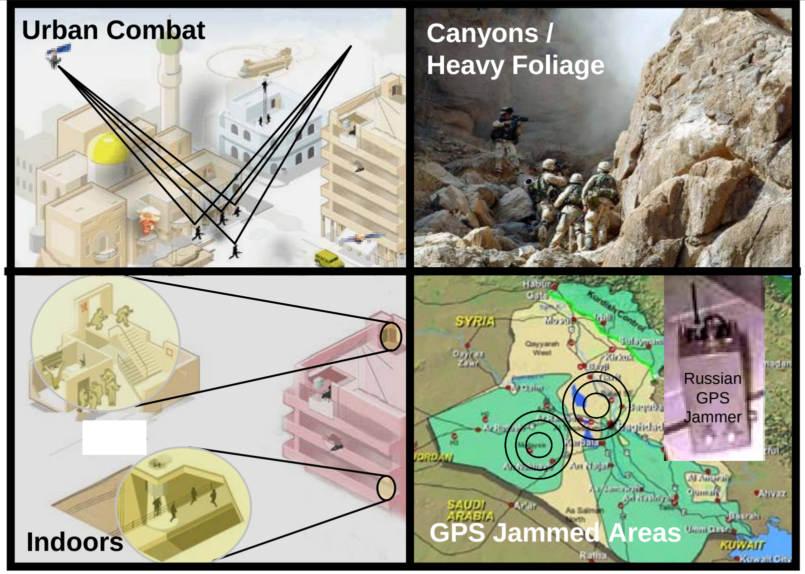
- **Disruptive innovation opportunity to address unmet needs**
  - **Antijam, Accuracy, Integrity, Availability**
- **Creates a more <u>Robust PNT</u> Constellation**
- **Integrates GPS's Psuedorange multilateraltion with Transit's FDOA**
- **Initial capability deployable by 2010**



Application: Early SOF iGPS Capability to SOCOM

US Opportunity:

Decisive Navigation Superiority that is Secure and Dependable



- More Robust GPS
  - **Accuracy, integrity, and availability**
- Keep GPS During Electronic Countermeasures
  - **iGPS AJ Prevents ECCM from interfering with DAGR**
- Improve GPS Availability in Restrictive Environments
  - **Forests, Mountainous, Urban**
  - **iGPS Redundant Dynamic Ranging Counteracts Sky Blockage in spite of High Mask Angles**
- Support Global JBFSA
  - **iGPS offers 2-way satellite data link and JBFSA GUI embedded in DAGR**
  - **Network of DAGRs can triangulate enemy jammer locations**
- Rapid (<2 min) Time to First Fix under Severe Jamming (>70 dB J/S)
  - **Improves battery life for extended missions**

A160 Background

- **Autonomous Vertical-UAS utilizing Optimum Speed Rotor technology coupled with other design features to achieve long endurance and long range with significant payload capability**

- **Wide mission range**
  - **C4ISR**
  - **Organic armed ISR**
  - **Utility missions**

- **DARPA-Army program, began in 1998 – presently in Phase I (started Aug 2003)**

Technical Approach

- **Advanced Rotor**
  - **Optimum (Variable) Speed Rotor (OSR), 50-100% RPM**
  - **Low Disk Loading**
  - **High Lift/Drag Blade Airfoils**
  - **Hinge-less Rigid In-Plane Rotor for Precision Control**
- **Fuselage**
  - **Aerodynamically clean retractable main gear**
- **Autonomous Vehicle Flight Control**
  - **Flight Waypoint Control**
  - **Auto take-off and land**
- **Structure**
  - **Lightweight high stiffness blades**
  - **Lightweight fuselage**
- **High Fuel Fraction**

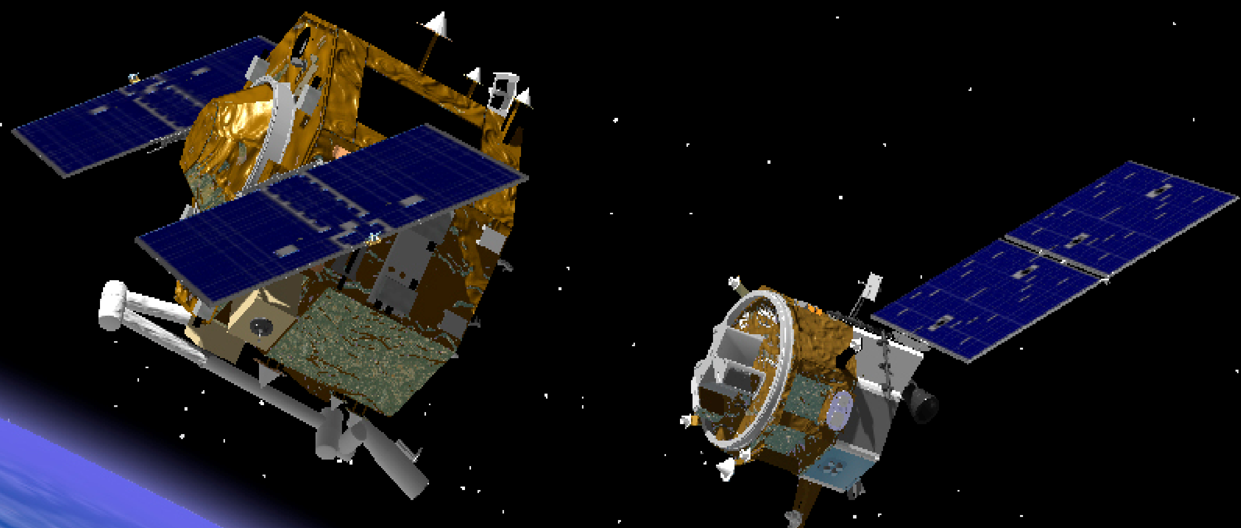
A160 Phase I Performance Goals

- 20 hrs (sea level) endurance with 300 lb payload
- HOGE of 15,000 ft altitude; flight at 30,000 ft altitude
- >2,200 nm range
- Airspeed to 140 knots

- Re-supply delivery of 1000 lb payload to a radius of 500 km
- System reliability to enable 1,000 flight hours between air vehicle losses

DARPA & Boeing’s Orbital Express:

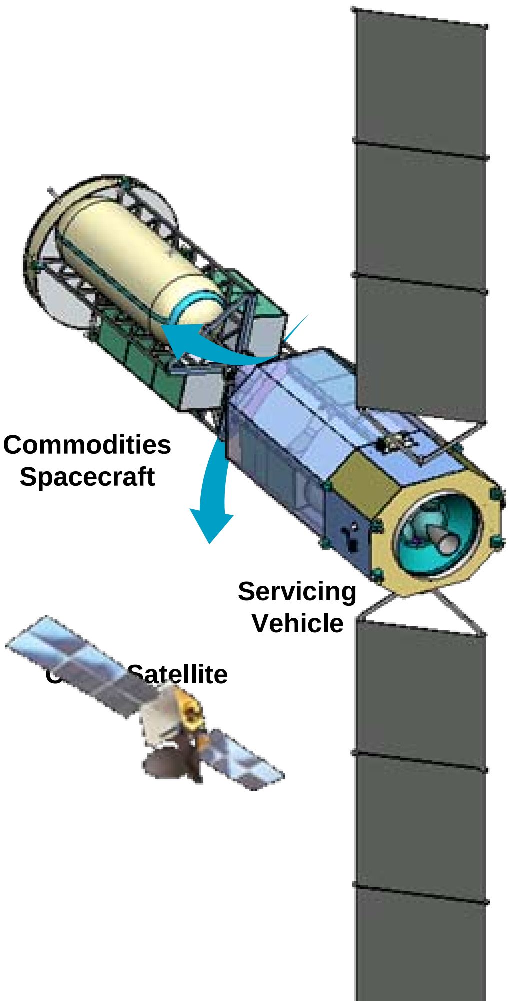
On-orbit servicing enhances space missions



Autonomous Rendezvous & Soft Docking allows:

- **Inspect & service satellites / spacecraft**
- **Deliver commodity consumables / cargo**
- **Assemble large space structures**

Future Systems Enabled by Orbital Express



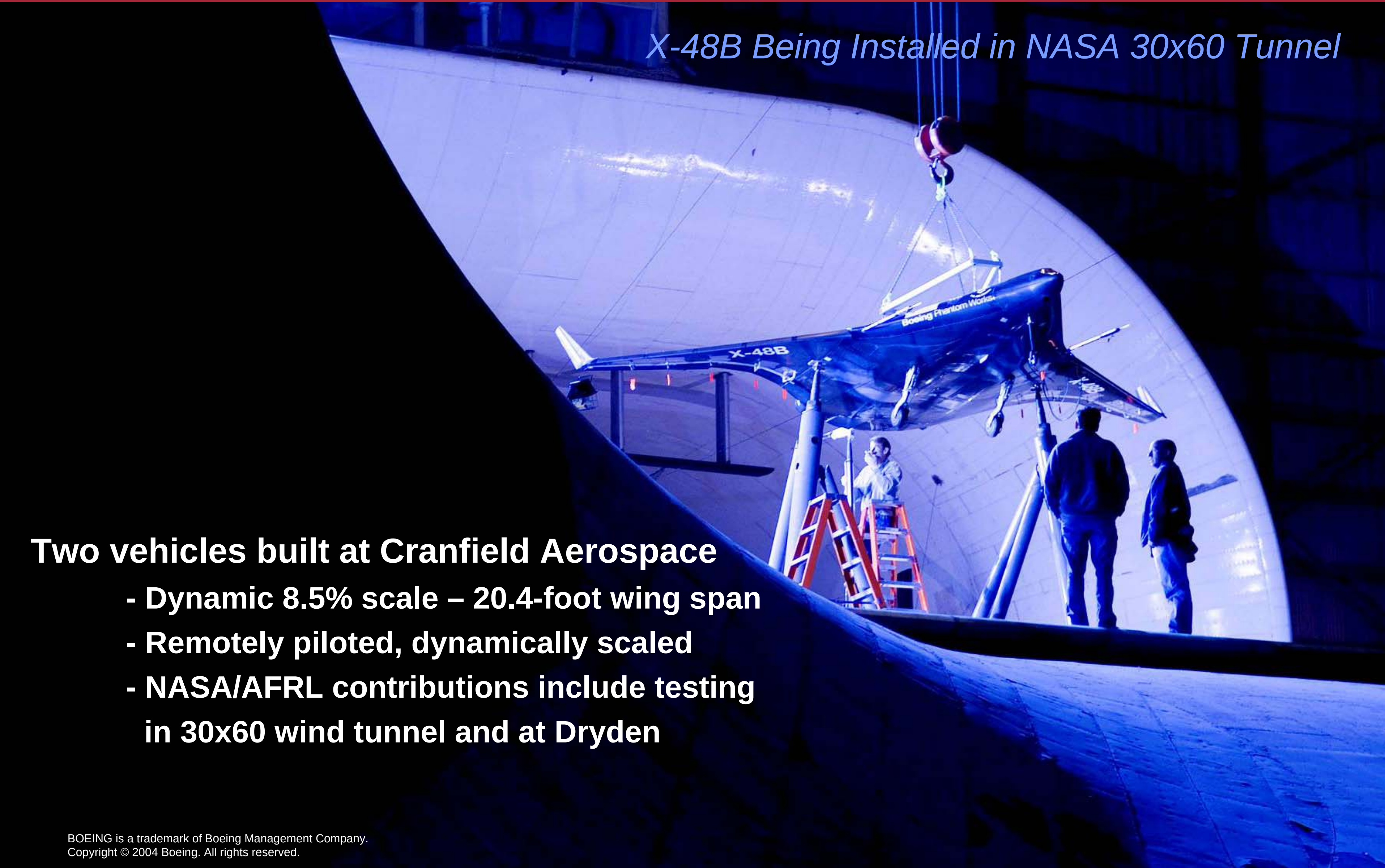
Demonstrated key technologies to build a future operational system.
The concept of operations provides:

- **A servicing vehicle to rendezvous with client vehicle.**
- **Required services.**
- **Rendezvous with a commodities depot to replenish supplies before servicing the next client vehicle.**

Capabilities enabled by servicing include:

- Refueling
  - Maneuverability
  - Resolution
  - Time over target
  - Repeated access
  - Increased life
  - Randomization
  - Avoidance
  - De orbit
  - Repositioning
  - Contingency refueling
  - Early operational capability
  - Coverage patterns
  - Reduce launch mass
- Replace or upgrade component
  - P3I – new technology infusion
  - Contingency replacement or repair
- On-orbit assembly, test, and checkout
  - Large space optics
  - NASA exploration concepts
- Asset Inspection

Blended Wing Body



X-48B Being Installed in NASA 30x60 Tunnel

Two vehicles built at Cranfield Aerospace

- **Dynamic 8.5% scale – 20.4-foot wing span**
- **Remotely piloted, dynamically scaled**
- **NASA/AFRL contributions include testing in 30x60 wind tunnel and at Dryden**

• BWB Low Speed Vehicle (X-48B)

Investigate

- Stall characteristics & departure boundaries
- Asymmetric thrust controllability
- Control surface hinge moments
- Dynamic ground effects

Vehicle Characteristics

- Max Equiv Airspeed: 118 kts
- Max Altitude: 10,000 ft MSL
- Vertical Load Factor Limits: +4.5 to -3.0 g's
- Flight Duration: 30 to 50 min
- Emergency Recovery System (Drogue, Parachute, and Air Bags)

X-48B As Initial Flight Mechanics Risk Reduction

- First flight July 20, 2007; 11 flights completed
- Addressing risk reduction
  - Low speed flight environment
  - Flight mechanics (flight control laws, stability and control characteristics)
  - Secondary Power (control surface / actuator power)

Summary: Transitioning Technology

- Fulfilling Customer Needs via Technology Innovation
- Balance of Technology Push and Systems Pull
- M&S, Experimentation and Demonstrations Critical

BOEING
Forever New Frontiers

FUTURE COMBAT SYSTEMS

FCS

One Team-The Army/Defense/Industry

"The Future is Here Now"

Inserting Technology Incrementally: Introducing FCS Technology into the Current Force

NDIA Conference

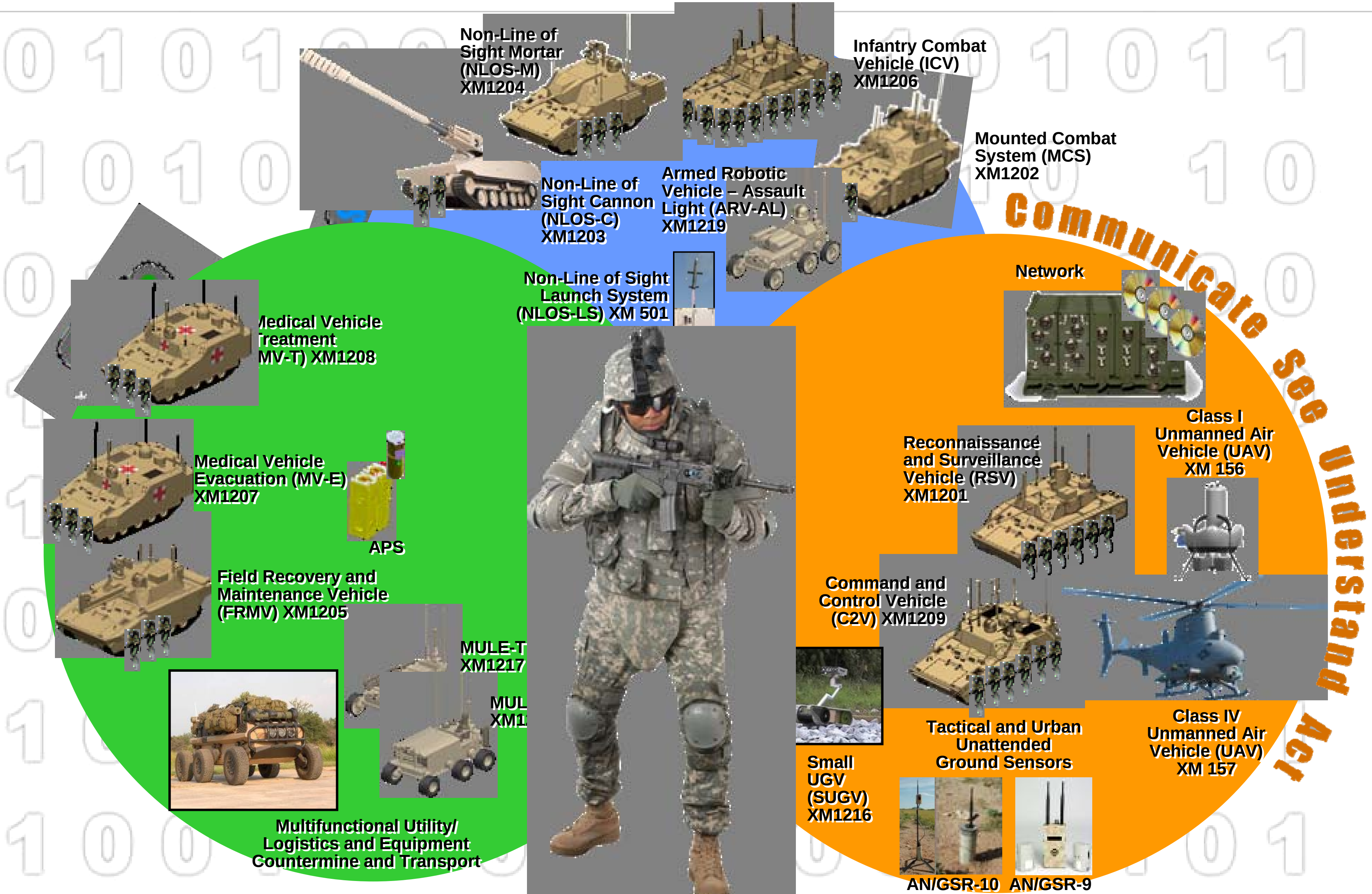
Dan Zanini

LSI Deputy Program Manager, Future Combat Systems

Senior Vice President, SAIC

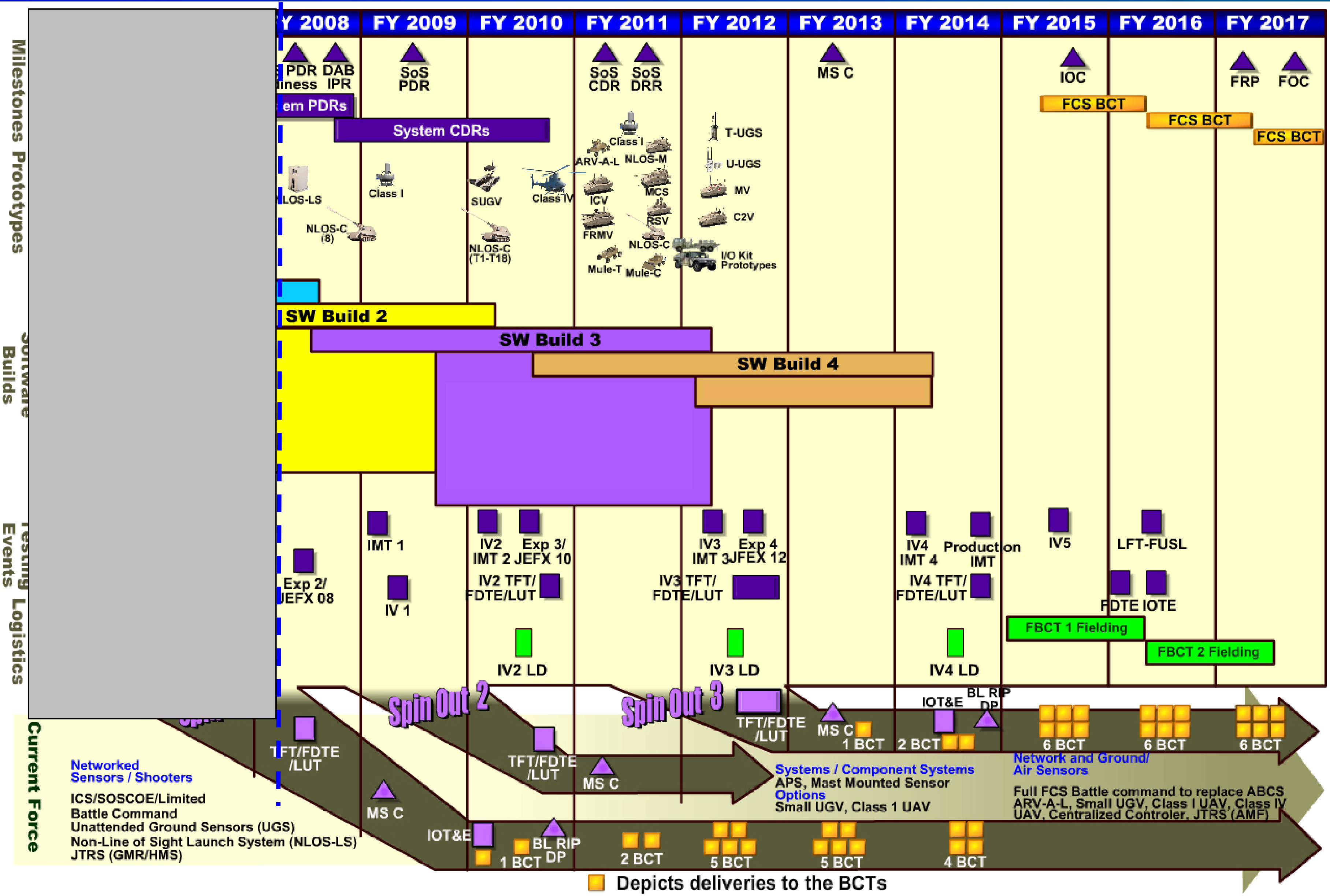
17 April 2008

Connect – Detect – Protect – Project…FCS



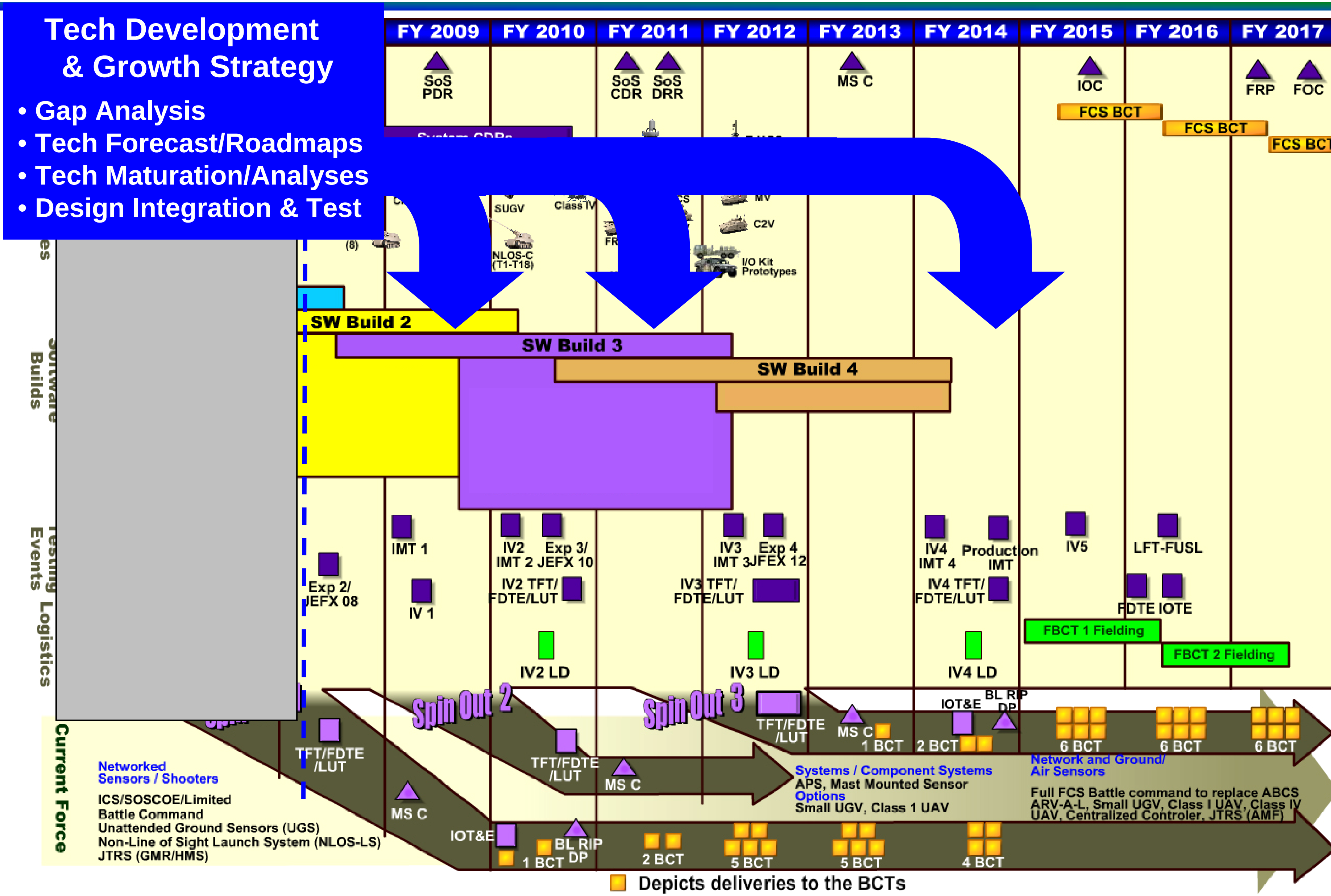
FCS (BCT) System-of-Systems Schedule

FUTURE COMBAT SYSTEMS
One Team-The Army/Defense/Industry



Potential for Inserting Technology/Capabilities

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry



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FCS Technology to the Force

Current Force Gap Analysis

FCS “Portfolio” Analysis

Recommended Spin Outs

Unit Set Capabilities

Subsystem Capabilities

Component Capabilities

Infantry Stryker Heavy

Fielding 6 current force BCTs/yr (76)

Current

Future

Fielding 15 FCS BCTs

B-Kit Spin Out 1 Status

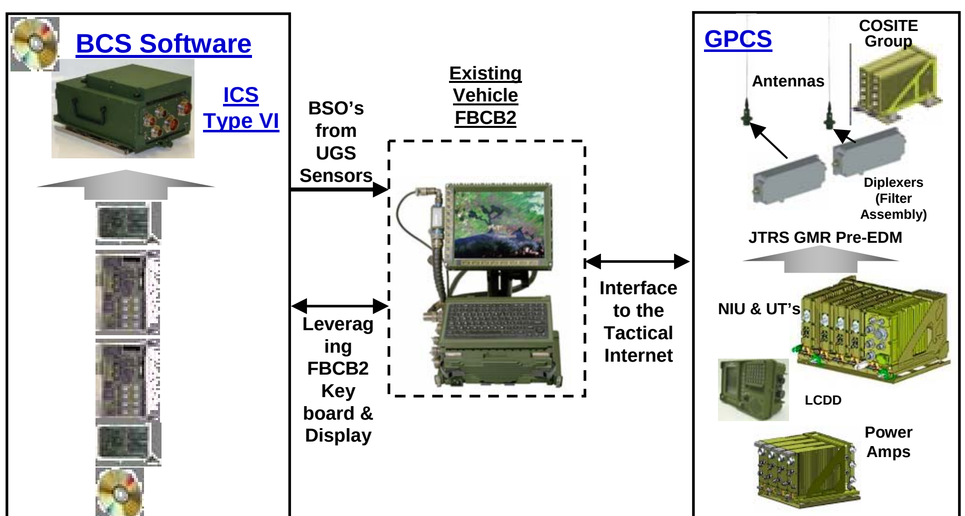


KEY ACCOMPLISHMENTS:

- ✓ **Abrams, Bradley and HMMWV NET**
- ✓ **SO1 B-Kit FQT SW to Current Force Vehicles**
- ✓ **B-Kitted HMMWV, Abrams and Bradley delivered for test**

FY08-09:

- **AETF Evaluation Events**
  - PTRR: 2Q FY08
  - TFT Dry Runs Start: 2Q FY08
  - TFT: 2Q FY08
  - FDT&E: 3Q FY08
  - LUT: 3Q/4Q FY08
- **Abrams and Bradley Final Safety Release: 2Q FY08**
- **Complete Abrams and Bradley IQT at APG: 3Q FY08**
- **SO 1 Milestone C: 2Q FY09**






UGS Spin Out 1 Status

FUTURE COMBAT SYSTEMS
One Team-The Army/Defense/Industry

U-UGS



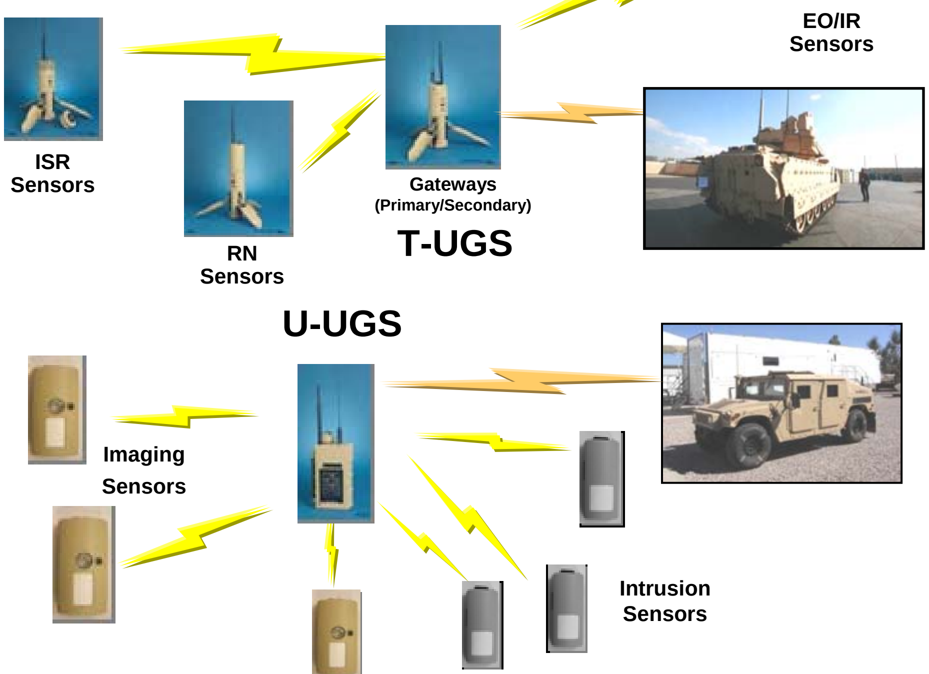
KEY ACCOMPLISHMENTS:

✓ **UGS NET**

✓ **T/U UGS prototypes delivered for test**

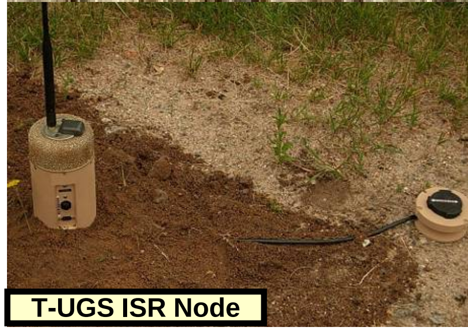
FY08-09:

- **AETF Evaluation Events**
  - PTRR: 2Q FY08
  - IQT: 2Q FY08
  - TFT Dry Runs Start: 2Q FY08
  - TFT: 2Q FY08
  - FDT&E: 3Q FY08
  - LUT: 3Q/4Q FY08
- **SO 1 Milestone C: 2Q FY09**



T-UGS





Non Line of Sight Launch System (NLOS-LS) Spin Out 1 Status

KEY ACCOMPLISHMENTS:

- ✓ **Current Forces Integration**
- ✓ **(AFATDS (FA Control Cell), FOS, CFFT)**
- ✓ **Container Launch Units (CLUs) Delivery**
- ✓ **Five prototype CLUs delivered**
  - One additional CLU in Feb
- ✓ **Conducted NLOS-LS NET**
- ✓ **Conducted NLOS-LS LOG De**

PAM

FY08-09:

- **NLOS-LS Flight Testing**
  - CFT-12: 2Q FY08
  - CTV-2: 2Q FY08
  - CFT-13: 3Q FY08
  - NLOS-LS GTV 1-9: 4Q FY08 - 1Q FY09
- **AETF Evaluation Events**
  - TFT: 2Q FY08
  - FDT&E: 3Q FY08
  - LUT: 4Q FY08
- **Award of Long Lead Items Contract: 2Q FY08**
- **SO 1 Milestone C: 2Q FY09**
- **NLOS-LS Flight LUT: 2Q FY09**
- **Production Decision/LRIP I Award: 3Q FY09**

CLU

Class I Unmanned Aerial Vehicle (UAV) Block 0 Acceleration

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Key Accomplishments

- ✓ **AETF NET**
- ✓ **Acceleration Reviews**
- ✓ **MAV Deployed with EOD and other units**

FY08-09:

- **Continue in theater assessment: pres-FY09**
- **C4 Network Integration: 1Q-3Q FY08**
- **E3 and Environmental Safety Tests: 3Q FY08**
- **Blk 0 Delta NET: 3Q-4Q FY08**
- **Proceed decision: 4Q FY08**

Small Unmanned Ground Vehicle (SUGV) Block 1 Acceleration

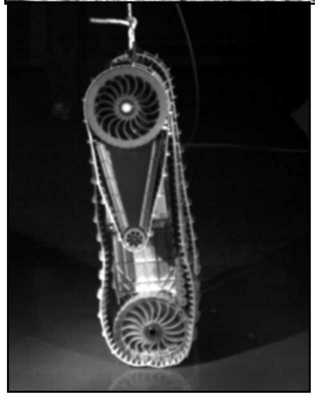
FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

Key Accomplishments:

- ✓ Mobility testing
- ✓ Drop test
- ✓ EMI testing
- ✓ Water resistance
- ✓ Safety release
- ✓ AETF NET Soldiers Trained
- ✓ 3 Prototypes delivered

FY08-09:

- NET: 2Q FY08
- User events/test: 3Q/4Q FY08
- C4 Network Integration: 2Q/3Q FY08
- Deliver 22 units to the AETF (3Q FY08) for experimentation testing scheduled for the Summer of 2008.
- Proceed Decision: 4Q FY08



NLOS-Cannon Status

FUTURE COMBAT SYSTEMS FCS
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Firing Platform 2006-2008


Prototype 1 - Integration

KEY ACCOMPLISHMENTS:

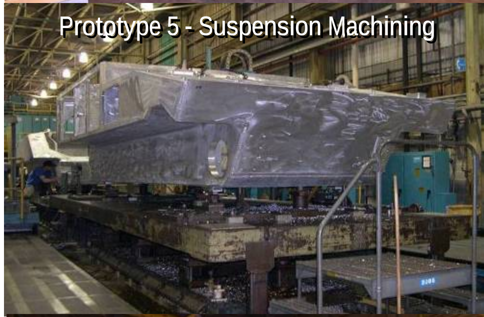
- ✓ **July 07 Completed Stability Testing**
- ✓ **Nov 07 Completed ROF/ACCS/DI Testing**
- ✓ **Dec 07 Fired Excalibur Mass Simulators w/Tactical Bases**
- ✓ **>1500 Rounds Fired on the Firing Platform as of 18 Feb 08**

FY08-10:

- **Safety Release - Maintenance & Re-Arm: 3Q FY08**
- **NLOS-C P1 Roll Out at Army Ball: 3Q FY08**
- **NLOS-C Congressional MS C: 1Q FY09**
- **Soldiers Driving/Firing NLOS-C at YPG: 2Q FY09**
- **NLOS-C Fielded to AETF: 4Q FY09**

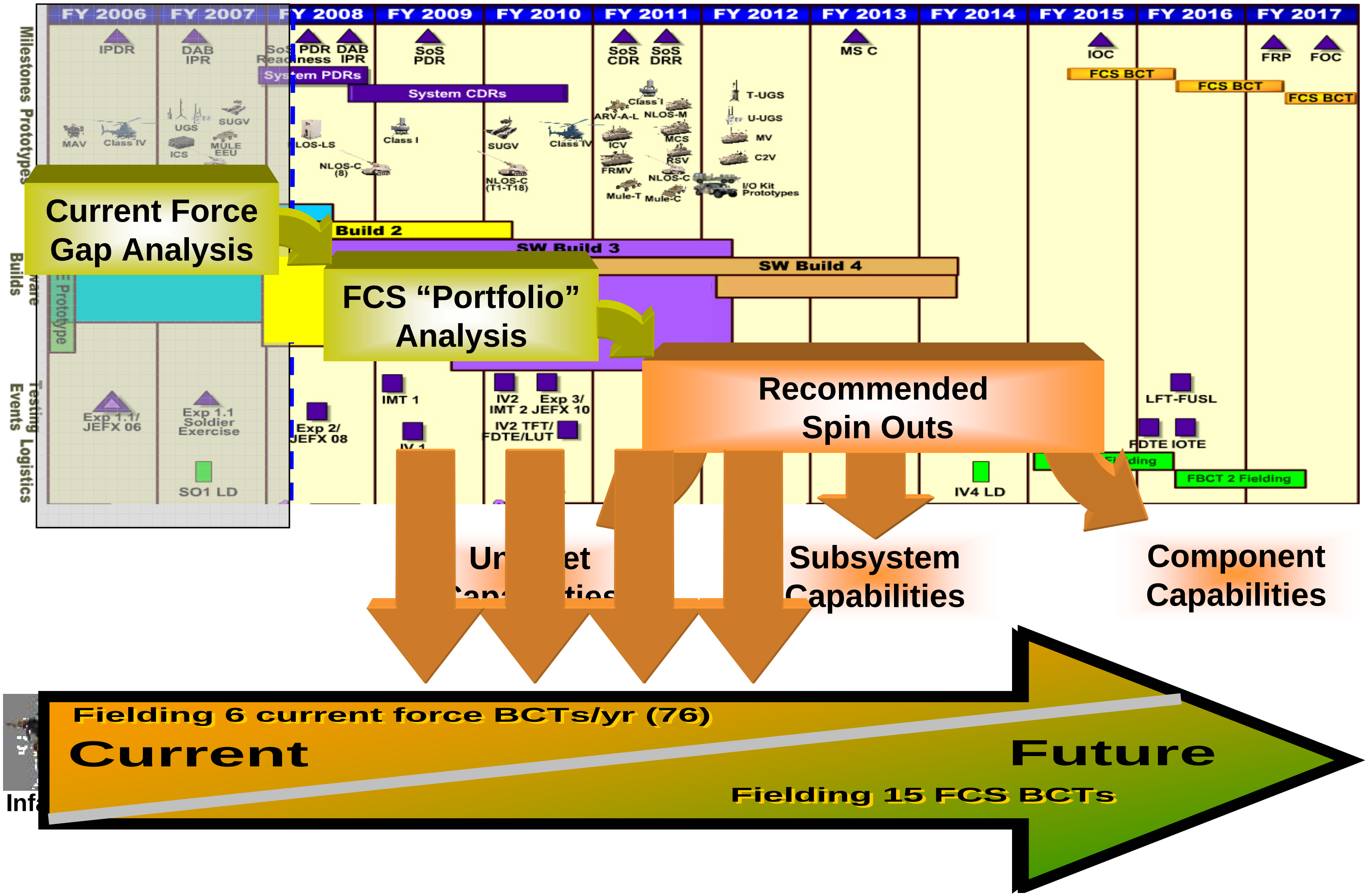

Prototype 3 - Integration


Prototype 4 – Ready for Integration


Prototype 5 - Suspension Machining


Prototype 6 - Hull Welding

FCS Technology to the Force



FCS – Reducing the "Log FOOTPRINT"

FCS Increment 1 Threshold Design (2012-2014)

FUTURE COMBAT SYSTEMS
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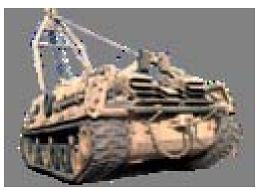
Current Force Maintenance

58 Abrams

109 Bradley



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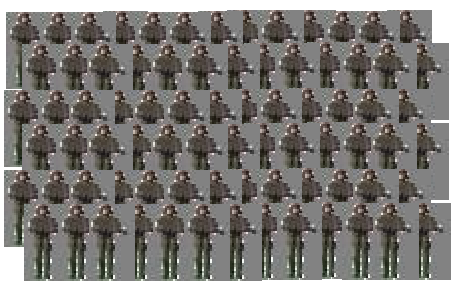


78 = Field Level

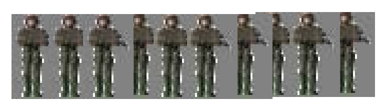
19 = Sustainment

FCS Maintenance

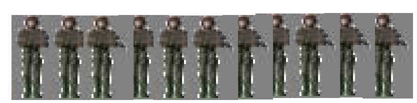
60 MCS

102 ICV

10 FRMV



10 = Field Level



<11 = Sustainment

Fewer soldiers required for logistics

FCS MGV Reliability Design Improvement Over Current Force Platforms

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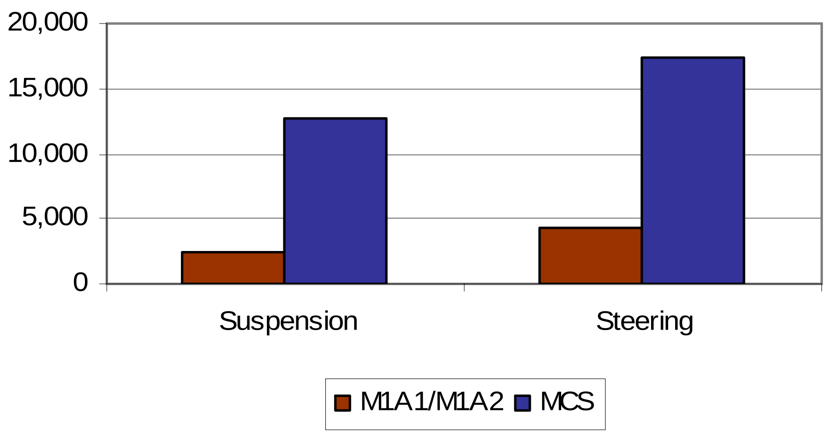
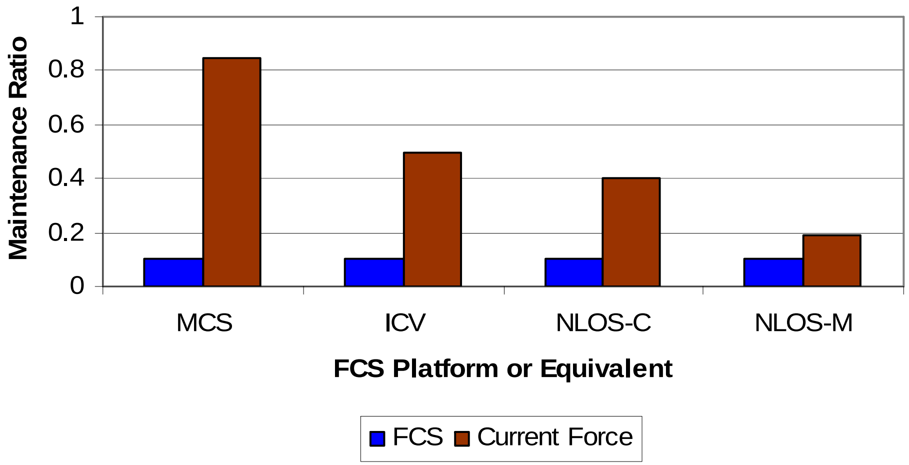
Mean Times Between System Abort (MTBSA) in Hours
(More is Better)



Maintenance Ratio (MR)
(Less is Better)



Commonality maintains high, consistent component reliability across FCS platforms

- MTBSA Source: RAM-T Cases, Sept 04
- MR Source: Affordability and Strategic Integration IPT
- All costs based on LSI estimates, not the Army Cost Position.


FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry
The Future is Now
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4/18/2008 3:30:20 PM

Cyberspace: New Frontiers in Technology Insertion

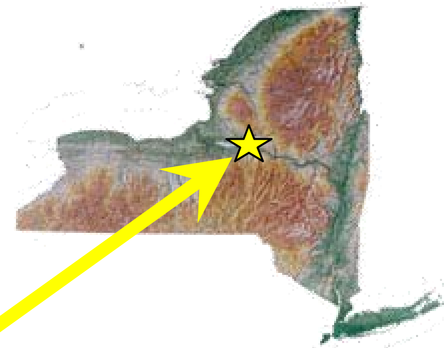
Dr. John S. Bay, ST

Chief Scientist,

Air Force Research Laboratory, Information Directorate

AFRL Structure

- **AFRL** — Maj Gen C Bedke
  - Staff
  - XP
  - Air Vehicles
  - Space Vehicles
  - Information
  - Munitions
  - Directed Energy
  - AFOSR
  - Materials & Manu-facturing
  - Sensors
  - Propulsion
  - Human Effectiveness



AFRL/RI
Core Technical Competencies (CTCs)

Information Exploitation

Information Fusion & Understanding

Information Management

Advanced Computing Architectures

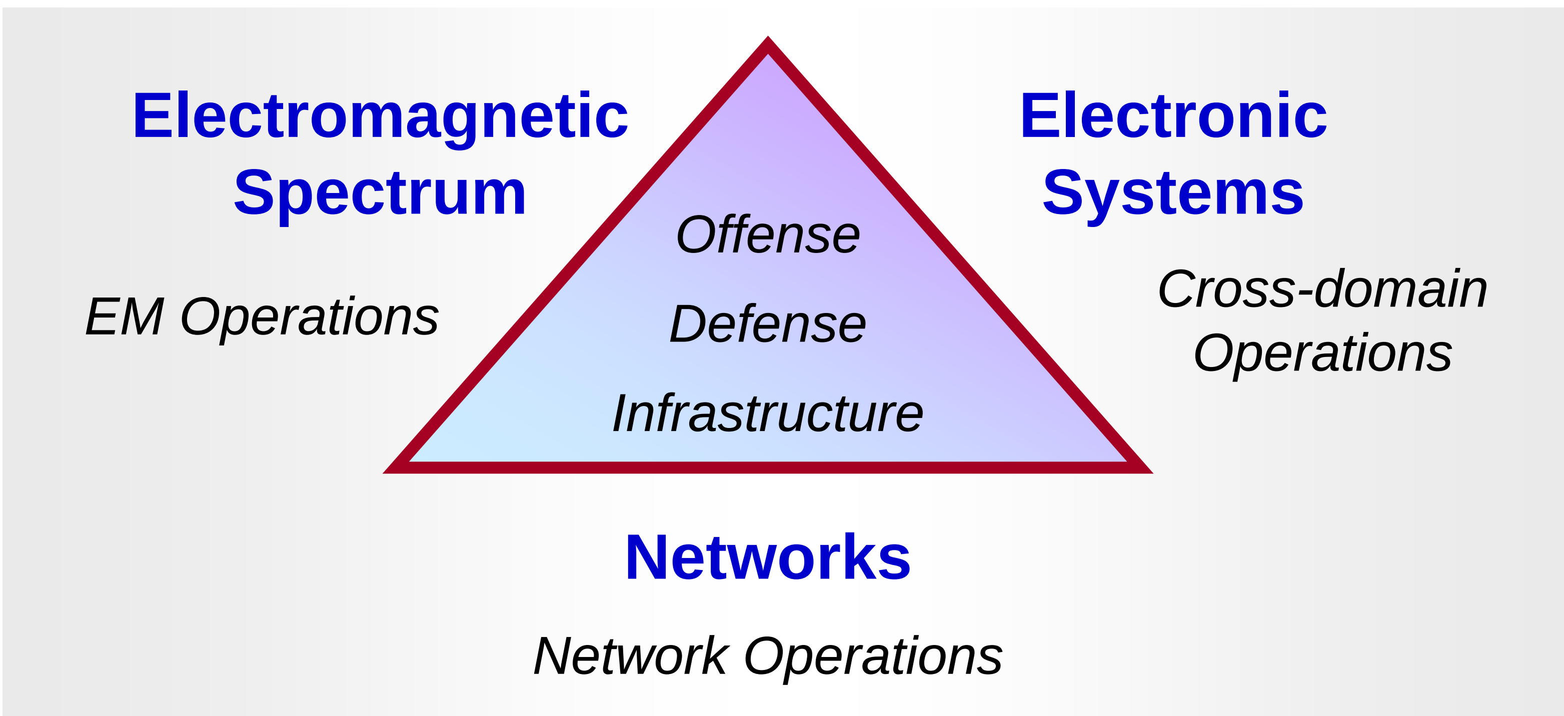
Cyber Operations

Connectivity

Command & Control

CyberSpace Operations

DoD Definition: Cyberspace is a domain characterized by the use of <u>electronics</u> and the <u>electromagnetic spectrum</u> to store, modify, and exchange data via <u>networked systems</u> and associated infrastructures



Lt Gen Bob Elder

Some Important Characteristics of Cyber Operations

- Low cost of entry
  - The enemy can be a disgruntled individual with a cheap computer
- Not characterized by physical or geographic boundaries
  - The enemy can be anywhere and everywhere, outside *and inside*
- R&D and Operations are done in highly classified environment
  - Makes information sharing difficult
- Often relies on exploits that are easily discovered and repaired
  - Sometimes, we only get "one shot"
  - Offense and defense are tightly coupled
  - Technology turnover/refresh

Characteristics of AFCYBER that Catch Our Attention

- Effects, C2, and assessment are to be implemented as integrated capabilities
  - Integrated with other kinetic and non-kinetic capabilities
- The 8th AF capabilities will be organized around an AOC
  - Implies known structure, CONOPs, and doctrine, *but only for air and space domains*
- The executing authority is the COMAFFOR/JFACC
  - Implies known resources, training, responsibilities, *but only for air and space domains*

The parity of Cyber with Air and Space domains suggests parallel concepts in C2, battle management, and intelligence technologies

Cyber Operations Technology Thrusts

1. Access 2. Stealth & Persistence 3. Cyber Intelligence 4. Effects (D5) Deny, Disrupt, Degrade, Deceive & Destroy	CYBER OFFENSE
5. Avoid 6. Defeat 7. Survive 8. Recover	CYBER DEFENSE
9. Situational Awareness 10. Education	CYBER SUPPORT

Warfighting Concepts with a Cyber Twist

- ATR
  - What is a “target” in cyberspace?
  - How do we recognize it when we see it?
- ISR
  - What sensors can we deploy, and how are these assets shared?
- EBO/EBA
  - In cyberspace, the observability of effects is tenuous
  - Second-order effects and cause/effect relationships even more so
- BDA
  - Cyber effects propagate in hard-to-detect ways; including in peoples’ behaviors. What is total effect? Can we determine in real-time?
- AOR
  - Can cyberspace be sensibly decomposed into manageable combatant commands?
- SA and PBA
  - “Situation” is an abstract concept in cyberspace.
  - Visualizations and dynamics (motion, patterns) are ill-defined
- C2 tools
  - Can kinetic and cyber tools be controlled with a single toolset?
  - Can kinetic and cyber tools be integrated/synchronized in a single operation?

AFCYBER Key Areas

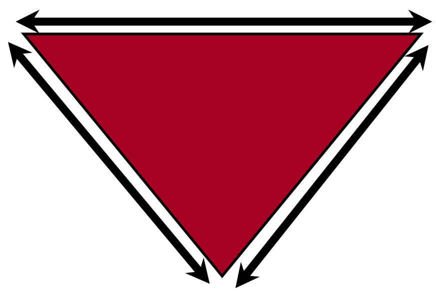
- **FY 07**
  - Cyber ORM
  - Software Assurance
  - Critical Infrastructure Identification
  - Offensive Cyber Program Research
- **FY08**
  - Mission Assurance
  - Security Enhancements (Full CAC compliance)
  - Expanded data encryption (at rest and in transit)
  - Sensitive data offline storage
  - Globally Linked AOCs
  - Offensive Cyber Program Development (Integrated with Air and Space C2)
  - DIB IA
- **FY09**
  - Expeditionary Networks
  - Counter IO: Data protection
  - IP camouflage
  - Active Defense
  - Critical Infrastructure Protect
  - Boundary monitoring
  - Cyber Control
- **FY10**
  - Network Survivability
  - Cyber Attack
  - Cyber Interdiction
  - Sensor Disruption
  - C2 Disruption
  - Cyber enabled weapons degradation
  - Electronic Sys Attack (w/ DE)

“Traditional” AFRL Transition

- **6.1 → 6.2 → 6.3, Critical Experiments and Advanced Technology Demonstrations**
- **Advanced Technology Council**

Lab (☆☆)

- Identify ATD Candidates
- Budget for Technology Programs
- Develop Transitionable Technologies



User (☆☆☆)

- Define Requirements
- Budget Transition Funds

Center (☆☆☆)

- Interpret Requirements
- Build Transition Program
- Integrate Into Systems

POM-Oriented Transition

ATD Categories

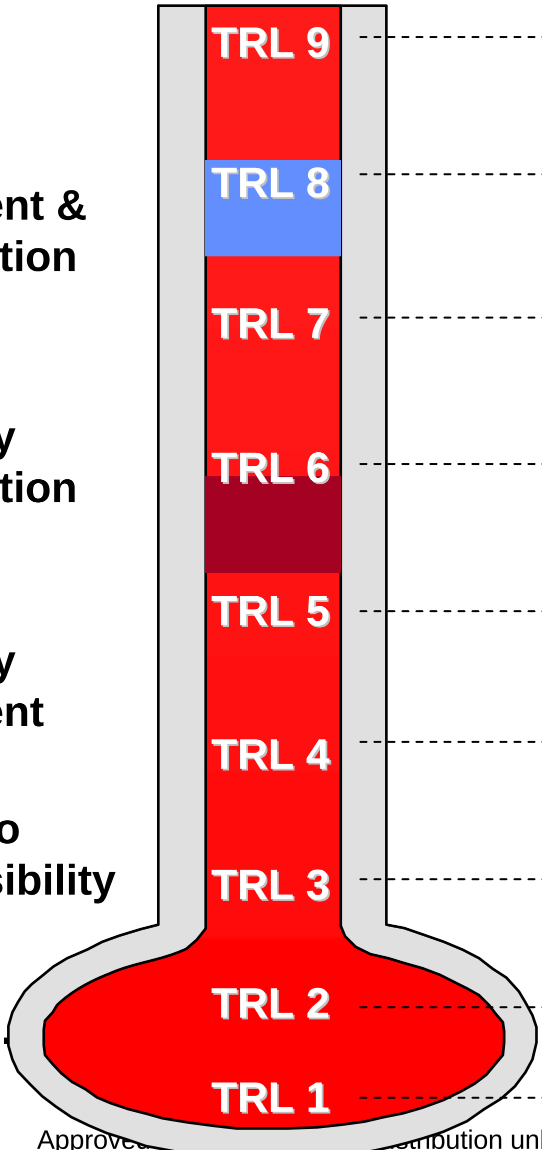
- *Category 1:* MAJCOM or Agency supports and has programmed required funding for transition within the FYDP
- *Category 2A:* MAJCOM or Agency supports and is committed to identify transition funding in the next Program Objective Memorandum (POM) cycle or Amended POM
- *Category 2B:* MAJCOM or Agency supports but is not currently able to program for transition funding

Traditional Acquisition

Traditional acquisition practices support the development, deployment, and sustainment of long term, highly capable systems

- Focus on minimum risk
- Stable requirements (or a known roadmap)
- Dedicated development and test cycles
- Refined over years based on large body of experience
- 10 year cycle typical for development to transition & Integration

Technology Readiness Levels



System Development & Demonstration

Technology Demonstration

Technology Development

Research to Prove Feasibility

Basic Tech. Research

- Actual system "Flight Proven" through successful mission operations
- Actual system completed and "flight qualified" through test and demonstration
- System prototype demonstration in an operational environment
- System/subsystem model or prototype demonstration in a relevant environment
- Component and/or breadboard validation in a relevant environment - environment can be simulated
- Component and/or breadboard validation in a laboratory environment
- Analytical & experimental critical function and/or characteristic proof-of-concept
- Technology concept and/or application formulated
- Basic principles observed and reported

The Current Landscape

Bridging The Technology Transition Gap

Source: AFC2ISRC GCIC AFISR ATC

RDT&E

S&T

6.1 Basic Research	6.2 Applied Research	6.3 Adv. Tech Dev	6.4 Program Define/ Risk Reduction	6.5 Engr/Manuf Development

Tech Base

Managed by AFRL

Managed by System Program Offices

Applied Technology Council

Means for Tech Transition

Advanced Technology Demo (ATD)
Advanced Concept Tech Demo (ACTD)
Technology Planning IPT
Technical Events (JEFX, CWID etc.)
SPD Initiative
Industry Initiative
Senior Leader Initiative

Tech Transition "Seam"

Emphasis is Necessary on Technology Transition

- Sustained Senior Leader Emphasis
- Continuous Communication
- Integrated Process
- Budget For Production Incorporation

The S&T Transition Struggle

Technology Standards

Acquisition Standards

New Ideas **Tech. Push** →

Tactical

- **Meets User Need**
  - **Specific Capability**
- **GOTS/COTS Avail.**
- **TRL Level Validated**
- **Production Capable**
- **Allows COTS Prod. Integration**

Strategic

- **Meets Planners Projections**
  - **General Technology**
  - **Future Capability**
- **General Applicability**
  - **Enhances Performance**
  - **Foundation (i.e. Open Syst.)**
  - **Lead Industry**
- **Expandability – General**
- **Flexibility – General**

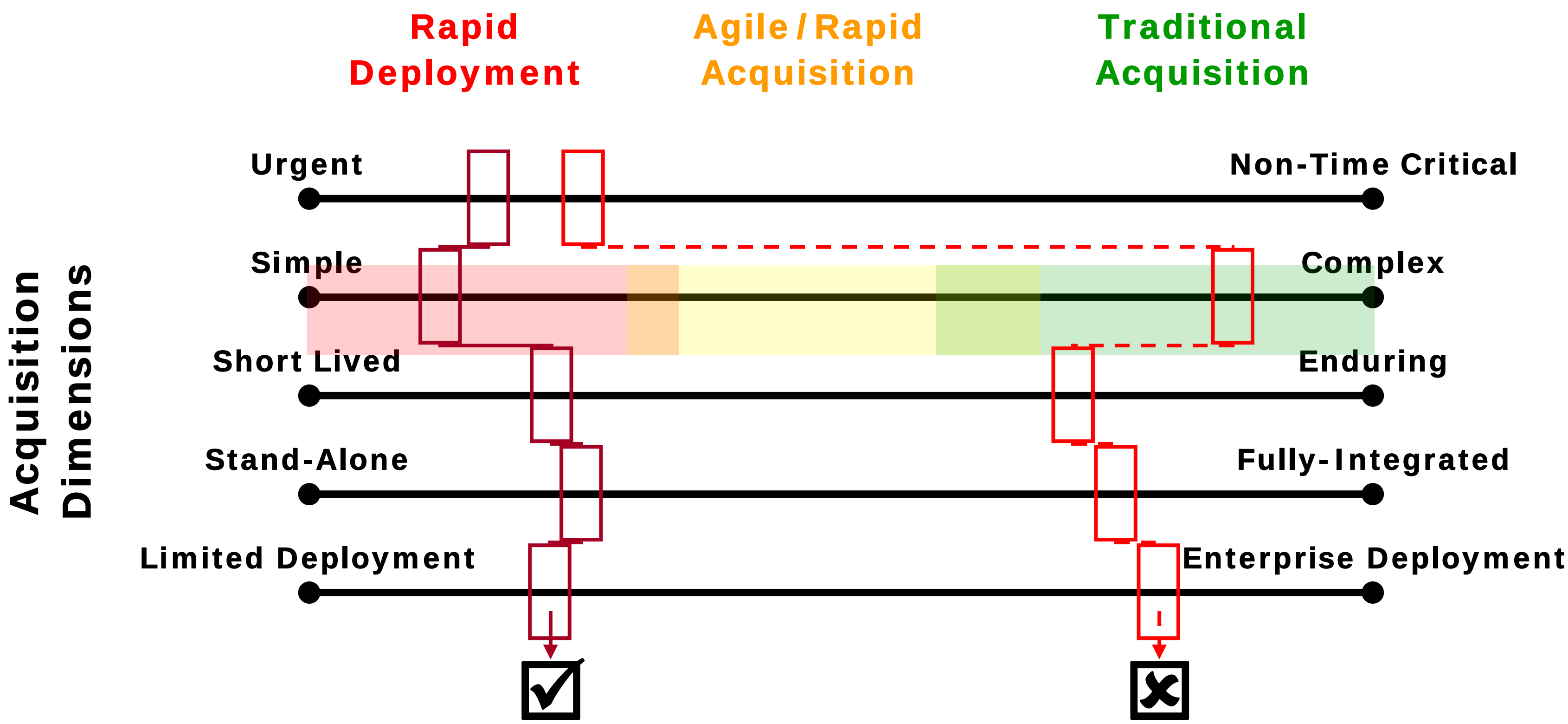
Transition Gap

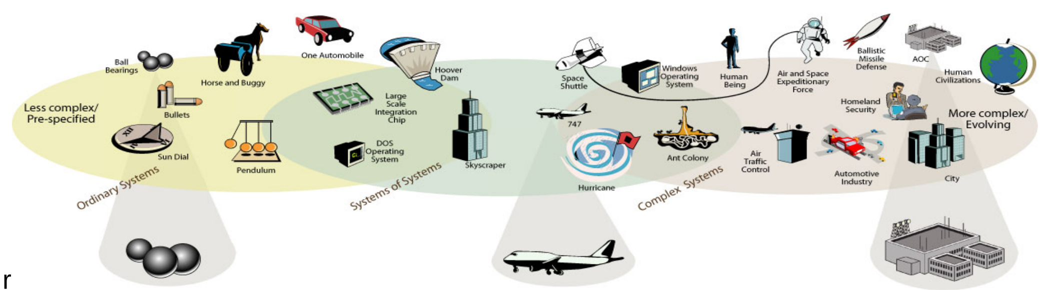
← **Req Pull** Current Needs

CYBER Transition Requires new Acquisition Processes

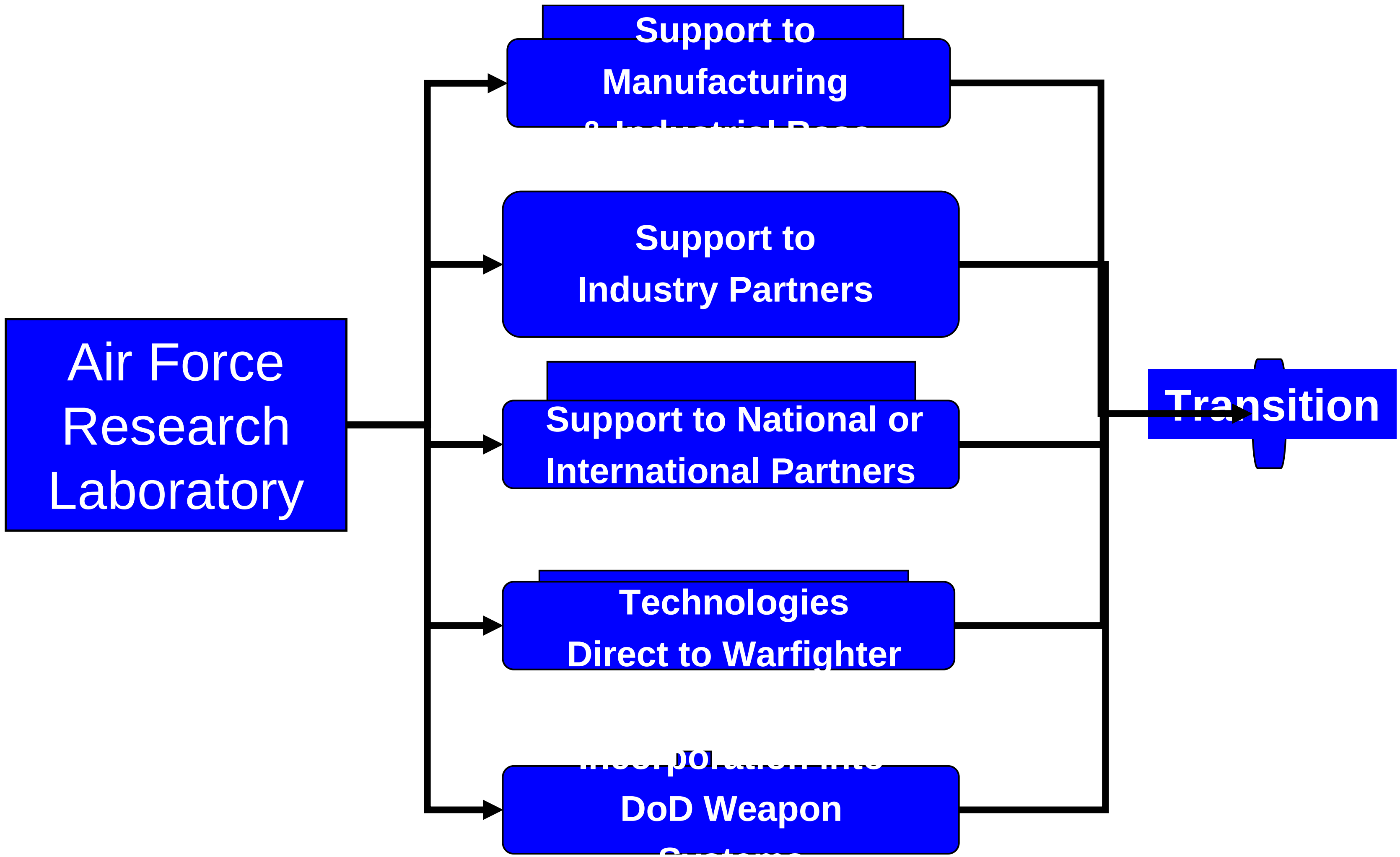
- **Cyber Acquisitions may require:**
  - **Very rapid, urgent fielding needs (days to weeks)**
  - **Agile development and fielding (months)**
  - **Traditional development, fielding, and sustainment (months to years) with regular capability "releases" or spirals**
- **Application to very short cycle times requires alternative approaches**
  - **Decreased research & development time**
  - **Limited test and verification**
  - **"Short tail" logistics**
- **Strategies to continually innovate and assess**
  - **threats and emerging technology,**
  - **Rapid prototyping**
  - **Supporting AFCYBER stated capability needs**
  - **Develop key partnerships**
- **Migration of some development and assessment efforts to "pre-need" phase**
  - **Emerging threat R&D strategy to complement reactive acquisition strategy**

Full Spectrum Acquisition

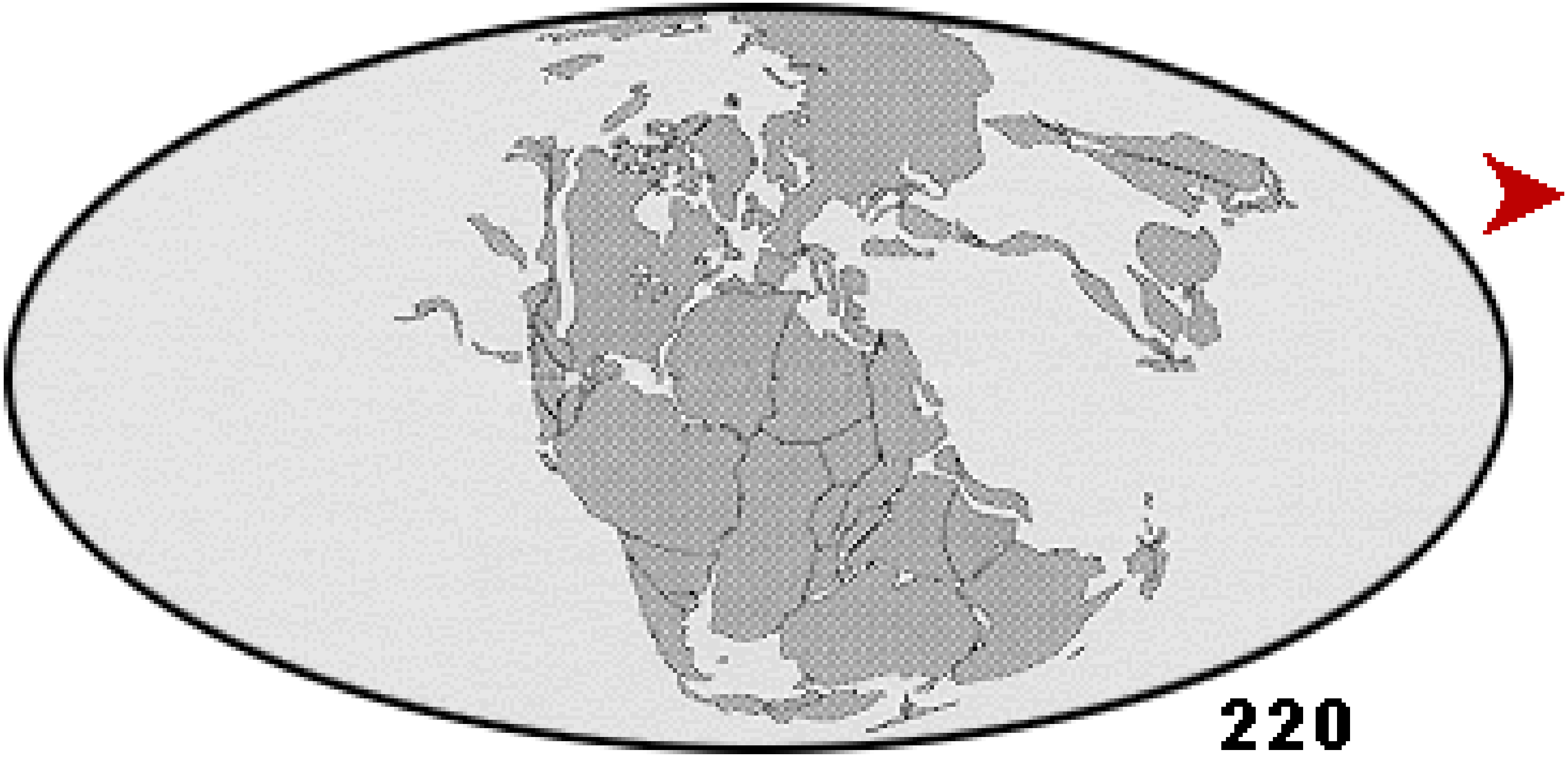




Alternative Transition Paths



Conclusions: The Changing Battlefield of CyberSpace



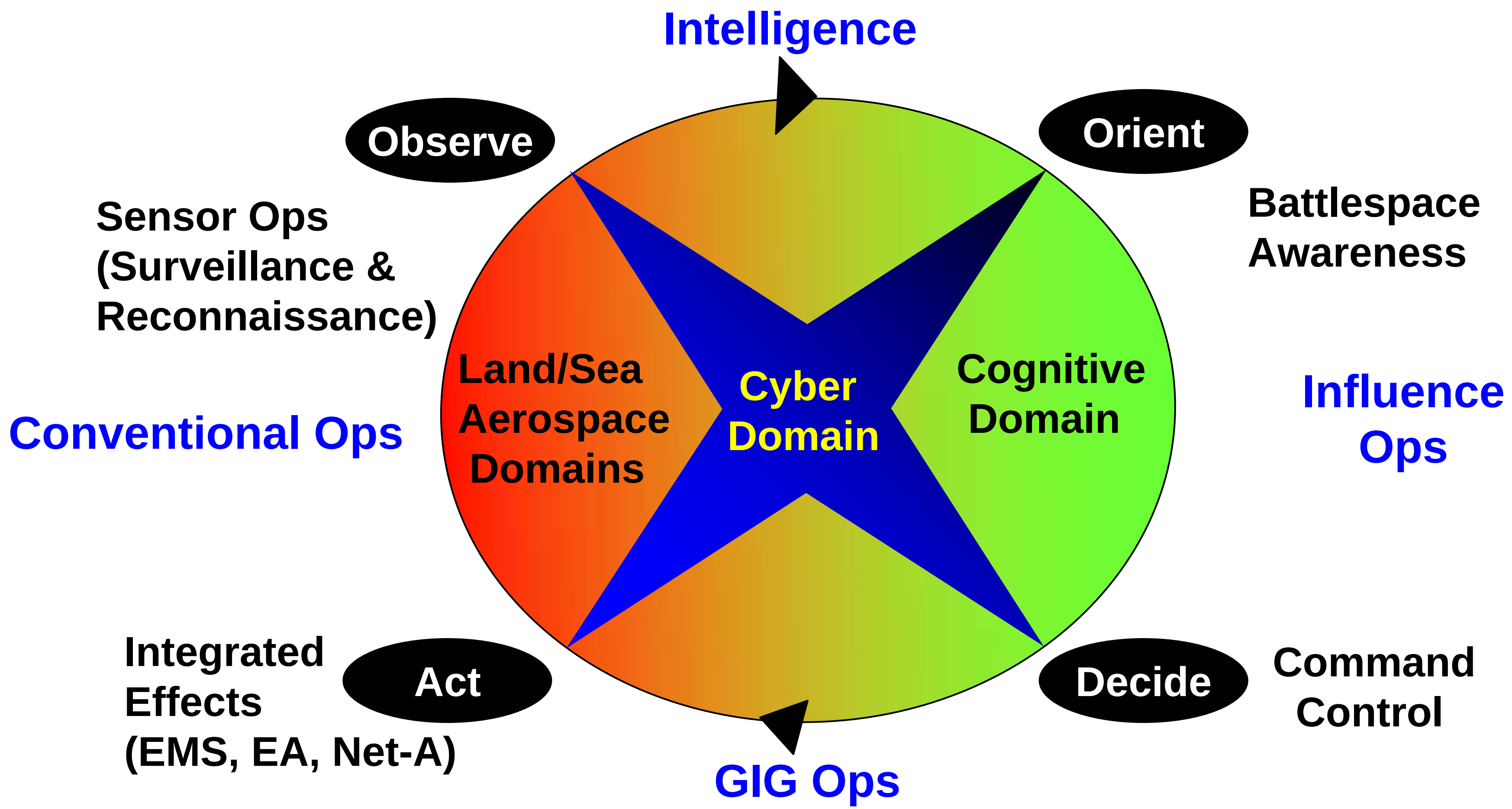
"Transition to WHAT?"

Summary

- Rapid research & development strategies
- Constant reassessment of changing landscape resulting in short duration R&D efforts and rapid technology transition
- New acquisition strategies required
- New relationship between research and acquisition
- Innovative challenges/opportunities for community to develop a responsive cyber research and development strategy to work with a full spectrum acquisition capability
- AFRL/RI to lead R&D for the cyber big “A” team

Questions?

The Battle in Cyberspace



Offense, Defense, Infrastructure Elements

Lt Gen Bob Elder

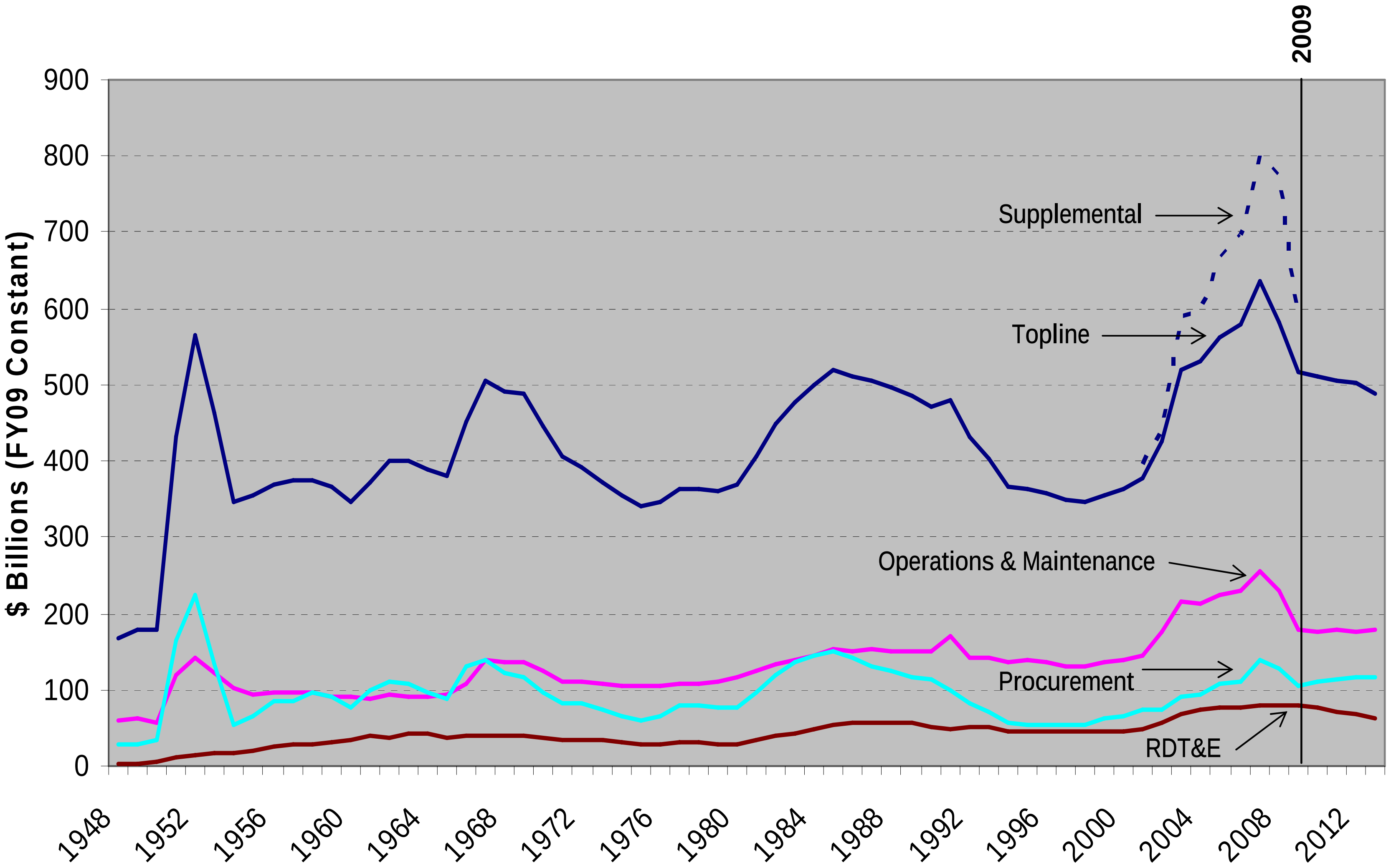
NDIA Science and Engineering Technology Conference/ DoD Technology Exposition

April 17, 2008

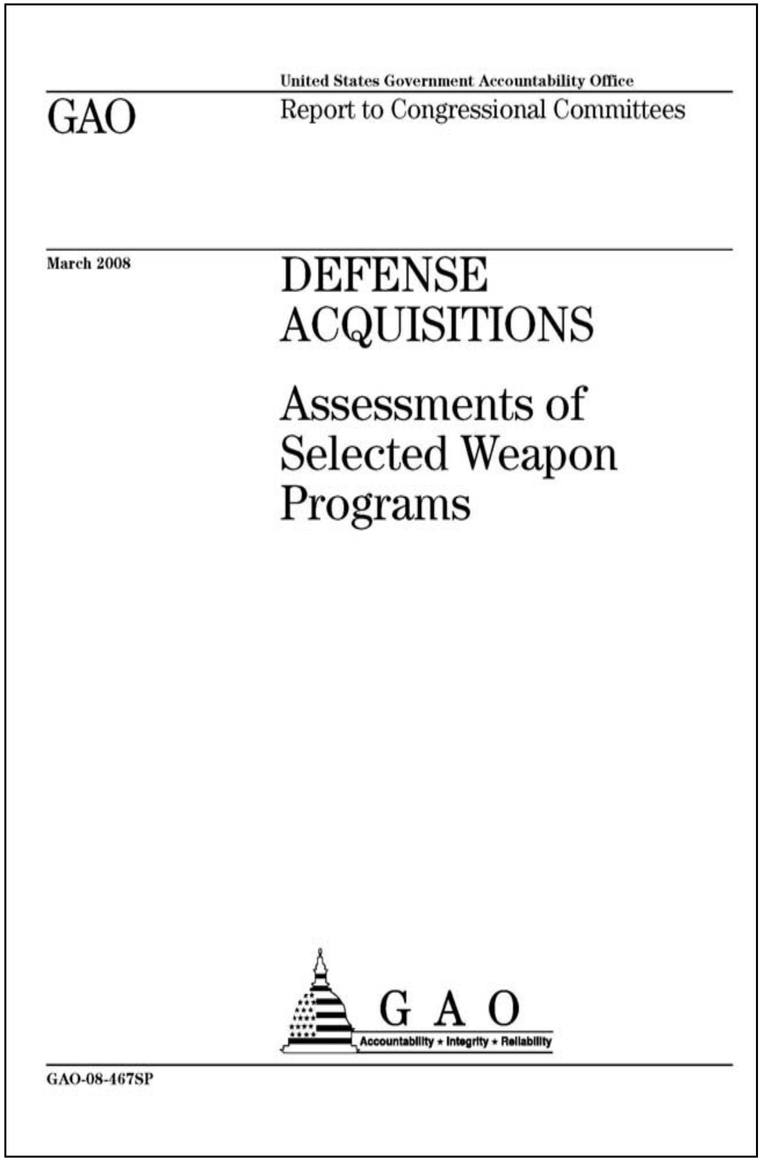
Gary Powell
OUSD(AT&L)
gary.powell@osd.mil

Defense Budget Trends

(DoD Budget Authority)



Source: USD (Comptroller) National Defense Budget Estimates for the FY 2009 Budget (Green Book)


United States Government Accountability Office

GAO

Report to Congressional Committees

March 2008

DEFENSE ACQUISITIONS

Assessments of Selected Weapon Programs

GAO

Accountability * Integrity * Reliability

GAO-08-467SP

"…total costs for the fiscal year 2007 portfolio of major defense acquisition programs increased 26 percent from first estimates …development costs … increased by 40 percent … In most cases, programs also failed to deliver capabilities when promised - often forcing warfighters to spend additional funds on maintaining legacy systems…Of the 72 weapon programs we assessed this year, no program had proceeded through system development meeting the best practices standards for mature technologies, stable design, and mature production processes – all prerequisites for achieving planned costs, schedule, and performance outcomes."

U. S. Department of Defense

Why Should DoD Invest in Basic Research?

A Presentation for

The 9th Annual NDIA Science & Engineering Technology Conference/DoD Tech Exposition

Dr. William S. Rees, Jr.

Deputy Under Secretary of Defense (Laboratories and Basic Sciences)

Office of the Director Defense Research and Engineering,

April 15-17, 2008

Context

- The growth rate of the world population is declining
- 90% of population growth is in developing and poorer countries
- 40% of the world's population – 2.5 billion people – live on less than $2 per day
- Proportion of working age adults (15-59) is expected to decrease in every area except Africa
- 880 million people were illiterate, 250 million children worked and 110 million school age children did not attend school, as of 2000

Source: "Joint Operating Environment" United States Joint Forces Command, December 2007,

Context

- By 2030, China is expected to have 348 million people over 60, nearly as many as the entire projected population of the US
- 13% of the global population lived in cities in 1900. Today the global proportion of the urban population is 49%. 60% of the globe's population - 4.9 billion people - will live in urban areas by 2030
- Massive urbanization – 17 of 22 "mega cities" will be in the developing world by 2015.

Source: "Joint Operating Environment" United States Joint Forces Command, December 2007,

Context

- Since the 1970's, weather/climate-related losses have increased about 10% per year and accounted for 88% of all property losses covered by insurers from 1980 to 2005
- India and China will develop "first world" energy appetites
- Many oil exporting countries may use production for their own economies

Source: "Joint Operating Environment" United States Joint Forces Command, December 2007

Context

- Current major supplies of petrochemical products will not keep pace with projected demand
- Only 12 years from now, machine intelligence could equal or surpass that of humans – eventually, it will become impossible to differentiate between man and machine
- Weapons of mass effect will shrink and proliferate: nuclear, bio, directed energy, nanotechnology, and CYBER

Source: “Joint Operating Environment” United States Joint Forces Command, December 2007

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Context

- Science, technology, and engineering are available globally
- US scientific leadership is at risk
- Multi-disciplinary technologies will have revolutionary impact - 70 % of world R&D is conducted outside the US
- China is now the third largest investor in R&D (adjusted for purchasing power), behind only the US and Japan

Source: “Joint Operating Environment” United States Joint Forces Command, December 2007

Context

- The United States is today a net importer of high technology products (+$54B in 1990 to -$50B in 2001)

Source: “Joint Operating Environment” United States Joint Forces Command, December 2007

OUTLINE

- DoD Basic Research
- DoD STEM Education
- Prize Competition

Leaders support Basic Research

- President Bush :

"…double federal support for critical basic research in the physical sciences…"

- The Secretary of Defense supports Basic Research

"… greater emphasis on basic research, which in recent years has not kept pace with other parts of the budget."

Basic Research

- Basic research is systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts ***without specific applications towards processes or products in mind.***

  It is farsighted high payoff research that provides the basis for technological progress.

Source: *DoD Financial Management Regulation,* Volume IIB, Chapter 5, June 2004, 050201 RDT&E Budget Activities.

Why Does DoD fund Basic Research?

- DoD is perpetually, permanently in the capability business
- By … gy
- Te
- Ba … ide
- Th
- Sci … ew te… technologies

We cannot know when a discovery will become a capability but we know with absolute certainty that without discovery, our capabilities remain static.

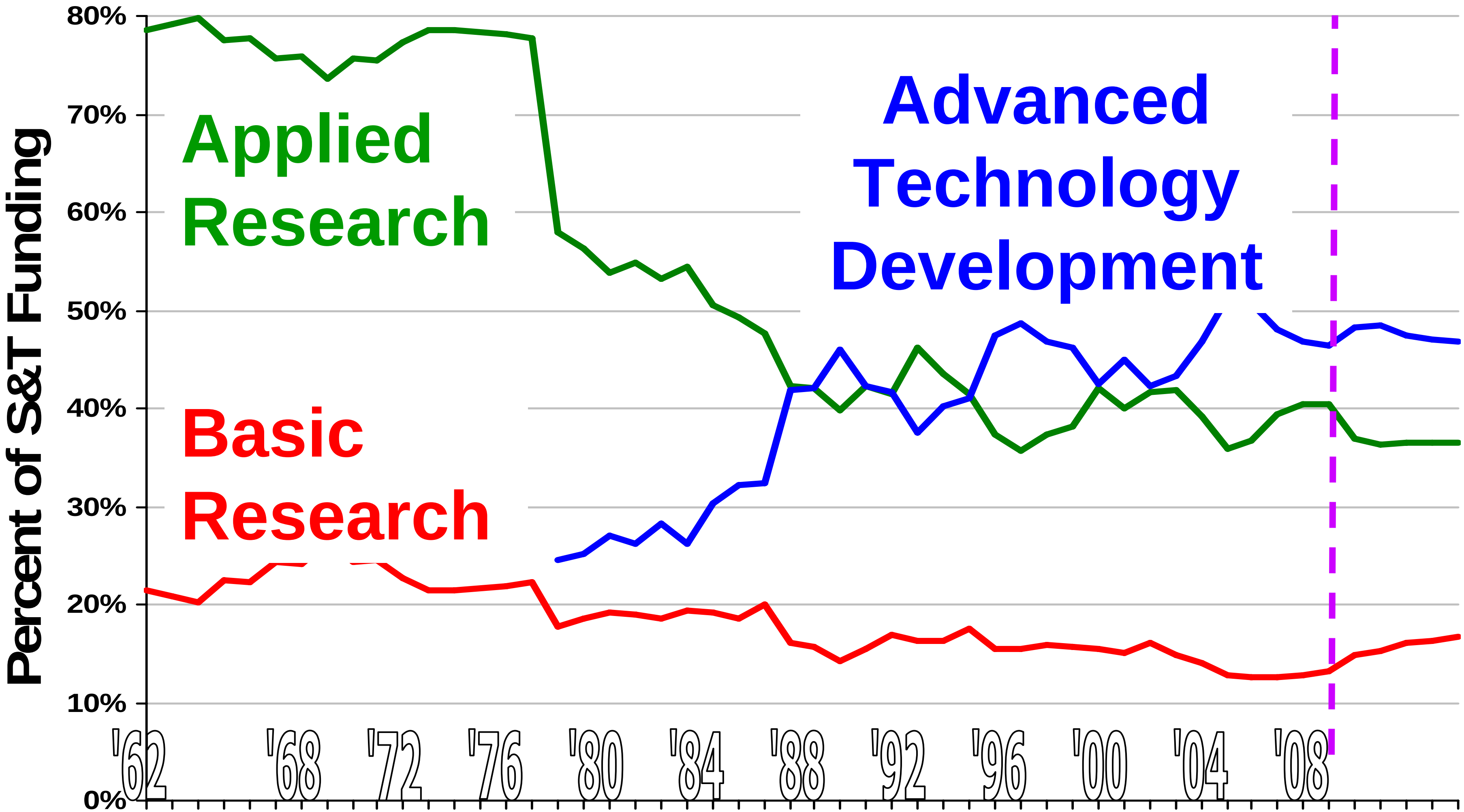
- Technologies move rapidly across borders
- If technology exists, it will be used, first in weapons

Why Does DoD fund Basic Research?

- Generates discoveries, new knowledge, and improved understanding
- Achieves technological superiority
- Prevents technological surprise
- Educates scientists and engineers in physical science disciplines
- Ensures that scientific expertise and engineering rigor supports DoD technical decisions
- Sustains the human talent and research infrastructure

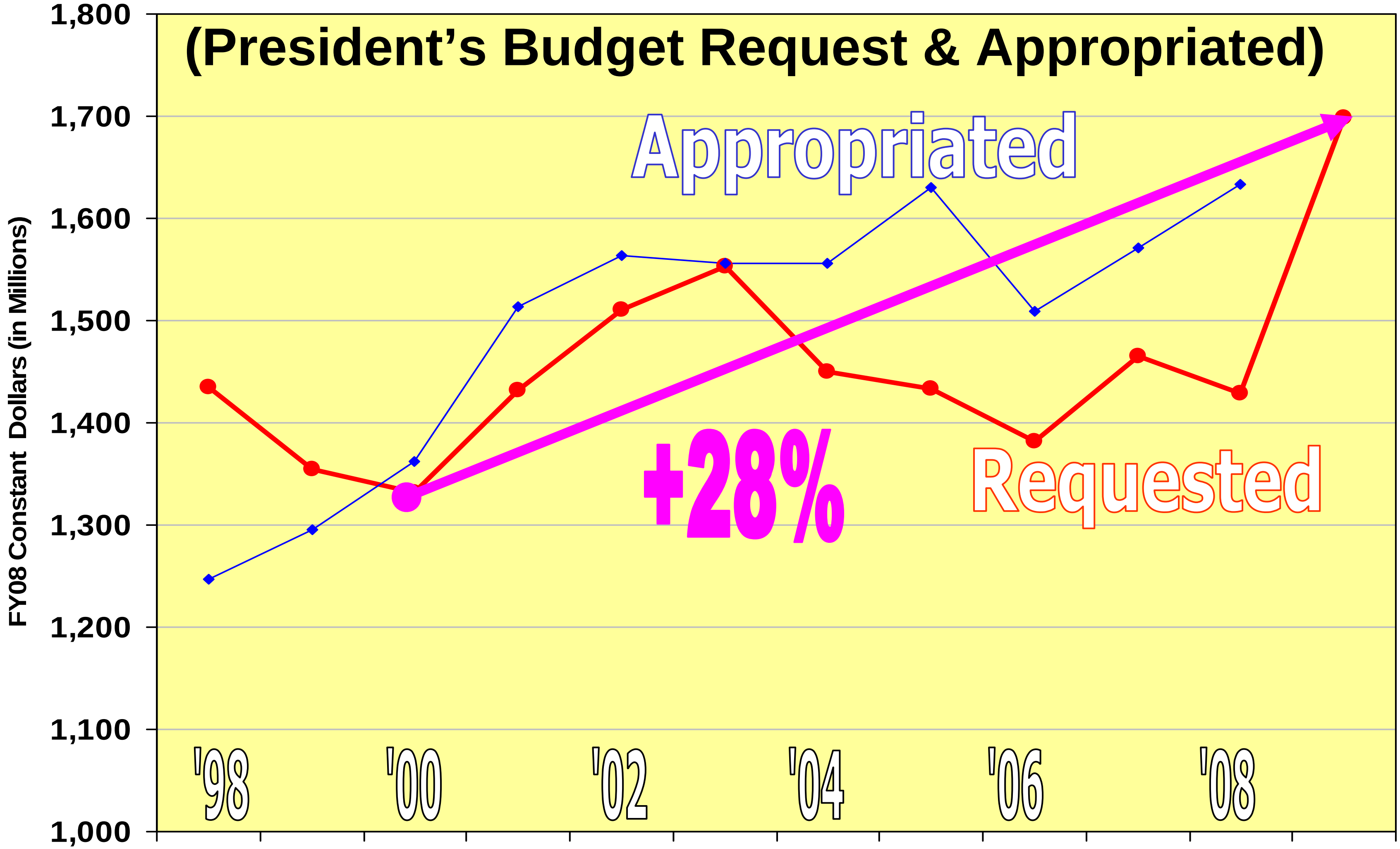
Don't expect Basic Research to solve all problems

DoD S&T Requests



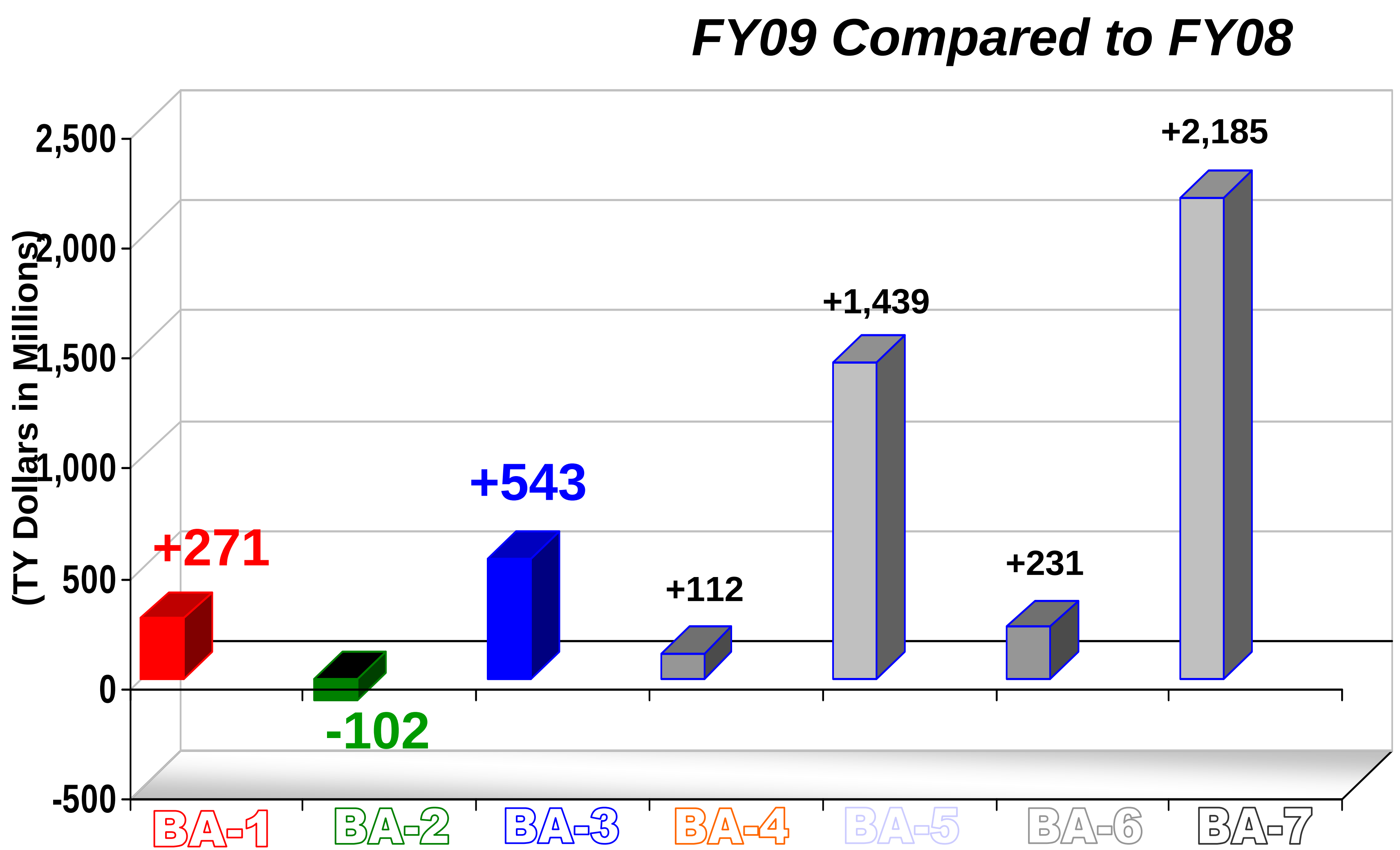
Note: Advanced Technology Development funding began in FY78

DoD Basic Research Funding FY1998-2009

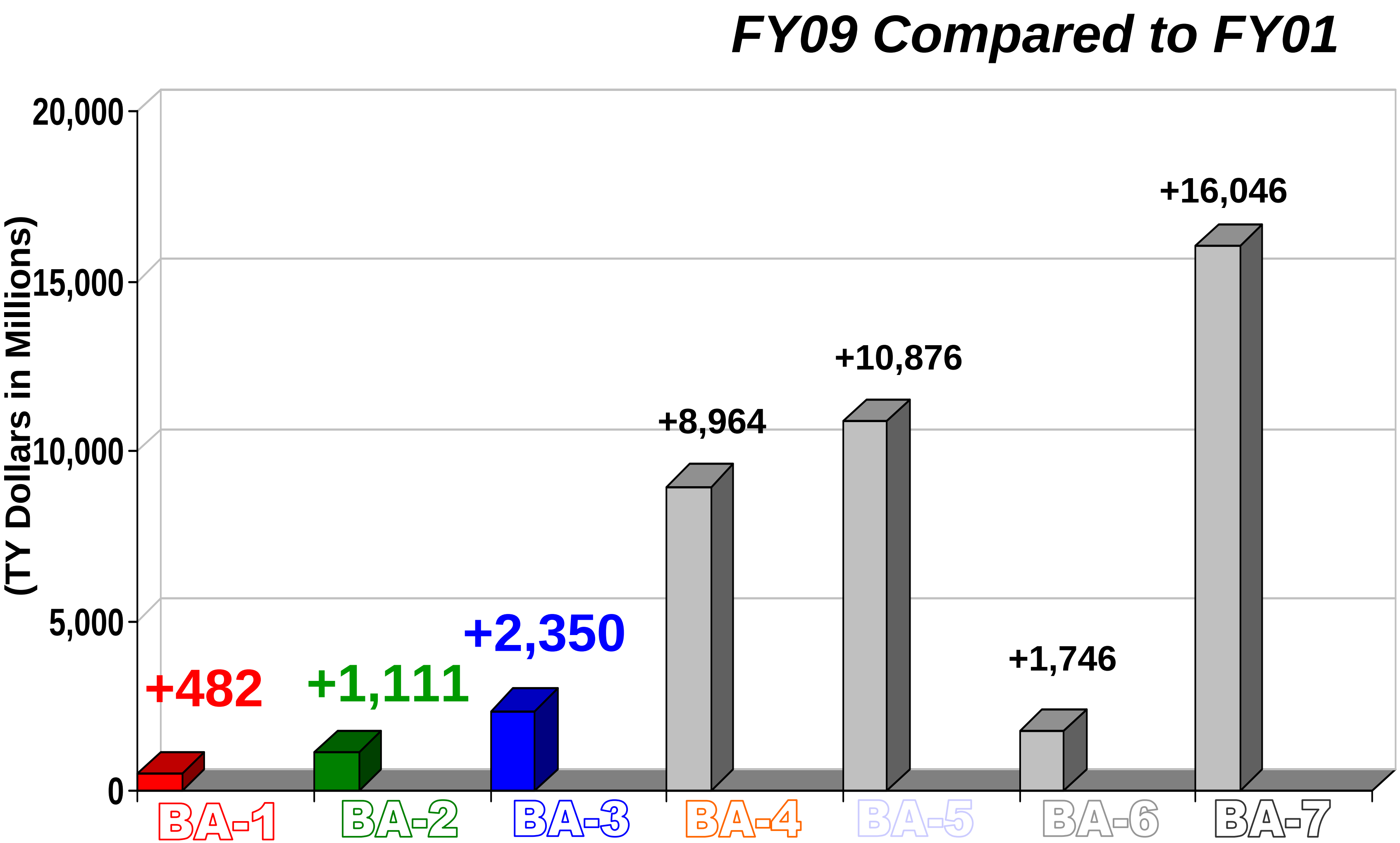


Source: DOD, DDR&E

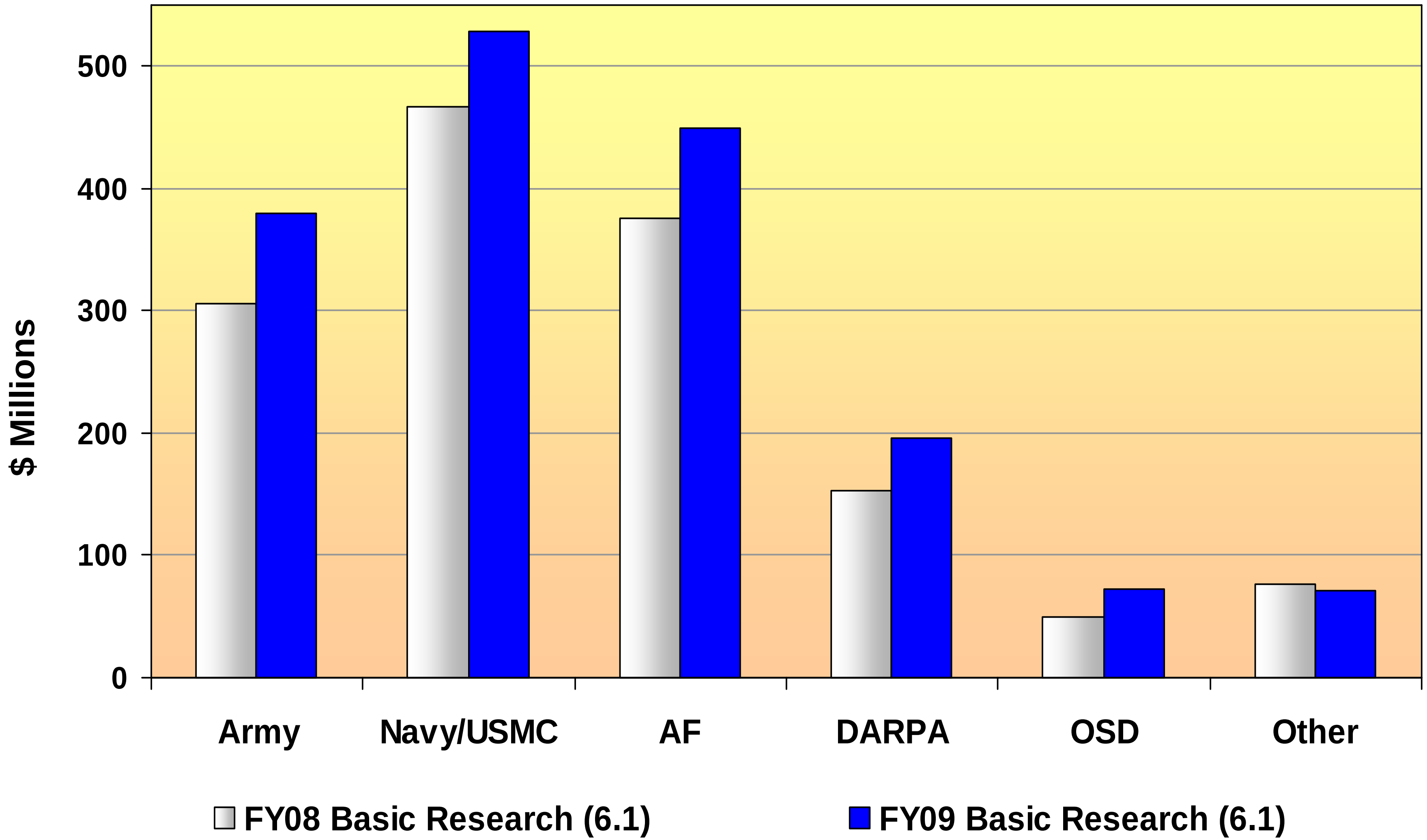
RDT&E Budget Request Growth



RDT&E Budget Request Growth

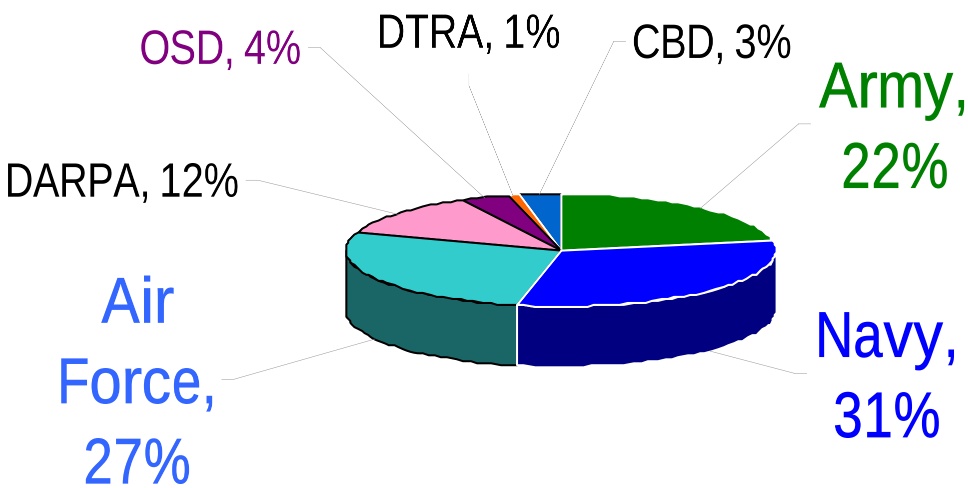


FY08 & 09 DoD 6.1 Budget Request



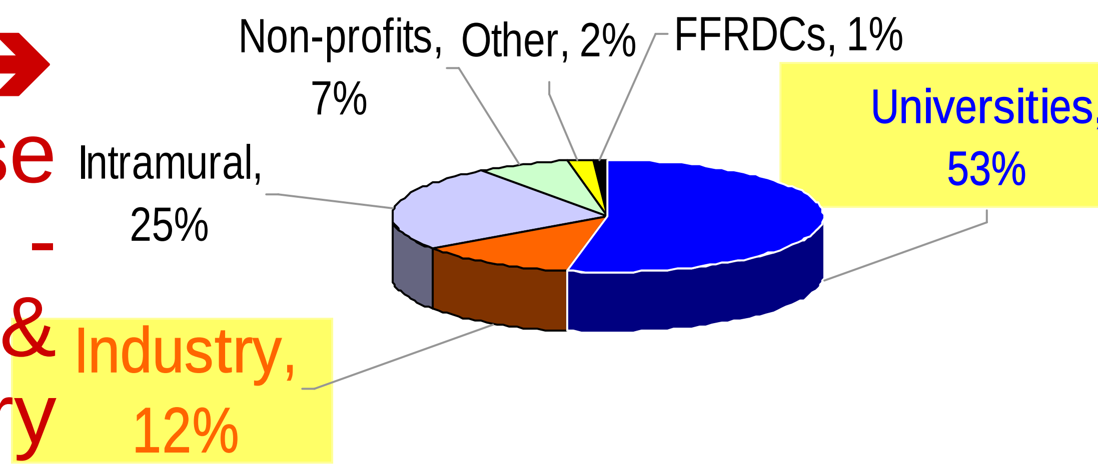
Source: DOD, DDR&E

Sources & Destinations of Defense Basic Research Funding



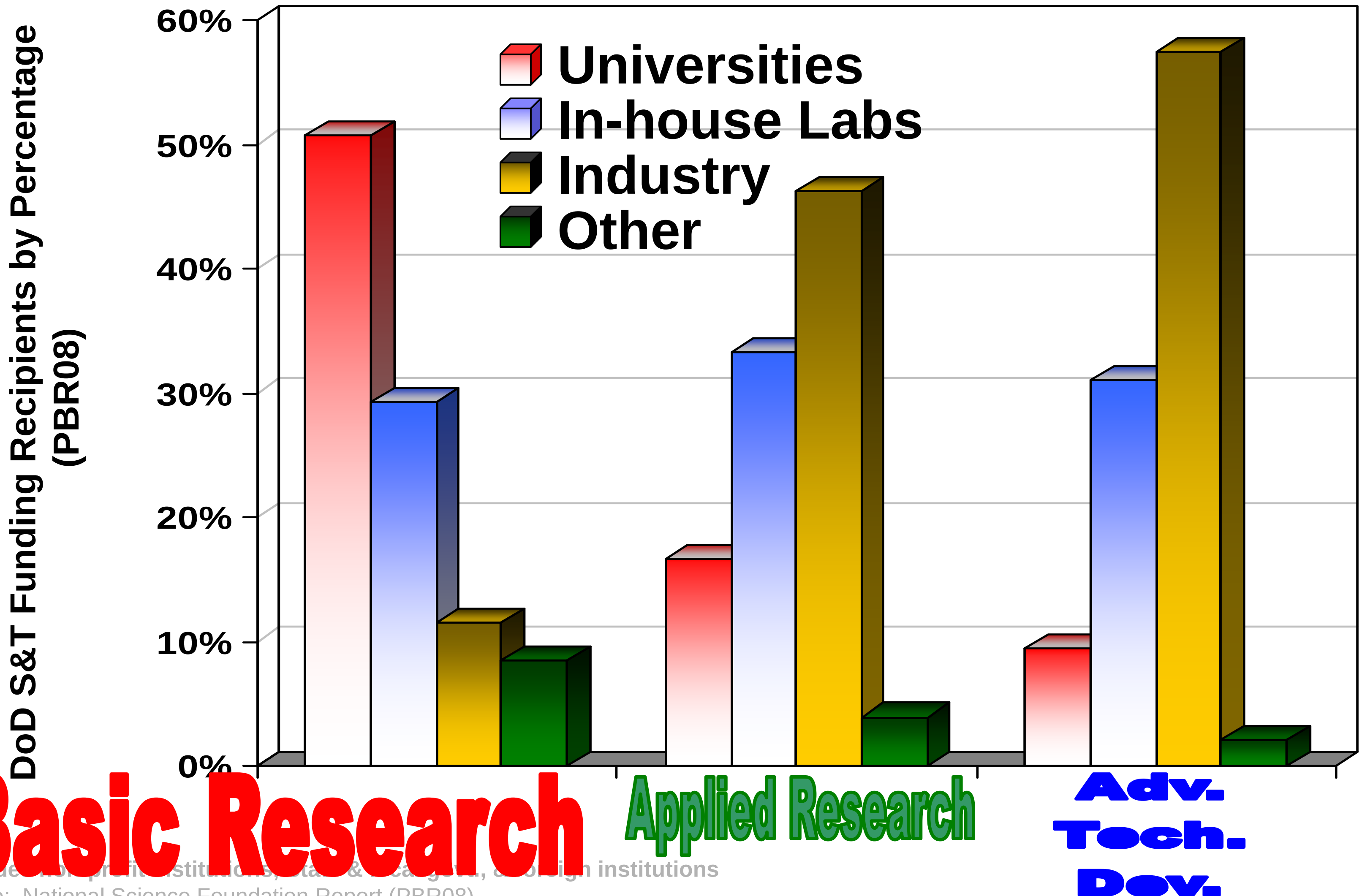
←Source 80% of Defense Basic Research is Investments by Military Departments

Destination→
Performers of Defense Basic Research - 65% to Universities & Industry



Sources: FY09 President's Budget & DoD component inputs to NSF Federal Funds for R&D survey (FY06– latest available)

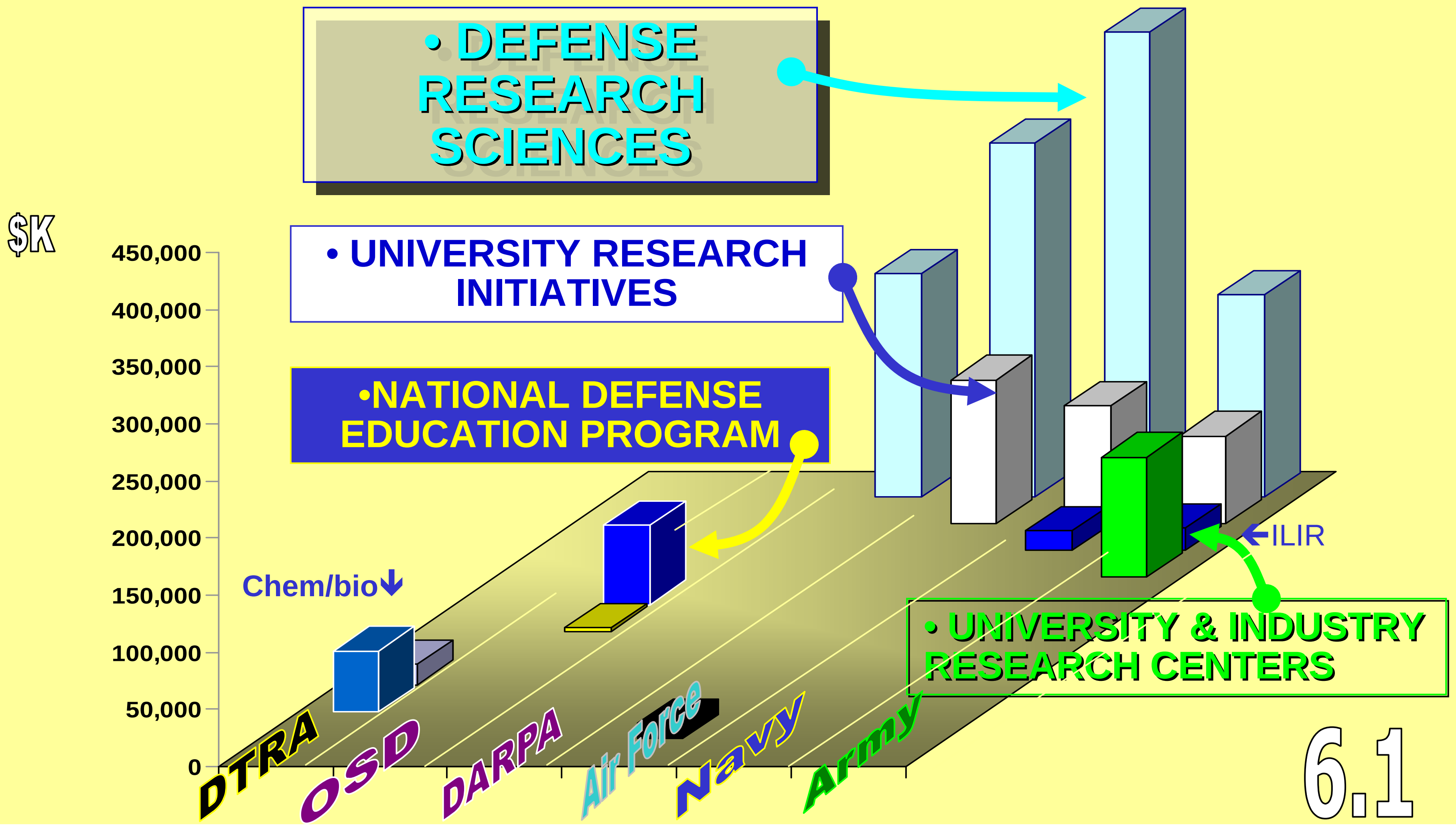
Recipients of DoD S&T Funds



*Includes non-profit institutions, state & local govt., & foreign institutions
Source: National Science Foundation Report (PBR08)

FY09 President's Budget Request for DoD Basic Research

U. S. Department of Defense



Source: DoD Comptroller R-1

Conceptual Strategic Planning Process

Joint Operational Capability Gaps

QDR, SPG

Not all joint operational capability gaps will have S&T capability gaps

Joint S&T Capability Gaps

JWSTP

Extant Service specific Basic Research program

Not all joint S&T capability gaps will demand basic research investment

Map S&T Gaps Against Services' Basic Research Programs

Joint, Basic Research investment gaps

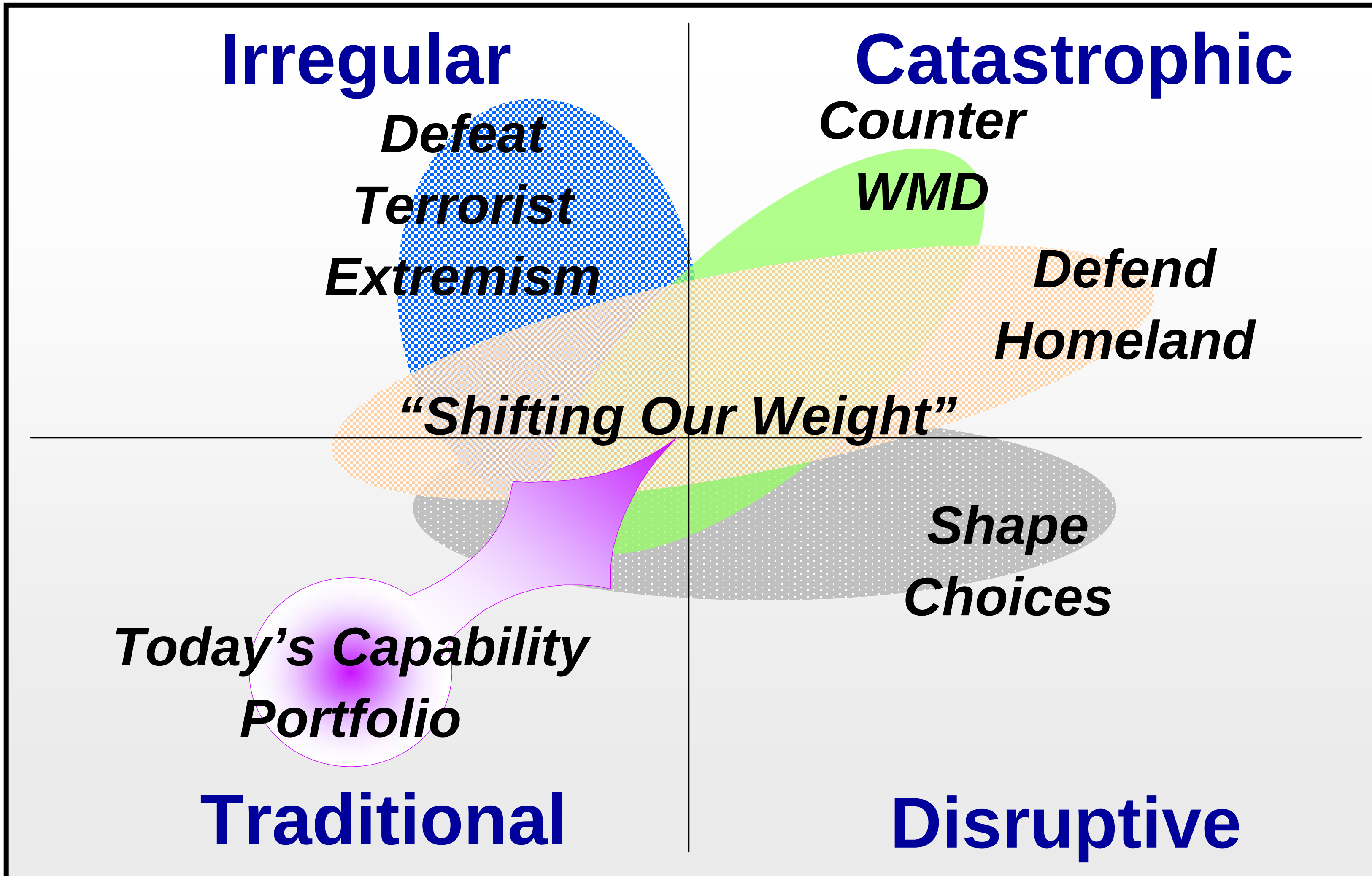
Some Service basic research initiatives address enterprise-wide issues

Department-level Basic Research Investment Guidance

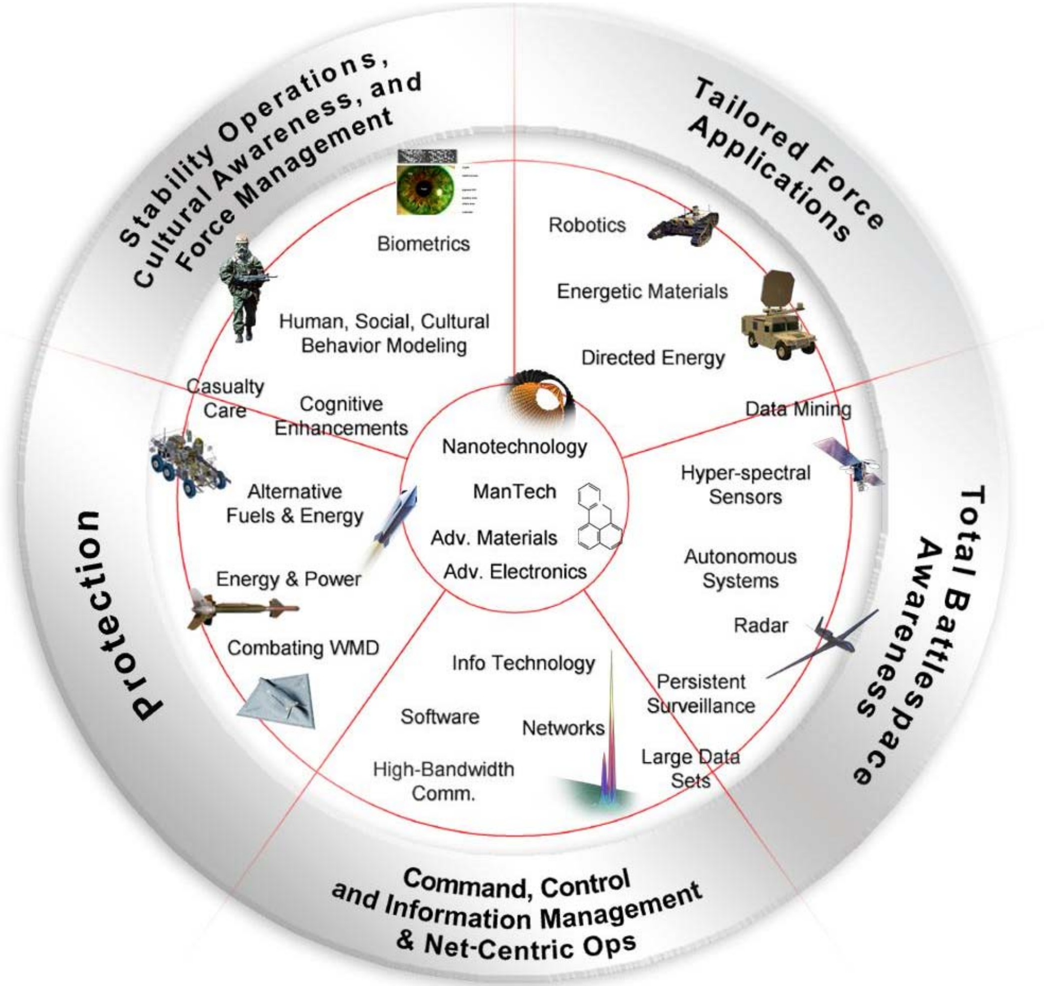
classified

unclassified

Quadrennial Defense Review

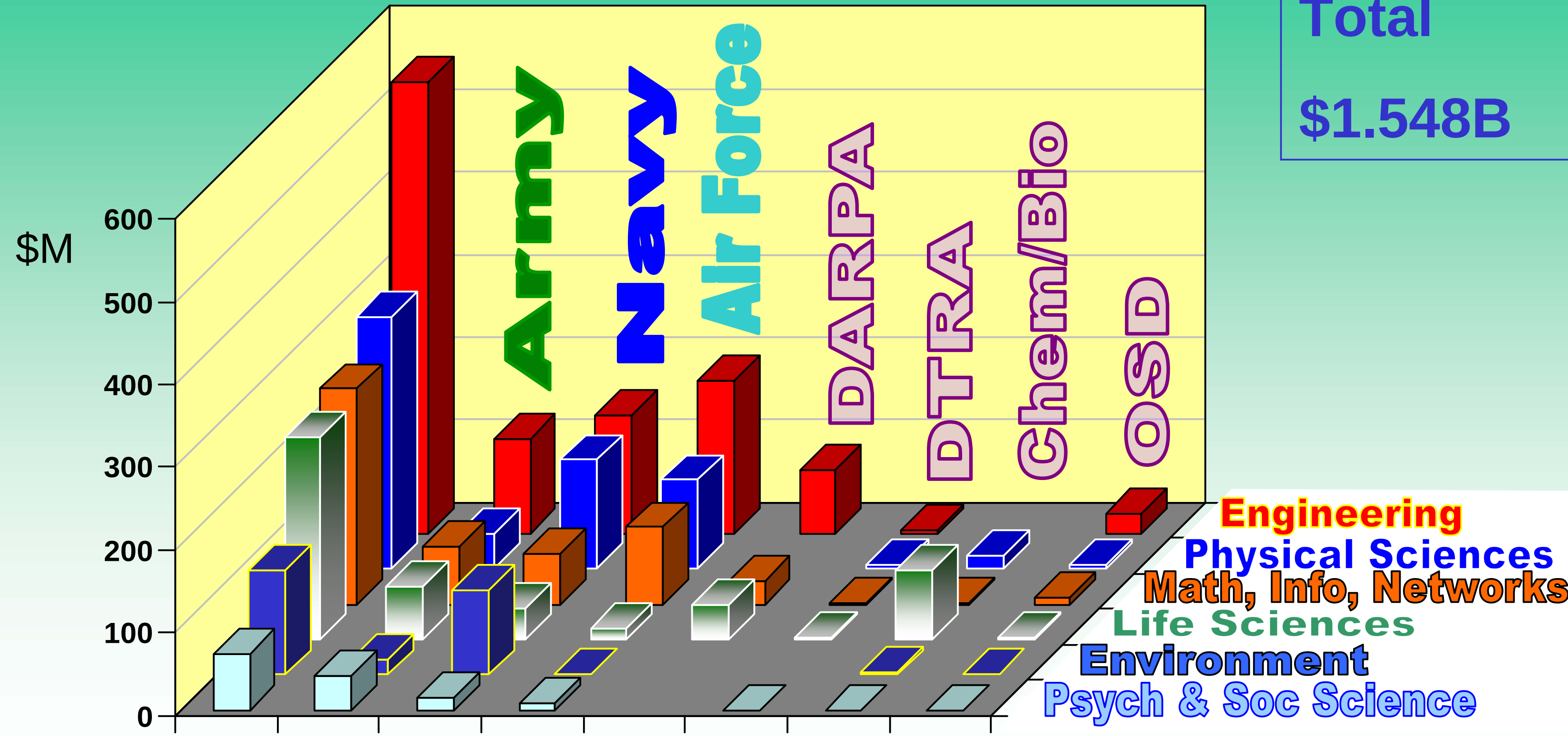


Desired S&T Investment Areas



(Joint Training is Ubiquitous)

FY07 DoD Basic Research
(by Taxonomy Category)



Total

$1.548B

Addition to DoD Basic Research

$M	FY08 PBR	FY08 Appropriation	FY09 PBR	Change from PBR 08	Real Change from PBR 08
Army	305.8	381.5	379.4	24.06%	21.36%
Navy	467.2	506.1	528.3	13.06%	10.61%
Air Force	375.2	407.7	452.3	20.55%	17.93%
Defense-Wide	279.9	338.3	338.7	21.00%	18.37%
Total Basic Research	1,428.1	1,633.7	1,698.6	18.94%	16.36%

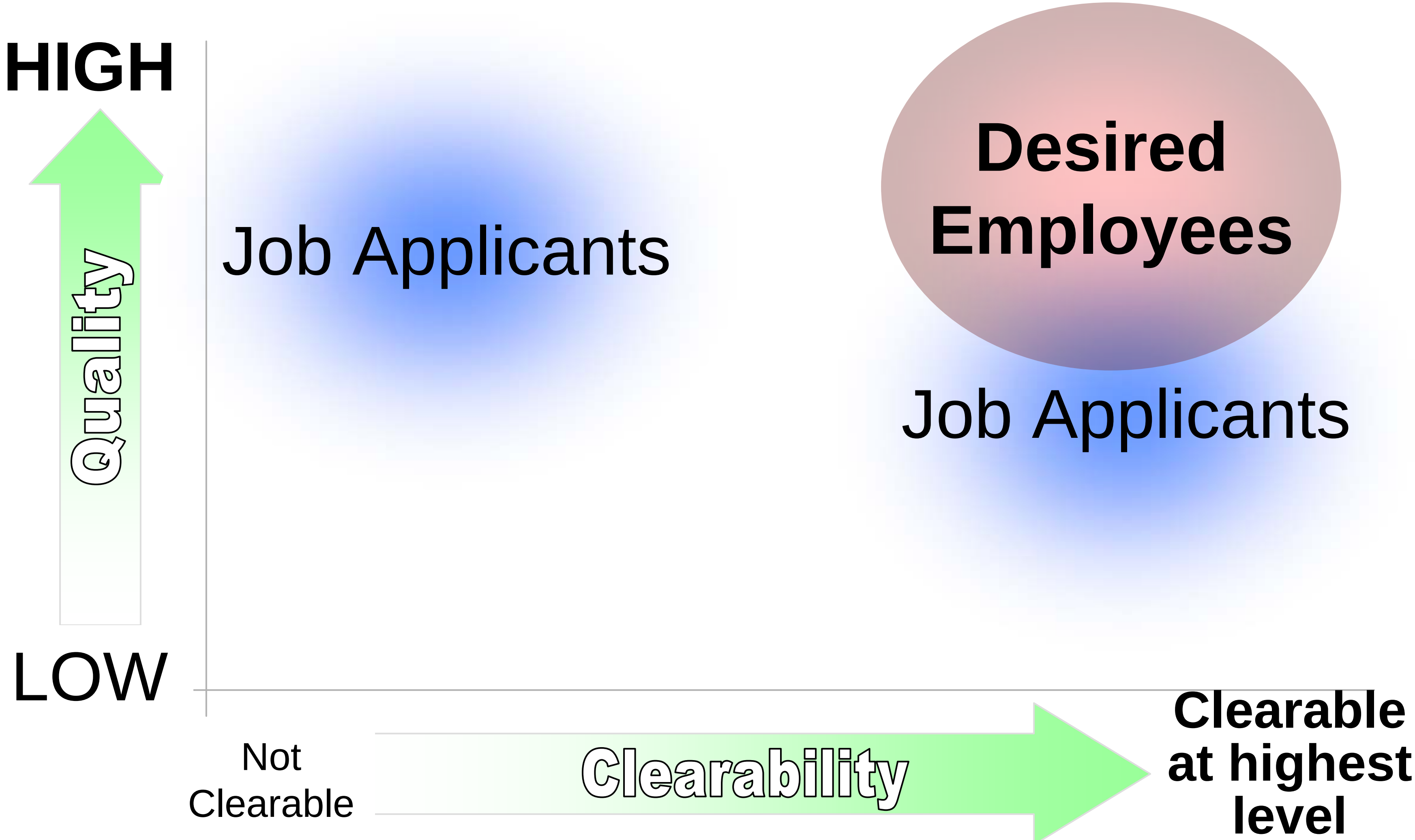
OUTLINE

- DoD Basic Research

- DoD STEM Education

- Prize Competition

A Unique National Security Problem



Opportunities

- "The development of a strategic S&T scouting effort linked to the US university and private

"When I compare our high schools to what I see when traveling abroad, I am terrified for our workforce of tomorrow."

- Bill Gates

- technology, and engineering education in the United States."

Source: "Joint Operating Environment" United States Joint Forces Command, December 2007, page 53
Rising Above the Gathering Storm, National Academy of Sciences, 2006

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Millennials are tomorrow's workforce

- They watch wars and revolutions live on TV and the Internet
- Elvis died 20 years before they were born
- Satellite radio has been around since they were 5 years old
- They have only known two presidents
- WWI started nearly a century before they were born
- They have never seen a film camera
- There have always been hybrid cars

Source: "**Millennial: About them**" Navy Recruiting Command briefing, 7 Feb 2008

Millennials are tomorrow's workforce

- They have always been online
- They have never known a world without digital phones or DVDs
- Soviet Union fell 7 years before they were born
- When Sputnik was launched, their parents were in kindergarten
- Their buddy lists span the globe.
- There has always been one Germany
- One electronic device does it all: TV, Internet, Phone, Music, Data, Computing

Source: "**Millennial: About them**" Navy Recruiting Command briefing, 7 Feb 2008

Millennials are tomorrow's workforce

Globalism

- Millennials grew up seeing everything in the world as:
  - Global
  - Connected
  - Open for business 24/7

Source: "**Millennial: About them**" Navy Recruiting Command briefing, 7 Feb 2008

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Millennials are tomorrow's workforce

- They are taking longer to graduate from college
- Only 37% of first-time freshmen at four-year schools earned their bachelor's degrees in four years
- Another 6% took up to six years

Source: "**Millennial: About them**" Navy Recruiting Command briefing, 7 Feb 2008

Millennials are tomorrow's workforce

- They are technology sophisticates
- Through media multitasking kids are spending 6.5 hours a day with media, but are packing more than 8.5 hours worth of exposure into that time

Younger kids have more and more media devices; of those 8-14 years old -

- 39% have cell phones
- 24% have a hand-held Internet device or PDA
- 12% have a laptop computer

Source: "**Millennial: About them**" Navy Recruiting Command briefing, 7 Feb 2008

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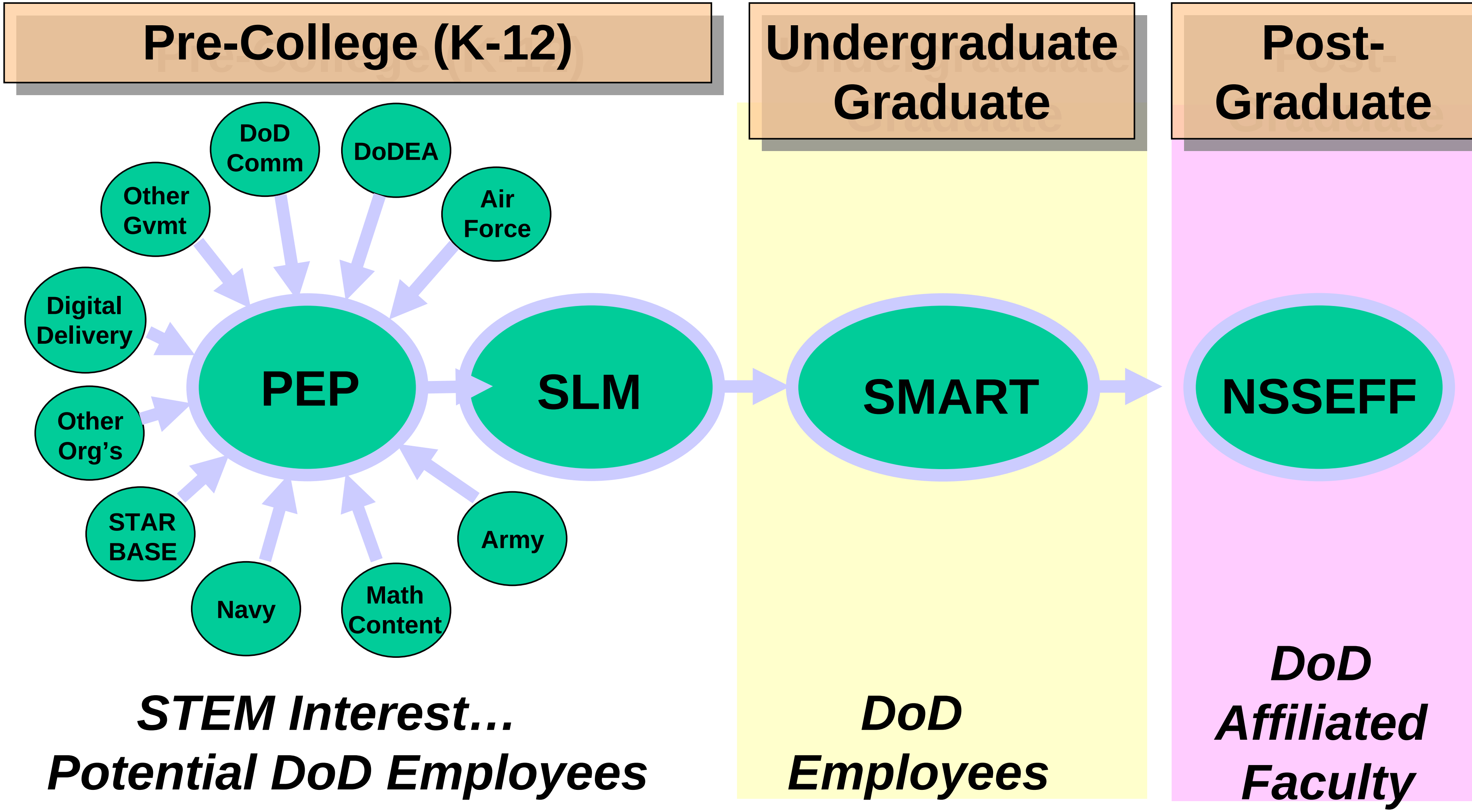
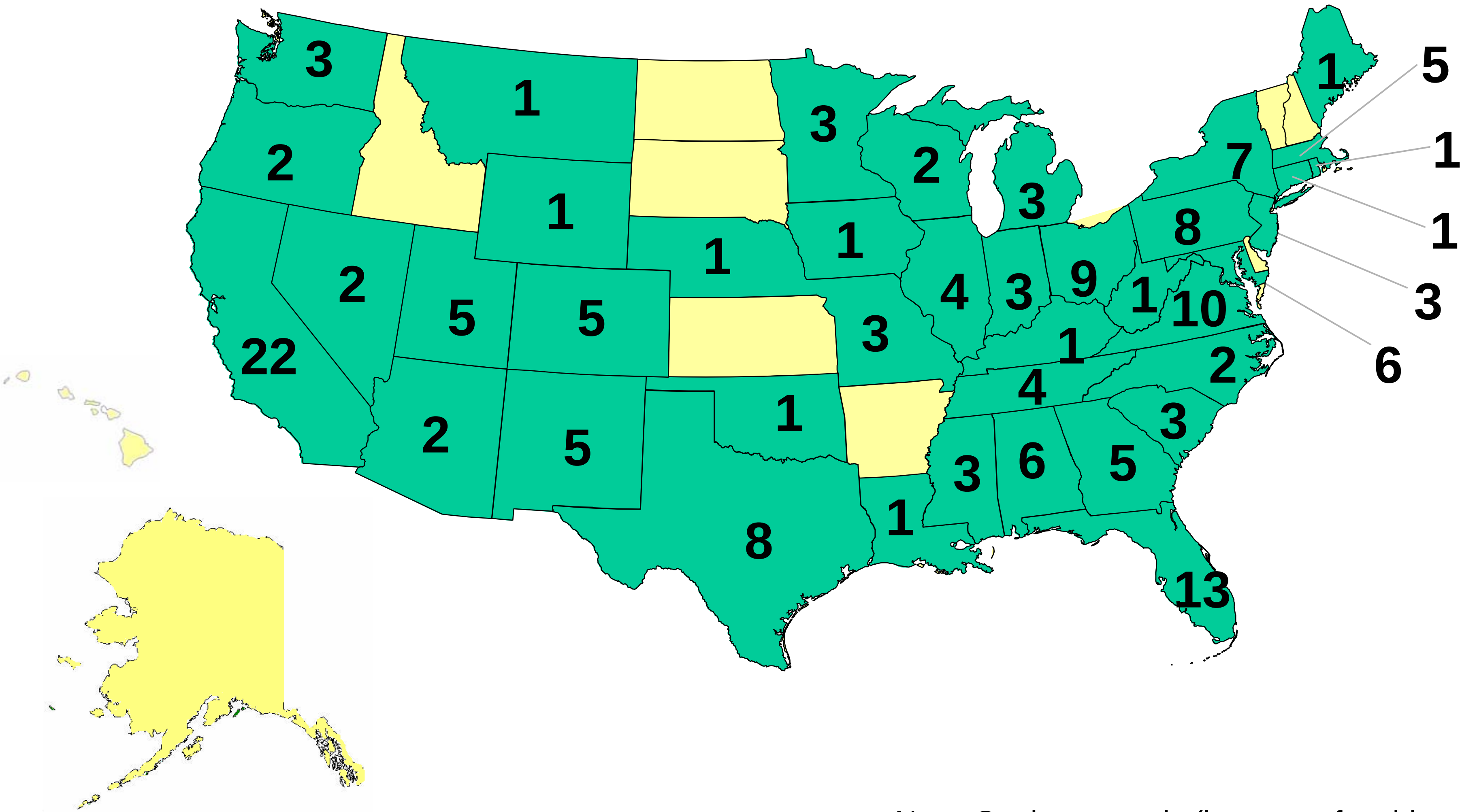
NDEP Portfolio Components

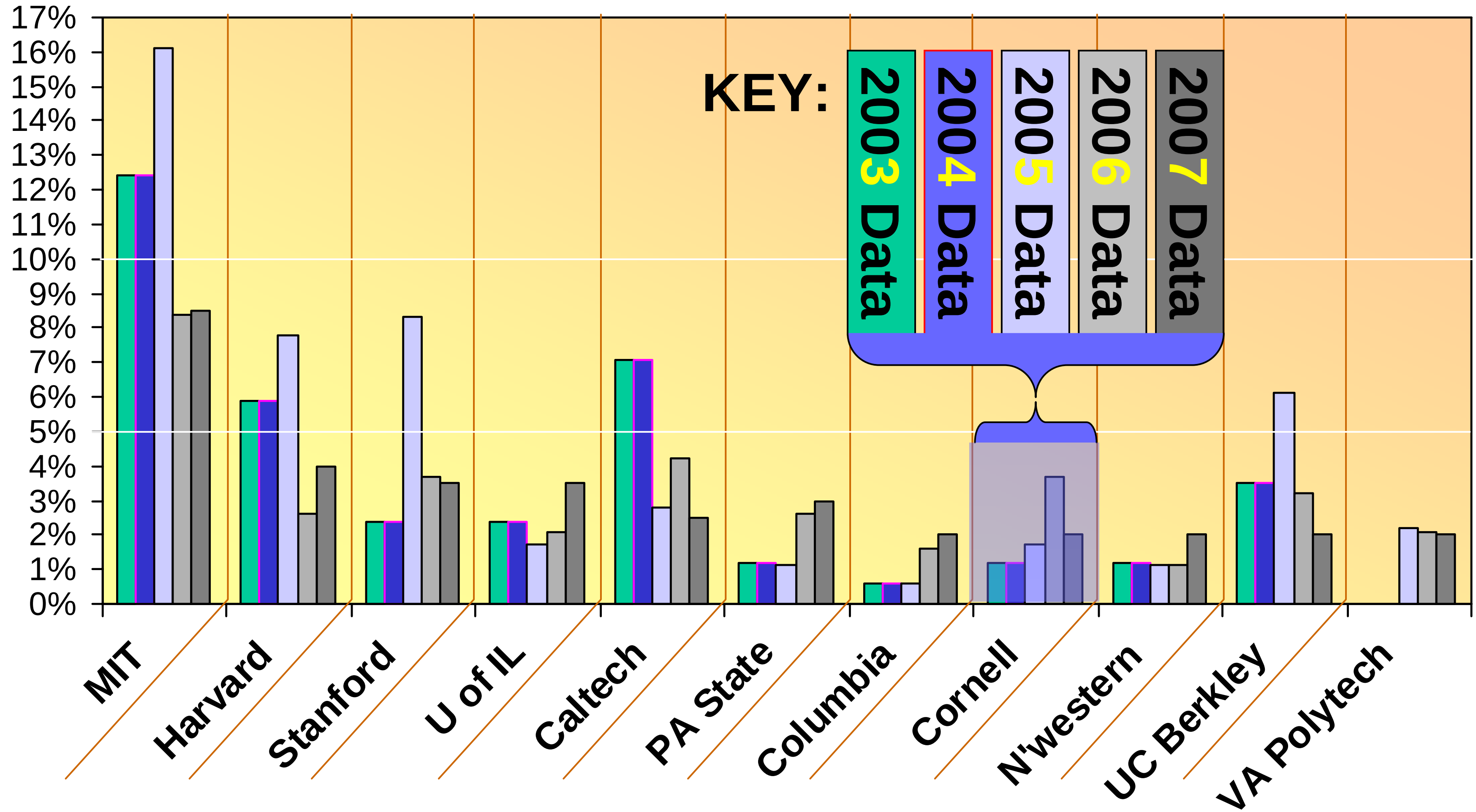


SMART's National Impact



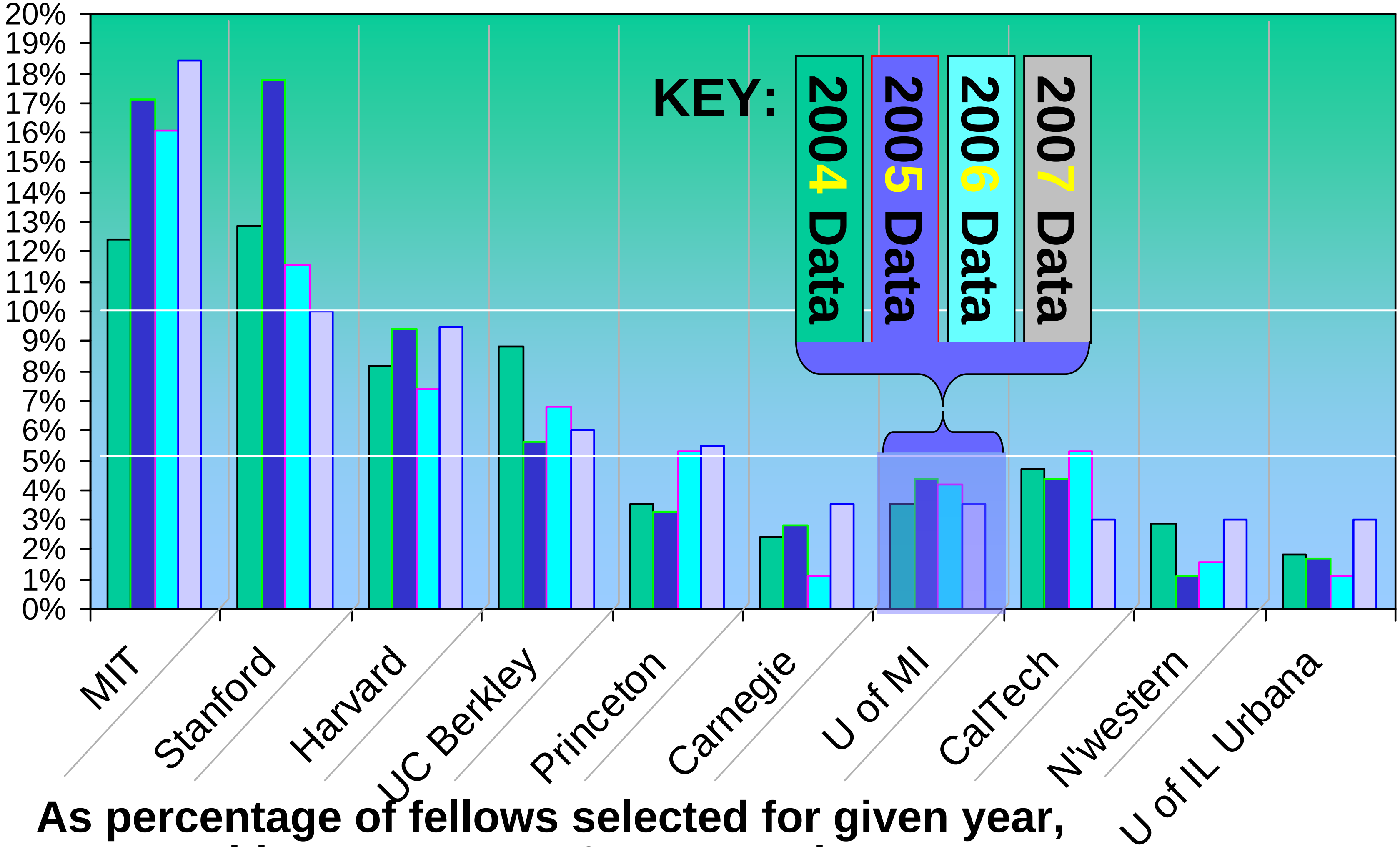
Note: Student awards (by state of residence)

NDSEG –Fellows' Undergraduate Schools



As percentage of fellows selected for given year, with respect to FY07 top numbers

NDSEG –Fellows' Graduate Schools



As percentage of fellows selected for given year, with respect to FY07 top numbers

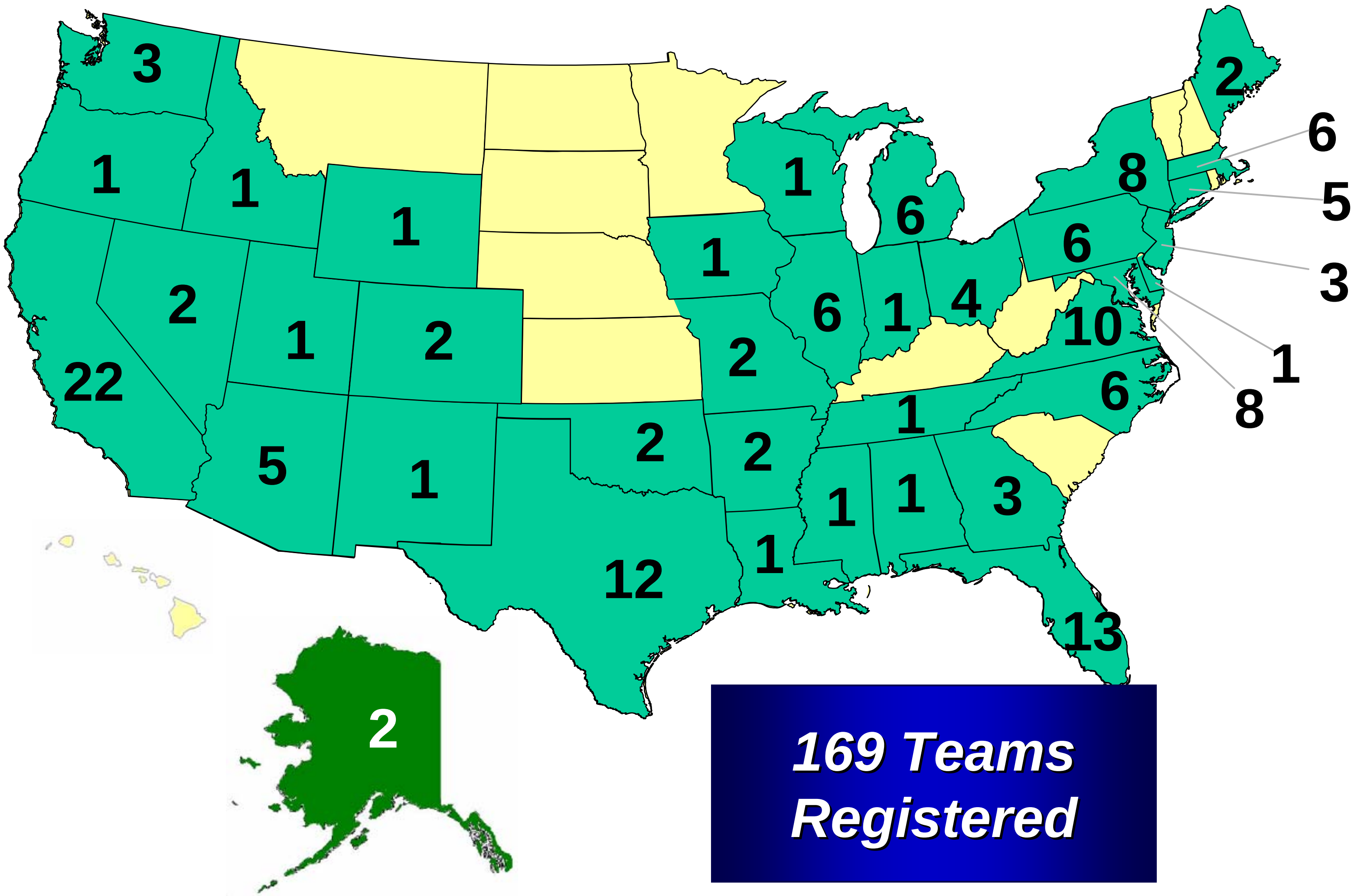
OUTLINE

- DoD Basic Research
- DoD STEM Education
- Prize Competition

Wearable Power Prize

- 1st Prize \$1M, 2nd prize 500K, 3rd prize: \$250K
- Goal: Reduce weight of Warfighters' power systems
- Competitors will produce prototypes that provide 20W average electric power continuously for 4 days, attach to a vest, and weigh 4 kg or less
- Capstone event will be held on October 4th, 2008, at the Marine Corps Air-Ground Combat Center, Twentynine Palms, California. See: http://www.dod.mil/ddre/prize

Wearable Power Prize Team Registrations



169 Teams Registered

Dr. William S. Rees, Jr.
Deputy Under Secretary of Defense
(Laboratories and Basic Sciences)

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Defense Research and Engineering

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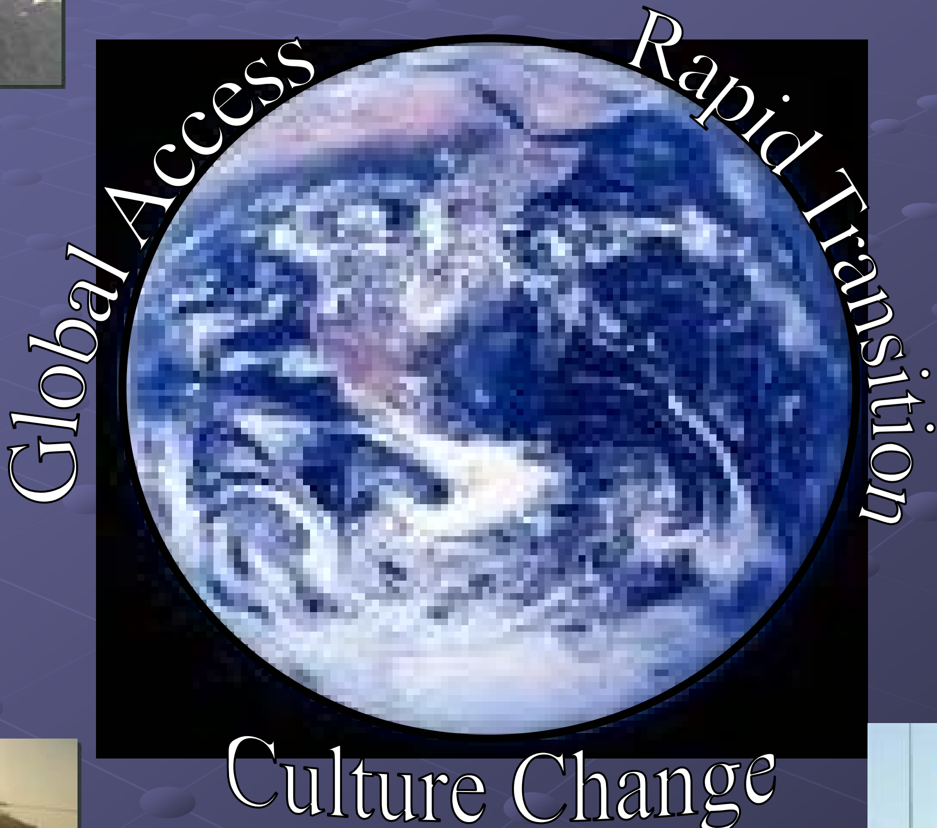
DOD Technology Innovation & Transition



Science and Engineering
Technology Conference
15 April 2008

Strategic Initiative for
Innovation and
Technology Transition

Kathleen L. Harger
Assistant Deputy Under Secretary of Defense
Innovation and Technology Transition

The Landscape Has Changed

Drivers Behind the Change

- Technology access now on a global scale
- Proliferation of potentially disruptive technologies
- Greater uncertainty of security challenges
- Fewer resources
- DoD no longer at forefront of most technology research
- Warfighting-relevant technologies have short refresh cycle

  ➔ "Time-to-market" is the imperative

But…

- Linear acquisition process
- "Inward-looking" culture
- Barriers to entry for non-traditional businesses

The Call to Change

Congress

- Public Law 107-314, Dec 2, 2002 Technology Transition Initiative
- Section 255 of the FY06 Defense Authorization Act Requesting DOD Report on Technology Transition Barriers and Challenges
- Public Law 109-163, Jan 6, 2006 Technology Transition
- GAO Report, "Best Practices: Stronger Practices Needed to Improve DoD Technology Transition Processes" (2006)

Advisory Committees

- Defense Science Board Task Force, "Technology Capabilities of non-DoD Providers" (2000)
- National Research Council of the National Academies, "Committee on Accelerating Technology Transition" (2004)
- Defense Science Board Summer Study, "21st Century Strategic Technology Vectors" (2006)
- Defense Science Board Task Force, "Defense Industrial Structure for Transformation" (2007)

The Call to Change

Office of the Secretary of Defense

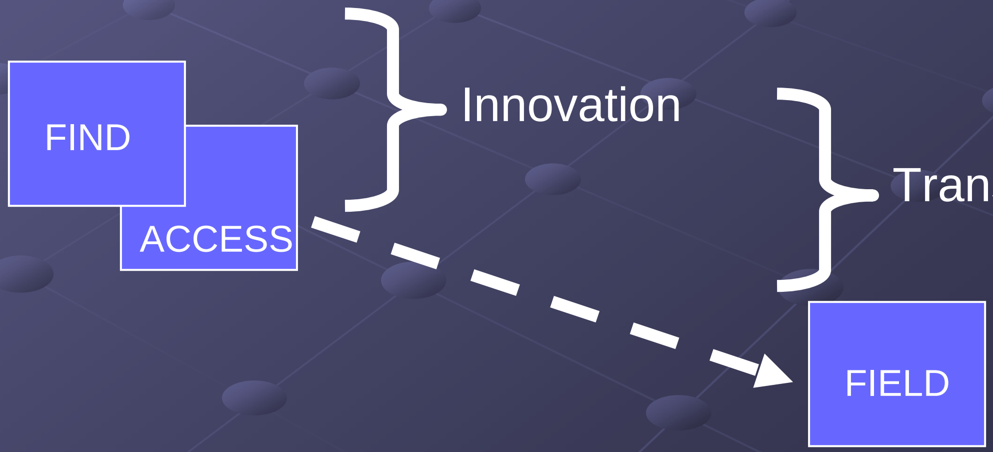
- Defense Acquisition Performance Assessment, Jan 2006
- Advocate for Innovation & Technology Transition created in Mar 2007
- DoD Report to Congress on Technology Transition, Sep 2007
- Strategic Initiative on Innovation and Technology Transition, Dec 2007

DepSecDef: “Breakdown the walls…that inhibit the efficient transfer of commercial technology into Warfighter hands”

USD (AT&L): “Drive the capability to defeat any adversary on any battlefield”

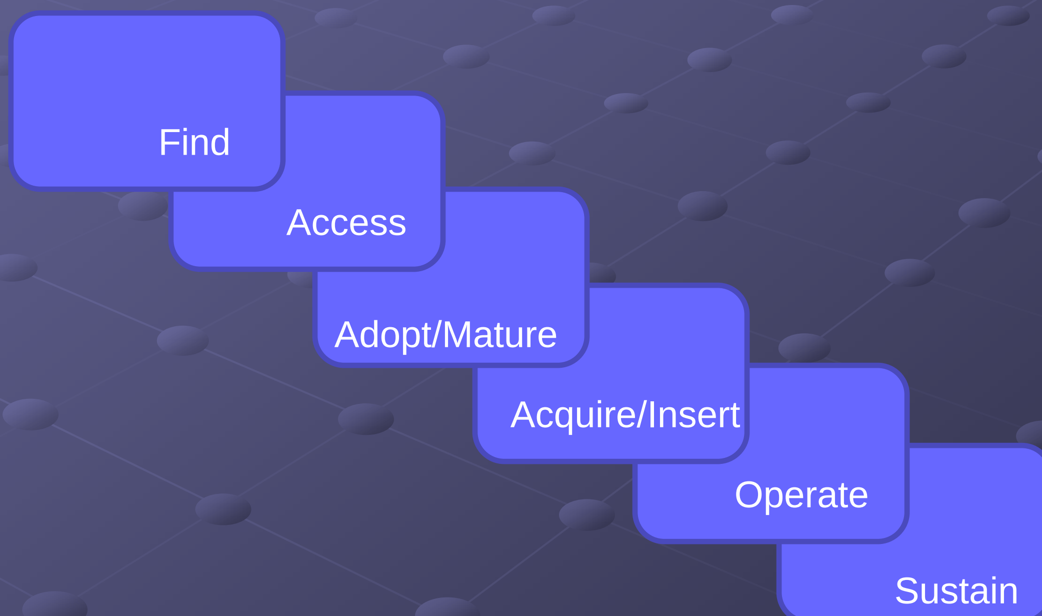
Strategic Initiative on Innovation & Technology Transition

Create an Enterprise-wide strategy for accelerating the movement of technology from any source to our warfighters

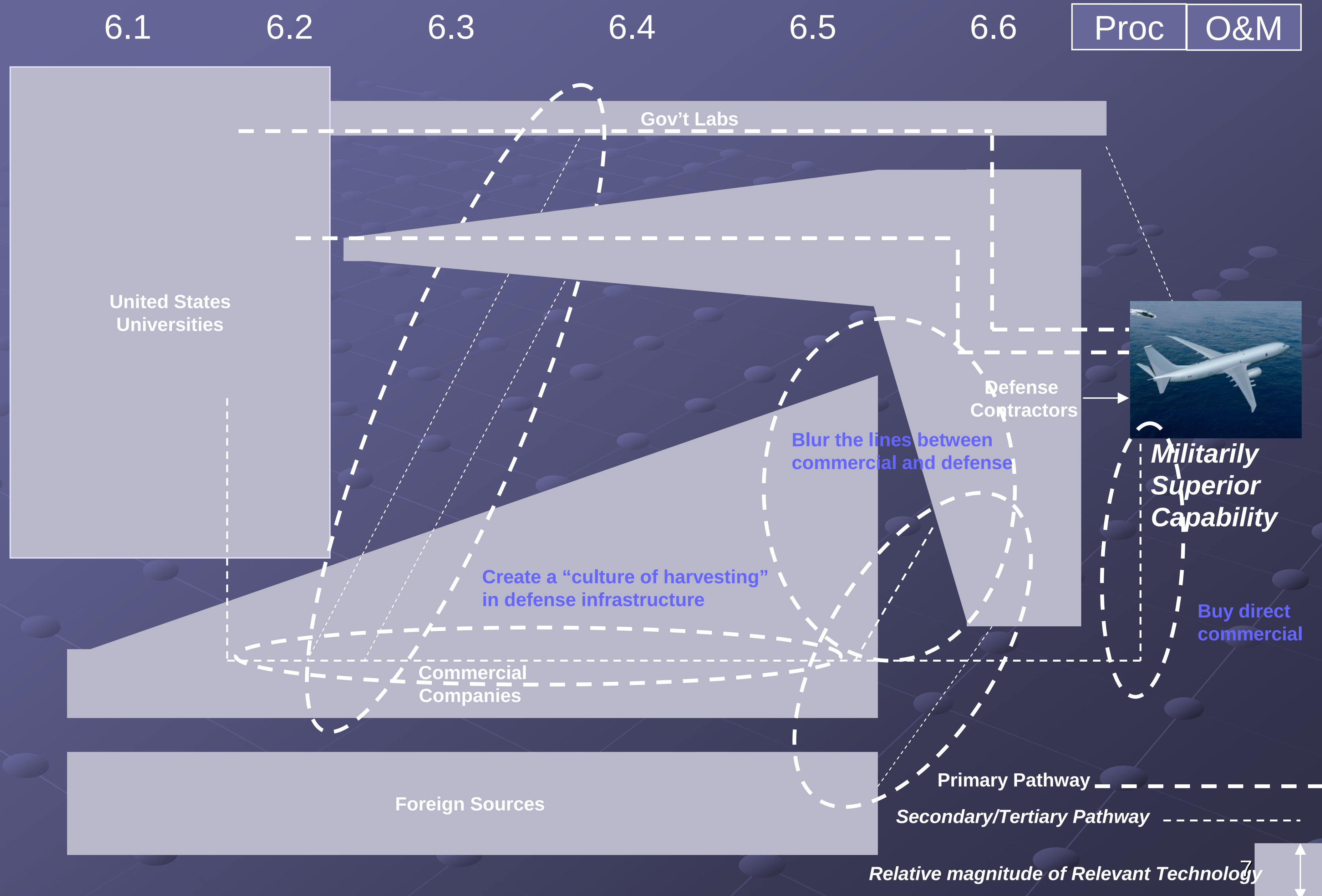


Technology Life Cycle

Innovation and transition must be inextricably linked in the Technology Life Cycle to address both urgent wartime needs and long-term military requirements



Solution Focal Points



Find

Access

Adapt/ Mature

Acquire /Insert

Operat e

Sustain

Cross-Cutting

	Near Term	Mid Term	Far Term
	FY 08 09 10 11	12 13 14	15 16 17 18
Front End	*Aggressive Communications And Business Practices To Attract Non-Traditionals (Selected Technologies)*	*Broaden Technology Range, Proliferated Best Practices*	*Expand Overseas Access, Few "Non-Traditionals"*
+			
Back End	*Leverage Selected Pathways To Move Solutions Through the System*	*Execute Big-A Reform, Defense Industry Incentivized to Harvest, ITAR Overhaul Industries*	*Blending of Defense and Commercial*
+			
Cross-Cutting	*Maximize Use of Existing Tools, Increase Rotations, Strengthen CTO*	*Proliferate Training Across DoD, Execute Human Resources Reform*	*Continue Training, Institutionalize Rotation Across Defense and Commercial*
=			
	Beginning of turning outward, End-to-end existence proof, Seeds of acquisition reform And 21st century leadership	Expansion of outward focus, Leverage defense base for harvesting, remove global barriers	Routine outreach, defense industry walls porous with routine commercial access, globally-savvy, entrepreneurial leadership

Near-Term Initiatives

- **Global Outreach:** Harvest technology and innovation in the private/global marketplace through collaborative venues whereby non-traditional sources can access information concerning DoD needs, opportunities for interactions, and streamlined approaches to doing business with DoD.

- **Barriers to Entry for Non-Traditional Suppliers:** Promote flexible contracting instruments through creation of a “non-traditional business cell” pilot program.

- **Strategic Linking of Agile Acquisition Programs:** Create enterprise-level strategy for deliberate and aggressive use of authorities and investment opportunities associated with agile acquisition.

- **Culture of Harvesting:** Create environment that rewards global outreach and attracts the best and brightest to collaborate with/work in our S&T and acquisition communities.

How Will We Know We've Succeeded?

- When we have an 'outward' looking culture in which we seek and access innovation from any source
- When it becomes standard practice to collaborate inside and outside the Department
- When we embrace the use of flexible contracting as a way of doing business
- When the linking of our agile acquisition authorities and investments, driven by a corporate strategy, results in more affordable and effective capabilities
- When our Warfighters can defeat any adversary on any battlefield

Contact Information

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LOCKHEED MARTIN
Innovation at a Large Scale
Ed Morris
Director, Hardware and Manufacturing
Lockheed Martin
Corporate Engineering and Technology
April 17, 2008

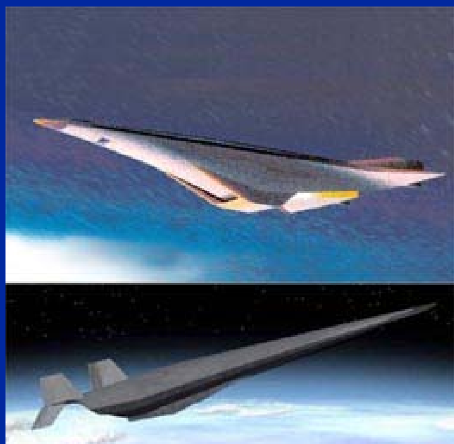
The Men and Women of Lockheed Martin

- ***140,000 Employees***
- ***70,000 Scientists and Engineers***
  - ***25,000 IT Professionals***
- ***Operations in 1,000 Facilities, 500 Cities, 50 States and 75 Countries***

Partners to Help Customers Meet Their Defining Moments

Redefining What Is Possible

Hypersonics



Biometrics

Return of Crew Space Exploration

Persistent Surveillance

Information Fusion

Unmanned
and Autonomous
Systems

A Passion for Invention

Lockheed Martin Business Areas

LOCKHEED MARTIN

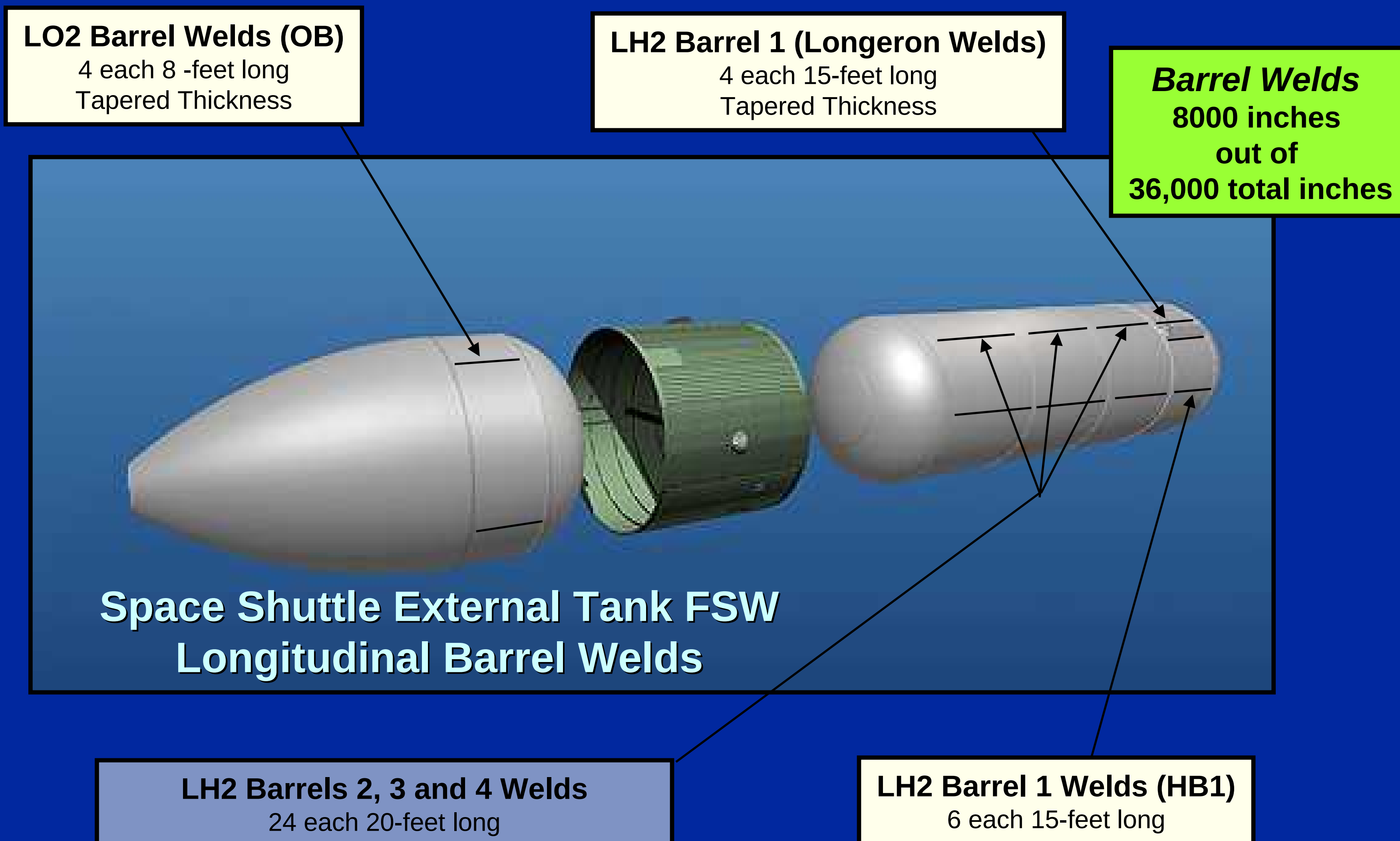
Aeronautics

Electronic Systems

Space Systems

Information Systems & Global Services

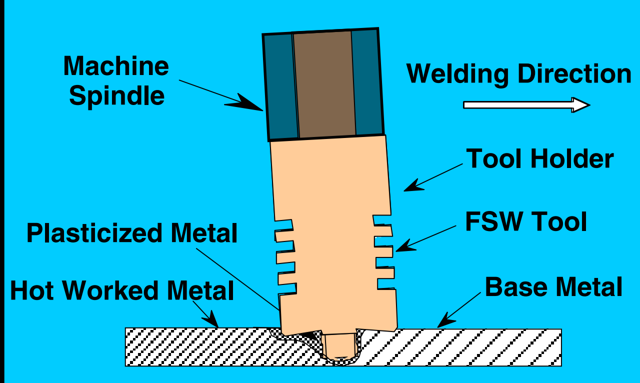
Large Scale Friction Stir Welding (FSW) for Performance & Cost



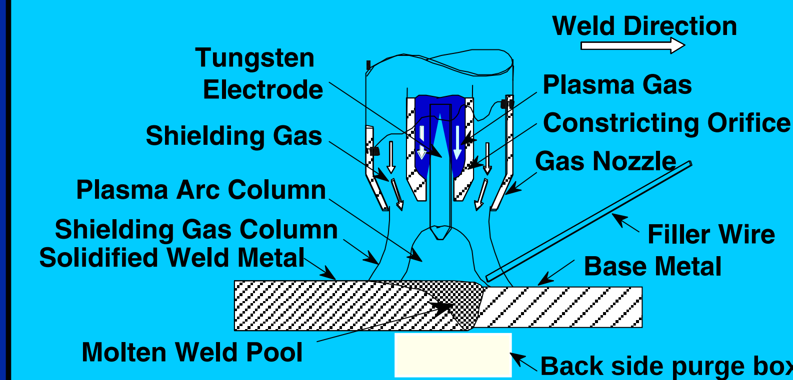
FSW – An Amazing Innovation!

FSW Versus Fusion Welding

Friction Stir Welding



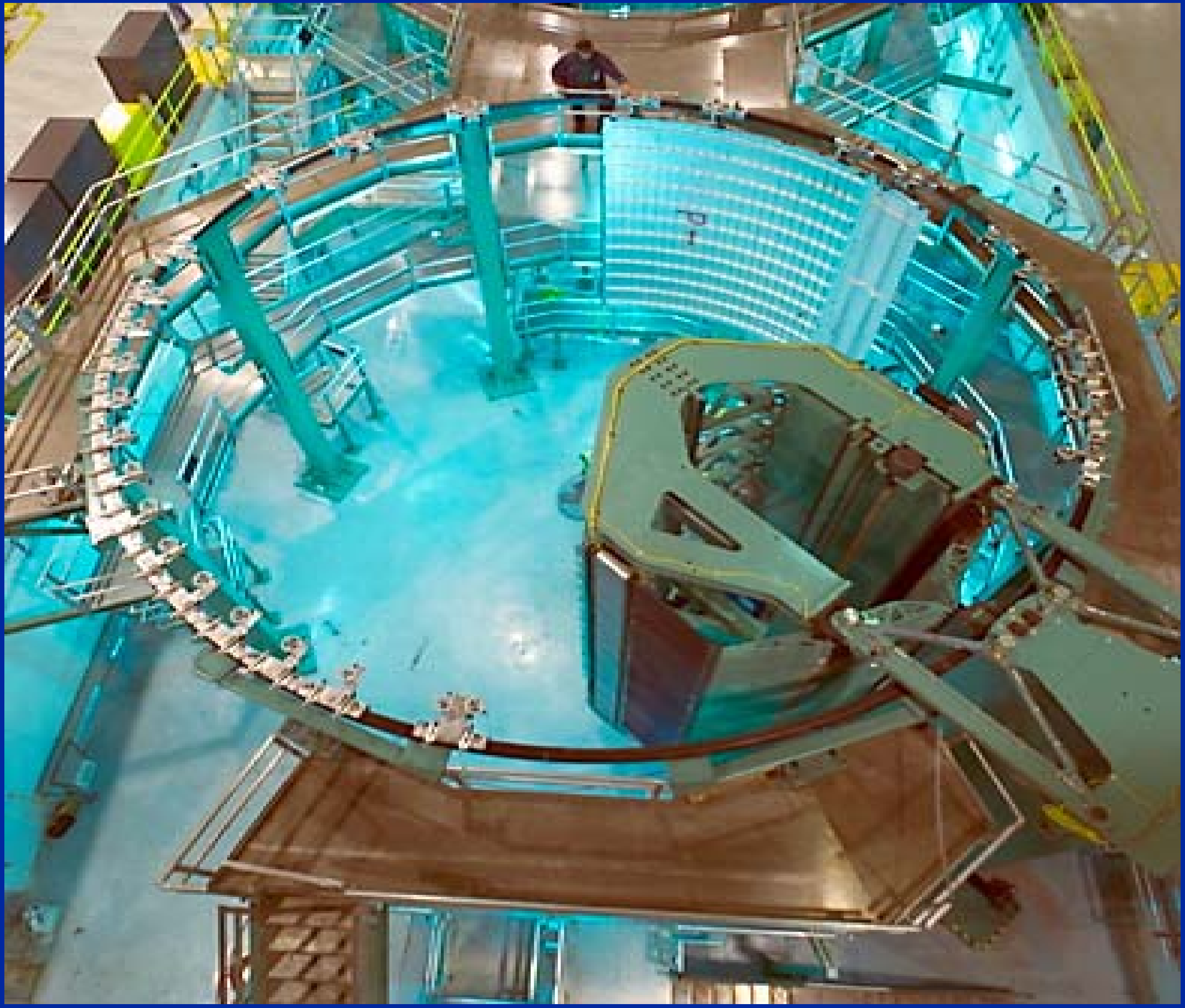
Soft Plasma Arc Welding (SPAW)



	FSW	Fusion
Weld Set Up	Schedule Selection Pin Tool Selection	Schedule Selection Shield Cup Design Orifice size Tungsten position Tungsten size/type Wire alloy and diameter
During Welding	Plunge depth/load Rotation speed Weld speed Centerline position Pin length (tapers)	Current Voltage Travel speed Wire feed rate APC/AVC Additional Reverse Current Plasma gas and flow Shield gas and flow Back side Purge gas and flow Pulse Frequency/Duty Cycle Arc gap Oscillator width (Cover pass only) Oscillator dwell (Cover pass only) Oscillator speed (Cover pass only)

Friction Stir Welding vastly reduces and simplifies the process variables

FSW Barrel Weld Tool



Manufacturing Process Simplicity on a Large Scale

Shop Floor Innovation: Flexible, Reconfigurable Factories

- Modular workstations with quick-connect utilities wired underneath the floor
- The workstations are daisy chained together forming work cells
- The stations are mobile, can be customized, and can be set to a variety of heights and configured with numerous shelving options
- They can be converted to class 10K flow booths to meet production needs
- The workstations and cells are so flexible that entire cells can be reconfigured in two hours

Fire Control Factory
Engineered Workstations

Engineered Workstation

- **Standardized approach and design engineered for flexibility and functionality**
- **Integrated casters and utility chase allow workstations to be disconnected, relocated and reconnected in a matter of minutes**
- **Utility chase for power, air, phone and LAN**
- **Need a class 10K flow booth? Simply wheel the portable flow booth to the workstation**

Lean + Agility = Affordability

10K Flow Booth Option

Relocate, Connect and Go

Fire Control Factory Engineered Equipment

Self-contained Oven and Mix Booth

- **Factory equipment designed to support rapid rearrangement & flexibility**
- **Custom designed oven set-up and mix station incorporate filtration system eliminating need to vent to the outside environment**
- **Casters and standard 110v power operation further simplifies rearrangement**

Integrated Composite Technology for Large Aircraft Structures

Optimize Cured Laminate Compensation (CLC) Process
- *Highly Accurate Thickness Control*
- *Integral to Cure Process*
- *No Machining Required*
- *Supports LO*

Future Mobility Platforms

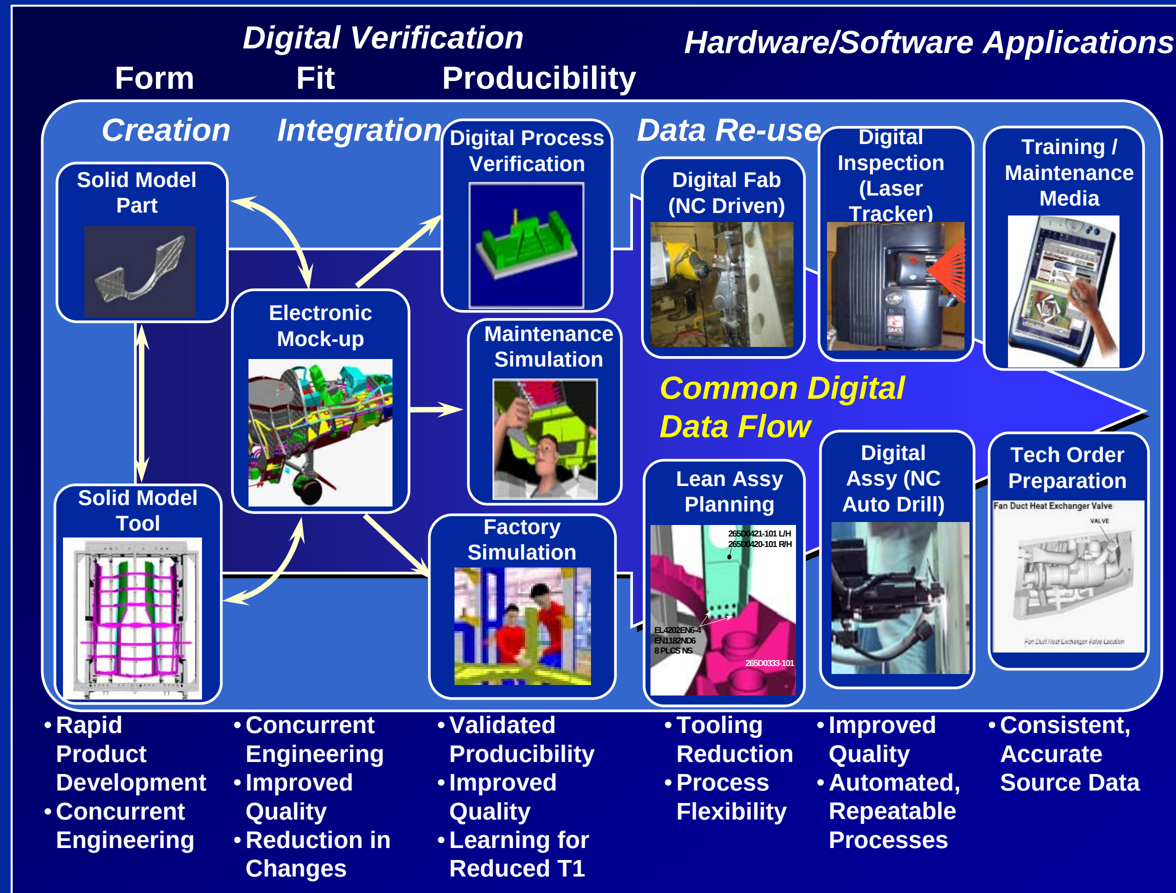
Future High Altitude UAV

Vacuum Assisted Resin Transfer Molding
- *Integrated caps*
- *Sandwich stiffened*
- *Elimination of fasteners*

Variable Stiffness Tailored Laminates
- *Increased design freedom*
- *Load path optimization*

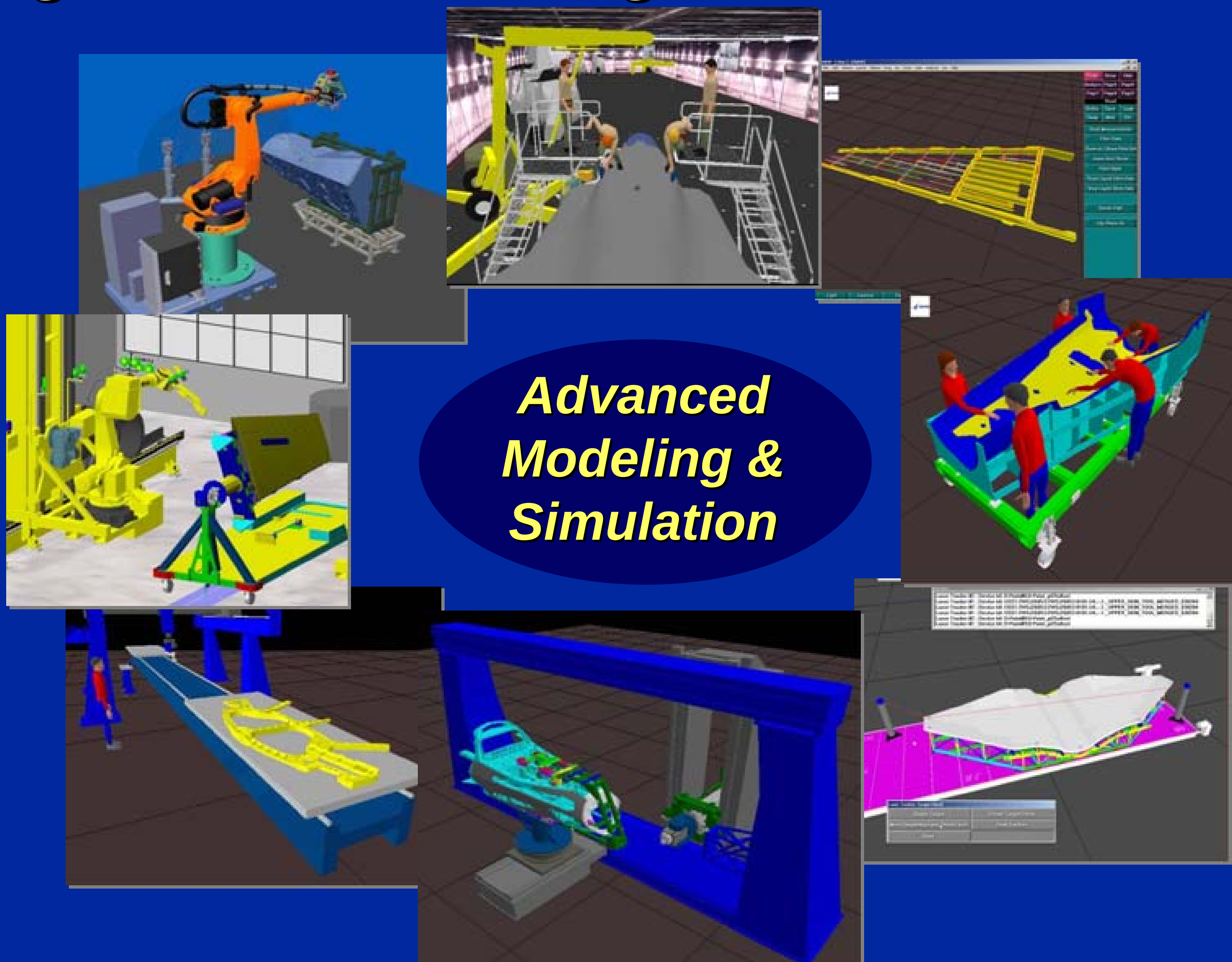
Common "Digital Thread" Is Key to Reduced Cost, Schedule and Risk

- **Solid Model Data Source**
  - *Single Exact Definition*
  - *Reduces Span Time for Creation*
- **Data Re-Use**
  - *Eliminates Interpretation Error*
  - *Reduces Task Span Times*
- **Digital Product / Process Verification**
  - *Form, Fit, & Producibility Verified Prior to Build*
  - *Improves Quality*
  - *Reduces Cost and Risk*
- **Concurrent Development Process**
  - *Reduces Program Span Time*



Form, Fit and Producibility of Parts and Tools To Be Verified in the Digital Mock-up Prior to BTP Release

Exploiting the “Digital Thread” Begins with Modeling & Simulation



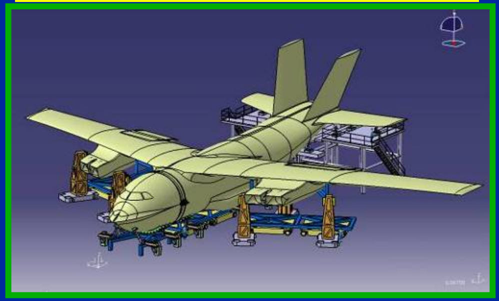
Large Scale Assembly Innovations Using Common Digital Thread

Automated Drilling Systems

Digital/Optical Wire Harness Assy.

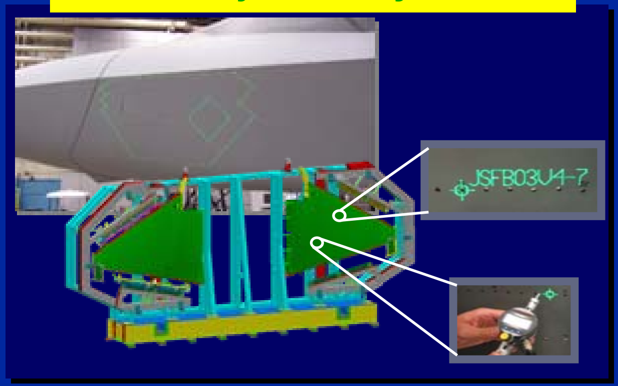
- Optically Identifies Connector Locations for discrete Wire locations
- Reduces Assembly Span Time by 50%
- Reduces Error in FACT Test Errors by over 100%.

Electronic Mate / Assy.



- Laser Tracking / Real Time Location
- High Tolerance Servo-Driven Jacks
- Eliminates Massive / Inflexible Tools

Laser Projection Systems



- Real Time Updates to Associated Data
- Projected at the Point–of–use
- Eliminates Need for Discreet Work Instructions/Drawing Access

Automated Robotic Paint/Coating Systems

- Accurate / Repeatable Application
- Digitally Driven from Engineering Data

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Industry Perspective:

The Challenge of Transitioning Innovative Technology

NDIA-Charleston
15 Apr 08

Mal O'Neill, PhD, NAE
LTG USA/CTO LMC (ret)

Agenda:

- Situation
- People
- Difficulties
- Successes
- Actions

What's happening to our products?

- <u>Complexity</u> is following Moore's law
- Transformational system requirements are daunting
- Customers' expectations increasing and expanding

Innovative Modernization is 4-D

- New customer
- New developer
- New process
- New product

Innovative Technology:

- **Promises major long term improvements in performance, cost, quality, and/or totally new capabilities**
  - Largely unproven
  - Faces competition/adversaries
  - Lacks advocates, especially with customer
  - Forces change
  - Adds risk for industry, developer and user

People Create Innovation

- Aging workforce – experience lost
- HS Math/Science scores poor
- Engineering enrollments down
- System Engineering only On-job
- Growing Demand for Engineers

Where are tomorrow's innovators?

philg@mit.edu

Why is Transitioning So Difficult?

- Uneducated decisionmakers
- New customers
- Acceptable legacy systems
- Monies needed
- Unknown unknowns
- Doctrine/Force Structure threatened
- Community of Practice damaged

Warfighter is Critical

- Operational Insights
- Value/impact of potential capability
- When/how much new capability is needed
- But he ---
  - Doesn’t understand the technology/potential
  - Might be wrong customer
  - Can’t articulate key knowledge to developer

“If I’d asked my customers what they wanted – they would have asked for a faster horse” Henry Ford

Industry Reluctant To Lead Transition

- **Prefers incremental modernization**

- Hesitates to provide leadership and resources

- Doubts credibility of innovators

Success – Nano Testimony

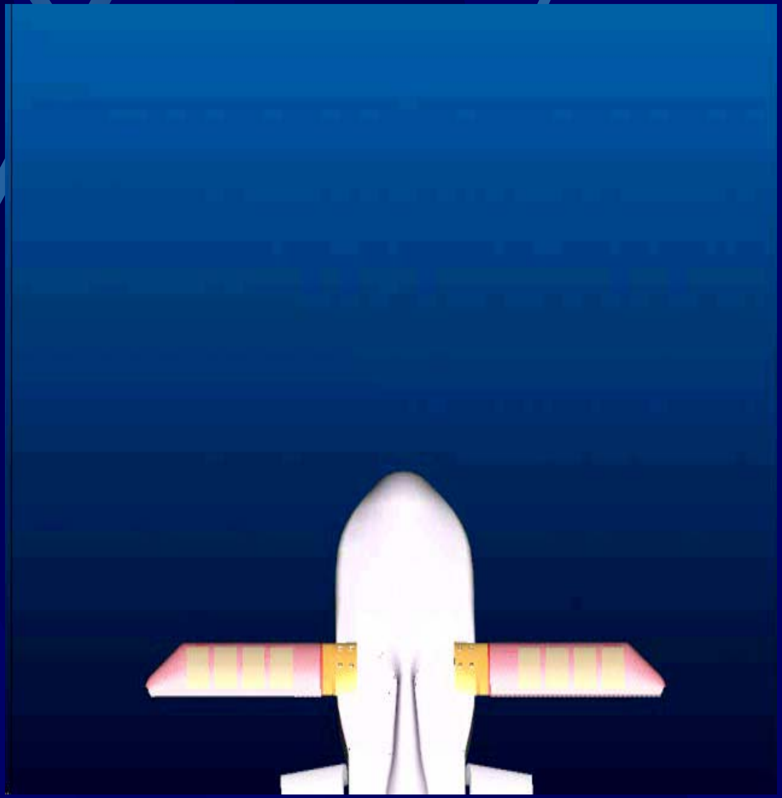
- **Don’t say “innovative” – avoid frontal assault**
- **Engage suppliers in modernization strategy**
- Worst vice is overselling!!! Credibility is Key!!

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

Nanomaterials Hit the Field

Success: DOD Nanomaterial

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



Extended Wing LOCAAS

Courtesy of Dr. Les Kramer, LMMFC

Success – JSF Lift Fan

- Lean team ‘87: USMC, DARPA and Lockheed
- USMC stayed in-charge
- DARPA support before IRAD $
- PM designed/advocated “lift fan”
- Competitor influenced final “lift fan” decision
- AF code convinced engine teams
- AF added strong staff/tech support

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

FIRST: STO-SSDash-VL

Courtesy of LMAero

Action: Materiel Developer

- Engage the internal R&D community
- Strengthen focus on new ideas
- Refresh labs/RDECs to ensure in-house capabilities in SE and across new domains

Reference: Mike Marshall, "From Science to Seapower"

Action: DOD AT&L

- Fund designated innovative technologies
- Add strong system engineering discipline
- Hire/support new S&Es
- Engage Industry/DOE/DHS/NSF

Action: Warfighter

- Include industry in Combat Developments
- Train cadre to examine capability options
- Use concept of “pilot” operations in field to evaluate new hardware
- Be willing to revise Doctrine, TOEs, TTPs

Action: Industry (1)

- Develop accountability
- Allocate resources
- Shield innovative technologies
- Develop credibility with customer
- Convince BOD/shareholders

Action: Industry (2)

- Establish Skunkworks
- Develop Mod-Sim-Test
- Tie above to Warfighter/Developer
- Explore the potential of new tech
- Educate system engineers, et al
- Allow failure

Summary/Conclusion

Transition is hard but essential for DOD success

Technical and engineering skills are vital

A team is required –

Industry/Warfighter/Developer

"I must work longer and harder each day to weave a world in which I can live."

Callahan, *Adrift – 76 Days Lost at Sea*

ANY QUESTIONS ?

BACKUP

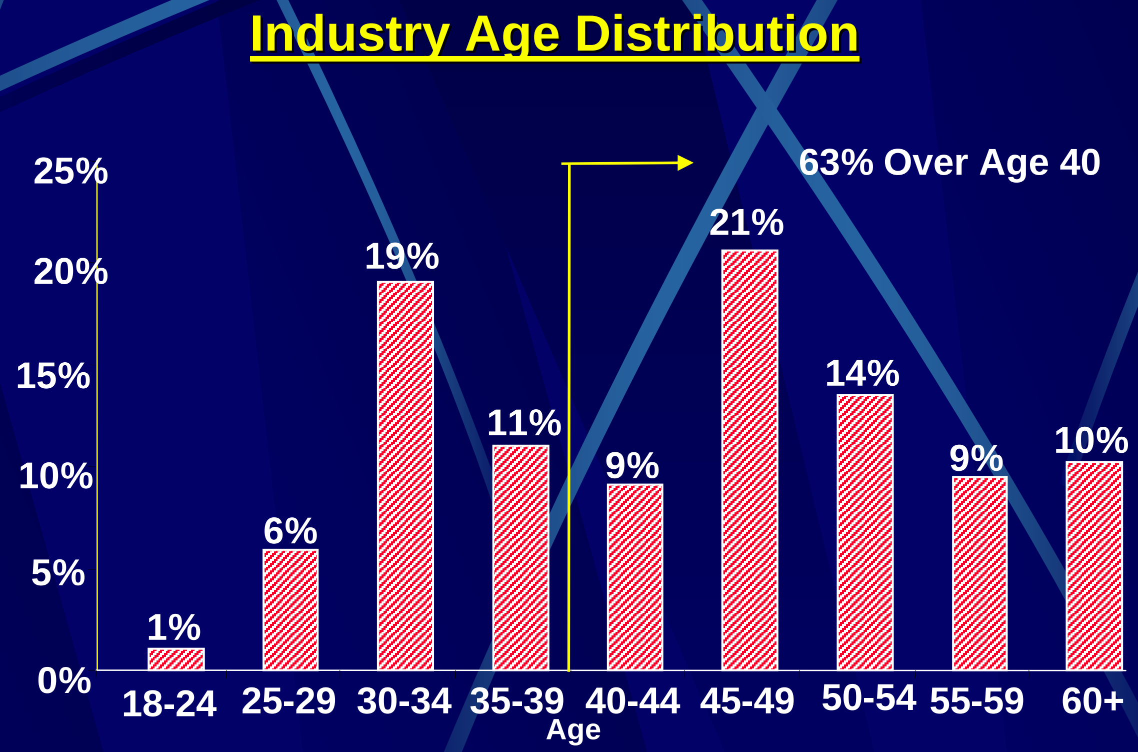
People Make Products Work

- John Roebling designed the Brooklyn Bridge, alone
- Frank Crowe drove the construction of Hoover Dam alone
- Ed Heinemann knew the Grumman A-4 better than anyone else
- Kelly Johnson knew <u>every</u> Lockheed airplane better than anyone else

Where are system engineers today?

philg@mit.edu

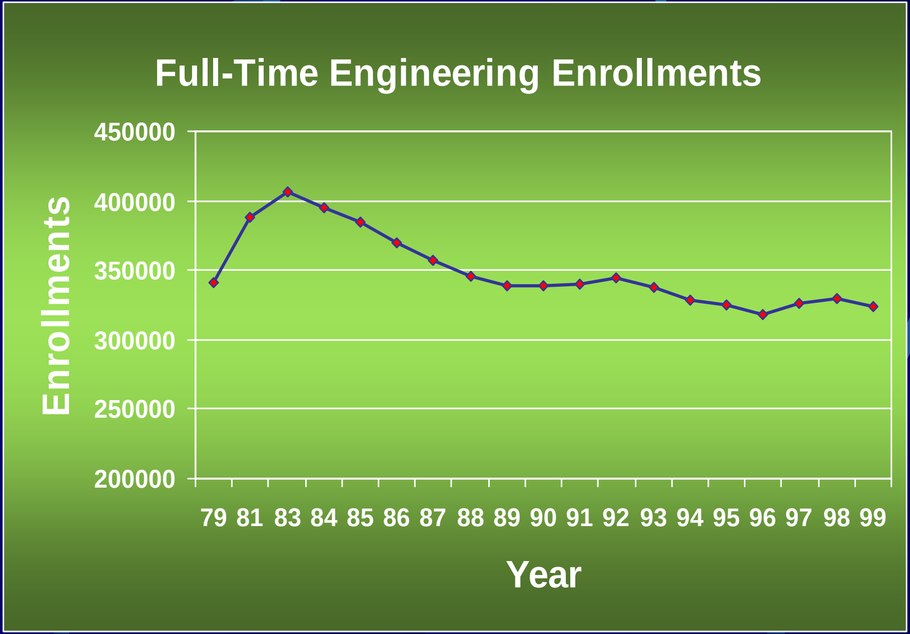
Aerospace Workforce Aging



Source: BAH Study

Industry losing many experienced SE's annually

Engineering Enrollment Down …



Source: National Science Foundation – Science and Engineering Indicators 2000

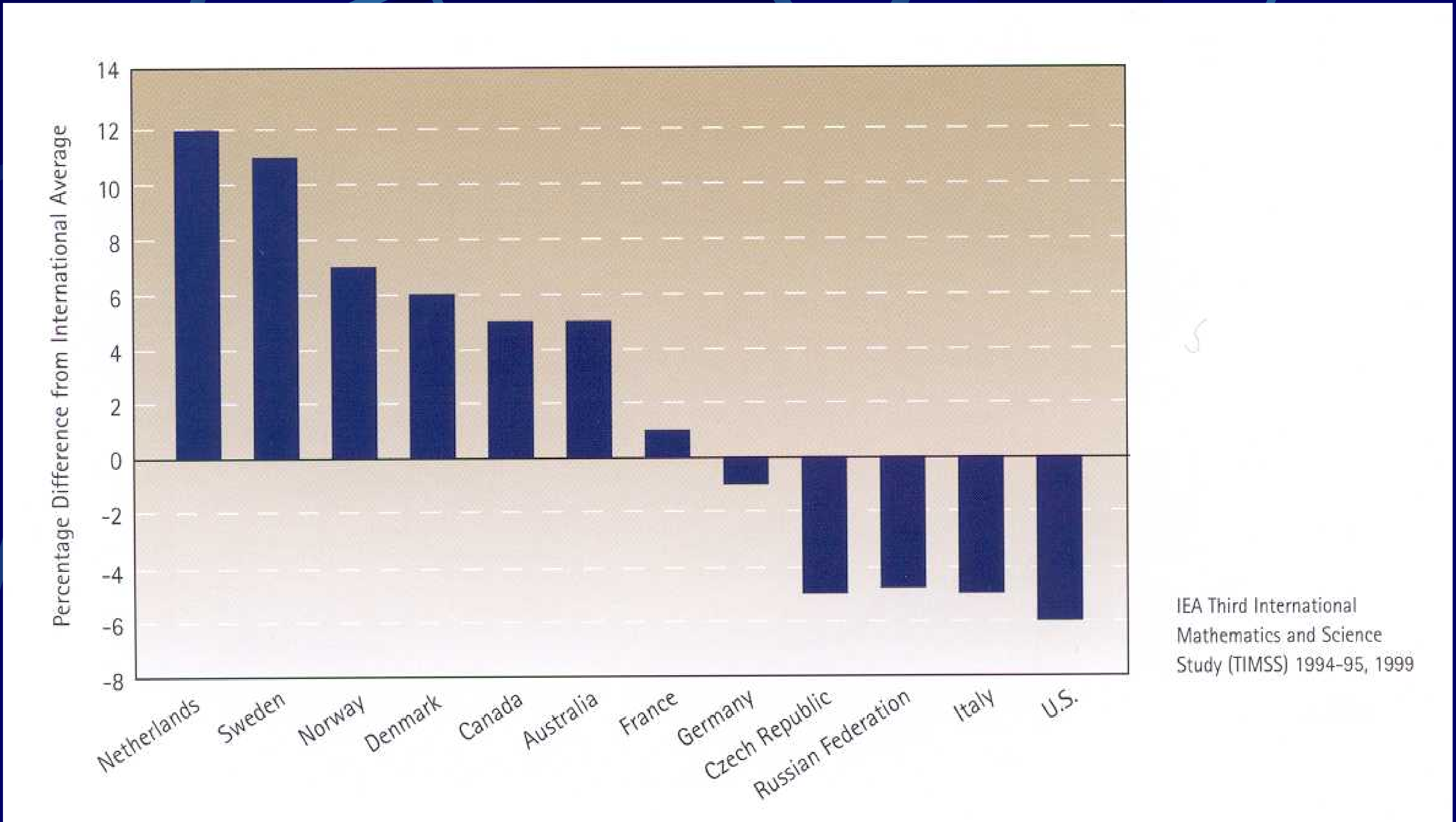
Engineering Graduates Selected Disciplines

Discipline*	1991	2000
Aerospace	4,072	2,175
Electrical	29,024	21,424
Mechanical	19,443	17,241
Computer	8,259	15,351
Total	60,798	53,189

Source: Engineering Workforce Commission

*System Engineering Discipline not available in most universities

U.S. 12th Graders Underperform in Math and Science



Source: The Second National Innovation Summit 2001, Council on Competitiveness

… While Demand Growing

U. S. Engineering Job Growth- Selected Disciplines 1998-2008

Discipline*	1998	2008	% Change
Aerospace	53,000	58,000	9.4
Electrical	357,000	450,000	26.0
Mechanical	220,000	256,000	16.4
Computer	5,626,000	11,144,000	98.0
Total	6,056,000	11,908,000	96.6

Source: U. S Bureau of Labor Statistics

*System Engineers needed for most DOD applications

Comparison Between Commercial and Defense Manufacturing Maturity

Bob Schafrik

GE Aviation

17 April 2008

imagination at work

Overview

- GE Aviation
- Commercial engine environment
- Military engine environment
- Materials technology examples
- Takeaways

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GE Aviation Product catalog ...

world's largest fleet

Commercial Power	**CT7** **CF34** **CF6** **GP7000**	**CF34** **CFM56** **GEnx** **GE90**	
Military Power	**T58/64** **J79/85** **F103** **F404/14** **F110**	**T700** **TF34** **F108** **F101/18** **F136**	
Marine & Industrial Power	**LM500** **LM2500** **LM6000**	**LM1600** **LM5000** **LMS100**	

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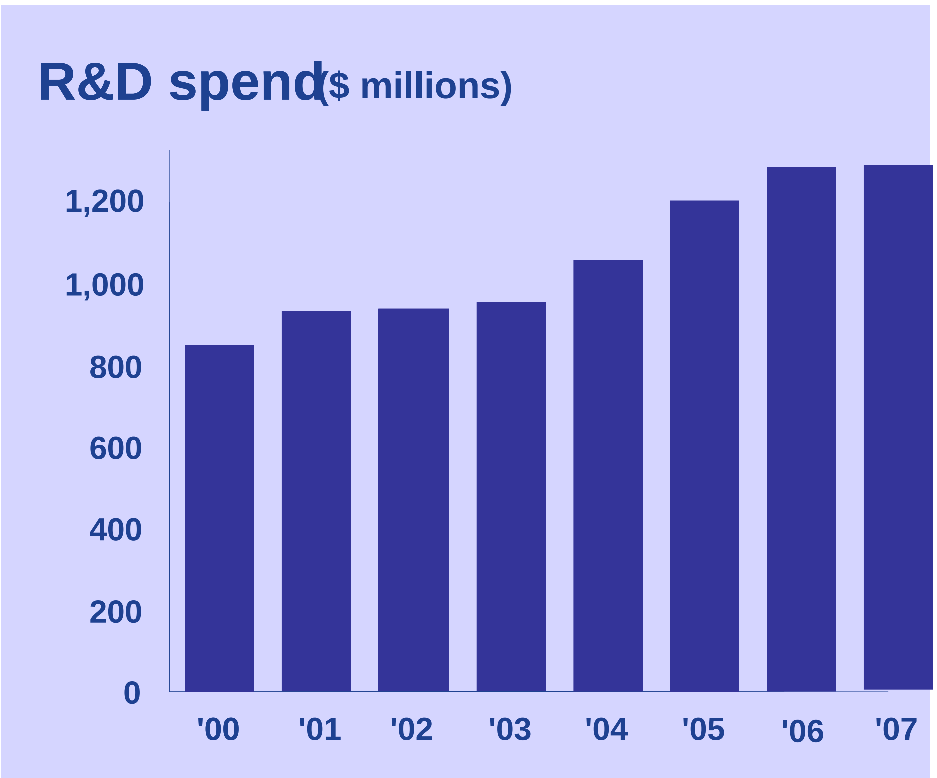
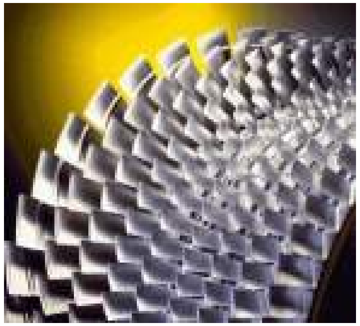
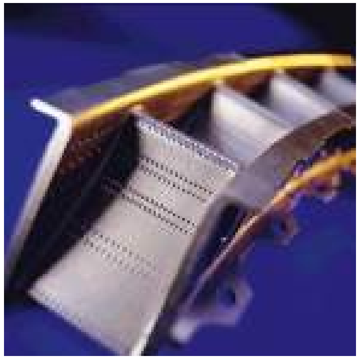
Today … highest R&D commitment in history … $8.3B since '00







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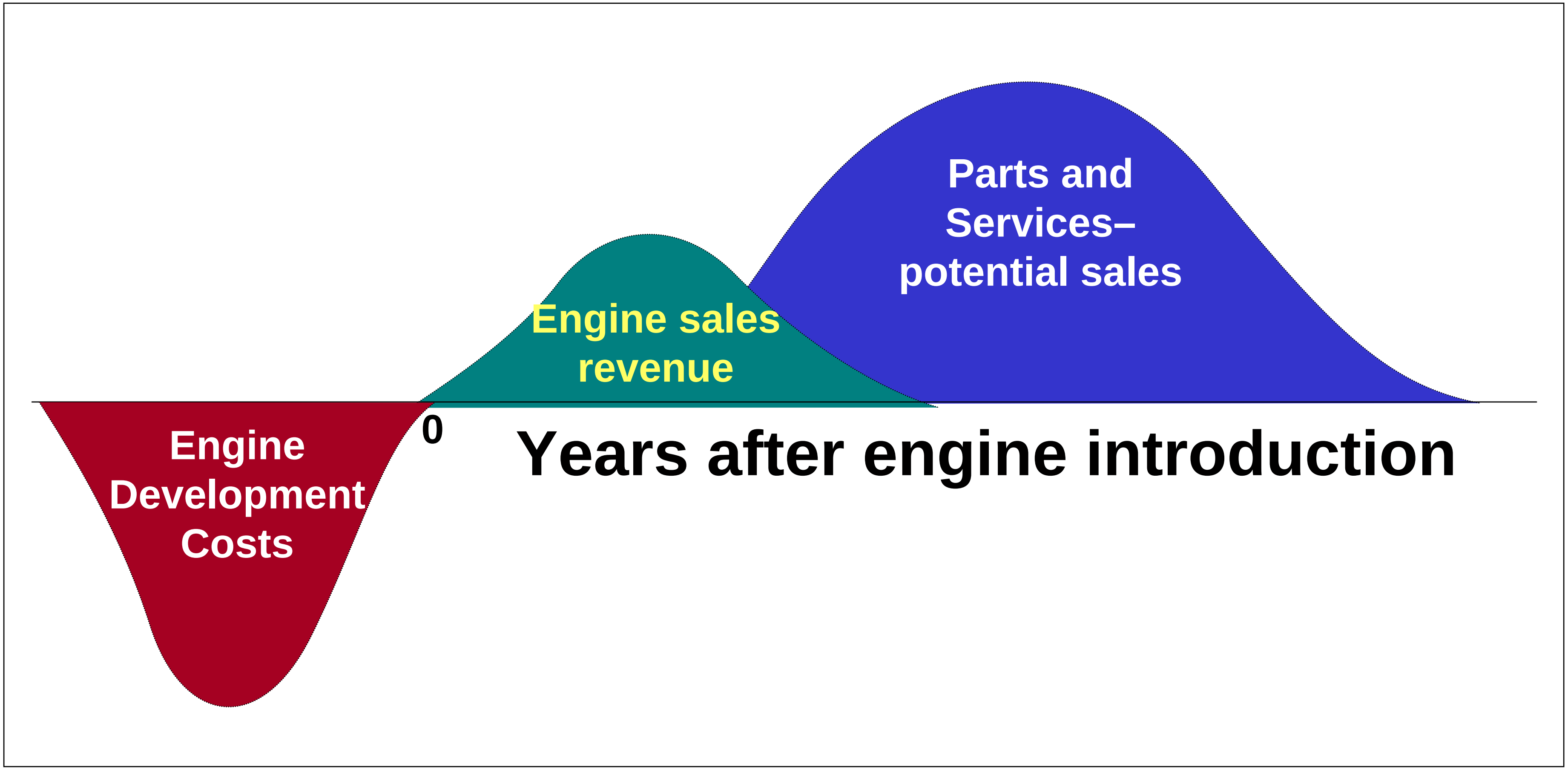
Comparison of Environments

	Commercial	Defense
Development Time	short	long
Cost Risk	OEM	DoD/Services
Schedule Risk	OEM	DoD/Services
*Build Rate	high	rarely high
No of Customers	large	limited
Product Improvements	Frequent	limited

Both environments are highly competitive

Commercial Engine Business Model



Commercial Business Case Perspective

- What does the Technology add to Customer Value
  - Benefits
- Will the Technology deliver the Benefits
  - How well do we understand the risks
  - What are mitigation plans
- What will the Technology Cost
  - Learning Curve
- Is the Business Plan prudent

Manufacturing Maturity Underpins the Answers to These Questions

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Commercial Programs Integrate TRL & MRL

- Producibility evaluated early in technology development cycle
  - Will not proceed without a clear path
  - Program gets added plus if MRL is high
    - Development uses production process
- Determine if Supply Base can meet production rate and cost goals
  - Single source vs. Dual source
- May need to develop new supply chain
  - Estimate Business Case for Suppliers

Commercial Development Stages

Feasibility	Demonstration	Maturation
TTG3	TTG6	TTG9
•Initial evaluation-lab scale •Estimates of key characteristics	•Sub-scale demonstration •Components produced to prelim specs •Production windows estim	•Process capability fully established >Production specifications in place >Supply chain established •All necessary property data obtained

Technology Creation—$Million Commitment

Component Design Only Applies Mature Technology

Demonstrator Programs

Product Creation—$Billion Dollar Commitment

Feasibility	Demonstration	Maturation
TG3	TG6	TG9
•Computer simulations, sub-scale testing of concepts •Performance estimates made	•Full scale testing •Product performance validated •Mature Technologies	•Production components designed •Product engines certified •Products enter service

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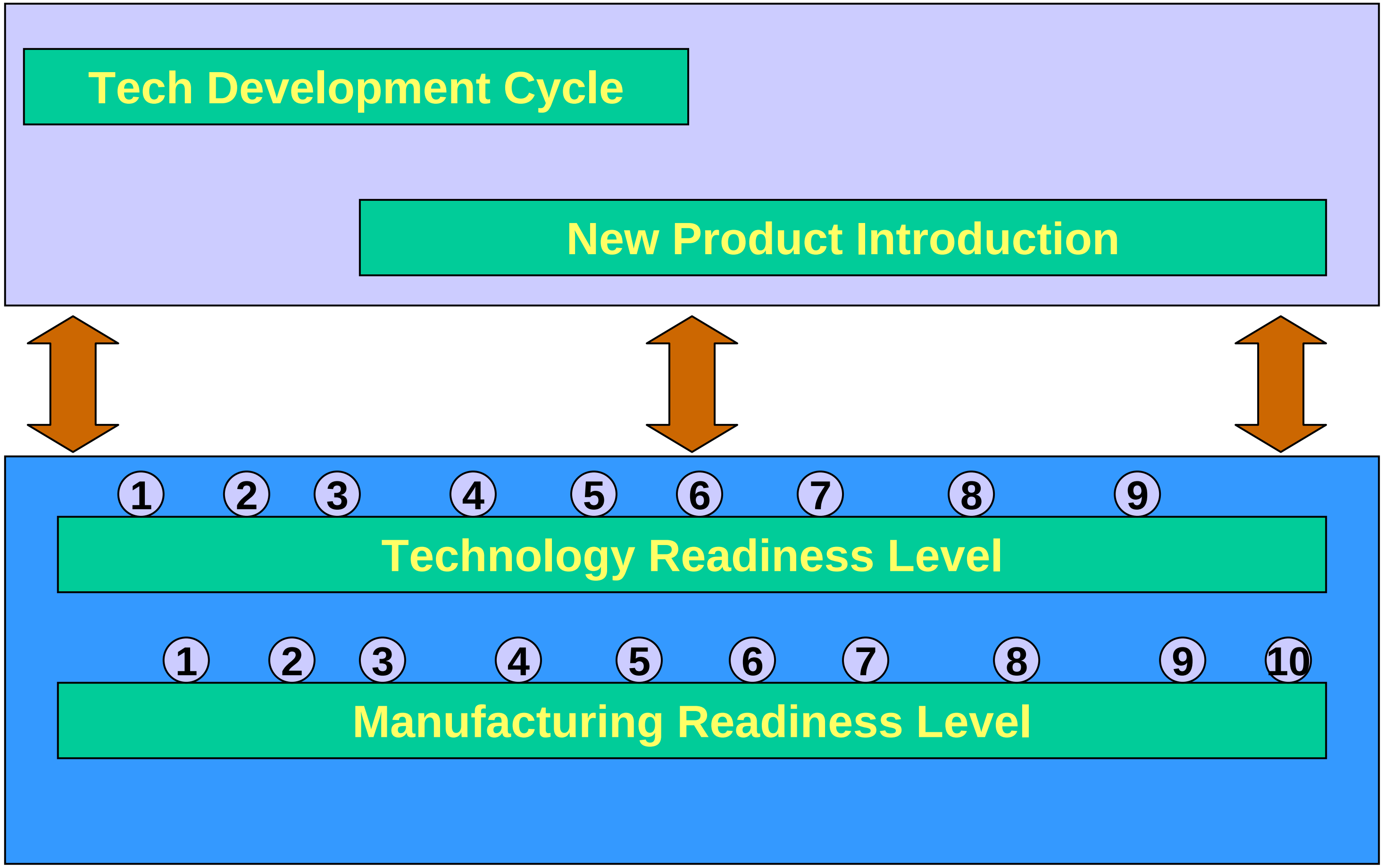
Producibility Challenges for Military Programs

- Mixed message to Supply Base
  - Early focus on OEM design & tech demos
  - Competition strongly encouraged
  - Social policy, political forces
- Long, drawn-out development timeline distorts investment decisions
  - Difficult to discern the “real” program
  - Limited trade-off of Performance vs. Producibility
    - Maintain budget profile by reducing production quantities

GE Aviation Support For MRL – TRL

Compatible With Commercial Development Cycle



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Materials Examples

- Powder Metal Turbine Disks
- Composite Technology
- Titanium Aluminides

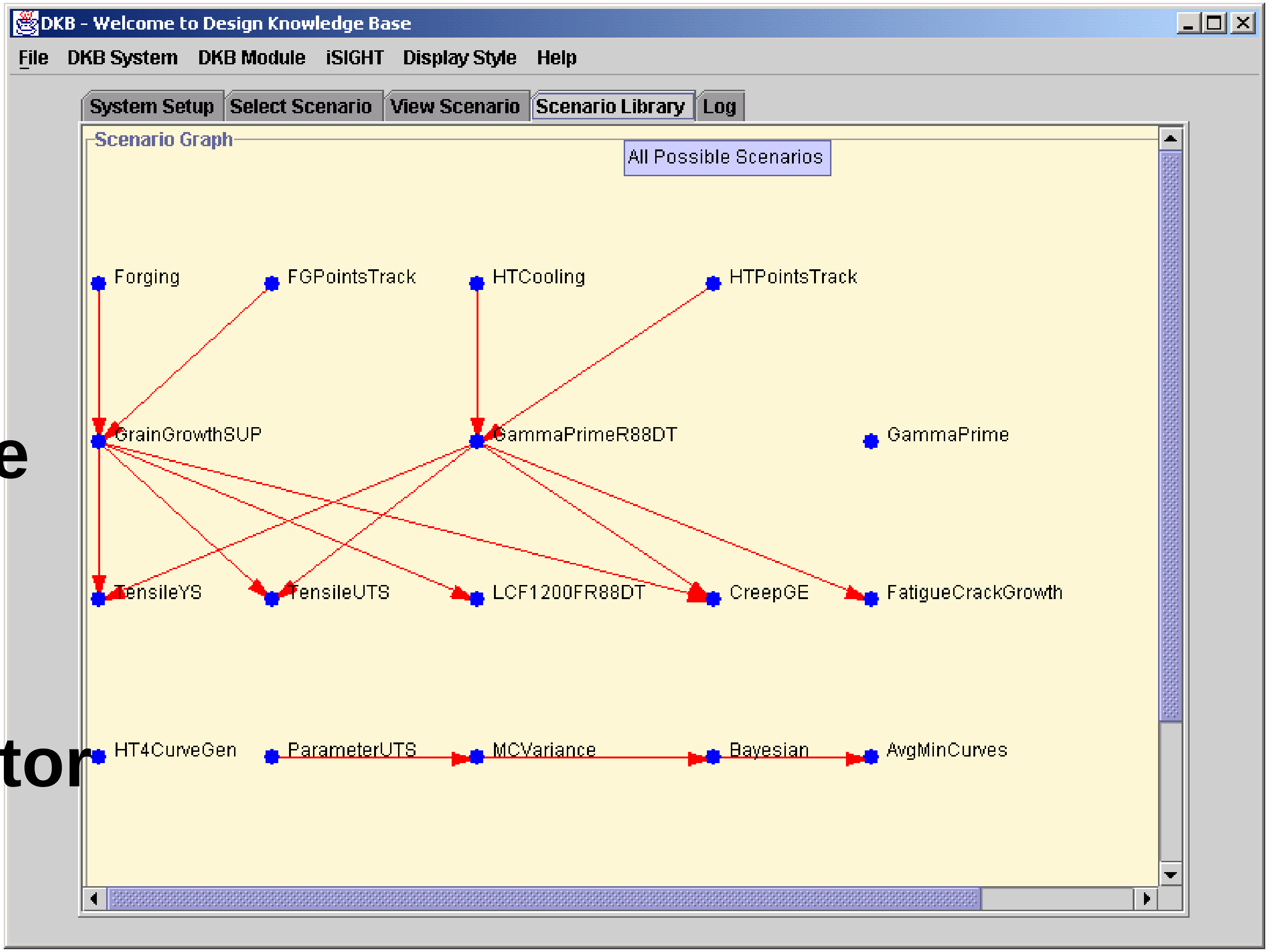
Go-Forward: Integrated Materials & Process Models

Processing

Microstructure

Properties

Curve Generator



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Takeaways

- Commercial program perspective
  - Develop a producible competitive system
    - Success depends on ability to perform
    - Manufacturing Readiness essential
- Military program perspective
  - Develop highly capable affordable system
    - Want leading edge technology NOW
    - Assume that market forces for supply chain
- OEMs are key to developing, focusing supply chain

Contact Information

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Department of Defense
Science and Technology Program
-- A Time of Continued Change --

Mr. Al Shaffer
Principal Deputy
Defense Research and Engineering
15 April 2008

VISION: To develop technology to defeat any adversary on any battlefield

Any Battlefield includes physical, cyber, space, undersea, etc

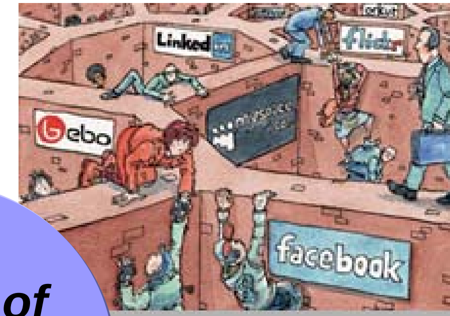
The Evolution to New Ideas

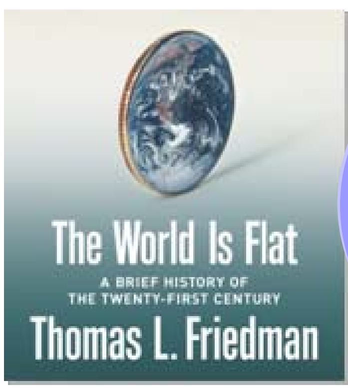
The DoD, Like the World, is moving from Physics Based to Multidisciplinary and Non-Kinetic Science

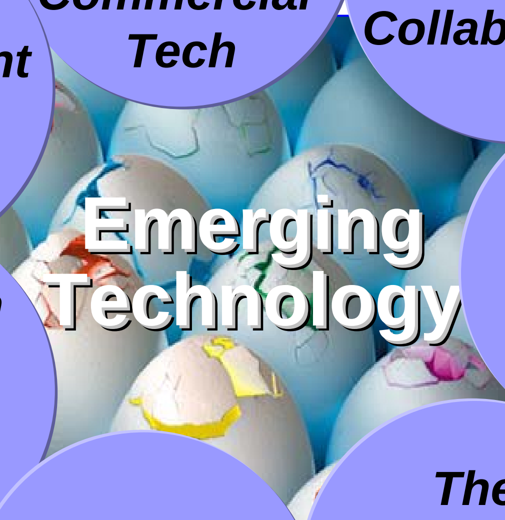
"Any sufficiently advanced technology is indistinguishable from magic."
~Arthur C. Clarke

"In times of change, learners inherit the Earth, while the learned find themselves beautifully equipped to deal with a world that no longer exists"
Eric Hoffer

A Changing World . . .







Disruptive Military Uses of Commercial Tech

Impact of Mass Collaboration

Development Pace

Economic Mega Trends

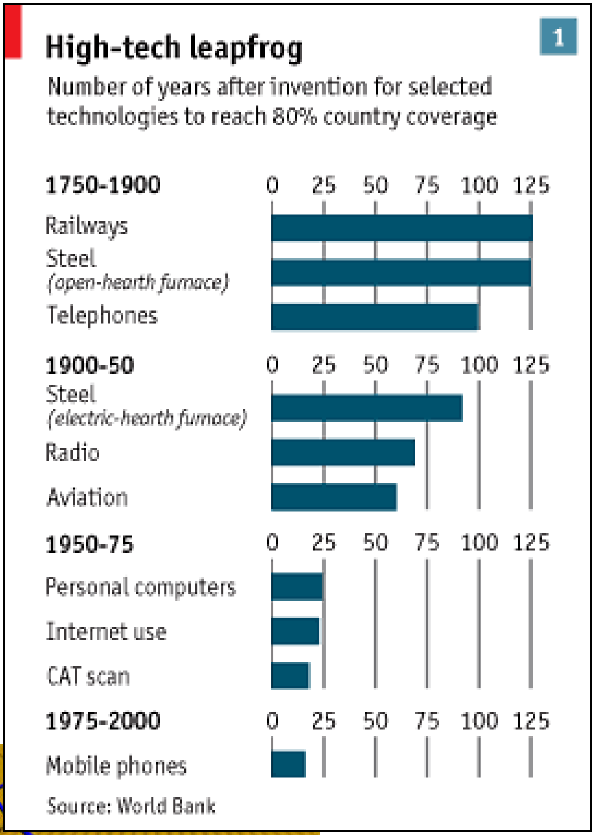
Expansion Of R&D Funding

The Black Swan Syndrome

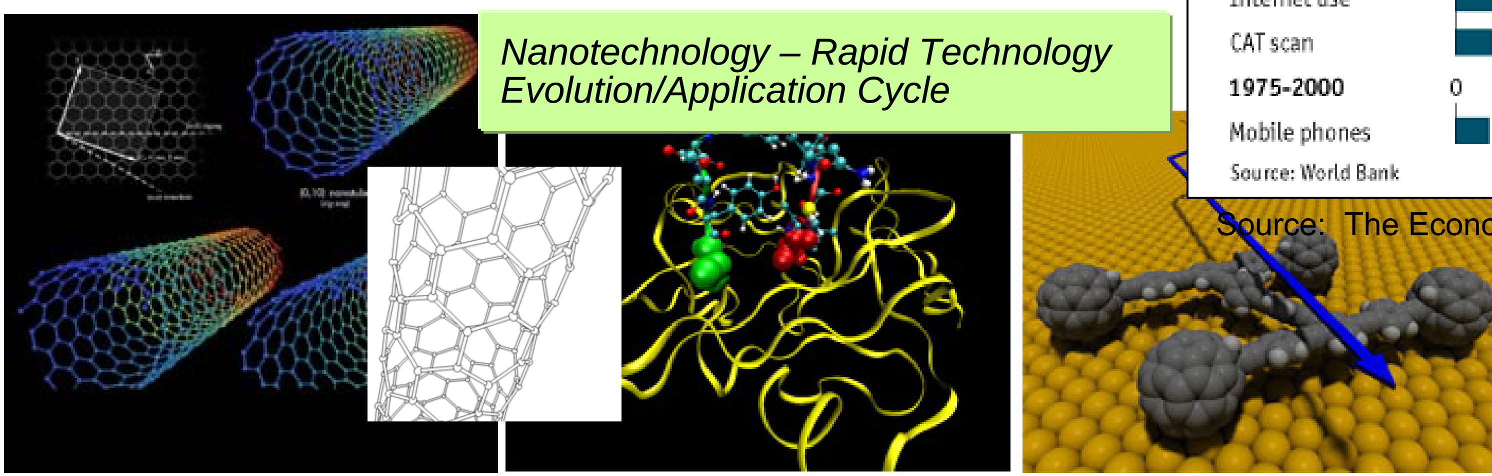
The Expanding Education Base

Pace of Technology Continues to Increase

- **Time between modeling of semiconducting properties of germanium in 1931 and first commercial product *(transistor radio)* was 23 years**
- **Carbon nanotube**
  - **Discovered by Japan (1991)**
  - **Researchers recognized carbon nanotubes were excellent sources of field-emitted electrons (1995)**
  - **"Jumbotron lamp" - nanotube-based light source available as commercial product (2000)**



Source: The Economist, Feb. 9, 2008

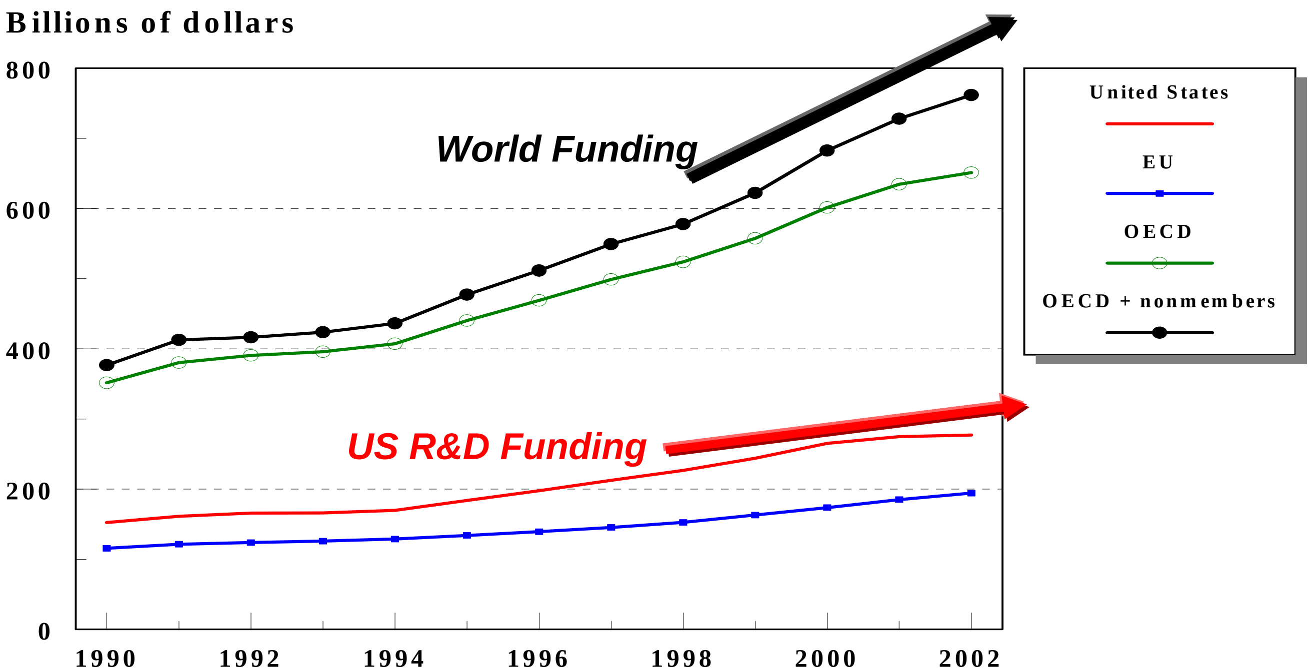


Nanotechnology – Rapid Technology Evolution/Application Cycle

International R&D trends

- **R&D expenditures are increasing robustly around the world, driven by both governments and industry.**

Figure 1. Estimated worldwide R&D expenditures: 1990-2002



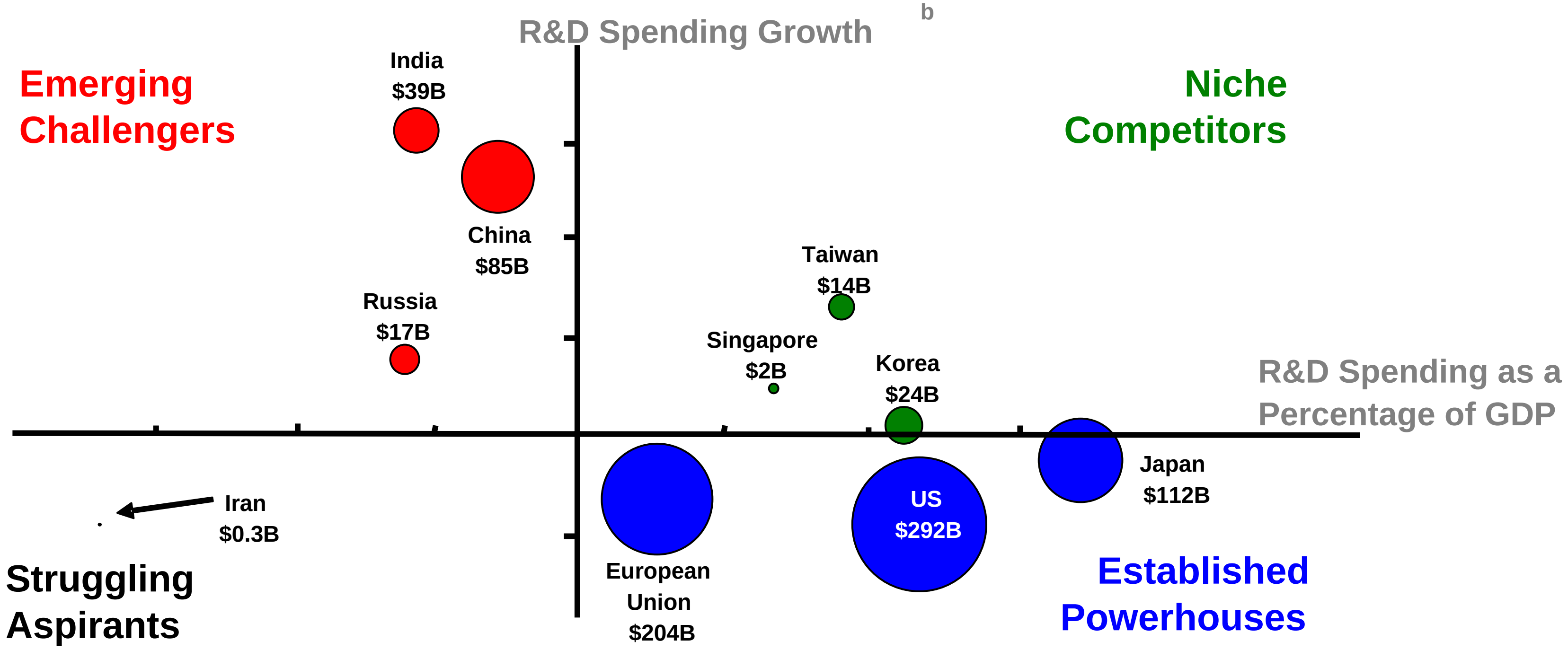
NOTE: Billions of current dollars converted with purchasing power parities.
EU data since 1998 include 10 new member countries.
SOURCE: OECD, Main Science and Technology Indicators database, November 2004

Source: National Science Foundation, S&E Indicators 2006

Global Technology (R&D) Spending and Growth

The R&D Spending Landscape - Selected Entities [a]

(Circle size reflects R&D spending levels.)

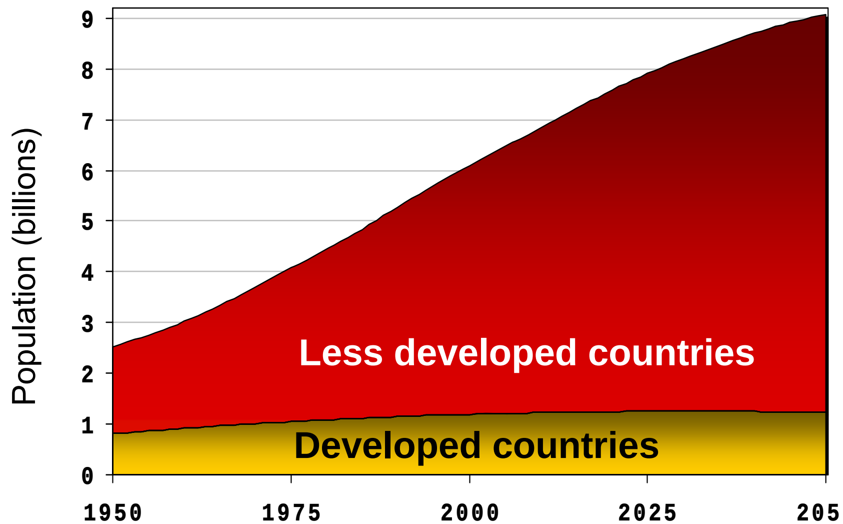


[a]R&D spending as a percentage of GDP and spending growth are defined in Figures 1 through 3. R&D spending levels are in current billions of PPP dollars.
[b]Growth rates are calculated since 2000, except for Russia, which was calculated since 1992 due to high uncertainty in the regression since 2000.
Sources: OECD, Main Science and Technology Indicators Volume 2005; UNESCO, Science Report 2005; Indian Ministry of Science and Technology, S&T Annual Report 2004-2005; H. Arfaei, "Status of Scientific Research -- Iran 2005", April 2005; CIA World Fact Books, 1981-1990, 1997- 2004; and World Bank, Development Indicators database, 1981-1990, 1997-2004.

Demographic Trends

- Demographic trends are the most predictable of the trend sets
- The major trends with significant defense implications:
  - North-South divide in age structure
    - Demographic "bonus" India, Latin America
    - Youth bulges in fragile states and migrant populations
    - Aging and low birth rates in key allies & China
  - International and internal migration
    - Push away from trouble
    - Pull to economic opportunity
    - Migrating political interests
  - Youth, conflict, and ideology
  - Urbanization

Massive Population Growth

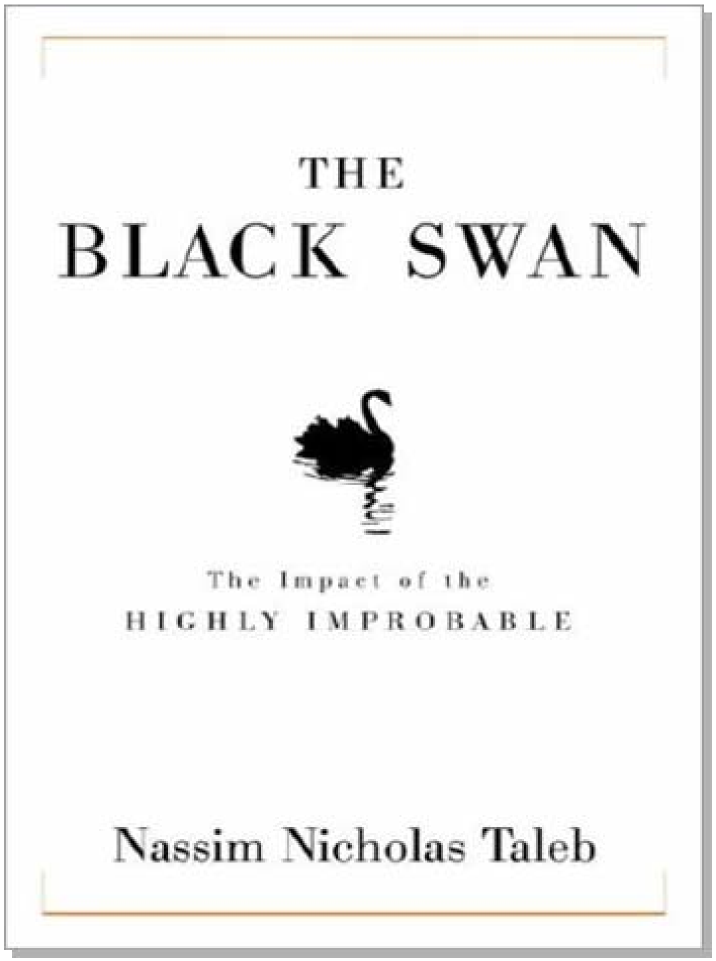


(Source: UN, World Population Prospects, The 2006 Edition, 2007)

Demographic change will increase stress on fragile states, create risks around access to resources, and generate a range of governance, societal, cultural, & health issues as states adjust to population transformations within and between states

The “Black Swan” Syndrome

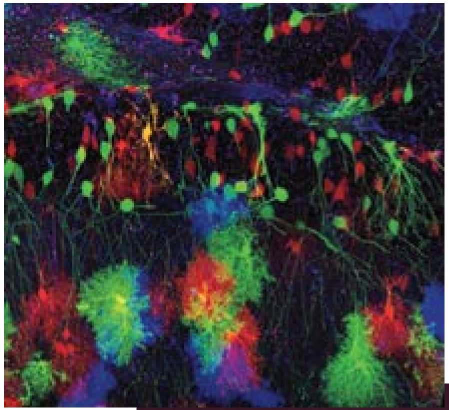
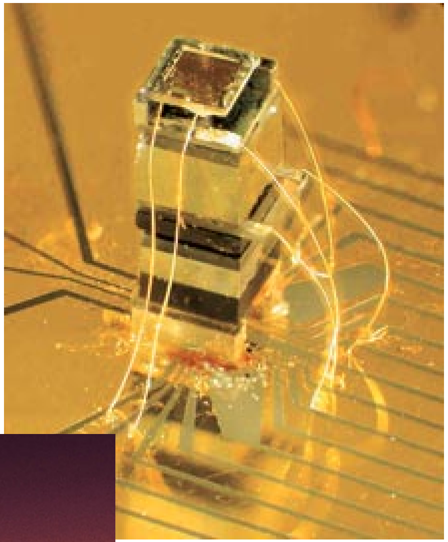
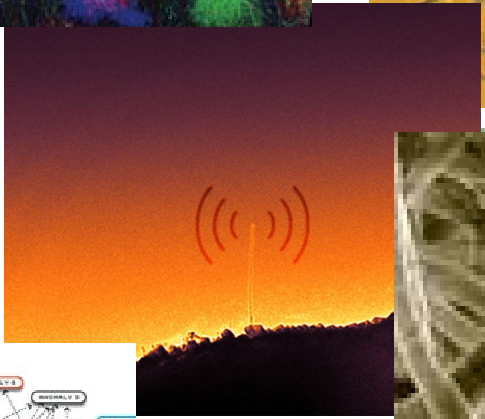
Cognitive biases create false expectations of predictability. Acknowledging uncertainty may allow us to adapt better to unforeseen events.

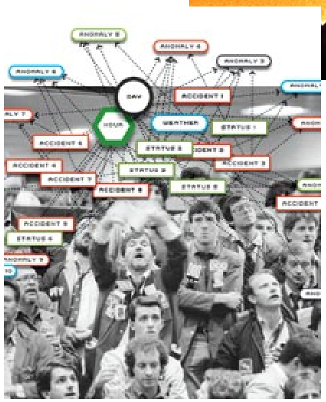
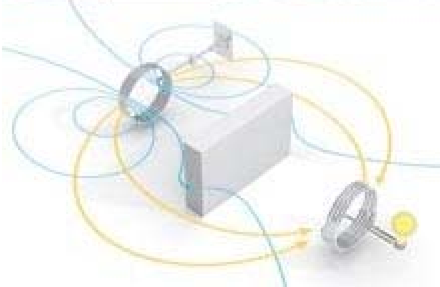


- “Black Swans”: ***large-impact, impossible to predict, and rare event beyond the realm of normal expectations***
  - 9/11, Google, internet bubble
- “Outside context problem”: ***Problem outside a given groups experience, with an immediate, ubiquitous and lasting impact upon it***
  - Perry’s Black Ships arriving in Japan
- “Accelerating change”: ***increase in rate of technological/ cultural/social progress in history (contrast to linear view)***
  - Accumulation of knowledge, access to knowledge and lowering of transactional barriers to knowledge

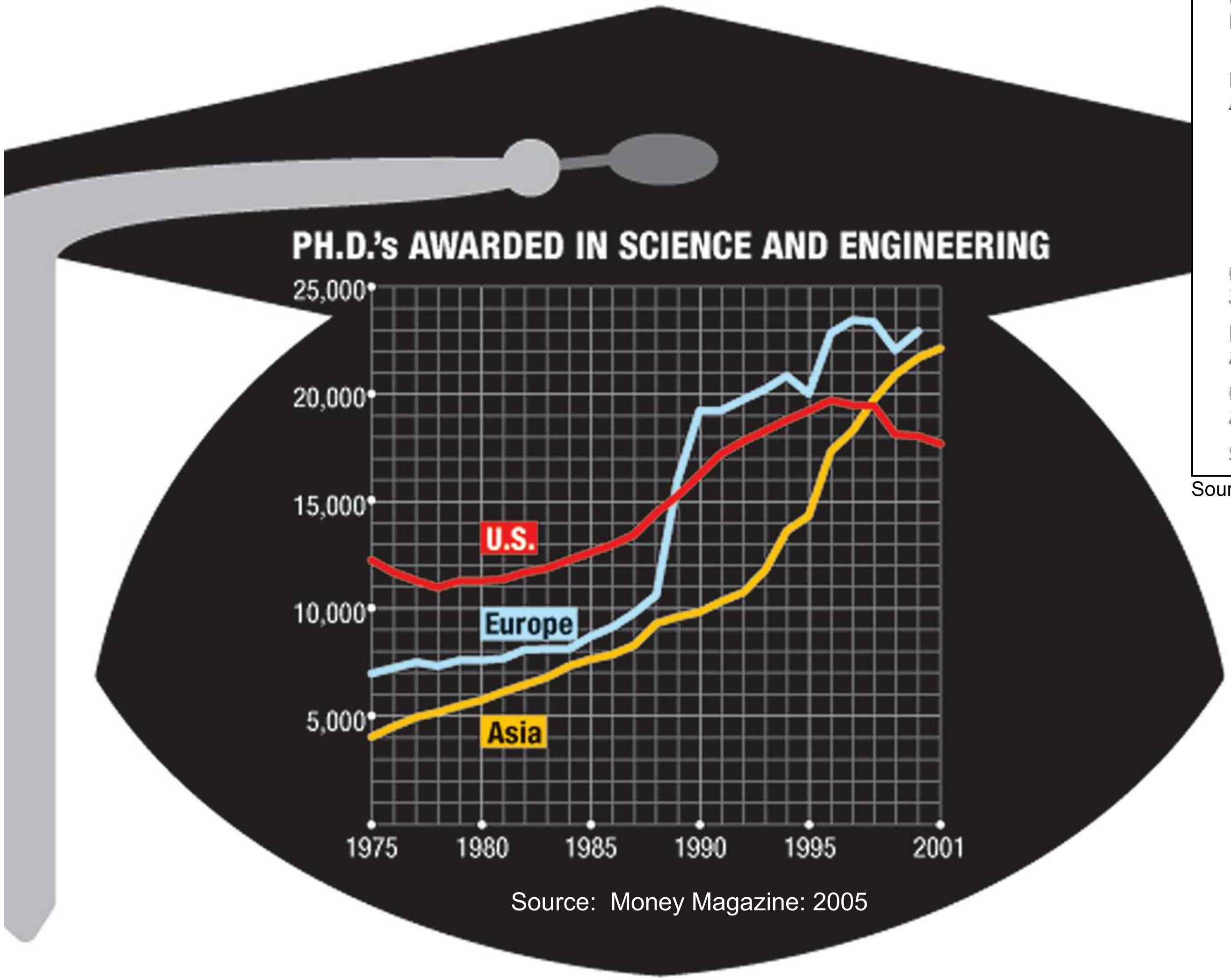
March/April 2008 MIT Innovations List of 10 Emerging Technologies

- *Cellulolitic Enzymes*
- *Atomic Magnetometers*
- *Surprise Modeling*
- *Connectomics*
- *Probabilistic CMOS*
- *Reality Mining*
- *Offline Web Applications*
- *Graphene Transistors*
- *Nanoradio*
- *Wireless Power*

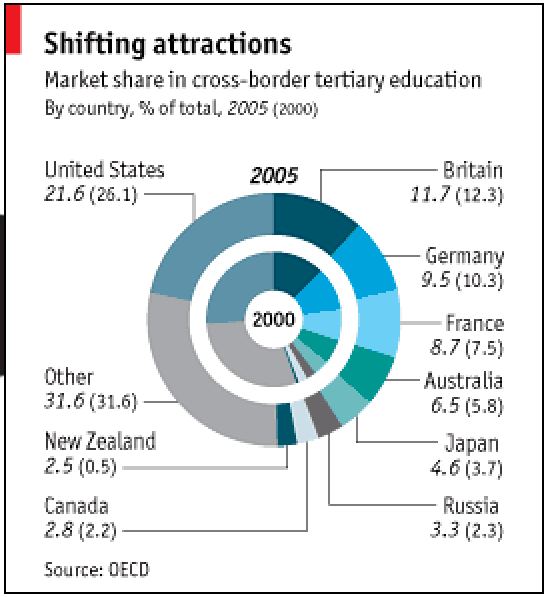




Comparison of Scientists & Engineers (S&Es)



Source: Money Magazine: 2005



Source: The Economist, Nov. 15, 2007

http://www.economist.com/research/articlesBySubject/displaystory.cfm?subjectid=2133650&story_id=10143217

Growth of Educated Asian Population

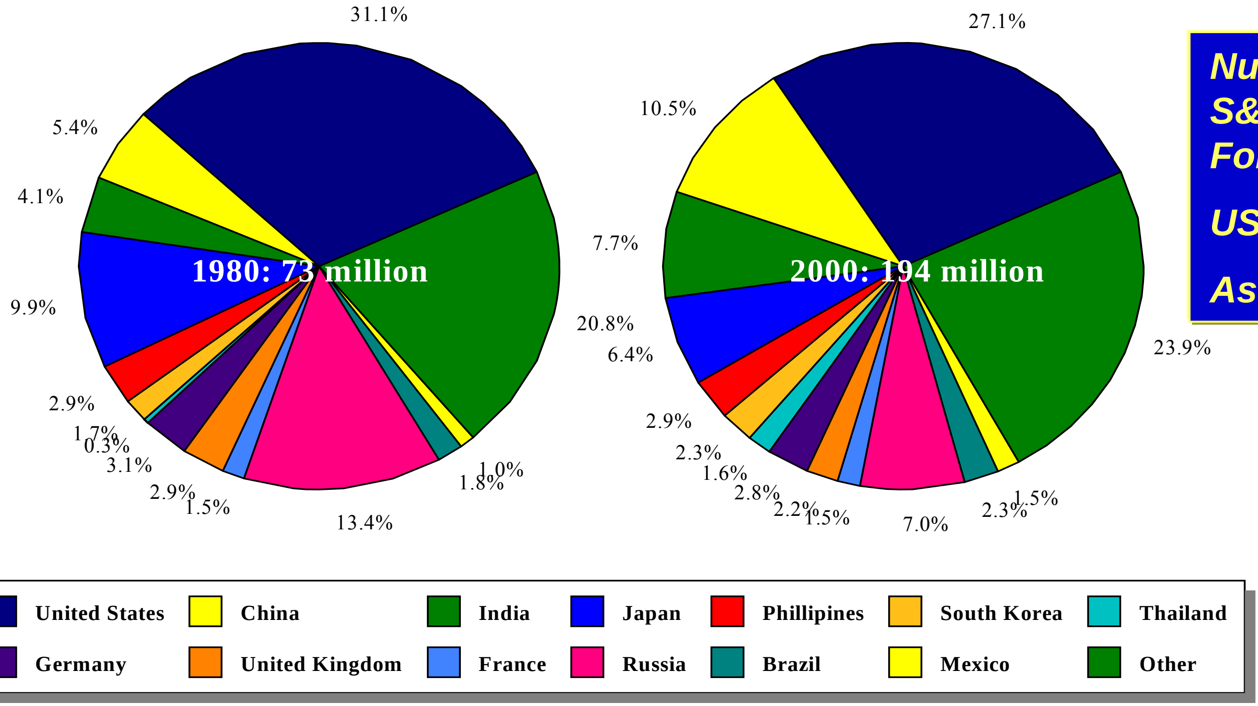
- **International S&E labor force data can only be approximated.**

Figure 20. Population 15 years and older with tertiary education, by country/region: 1980, 2000

Number in S&E Labor Force, 1980:

US 22.8M

Asia: 17.7M



Number in S&E Labor Force, 2000:

US 52.6M

Asia: 60.9M

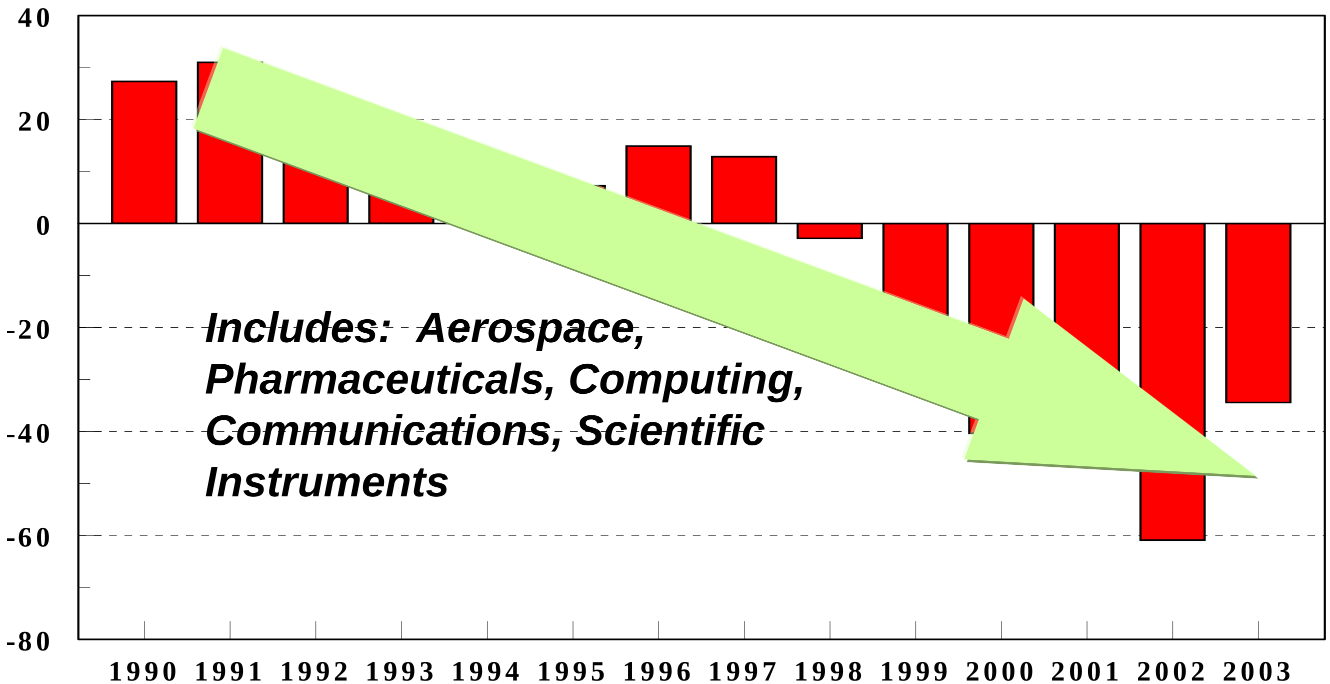
SOURCE: Adapted from R.J. Barrow and and J. Lee, Center for International Development: International Data on Educational Attainment, 2000

Source: National Science Foundation, S&E Indicators 2006

U.S. trade balance – high tech industries

- **The trade balance of U.S. high technology industries has turned negative**

Figure 12. U.S. trade balance for five high technology industries: 1990-2003
Billions of dollars



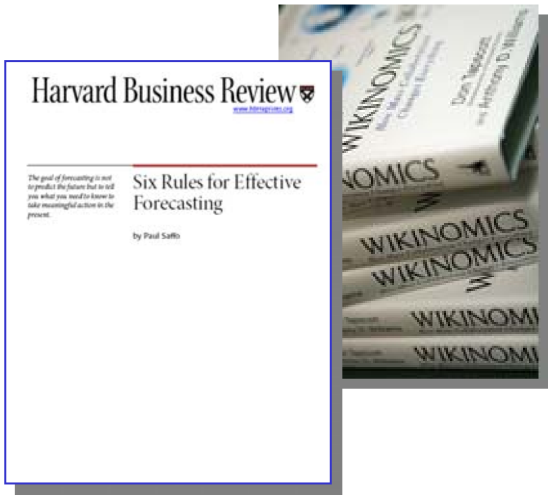
NOTE: Includes aerospace; pharmaceuticals; office and computing equipment; communication equipment; and scientific instruments.
SOURCE: Global Insight and S&E Indicators 2006

Source: National Science Foundation, S&E Indicators 2006

Forecasting Future Disruptive Technology—Mass Collaboartion

- DoD & National Academies
- Teaming to produce a recurring technology forecast that is a:
  - Multidimensional Description of the technology
    - Estimation/description of impact
    - Temporal profile of development
  - Based on a wide group of experts
    - Develop a New web collaboration environment
    - Industry, academia, venture capitalists, government experts, etc.
    - Use collaboration environment to access a global community
  - Examines both traditional and non-traditional technology trends

Looking more than 15 years ahead . . .



Using mass collaboration as the tool for "*Effective Forecasting*"

Disruptive Technology

The Non-Textbook Definition

- Rapid evolution from old, stable technology to new, dominating technology
- A technology surprise that gives a competitor an advantage
  - Business - Technology that overturns market
  - Military - Technology that causes a fundamental change in force structure, basing, and capability balance
- Disruptive Technologies can be intended or unintended - but both represent change
- Disruptive Technologies may arise from systems or enabling technology

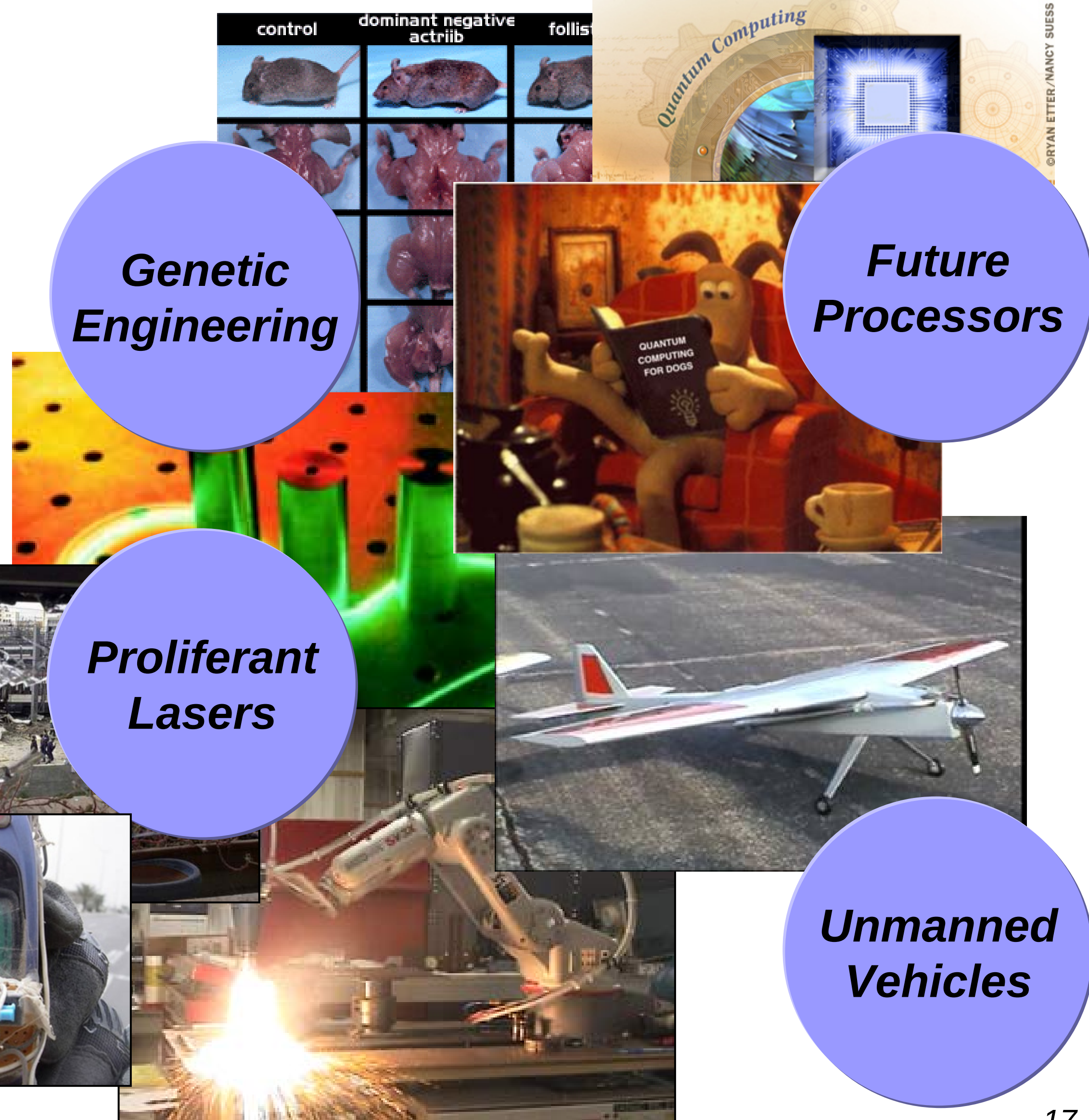
Desert Storm

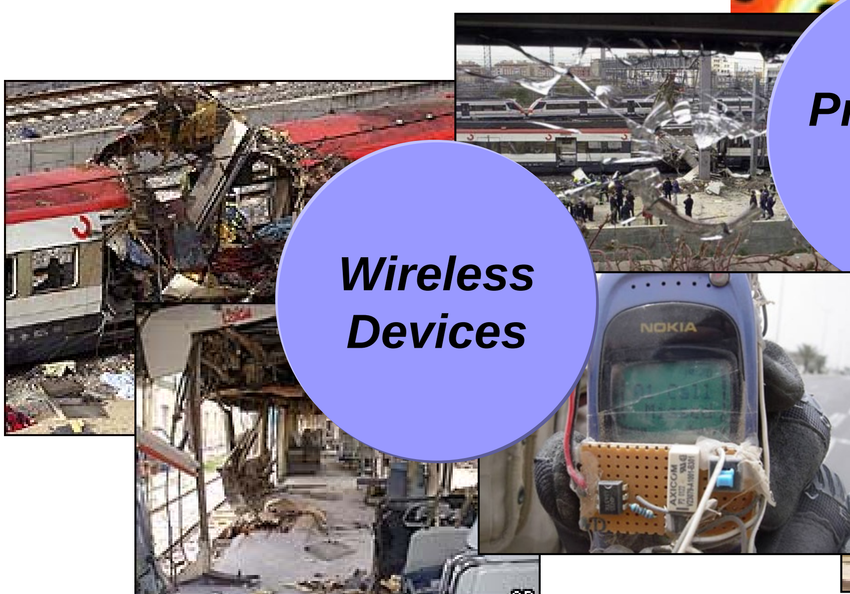
- The advent of information-based warfare feeding the emergence of irregular warfare

- US dominance over Soviet-era systems “shocked” potential adversaries and combined to give US conventional superiority
  - Precision Weapons
  - Night Vision
  - Low Observability
  - Networked Systems

R&D Expansion & "Disruption"
--Applications of Commercial Technologies--

- Fundamentally can have global impact & change the balance and approach to force expression
- Drives and fuels the need for & new innovative concepts
- Includes how new capabilities are built on emerging technology
- Appearing increasingly from the global commercial marketplace





An information age Pearl Harbor?

NO….but this guy is far cry from Imperial Japan

George Hotz, 17, of Glen Rock, New Jersey holding the iPhone® that he separated from the AT&T network and used on the T-Mobile Network. Career goal: hack the human brain

- Apple and AT&T released the iPhone on 29 June
- An exclusive agreement guaranteed the iPhone could only be used on AT&T's mobile network
- Hotz spent approximately 500 hours working on his "summer project"
- The hack was announced on 24 August.
  - AT&T - market cap: $245B
    - annual revenue: $90B
  - Apple - market cap: $117B
    - annual revenue: $23B
  - Hotz - PRICELESS

This is the new asymmetry—victory goes to the agile and innovative

Trends

- **Increasing**
  - **International Science and Technology Relative to the US**
  - **Industrial Globalization of R&D**
  - **Pace of Technology Development**
  - **US Trade Balance in High-Tech Goods**
  - **Potential for "*Hybrid*" Disruption**
  - **Mass Collaboration "*Flattening*" the world**
- **Decreasing**
  - **US Production of Global Scientists and Engineers relative to World**

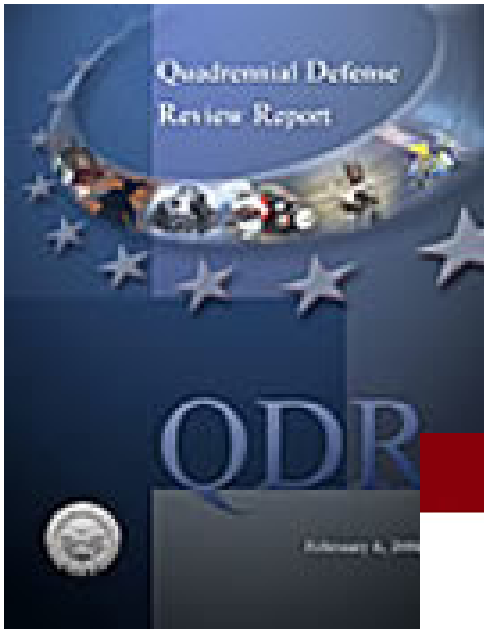
US High Technology Advantage not Assured

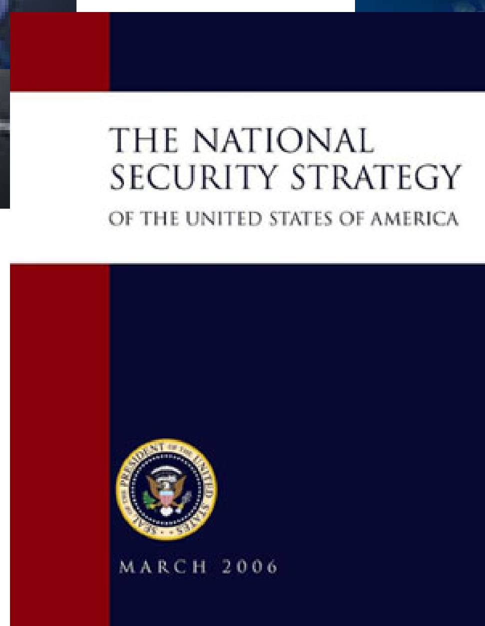
Competition Increasing

Therefore, Have to Work on "High Payoff" Areas

Where are we going?

S&T Strategy and Plans

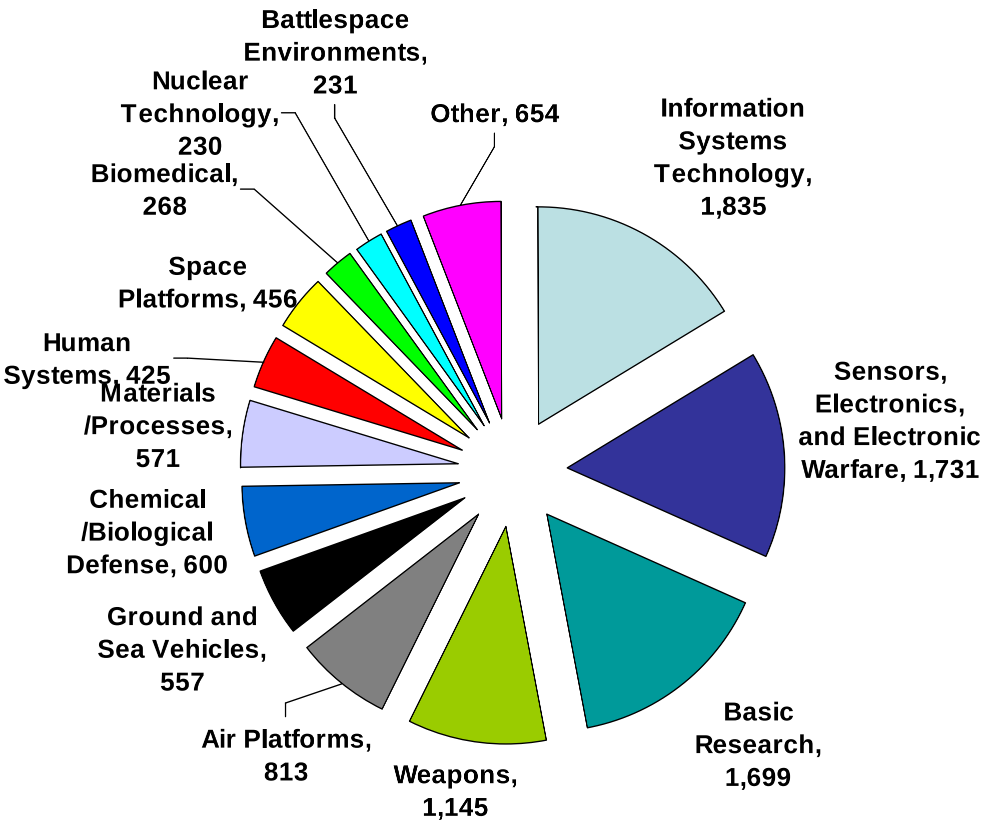




Defense Science and Technology Strategy and Planning

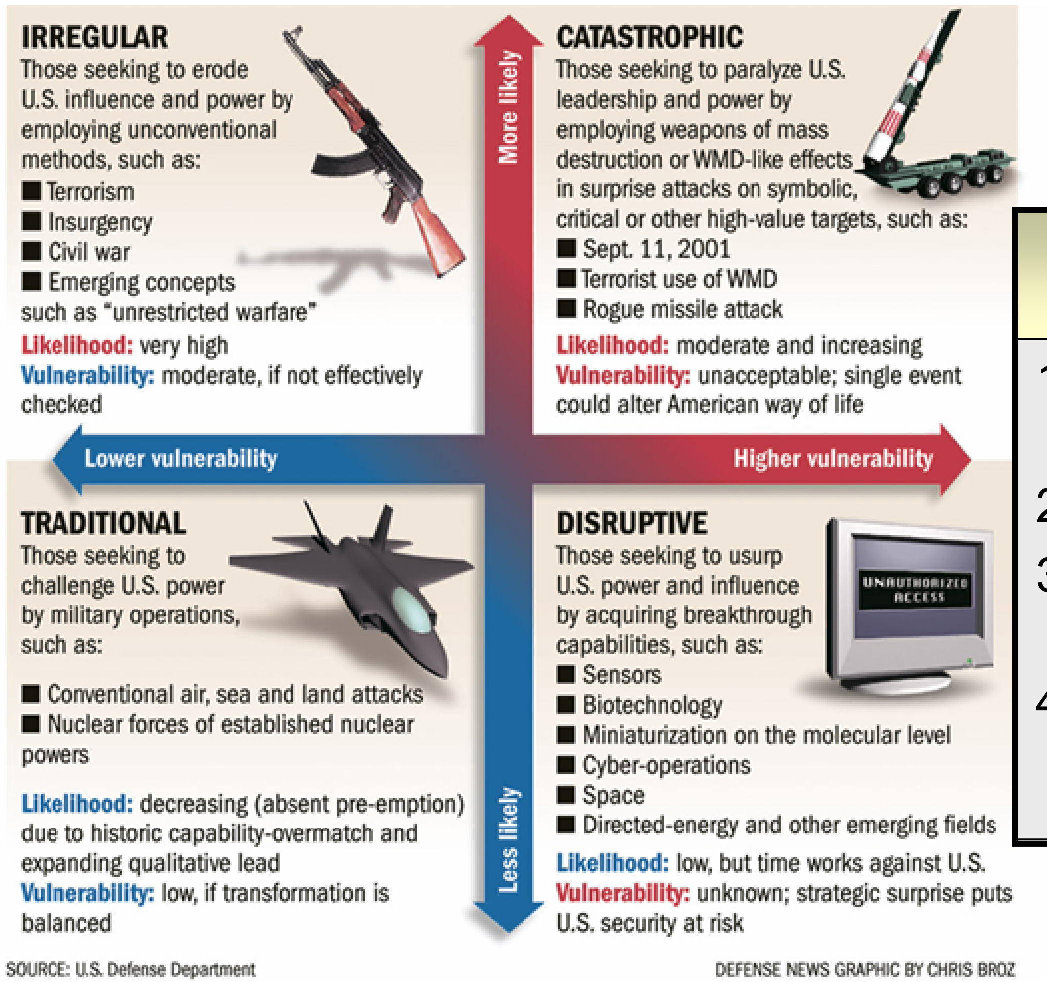
Where is the DoD S&T money going?

- **Funding**
  - Current year S&T dollars: $10.77B FY08 to $11.48B FY09
  - Percent of DoD funding: 2.24% FY08 to 2.22% FY09
  - Over 50% of total investment in 4 functional areas:
    - Information Systems (1.8B)
    - Sensors, Electronics / EW (1.7B)
    - Basic Research (1.7B)
    - Weapons (1.1B)



DoD S&T program is focused on "sensing and shooting" But is changing……………………………..

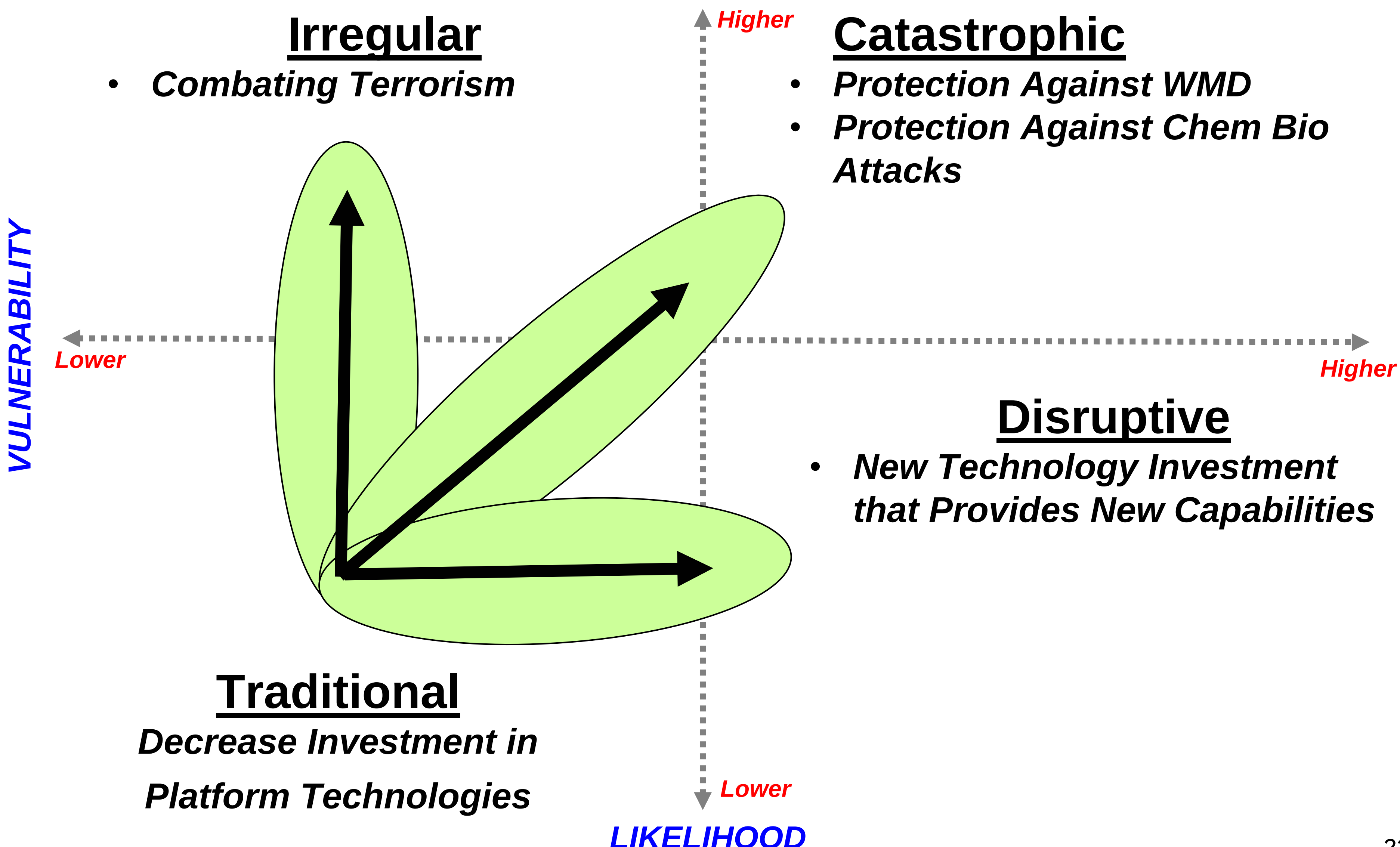
2006 QDR Challenge Construct



Four Hard Problems

1. Build partnerships to defeat terrorist extremism
2. Defend the homeland in-depth
3. Prevent acquisition or use of WMD by hostile actors.
4. Shape choices of countries at strategic crossroads

National Defense Strategy Drives Investment Strategy



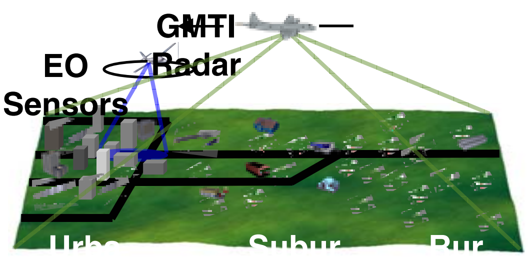
Science and Technology Enabling Technology Priorities

- **Technology focus areas:**
  - **Biometrics and Biological exploitation**
  - **Information technology and applications**
  - **Persistent Surveillance Technology**
  - **Networks and Communication**
  - **Human, Social, Cultural, and Behavioral Modeling**
  - **Language**
  - **Cognitive Enhancement**
  - **Directed Energy**
  - **Autonomous systems**
  - **Hyperspectral sensors**
  - **Nanotechnology**
  - **Advanced Materials**
  - **Energy and Power**
  - **Affordability**
  - **Combating Weapons of Mass Destruction Technologies**
  - **Energetic Materials**

In Blue—Areas with Substantial Increases in FY08/09 President's Budget Request

Increased S&T Requests Addresses Capability Gaps

- Special ("non-kinetic"/enabling) technologies:
  - Clandestine Tagging, Tracking and Locating
  - Biometrics
  - Human, Cultural, Social Behavior Modeling
  - Networks
  - Persistent Surveillance



- Technologies to decrease energy consumption/increase alternatives
- Combat and tactical armor for protection against a range of threats
- Accelerating transition to fielded systems

Investment shifted away from platform-specific technologies

Increased S&T Requests Addresses Capability Gaps

- New technology/emphasis areas
  - $270M increase to Basic Research
    - SecDef initiative to increase peer-reviewed basic research
      - To develop innovative solutions
      - Enhance the science and engineering personnel base
    - Increase will support targeted focus areas for
      - Early to mid-career scientists and engineers with a team of students and post docs
      - Single Investigator awards with larger grants
    - Emphasis will be on emerging technology areas, e.g.,
      - Cyber protection and information assurance
      - Biosensors and biometrics
      - Human sciences (cultural, cognitive, behavioral, neural)
      - Software sciences and materials
      - Immersive sciences for training and mission rehearsal
      - Power and energy management
    - Anticipate about 500 focused research efforts

Increased S&T Requests Addresses Capability Gaps

- New technology/emphasis areas *(Cont'd)*
  - Increased protection for dismounted troops and ground forces
  - Research in plasma and meta-materials to address emerging threats
  - Cyber protection
  - Hypersonics/Prompt Global Strike (Blackswift) – New technology prototype **

Shocks from the Past Century

Categories of trends
- Conflict
- Demographics
- Economy
- Environment
- Governance
- Science & Technology
- *Note: Size of circle indicates impact*

❑ Strategic shocks can change how we think about security and the role of the military, e.g.:

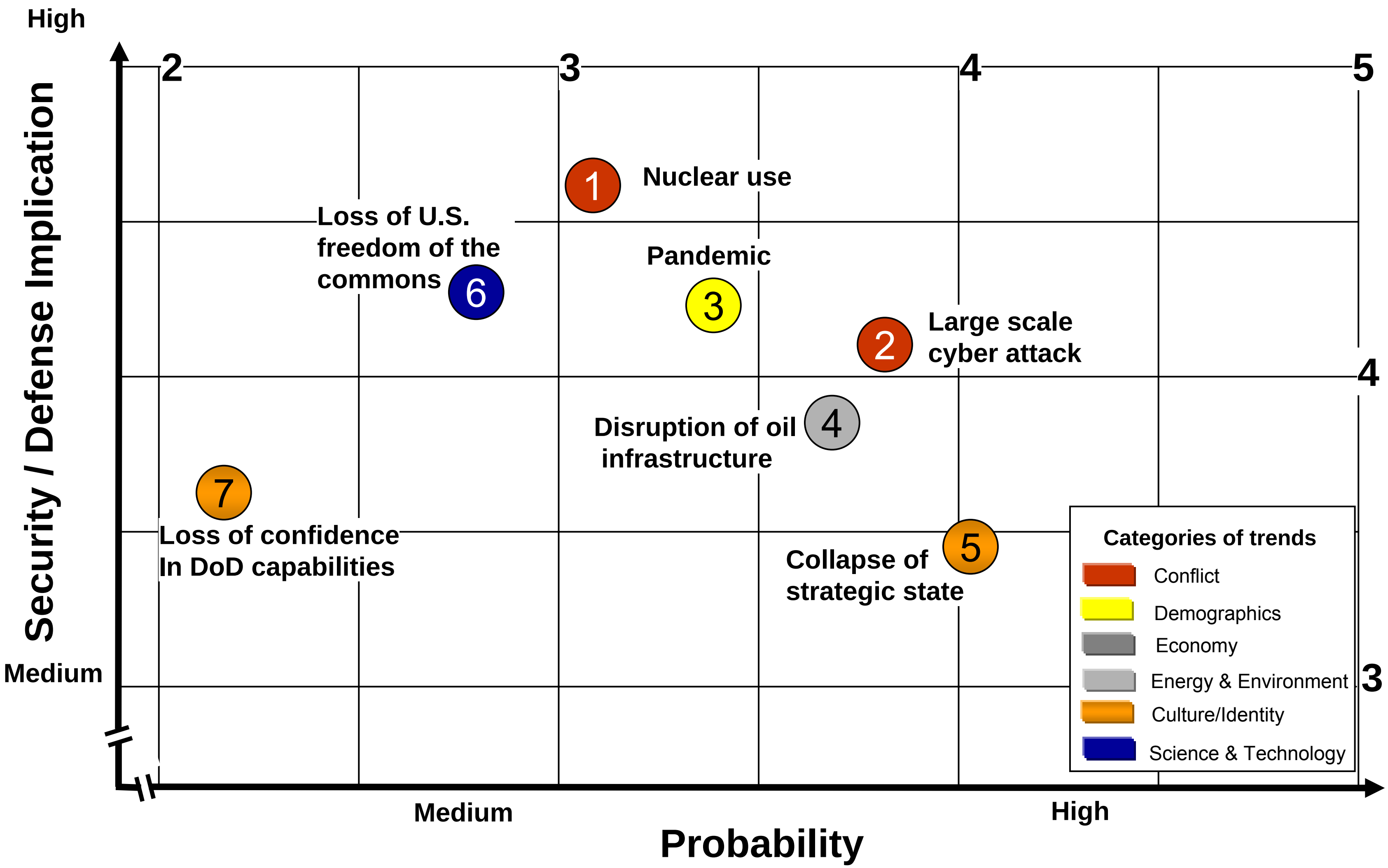
	1929	1941	1945-1955	1957	1989-1991	2001	2005
Shock	**Great Depression**	**Pearl Harbor**	**Atomic Revolution**	**Sputnik**	**Fall of the Soviet Union**	**9/11 Attacks**	**Katrina**
Implications for: Military	• Reduced role of military in society	• Led to two-front war; Made intelligence a core element of operations	• Nuclear warfare and capability become primary military mission	• Space as a military domain	• Led to the drawdown of the U.S. military – shifted focus to peace-keeping missions	• Made homeland defense and irregular warfare central military missions	• Increased military role in managing domestic catastrophes
Implications for: Security	• Reinforced isolationist tendencies in the U.S.	• Recognition of vulnerability – led to international engagement and industrialization for war on home front	• Emergence of MAD and escalation management	• Space leveraged for national power and prestige	• End of bipolar world	• Redefined security for the American public – CT emerges as USG focus	• American public looks to the federal, rather than local, government for disaster relief

Cold War (Atomic Revolution through Fall of the Soviet Union)

In retrospect, these shocks were the product of long-term trends

Analysis of Potential Shocks (2 of 2)

- **Relative impact and likelihood out to 15 years**



FROM OUSD (Policy) – Future Shocks Study

VISION: To develop technology to defeat any adversary on any battlefield

Any Battlefield includes physical, cyber, space, undersea, etc

QUESTIONS?

Young Memo

- **Technology focus areas:**
  - **Active and Conventional Armor Technology**
  - **Defeat Speed of Light Systems**
  - **Immersive Training**
  - **Cyber Protection**
  - **Handling Large Data Sets**
  - **Human, Social, Cultural, and Behavioral Modeling**
  - **Cognitive Enhancement**
  - **Autonomous systems**
  - **Hyperspectral sensors**
  - **Nanotechnology**
  - **Advanced Materials**
  - **Energy and Power**
  - **Biometrics**
  - **Network Technology**
  - **Combating Weapons of Mass Destruction Technologies**

In Blue—Areas with Substantial Increases in FY08/09 President's Budget Request

2006 RAND Study*: Top 16 Technology Applications

Need to understand the second-order effects of emergent technologies on the DoD

- ⇒ Cheap solar energy
- ⇒ Rural wireless communications
- ✓ Communication devices for ubiquitous information access anywhere, anytime
- • Genetically modified (GM) crops
- ⇒ Rapid bioassays
- ⇒ Filters and catalysts for water purification and decontamination
- ⇒ Targeted drug delivery
- • Green manufacturing
- ✓ Ubiquitous RFID tagging of commercial products and individuals
- ⇒ Hybrid vehicles
- ✓ Pervasive sensors
- ⇒ Tissue engineering
- ⇒ Improved diagnostic and surgical methods
- ⇒ Wearable computers
- ✓ Quantum cryptography
- • Cheap autonomous housing

✓ Direct Military Application

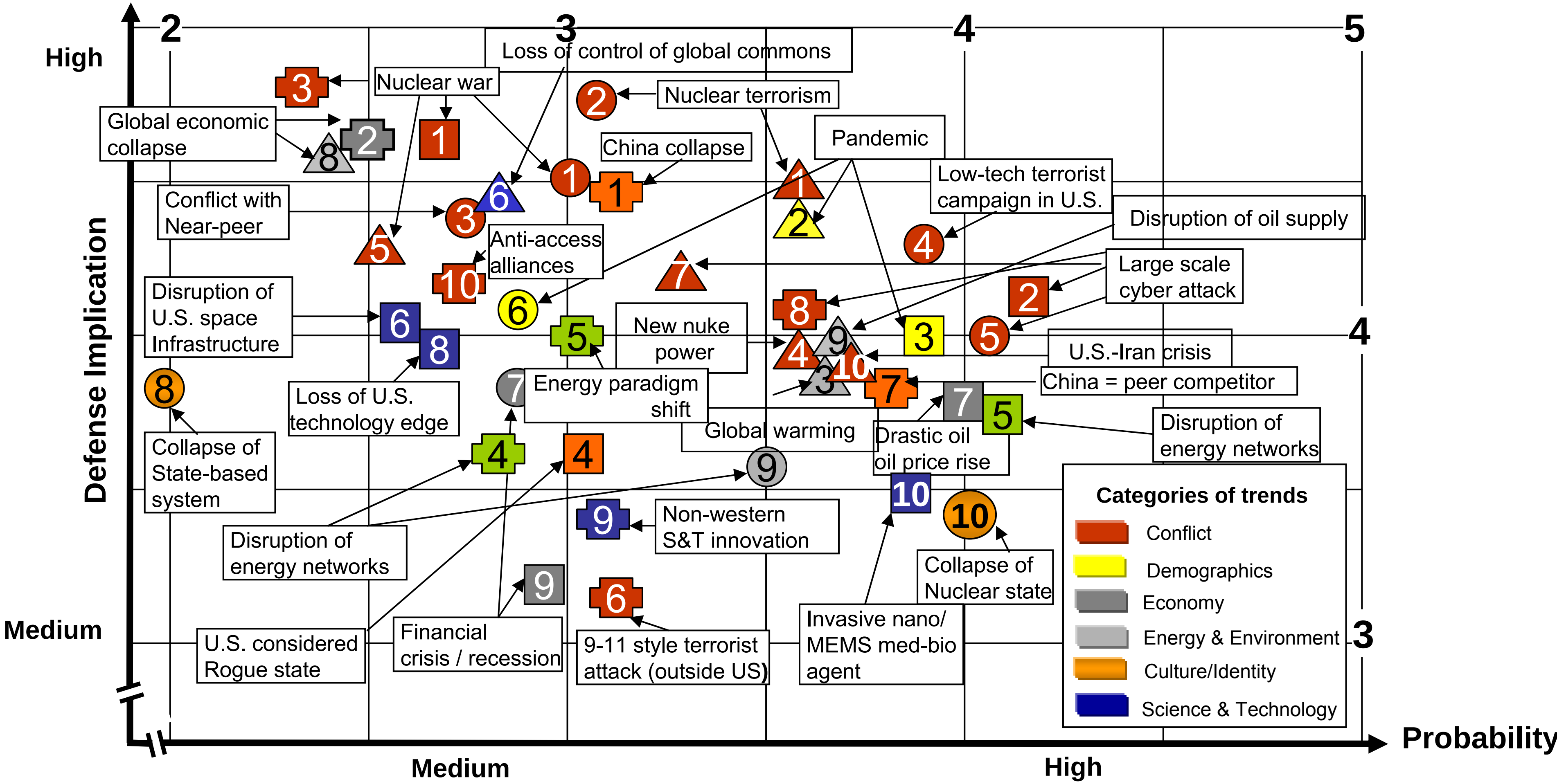
⇒ Indirect Military Application

• No Military Application

*** The Global Technology Revolution 2020, In-Depth Analyses***

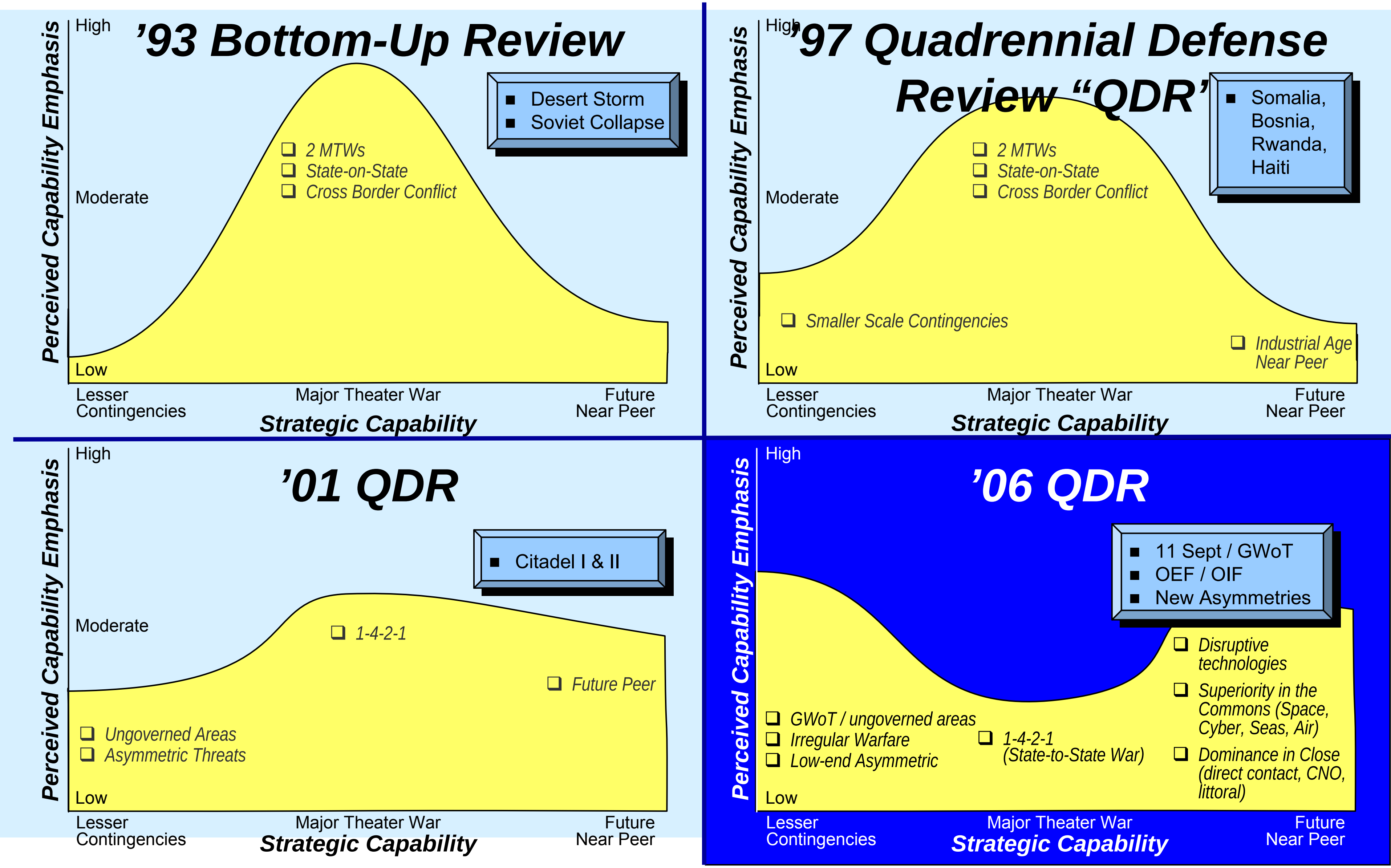
Analysis of Potential Shocks (1 of 2)

- **Relative impact and likelihood out to 15 years**



Source: Compare and contrast three symposiums: 08 June, 27 August, 25-26 September 2007 and 18-19 December 2007
Johns-Hopkins University APL Warfare Analysis Laboratory, Laurel MD and Booz Allen Hamilton Inc, Herndon VA

Decade of Strategic Evolution



Building the Science and Engineering Base

- We need to continually develop, mature and field technology to stay ahead of our adversaries
- President Bush acknowledged the importance of science and engineering development in his January 2008 State of the Union address

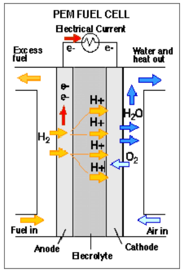
"To keep America competitive into the future, we must trust in the skill of our scientists and engineers and empower them to pursue the breakthroughs of tomorrow… I ask Congress to double federal support for critical basic research in the physical sciences and ensure America remains the most dynamic nation on Earth.."

President George W. Bush, State of the Union address, January 28, 2008

"As changes in this century's threat environment create strategic challenges – irregular warfare, weapons of mass destruction, disruptive technologies – this request places greater emphasis on basic research, which in recent years has not kept pace with other parts of the budget."

Secretary of Defense Posture Statement on the FY09 Budget, February 2008

Energy Security Challenge



Supply

- **Conventional fossil fuels**
- **Synthetic fossil fuels** (e.g. coal, shale oil and tar sands derived fuels)
- **Alternative fuels** (e.g. biodiesel, alchohols, hydrogen, etc.)
- **Renewables** (e.g. solar, geothermal, wind)
- **Novel supply** (e.g. fuel cells)
- **Exotics** (e.g. isomers)

$$CH_4 + \tfrac{1}{2}O_2 \rightarrow 2H_2 + CO$$
$$(2n+1)H_2 + nCO \rightarrow C_nH_{2n+2} + nH_2O$$

Demand

- **Conservation Initiatives**
- **Fixed base**
- **Tactical base**
- **Platforms**
- **Efficiency**
- **Life-Cycle Cost**

$

Assured Distribution

- **Direct oil / fossil fuel costs**
- **Policy, processes and risk assessment**
- **Refining Capacity**
- **Doctrine**

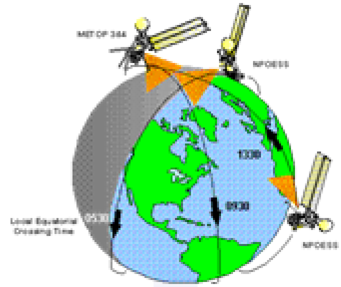
Convergence for Energy Security

DoD S&T is a Partnership

Link to the Warfighter

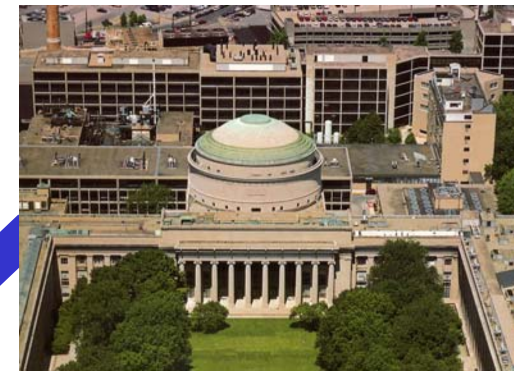
Service Labs

Expanded Resource Base



Interagency

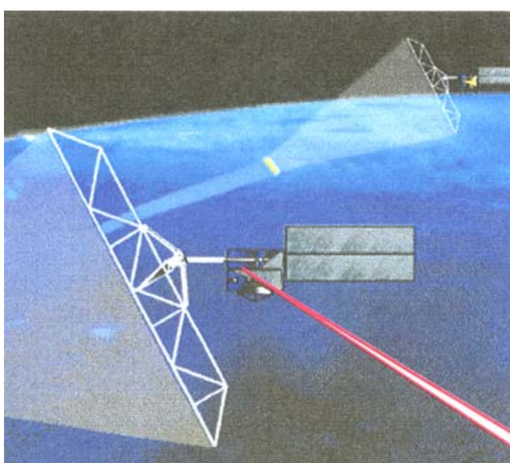
New Ideas, Knowledge



Universities

Maximum National Security Payoff

DARPA



High Risk, High Payoff

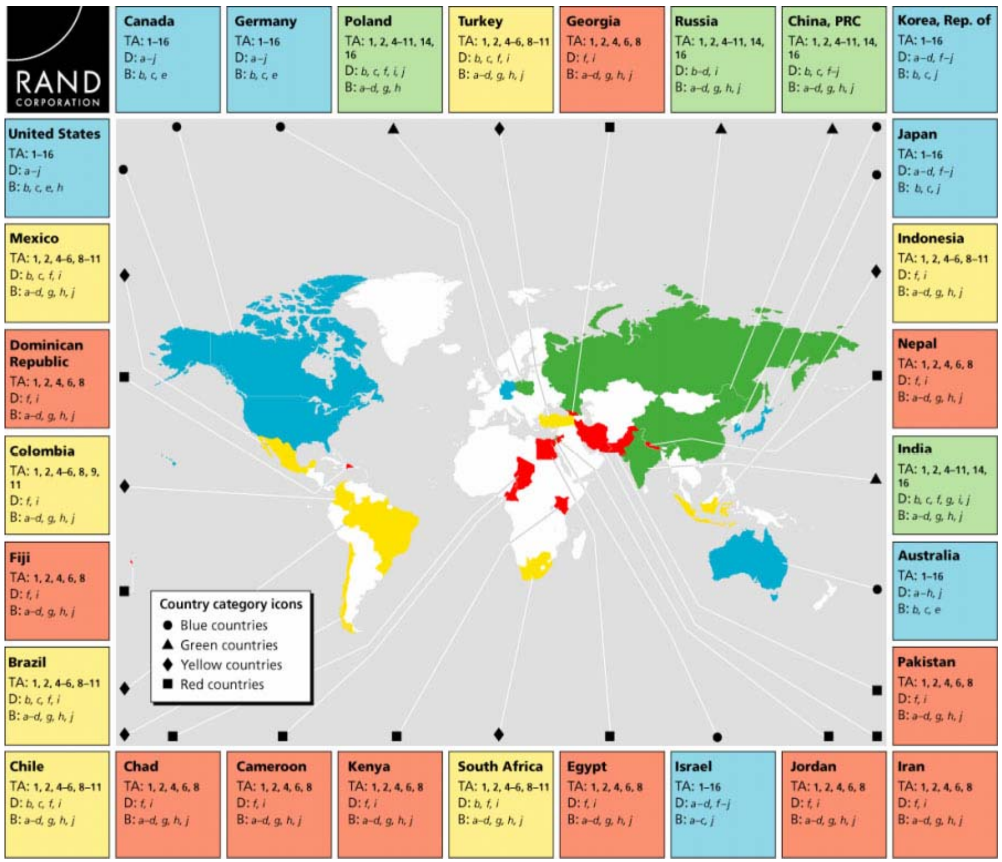
International

Coalition Capability

Industries

Innovation, Transition

Selected Countries Capacity to *Acquire* the Top 16 Technology Applications*



Scientifically advanced

Scientifically proficient

Scientifically developing

Scientifically lagging

**** The Global Technology Revolution 2020, In-Depth Analyses***

- ***Held at Irvine Ca, Nov 2006***

- ***The Most Probable Future Technology Shocks areas are:***

Biotechnology

Nanotechnology

Information Technology

Potential Military Applications:

- High Energy Fuels	**- Advanced Materials**	**- Assisted Decision Making**
- Bio-based Computers	**- Energy Storage / Distribution**	**- Aided Target Recognition**

Science and Technology and the Joint Warfighter

MG William J. Troy

Vice Director
Force Structure, Resources, and Assessment
Joint Staff, J8

Joint Staff Roles in S&T

- The "Voice of the Warfighter"
  - Consolidate needs of the COCOMs (via Integrated Priority Lists – IPLs) into JROC validated Capability Gaps
  - JUONs
  - JCTD validation

BOTTOM LINE:

Ensure the Joint Warfighter has the required capabilities to execute the assigned mission in a resource constrained environment…

JCIDS Update

- Senior Warfighters' Forums (SWarFs)
- Focus on Cross-cutting Issues
- JCA Rebaseline
  - Nine Tier 1 JCAs
    - Approved by DAWG to Tier 3
  - Two new FCBs:
    - Building Partnerships
    - Corporate Management
- Gap Prioritization
  - New Integrated Priority Lists (IPLs) from COCOMs recently submitted, gap analysis/formulation/ prioritization in progress
- FY08 NDAA Provisions

Warfighter-Influenced Direction for DoD S&T…

- What has 5 years of war told us to help shape the direction of DoD S&T?
  - ISR
    - Readily available and tailorable coverage
  - Robotics
    - Same/improved capabilities, keeping Soldiers and Marines out of harm’s way
  - Force Protection
    - Armor Protection vs. Armor Defeat – where does it end?
  - Managing violence in a dense battlespace
    - Interoperability, C2, Precision Fire

Interoperability and Interdependence on Demand in a Fluid Situation

- Ground Forces
  - Army Tanks and Infantry
  - Marine LAV and AAV
- Rotary Wing Forces
  - Army and Marine Helicopters
- Fixed Wing Forces
  - Navy and Air Force Fighters
- Special Operation Forces
- Coalition Forces
- Fully integrated and task organized

Joint and Coalition combined forces, executing together with Unity of Effort and Unity of Command in a space no larger than *Pentagon South Parking*

Success …

- Solutions to warfighter needs with an S&T solution

  – Predator (ACTD)

  – Counter Radio controlled improvised explosive device Electronic W
  (CREW) IED Electronic Jamming (JUONS)

  – Joint Precision AirDrop System (JPADS) (ACTD)

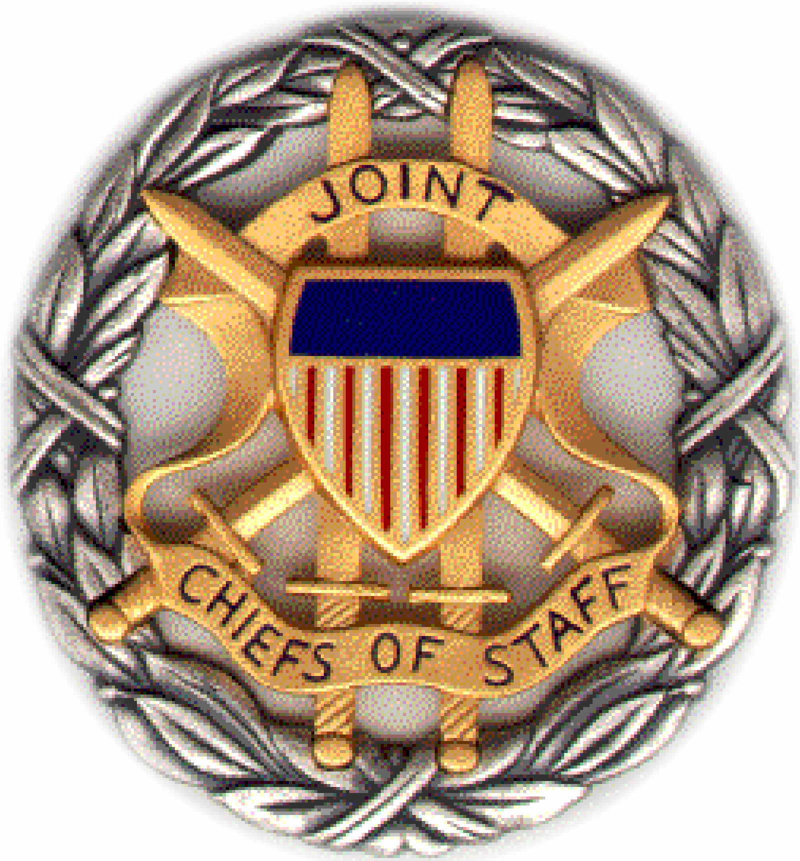
…and the Future

- Currently SEVEN “Technologically Challenged” JUONS - the “hottest” issues from the warfighter on the front lines
  - Six are related to counter IED
  - One is related to renewable energy

- Currently handled by the JRAC through JIEDDO, appropriate FCB, OSD (AS&C), DSTAG currently not involved

- For discussion: Should the DSTAG become involved with these?
  - Meets monthly - can react quickly
  - Represents DoD-wide S&T agencies, providing increased visibility
  - May be able to provide solutions for these JUONS, stand up Ad-Hoc Technology Focus Team, leverage other R&D/R&E projects, etc.

QUESTIONS/COMMENTS



Defense Policy Implications of Global Technology Trends

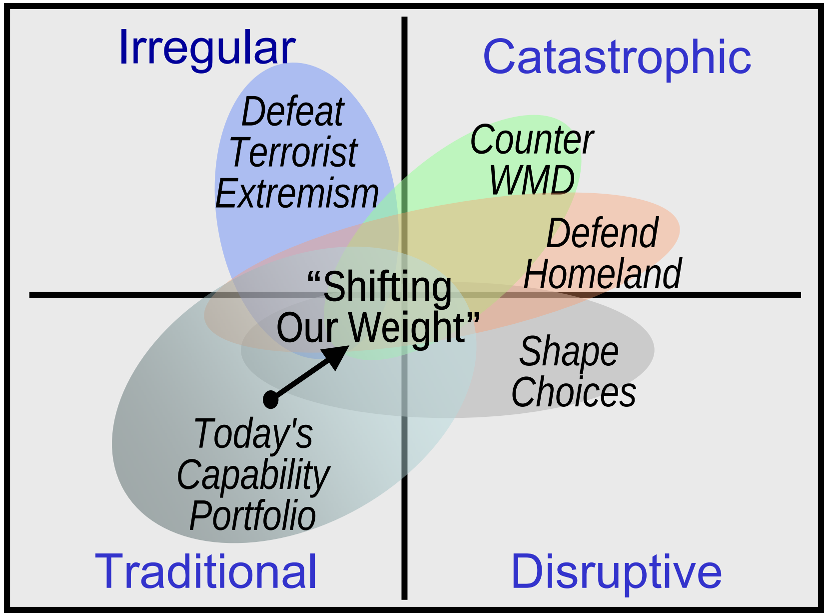
28 December 2007

Col W. Eric Herr

ODASD Policy Planning

The 2006 QDR Construct

- The 2006 QDR used the "Quad Chart" to analyze the changing nature of warfare



Four Hard Problems
1. Build partnerships to defeat terrorist extremism 2. Defend the homeland in-depth 3. Prevent acquisition or use of WMD by hostile actors. 4. Shape choices of countries at strategic crossroads

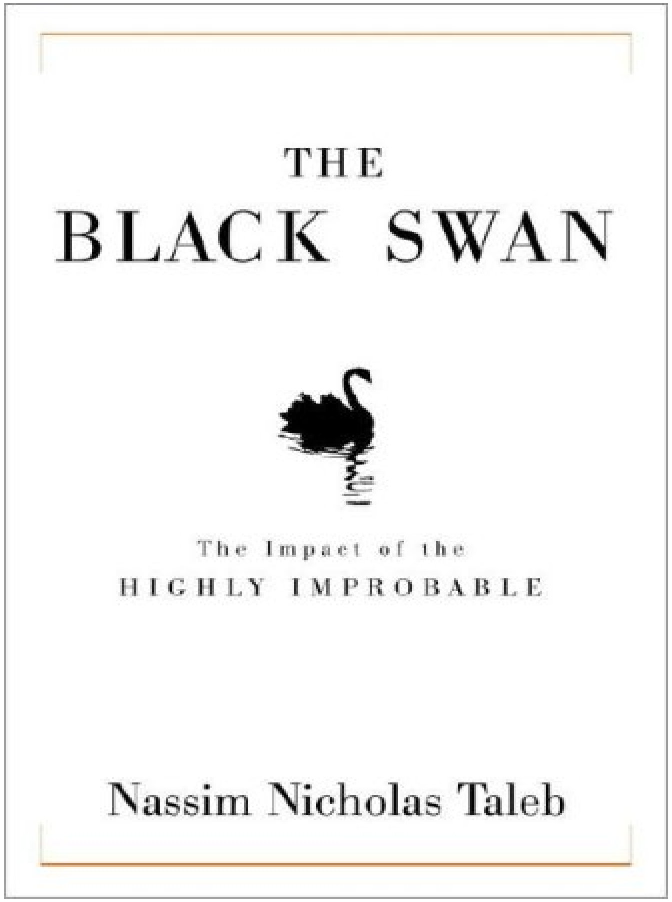
This construct is the basis for our current defense strategy

Understanding the 21st Century

- The "Quad Chart" was the strategic construct for the 2005 National Defense Strategy and 2006 Quadrennial Defense Review
- A new strategic construct might be more appropriate in preparation for the next set of strategic documents
- This model should account for the increasing complexity of the global environment
  - Many non-military factors disrupt international security – we need to better anticipate and respond to these disruptive events

"Black Swan Theory"

Cognitive biases create false expectations of predictability. Acknowledging uncertainty may allow us to adapt better to unforeseen events.



- "Black Swans": ***large-impact, impossible to predict, and rare event beyond the realm of normal expectations***
  - 9/11, Google, internet bubble
- "Outside context problem": ***Problem outside a given groups experience, with an immediate, ubiquitous and lasting impact upon it***
  - Perry's Black Ships arriving in Japan
- "Accelerating change": ***increase in rate of technological/ cultural/social progress in history (contrast to linear view)***
  - Accumulation of knowledge, access to knowledge and lowering of transactional barriers to knowledge

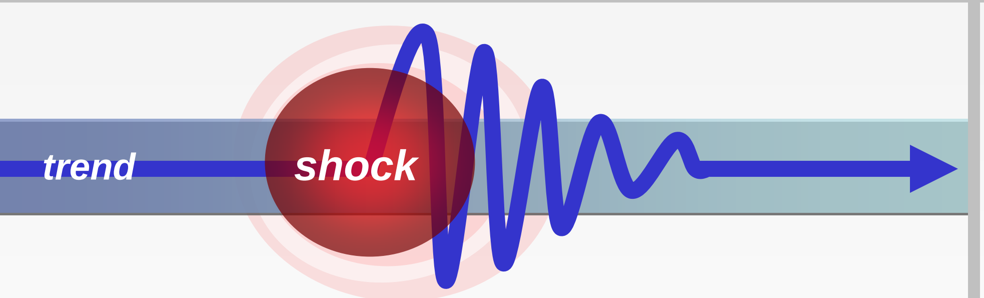
"But there are also "**unknown unknowns**" — the ones we don't know we don't know.**"** *Former Secretary of Defense Donald Rumsfeld, Feb 12, 2002.*

Purpose and Outline

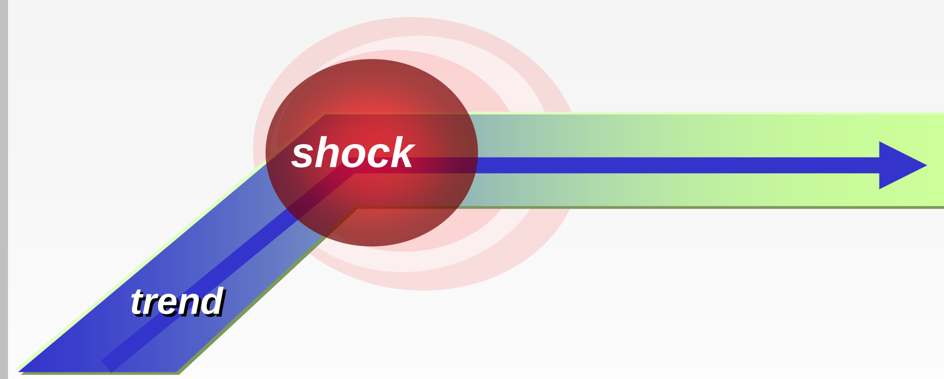
- Purpose
  - Examine U.S. defense and security implications of future technology trends and potential shocks
- Outline
  - Summarize five technology areas by outlining:
    - Current assessment
    - Future trends
    - Defense implications
    - Potential shocks
  - Technology Meta-Trends
  - Way Ahead

Understanding Strategic Shocks

- What is a "strategic shock"?
  - An event that punctuates the evolution of a trend (a discontinuity that either rapidly accelerates its pace or significantly changes its trajectory) and, in so doing, undermines the assumptions on which our current assumptions are based.



9/11, Pearl Harbor



Resurgence of violent Islamic Extremism Fall of Soviet Union

- ❑ Some "strategic shocks" may not surprise us we actively plan for them, both to reduce the risk of their occurrence and to be positioned to act
- ❑ Other "strategic shocks" may catch us unaware and unprepared

The Genesis of Trends and Shocks

- With hindsight, it is clear that most shocks are the product of long-term trends

- Furthermore, shocks are less disruptive when we have anticipated and responded to the underlying trends

- The challenge is identifying key trends and pre-adaptation for strategic shocks before they occur
  – Reviewing how effective the United States was in foreseeing major trends in the previous century illustrates this effect

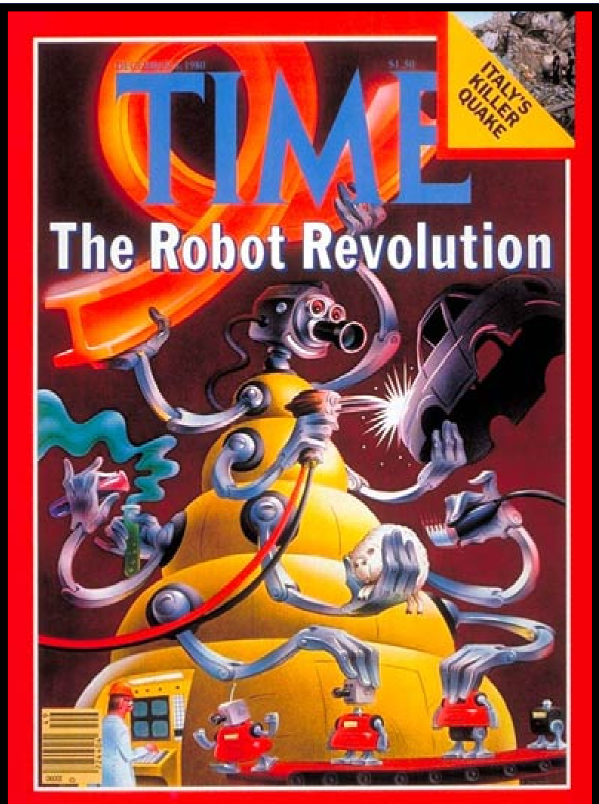
Reviewing Major Trends

Globalization

Categories	*Trend Examples*
Conflict	• **Increasing lethality and scope of irregular challenges** • **Military operations in new domains** • ***Rise of China*** — ***Rise of a Near-Peer Competitor*** • ***Cyber war*** — ***Cyber Warfare*** • ***Increasing nuclear proliferation*** — ***Highly Proliferated World***
Demographics	• ***Youth bulge—87% of 10-19 year-olds live in dev. states*** — ***Geopolitical Demographics*** • ***Global aging: The ranks of those over age 60 are growing about 2% each year – 60% faster than the overall population. Primarily affects: Europe, Japan*** • **Urbanization — by 2025, nearly 60% of global population will live in cities**
Economy	• **Growing gap between rich and poor countries** • **Increasing regional and global integration of economies** • **Increasing Asian influence in international markets**
Environment	• ***Disruptions to resource distribution (e.g., water, energy)*** — ***Winners and Losers*** • ***Climate change leading to rise in sea level, changing climatic zones, weather patterns***
Governance	• **State remains dominant unit in international system** • **Strong, but challenged, US leadership in international arenas (e.g., global commons)** • **Increasing influence of the individual, private sector, NGOs on international system** • ***Increasing salience of trans/sub-national identities*** — ***Anthropological Lens on Conflict*** • ***Strong national and sub-national bonds sustained and reinforced through web and remittances*** • **Increasing tension between the "individuals rights" versus "groups rights"**
Science & Technology	• *Technology: Information, Nanotechnology, Bio, Energy, Robotics* — ***Five Revolutions*** • **Increased proliferation of technologies and knowledge**

Technology surprise?

Promises raise expectations – delivery tends to lag



8 December 1980

21 August 1995

- Late delivery desensitizes decision makers to need for change
- True bolts from the blue are possible, but unlikely
- Intersecting revolutions hypothesis

Purpose and Outline

- Purpose
  - Examine U.S. defense and se
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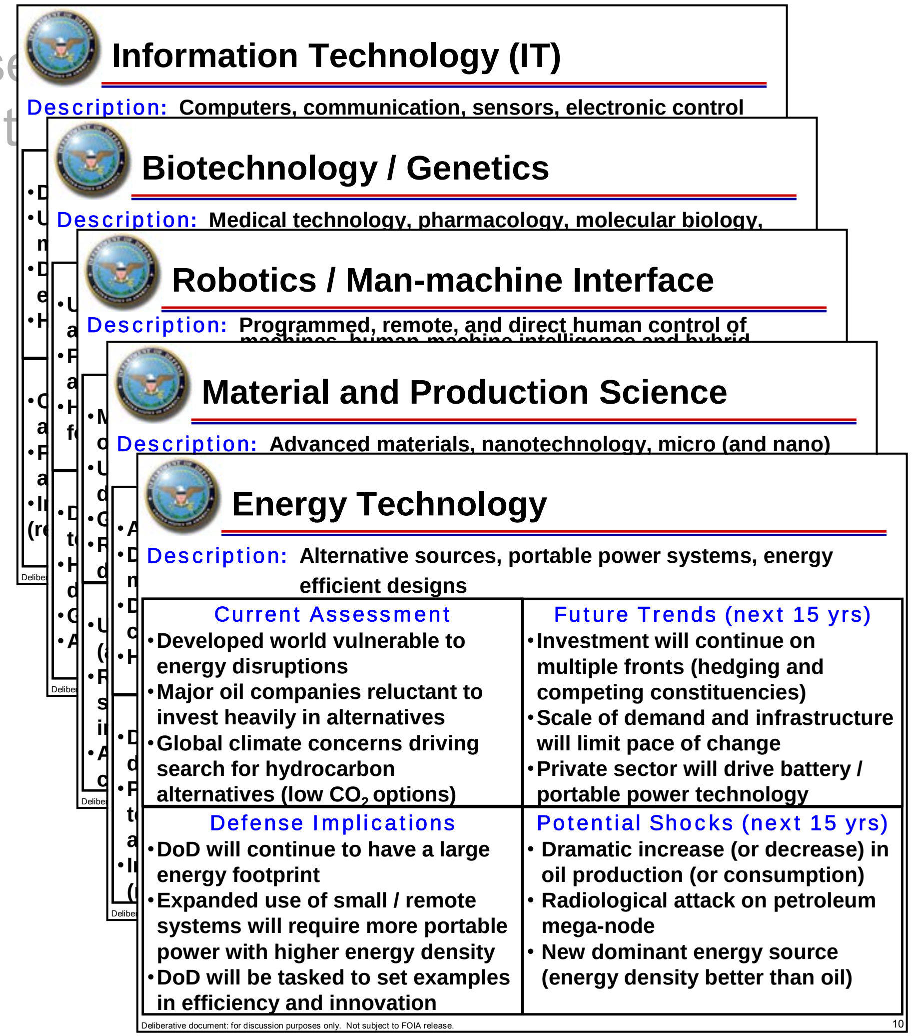

Information Technology (IT)

Description: Computers, communication, sensors, electronic control

Biotechnology / Genetics

Description: Medical technology, pharmacology, molecular biology,

Robotics / Man-machine Interface

Description: Programmed, remote, and direct human control of

Material and Production Science

Description: Advanced materials, nanotechnology, micro (and nano)

Energy Technology

Description: Alternative sources, portable power systems, energy efficient designs

Current Assessment	Future Trends (next 15 yrs)
•Developed world vulnerable to energy disruptions •Major oil companies reluctant to invest heavily in alternatives •Global climate concerns driving search for hydrocarbon alternatives (low CO_2 options)	•Investment will continue on multiple fronts (hedging and competing constituencies) •Scale of demand and infrastructure will limit pace of change •Private sector will drive battery / portable power technology
Defense Implications	**Potential Shocks (next 15 yrs)**
•DoD will continue to have a large energy footprint •Expanded use of small / remote systems will require more portable power with higher energy density •DoD will be tasked to set examples in efficiency and innovation	• Dramatic increase (or decrease) in oil production (or consumption) • Radiological attack on petroleum mega-node • New dominant energy source (energy density better than oil)

Deliberative document: for discussion purposes only. Not subject to FOIA release. 10

Information Technology (IT)

Description: Computers, comm, sensors, networks, electronic control systems, information storage, manipulation, and display

Current Assessment	Future Trends (next 15 yrs)
• DoD leads in Military C4ISR • U.S. private sector leads global IT markets (rising competitors) • DoD is a market follower in enterprise systems • High investment (and cost) area	• Moore's law continues / Bandwidth increases (fiber and wireless) • IT will accelerate change other areas (Bio/Materials) • Decreasing quality / disposability (in hardware and software)
DoD Implications	**Potential Shocks (next 15 yrs)**
• Continued increasing influence in all mission areas • Free movement of knowledge (blue and red) • Increasing exploitation potential (red and blue)	• Large-scale SCADA (system control & data acquisition) attack • Accessible quantum encryption • Quantum computing becomes widely available

Biotechnology / Genetics

Description: Medical technology, pharmacology, molecular biology, biochemistry, bioinformantics, and genetic engineering

Current Assessment	Future Trends (next 15 yrs)
• **U.S. private sectors leads in (most areas)** • **Free cross-border collaboration and movement of knowledge** • **High dual-use potential, light footprint, difficult to assess intent**	• **Dramatic cost reductions in gene sequencing equipment** • **Expanding / accessible databases** • **Social and cultural norms will limits some advances (in U.S.)** • **Increasing demands from aging (and wealthy) populations**
DoD Implications	**Potential Shocks (next 15 yrs)**
• **DoD has traditionally focused technology on machines (not men)** • **Human performance has a dramatic effect on all operations** • **Greatest asymmetric danger** • **Ambiguous U.S.G. authorities**	• **Development of performance degradation technology** • **Attack with engineered pathogens** • **2-10X Human Performance Enhancement: sleep, endurance, strength, cognitive ability** • **Massive failure in food supply**

Robotics / Man-machine Interface

Description: Programmed, remote, and direct human control of machines, human-machine intelligence and hybrid systems

Current Assessment	Future Trends (next 15 yrs)
• **Man (or man-machine) interface often limits system performance** • **U.S. leads the world in unmanned defense systems** • **Growing investment (cost) area** • **Rising powers will apply low cost, dual-use technology**	• **Increased focus on neural function, perception, and cognition** • **Expansion of autonomous systems and virtual presence** • **Rapidly emerging threats** • **New vulnerability sets (links, data, control)**
DoD Implications	**Potential Shocks (next 15 yrs)**
• **Unmanned systems have proven (and increasing) value** • **Remotely-manned and hybrid systems can be used in increasingly complex missions** • **Amputation / neurological casualties from IEDs**	• **Fused human-machine intelligence** • **Low cost, swarming systems or autonomous precision attack systems**

Material and Production Science

Description: Advanced materials, nanotechnology, micro (and nano) electromechanical devices, prototyping, production

Current Assessment	Future Trends (next 15 yrs)
• Area of U.S. competitive advantage • DoD is the global leader in existing mission areas (air-sea-land-space) • DoD will follow in expanding commercial markets • High dual-use potential	• Rapidly expanding nano and MEMS (commoditization) • Increasing focus on MEMS/NEMS • Continued convergence of IT, robotics, and bio technology • Increased emphasis on reducing development to market timelines
DoD Implications	**Potential Shocks (next 15 yrs)**
• Dual-use makes this technology difficult to control • Proliferation will reduce DoD's technical edge and expand asymmetric attack options • Increased reliability / reduced cost (must pair with agile acquisition)	• Proliferation of highly energetic materials • Invasive nano particles/NEMS used as medical or biological agents; delousing • Sensor dust, ubiquitous sensing • Broad-band metamaterials

Energy Technology

Description: Alternative sources, portable power systems, energy efficient designs

Current Assessment	Future Trends (next 15 yrs)
• **Developed world vulnerable to energy disruptions** • **Major oil companies reluctant to invest heavily in alternatives** • **Global climate concerns driving search for hydrocarbon alternatives (low CO_2 options)**	• **Investment will continue on multiple fronts (hedging and competing constituencies)** • **Scale of demand and infrastructure will limit pace of change** • **DoD must will drive battery / portable power technology**
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An information age Pearl Harbor?

NO….but this guy is far cry from Imperial Japan

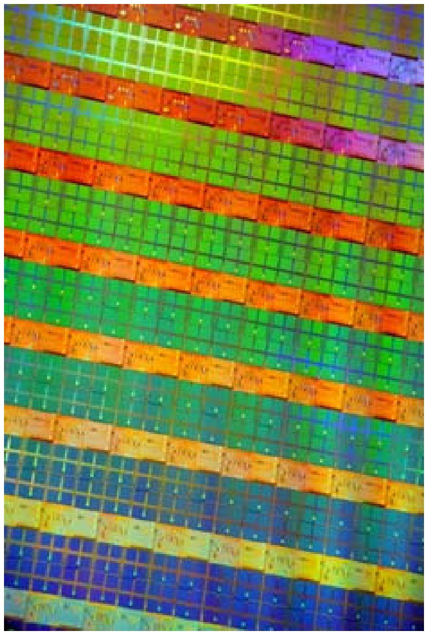
George Hotz, 17, of Glen Rock, New Jersey holding the iPhone® that he separated from the AT&T network and used on the T-Mobile Network. Career goal: hack the human brain

- **Apple and AT&T released the iPhone on 29 June**
- **An exclusive agreement guaranteed the iPhone could only be used on AT&T's mobile network**
- **Hotz spent approximately 500 hours working on his "summer project"**
- **The hack was announced on 24 August.**
  - **AT&T - market cap: $245B**
    - annual revenue: $90B
  - **Apple - market cap: $117B**
    - annual revenue: $23B
  - **Hotz - PRICELESS**

This is the new asymmetry—victory goes to the agile and innovative

Recent Developments

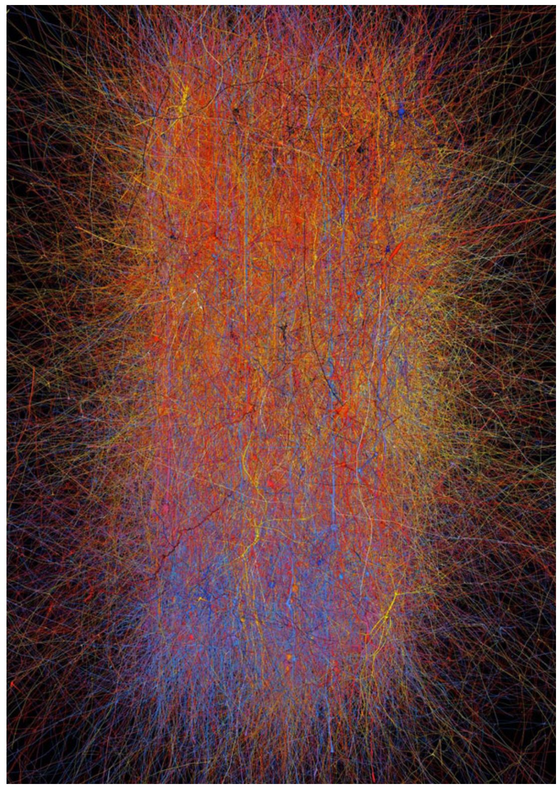
Hafnium oxide: 45nm transistors



A beam of light travels less than a tenth of an inch during the time it takes a 45nm transistor to switch on and off.

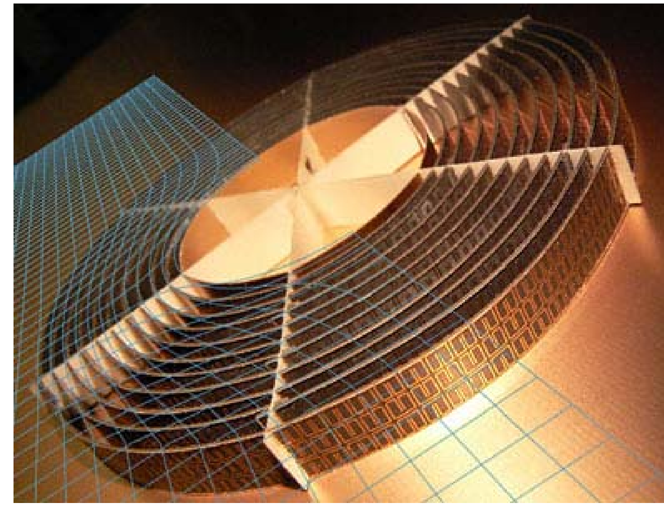
Surprise revival of Moore's law just before anticipated end of silicon chip progress

Supercomputer neuro-map: 10,000 neurons and 30 million connections

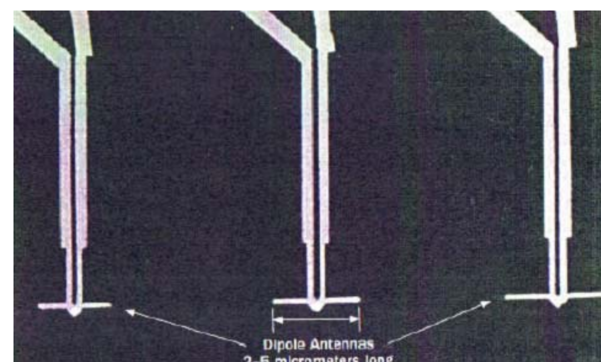


Scientists are now planning to model the entire human brain within just 10 years - "fantastic acceleration in brain research"

Metamaterials: 2D microwave "invisibility cloak"



From theory to tech demonstration in 5 months



Nano Antennas: receiving infrared RF signals

Could lead to sensors a million times more sensitive than current technology. First predicted in 1960s

Age of Scientific Innovation

- Paradigm-shifting scientific discoveries have historically occurred at a young age
  - Newton – 24; Darwin – 22; Einstein - 26
- Mid-career scientists are now considered to be most productive--if measured by lists of publications
  - May be due to longer training phases, accumulative advantage, focus on acceptance vs. discovery
- Scientific and technological discovery and innovation are not limited to academic publications and PhD’s.
  - Some of the most successful innovators of recent decades have been college drop-outs
    - Bill Gates, Steve Wozniak, Michael Dell
  - Some of the most threatening innovators have been under the age of twenty-five
    - Global Bot “Mastermind” – 18 year old alleged by FBI to lead effort of infecting and controlling over a million computers world-wide
    - Godfather of Cyber Terrorism – recently arrested 22 year old Al Qaeda internet operative
    - World’s Most Famous Hacker – Kevin Mitnick, who broke into DEC computers to steal their operating system development software at 16

Technology Meta-Trends (1)

❑ Technological change is accelerating

- Accelerating application of knowledge and technology
  - ➢ Past – Change limited by state-based science, technology, capital
  - ➢ Future – Change limited by interest, policy, and law
- Increasing rate of "paradigm shifts"
- Invention/innovation speeds up invention/innovation (feedback loop)

❑ U.S.'s technological advantage eroding

- Free-flowing factors of production: S&T, labor, capital
- Nation state risk aversion: bureaucratic, conservative governance
- U.S. economy may fall to world's 3rd largest in latter half of century
- Increasing number of 6-Σ individuals migrating into productive sector in China/India

❑ Discovery may rely more on global collaboration than years of graduate study

- Innovation as a "young man's game" (Planck) vs. the realm of experienced, qualified experts

Technology Meta-Trends (2)

- "Silicon" computing power on path to exceed "carbon" computing power
  - Implications of machines surpassing computing power of human brain
- Super-empowerment and new global actors
  - Technology investment geared to empower the individual - personal transportation, communications, finance, entertainment, health care
  - Proliferation of "new" technologies in the hands of agile adversaries
    - Nation-state's destructive power available to single decision-makers
    - Growing access to converging technologies (speed, cost, scope)
- Unforeseeable technology innovation – the third step
  - How will technology used in ways we cannot predict?
  - How will technology change the way we think and organize?
- Perception U.S. less open to foreign students and scholars
  - Enrollment declined in 2003-07 for first time since 1971; however, 2006-07 school year saw increase
  - Post-9/11 restrictions make European institutions seem more attractive

Recommendations – People

- Make government lab resources more widely available to University researchers and develop programs to continue those relationships
  - Expand Summer Faculty Research Program and Sabbatical Leave Program (ASEE); Post-doctoral fellowship (ASEE); Defense Science and Engineering Graduate Fellowships
- Develop and expand existing innovative hiring, employment, and contracting authorities
  - Intergovernmental Personnel Act, Highly Qualified Experts, industry fellowships, SMART program, NSEP
  - Develop attractive rotational career paths and collaborative opportunities
- Partner with research and development competitions
  - Odyssey of the Mind, Exploravision, Science Olympiad, FIRST, Idea to Project

Recommendations – Horizon Scanning

- Enhance organizations with staff and methodology to alert senior leaders to disruptive trends, shocks, and potential mitigation
  - Build technology intelligence program that includes technology scanning and collaboration with partners, private sector – X2 as a model
  - Link tech intelligence to technology red teaming and blue teaming process (DDR&E)
    - Technology war-gaming / Identify indicators and red lines
  - Integrate operational perspectives by recruiting and strategically placing/detailing "technology scouts"
    - Services and Defense Agencies
    - Intern, externs, fellows, and gray beards
  - Develop protocols to raise major issues to senior leadership
  - Share information and increase visibility across government

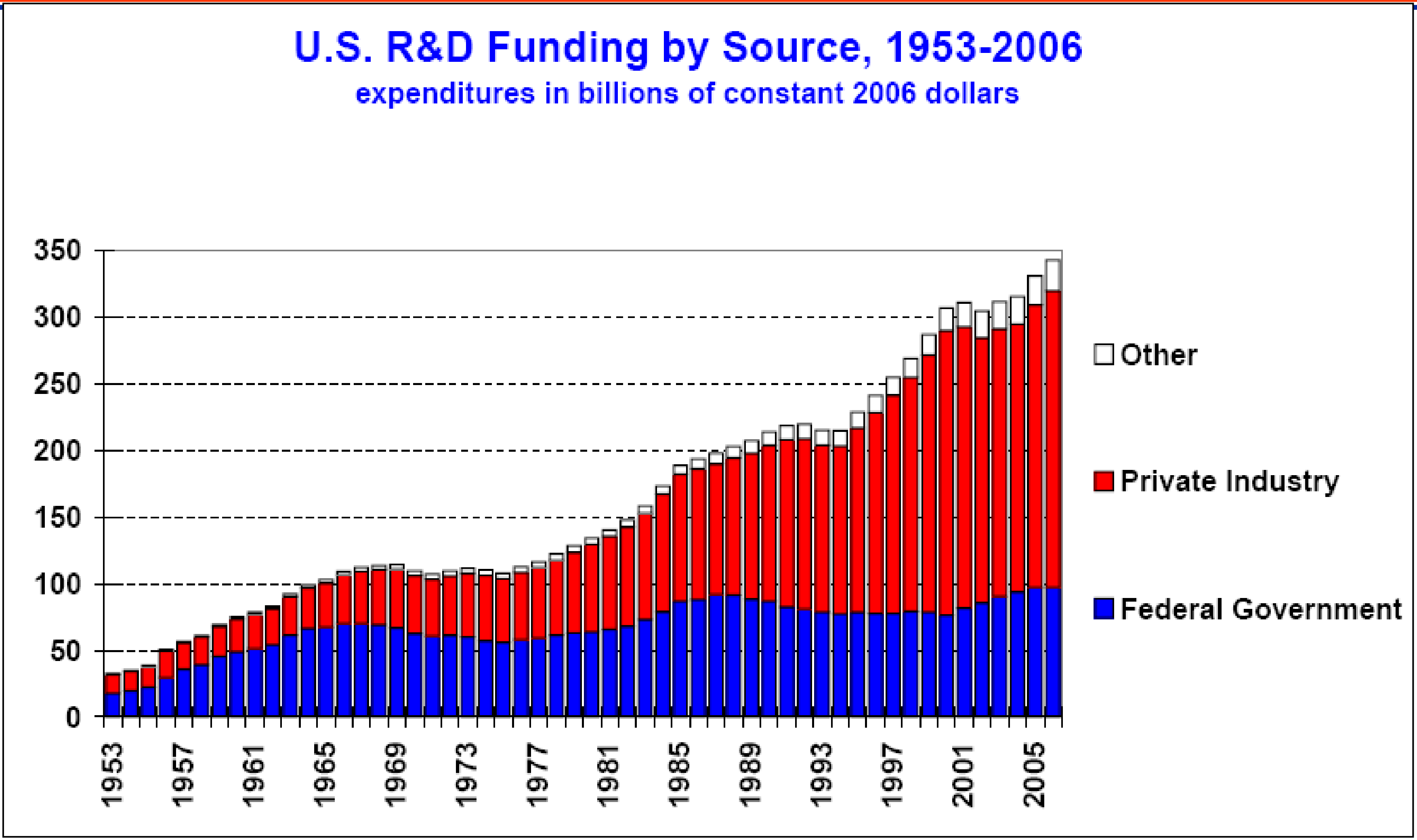
Recommendations – Leveraged Innovation

- Sponsor technology research and "challenges" that focus on interdisciplinary research and applications
- Examples: DARPA challenges, MURIs, tech venture funds that
  - Open doors for groups pursuing innovative research that would not/could not pursue access to DoD market
  - Award winners, dramatic innovators – continue relationship high potential teams
  - Provide seed money to promising teams (tech CERP) for ideas
- Example focus areas:
  - Energy: portable power; domestically sources compatible with legacy equipment and infrastructure; carbon neutral / carbon sequestration
  - TTL: "Naked man" problem; tag at a distance; stand-off detection of fissile material

Questions?

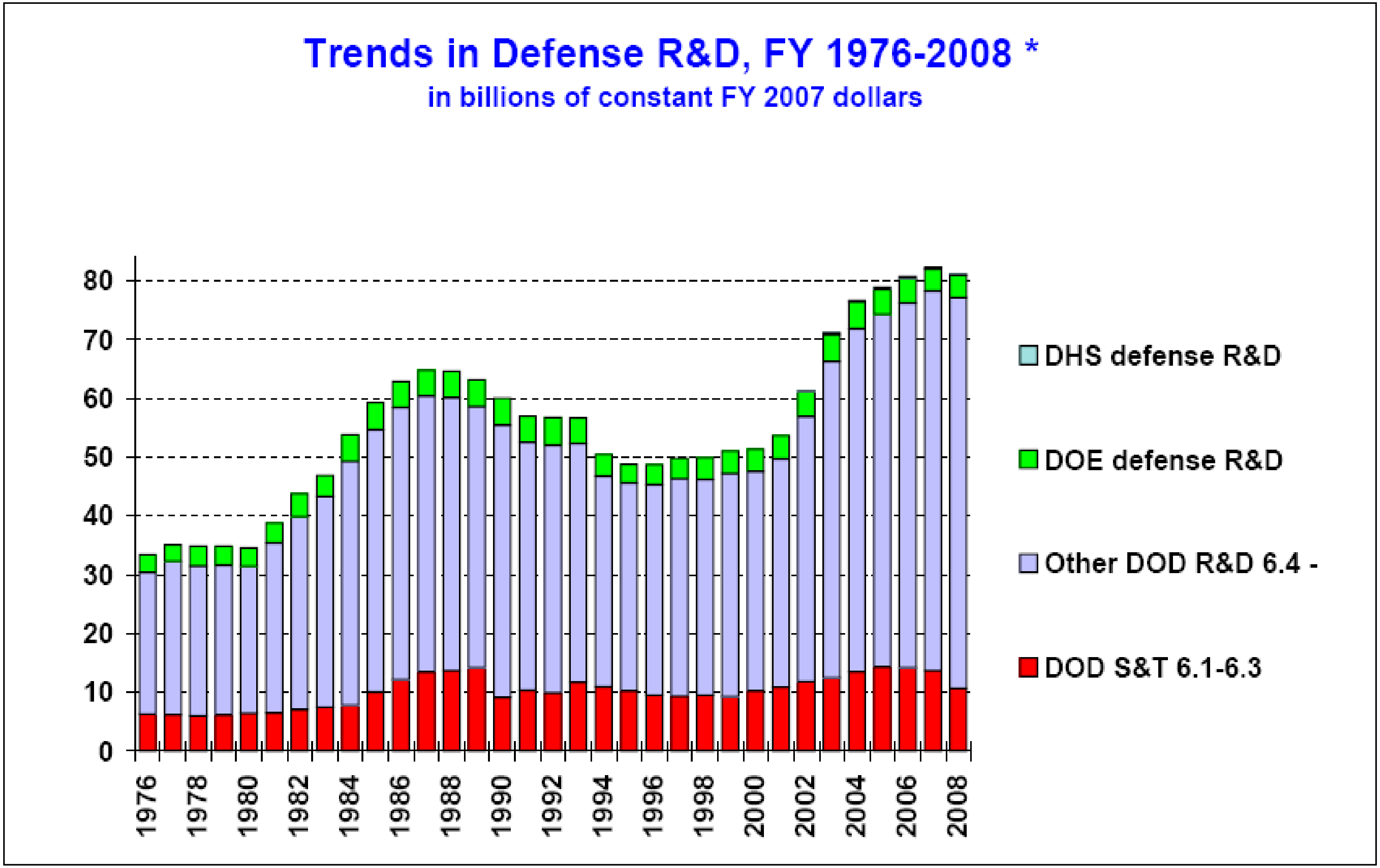
BACKUPS

Decreasing Weight of USG Investment



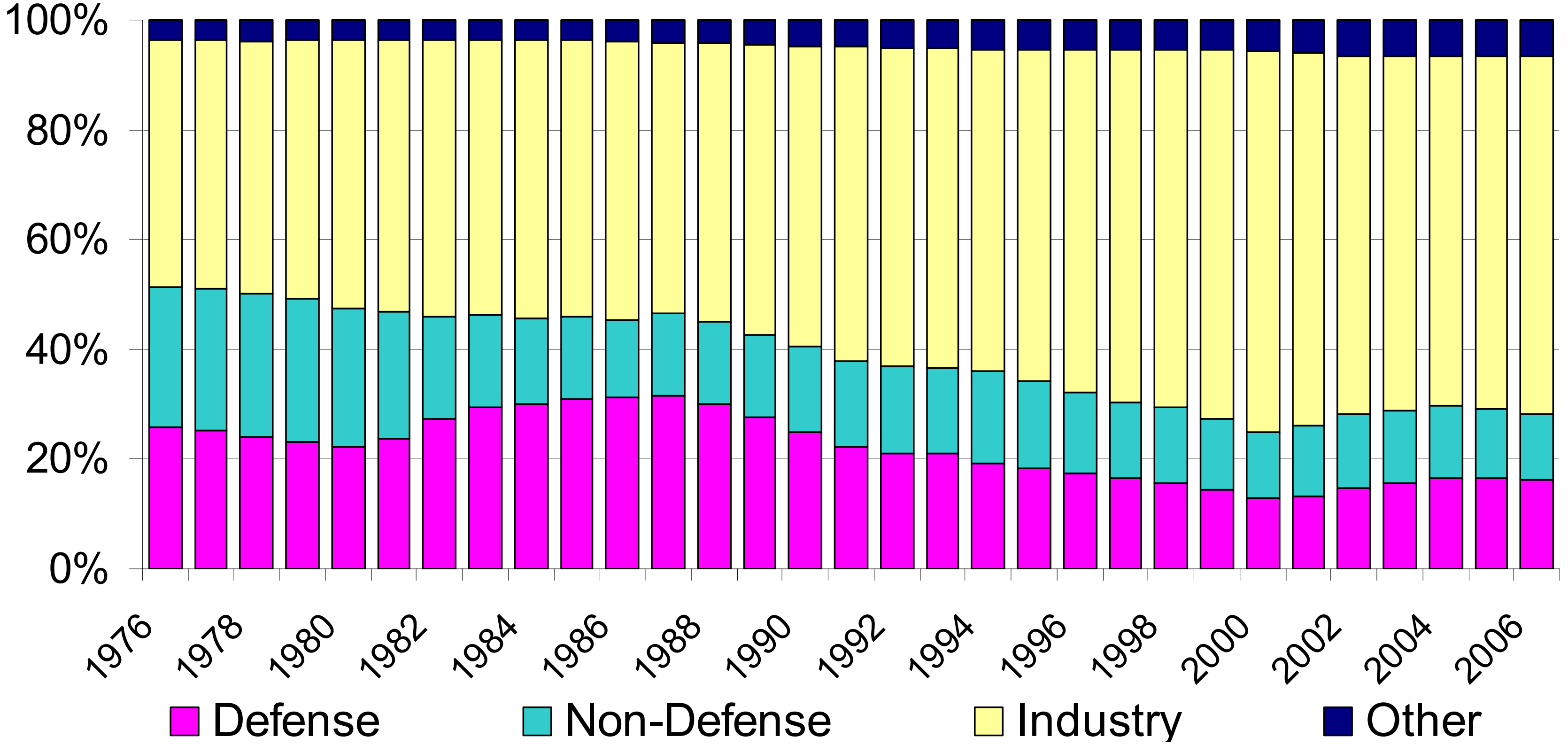
Source: NSF, Division of Science Resources Statistics. (Data for 2005 and 2006 are preliminary.)
APRIL '07 © 2007 AAAS

Defense R&D



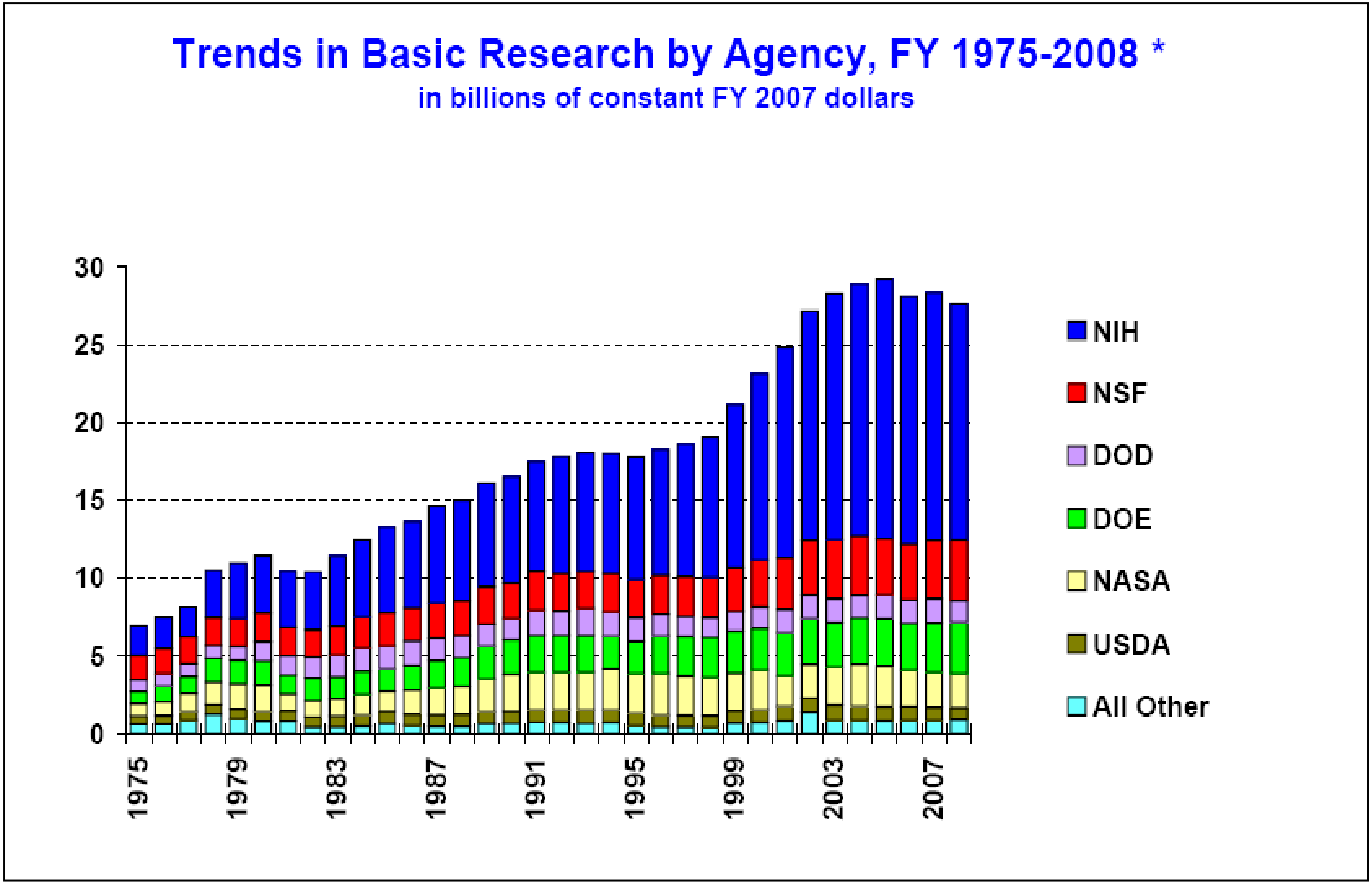
Trends in Defense R&D, FY 1976-2008 *
in billions of constant FY 2007 dollars
80
70
60
50
40
30
20
10
0
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
DHS defense R&D
DOE defense R&D
Other DOD R&D 6.4 -
DOD S&T 6.1-6.3

30 Year Trend in U.S. R&D Investments

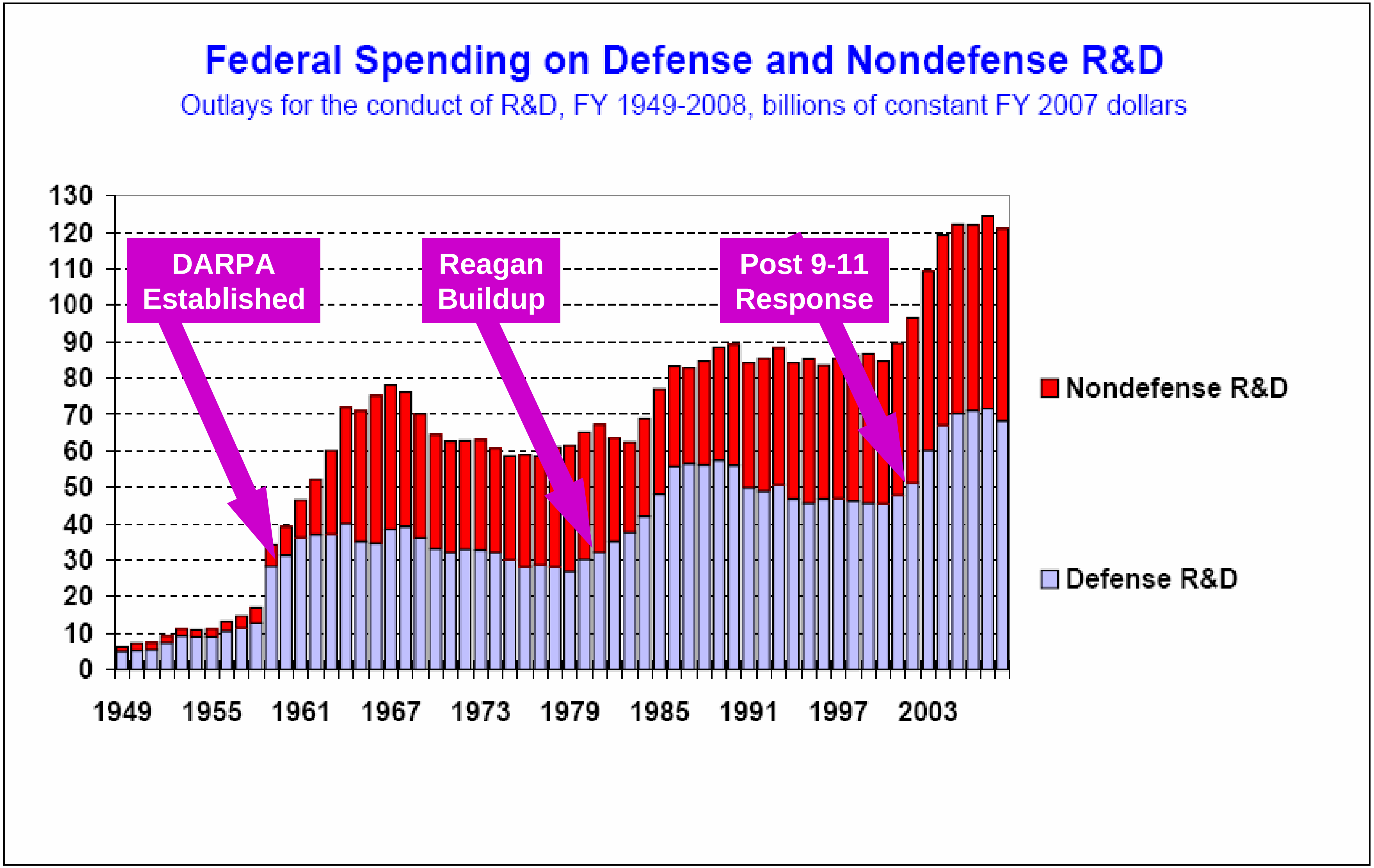


- DoD R&D effort down from 26% to 16% of U. S. total
- Total Federal effort down from 51% to 28%
- Industry R&D effort up from 45%to 65%
- Non-profits, educational institutions, state, and local up from 4% to 7%

Basic Research (BA 1)



DoD R&D is about half of U.S.G. total



The Importance of Horizon Scanning

- Inductive logic – necessary and overwhelmingly attractive
  - *The sun will rise tomorrow…*
  - *78 percent of Americans support…*
  - *The top mutual performing fund for the last ten years…*
- The law of large numbers
  - Regression analysis, curve fitting, and forecasting
  - Sufficient and random sampling of independent variables
- The farmer and the chicken
  - When do we have enough information?
  - Should we constantly challenge our current ideas and theories?
  - Should we take every day one day at a time?

One Effect of Quantum Computing:
Ability to Break RSA Public Key Encryption

The RSA algorithm was invented in 1977; it is a *computationally secure* based on four parameters: P, Q, E, and D

- *P* and *Q*, two large prime numbers
- *E* such that *E* is greater than 1, *E* is less than *PQ*, and *E* and *(P-1)(Q-1)* have no prime factors in common
- *D* such that (DE - 1) is evenly divisible by (P-1)(Q-1)

The encryption function is *C = (T^E) mod PQ*   (C is the ciphertext)

- The *public key* is the pair *(PQ, E)*

The decryption function is *T = (C^D) mod PQ*   (T is the plaintext)

- The *private key* is the number *D*

One can publish the public key freely

- There are no practical methods of calculating *D*, *P*, or *Q* given only *(PQ, E)*
- If *P* and *Q* are each 1024 bits long, the sun will burn out before the most powerful classical computers can factor PQ into *P* and *Q* *(quantum computer could do it in minutes)*

Quantum computers undo the computational security of public key encryption

Research & Development Budget Categories

Budget Activity 1: Basic Research
Budget Activity 2: Applied Research
Budget Activity 3: Advanced Technology Development (ATD)

(S&T)

Budget Activity 4: Advanced Component Development and Prototypes (ACD&P)
Budget Activity 5: System Development and Demonstration (SDD)
Budget Activity 6: RDT&E Management Support
Budget Activity 7: Operational System Development

RDT&E

Budget Activities 1 through 3 are often collectively referred to as Science and Technology (S&T)

Budget Activities 4,5 and 7 are normally associated with acquisition programs

Budget Activity 6 funds RDT&E infrastructure

Research & Development Budget Categories

Budget Activity 1: Basic Research, the systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind (formerly known as 6.1)

Budget Activity 2: Applied Research, the systematic study to understand the means to meet a recognized and specific need (formerly known as 6.2)

Budget Activity 3: Advanced Technology Development (ATD) includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment (formerly known as 6.3)

We Don’t Know What We Don’t Know

“By 2020, organic electronics should provide for increased brightness of widespread lighting systems and displays.”

RAND, *The Global Technology Revolution 2020*
(Released in 2006)

Super-vivid, super-efficient displays
New OLED displays for mobile gadgets are poised for debut in U.S. and European markets

Technology Review
November 06, 2006

Sony: 1,000,000:1 OLED TV on sale in 2007

Engadget
Posted 12 April 2007

Performance Remediation

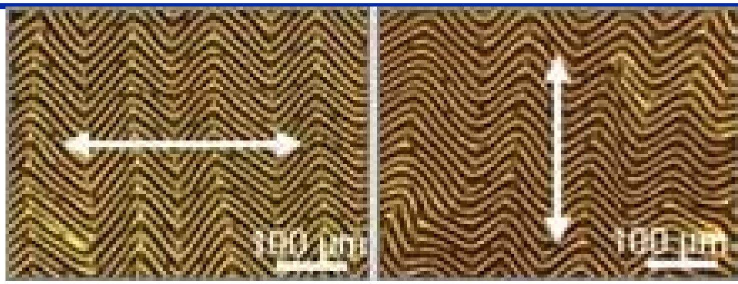
World First Power Ankle

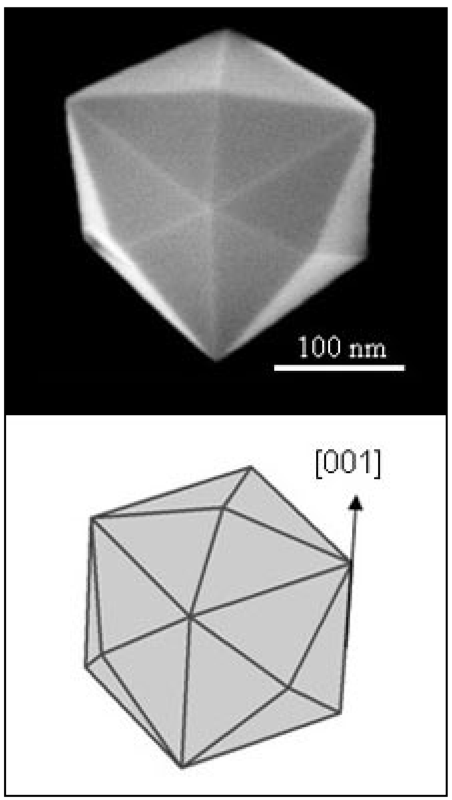
- Developed at biomechatronics group at the MIT Media Lab
- Small battery-powered motor mimics the energy-storage capacity of the human ankle
- Power-assisted spring propel the foot forward as it pushes off the ground
- about 20 percent more efficient than past devices
- Tested in partnership with Military Amputee Research Program

Brain-Machine Interface

- Emotiv Systems electro-encephalograph (EEG) cap
- On sale to software developer's
- Used to build games that use the electrical signals from a player's brain to control the on-screen action
- Could be useful in virtual-world games, such as Second Life
- Commercial successful remains uncertain

Current Materials Research





Sheets of Stretchable Silicon
Researchers have shown that ultrathin sheets of silicon can stretch in two dimensions--opening up the possibility of electronic eyeballs and smart surgical gloves.

Technology Review
May 15, 2007

Better Catalysts for Fuel Cells
Nanoparticles with a completely new shape may lead to cheaper catalysts that could make many experimental-energy technologies more practical.

Technology Review
May 15, 2007

Public Companies with $150B* in Revenue (why oil matters so much)

$366.24B	Exxon Mobil Corporation engages in the exploration, production, transportation, and sale of crude oil and natural gas.	Irving, TX
$355.38B	Wal-Mart Stores, Inc. operates retail stores in various formats worldwide.	Bentonville
$318.13B	Royal Dutch Shell plc, through its subsidiaries, engages in the exploration, production, and trading of various energy resources worldwide.	The Hague
$263.89B	BP p.l.c. provides fuel for transportation, energy for heat and light, retail services, and petrochemicals products.	London
$209.84B	Toyota Motor Corporation operates in the automotive industry worldwide.	Toyota City
$204.78B	DaimlerChrysler AG engages in the development, manufacture, distribution, and sale of automotive products, including passenger cars, trucks, vans, and buses worldwide.	Stuttgart
$191.74B	General Motors Corporation and its subsidiaries engage in the development, production, and marketing of cars, trucks, and parts worldwide.	Detroit
$189.82B	Chevron Corporation operates as an integrated energy company worldwide.	San Ramon
$176.14B	TOTAL S.A., together with its subsidiaries, operates as an integrated oil and gas company worldwide.	Paris
$167.21B	General Electric Company (GE) is a diversified industrial corporation.	Fairfield , CT
$164.72B	Ford Motor Company and its subsidiaries design, develop, manufacture, and service cars, trucks, and parts worldwide.	Dearborn, MI
$162.22B	ConocoPhillips operates as an integrated energy company worldwide.	Houston, TX
$152.55B	AXA, through its subsidiaries, provides global financial protection and asset management services.	Paris
$141.44B	China Petroleum & Chemical Corporation, through its subsidiaries, operates as an integrated oil and gas, and chemical company in the People's Republic of China and Hong Kong.	Beijing

U.S. Science and Math Literacy

Average science score of eighth grade students, by country: 2003

Country	Score
International average	473
Singapore	578
Chinese Taipei	571
South Korea	558
Hong Kong, China	556
Estonia	552
Japan	552
Hungary	543
Netherlands	536
United States	527
Australia	527
Sweden	524
Slovenia	520
New Zealand	520
Lithuania	519
Slovak Republic	517
Belgium	516
Russian Federation	514
Latvia	512
Scotland	512
Malaysia	510
Norway	494
Italy	491
Israel	488
Bulgaria	479
Jordan	475
Moldova	472
Romania	470
Serbia	468
Armenia	461
Iran	453
Macedonia	449
Cyprus	441
Bahrain	438
Palestinian National Authority	435
Egypt	421
Indonesia	420
Chile	413
Tunisia	404
Saudi Arabia	398
Morocco	396
Lebanon	393
Philippines	377
Botswana	365
Ghana	255
South Africa	244

Average higher than U.S. average
Average not measurably different from U.S. average
Average lower than U.S. average

SOURCES: P. Gonzales, J.C. Guzman, L. Partelow, E. Pahlke, L. Jocelyn, D. Kastberg, and T. Williams, *Highlights From the Trends in International Mathematics and Science Study (TIMSS) 2003*, U.S. Department of Education, National Center for Education Statistics, NCES 2005-005, table 9 (2004); and data from International Association for the Evaluation of Educational Achievement, *Trends in International Mathematics and Science Study (TIMSS)* (2003).

Science and Engineering Indicators 2006

Average mathematics literacy score of 15-year-old students, by country: 2003

Country	Score
OECD countries	500
Finland	544
South Korea	542
Netherlands	538
Japan	534
Canada	532
Belgium	529
Switzerland	527
New Zealand	523
Australia	524
Czech Republic	516
Iceland	515
Denmark	514
France	511
Sweden	509
Austria	506
Germany	503
Ireland	503
Slovak Republic	498
Norway	495
Luxembourg	493
Poland	490
Hungary	490
Spain	485
United States	483
Portugal	466
Italy	466
Greece	445
Turkey	423
Mexico	385
Non-OECD countries	
Hong Kong, China	550
Liechtenstein	536
Macao-China	527
Latvia	483
Russian Federation	468
Serbia and Montenegro	437
Uruguay	422
Thailand	417
Indonesia	360
Tunisia	359

Average higher than U.S. average
Average not measurably different from U.S. average
Average lower than U.S. average
OECD = Organisation for Economic Co-operation and Development

SOURCES: M. Lemke, A. Sen, E. Pahlke, L. Partelow, D. Miller, T. Williams, D. Kastberg, and L. Jocelyn, *International Outcomes of Learning in Mathematics Literacy and Problem Solving: PISA 2003 Results From the U.S. Perspective: Highlights*, U.S. Department of Education, National Center for Education Statistics, NCES 2005-003, table 2 (2004); and data from OECD, Programme for International Student Assessment (PISA) (2003).

Science and Engineering Indicators 2006

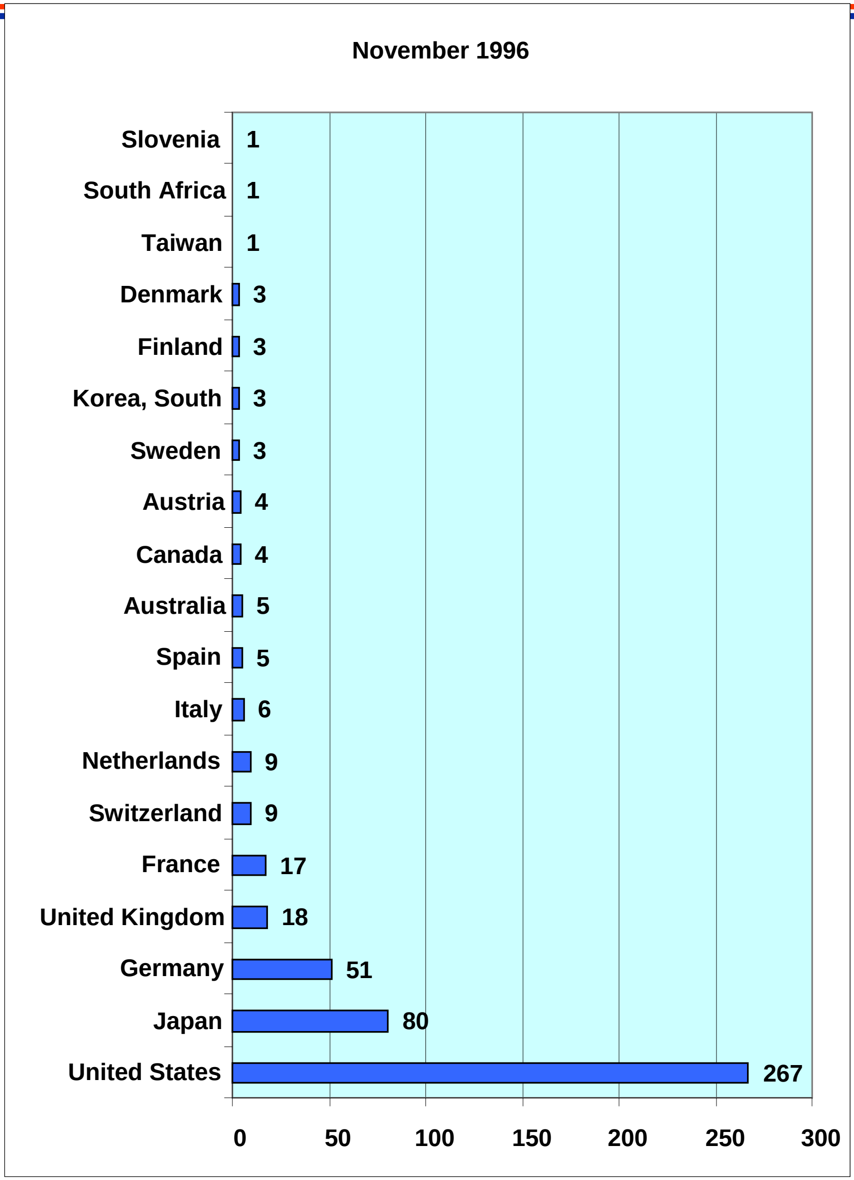
Rise of China's R&D Efforts

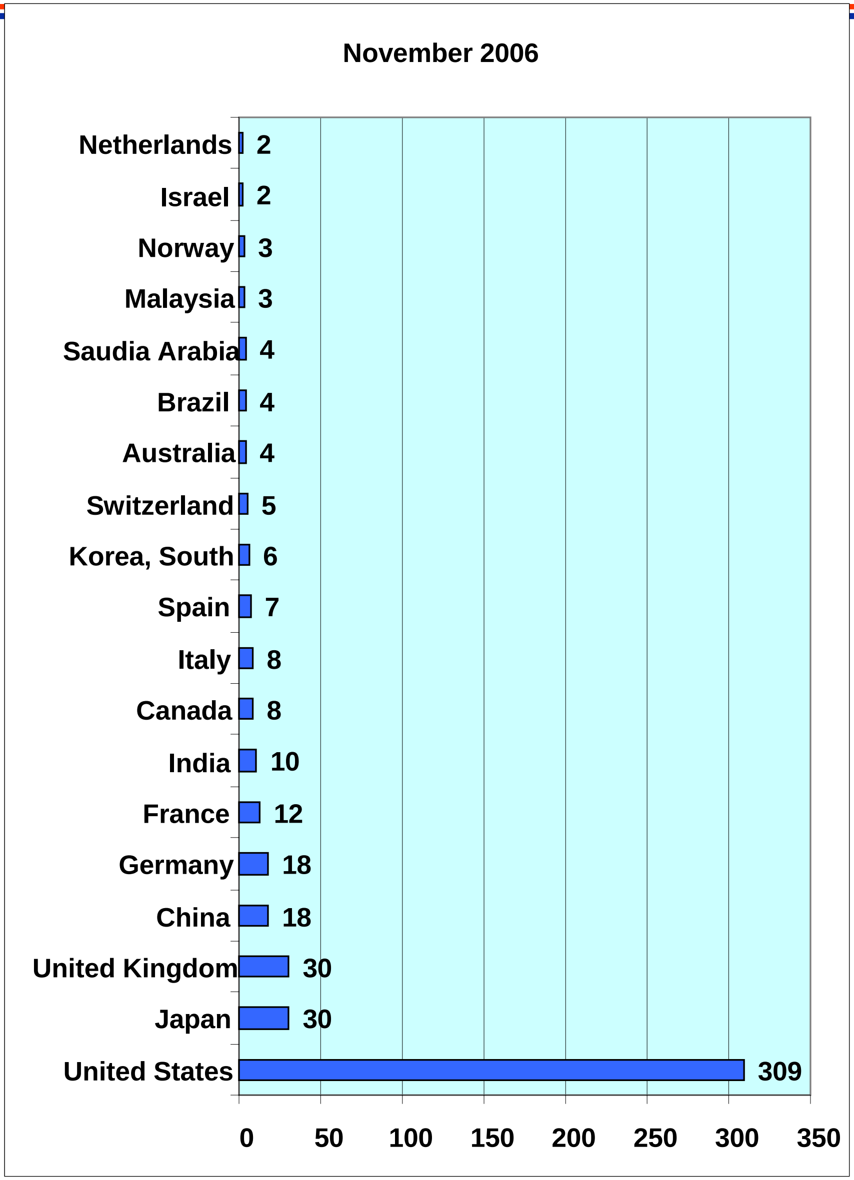
- U.S. Leads World in R&D Spending, China Moves to 3rd Place

  The United States continues to lead the world in R&D with 34 percent of world R&D spending in 2005, according to data from the OECD. U.S. industry, government and other sectors spend more on R&D than the entire EU combined. The U.S. share has declined from 40 percent during most of the 1990s. China has increased its R&D performance dramatically in recent years and is just narrowly the 3rd largest performer of R&D (adjusted for purchasing power), and will overtake 2nd place Japan in 2006.
- In scientists and engineers employed in R&D activities, China is already 2nd in the world behind only the United States.

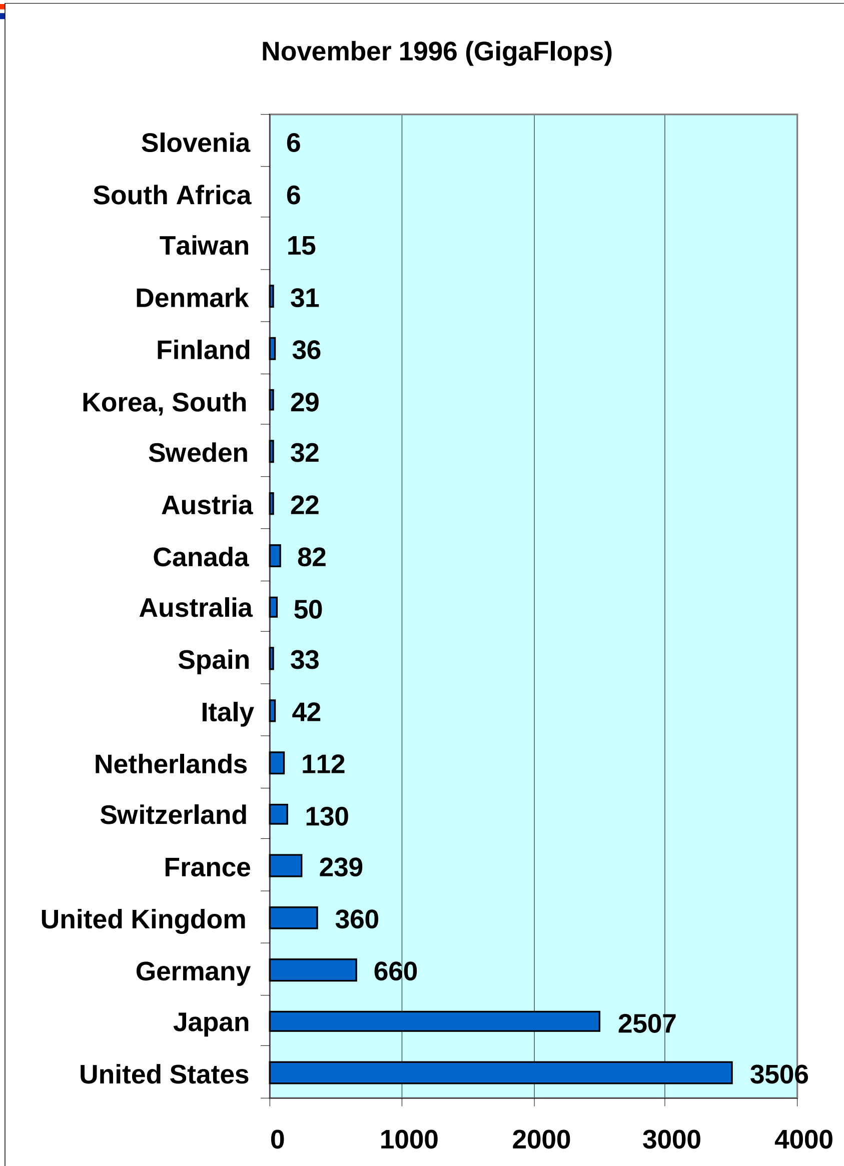
May 15, 2007
American Association
for the Advancement of Science

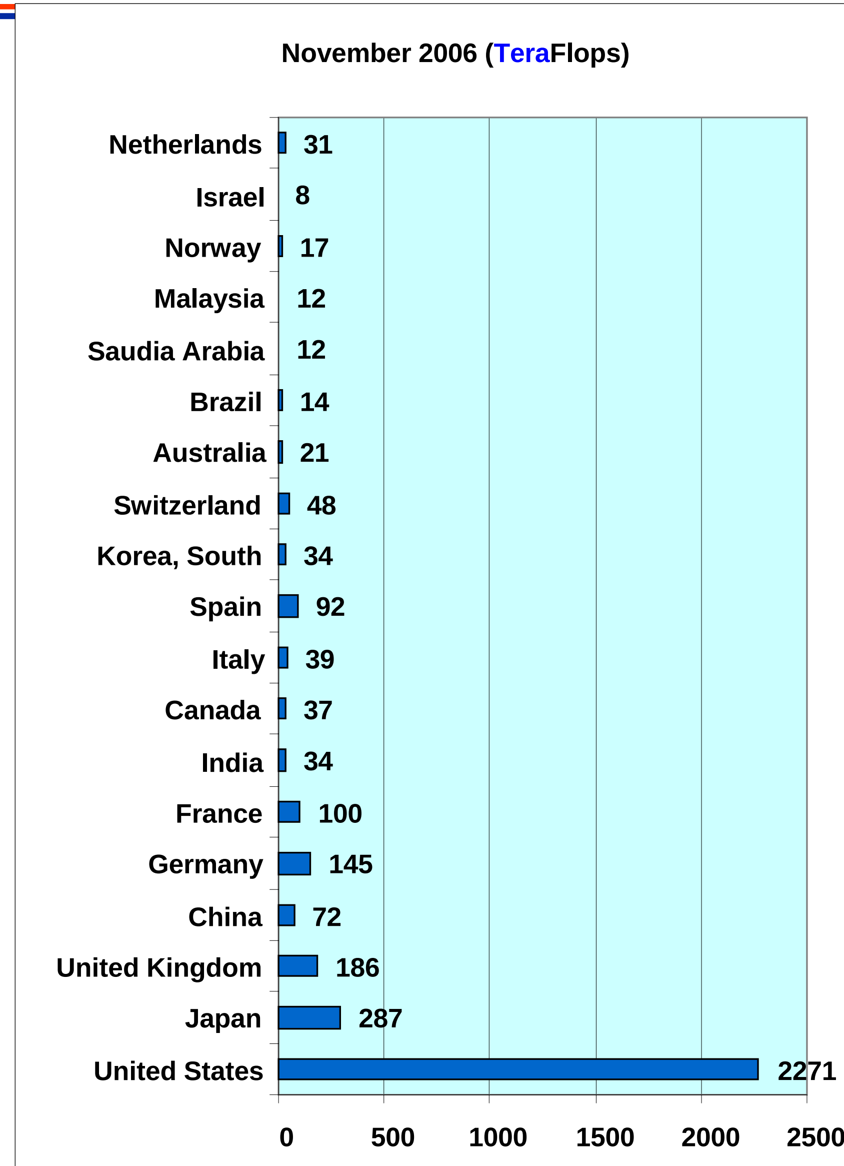
Super Computers: Number of Top 500





Super Computers: Processing





Selected Sources

- *Science and Engineering Indicators 2006.* Two Volumes

  National Science Board
  National Science Foundation, 2006
- *21th Century Strategic Technology Vectors*

  Defense Science Board, 2006
- *Proceedings*, Australia-U.S. Bilateral Emerging Technology Conference

  May, 2007
- *Converging, Combining, Emerging*

  Dr. George Poste, Presentation,
  Highland Forum XXXII
- *Steering Group Report: Brain Science as a Mutual Opportunity for the Physical and Mathematical Sciences, Computer Science, and Engineering*

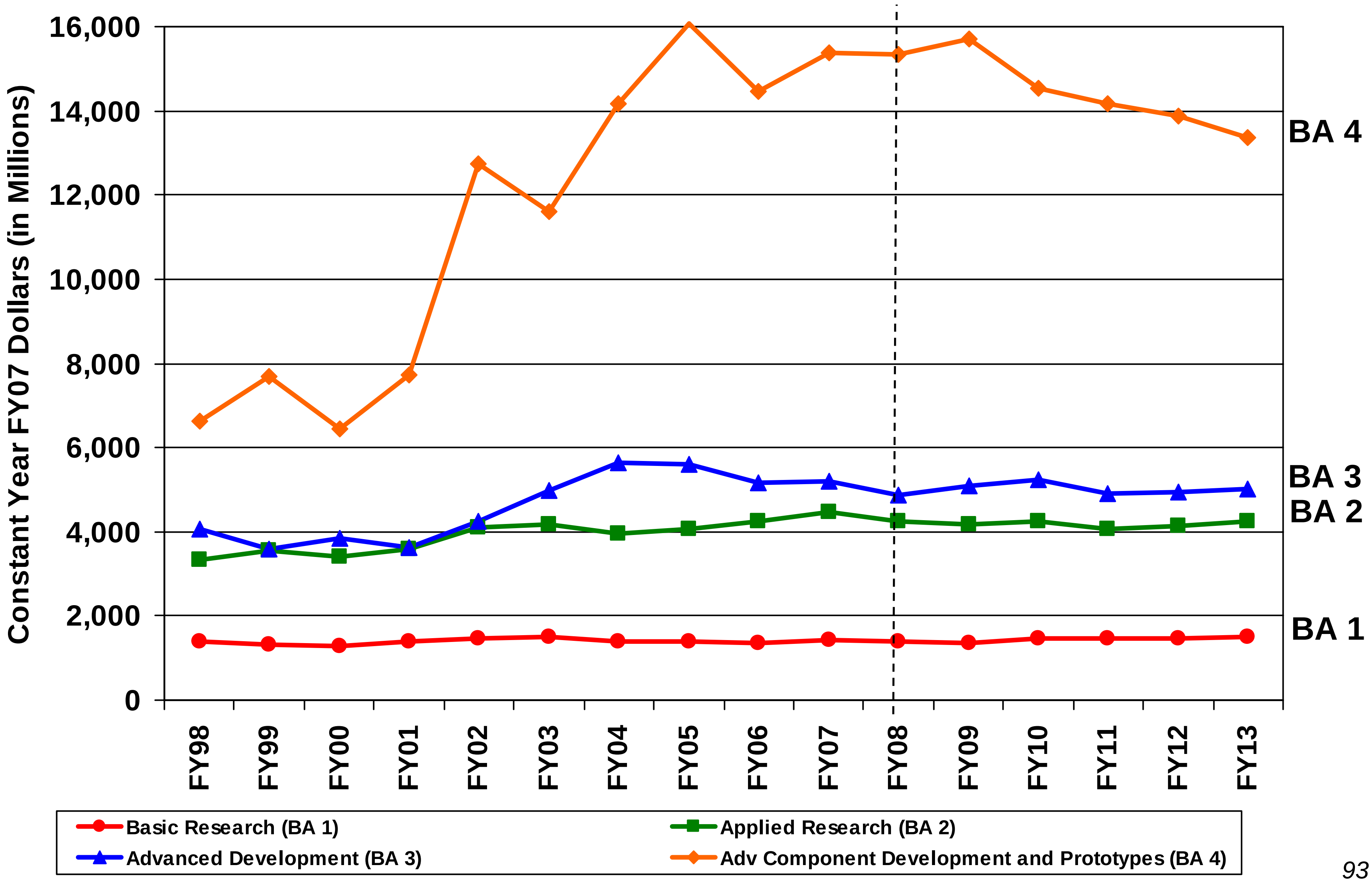
  National Science Foundation
  August 2006
- *Globalization, Biosecurity, And The Future of The Life Sciences*

  Institute of Medicine and National Research
  Council of the National Academies, 2006
- *Human Performance Modification Collaboration Workshop Report*

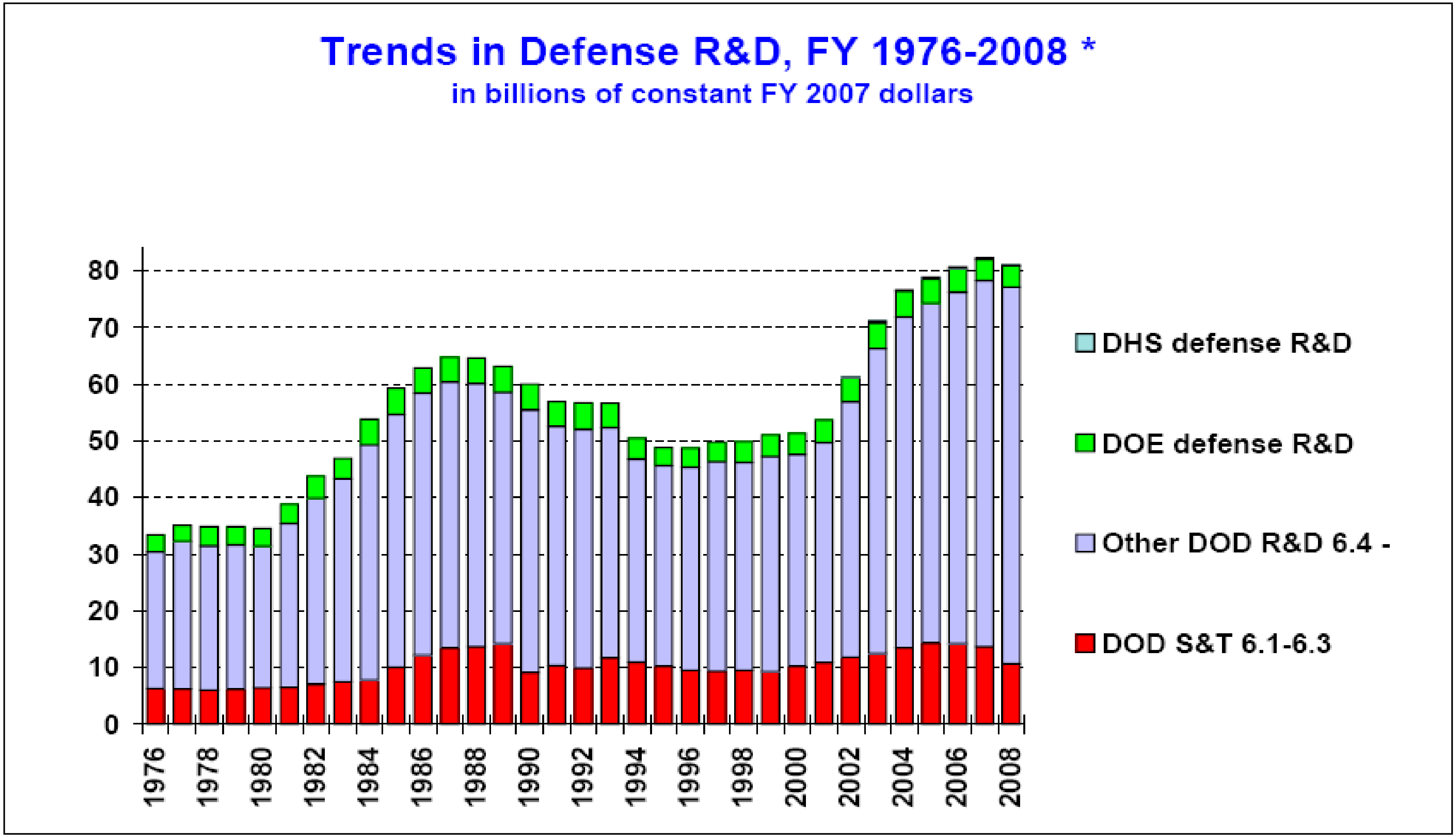
  Dr. Adam Russell and Ms. Bartlett Bulkley
  Scitor Corporation, 2006
- *The Global Technology Revolution 2020, In-Depth Analyses Bio/Nano/Materials/Information Trends, Drivers, Barriers, and Social Implications*

  Richard Silberglitt, Philip S. Antón, David R. Howell, Anny Wong
  RAND, 2006

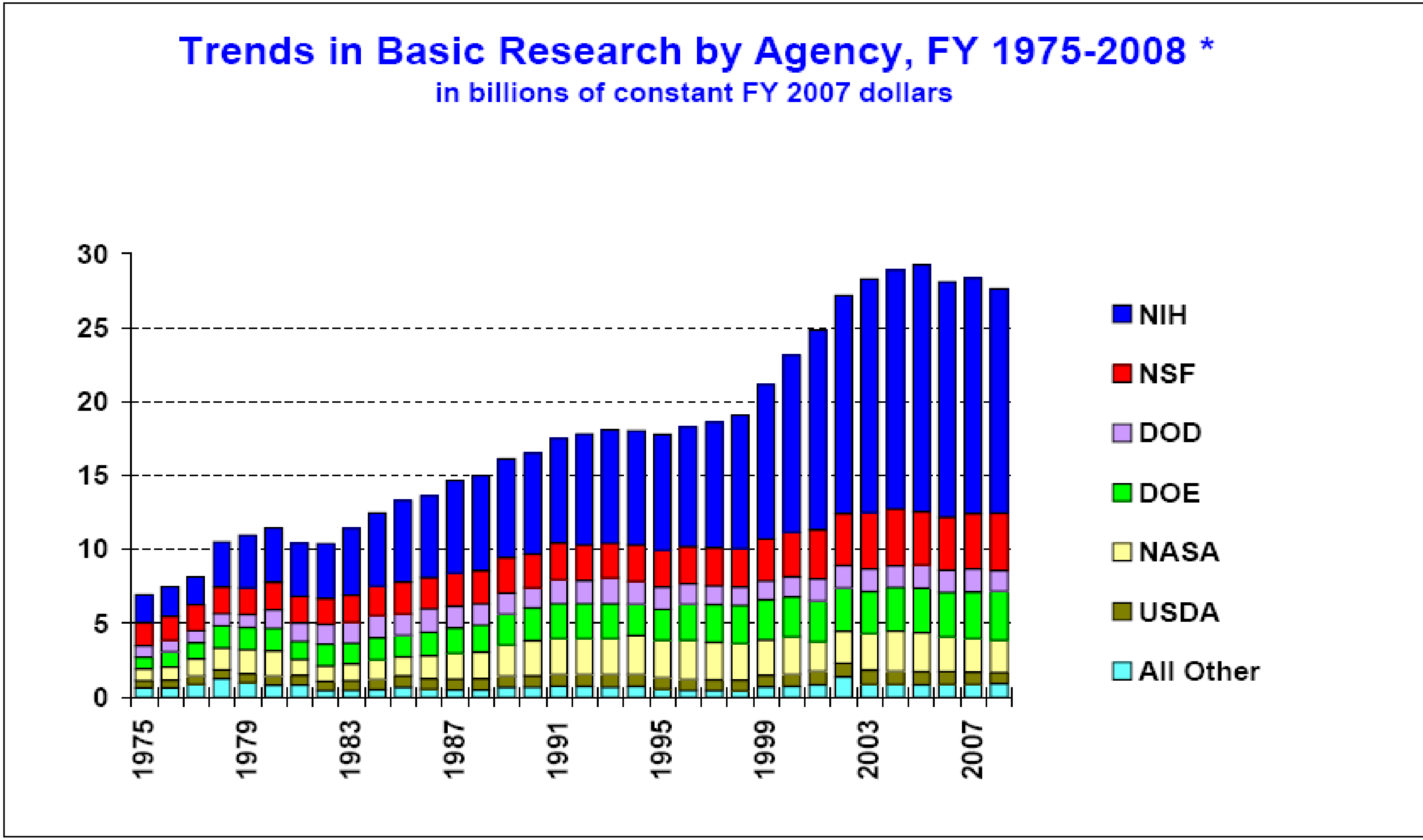
DoD R&E Funding By Budget Activity
President's Budget Requests - in FY07 Constant Dollars



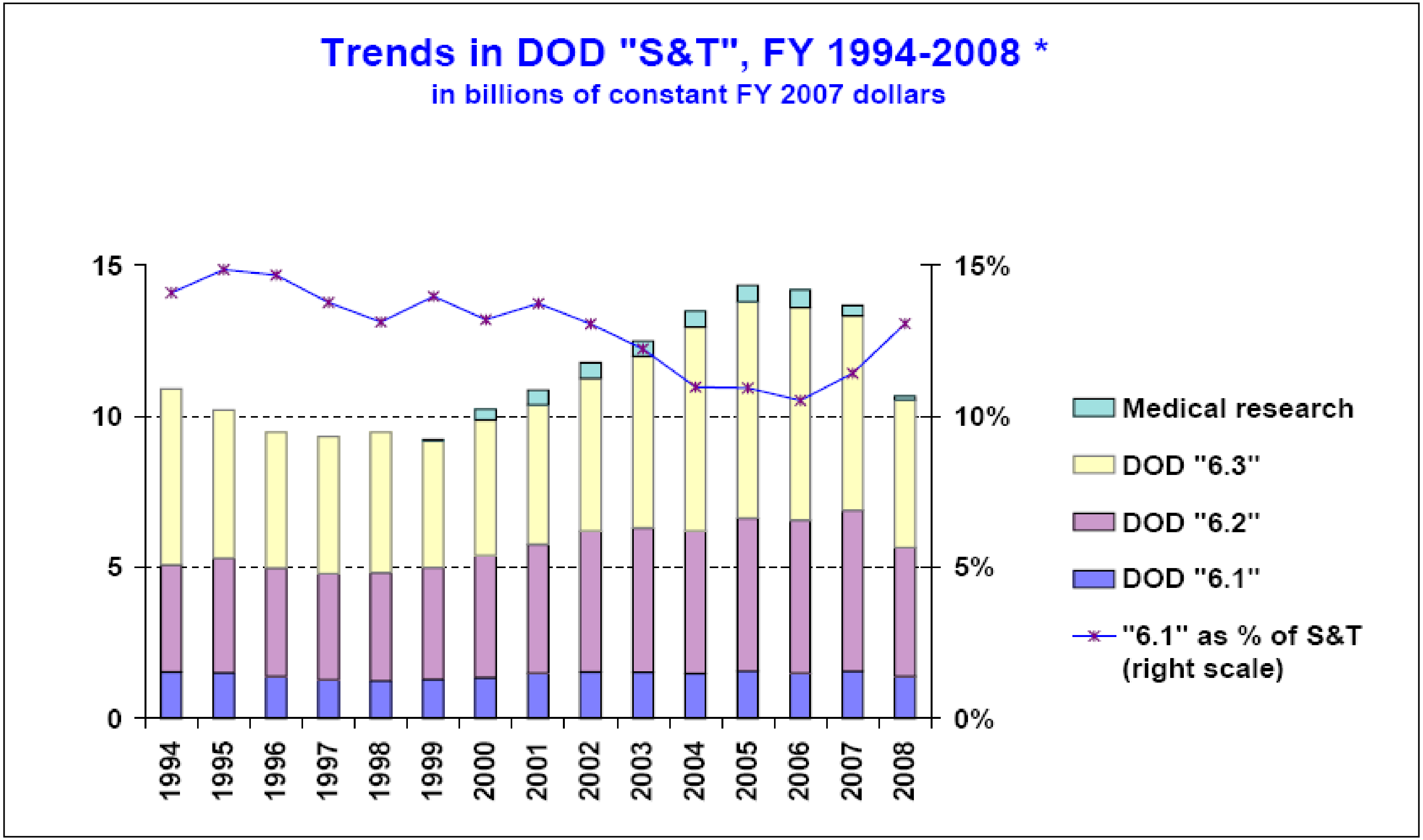
Defense R&D Spending



Federal Basic Research Spending



DOD S&T Spending



Moore’s Law Continues

FUTURE TECH

5-TERABYTE HARD DRIVES

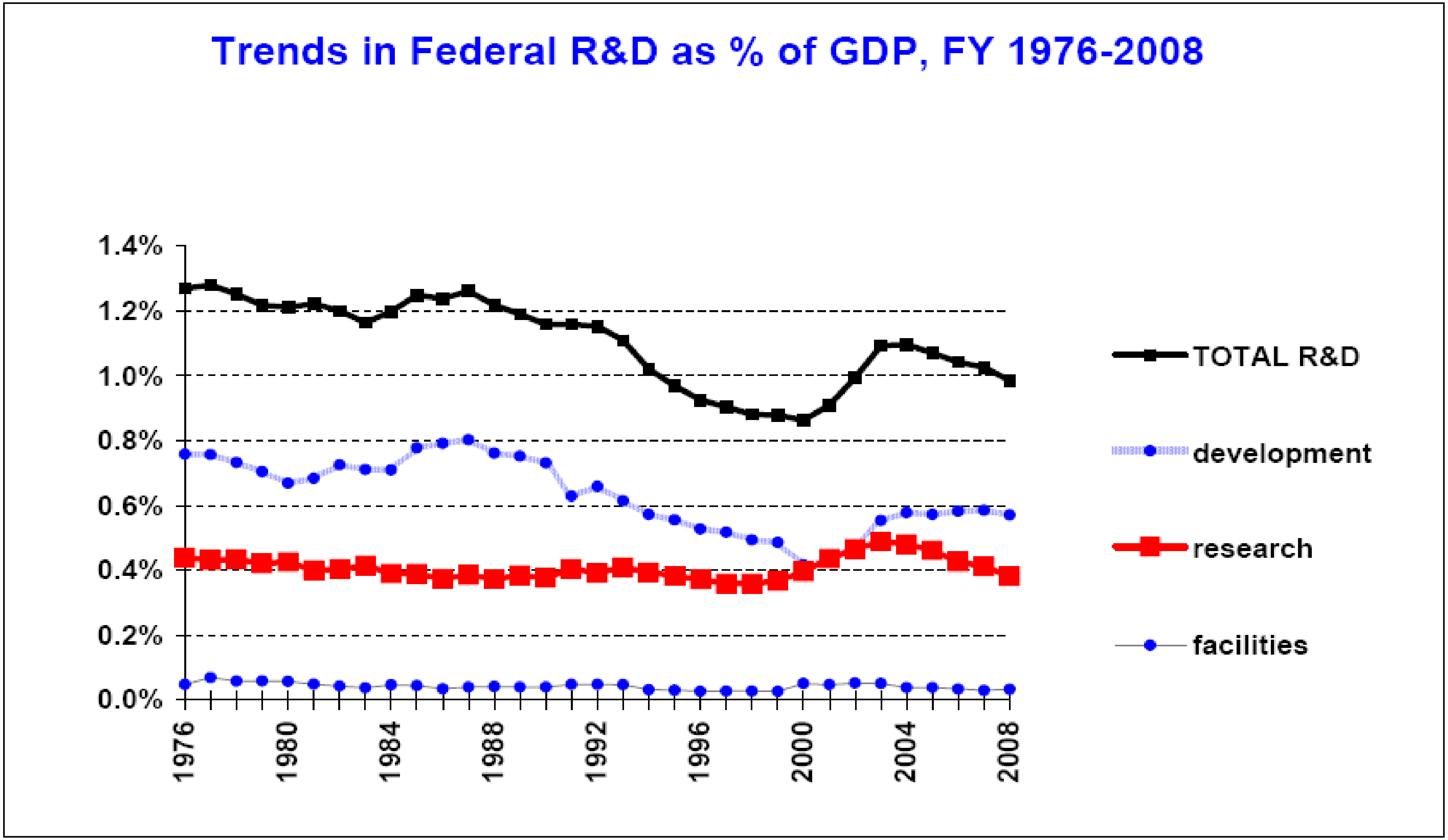
AROUND THE year 2013, the gigabyte will become passé, thanks to a team of researchers at Toshiba and Tohoku University. By then, their recently developed hard-drive technology should lead to 5TB desktop drives and 1TB 2.5-inch notebook drives. Called Nanocontact Magnetic Resistance (NC-MR), the technology greatly boosts a drive head’s ability to detect tiny changes in magnetic fields. Down the road, NC-MR should let manufacturers increase storage density from the current 178.8 gigabits per square inch all the way up to 1 terabit per square inch. Heat-Assisted Magnetic Recording (HAMR), being developed by Seagate and others, should eventually push storage density even higher—perhaps to 50 terabits per square inch by 2019.

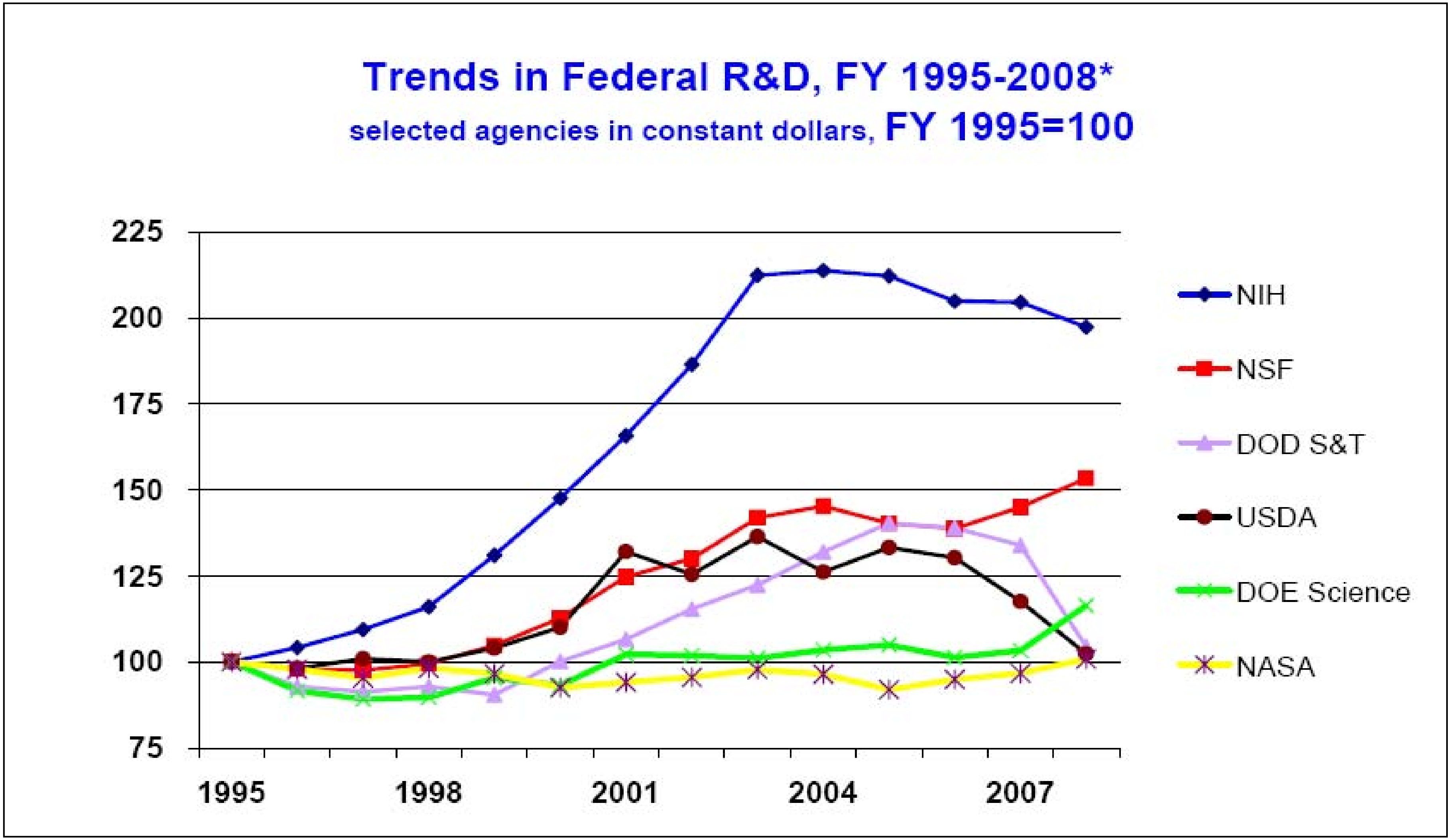
WWW.PCWORLD.COM / AUGUST 2007

45nm Size Comparison

- A nail = 20 million nm
- A human hair = 90,000nm
- Ragweed pollen = 20,000nm
- Bacteria = 2,000nm
- Intel 45nm transistor = 45nm
- Rhinovirus = 20nm
- Silicon atom = 0.24nm

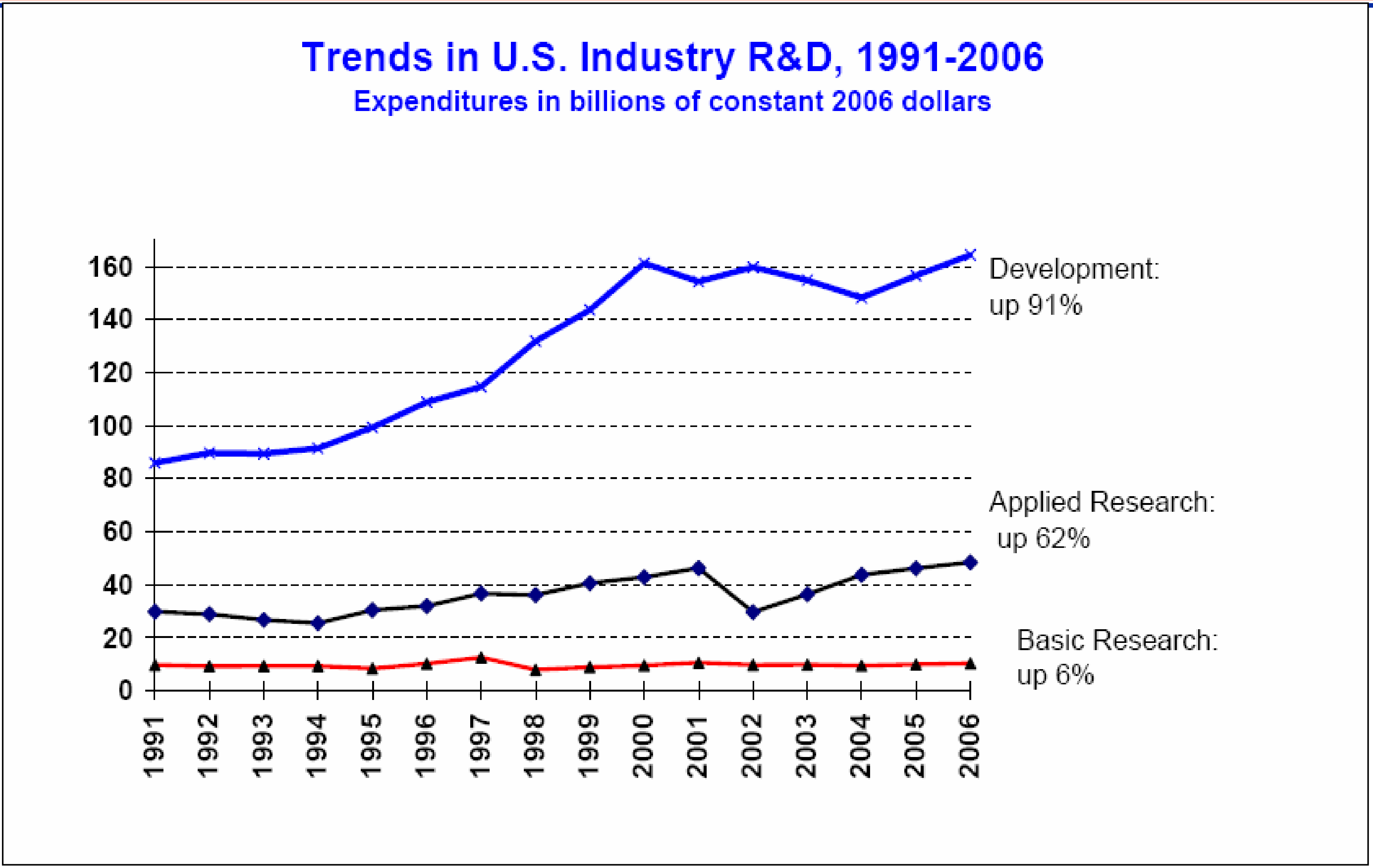
Federal R&D Spending





Trends in Federal R&D, FY 1995-2008*
selected agencies in constant dollars, FY 1995=100
225
200
175
150
125
100
75
1995
1998
2001
2004
2007
NIH
NSF
DOD S&T
USDA
DOE Science
NASA

Industry R&D Trends



Strategic Missile R&D Thrusts

- Science & Technology (BA 6.1-6.3)
- Radiation Hardened Electronics
- Technology for Sustainment of Strategic Systems
- Position, Navigation & Timing

- Thermal Protection Systems Materials & Structures
- Strategic Applications Programs (BA4 Air Force & Navy)
- Guidance
- Re-entry Vehicles
- Propulsion
- Command & Control

The need for technical intelligence . . .

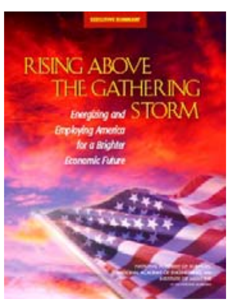
The Direction of Technical Intelligence

- **Other than WMD and terrorism, we see little strategic threat to US from today's forces, but:**
  - **Are we effectively projecting future foreign technology, capabilities, threats & emerging applications**
- **Possible threats to continued US military advantage are largely technology based, and rate of change of technology is increasing**
- **US maintains capability advantage unless:**
  - **New technology from adversary (e.g. stealth, PGM, NVDs)**
  - **Disruptive Technologies (radar, satellites, anti-satellite technologies)**
- **Therefore, must enhance technology intelligence to minimize surprise from**
  - **New technology from adversary**
  - **Technology/tactics that can mitigate our capability advantage**

Future Tech-Intel Motivation

“Move away from Lists of Lists”

- We need to understand global technology developments, evaluating their potential impact on national security
- Global development is so prolific that is difficult to keep up, much less address impact
- Limited funding, limited analysts, limited time prevent us from looking at everything
- Multiple analyses and lists of emerging tech exist, but most do not address impact to DoD or national security; those that do are typically generated by very small group with focused agendas
- Our concern remains “are we missing something” and “how do we better identify & track trends” because . . .



To avoid technology surprise we are moving to plan for an uncertain future, recognizing the global collaborative landscape by forecast future emerging technology & disruptive applicatons

Radiation Hardening Applications Program (RHAP)

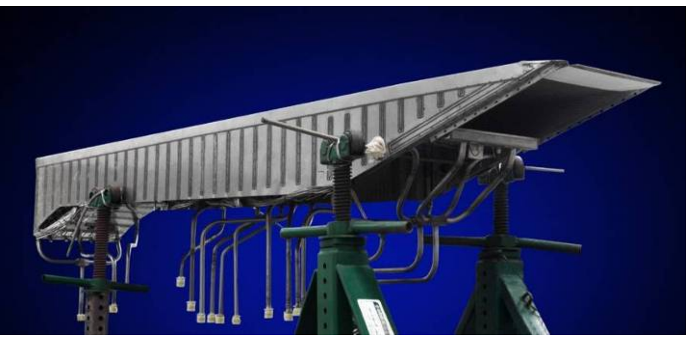
Objectives

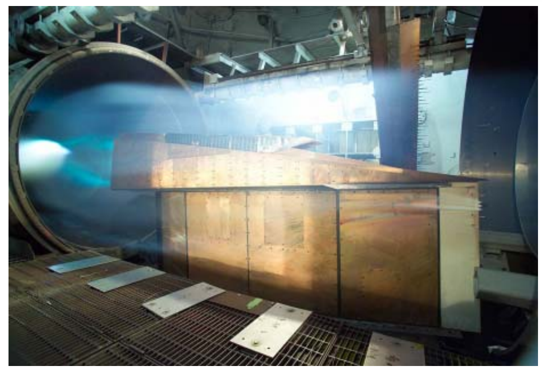
- **Develop a tool to model strategic system radiation effects**
  - **EMP missile plume coupling**
  - **Electrical parasitics noise coupling**
  - **Multi-wire cable SGEMP**
- **Develop a hardened boundary scan technology for mixed-signal integrated circuit application to improve testability**

Payoffs

- Improve the understanding of system survivability
- Improve the quality of radiation testing
- Cost savings to the program by reducing time in isolating failures
- Reduce assembly reworks by detecting / isolating analog faults
- Capture unique skills in RAD Hard system design

Air Force Hypersonic X-51 Scramjet Engine Demo (SED)





Description

Flight Demo HyTech HC Scramjet Engine

- Fixed geometry scramjet, 12 min durability
- Waverider airframe w/ ATACMS booster
- Proves scramjet performance in flight

Technologies

- Scramjet operating from Mach 4.5 to 7+
- Affordable, high lift-to-drag airframe
- Storable endothermic hydrocarbon JP fuel

Benefits to the War Fighter

Near Term: Affordable Fast Reaction Standoff Weapon

- Time sensitive targets: rapid response, long range standoff (600 NM in 10 min)
- Deeply buried targets: terminal velocity 1K-4K fps
- 250-500 lb modular payload (penetrator, explosive, or submunition)
- Reduced vulnerability to enemy air defenses

Far Term: Affordable On-demand Access to Space with Aircraft-like Operations

Bottom Line: Warfighter Confidence

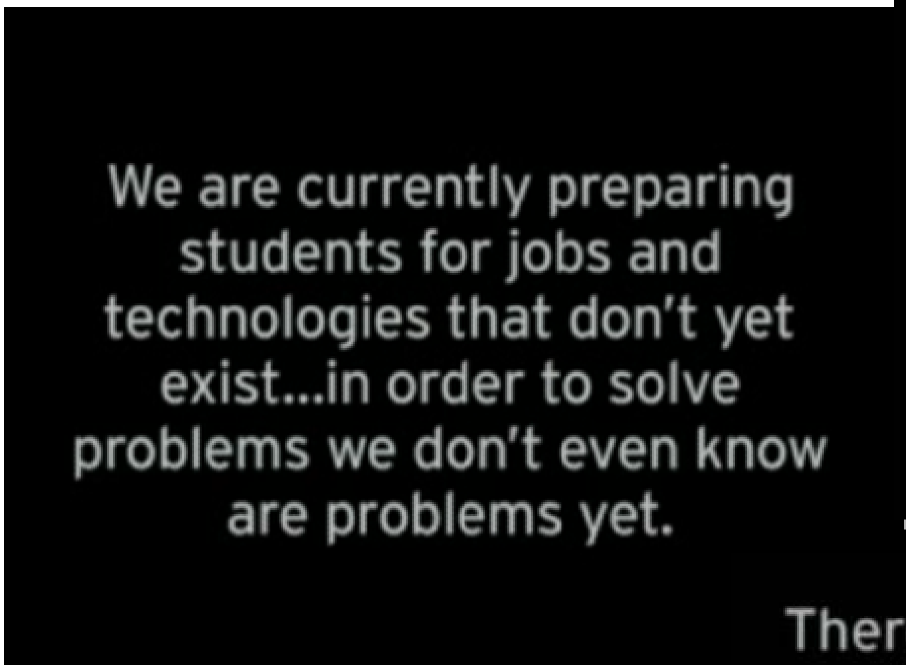
Right Materiel, Right Place,
Right Time, at the Right Cost -

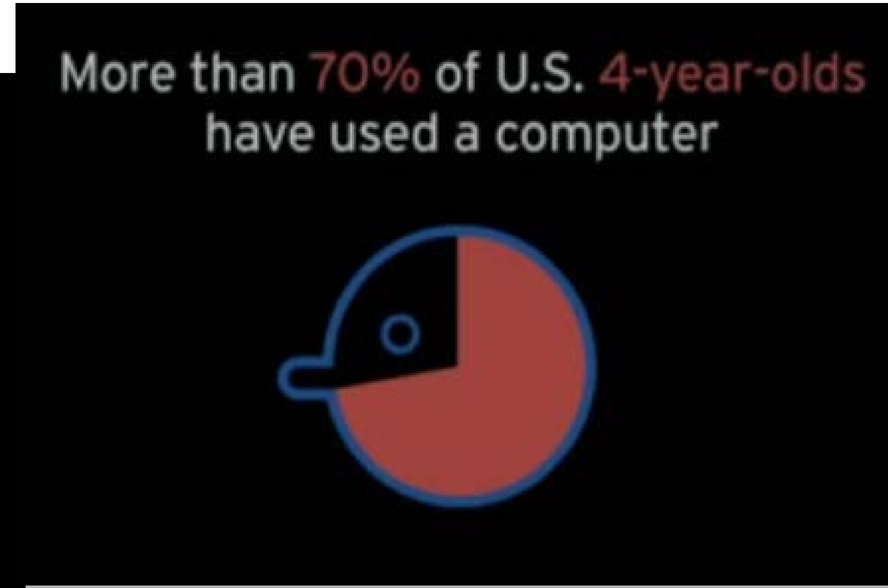
All The Time

Planned Tasks Beginning in FY08

- **Enhanced Ballistic Reentry Vehicle**
  - **Future systems may require current ballistic RVs to fly at extended ranges**
  - **Identify current RV "weak links" for extended range ballistic flight**
  - **Design improvements for identified "weak links"**
  - **Current funding does not support flight testing**
- **Advanced Fuze Alternatives**
  - **Fielded fuzes utilize 1970's and 80's technology**
  - **Evaluate technologies for future fuze concepts**
  - **Reduce costs and increase maintainability while maintaining current capability and nuclear hardness**

Shift Happens . . .

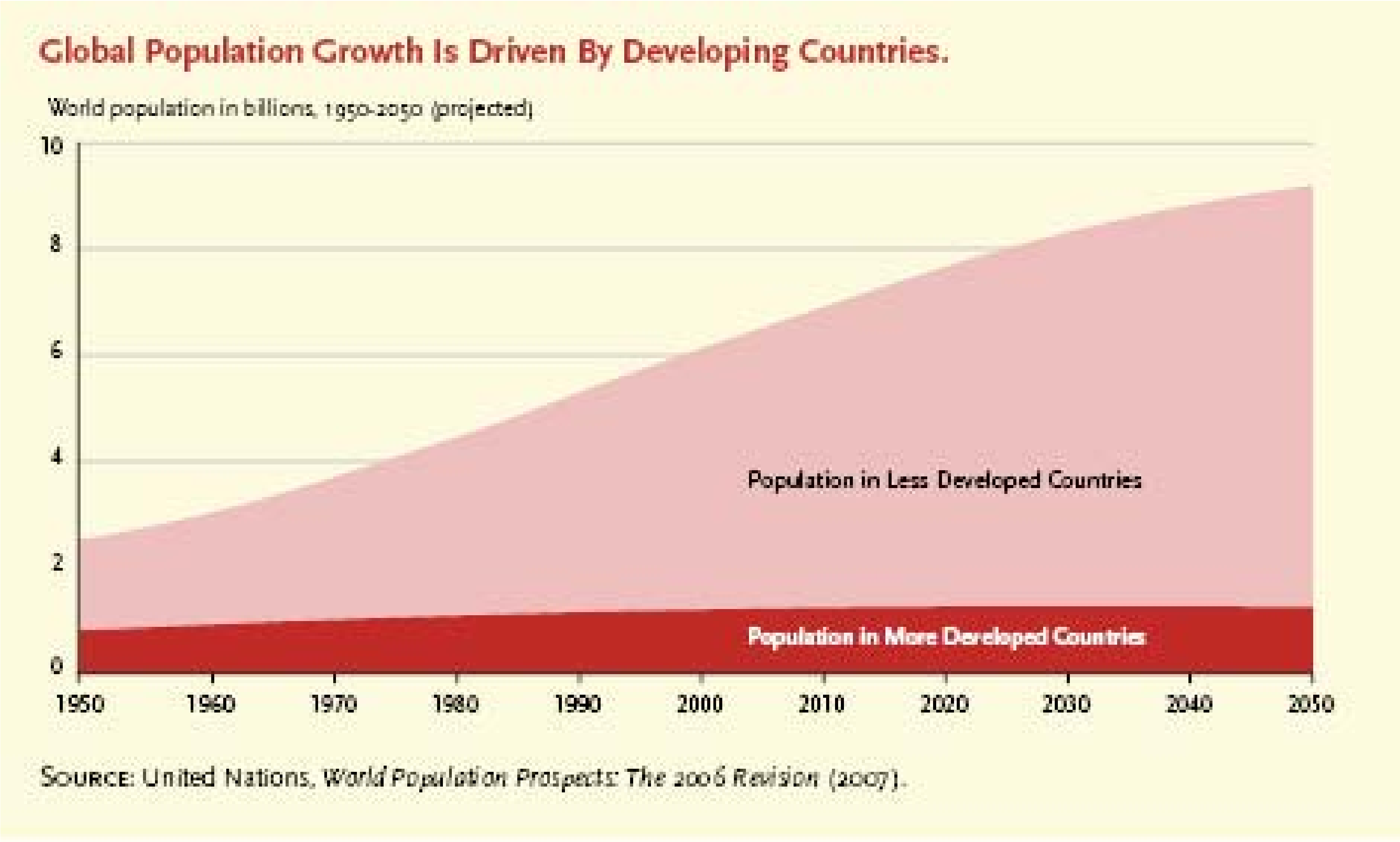




An Uncertain, Changed World

- Technology Maturation Cycle
- Intellectual Capital Center Shifts
- Economic Factors Affecting R&D

Population Trends



Changing Security Environment
Four Challenges

VULNERABILITY — Higher / Lower

LIKELIHOOD — Lower / Higher

$ $ $

Irregular

- Unconventional methods adopted by non-state and state actors to counter stronger state opponents.
- (e.g., terrorism, insurgency, civil war, and emerging concepts)

Catastrophic

- Acquisition, possession, and use of WMD or methods producing WMD-like effects against vulnerable, high-profile targets by terrorists and rogue states.
- (e.g., homeland missile attack, proliferation from a state to a non-state actor, devastating WMD attack on ally)

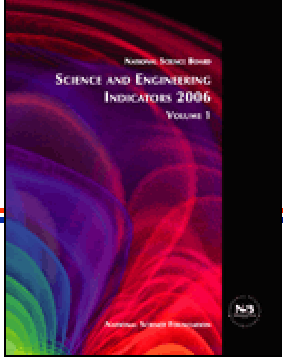
Traditional

- Military capabilities and military forces in long-established, well-known forms of military competition and conflict.
- (e.g., conventional air, sea, land forces, and nuclear forces of established nuclear powers)

Disruptive

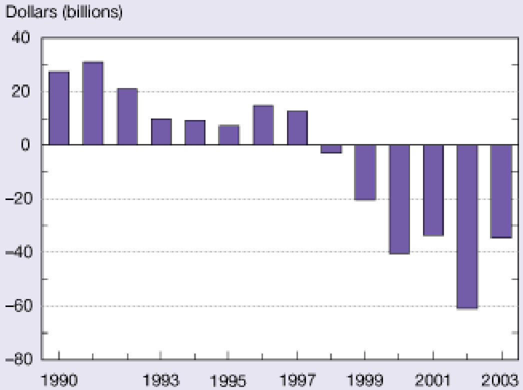
- International competitors developing and possessing breakthrough technological capabilities intended to supplant U.S. advantages in particular operational domains.
- (e.g., sensors, information, bio or cyber war, ultra miniaturization, space, directed-energy, etc)

Uncertainty is the defining characteristic of today's strategic environment



More on the Trade Gap

Figure O-12
U.S. trade balance for five high-technology industries: 1990–2003

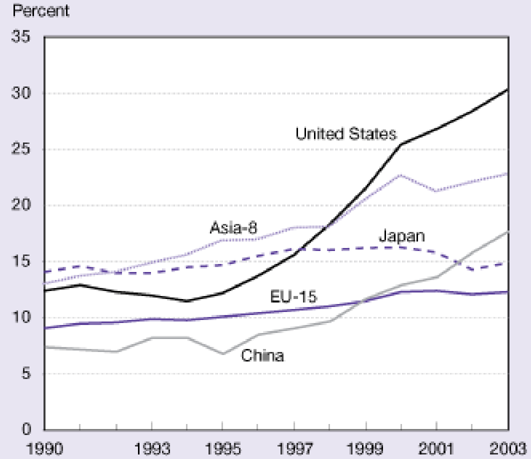


NOTE: Includes aerospace, pharmaceuticals, office and computing equipment, communications equipment, and scientific instruments.

SOURCES: Global Insight, Inc., World Industry Service database (2005). Historical data from United Nations Industrial Development Organization, United Nations System of National Accounts, Organisation for Economic Co-operation and Development; and country sources. See appendix table 6-4.

Science and Engineering Indicators 2006

Figure O-10
High-technology share of total manufacturing, by country/region: 1990–2003



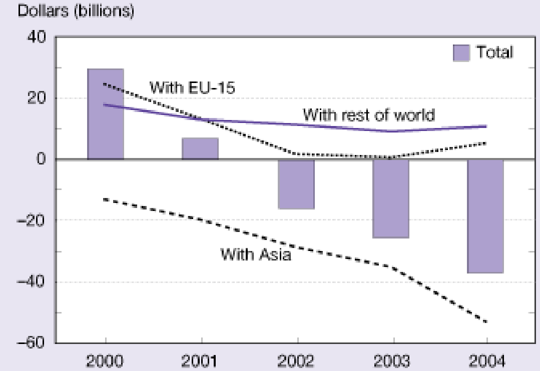
EU = European Union

NOTE: Asia-8 includes South Korea, India, Indonesia, Malaysia, Philippines, Singapore, Taiwan, and Thailand.

SOURCES: Global Insight, Inc., World Industry Service database (2005). Historical data from United Nations Industrial Development Organization, United Nations System of National Accounts, Organisation for Economic Co-operation and Development, and country sources. See appendix table 6-2.

Science and Engineering Indicators 2006

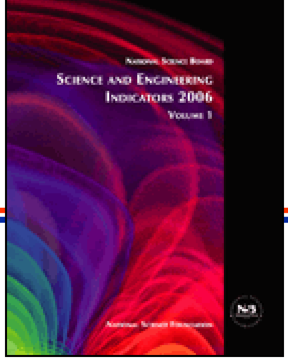
Figure O-13
U.S. trade balance in high-technology goods: 2000–04



EU = European Union

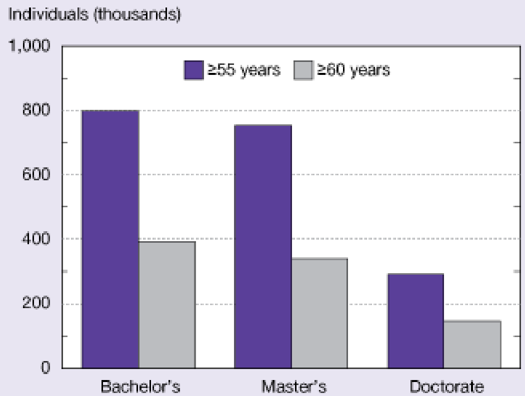
SOURCE: U.S. Census Bureau, Foreign Trade Division, special tabulations (March 2005). See appendix table 6-6.

Science and Engineering Indicators 2006



More on Education

Figure O-35
Individuals in U.S. S&E labor force nearing retirement age, by degree level: 2003

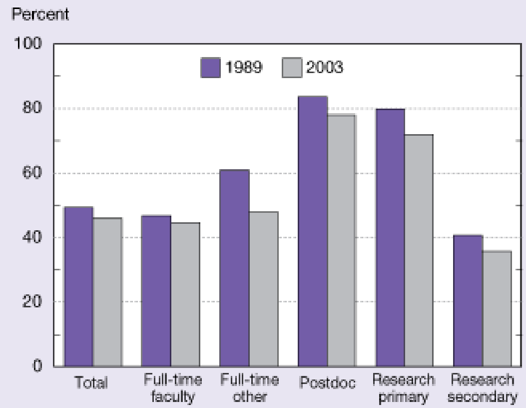


NOTE: Preliminary estimates made in 2005 based on 2003 data

SOURCE: National Science Foundation, Division of Science Resources Statistics, National Survey of College Graduates, preliminary estimates (2005).

Science and Engineering Indicators 2006

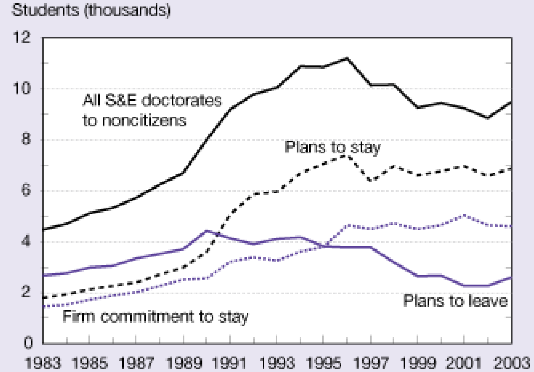
Figure O-43
Academic S&E doctorate holders receiving federal support for research: 1989 and 2003



SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Doctorate Recipients, special tabulations. See appendix table 5-37.

Science and Engineering Indicators 2006

Figure O-31
Foreign student plans to stay in United States after receipt of U.S. S&E doctorate: 1983–2003



SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates, special tabulations (2005). See appendix table 2-33.

Science and Engineering Indicators 2006

Capabilities to Defeat Terrorist Networks

- Persistent surveillance
- Locate, tag, and track terrorists in denied areas
- Capabilities to fuse intelligence
- Language and cultural awareness
- Non-lethal capabilities
- Joint coordination, processes and systems

Non-kinetic capabilities

- Urban warfare capabilities
- Prompt global strike
- Riverine warfare capabilities

Kinetic Capabilities

All These Capabilities are Joint, Coalition Centric

Capabilities to Defend the Homeland In Depth

- Interoperable, joint command and control
- Enhanced air and maritime awareness
- Consequence management
- Broad spectrum medical countermeasures

Non-kinetic capabilities

All These Capabilities are Joint, Coalition Centric

Capabilities to Prevent the use of Weapons of Mass Destruction

- **Locate, tag, track, and characterize**
- **Stand off fissile material detection**
- **Wide area persistent surveillance**
- **Capabilities to "render safe" WMD**
- **Non-lethal weapons**

Non-kinetic capabilities

All These Capabilities are Joint, Coalition Centric

Capabilities to Shape the Choices of Countries at Strategic Crossroads

- Improved language and cultural awareness
- Persistent surveillance (penetrate and loiter)
- Cyberspace shaping / defense
- Secure broadband communications
- Integrated defense against all missiles

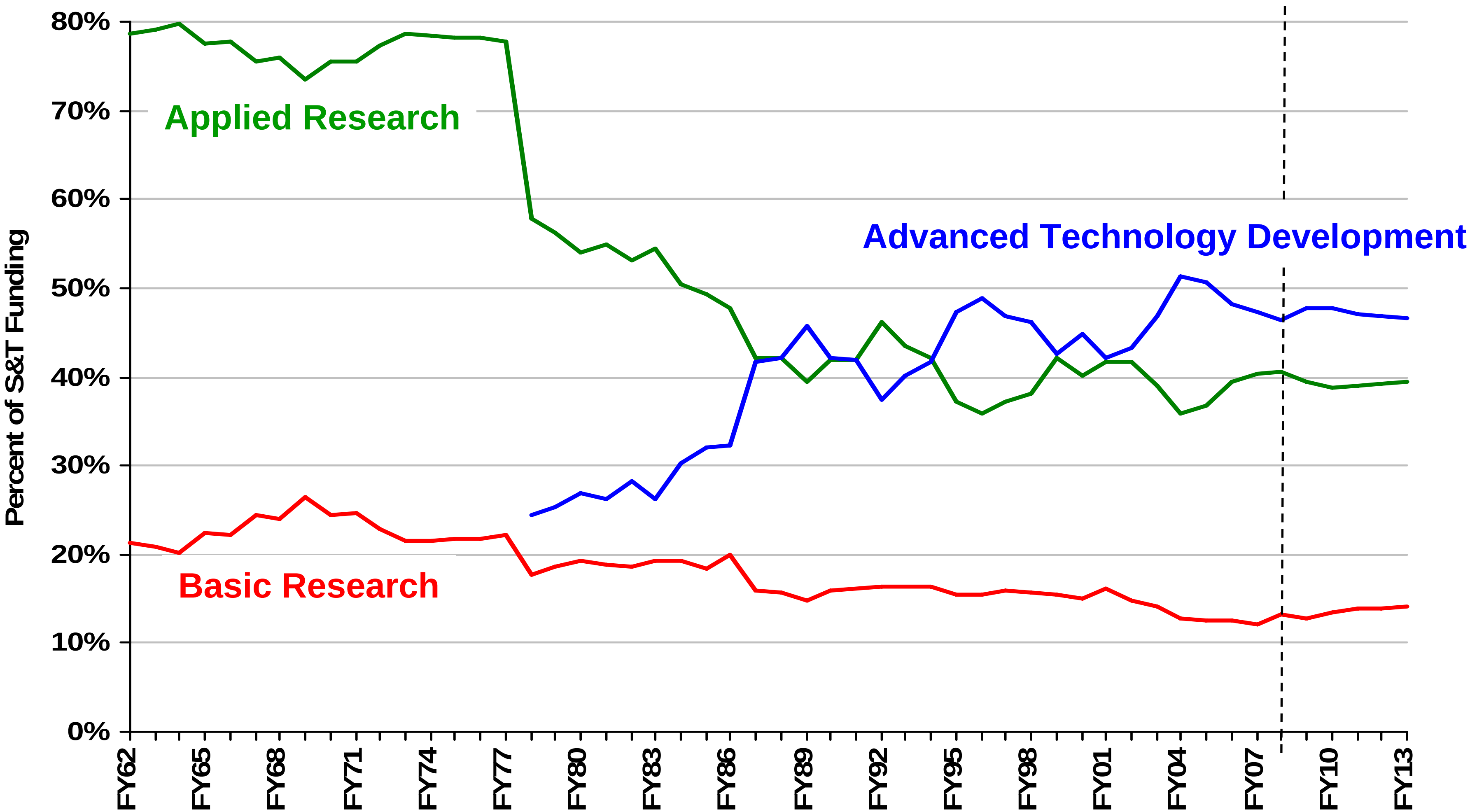
Non-kinetic capabilites

- Prompt, high-value global strike
- Air dominance
- Undersea stealth

Kinetic

Most of These Capabilities are Joint, Coalition Centric

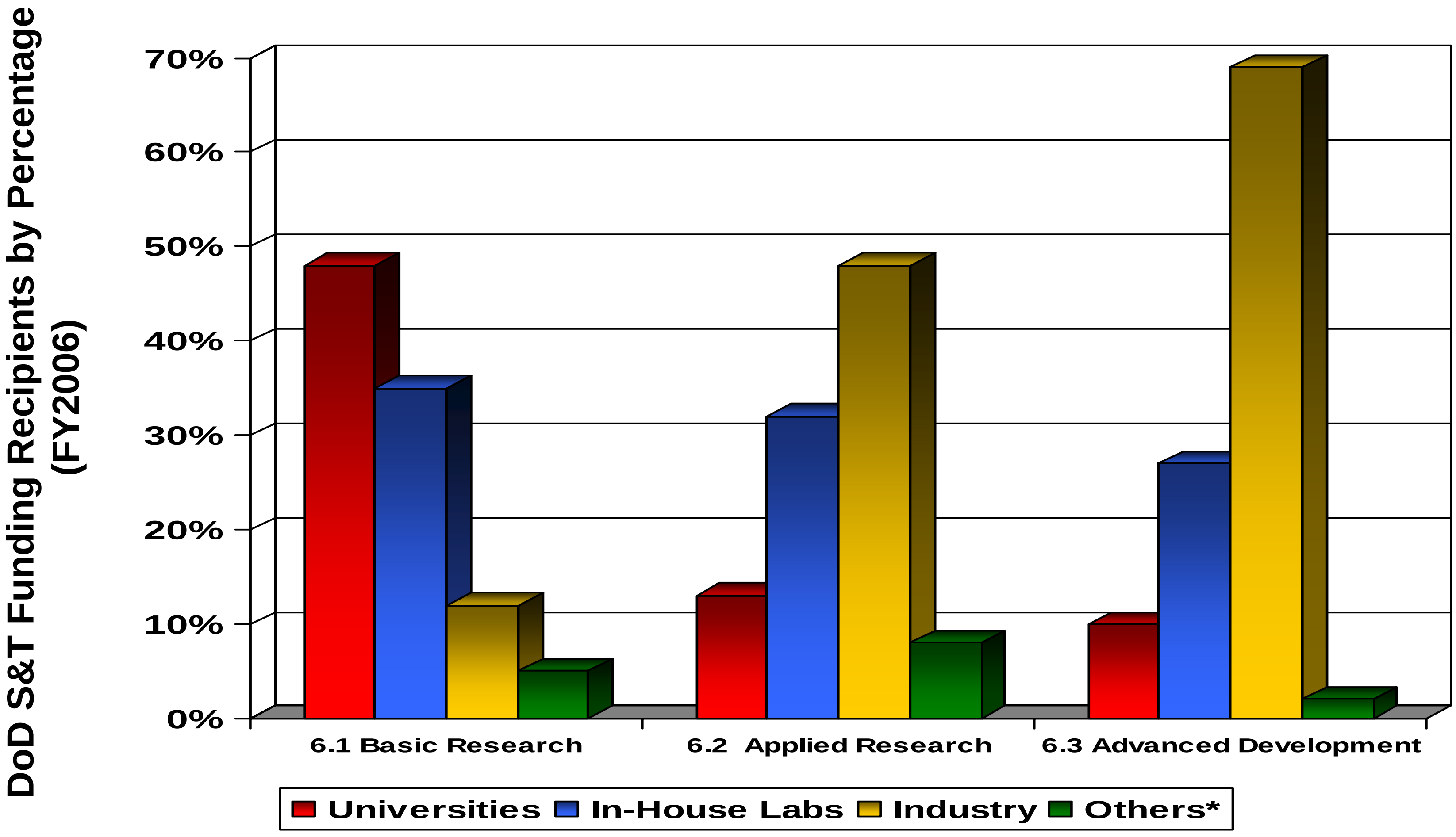
DoD S&T Requests
- by Percent Budget Activity -



DoD is increasing emphasis on nearer-term projects

** ***Note:*** Advanced Technology Development funding began in FY78

Recipients of DoD S&T Funds



***Includes non-profit institutions, State & local govt., & foreign institutions**

Source: National Science Foundation Report (FY 2006)

Technology for Sustainment of Strategic Systems (TSSS)

DoD Science and Technology Program Initiated by USD(AT&L)
in response to the highest priority needs identified by USSTRATCOM

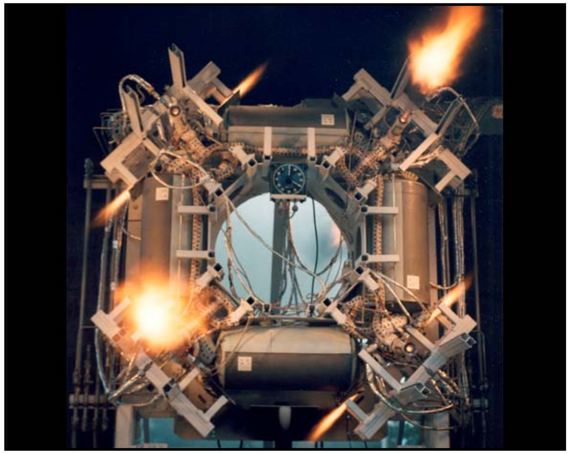
Missile Propulsion
Post-Boost Control System Propulsion, Valve Technology & Materials
Ageing and Surveillance
Missile Flight Sciences
Missile Electronics
Underwater Launch
Guidance Navigation and Control for Strategic and Precision Strike
Ordnance Initiation Technology for Strategic Missile Systems
Submarine Navigation

TSSS supports the capability to sustain and upgrade existing Inter-Continental Ballistic Missiles (ICBM) and Fleet Ballistic Missiles (FBM) systems and to engineer, design, and develop new ballistic missile systems. Contributing factors include maintaining system safety, reducing operations and maintenance (O&M) costs, increasing service life of existing systems, and reducing reliance on physical testing of existing strategic systems.

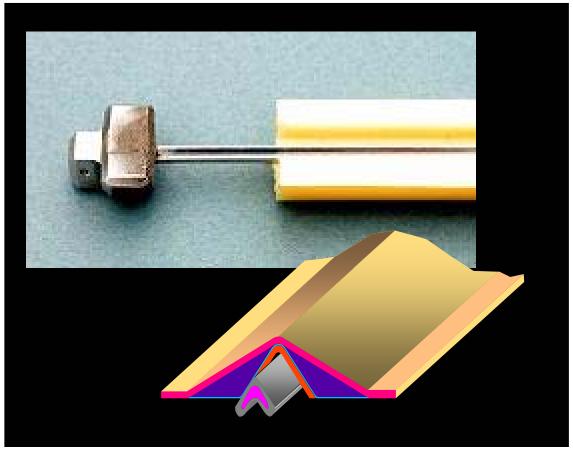
TSSS Technology Objectives

Missile Propulsion

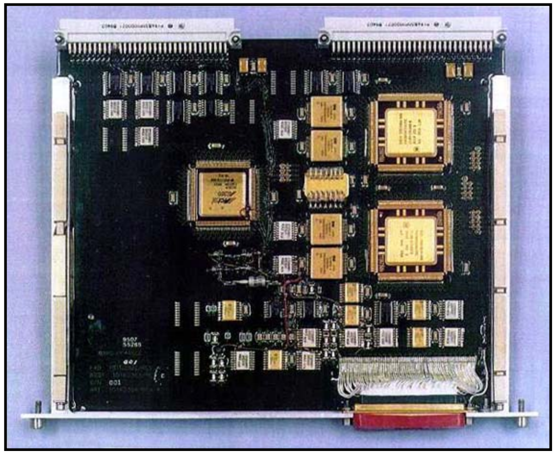
Post Boost Control



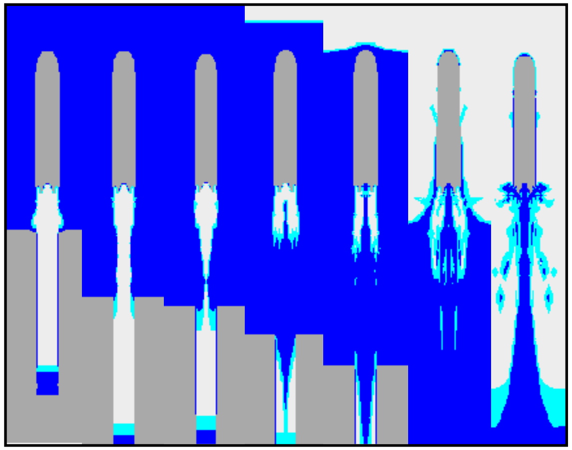
Ordnance



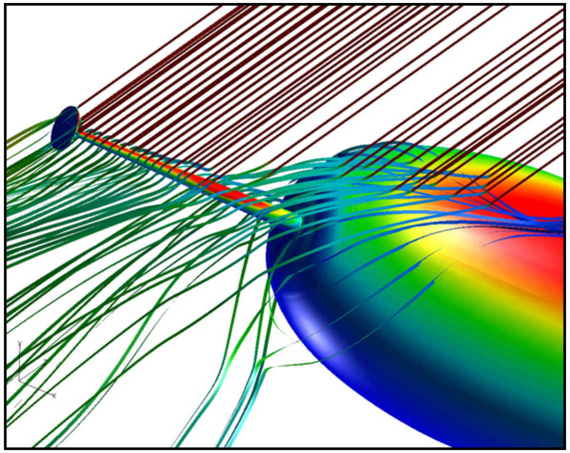
Missile Electronics



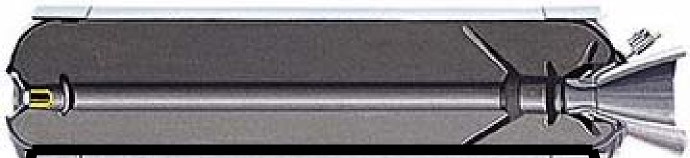
Underwater Launch



Flight Sciences & Analysis

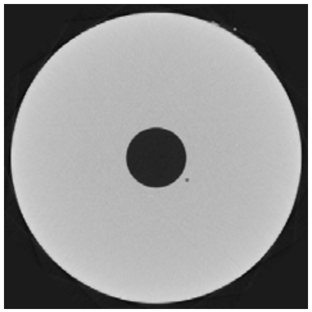


TSSS - Aging and Surveillance

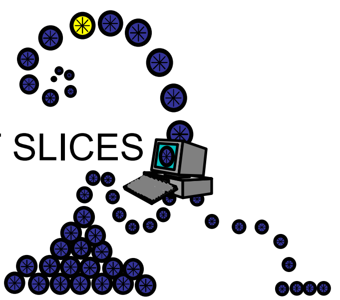


NDE Data Processing Program

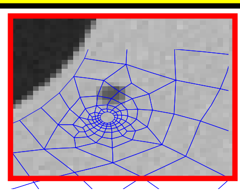
CT Flaw Detection



Automated Flaw Evaluation

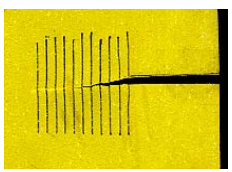


Critical Defect Assessment Program

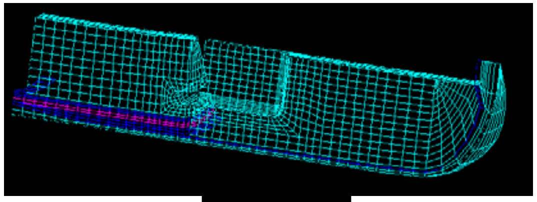


Automated Flaw Meshing

Automated Fracture Propagation



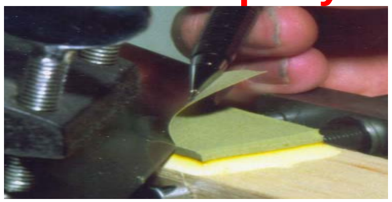
3D Structural/Ballistic Modeling



Service Life Prediction

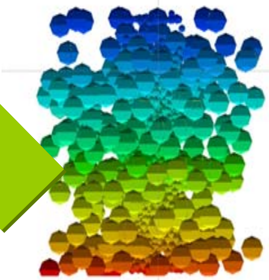
Service Life Prediction Technology Program

Chemical/Mechanical Property Assessment

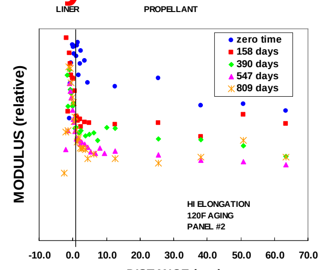


Polymer Mechanics

Particle Packing



Chemical/Mechanical Property Prediction



Strategic Propulsion Applications Program (SPAP)

Objectives

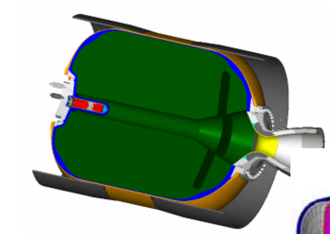
- Demonstrate/validate emerging technologies suitable for ICBM/SLBM
- Maintain critical skills and tools
- Improve predictive aging models/techniques
- Demonstrate Systems Engineering Skills for systems and subsystems integration
- Reduce development/qualification time required to initiate production of alternative components

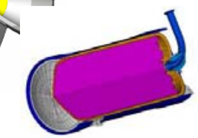
Payoffs

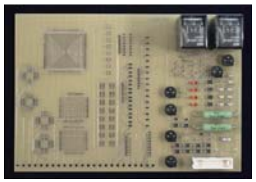
- Viable alternative technologies in support of D5 Life Extension
- Demonstrations of affordable and high performance technologies for boost motor, PBCS and ordnance
- Maintenance of SLBM-unique development and sustainment skills related to high-energy, high-elongation Class 1.1 Propellant
- Elimination of hazardous materials in Ordnance

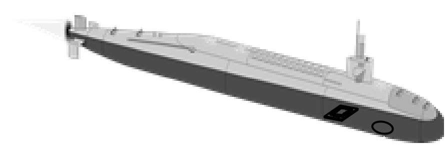
Strategic Missile System Technology Efforts (ICBM and SLBM)

- Technology for the Sustainment of Strategic Systems (TSSS)
  - Propulsion (IHPRPT)
    - Missile Boost Propulsion
    - Post Boost Control System Propulsion
    - Aging and Surveillance – Life Prediction, NDE
  - Guidance Navigation and Control
  - Navigation Sonar
  - Ordnance
  - Electronics
  - Systems Engineering Tools









Emphasizes Technology Sustainment
(Reduced Cost of Ownership, Increased Performance)

Guidance Applications Program (GAP)

Objectives

- **Provide a minimum strategic guidance technology design and development capability**
- **Transition to a long-term readiness status to support deployed systems**
- **Focus on modern replacement alternatives to antiquated or obsolete technologies which provide radiation hardened velocity, attitude (gyro) and stellar sensing capabilities with strategic performance**

Payoffs

- Preserves critical design and core development capability
- Allows for orderly replacement of unsupportable technologies
- Applications to alternate missions
- Lower life cycle costs

QDR Priority Formulation

- **Balanced what the US wants to protect against (Strategic Challenges) and outcomes the US wishes to accomplish (Strategic Outcomes)**
  - **Strategic Challenges**
    - **Traditional**
    - **Irregular Warfare**
    - **Combating WMD**
    - **Disruptive**
  - **Strategic Outcomes**
    - **Defeat Terrorist Networks**
    - **Defend the Homeland in-Depth**
    - **Shape Choices of Countries at Strategic Crossroads**
    - **Prevent the Use of WMD**

QDR In A Banner – A Shift in Emphasis from "Kinetic" to "Non-Kinetic" Systems

Technology and the Modern World

" We can't solve problems by using the same kind of thinking we used when we created them"

Albert Einstein

There is no reason anyone would want a computer in their home
Ken Olson, President, DEC, 1977

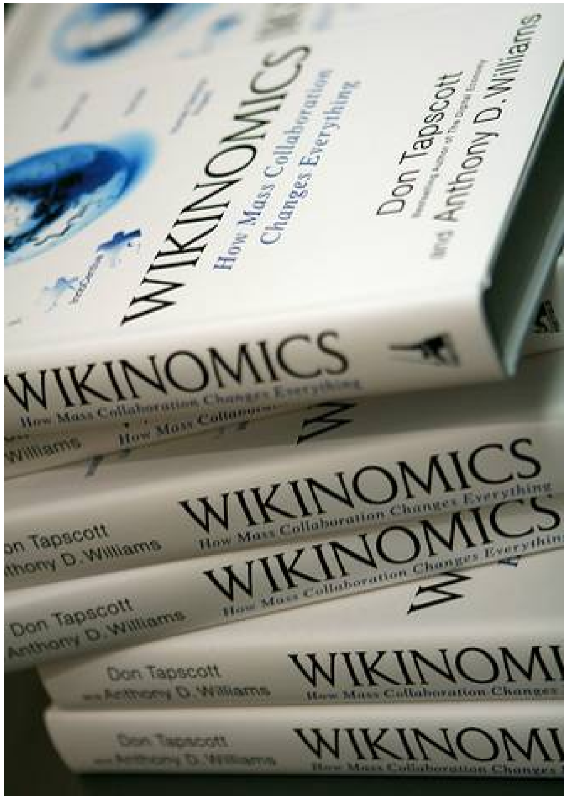
Everything that can be invented has been invented
Charles Duell, Commissioner US Patent Office,1899

"I think there is a world market for maybe five computers."
Thomas Watson, IBM Chairman, 1943

"640K ought to be enough for anybody."
Bill Gates, CEO of Microsoft, 1981

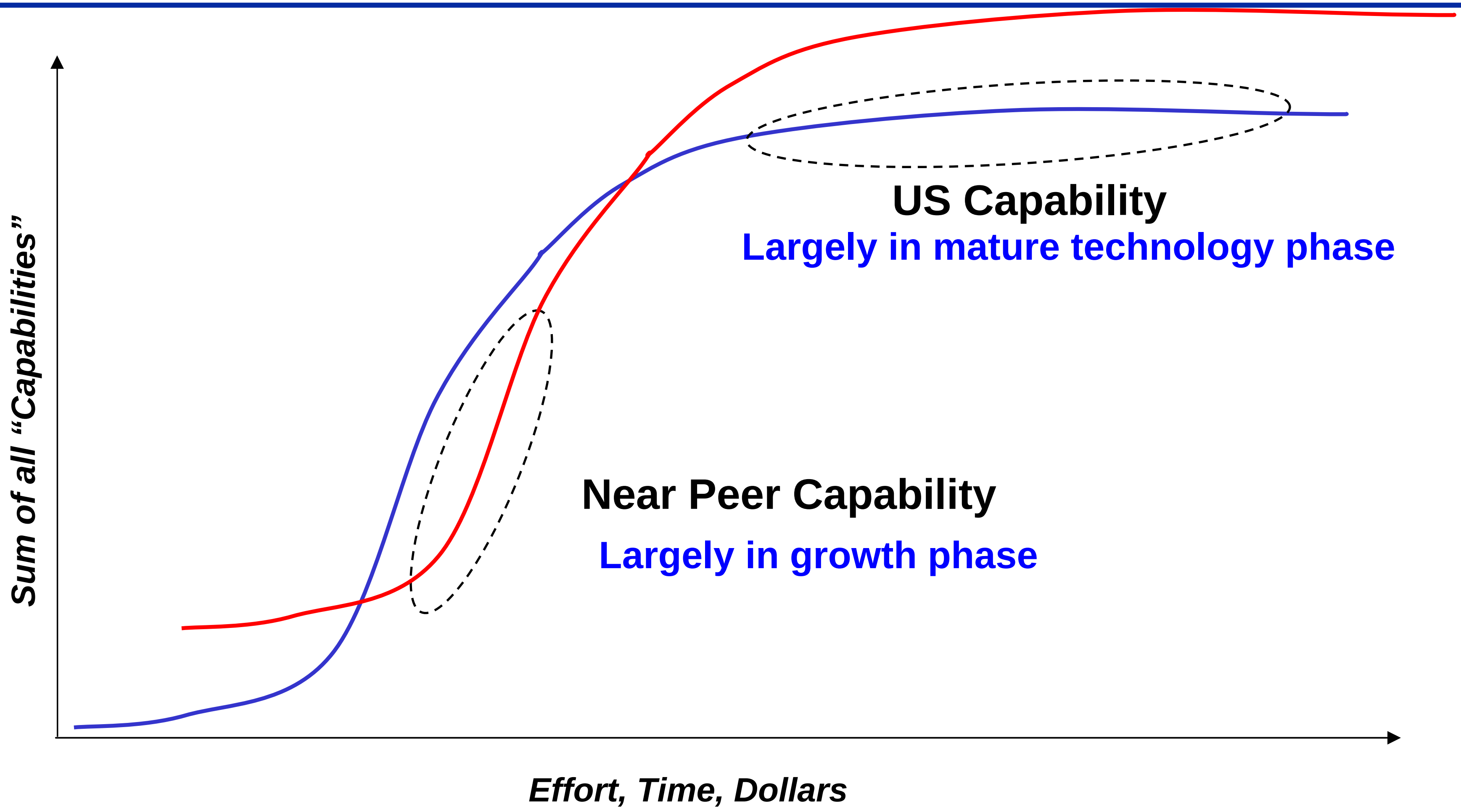
If you don't know where you are going, you might end up someplace else
Yogi Berra

These changes, among others, are ushering us toward a world where knowledge, power and productive capability will be more dispersed than at any time in our history – a world where value creation will be fast, fluid, and persistently disruptive.
Don Tapscott and Anthony Williams, Wikinomics



"The conjunction of 21st century internet speed and 12th century fanaticism has turned our world into a tinderbox" -- Tina Brown ,Washington Post, 19 May 2005

What Can Happen if We Hold onto Mature Technology Too Long



ASSERTION: Without changing the US investment profile, US could spend more yet have capability gap close

Technological "Shock" of Desert Storm

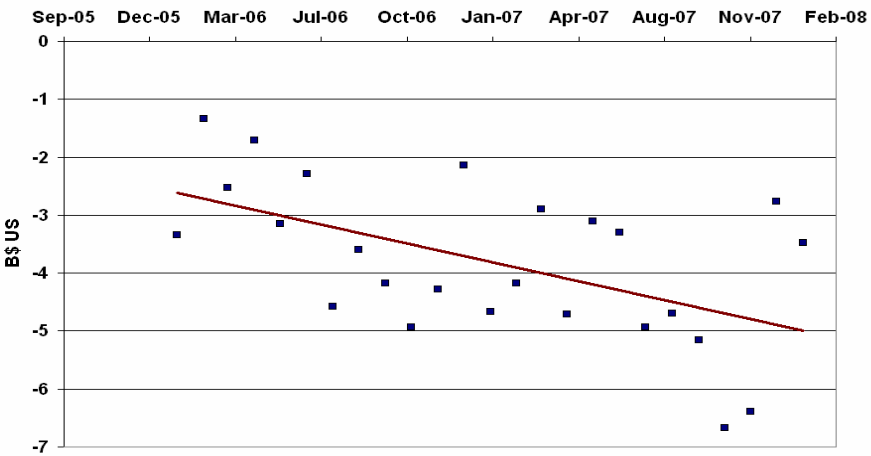
- Based on dominant US capabilities "in the commons"
  - Low observability
  - Spaced-based capabilities
    - Comms
    - GPS
  - Night Vision
  - Info Ops
  - Missile Defense



Mega-Trends Economy

The US Trade Balance

US Advanced Technology Products Trade Balance



Source: The Economist, Jan 24, 2008

- US Merchandise Trade Balance for 12 Months ending December 2007: 815.6B$
- Largest Advancing Technology deficits in these areas (2007YTD)
  - Information technology -7.9B
  - Life Sciences -1.7B
  - Opto-electronics -1.5B
  - Advanced Materials -0.8B
- Losses Outpaced gains in:
  - Aerospace +4.0B
  - Electronics +1.9B
  - Biotechnology +0.3B

Source: The Economist, March. 8, 2008

Source (FT900: U.S. International Trade in Goods and Services, Released January 2008, US Cencus Bureau), Data not Seasonally Adjusted
http://www.census.gov/foreign-trade/Press-Release/current_press_release/press.html

Disruptive Technologies

Frequently Take a Forcing Function

Technology	Approximate Date Of First Lab Demo		Approximate Date of First Military Apps	Technology
Radio	1901		1914	Electronics
Airplane	1903	*World War I*	1916	Internal Comb
Vacuum Tube	1906		1915	Electronics
Mechanized Tank	1916		1916	Engine/Metals
Liquid-Fueled Rockets	1922		1944	Chem/Metals
Radar	1925		1939	Electronics
Gas Turbine	1935		1944	Metals
Digital Computer	1943	*World War II*	1945	Electronics
Ballistic Missile	1944		1945	Chem/Guide
Nuclear Weapons	1945		1945	Physics
Transistor	1948		1957	Electronics
Inertial Navigation	1950		1955	Electronics
Nuclear Propulsion	1950		1954	Physics
Artificial Earth Satellites	1957	*Cold War*	1960	Computers
Integrated Circuit	1960		1970	Electronics
Laser	1961		1967	Photonics
Precision Weapons	1965		1967	Electronics

One function of S&T – Keep the pantry stocked

Disruptive Technology
A Case Study

- Digital Equipment Corporation:
  - 1957 -- Founded
  - 1960 -- Programmable Data Processor 1 (PDP-1) Introduced
    - World's First Minicomputer
    - 10% cost of Mainframe Computers
  - 1965 -- PDP-8 Rolled-out; World's #1 Selling Computer
  - 1970's – 1990—DEC #2 International Computer Sales
  - 1990 -- 120,000 Employees; Revenues $14B
  - 1998 – Company Bought by Compaq—and Dead

"It was the sudden demise of DEC that first drew my attention. How could a company, once described by Business Week as a freight train that obliterates all competitors, fall so precipitously?" Interview with Clayton Christensen, Harvard Business School on Line, April 1999

Central Technical Support Facility (CTSF)

U.S. Army Materiel Command

Terry Edwards
Chief Information Officer (CIO)
Chief Technology Officer (CTO)
HQ Army Materiel Command, CIO-G6
Ft. Belvoir, VA, 22060

April 15, 2008

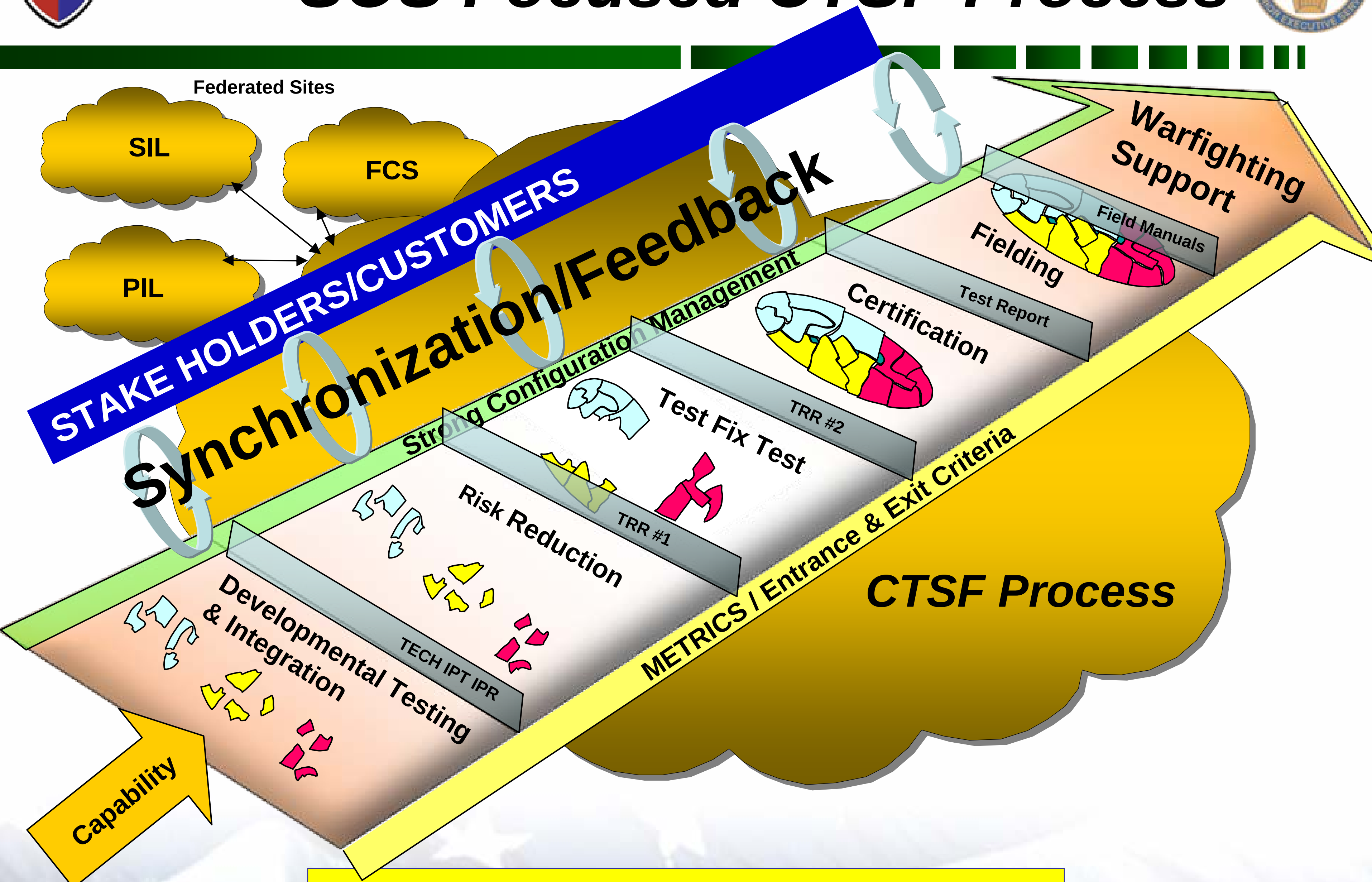
"Need to be faster, more agile, less bureaucratic - Need to fight this every day"

CTSF Mission

The CTSF provides a unique, innovative, and scalable environment, with skilled and dedicated personnel, using qualified synergistic processes in order to support the DoD's net enabled strategic vision by executing configuration management, systems engineering support, and interoperability certification testing for Army and Joint C4I providers.

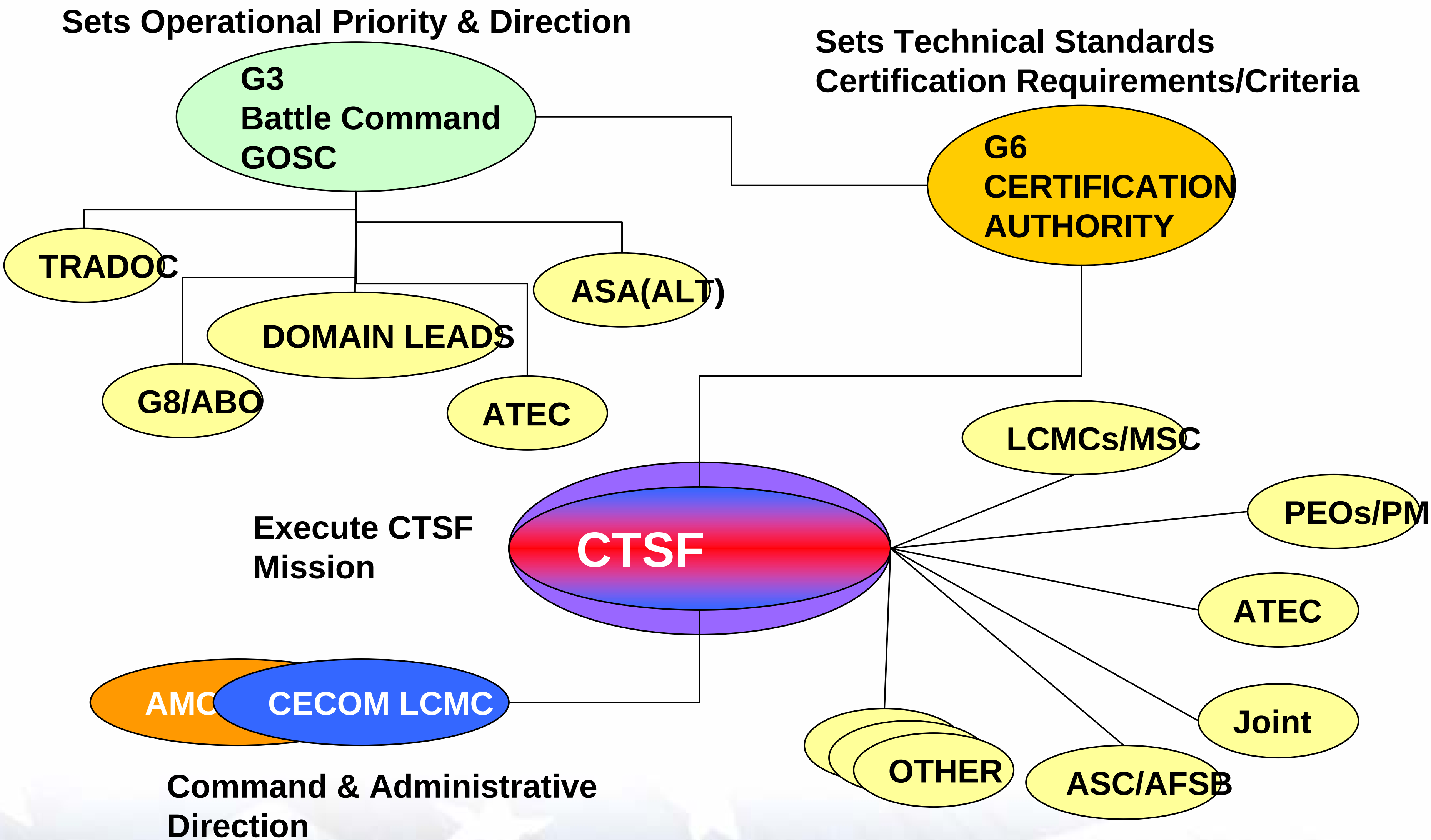
Promote a Lean Culture in All We Do.

SOS Focused CTSF Process



Promote a Lean Culture in All We Do.

Governance Structure



Promote a Lean Culture in All We Do.

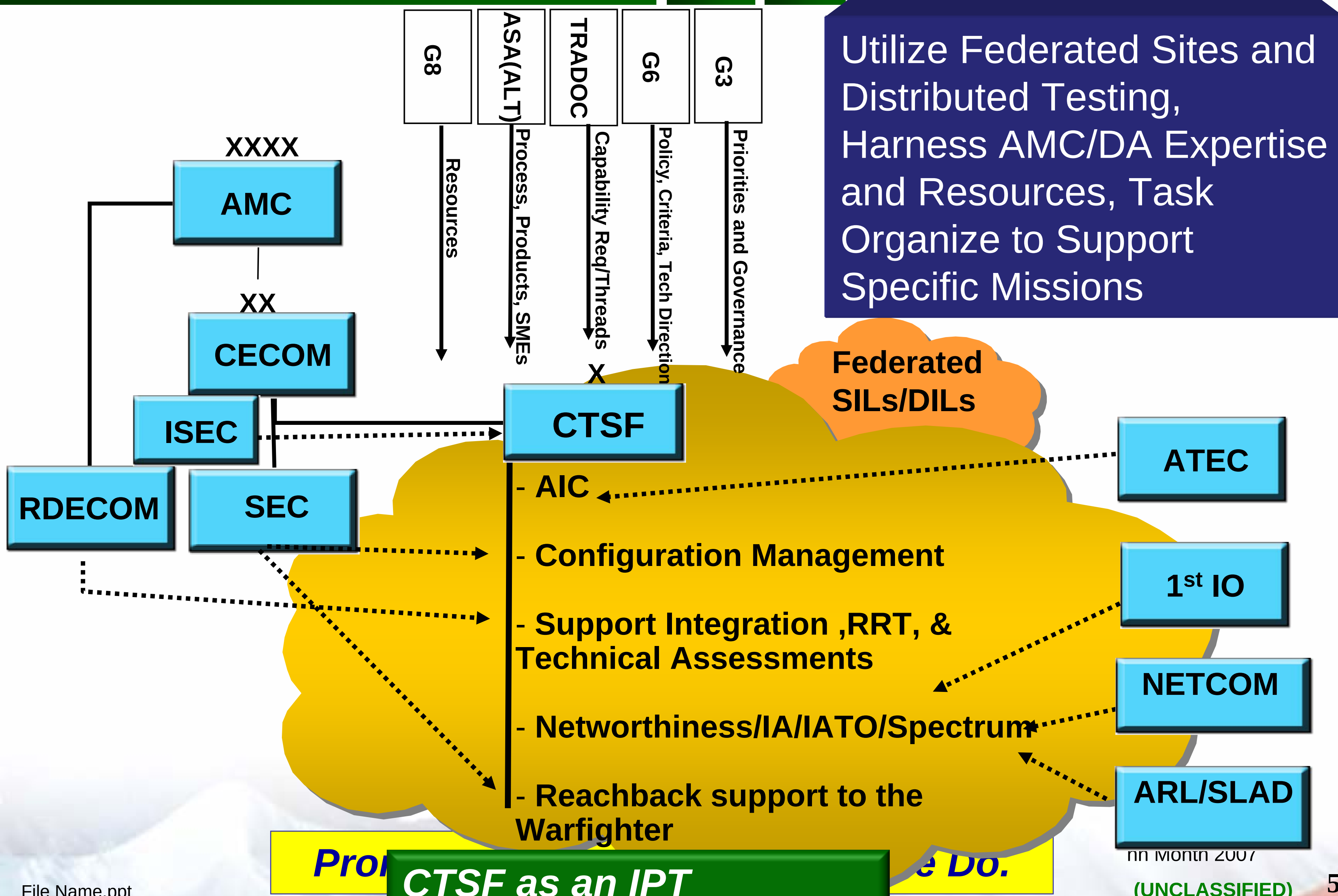
CTSF The Stats…

- **250,000 sq ft Facility:** 41,305 square feet dedicated to integration, testing and certification
- **Fully Wired Infrastructure:** with tactically representative routers, switches, hubs, fiber, 10Base2, 10BaseT and video to provide flexibility for test and exercise reconfiguration.
- **Instrumented Facility** for data collection and reduction equipment to support a vehicle platform to Corps level architecture, fully instrumented with SIM/STIM and data collection/reduction capability.
- **Configuration Control Capability** to support integration and fielding of Software
- **High Speed Communication Links** to facilities at Ft. Hood and externally to sister service sites, battle labs and contractor facilities; DREN access.
- **Established Processes** to support integration, testing, configuration management and training "Go to War" software.

Over 900 government civilians, and contractors form the Team of the CTSF to support, maintain & sustain the Army's digital systems deployed world- wide.

Promote a Lean Culture in All We Do.

Leveraging The Army "Task Organize for Success"



Partnering is Key

Promote a Lean Culture in All We Do.

Key to CTSF Success

- Unity of Command - no barriers, organizations coming together to get the job done on behalf of the Warfighter, synchronization of efforts
- CTSF missions serve many customers (i.e. G3, G6, ASA(ALT), G8, ATEC, Joint and Coalition Warfighters)
- Synergy → Focused on Warfighter Needs
- In depth technical understanding of systems
- Knowledge of warfighter needs and constraints
- A set of disciplined processes for Testing, CM, and System Engineering
- Formal/Informal Partnerships (PMs, Warfighter, Test Community, Joint Community, PdM Netops)
- Adaptable and Responsive
- Honest Broker
- Well known across Army → DoD

Promote a Lean Culture in All We Do.

Questions?

Serving our Army at War

CTSF

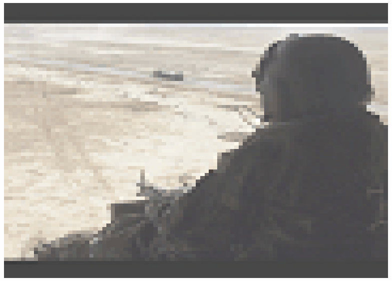
Relevant and Responsive

Promote a Lean Culture in All We Do.

Back-Up

CTSF Vision

To become a customer valued organization ensuring the best net-centric C4I capabilities are available to US Army, Joint and Coalition Warfighters.



Bottom Line: CTSF is the Interoperability "Check Ride" for Current & Future Army Programs

Promote a Lean Culture in All We Do.

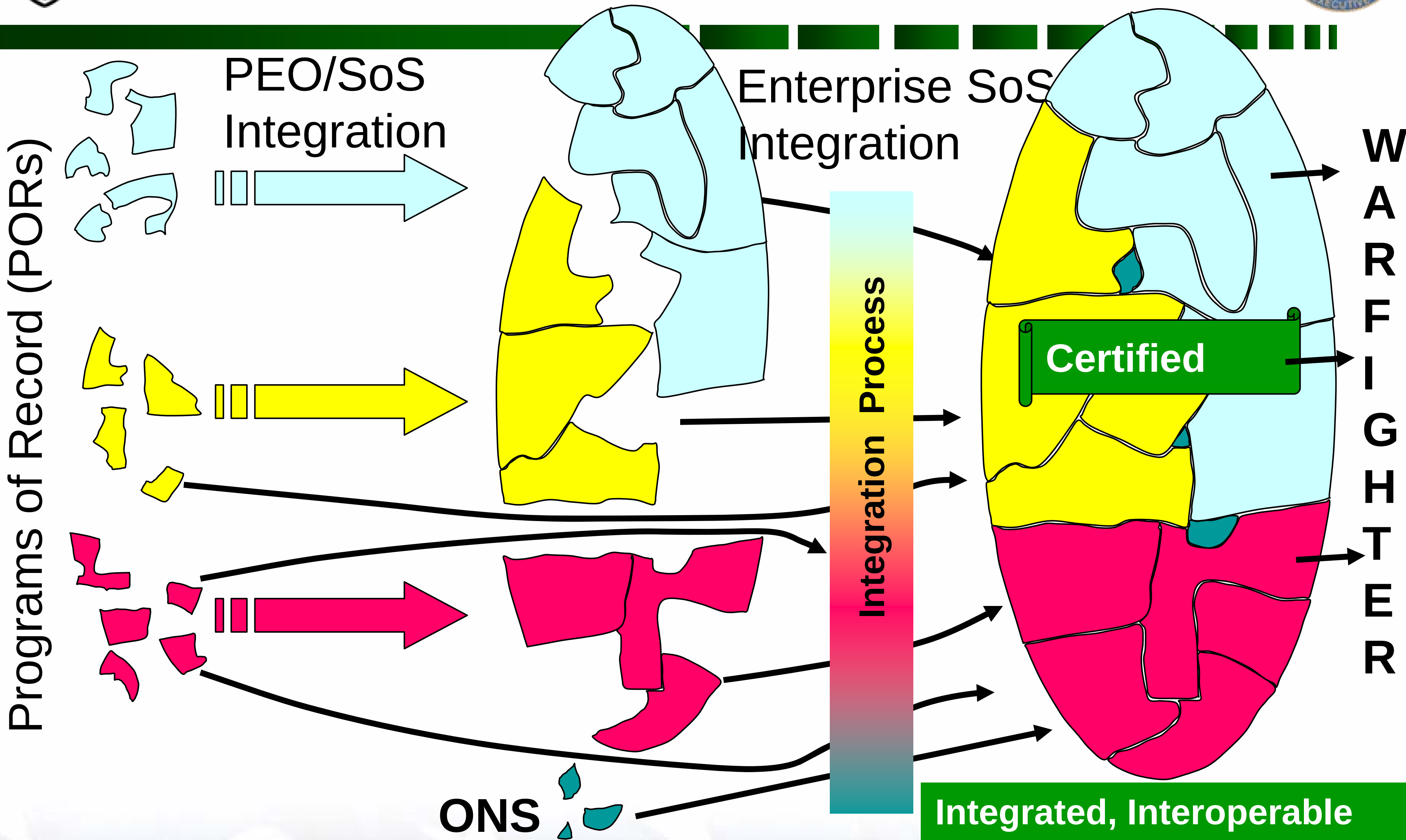
CTSF Organizational Evolution

Integration	Integration and Certification	
PEO C3T	PEOs, G6, CECOM, G3, G8	AMC, CECOM, PEOs, G6, G3, G8
CTSF *Trail Boss*	CTSF *Director*	CTSF *Director*
1 Digital Div *Proof of Principal* *SW Functionality*	*10 Digital Divs* *40+ BCTs* *C2 Interoperability*	*Future Digital Force* *Net Centric* *Interoperability*
11 Systems	***SWB 1 - 75+ Systems***	***Syst... AIC*** ***TB...***
ABCS Integration	**SoS Interoperability**	**A... Interop...ty**

JOINT

Promote a Lean Culture in All We Do.

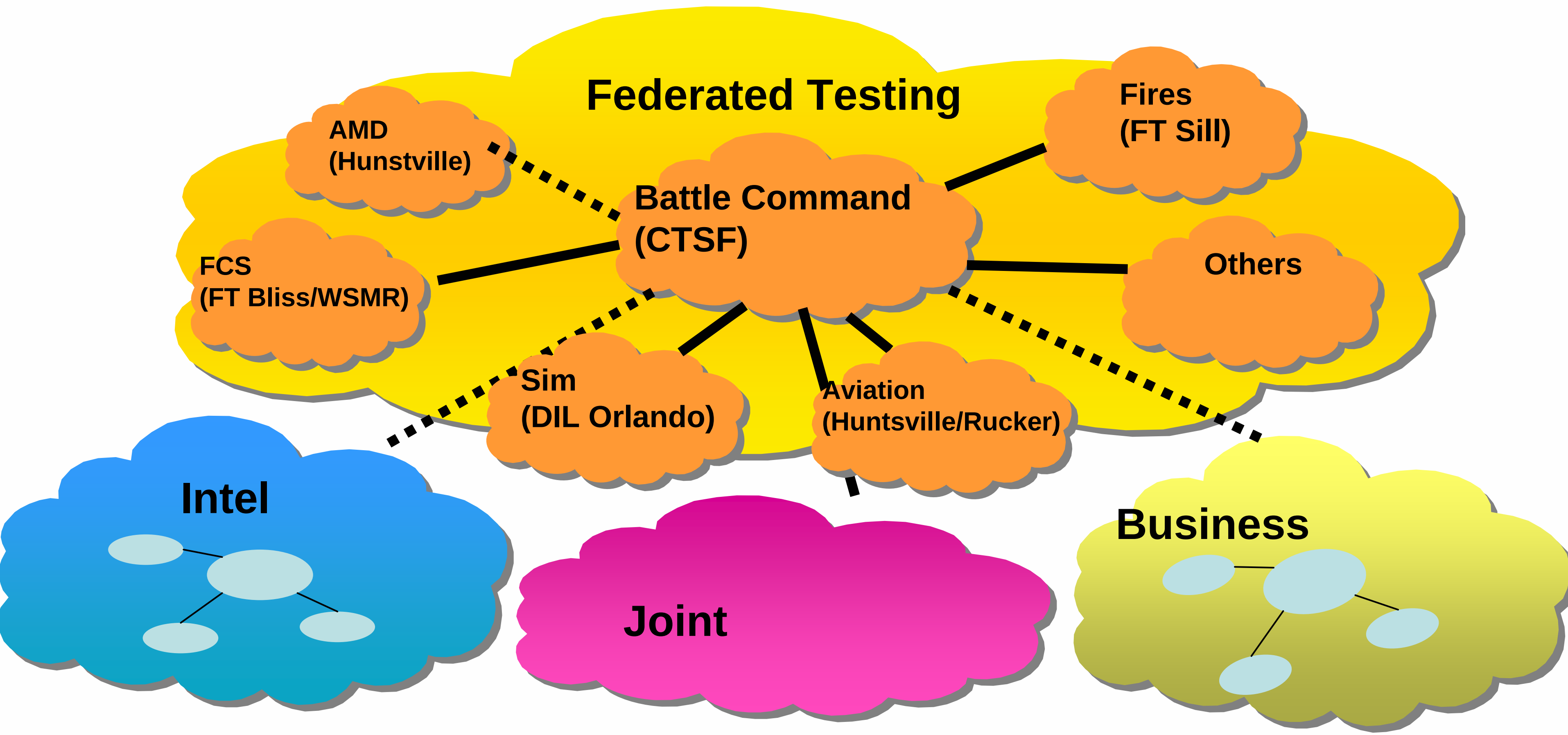
CTSF SOS Focus



Integrated, Interoperable Capabilities to the Warfighter!

Promote a Lean Culture in All W

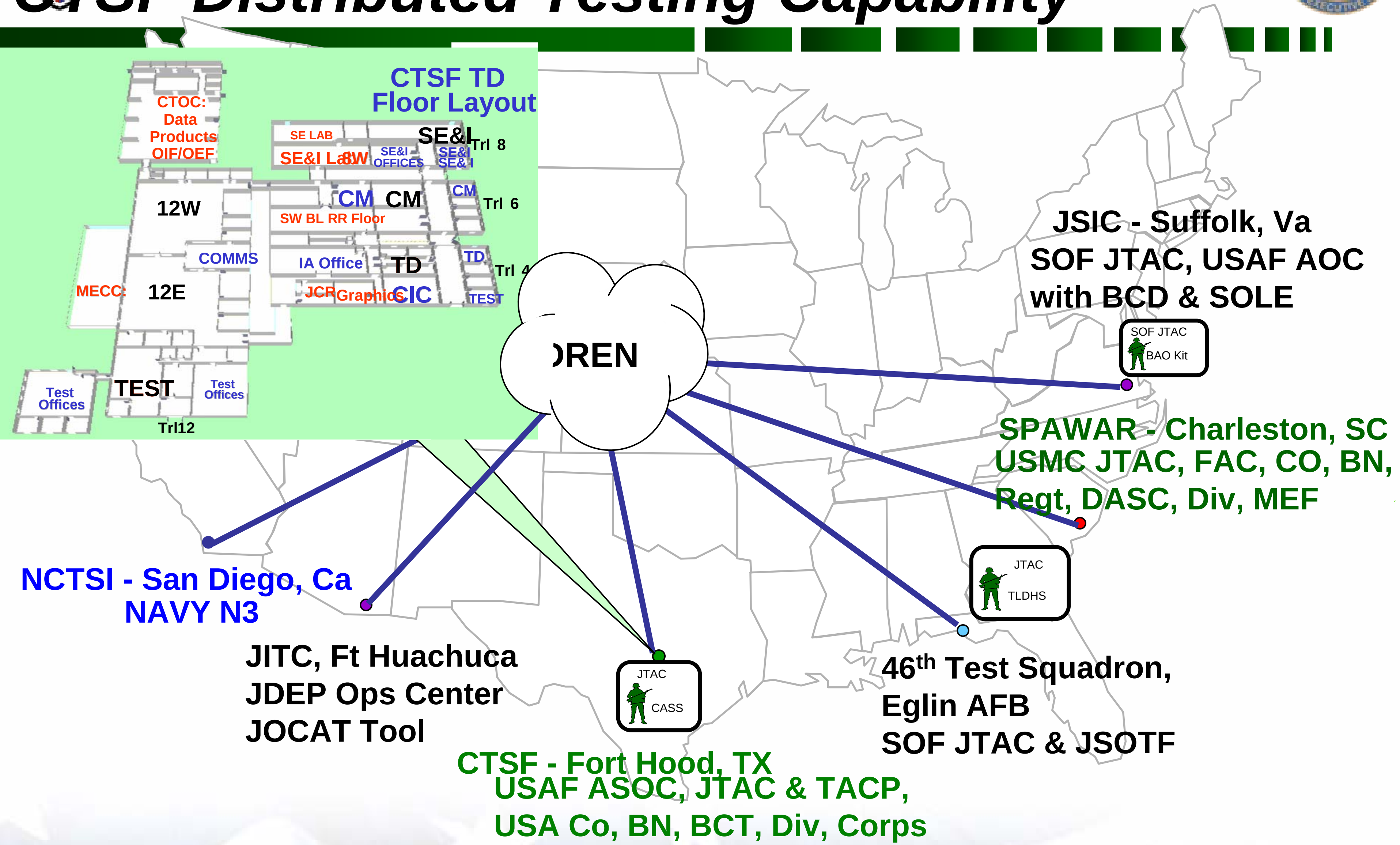
FANS Concept of Execution



Federated Army Net-Centric Sites

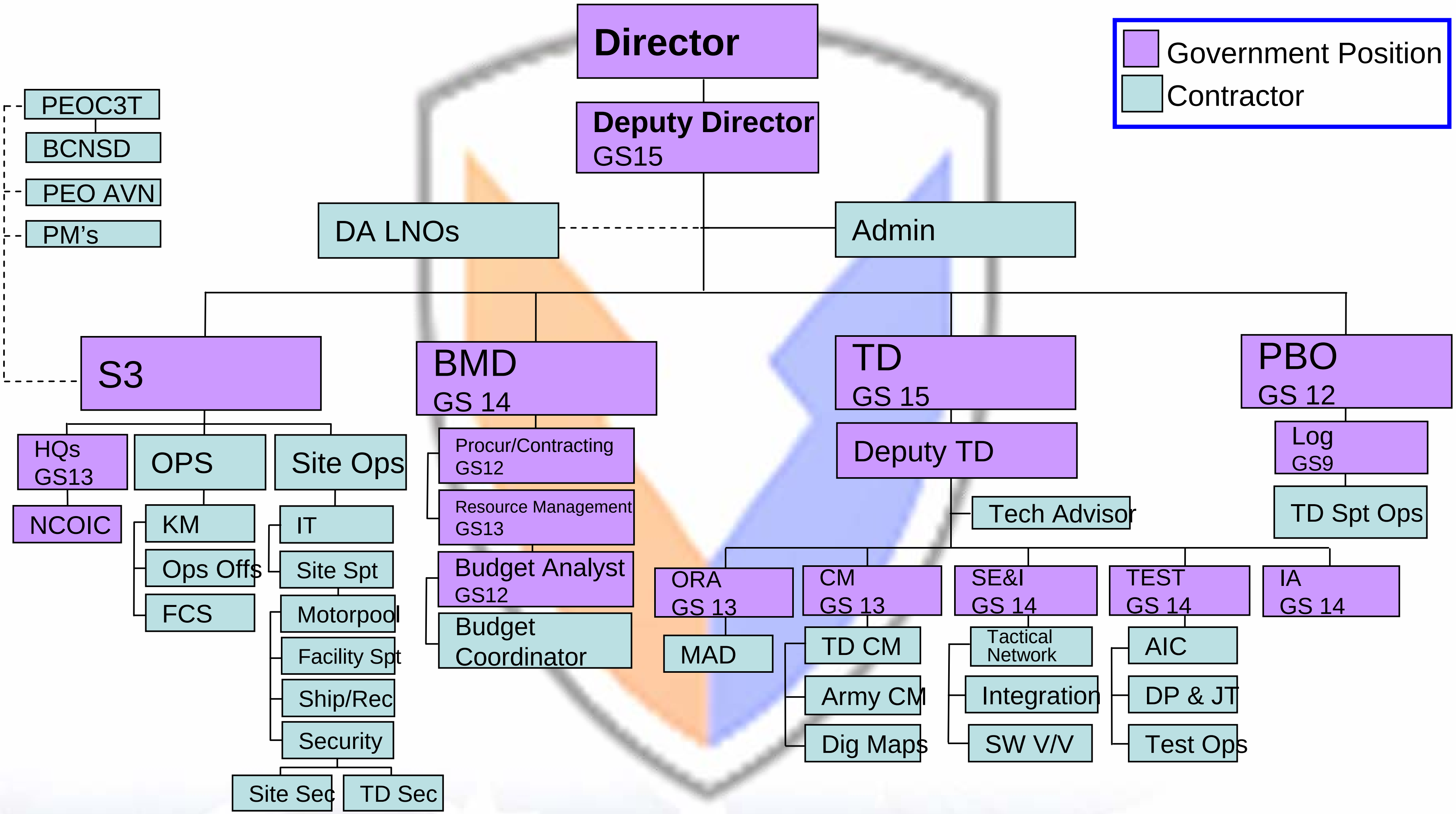
Promote a Lean Culture in All We Do.

CTSF Distributed Testing Capability



Promote a Lean Culture in All We Do.

CTSF Organization

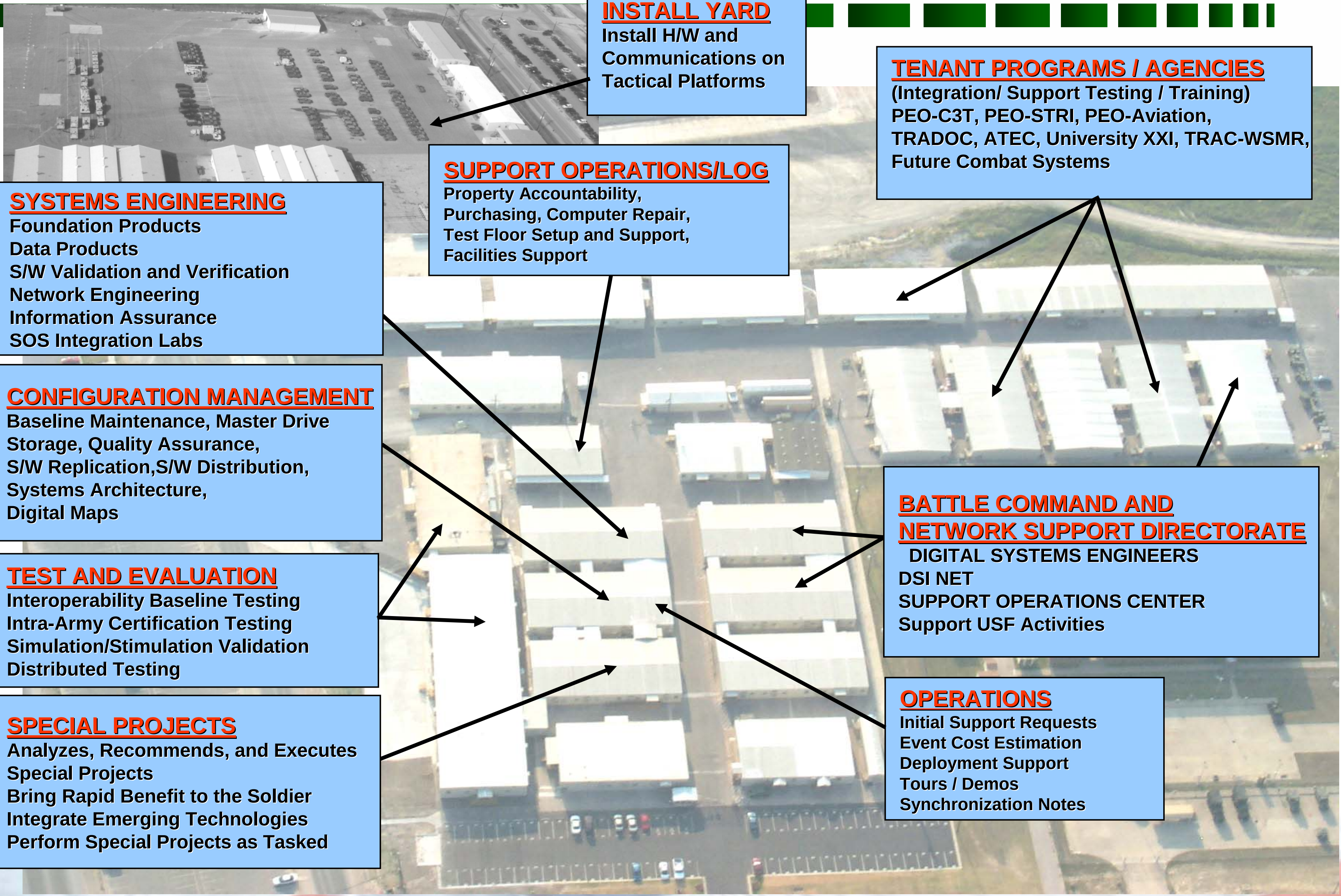


Promote a Lean Culture in All We Do.

CIO/CTO G6

(UNCLASSIFIED)

CTSF Campus



INSTALL YARD
Install H/W and Communications on Tactical Platforms

TENANT PROGRAMS / AGENCIES
(Integration/ Support Testing / Training)
PEO-C3T, PEO-STRI, PEO-Aviation, TRADOC, ATEC, University XXI, TRAC-WSMR, Future Combat Systems

SUPPORT OPERATIONS/LOG
Property Accountability,
Purchasing, Computer Repair,
Test Floor Setup and Support,
Facilities Support

SYSTEMS ENGINEERING
Foundation Products
Data Products
S/W Validation and Verification
Network Engineering
Information Assurance
SOS Integration Labs

CONFIGURATION MANAGEMENT
Baseline Maintenance, Master Drive Storage, Quality Assurance,
S/W Replication,S/W Distribution,
Systems Architecture,
Digital Maps

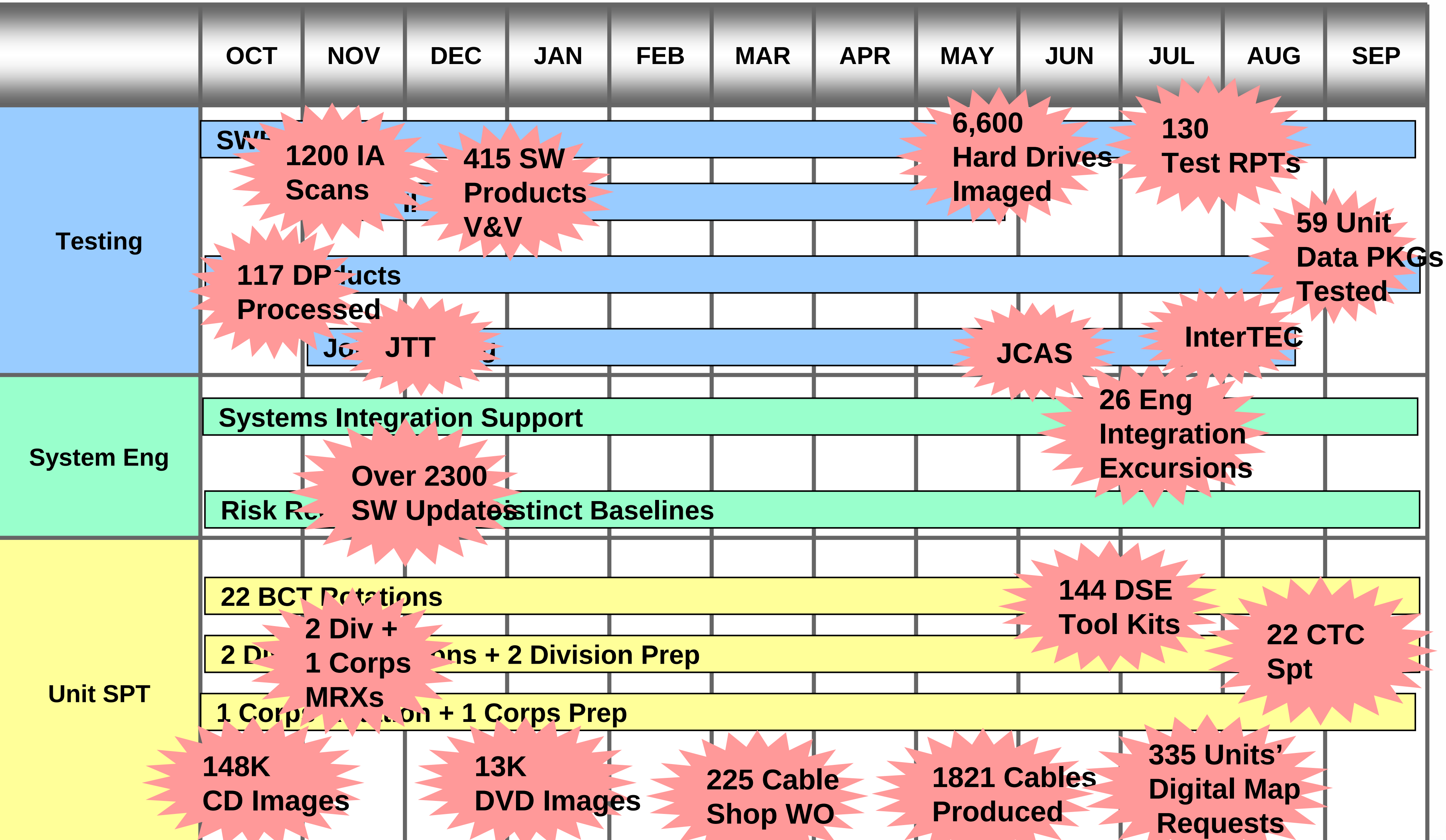
BATTLE COMMAND AND NETWORK SUPPORT DIRECTORATE
DIGITAL SYSTEMS ENGINEERS
DSI NET
SUPPORT OPERATIONS CENTER
Support USF Activities

TEST AND EVALUATION
Interoperability Baseline Testing
Intra-Army Certification Testing
Simulation/Stimulation Validation
Distributed Testing

OPERATIONS
Initial Support Requests
Event Cost Estimation
Deployment Support
Tours / Demos
Synchronization Notes

SPECIAL PROJECTS
Analyzes, Recommends, and Executes Special Projects
Bring Rapid Benefit to the Soldier
Integrate Emerging Technologies
Perform Special Projects as Tasked

FY07 Accomplishments



Promote a Lean Culture in All We Do.

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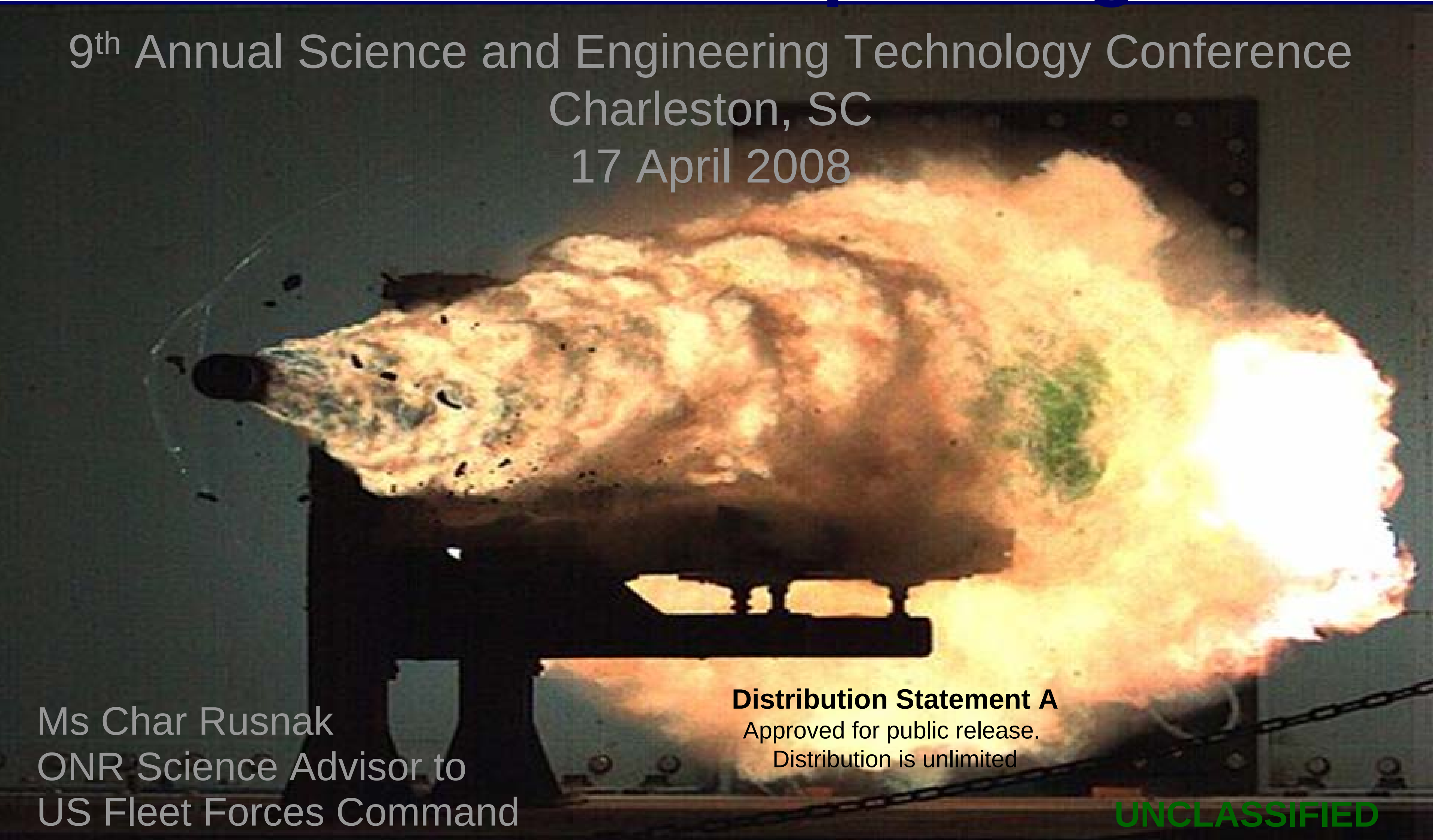
Technology Insertion: Fleet/Operating Forces



9th Annual Science and Engineering Technology Conference
Charleston, SC
17 April 2008

Ms Char Rusnak
ONR Science Advisor to
US Fleet Forces Command

Distribution Statement A
Approved for public release.
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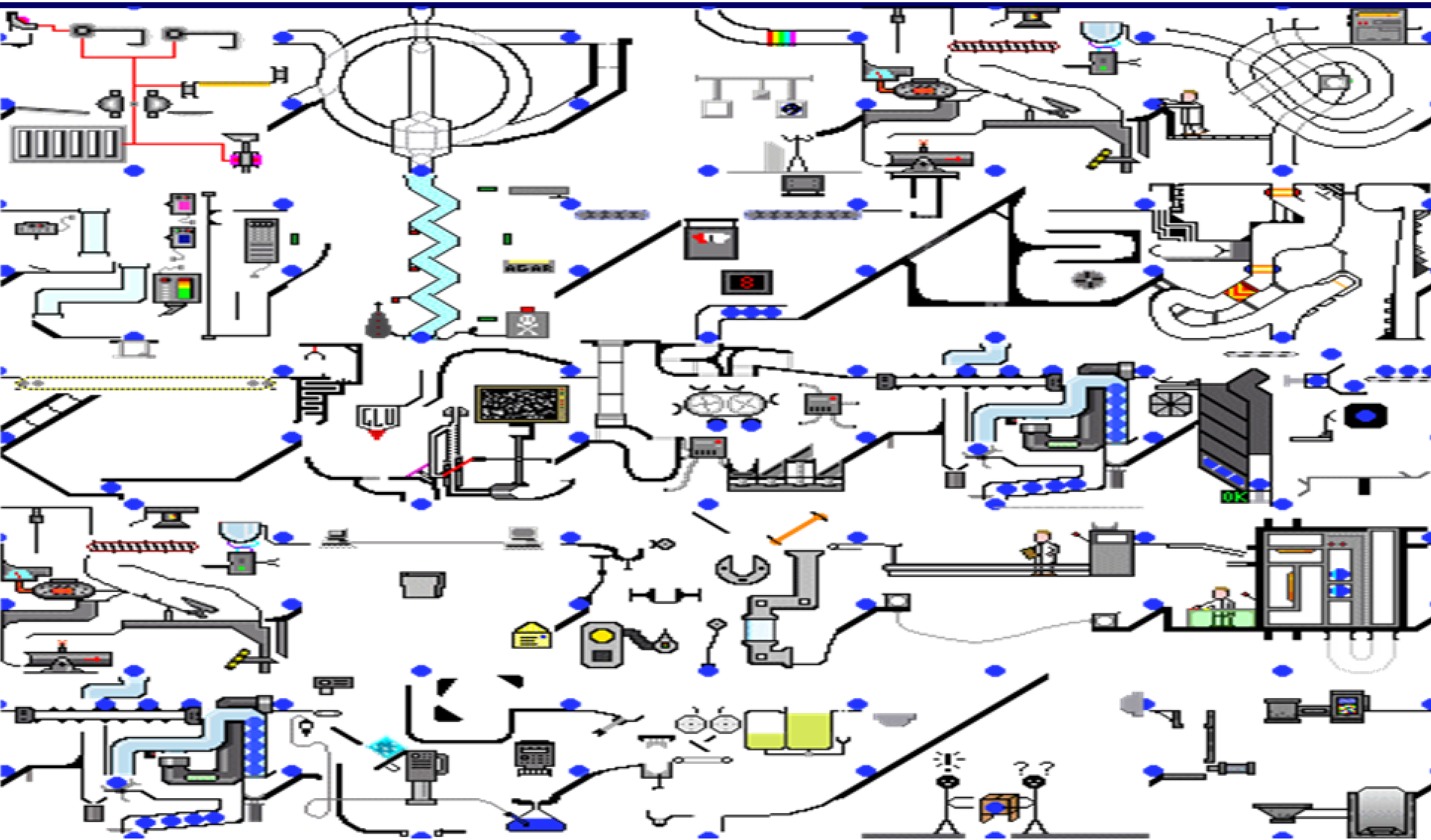
UNCLASSIFIED

Overview

- War Fighter Requirements Articulation
- War Fighter – S&T Community Interaction
- Technology Insertion Programs

Simplified S&T Process



Navy Senior Leader S&T Oversight

Technology Oversight Group – Navy Representatives

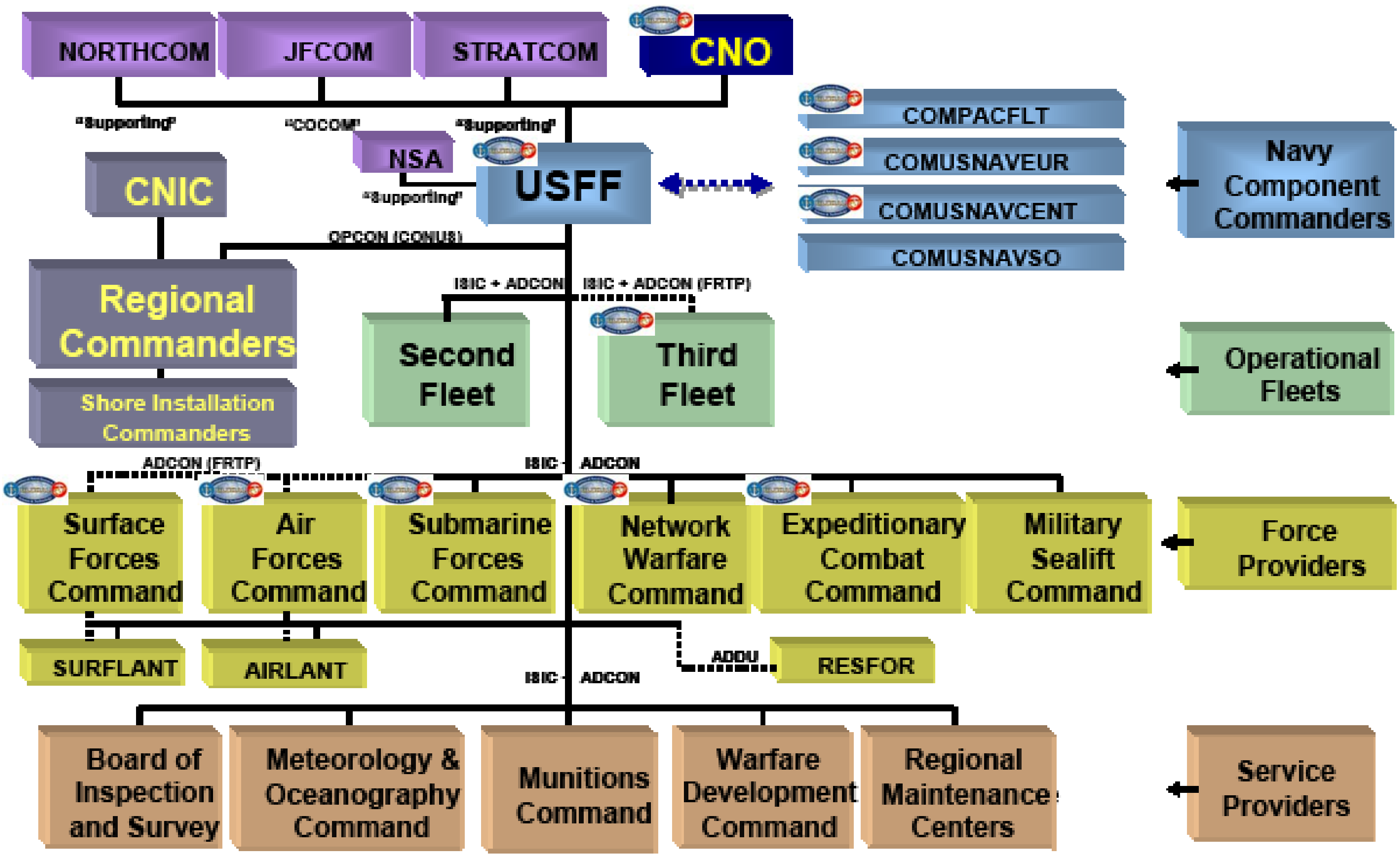
- Principal Deputy Assistant Secretary of the Navy, Research Development and Acquisition
  - Acquisition/Transition
- Chief of Naval Research
  - Technology Development
- Deputy Chief of Naval Operations, Integration of Capabilities and Resources (CNO N8)
  - Resources and Requirements
- Deputy Commander US Fleet Forces Command
  - Fleet War Fighting Requirements

US Fleet Forces Command Missions Functions and Tasks

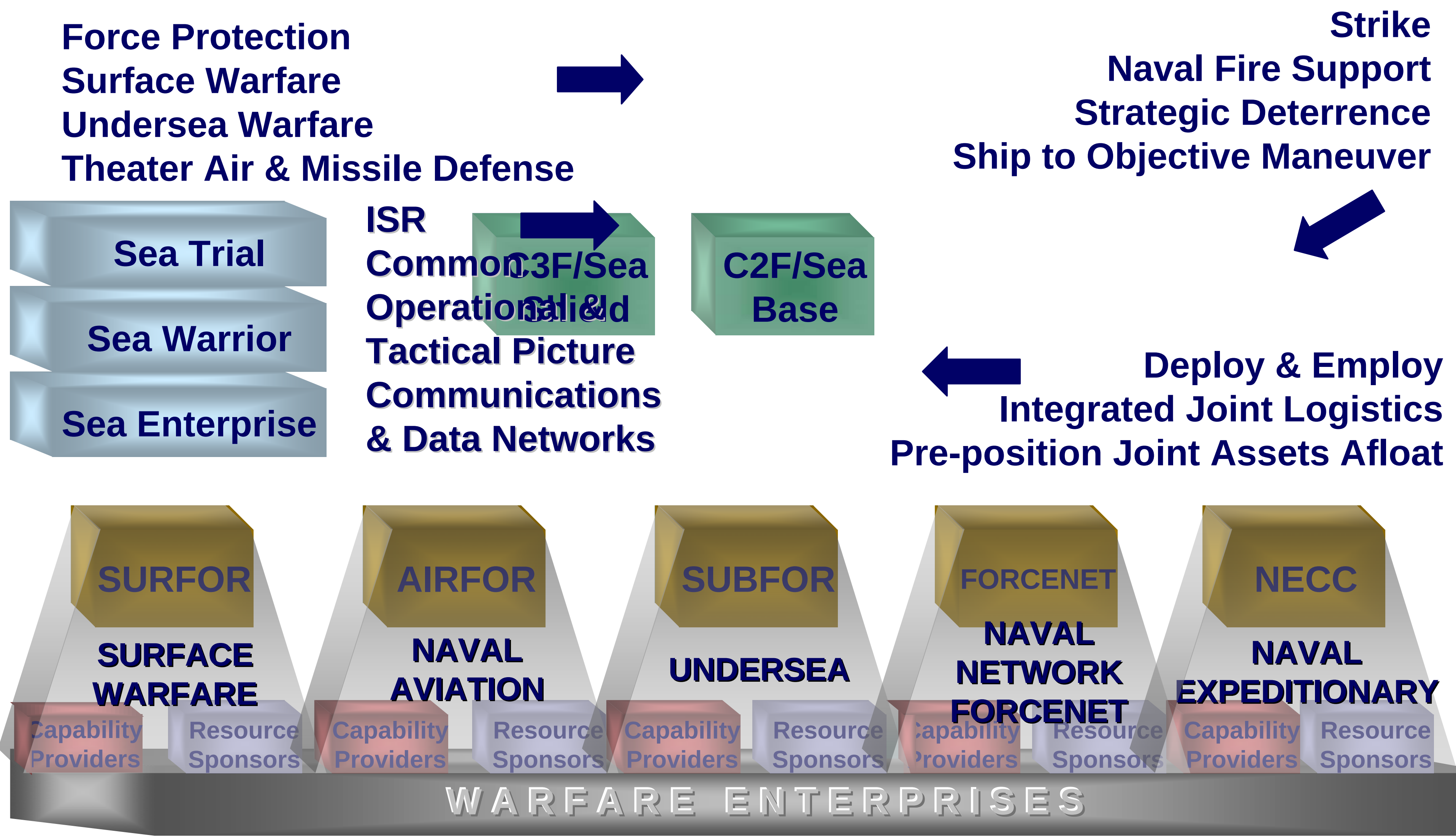
- **OPNAV INSTRUCTION 5440.77**
  - Section 2c: USFLTFORCOM will integrate and articulate authoritative fleet war fighting, readiness, and personnel capability requirements to the Chief of Naval Operations (CNO)
  - Section 5d1: (USFLTFORCOM will) Coordinate integration of US Pacific Fleet (PACFLT), US Naval Forces European Command (NAVEUR), US Naval Forces Central Command (NAVCENT), and US Naval Forces Southern Command (NAVSO) war fighting, readiness, personnel and capability requirements to the CNO

USFF Command Relationships

USFF Annual Plan 2008



Sea Power 21



Force Protection
Surface Warfare
Undersea Warfare
Theater Air & Missile Defense
Strike
Naval Fire Support
Strategic Deterrence
Ship to Objective Maneuver
Sea Trial
Sea Warrior
Sea Enterprise
ISR
Common Operational Tactical Picture
Communications & Data Networks
C3F/Sea Shield
C2F/Sea Base
Deploy & Employ
Integrated Joint Logistics
Pre-position Joint Assets Afloat
SURFOR
SURFACE WARFARE
AIRFOR
NAVAL AVIATION
SUBFOR
UNDERSEA
FORCENET
NAVAL NETWORK FORCENET
NECC
NAVAL EXPEDITIONARY
Capability Providers
Resource Sponsors
WARFARE ENTERPRISES

S&T Program Selection
Top Down, Requirements Driven

- Overarching National, Joint and Navy Strategies
- War Fighting Requirement Analysis
- Analysis of Existing Capabilities
- Gap Identification
  - Near Term (Fleet Focus)
  - Far Term
  - S&T Project Development to Address War Fighting Gaps
  - Fleet Input to Prioritize Execution of S & T projects
- War Fighter and S&T Community Work Together to Develop Capabilities to Fill Gaps

Technology Insertion Programs

- Future Naval Capabilities (FNC)
  - Provides capabilities to close war fighting gaps
  - Up to 5 years
  - Potential for Joint Capability Technology Demonstration (JCTD) program
    - Build upon FNC adding Joint/Coalition/Agency capability

- Rapid Technology Transition
  - Increases rate that new, innovative, and potentially disruptive technologies are inserted into acquisition programs
  - Technology Readiness Level 6 or higher, 2 yr, $2M program

Technology Insertion Programs (cont.)

- Rapid Development and Deployment Program
  - Rapid development and fielding of prototype solutions to meet urgent needs in the Global War on Terrorism
  - Validated Naval urgent need that requires rapid (270 days) development of material solutions not readily available off-the shelf
    - Naval Innovation Laboratory
- Sea Trial
  - Speed development of new concepts and technologies to the war fighter
    - Wargaming, experimentation, and exercises
  - Candidates with the greatest potential to provide dramatic increases in war fighting capability

Summary

- USFF is responsible for integrating and articulating authoritative fleet war fighting requirements to the CNO
- Navy S&T requirements are a part of the overall Navy requirements generation process
  - Senior leadership oversight
- Representatives from requirements, resources, development and acquisition work together from the beginning to support technology transfer in the Navy
- Multiple venues are available for technology transfer

Office of Naval Research

USN

GLOBAL

Science & Technology

Sea Power 21

Anti-Submarine Warfare
Defensive Surface Warfare
Theater Air & Missile Defense
Force Protection, Mine Warfare
C3F/Sea Shield
Naval Fire Suppor
Strategic Deterrenc
Offensive Surface Warfar
Ship to Objective Maneuve
Sea Trial
Sea Warrior
Sea Enterprise
ISR
Common Operational & Tactical Picture
Communications & Data Networks
FORCENET
C2F/Sea Strike
C2F/Sea Base
Deploy & Emplo
Integrated Joint Logistic
Pre-position Joint Assets Aflo
SURFOR
SURFACE WARFARE
AIRFOR
NAVAL AVIATION
SUBFOR
UNDERSEA
NNWC
NAVAL NETWORK FORCENET
NECC
NAVAL EXPEDITIONAR
apability roviders
Resource Sponsors
Capability Providers
Resource Sponsors
Capability Providers
Resource Sponsors
apability roviders
Resource Sponsors
Capability Providers
Resourc Sponso
WARFARE ENTERPRISES

Honeywell Aerospace MRA's for Systems & Product Families

NDIA Science, Engineering, & Technology Conference
Manufacturing Technology Industry Panel

Dr. Al Sanders
Advanced Manufacturing Engineering
Honeywell Aerospace
April 17, 2008

Honeywell

Honeywell MRL History

Honeywell

- **MRL used on key NPD programs since fall 2005**
  - Criteria based on May 2005 DoD TRA Deskbook definitions
  - Maturity model developed to baseline key NPD programs
  - Assessments driven by newly formed AME organization
  - Over 300 assessments (including updates) conducted to date

- **Enabling DFM analysis tools developed to assist evaluations**
  - Quantitative first order analyses to identify design shortfalls
  - Enable "what if" analyses to quantify impact of design changes
  - Score card metrics developed to report and track improvements

- **Recent MRL applications on key programs and pursuits**
  - DARPA Micro Air Vehicle (MAV) lab to production transition
  - Army HTS900 Milestone C review leading to an LRIP decision
  - Airbus A350 XWB Avionics and Mechanical Systems pursuits

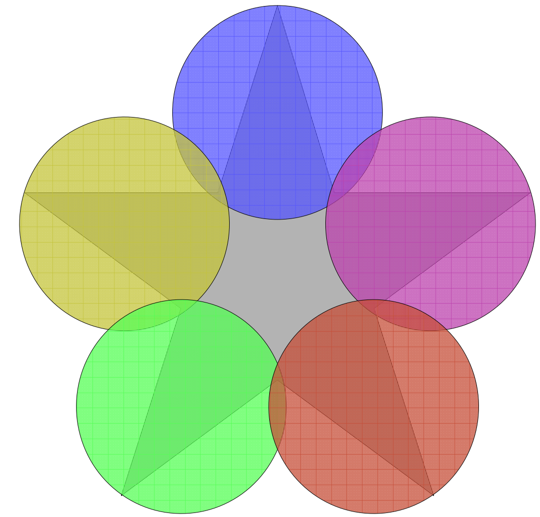
MRL Assessments Integral to AME Operating System

Honeywell MRL Maturity Assessment

Honeywell

- **Manufacturing Readiness Levels**
  - Based on DoD Definitions & Exit Criteria
  - Scoring criteria include product focus
  - Allow product or technology baselines
- **Honeywell MRL maturity assessment**
  - Five rating categories (threads)
  - Standardized exit criteria for each level
  - Maps to TRL & IPDS Process

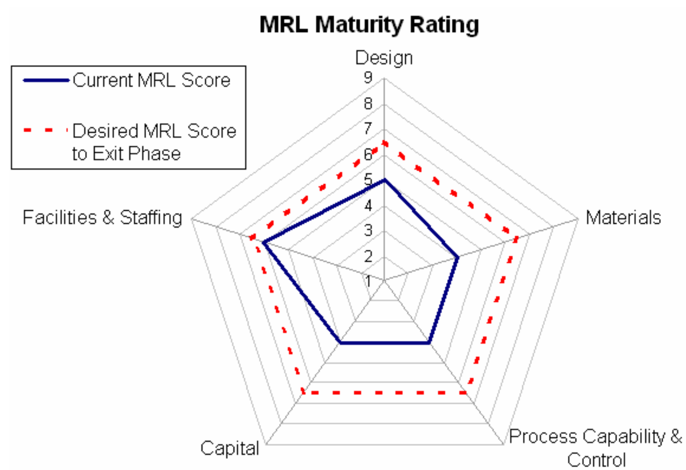
Manufacturing Readiness Elements



Paper Studies | Technology Development | Technology Insertion

Technology Readiness Level (TRL)											
TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6	TRL 7		TRL 8	TRL 9		
Basic principles observed and reported	Technology concept and/or application formulated	Analytical and experimental critical function and/or characteristic proof of concept	Component and/or breadboard validation in laboratory environment	Component and/or breadboard validation in relevant environment	System/subsystem model or prototype demonstration in a relevant environment	System prototype demonstration in the actual relevant environment or application		Actual system completed and "flight qualified" through test and demonstration	Actual system "flight proven" through successful mission operations		
Manufacturing Readiness Level (MRL)											
MRL 1	MRL 2	MRL 3	MRL 4	MRL 5	MRL 6	MRL 6.5	MRL 7	MRL 8	MRL 9	MRL 10	
Manufacturing gap assessment	Manufacturing concept formulation	Manufacturing concept development	Laboratory manufacturing processes identified	Manufacturing process development	Critical manufacturing process development	Prototype manufacturing system	Prototype manufacturing demonstration	Manufacturing process maturity demonstration	Manufacturing processes proven	Sustain and continuous improvement	
Pre-IPDS			IPDS 1	IPDS 2		IPDS 3	IPDS 4	IPDS 5	IPDS 6		IPDS 7
Novel Concepts and Emerging Technologies			Pre-Concept	Concept		Product Definition	Detailed Design	Product Validation	Delivery, Support, & Improvement		Sunset

Linkage to DoD Milestones A B C

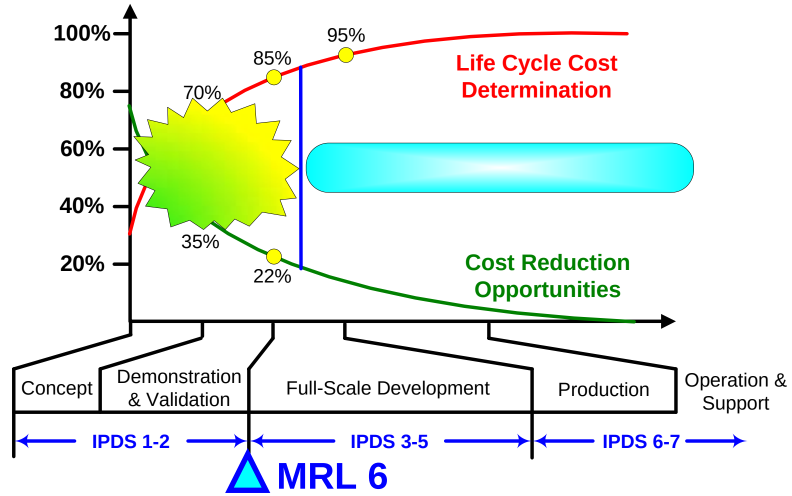


Original DoD Criteria used as Basis for Internal MRL Model

Early MRL Motivation at Honeywell

Honeywell

- Early decisions responsible for many production ramp issues
  - Actual costs exceed estimates
  - Quality levels below expectations
  - Low yield and delivery problems
  - Service related reliability issues
  - Supply chain inefficiencies



Source: DARPA Rapid Design Exploration & Optimization Project

- MRL's drive proactive planning
  - Sets agenda for risk mitigation
  - Mfg requirements defined early
  - Optimal supply chain strategies
  - Synchronizes SBU/ISC/E&T
  - Applies to both technology AND system development programs

What does MRL 6 Mean?

Manufacturing Risks Identified & Planned For

- *Design Cost & Producibility Drivers*
- *Potential Availability & Yield Issues*
- *Baseline Architecture DFM Shortfalls*
- *Industrial Base Capability Gaps*
- *Capital Investment Needs & Rationale*
- *Alignment of Supply Chain Strategies*

Critical to Identify and Plan for Shortfalls in Early Phases

MRL Applications within Honeywell

Honeywell

- **Technology Development (Low TRL, Low MRL)**
  - Many technology demonstrators push manufacturing limits
  - MRL maturation being driven lock-step with TRL maturation
- **New Product Development (High TRL, Low MRL)**
  - Mature “similar to” baselines often have producibility issues
  - Key is pinpointing shortfalls early during concept definition
- **Supplier Transition/Reposition Risk Mitigation**
  - Global supply base continues to be an ever changing entity
  - Knowing gaps early accelerates supplier development
- **“Red” Program Deep Dives and Recovery Plans**
  - Pinpoints root cause of problem areas needing attention
  - Focuses program recovery on next steps to address gaps

MRL has Applications throughout Product Life Cycle

MRL and Enabling AME Tool Linkage

Honeywell

Assessments for sub-systems (e.g. avionics box)

- **Assessment triggers to identify high risk sub-systems & components**

- **Manufacturing Readiness Level (MRL) maturity model**
  - **-Macro view of systemic supply chain top level risk areas**
  - **-Enables proactive risk identification and mitigation plans**

Assessments for components (e.g. circuit card assembly)

- **Complexity analyses to quantify manufacturing difficulty**
  - **-Captures first order design attributes driving complexity**
  - **-Enables "what if" design simplification trade studies**
- **Yield analyses for up-front prediction of quality targets**
  - **-Correlates defect opportunities with process capability**
  - **-Establishes "upper bound" on anticipated first pass yield**
- **DFM score card analyses to quantify impact of DFM violations**
  - **-Quantifies impact of first order DFM drivers on producibility**
  - **-Enables designs to be "graded" based on ease of producibility**

AME Enabling Tools Developed to Assist Assessments

Platform/System MRL Scorecard

Honeywell

Sub-Systems	AME Prod Line Mgr	Priority	IPDS Phase	Risk Assess WS Complete (Stat)	Overall MRL Assessment (MRL)	Producibility Metric	Complexity Assessment (Tool data)	Yield Assessment (Tool data)	DFM Scorecard (Tool data)	Greensheet Impact (GS)	Comments
Integrated Avionics Unit					5						
Chassis Cabinet	J. Smith	High	6	Y		TBD	TBD	TBD	TBD	Y	Sheet-metal cabinet with low yield (66%) and card insertion issues
Power Supply CCA	J. Smith	High	6	Y		TBD	TBD	TBD	TBD	TBD	(To be scheduled)
Processor CCA	J. Smith	High	5	Y		G	G	G	G	G	Closing Manufacturing and test issues for final release to production line
Control I/O CCA	J. Smith	High	6	Y		Y	G	Y	Y	Y	Redesign required to address 486 processor obsolescence issue, functional test unit needs troubleshooting
Generic I/O CCA	J. Smith	High	6	Y		TBD	TBD	TBD	TBD	TBD	(To be scheduled)
Control Module	J. Smith	High	5	Y		G	G	G	G	G	Closing out manufacturing and test issues for final release to production line
Crew Interface Display Unit					7						
Flat Panel Display	B. Johnson	High	6	Y		Y	Y	Y	Y	Y	Moderately complex design requiring [illegible] assembly, moderate DFM violations noted
Graphics Processor CCA	B. Johnson	High	5	Y		G	G	G	G	Y	Just completing IPDS Phase 5 with TSO submitted
Tray	B. Johnson	Low	6	N/A		N/A	N/A	N/A	N/A	N/A	COTS purchased part
Backshell I/O Connector	B. Johnson	Low	6	N/A		N/A	N/A	N/A	N/A	N/A	COTS purchased part
Backshell Power Connector	B. Johnson	Low	6	N/A		N/A	N/A	N/A	N/A	N/A	COTS purchased part
Cursor Control Device	B. Johnson	Low	6	N/A		N/A	N/A	N/A	N/A	N/A	COTS purchased part
Multifunction Keyboard	B. Johnson	Low	6	N/A		N/A	N/A	N/A	N/A	N/A	COTS purchased part
Reversion / Dimming Panel	B. Johnson	Low	6	N/A		N/A	N/A	N/A	N/A	N/A	COTS purchased part
Electronic Standby Indicator	B. Johnson	Low	6	N/A		N/A	N/A	N/A	N/A	N/A	COTS purchased part
Inertial Reference System					5						
Processor CCA	H. Simpson	M	4	Y		R	G	G	R	G	[illegible] DFM violations, DFM scorecard =60%
Power Supply CCA	H. Simpson	M	4	Y		G	G	G	G	G	[illegible] manufacturing issues
MEMS Gyro CCA	H. Simpson	M	6	Y		R	Y	R	Y	[illegible]	Moderately complex board (5.3), significant yield issues (30%), DFM scorecard=87%, yield improvement re-spin not included in green sheet
Accelerometer CCA	H. Simpson	M	3	Y		Y	G	Y	Y	G	Low complexity board (2.7), predicted first pass assembly yield of 80%,
Connector CCA	H. Simpson	M	4	Y		G	G	G	G	G	[illegible] manufacturing issues

Green – No Concern

Yellow – Minor Concern

Red – Major Concern

Sub-System BOM Breakdowns

MRL & DFM Assessment Results

Green Sheet Assumption Impact

Assessment Details and Next Steps

Scorecard "Bundles" Component Level Assessments

Summary and Conclusions

Honeywell

- Streamlined product MRL assessment developed for internal use
  - Leverages industry standard criteria in a repackaged format
  - MRL assessments called out as part of internal IPDS process
  - Proprietary enabling DFM tools developed to assist with ratings
  - Over 300 assessments (including updates) conducted to date
  - Process used during key pursuits to understand risks/opportunities

- Investigation of MRL for “aircraft system” concept evaluations
  - DoD criteria applicable to component technology development
  - Honeywell version adapted criteria to reflect a sub-system focus
  - System level application requires “system engineering” philosophy
  - Tier 1 MRL (new) would focus on overall supply chain architecture
  - Tier 2 MRL (current) would focus on component level manufacturing

Early Industrial Base Design around Product is Key

Questions?

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Honeywell

Raytheon

Customer Success Is Our Mission

Technology & Manufacturing Readiness Assessments @ RMS

Dale Iverson

April 17, 2008

Contents

- History of Technology & Manufacturing Readiness Assessment (T&MRA) Activities at RMS
- T&MRA Project
- Lessons Learned

History of T&MRA Activities at Raytheon Missile Systems (RMS) – 2005 & 2006

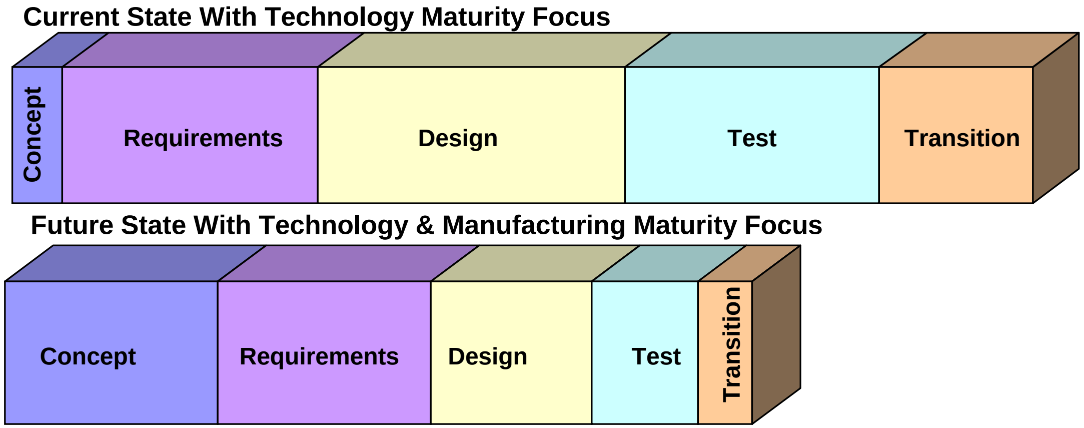
Raytheon

- **2005**
  - – RMS leader attended Defense Acquisition University course…first delivery of Manufacturing Readiness Level (MRL) materials
  - – ManTech white papers, quad charts & proposals require MRLs & notional MRL Maturity Plans (MMP)
- **2006**
  - – RMS employees attended MRA training course established by Air Force Research Lab (AFRL)
  - – 2-Part Pilot MRAs conducted by AFRL on AMRAAM Program
  - – RMS Kicked-off T&MRA Project with Raytheon Six Sigma Team
  - – Full Time MRA Manager assigned to Air-to-Air Product Line
  - – Joint Service ManTech Program Awarded, required MMP
  - – Conducted first independent T&MRA on Radome portfolio
  - – T&MRA @ RMS website goes live

Raytheon

It Simply Makes Good Business Sense!

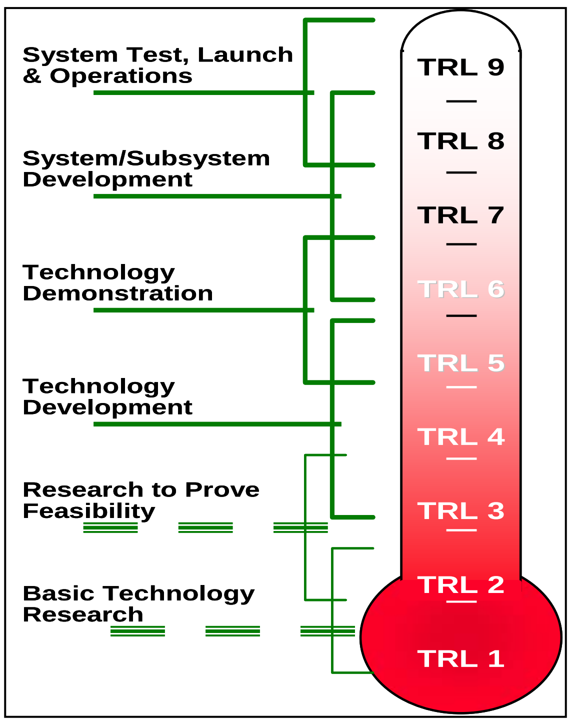
- Establishing TRLs, MRLs and maturity plans in accordance with the DoD's TRA & MRA requirements is not only necessary to support customer led assessments, but also:
  - T&MRA processes can change the culture by driving a collaborative partnership between programs, design and manufacturing engineering earlier in the product development life cycle where maturity efforts can have greatest impact on improving program affordability and predictability
  - Lower risk designs lead to shorter development cycles with fewer design re-starts, more accurate delivery dates, and lower overall development costs
    - Can mitigate 20% post CDR cost growth trend noted in GAO reports
    - Cost reductions of 30% or more can be achieved



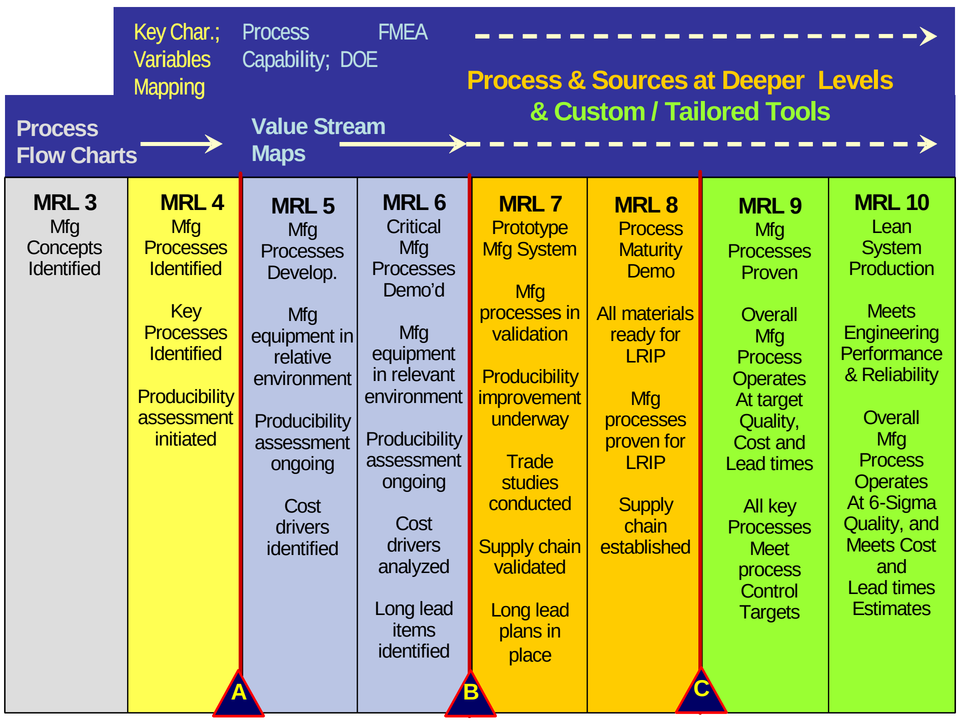
T&MRA @ RMS Project Vision

Technology & Manufacturing Readiness is integrated and measured in RMS business practices and culture.

Established TRA Process:
Technology Readiness Assessment



New MRA Process:
Manufacturing Readiness Assessment



T&MRA @ RMS Project Focus Areas

- Awareness & Training
  - T&MRA socialization across RMS & Raytheon
  - T&MRA preparation and facilitation training
- T&MRA Knowledge Management
  - Environmental scanning, knowledge capture, information warehousing & easy access (e.g. website, docushare and eRooms)
  - Capture lessons learned from internal & external cycles of learning
  - Assist DoD in the shaping MRA regulations, policies, and processes
- Standardization of T&MRA @ RMS Processes
  - 10-Step process created (includes capture of lessons learned)
  - Aligned with DoD MRA process, combined with DoD's TRA
- Directive System Support
  - Modify Directives, Proposals, Contracting, Practices, Instructions, etc. to support consistent and compulsory deployments

T&MRA Website for Knowledge Capture & Reuse

Raytheon

Links

- Defense Acquisition University
- Defense Acquisition Guidebook
- Acquisition Community Connection
- DAU - Manufacturing Readiness Assessments
- DoD ManTech
- MRL Assist

T&MRA Tool Box

- MRL Matrix & Definitions+
- T&MRA Baseline & Planning Workbook
- TRL HW & SW Definitions (DAG October 2004)
- T&MRA Summary Report Template

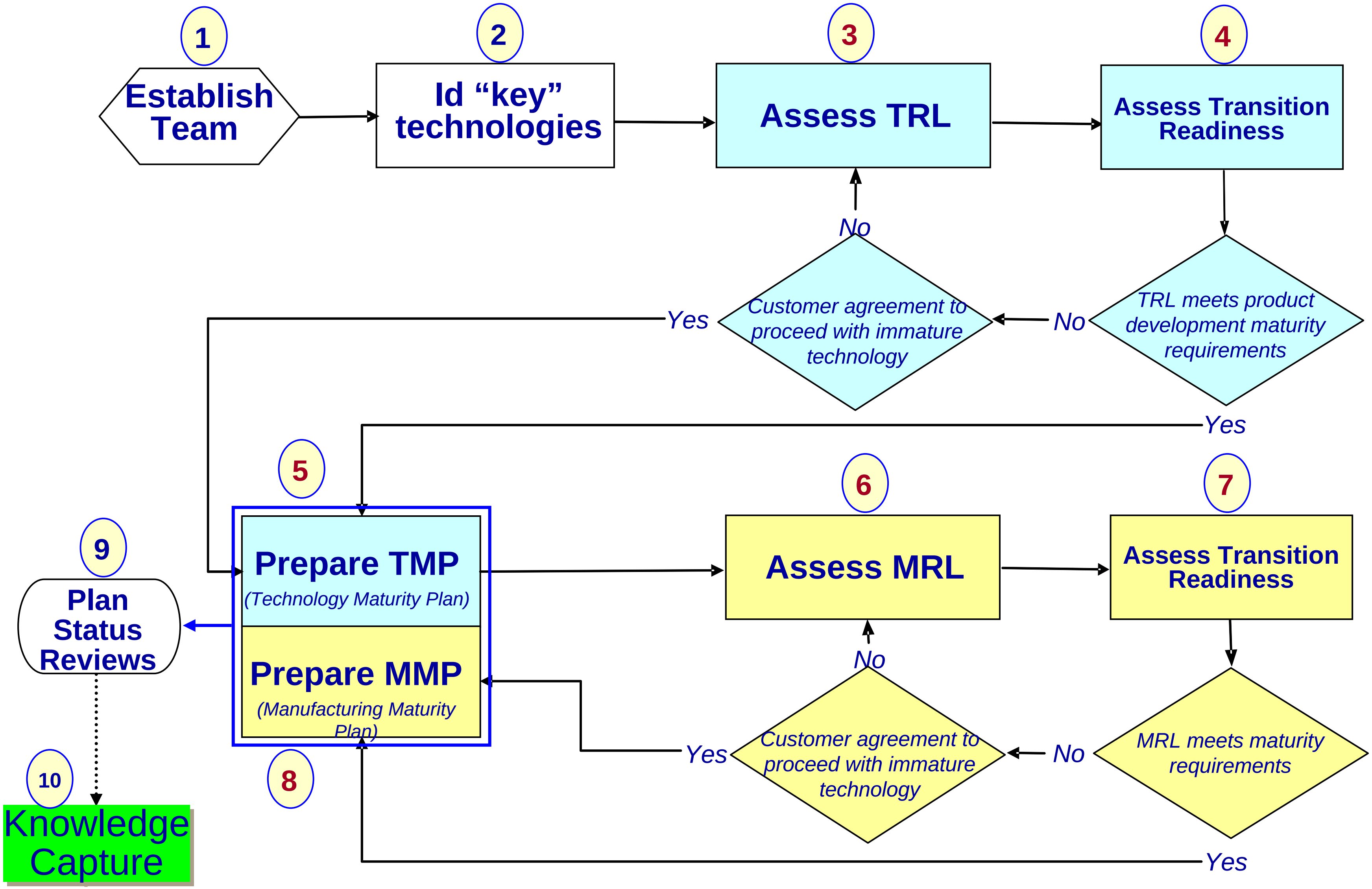
Reference Materials

- 2007 Defense Manufacturing Conference
- 2007 Technology Maturity Conference
- AFRL MRA Workshop - 2006 DMC
- DoD Integrated Management Framework - Back
- DoD Integrated Management Framework - Front
- GAO-07-706SP Assessments of Selected Weapon Programs, March 2007
- Manager's Guide to Technology Transition in an Evolutionary Acquisition Environment, Version 2.0, June 2005
- Misc. T&MR Presentations
- Senate Report 109-254, National Defense Authorization Act for Fiscal Year 2007, May 9, 2006
- T&MRA Process Training
- T&MRA Overview
- Technology Readiness Assessment (TRA) Deskbook, May 2005

History of T&MRA Activities at RMS - 2007

- T&MRA 10-Step Process developed – aligned with MRA
- T&MRA awareness seminars conducted across RMS
- Project Lead attended 2-week DAU course with DoD PMs; teams conducted notional MRAs from GAO facts & data
- MRAs considered good Management practice - not plus-ups
- T&MRL baselines in 3 major proposals (lessons learned)
- T&MRA added to RMS Manufacturing Excellence Model
- Early T&MRL requirements for Architectural Review Boards
- Participated in JDMTP's MRA Working Group with Industry
- "T&MRA @ RMS" presented at Raytheon Symposiums and Defense Manufacturing Conference
- MRL maturity included in Operations Strategy and Reviews

Combined “Technology & Manufacturing Readiness Assessment” Model



History and Plans for T&MRA Activities at RMS - 2008

Raytheon

- T&MRA detailed 10-step process training developed
- T&MRA tools refined and added – to assess current state, develop maturity plans, report progress and document T&MRA
- Corporate IPDS Change Review Board scheduled to review T&MRA for potential incorporation into IPDS to ensure consistent and compulsory deployment in 2008
- T&MRA project lead scheduled to present *“T&MRA @ RMS”* at this year’s:
  - National Defense Industry Association (NDIA) Science & Engineering Technology Conference in April
  - Enterprise Process Group Workshop in July

Tool to Capture, Plan and Status T&MRLs and Maturity Plans

Raytheon

- Tool created to demo important T&MRA planning & reporting characteristics
  - Facilitates and documents the Baseline & Current State T&MRLs by MRL Matrix Thread
  - Potential to roll-up 10 separate technology assessments to an assembly level TRL & MRL
  - Transition Risk Color Coding based on DoD Best Practices for each phase of PDLC

Program: example: HyperSonic Missile Program
Product Description: example: Guidance & Navigation Unit (GNU)
Product Development Phase: Technology Development
Transition Readiness Goals: 6
T&MRL Valuation Method: **Lowest T&MRL Values**
Most Recent Assessment Date: None

Roll-Up T&MRLs

All **Baseline** Values				All **Current** Values			
Low TRL	4.0	Low MRL	3.0	Low TRL	6.0	Low MRL	3.0
High	8.0	High	5.0	High	6.0	High	3.0
Avg	5.8	Avg	4.0	Avg	6.0	Avg	3.0

T&MRL Assessments (Max. 10 Technologies per Roll-Up)

#	MRL Matrix Evaluation Threads	#	MRL Matrix Sub-Thread	Acronym 1 Baseline	Acronym 1 **Current**	Acronym 2 Baseline	Acronym 2 **Current**	Acronym 3 Baseline	Acronym 3 **Current**	Acronym 4 Baseline	Acronym 4 **Current**
1	Technology & Industrial Base	1	Technology Readiness Level (TRL)	5	6	4		6		8	
		2	Technology Transition to Production	4	5	4		6		7	
		3	Manufacturing Technology Development	4	5	4		6		7	
2	Design	4	Producibility Program	5	6	4		6		7	
		5	Design Maturity	5	5	3		6		5	
3	Materials	6	Maturity	3	5	3		6		5	
		7	Availability	5	5	4		6		6	
		8	Supply Chain Management	5	5	5		6		6	
		9	Special Handling	7	7	7		5		6	
4	Cost & Funding	10	Production Cost Knowledge (Cost Modeling)	4	5	4		5		6	
		11	Unit Production Costs	4	4	4		6		6	
		12	Manufacturing Investment Budget	3	4	3		6		7	
5	Process Capability & Control	13	Modeling & Simulation (Product & Process)	3	3	3		6		7	
		14	**Manufacturing Process Maturity**	5	5	4		6		7	
		15	Manufacturing Technology Initiatives					8		7	
		16	Process Yields & Rates	5	5	4		5		5	
6	Quality Management	17	Quality Management Including Supplier Quality	5	6	4		6		6	
7	Manufacturing Personnel	18	Manufacturing Personnel	6	6	5		6		6	
8	Facilities	19	Facilities	7	7	6		8		7	
9	Manufacturing Management	20	Manufacturing Planning & Scheduling	5	5	4		7		7	
		21	Materials Planning	6	6	6		7		7	
		22	Tooling & Special Test Equipment	5	6	5		6		7	
			Baseline MRL (excludes TRL):	3.0		3.0		5.0		5.0	
			Current MRL (excludes TRL):		3.0		-		-		-
			High MRL (excludes TRL):	7.0	7.0	7.0	0.0	8.0	0.0	7.0	0.0
			Low MRL (excludes TRL):	3.0	3.0	3.0	0.0	5.0	0.0	5.0	0.0
			Average MRL (excludes TRL):	4.8	5.3	4.3	#DIV/0!	6.1	#DIV/0!	6.4	#DIV/0!

Transition Readiness Risk Guide by PLC Phase

CR	TD	SDD	LRIP
4	6	8	9
1	1	1	1
2	2	2 High Risk	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
Low Risk	8	8	8
9	9	9	9
10	10	10	10

T&MRL Maturity Planning for Each Technology Assessed

Raytheon

- Plan vs Actual TRL and MRL with transition readiness risk color codes
- Detailed tasks, POC, rationale, dates, funding, and sources of funding
- "What-if?" analysis capability

Program: Hypersonic Missile Program
Product Description: Guidance & Navigation Unit
Product Development Phase: Technology Development
Transition Readiness Goals: 6
T&MRL Valuation Method: **Lowest T&MRL Values**

Key Technology Assessed: Sensor **Acronym:** Acronym 1

Manufacturing Readiness Level - MRL

Item #	Task Description	Rationale/Evidence/Risks to Completion	Responsible POC	Plan Due Date	Complete Date	MRL Increase	Funding Req'mts	Funding Type	Funded (Y/N)	MRL Base Plan	MRL Act'l
1.00	Baseline MRL	Rationale/Evidence/Risks to Completion	Name		10/07					3	3
1.01	Maturity Advancement Action 1	Rationale/Evidence/Risks to Completion	Name	12/07	11/07		$100 K	IRAD	Y	3	3
1.02	Maturity Advancement Action 2	Rationale/Evidence/Risks to Completion	Name	01/08	12/08		$20 K	IRAD	Y	4	3
1.03	Maturity Advancement Action 3	Rationale/Evidence/Risks to Completion	Name	01/08	01/08		$45 K	Contract	Y	4	3
1.04	Maturity Advancement Action 4	Rationale/Evidence/Risks to Completion	Name	02/08	01/08	1	$30 K	Contract	Y	5	4
1.05	Maturity Advancement Action 5	Rationale/Evidence/Risks to Completion	Name	02/08	02/08	1	$10 K	Contract	Y	5	5
1.06	Maturity Advancement Action 6	Rationale/Evidence/Risks to Completion	Name	03/08	02/08		$25 K	Contract	Y	6	5
1.07	Maturity Advancement Action 7	Rationale/Evidence/Risks to Completion	Name	03/08			$25 K	Contract	Y	6	0
1.08	Maturity Advancement Action 8	Rationale/Evidence/Risks to Completion	Name	05/08			$1,200 K	Capital	N	7	0
1.09	Maturity Advancement Action 9	Rationale/Evidence/Risks to Completion	Name	07/08			$260 K	Contract	Y	7	0
1.10	Maturity Advancement Action 10	Rationale/Evidence/Risks to Completion	Name	08/08			$50 K	Contract	N	8	0
1.11											0
1.12											0
1.13											0
1.14											0
1.15											0
1.16											0
1.17											0
1.18											0
1.19											0
1.20											0

MRL funding plan:	$1,765 K	Current MRL	5
Funded:	$515 K	MRL Plan Complete?	N
Unfunded:	($1,250 K)	In Risk Register?	Y

Raytheon

Key Lessons Learned

- Cultural change...T&MRA is a means to facilitate earlier collaborations between design engineering, manufacturing and supply chain during any phase of PDLC
- Leadership & Assessment Team alignment required before T&MRA deployments
- TRLs & MRLs should be established at the critical technology levels (best practice)
- Wherever possible, the T&MRA should be completed prior to developing a proposal to ensure technology, design & manufacturability risks are accounted for:
  - Assess program feasibility and technology transition readiness (risks)
  - Program cost and schedules should include maturity plans and goals
  - Identify key manufacturing processes that need to be matured for program success

Key Lessons Learned

- Command media revisions required for consistent & compulsory use
- Tailoring of assessment based on fidelity level desired
- MRA and Production Readiness are not the same
- Systems Engineering organization to own the T&MRA process
- Need further development and integration of tools and management systems to capture, plan and report T&MRL progress
- MRL Matrix can be enhanced further to focus on Manufacturing Process Maturity
- **Low MRLs are not necessarily an issue…not having a maturity plan is!**

In Summary…

- TRLs are part of our culture at Raytheon…more discipline required
- MRLs are relatively new…Industry is still in early stages of adoption
  - Sense of urgency within the DoD – TRA & MRA processes are being taught to and deployed by our customers…and for very compelling reasons
  - Acquisition Policy, Guidance and Legislation associated with TRA & MRA are in place and/or currently under revision & development for 2008 release
- The use of T&MRA processes will not guarantee program success
- T&MRA processes and tools will:
  - Change culture - bridge the divide between engineering & manufacturing
  - Provide insight into current state technology & manufacturing maturity and capability
  - Identify contributing factors & issues driving the “Gaps” in T&MRL maturity
  - Identify the type and significance of risks to program cost, schedule and performance
  - Lead to more accurate, time phased, and priced maturity plans
  - **Improve program affordability <u>and</u> predictability**

T&MRA @ RMS

If you have any questions, feel free to contact me at:

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Army Science and Technology

NDIA

9th Annual Science & Engineering Technology Conference

Dr. Thomas H. Killion
Deputy Assistant Secretary for Research and Technology/ Chief Scientist

15 Apr 2008

Outline

- ***Army Science and Technology (S&T) Strategy and Funding***
- ***Future Force Technologies***
- ***Future Combat Systems***
  - ***Spinouts to the Current Force***
- ***S&T Insertions to Current Operations***
- ***Basic Research Thrusts***


I'VE BEEN ASKED TO GIVE A PRESENTATION AT THE TRADE SHOW.
S. Adams
I'D LIKE YOU TO PUT THAT TOGETHER FOR ME, ALICE.
WHAT'S YOUR TOPIC?
© 1997 United Feature Syndicate, Inc.
7/14/97
TECHNOLOGY. THEY DIDN'T SAY IF I'M FOR IT OR AGAINST IT.
I'LL LEAVE SOME WIGGLE ROOM.

Science & Technology for a Campaign Quality Army with Joint & Expeditionary Capabilities

Current Force

~100 lb. load

Limited network

> 70 tons

< 10 mph

Enabling the Future Force

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

Enhancing the Current Force

Future Force

< 40 lb. load

Fully networked

< 30 tons

> 40 mph

Elements of Army S&T Strategy

- *Ensure investments are aligned with Army missions and capability needs*
- *Maintain balanced & responsive portfolio across*
  - *Elements of investment (6.1/6.2/6.3)*
  - *Disciplines and technology areas*
  - *Performers (intramural/extramural)*
  - *Capability pull and technology push*
- *Sustain critical infrastructure—people and physical—responsive to Army needs*
- *Communicate S&T vision and approach to senior decision makers, key stakeholders, partners and customers*
- *Establish and refine processes and metrics to promote innovation, efficiency & effectiveness, and facilitate transition*

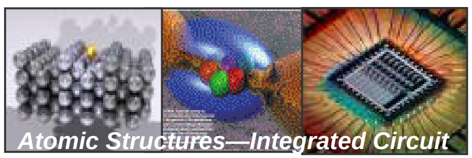
FY09 Funding—Research to Systems

3 Different Types of S&T Investments

S&T $1.8B — **Development** (RDT&E) $8.7B — **Acquisition** (Procurement) $24.6B

6.1: Basic Research
$379M (21% of S&T)

Nanoscience

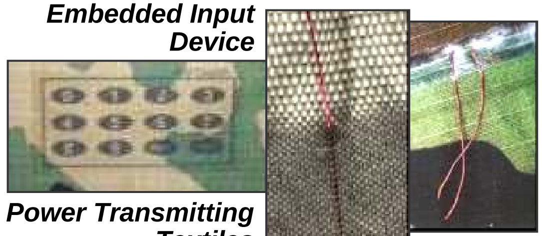


- Understanding to solve Army-unique problems
- Knowledge for an uncertain future

67% Universities/Industry

6.2: Applied Research
$724M (39% of S&T)

Integrated Textile Conductors



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

35% Industry

6.3: Advanced Technology Development
$739M (40% of S&T)

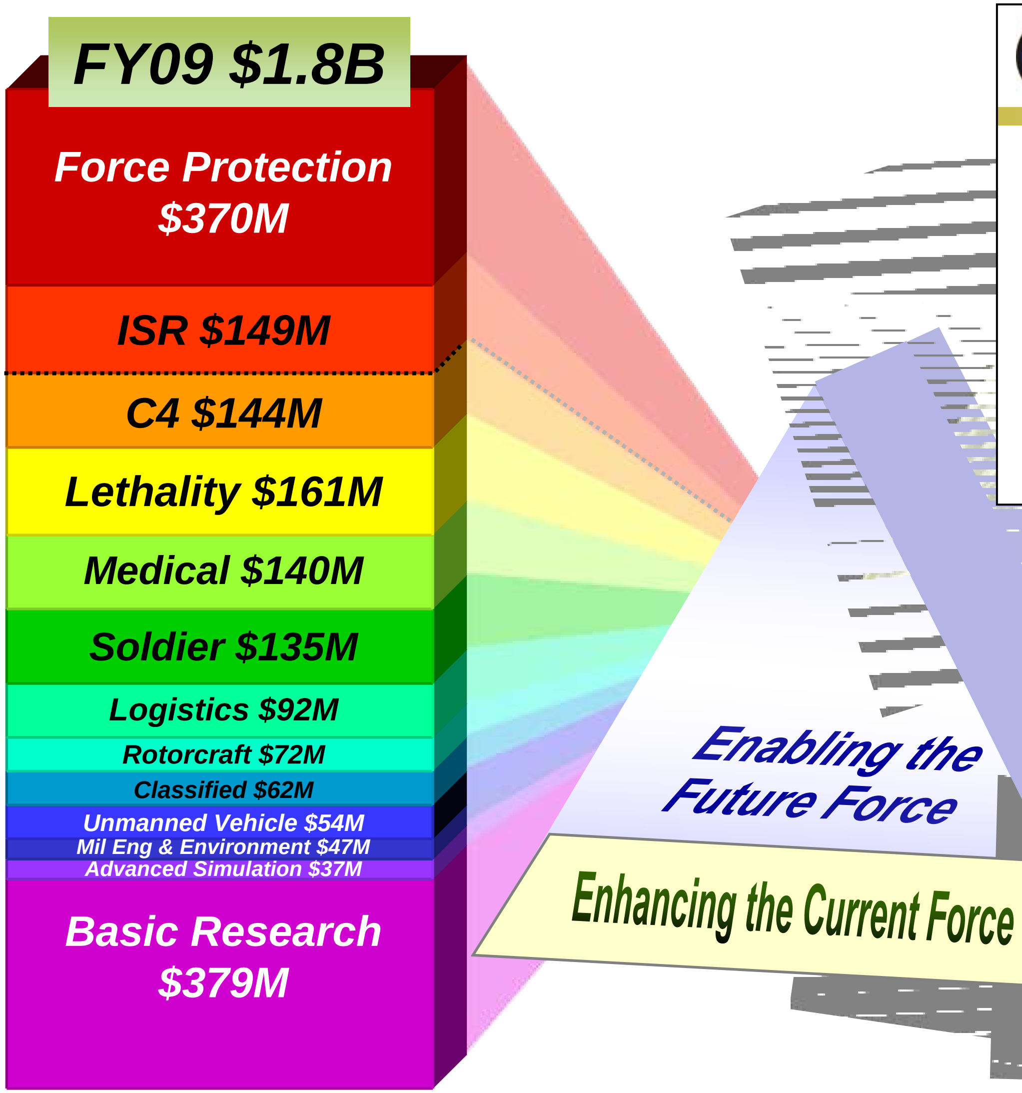
Precision Air Drop—50 meters

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

60% Industry

Far Term — Mid Term — Near Term

Technology Area Investments to Satisfy Gaps—New Capabilities



Current Force Capability Gaps Areas

6th Gap Analysis

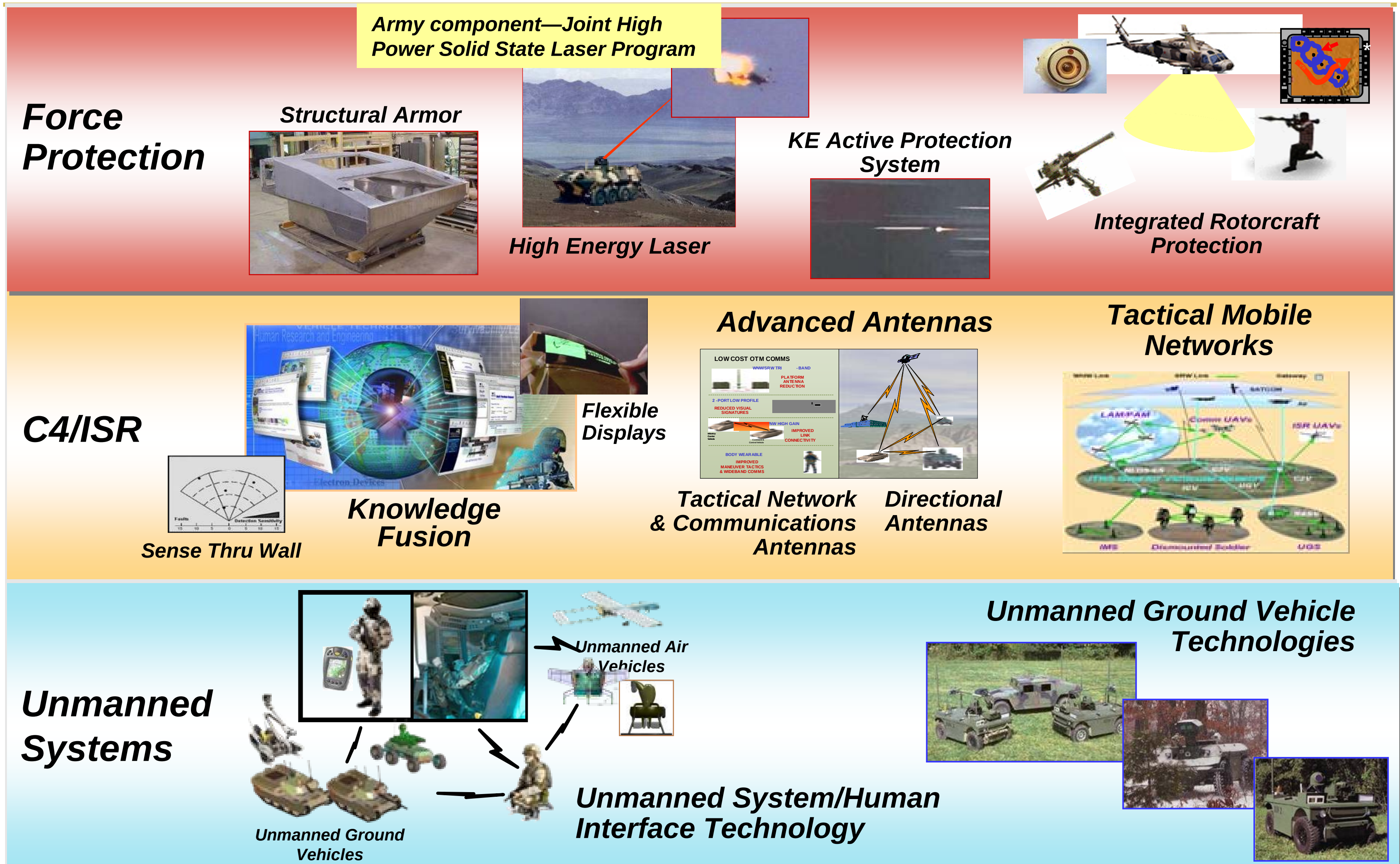
1. Protect Force in Counterinsurgency Operations
2. Networked Enabled Battle Command
3. Logistics and Medical in Counterinsurgency Operations (COIN) and non-contiguous battlespace
4. Soldier Protection in Counterinsurgency Environment
5. Tactical Communications
6. Joint Interoperability, Coalition, and Interagency Operations
7. Train the Force How and As it Fights
8. Timeliness of Analysis and Information Dissemination
9. Ability to Conduct Joint Urban Operations
10. Information Operations

Future Force Capability Gap Areas

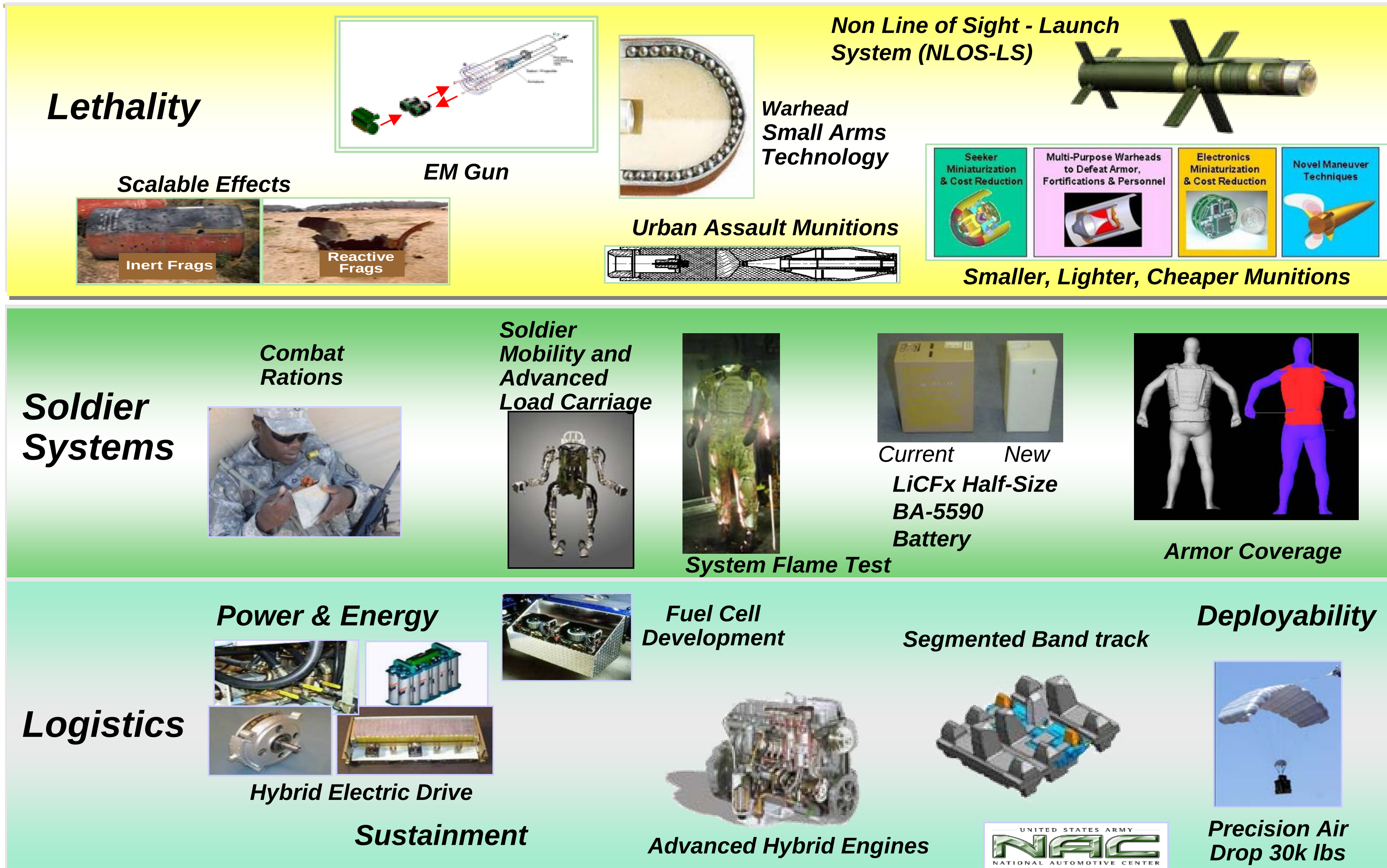
CNA FY 10-15

1. Modular, Scalable and Tailorable Battle Command and Control
2. Strategic Force Projection / Intra-theater Operational Maneuver and Sustainment
3. Dynamic, Uninterrupted Communications Network
4. Capability for Lethal / Non-Lethal Overmatch
5. Modular, Tailorable Forces
6. Enhanced Collection, Exploitation and Dissemination
7. Enhanced Soldier Protection
8. Sustainment of Modular Forces
9. Enhanced Platform / Group Protection
10. Ability to Train the Force How and As it Fights

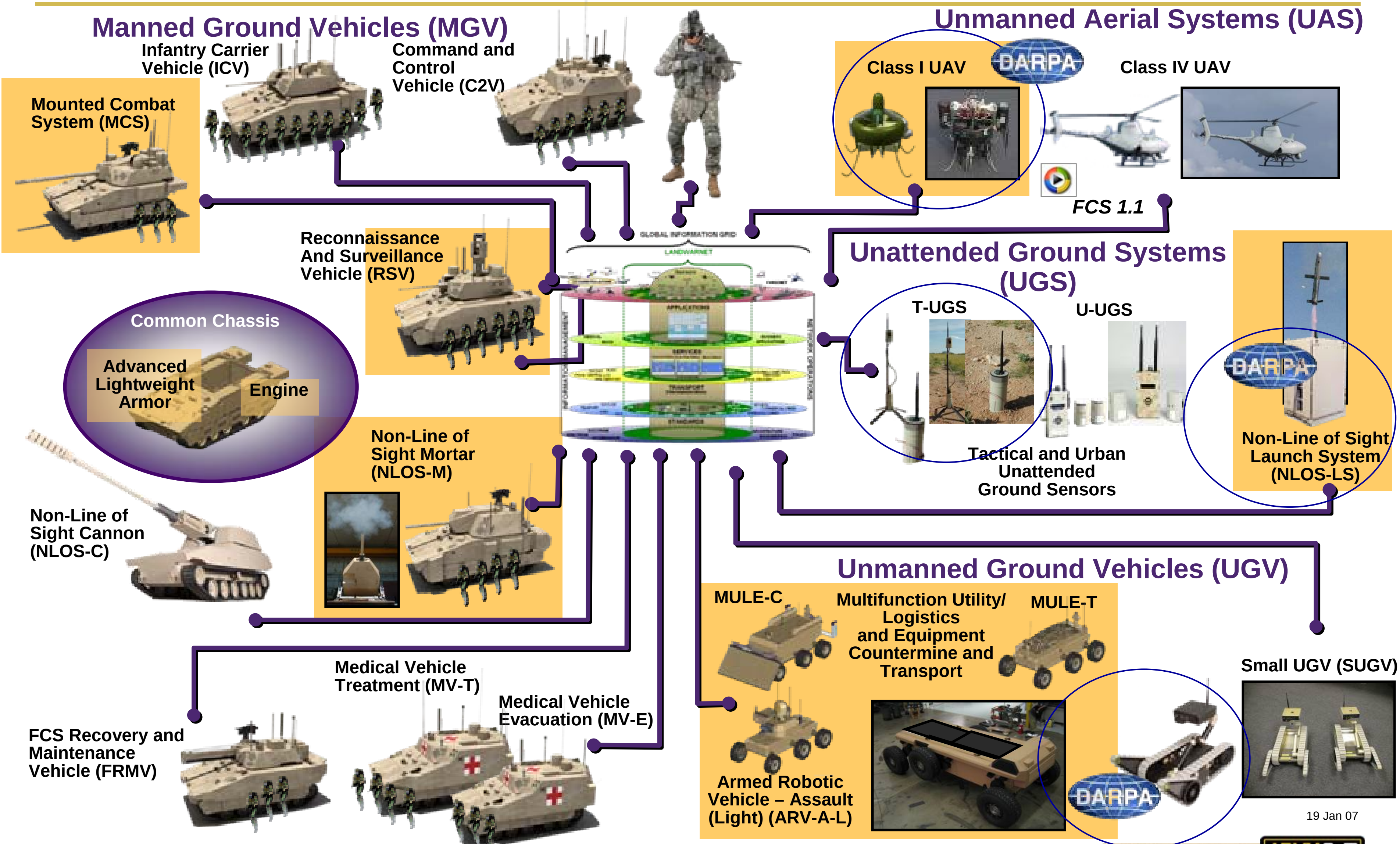
Future Force Technologies



Future Force Technologies



Future Combat Systems— Spinouts to the Current Force



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Technology Insertions for Current Operations

Benefiting from Past Investments

Interceptor Body Armor

PackBot Sensors

Blue Force Tracking

Guided MLRS

Adapting/ Accelerating On-going S&T Programs

Mobile Remote Access & Information Diagnostics

Every Soldier A Sensor Simulation

USMC Dragon Fire II with Lightweight Counter Mortar Radar (LCMR)

Mine Detecting Ground Penetration Radar (GPR)

Leveraging Scientist & Engineer Expertise

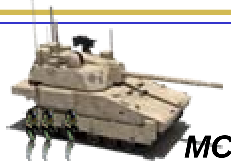
Enhanced Rocket, Mortar & Sniper Detection

RG-31 Engineer Vehicle Add-on Armor Kit

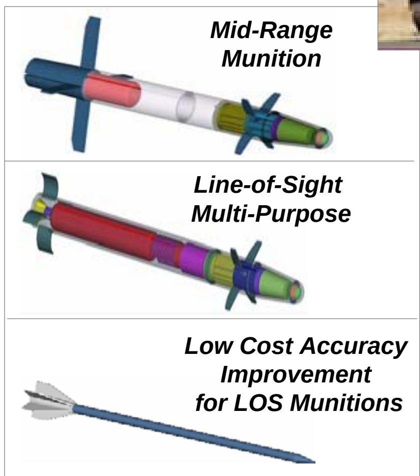
Hellfire Launch On Predator

HMMWV Expedient Armor

Accomplishments—2007



MCS



Mounted Combat Systems & Abrams Ammunition System Technologies

Future Force Warrior (FFW)

C4ISR—On The Move Experiment

Add On Armor & EW Subsystems

Buffalo

MRAP

HMMWV

Battlemind Training

Basic Research Thrusts

Research in human-engineered and biologically-evolved networks to improve performance, increase reliability and enhance network-centric mission effectiveness

Revolutionize military training and mission rehearsal through the development of technology and art for simulation experiences and the development of virtual human technology

Research to understand biological construction of novel materials, structures and processes to develop biologically-derived materials, sensing systems, information processing and power and energy

Discover, develop and exploit robotic devices and systems with highly sophisticated sense, response and processing systems approaching that of biological systems to dramatically enhance Soldier survivability

Research in understanding the functional brain to improve training techniques, human-machine interface design, the nature of traumatic brain injuries, and to more fully understand the decision-making process

Discover and create new materials with properties that will revolutionize military technology and make Soldiers less vulnerable to the enemy and environmental threats

Generate advances in quantum sciences that will enable revolutionary approaches to information processing, cryptography, information assurance, and communication

Predicting the Future

It's tough to make predictions, especially about the future. Some famous technology predictions include:

- ***"Heavier-than-air flying machines are impossible."***
  - ***Lord Kelvin, 1895***
- ***"Airplanes are ...of no military value."***
  - ***Marshal Ferdinand Foch, 1911***
- ***"Who ... wants to hear actors talk ?"***
  - ***H. M. Warner, 1927***
- ***"... (T)here is world market for maybe five computers."***
  - ***T. Watson, IBM Chairman, 1943***
- ***"640k (RAM) ought to be enough for anybody."***
  - ***Bill Gates, 1981***

Army S&T…
Engine of Transformation

CERDEC Contributions to Army Battle Command Networking Efforts

CERDEC
US ARMY – RDECOM

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

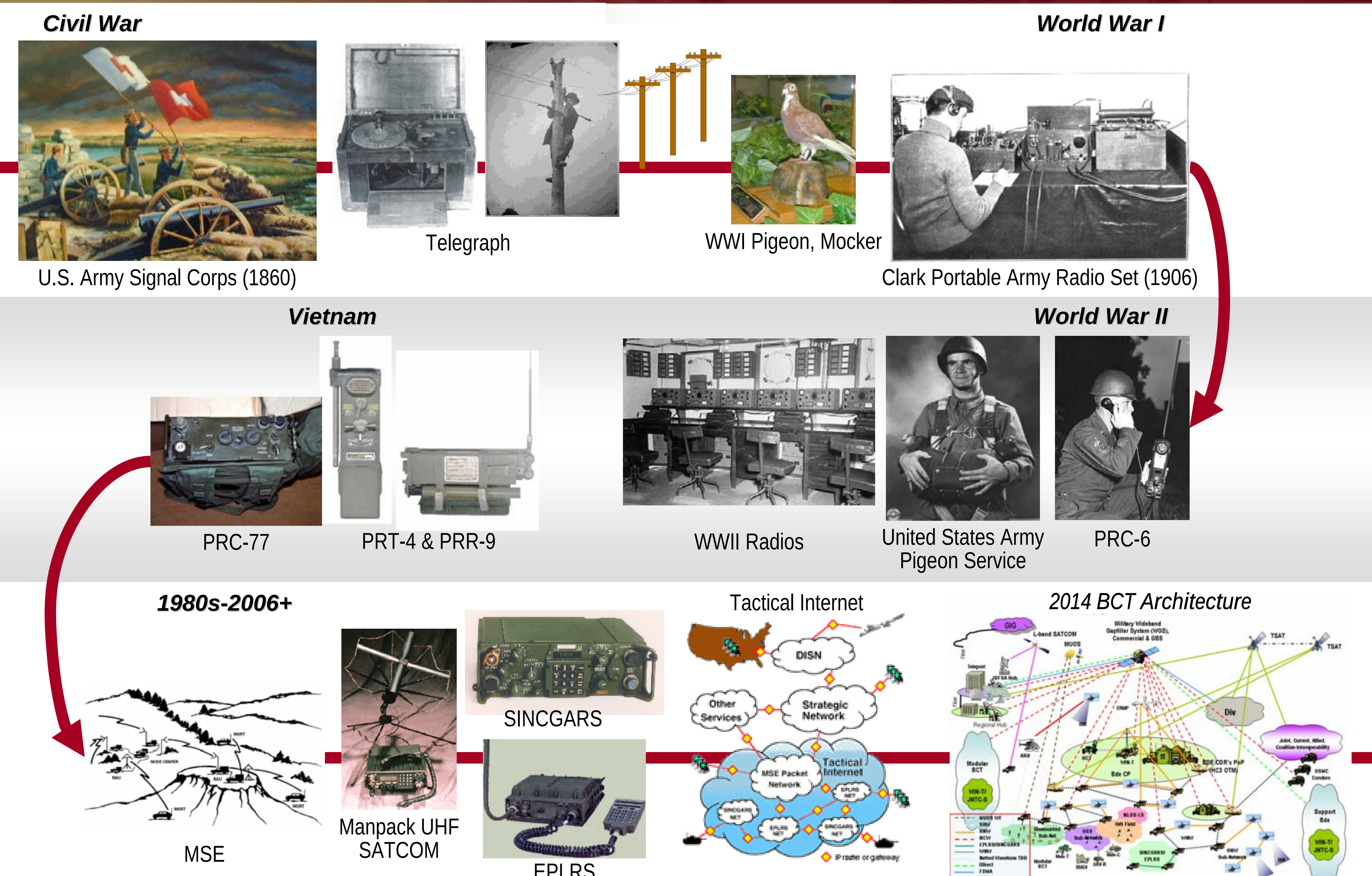
Mr. David Jimenez

Director, Space & Terrestrial Communications Directorate

RDECOM

Evolution of Army Networking

CERDEC US ARMY – RDECOM



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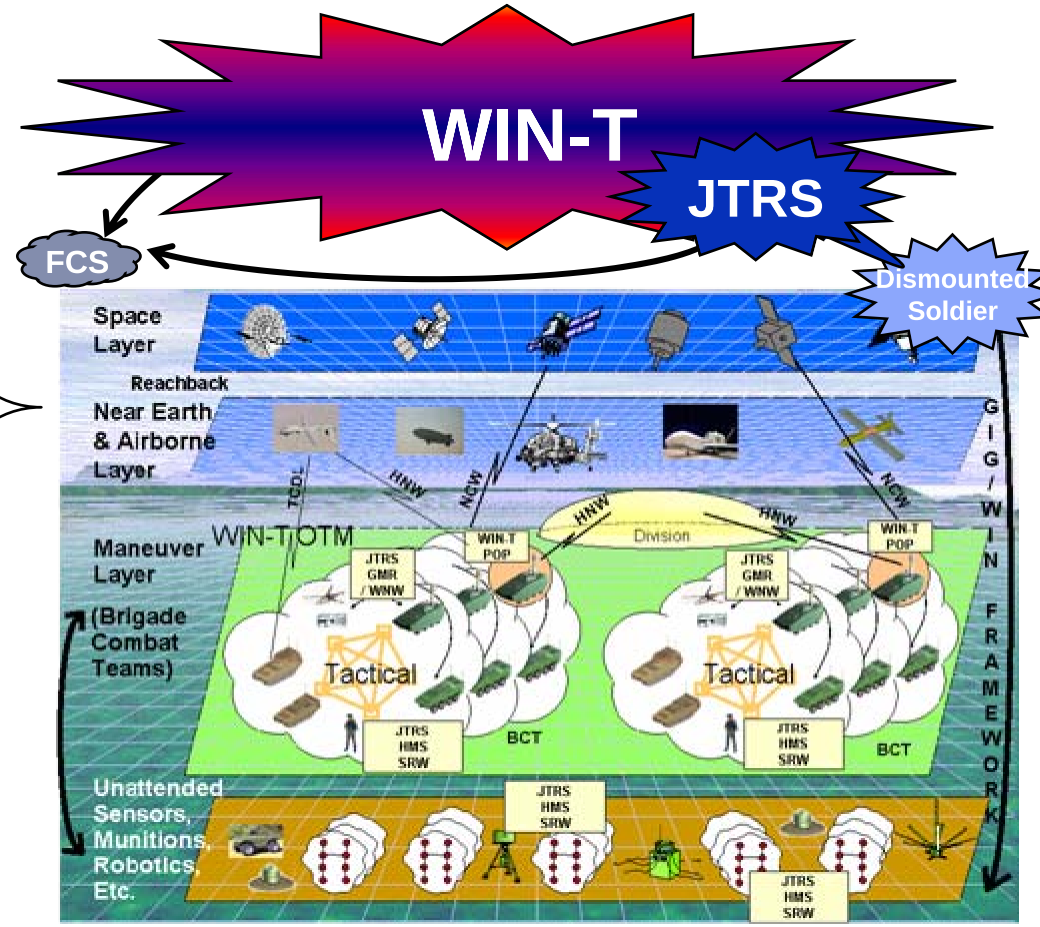
Major Communications Thrusts

Connectivity **Capacity** **Security**

- Mobile Networking
- Antennas
- Information Assurance

Future Force Comms Systems



Comparison of Commercial & Military Communications Architecture

Commercial

- Mobile Subscriber, Fixed Infrastructure
- Pre-configured Networks
- Tall, Fixed Antenna Towers
- Fiberoptic Internodal Connections
- Spectrum Availability
- Fixed Frequency Assignments
- Protection: None ➲ Privacy (single level)
- Interference Rejection is Somewhat Important
- Low probability of Detection (LPD) is not an issue

COMMERCIAL	TACTICAL
 High Bandwidth	 Small Bandwidth
 Primarily Robust Static Infrastructure	 Radio-Based Highly Mobile Comms
 Highly Skilled Large Teams	 MOS w/Multi-duties

Military

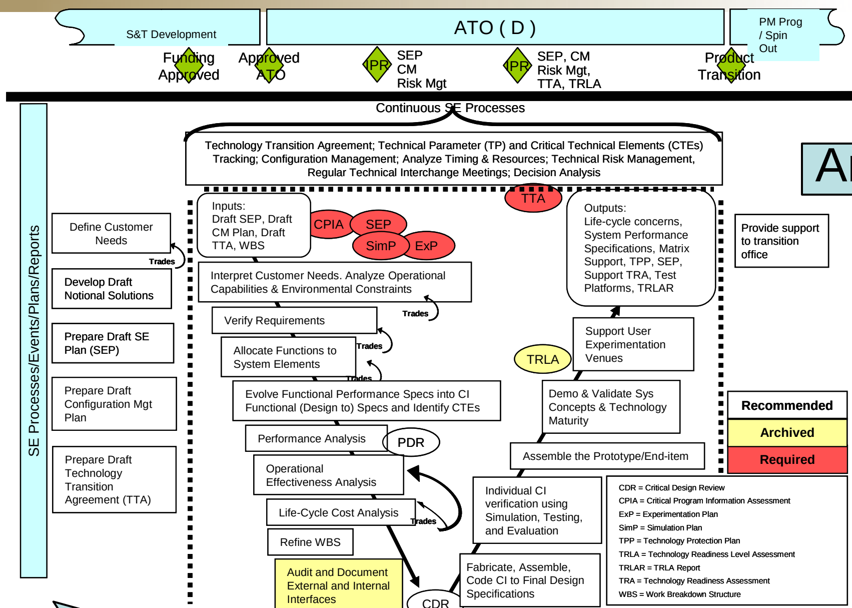
- Mobile Subscriber - Mobile Infrastructure
- Ad Hoc, Self Organizing Networks
- Small, Easily Erectable Masts; Low Profile OTM Antennas
- Mobile, Wireless, Internodal Connections
- Restricted Frequency Assignments; Geographically Impacted
- Protection: None ➲ Top Secret/ SI (Multiple, Simultaneous Levels)
- Interference Rejection and Antijam are Critical
- Low Probability of Detection (LPD) is Critical

Strategy = *Adopt* | *Adapt Modify* | *Develop and/ or Influence*

Systems Engineering (SE) Approach

RDECOM

CERDEC US ARMY–RDECOM



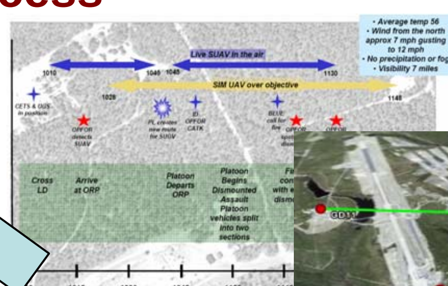
SE Process

Analysis

Applied to Customers Requirements:
FCS BW for BC
FCS Voice Architecture Study
FCS Network Assumptions Whitepaper
Tactical Network Ground Forces Study
Etc….

Test & Validation

Lessons Learned



PM C4ISR OTM

Architecture
- **Operational Views**
- **System Views**
- **Technical Views**
- **Network Model Development**

Network M&S
- **OPNET**
- **CES/QUALNET**
- **NETWARS**

Field & Experimental Testing/Evaluation
- **PM C4ISR OTM**
- **Data Collection**

Emulation

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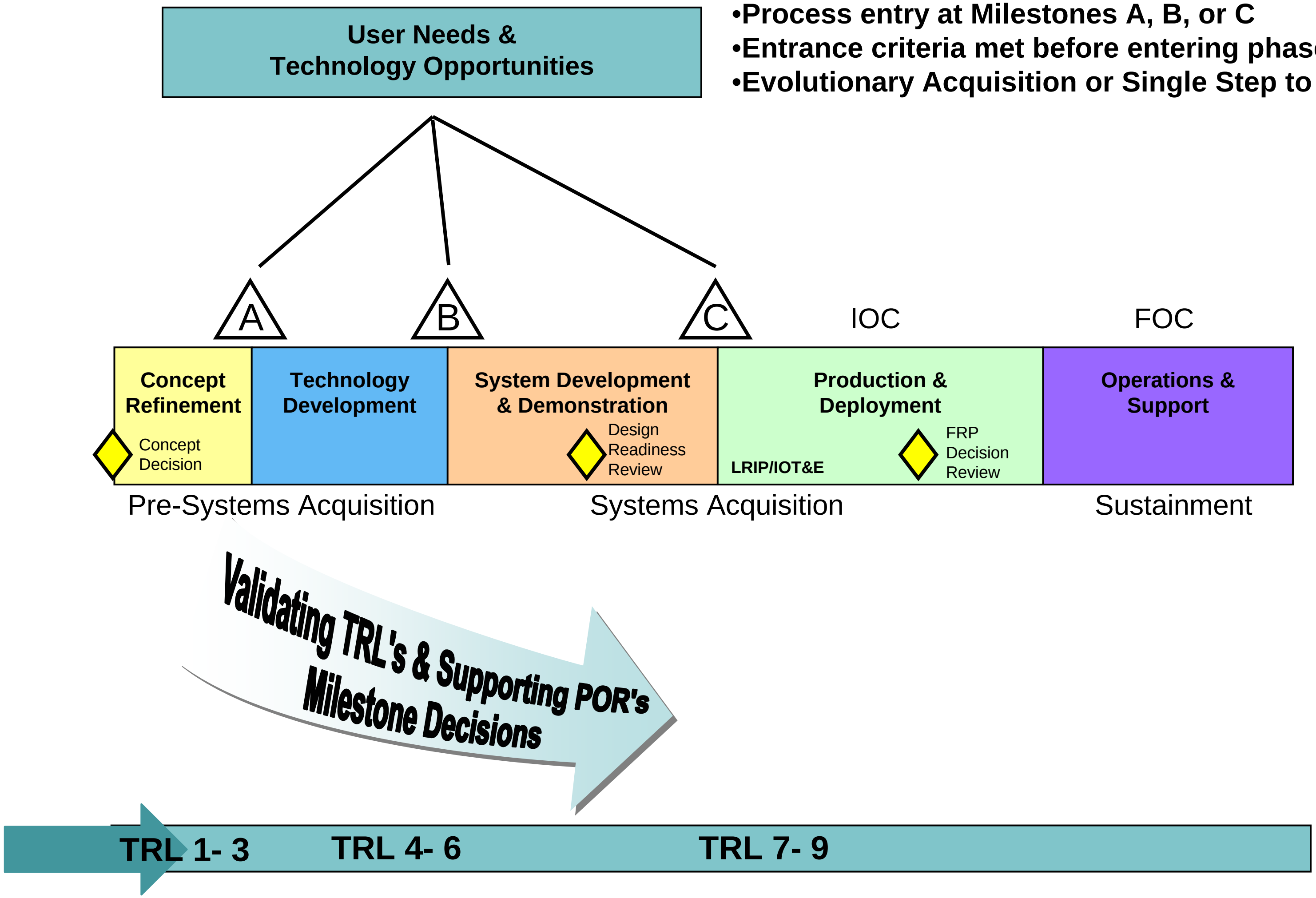
Technology Development and Maturation

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



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PM C4ISR On-The-Move

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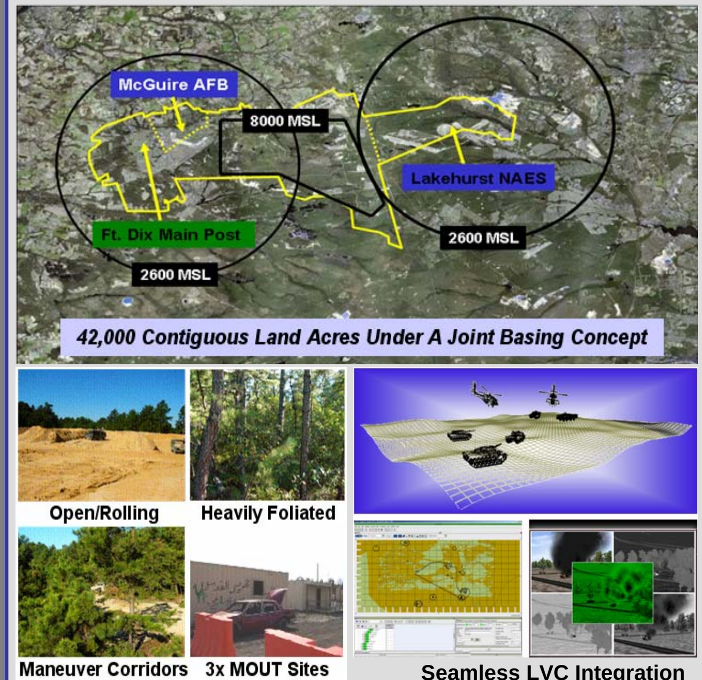
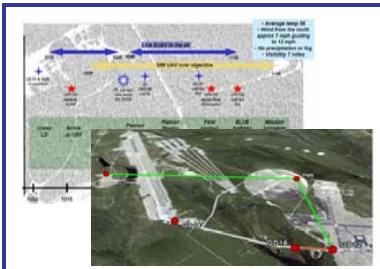
- R&D ***venue*** offering the ***Tech Base*** and ***Programs of Record*** a ***continuous*** and enduring ***evaluation*** capability for Network Centric Warfare (NCW) concepts
- Conducts Live, Virtual, and Constructive ***technology demonstrations*** currently supporting scales on the order of ***100 live and 3,000 virtual/constructive*** entities
- Provides a ***relevant environment*** to assess emerging technologies in a C4ISR ***System-of-Systems (SoS)***
- ***Mitigate risk*** for FCS Concepts, Future Force technologies
- Opportunities for ***acceleration of technology insertion*** into the Current Force
- Venue for ***validation of Technology/Software/ Integration Readiness Levels***
- Includes a ***state-of-the-art instrumentation, data collection & reduction*** (IDC&R) tool suite that supports the quantification of NCW activities
- Employs system of systems engineering methods that promote ***rapid SoS reconfiguration*** and enable repeatable assessments
- Has a diverse set of experience over the past seven years in working with dozens of government and industry partners to ***integrate and execute large-scale, distributed Live/Virtual/Constructive events***

Fort Dix – McGuire AFB – Lakehurst NAES Joint Megabase

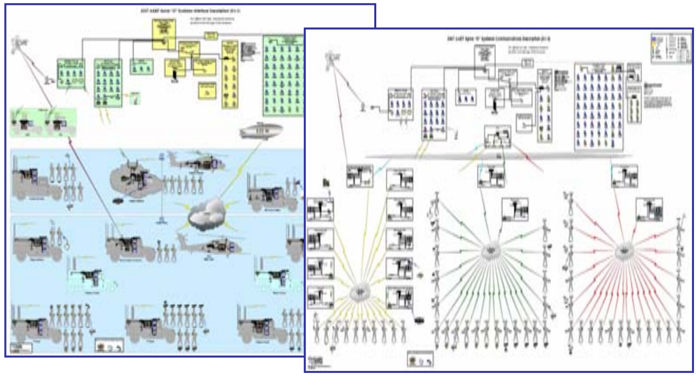




Seasoned team of subject matter experts & analysts

Warfighters and scientists working side by side

Seven years of field experimentation experience



SoS engineering processes & procedures – rapid prototyping frameworks

Linking Battle Command Metrics Across Multiple Domains

Technical Metrics	System Knowledge	Operational Metrics
C4ISR System Performance	**Quality of Information**	**Soldier Unit Performance**

Technical Metrics

C4ISR System Performance

- Network Connectivity
- Message Completion Rate
- Probability of Detection
- Probability of Identification
- Detection Accuracy
- Power Usage
- Visualization Resolution

System Knowledge

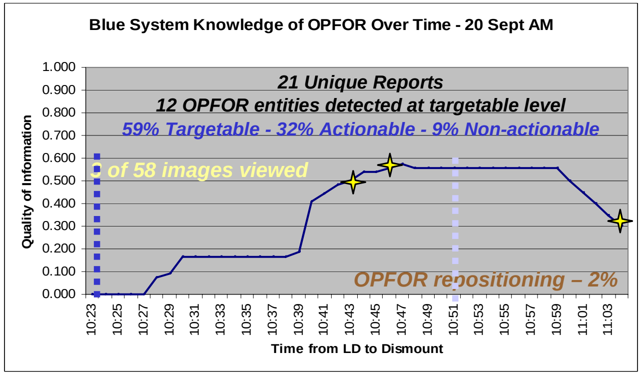
Quality of Information

- Accuracy, Completeness & Timeliness of Information about Threat
- Level of Situational Awareness Achieved
- Number and Types of Decisions Made

Operational Metrics

Soldier Unit Performance

- Time to Execute Mission
- Blue Losses
- Red Losses
- Degree of Surprise
- Ability to Maneuver Undetected
- Number of PIR Satisfied



Quantifying How Technical Performance Impacts Operational Effectiveness

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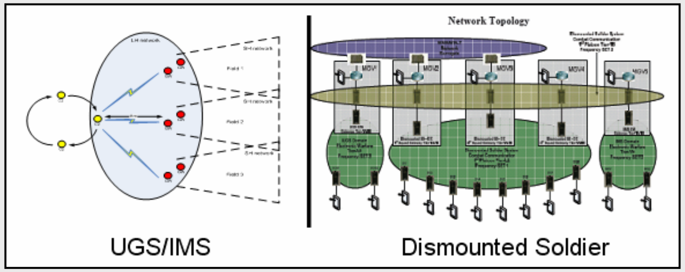
Support to PM Programs and Tech Base Efforts

PM WIN-T 2007 Increment 2
Engineering Field Test
- Critical Technology Elements
- Network Scalability



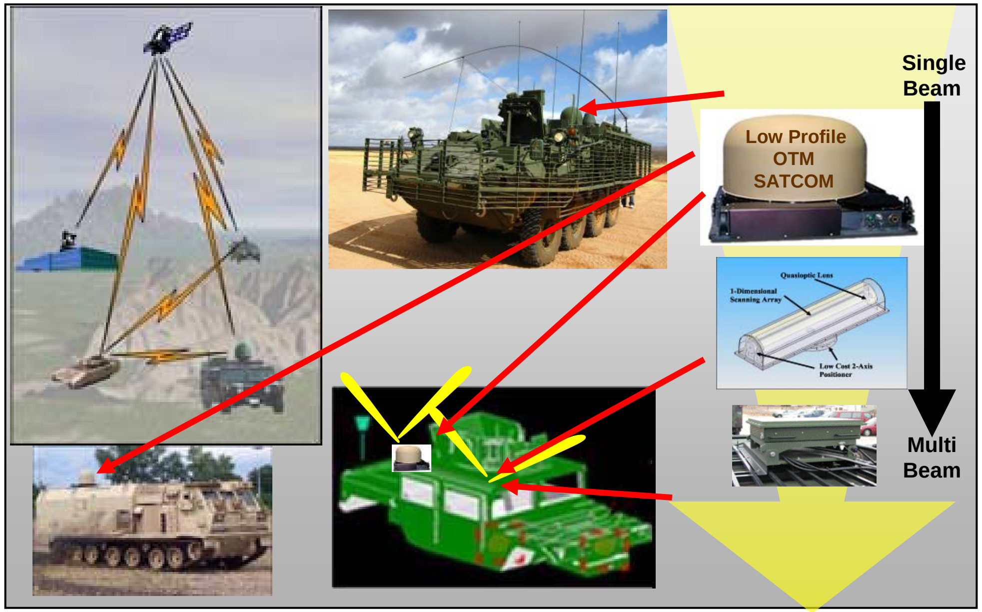
JTRS SLICE SRW 2006/7
Technical Field Tests
- Waveform maturation

PM C4ISR OTM
SEE FIRST
UNDERSTAND FIRST
ACT FIRST
FINISH DECISIVELY.
ENABLING THE FUTURE FORCE

PM FCS 2007
Technical Field Tests
- SUGV Teleoperation
- T-UGS / U-UGS
- NEBC Technology Transition

Natick Soldier Center 2006/7
Future Force Warrior
- Exit Criteria Testing
- Transition to PEO Soldier

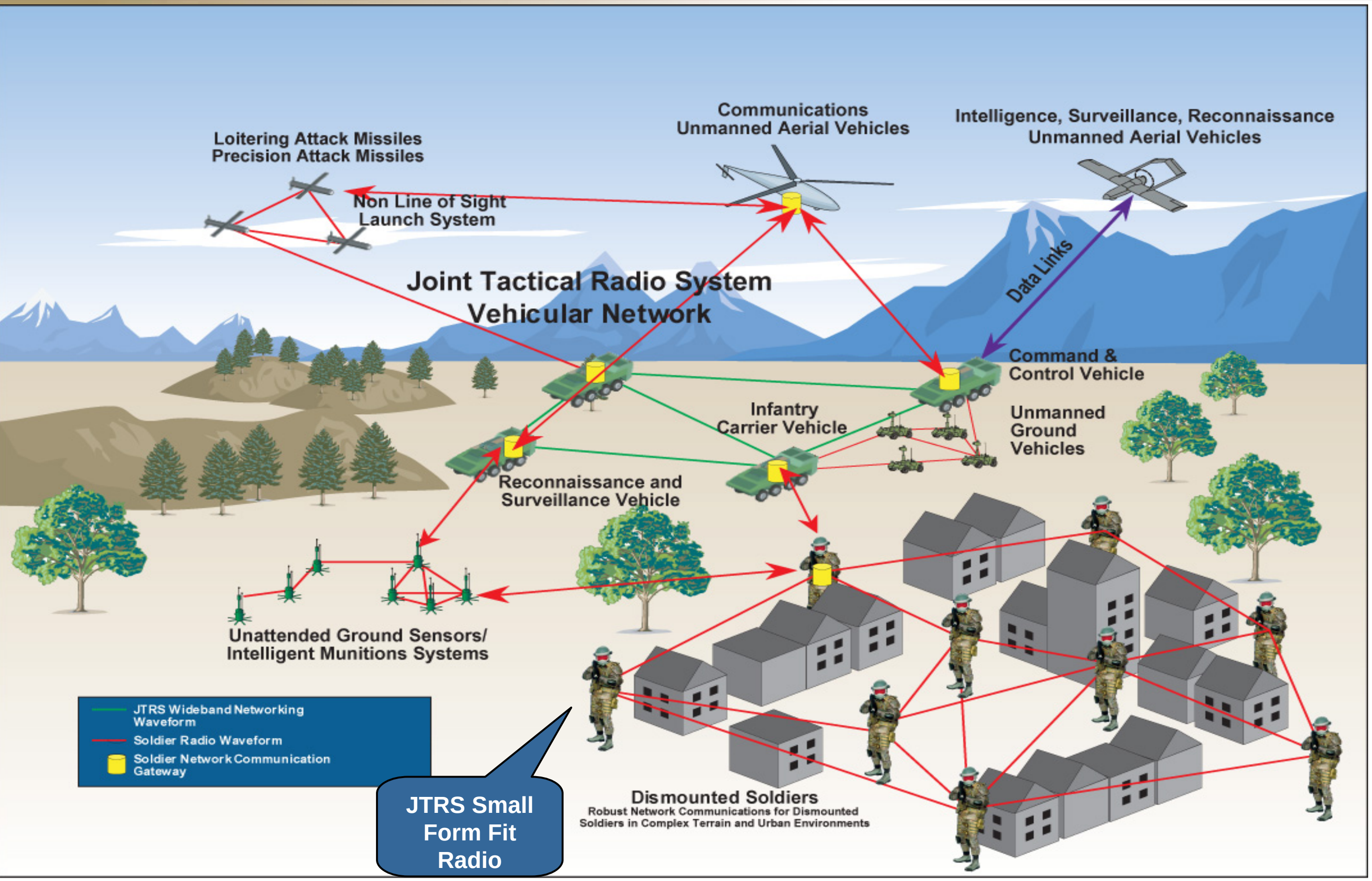
Networking Technology Transitions



- *Body Wearable Antenna Technologies for SRW*
- *2 Port Low Profile Antenna for Wideband Networking Waveform (WNW)/ Soldier Radio Waveform (SRW) bands*
- *Antenna optimization Modeling and Simulation for Command & Control Vehicle (C2V) and Reconnaissance & Survivability Vehicle (R&SV)*

- *Tactical Wireless Network Assurance*
  - *- Black Side Intrusion Detection system*
- *Soldier Radio Waveform*
  - *- Mobile AdHoc networking for Soldiers, sensors, munitions*
- *Command and Control of Robotic Entities (C2ORE)*
  - *- UAV mission planning and execution software autonomously controls multiple UAVs*
  - *Enhances planning and management of unmanned sensor assets (UGS, UAV, UGV, etc)*

Soldier Radio Waveform (SRW) Communications Within the Emerging C4ISR Architecture




Ground Soldier System


Unmanned Ground Vehicles


Unmanned Aerial Vehicles


Intelligent Munitions Systems


Unattended Ground Sensors


Non-Line of Sight-Launch Systems

The Soldier Radio Waveform is a mobile, ad-hoc, networking waveform developed and transitioned to provide improved voice and data communications, for platforms with Size, Weight, and Power constraints. Hosted on Joint Tactical Radio Systems (JTRS) Handheld Manpack Small Form Factor (HMS) and **Ground Mobile Radio (GMR)**

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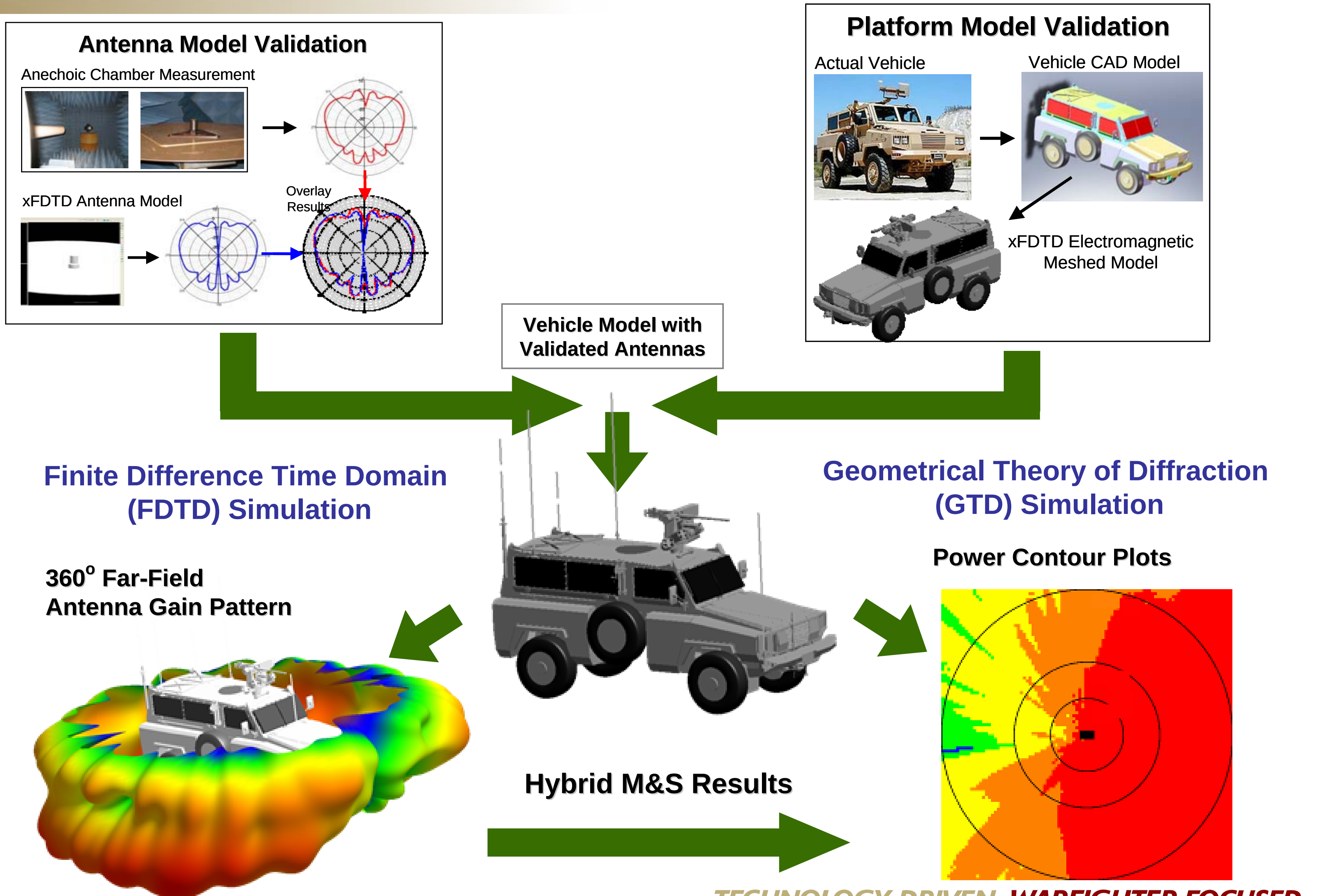
Antenna M&S Performance on Vehicles Process



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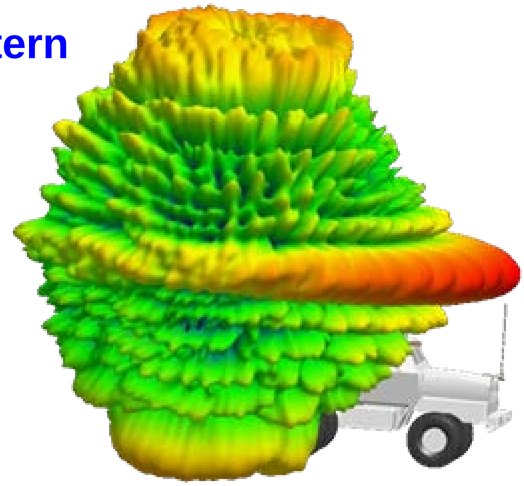
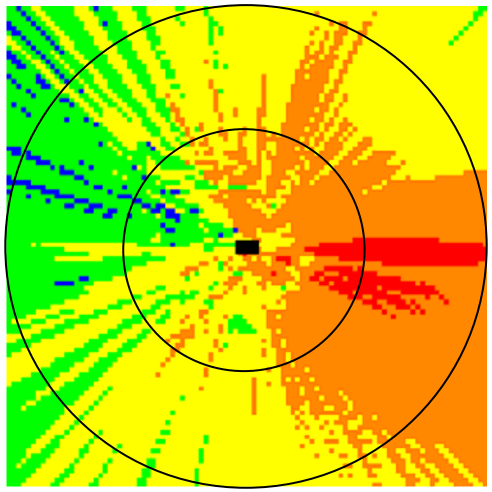
Example: MRAP Antenna Placement Optimization

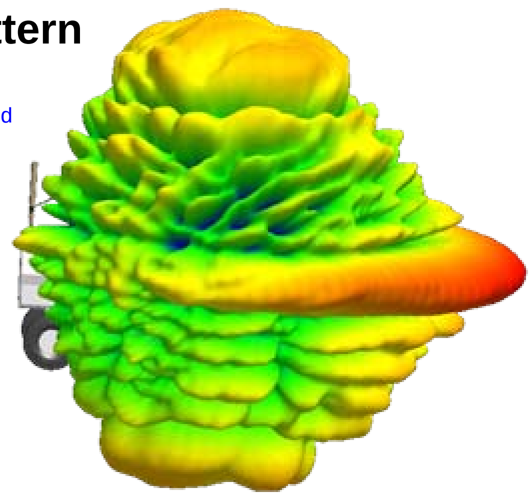
SPAWAR Recommended Location **Poor Pattern**

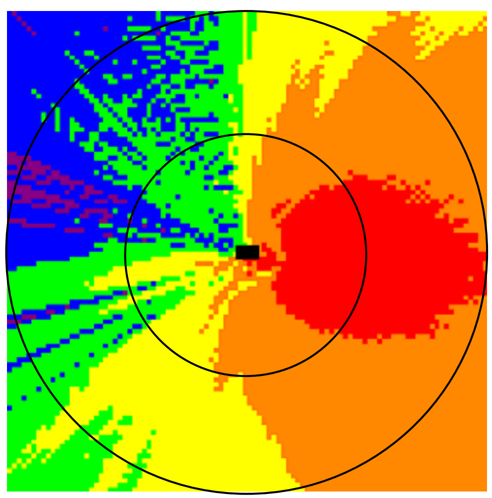




CERDEC M&S Placement with **Optimized Pattern**

115 Antenna Base @ 2 meters Above Earth Ground





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D.C4.2006.04 / Tactical Network and Communications Antennas (TNCA)

Purpose:

- *Develop Affordable, Low Profile Solutions For OTM SATCOM*
- *Develop Affordable Directional Antennas for Terrestrial Directional Networking*
- *Develop Omni-directional Antennas With Higher Gains, Lower Profiles with Ballistic Radomes, and Multiple Ports to Reduce the Number of Platform Antennas*
- *Develop Integrated Antennas for Dismounted Soldier*
- *Develop Distributed Antennas to Improve Omnidirectional Antenna Performance and Reduce Cosite Interference*

Products:

- *Low Cost Ku/Ka Band OTM SATCOM Antenna Systems*
- *Low Cost X-band Point Of Presence*
- *Efficient Ku and Ka Band Power Amplifiers*
- *Low Profile Single Beam Ku/Ka SATCOM Ant System*
- *Low Profile Multibeam Ku/Ka/Q SATCOM Ant Analysis*
- *Affordable Terrestrial Directional Antennas*
- *WNW High Gain Omni Antennas*
- *2-Port Low Profile Omni Antennas with Ballistic Radome supporting multiple waveforms (Ground/RW)*
- *3-Port Tri-band Omni Antennas*
- *Integrated Body Wearable Antennas*
- *Distributed Antenna Array*

Payoffs:

- *Affordable OTM SATCOM and Terrestrial Directional Ants.*
- *Reduced Visual Signatures & Antenna Counts*
- *Improved Link Connectivity and Ballistic Protection*
- *Reduced Platform Power Consumption*

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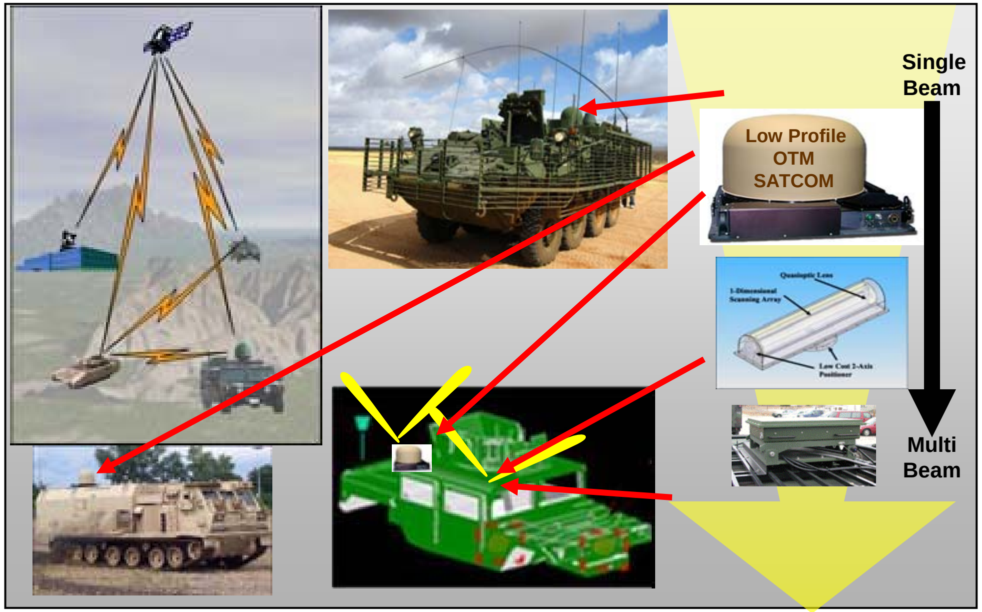
D.C4.2009.01 / Affordable Low Profile Satellite (ALPS) Comms On-the-Move



Purpose:

- *Develop, mature, and demonstrate low profile antennas for directional and satellite communications (SATCOM) on-the-move (OTM)*

Products:

- *Low-profile, single-beam (Ku/Ka) antenna*
- *Low-profile, multi-beam (Ka/Q) antenna*
- *Single-beam high capacity communications capability (HC3) (Ka/Q) antenna*
- *Small aperture blue force tracking (BFT) antenna*
- *C/Ku Affordable Directional Antenna*
- *Integrated Ka/Q-band Power Amplifier*

Payoff:

- *Increased Communications Capabilities at all echelons through greater use of SATCOM OTM*
- *Reduced platform burden through reductions in antenna size, weight, and power(SWaP)*
- *Increased survivability through reduced visual signature*
- *Affordable SATCOM OTM for the warfighter through antenna cost reductions*

D.C4.2003.01. / Tactical Wireless Network Assurance (TWNA)

Purpose:

To develop and transition wireless network protection solutions for a tactical Mobile Ad-hoc Networking (MANET) environment that is typical of WIN-T and the Future Force.

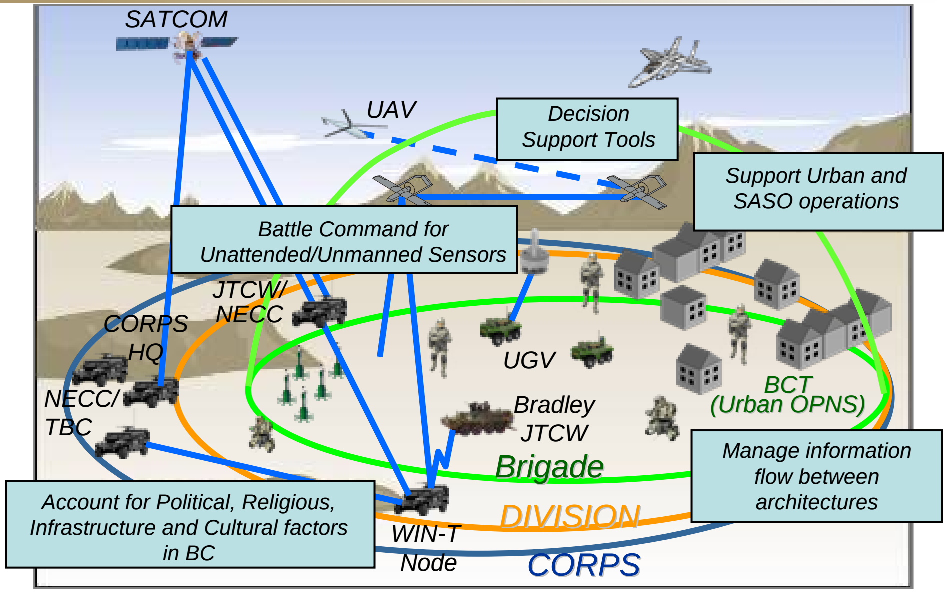
Product:

- Tactical security administration tool for mobile wireless environment.
- Intrusion Detection Algorithms for MANET routing protocols
- Tactical Public Key Infrastructure (TPKI)
  - Architecture
  - Certificate Issuance
  - Field Replacements
  - Revocation

Payoff:

- Prevent threat Information Warfare attacks from damaging mobile networks.
- Maintain Warfighter trust/confidence in battlefield information.
- Reduce system and network vulnerabilities.

D.C4.2006.01 / Network Enabled Command and Control (NEC2)



Purpose:

Develop and transition software and algorithms that tailor and manage the flow of Battle Command (BC) information and C2 services between current and future systems throughout all phases of operations and environments

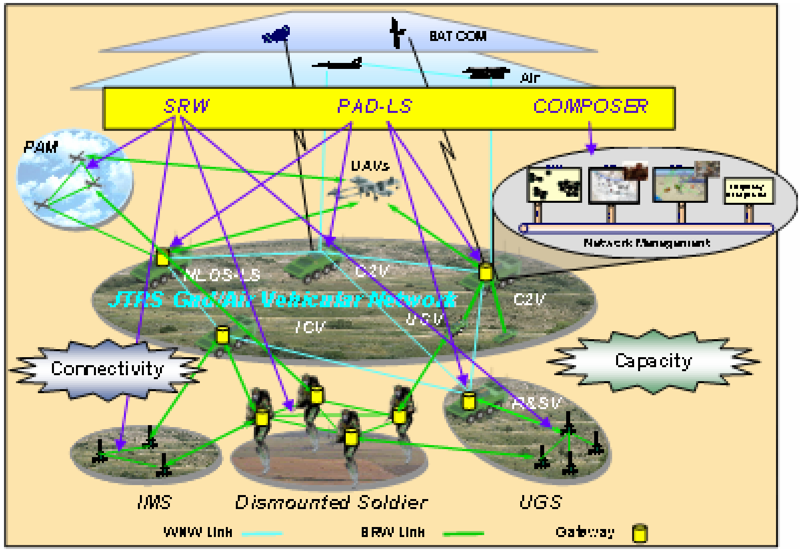
Products:

- ***Battle Command Planning/execution/re-planning products for:***
  - ***Dismounted applications in Complex and Urban Terrain***
  - ***Current Force Tactical C2 Systems***
  - ***Unmanned systems and sensors***
  - ***Decision support tools that account for political, religious, cultural and other factors***
- ***Managed Connectors that govern the flow of information between disparate architectures while globally managing resources***

Payoff:

- ***Increased speed/quality of BC planning and execution adjustments***
- ***Improved commanders' understanding of Battlespace and related factors***
- ***Faster decision-making***

D.C4.2006.03 / Tactical Mobile Networks (TMN)



Purpose:

- Develop Soldier Radio Waveform (SRW) for Dismounted Soldier and manned & unmanned systems.
- Develop communications and networking technologies that address Future Force constraints for bandwidth and connectivity while on the move.

Product:

- JTRS Software Communications Architecture (SCA) v2.2 compliant, energy-efficient Soldier Radio Waveform (SRW)
- PILSNER Proactive Diverse Link Selection (PAD-LS) algorithms to enhance OTM connectivity and capacity
- Faster than real time dynamic link estimation for connectivity and capacity for Network Management and man in the loop experimentation

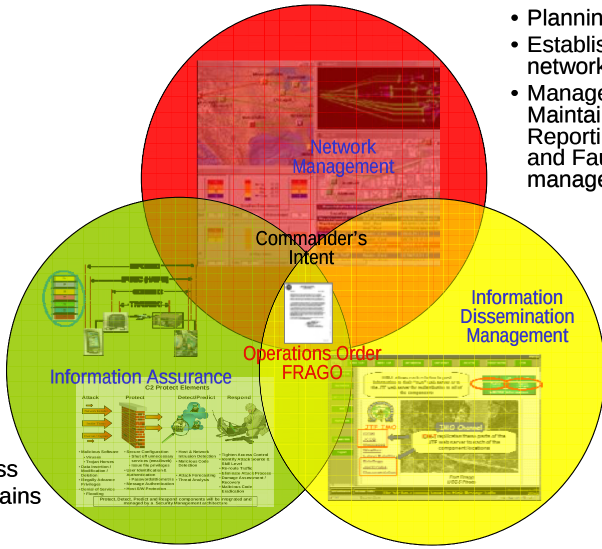
Payoff:

- Energy efficient voice & data tactical communications for Ground Soldier Systems/Future Force Warrior and sensor-to-shooter linkages
- Increased OTM connectivity and usable bandwidth
- Enable commanders to plan communication coverage for OTM Coarse Of Action (COA)
- Addresses PM FCS (BCT) Critical Technology #7B (SRW), Risk #93 mitigation (SRW Availability) to support “Network Ready”

•COMPOSER: Comms Planner for Operational and Simulation Effects with Realism

D.C4.2008.02 / Tactical Information Technologies for Assured Network Operations (TITAN)

- Planning/Replanning
- Establishing the network
- Management, Maintaining and Reporting (Monitoring and Fault management)



•Secure the network
•Protect the information
•Allow information sharing across security domains

Find, manage and display information

Purpose:

- Develop, mature, and demonstrate modular tools and technologies that significantly improve the network planning and management of the tactical network
- Develop, mature, and demonstrate security tools to protect mobile networks from attacks and allow information to be shared across security domains
- Develop, mature, and demonstrate agent enhanced Battle Command (BC) tools to enable real time situational awareness and relevant strategic and tactical battlefield information sharing

Products:

- Automated Network Management (NM) Tools
- Information Assurance (IA) Tools
- Space/Strategic and Tactical Information Dissemination and Management (ID&M) Applications and COA development

Payoff:

- Reduce manpower and network management configuration time
- Share information across security domains while ensuring trust/confidence in information being sent to the Warfighter
- Improve information sharing by providing relevant information from strategic to a tactical operational unit

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Future Networking Technologies

- **Affordable Satellite Antennas for Transformation Comm Systems**
  - On The Move Multi band, single/multi beam
  - Affordable phased array antennas
- **Advanced Wireless Security Services**
  - Integrated Information Assurance (IA) Correlation and Response
  - Software Cross Domain Security Services
- **Cognitive Networking**
  - Multi-Function RF systems (Radio / EW)
  - Dynamic Spectrum Access Capabilities
  - Adaptive middleware for applications to adjust to network conditions.

Process for Cognitive Network Project Development

Req'ts Definition

HW/SW Architecture

Current Knowledge base Inputs: DARPA, Industry, ARL Etc…

Disciplined Systems Engineering Approach

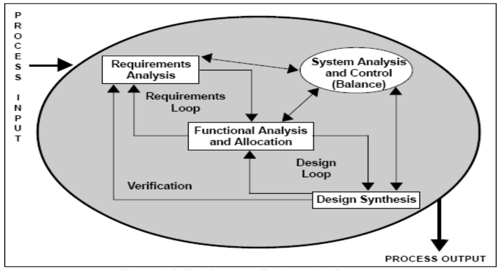


Figure 1-3. The Systems Engineering Process

- A. Dynamic Spectrum Process & Sensing
- B. Networking
- C. Data Exchange & Dissemination
- D. Information Assurance
- E. Applications
- F. Cognitive Management
- G. HW Design & Development
- H. Cross Layering
- I. System Evaluation

Simulation/ Emulation → Development Of Prototypes → Testing/ Demos

Analytical Assessment Using Req't & CBMANET Scenario

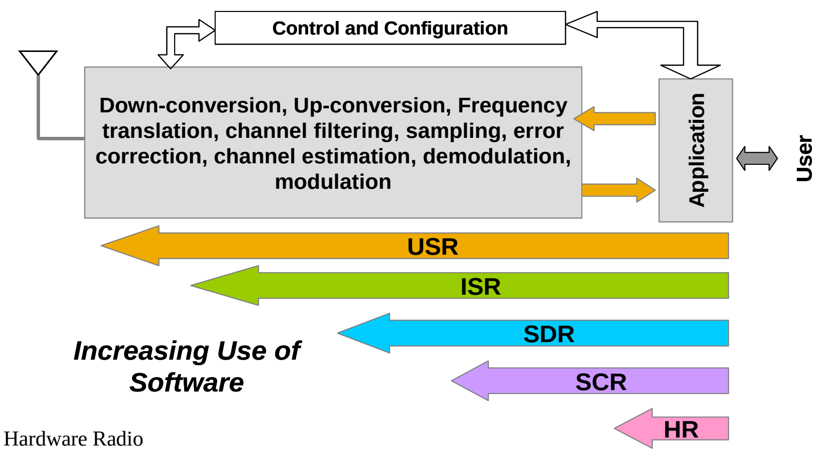
RDECOM

Cognitive Network & Radio Study

CERDEC US ARMY–RDECOM

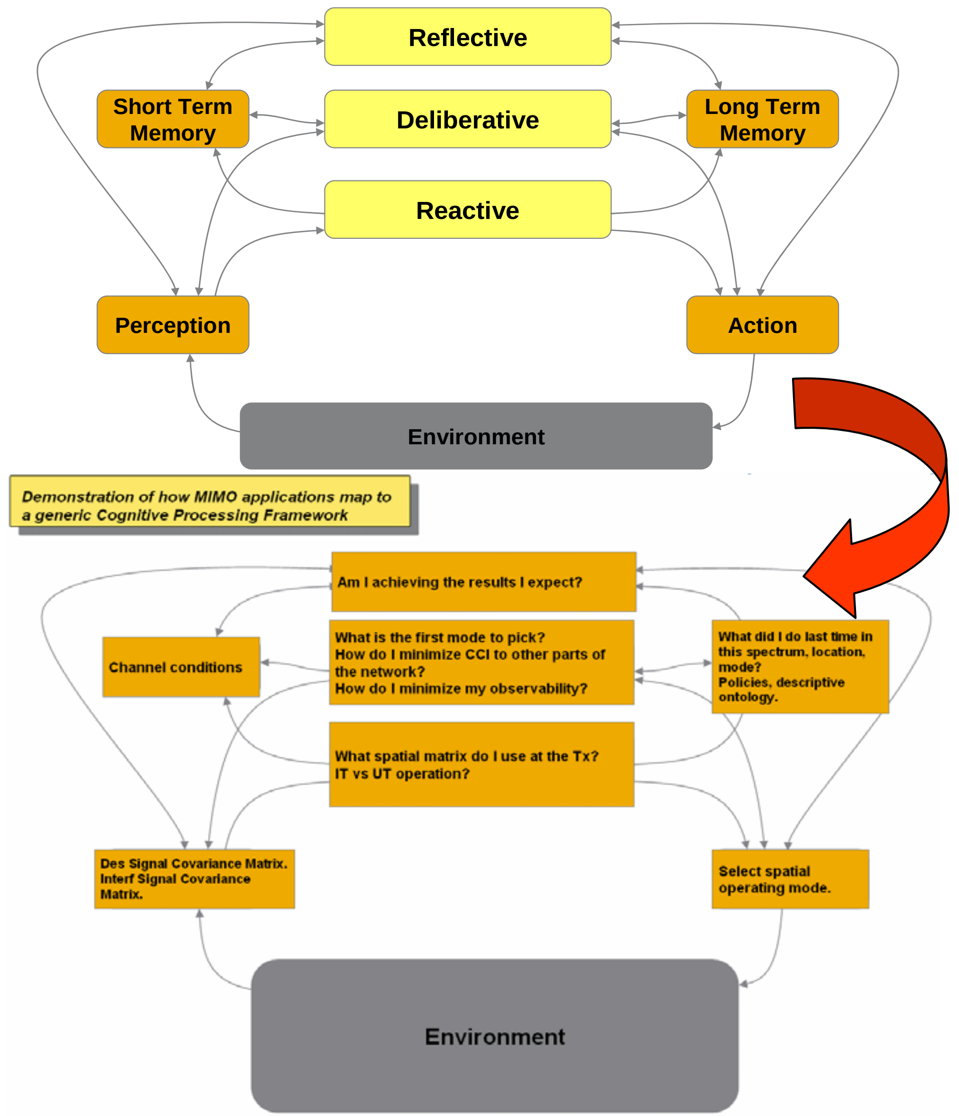
Description: A cognitive network consists of technologies that can perceive current network conditions, and then sense, plan, decide and act on those conditions. The network can learn from these adaptations and use them to make future decisions, all while taking into account end-to-end performance goals and user needs

Benefits: A cognitive radio has awareness of changes in its environment and adapts its operating characteristics to improve its performance or to minimize a loss in performance



HR – Hardware Radio
SCR – Software Controlled Radio
SDR – Software Defined Radio
ISR – Ideal Software Radio
USR – Ultimate Software Radio

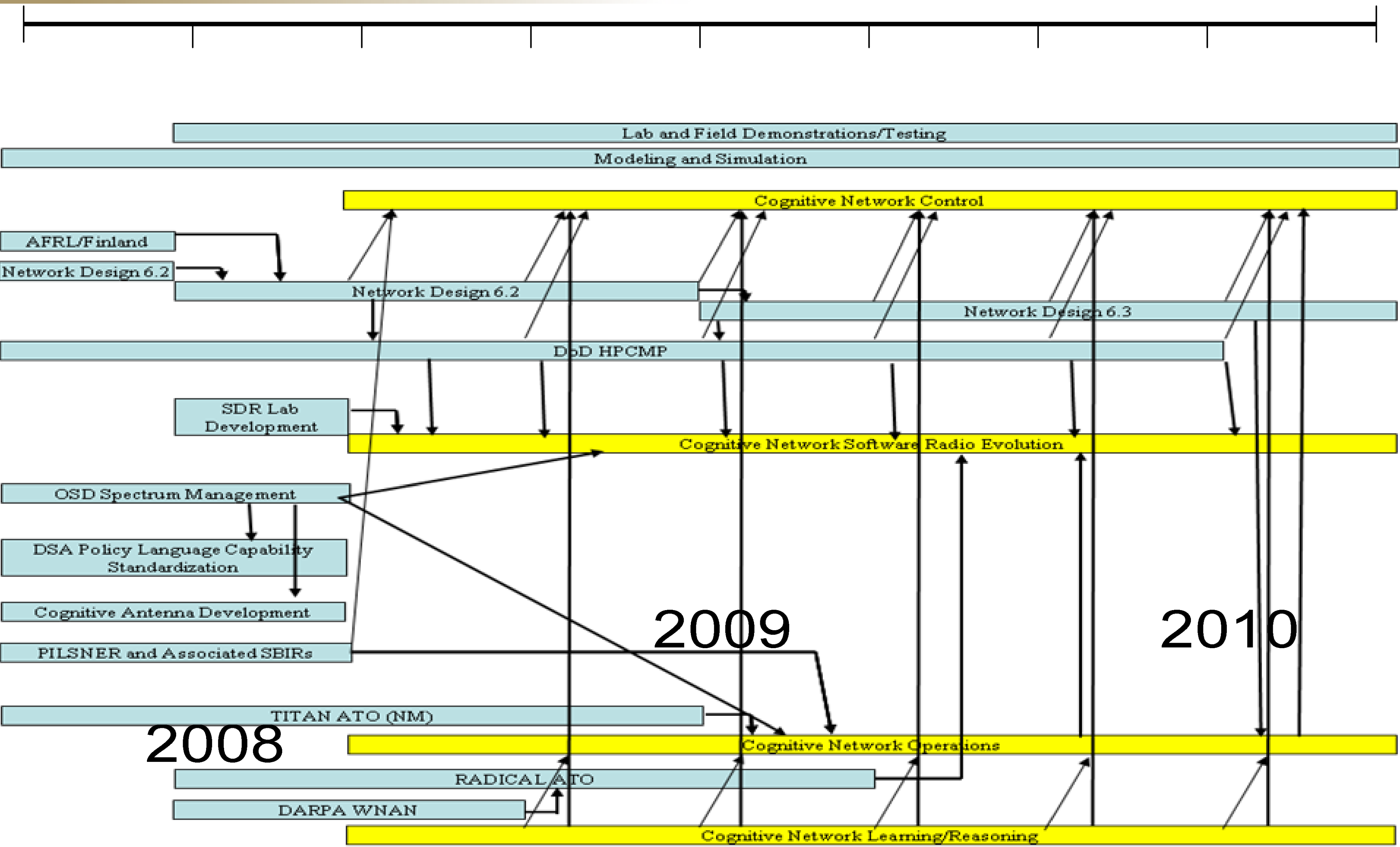
Generic Cognitive Processing Framework – An Example



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Approved for public release; distribution is unlimited.

Cognitive Network High-Level Roadmap



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Example: Cognitive Radio Benefits

Current Radio Architectures

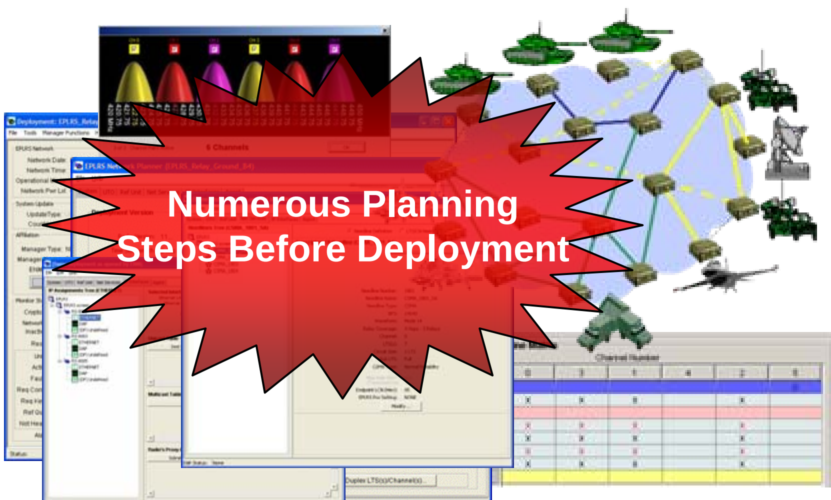
- Extensive planning before deployment
- Detailed organization structure required accounting for every radio
- Detailed definition of Comm. Circuits and static routing procedures
- Intensive training for network development
- Static Network Configuration
- Limited network adjustment
- Individual nodes unaware of conditions experienced by other nodes
- Unaware of context of operation

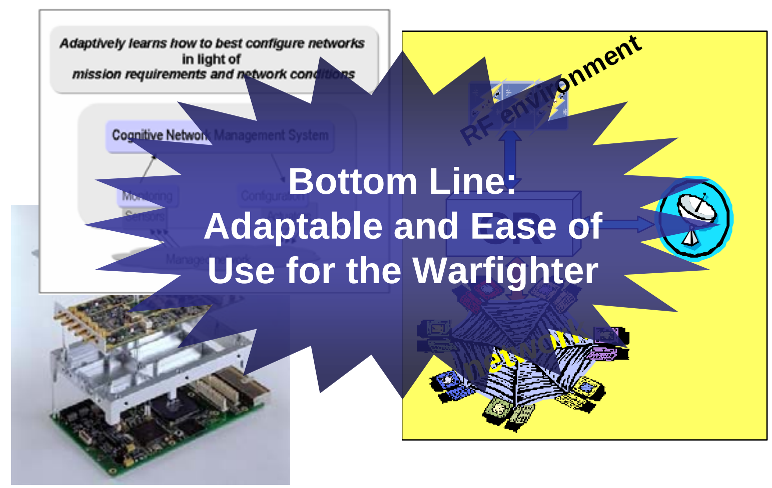
Cognitive Radio R&D

Future Cognitive Radio Architectures

- Automated Policy Planning
- Policy Adjustment Based on Needs
- Less “Knobs” for the Warfighter
- Lessens training required for operators
- Decisions made to meet requirements of user with minimal interaction
- Variable network configurations in real-time
- Automated response fostering optimum network performance
- Learning from user experiences in entire network to adjust goals
- Automatic adaptation based on changing context

Legacy Example: EPLRS





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Questions?

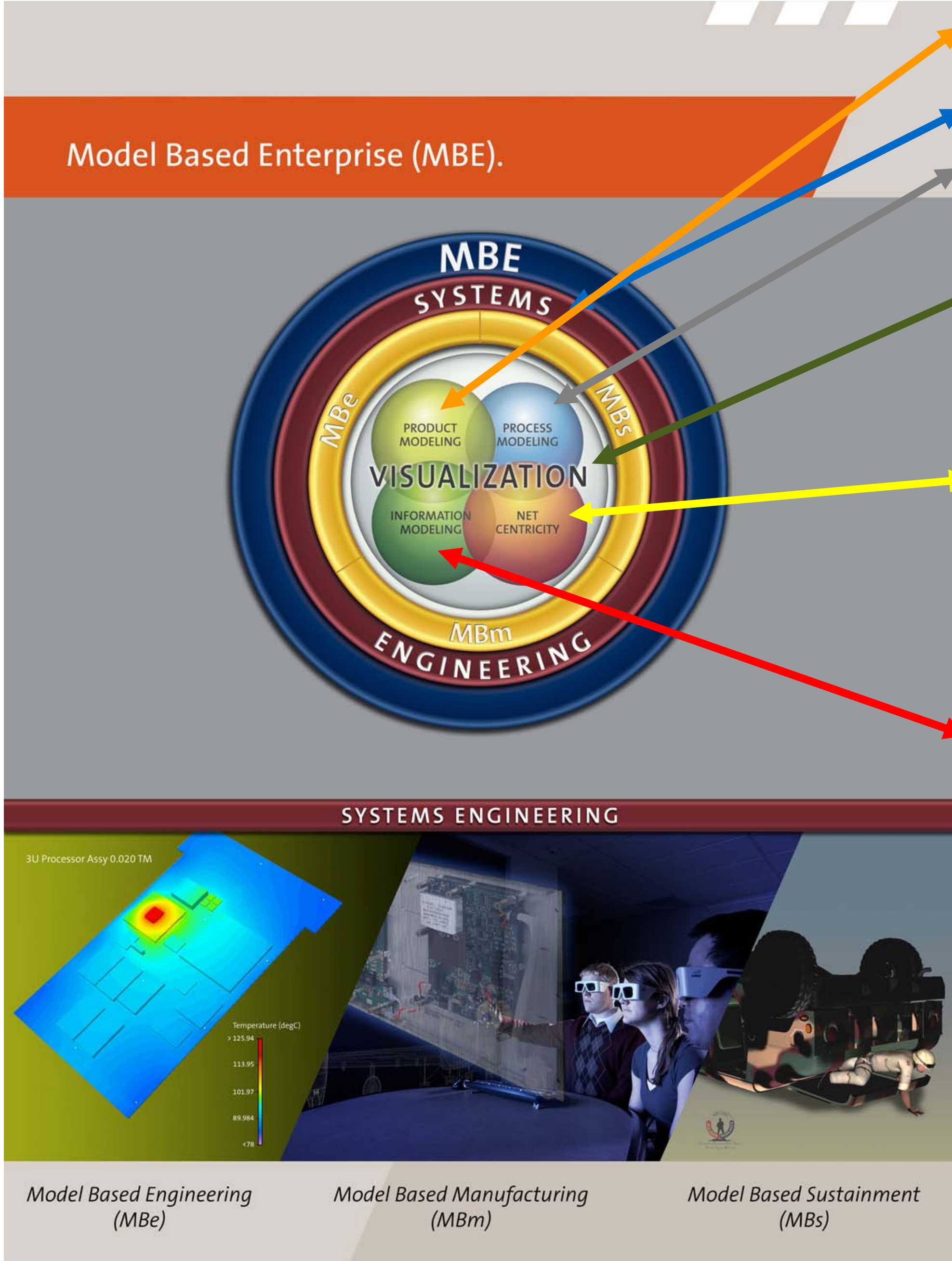
Model Based Manufacturing – Predicting Future Performance

Jim Lorenz
Manager, Advanced Industrial Engineering
April 17, 2008

Agenda

- MBE Overview
- MBm Projects
- MBm/MRL Relationship
- Summary

What is the Model Based Enterprise?



Model Based Enterprise: An integrated environment which allows prediction of future performance, facilitates efficient use of tools and processes and enables multi-disciplinary decision making throughout the entire life cycle

Product modeling

Systems Engineering

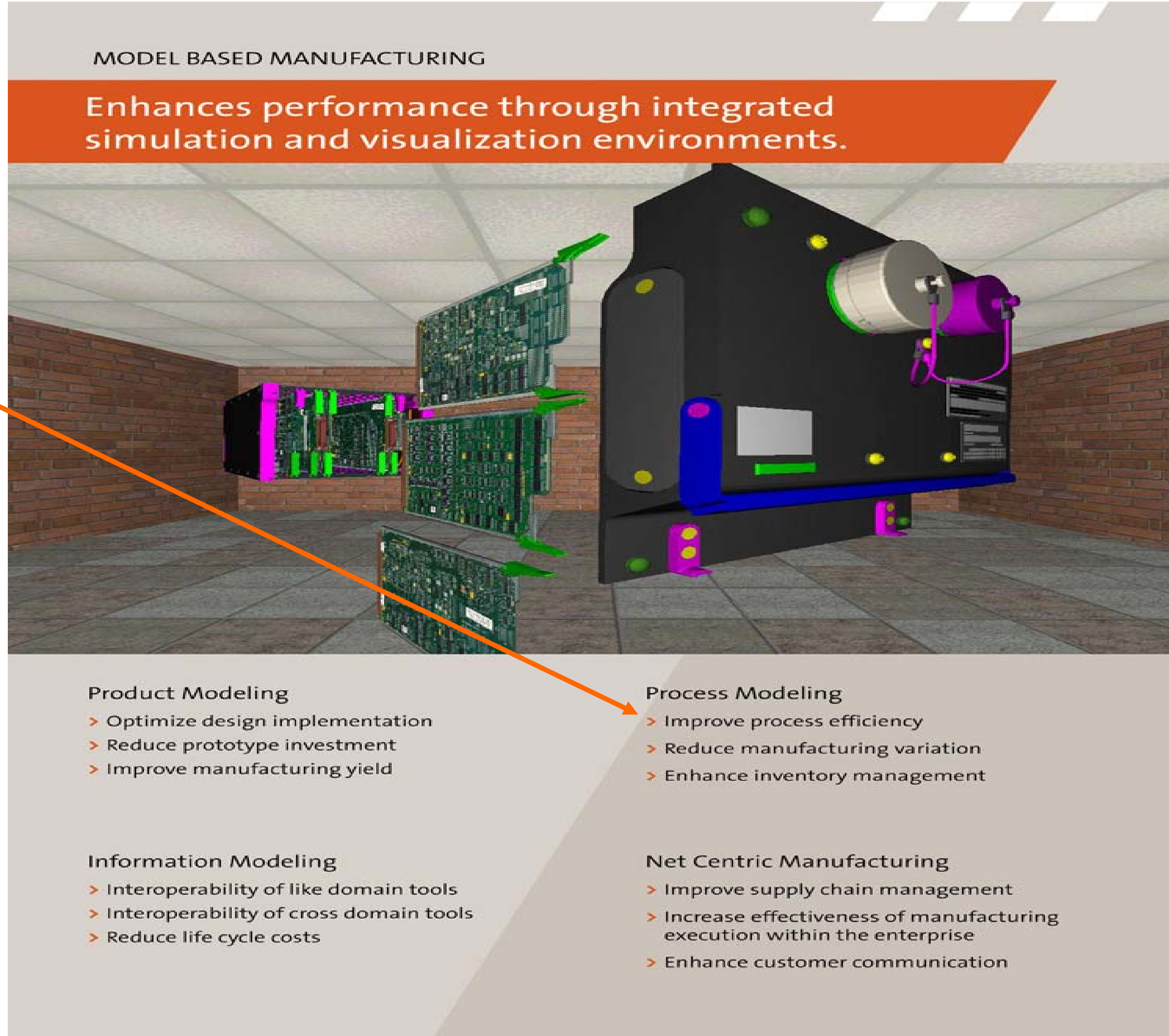
Whether MBe, MBm or Mbs, visualization

Net Centricity ensures the availability of managed information at the right place and time, supporting multi functional decision making and execution across the extended enterprise

Information modeling incorporates standard formats to ensure interoperability of like and cross domain decision making tools and processes

Process Modeling:

Improve process efficiency



MBE Active Industry Projects and Opportunities

PDES, Inc.

MBe – Model Based Engineering

MBm – Model Based Manufacturing

MBs – Model Based Sustainment

NEXT GENERATION MANUFACTURING TECHNOLOGY INITIATIVE

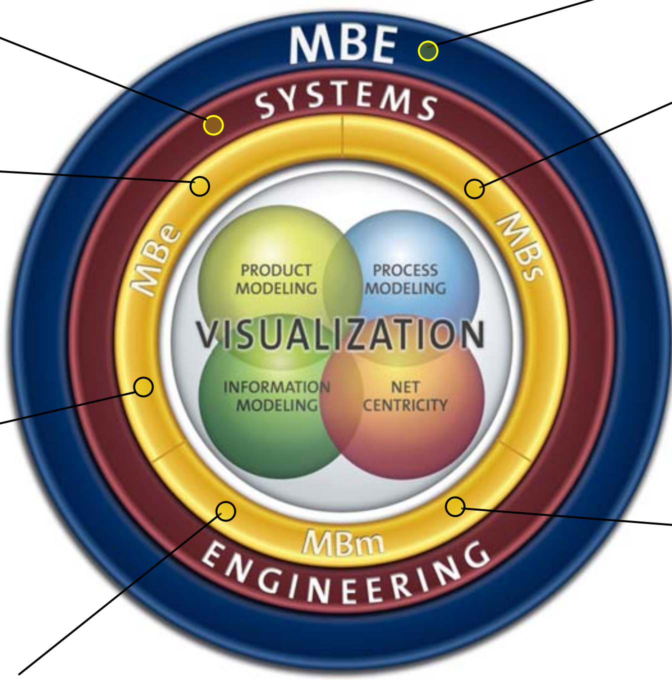
Systems Engineering (AP233)

MBE-IF Testing

System Life Cycle Support

Engineering Analysis - STEP Composites and CAE Visualization in Adobe Acrobat

EM Pilot – Warpage Simulation



Potential MBs Project:

Long Term Data Retention

Value Stream Mapping

Potential MBe Project:

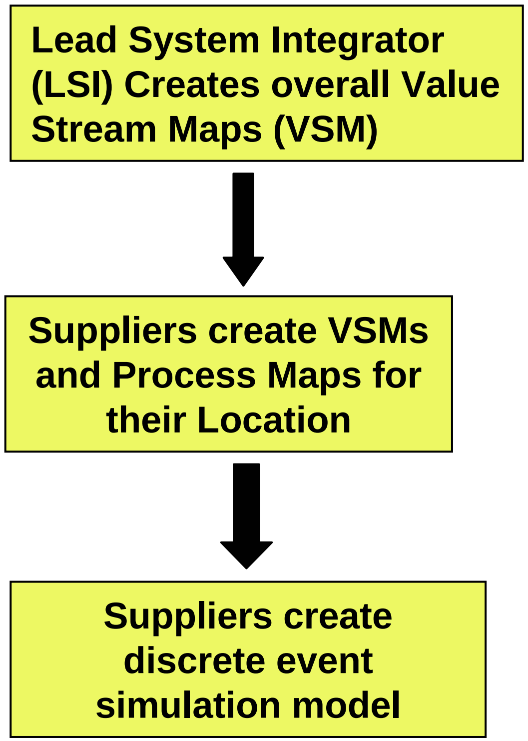
ECAD/MCAD Integration

Flow Equivalent Servers

Potential MBm Projects:

- **Next Generation Supply Chain Modeling**
- **Integrated Flow Modeling and Physical Layout**
- **Design For Ergonomics**
- **Cognitive Virtual Environment**

Process Modeling: VSM to Simulation (Current State)



Issues with Current State:

- Discrete event simulations are time consuming to create and duplicate much of the effort to generate the VSM
- Suppliers are hesitant to share simulation data because it can include intellectual property
- Inconsistencies in how simulations are done make it difficult to gather information from a large supply chain

Process Modeling: VSM to Simulation (Future State)

Lead System Integrator (LSI) Creates overall Value Stream Maps (VSM)

Suppliers create VSMs and Process Maps for their Location

Standard mapping definitions (including simulation data)

Suppliers create discrete event simulation model

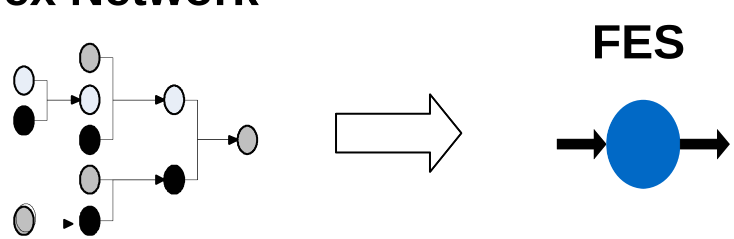
Model converted by suppliers to Flow Equivalent Servers (FESs)

LSI integrates FESs into overall Value chain simulation

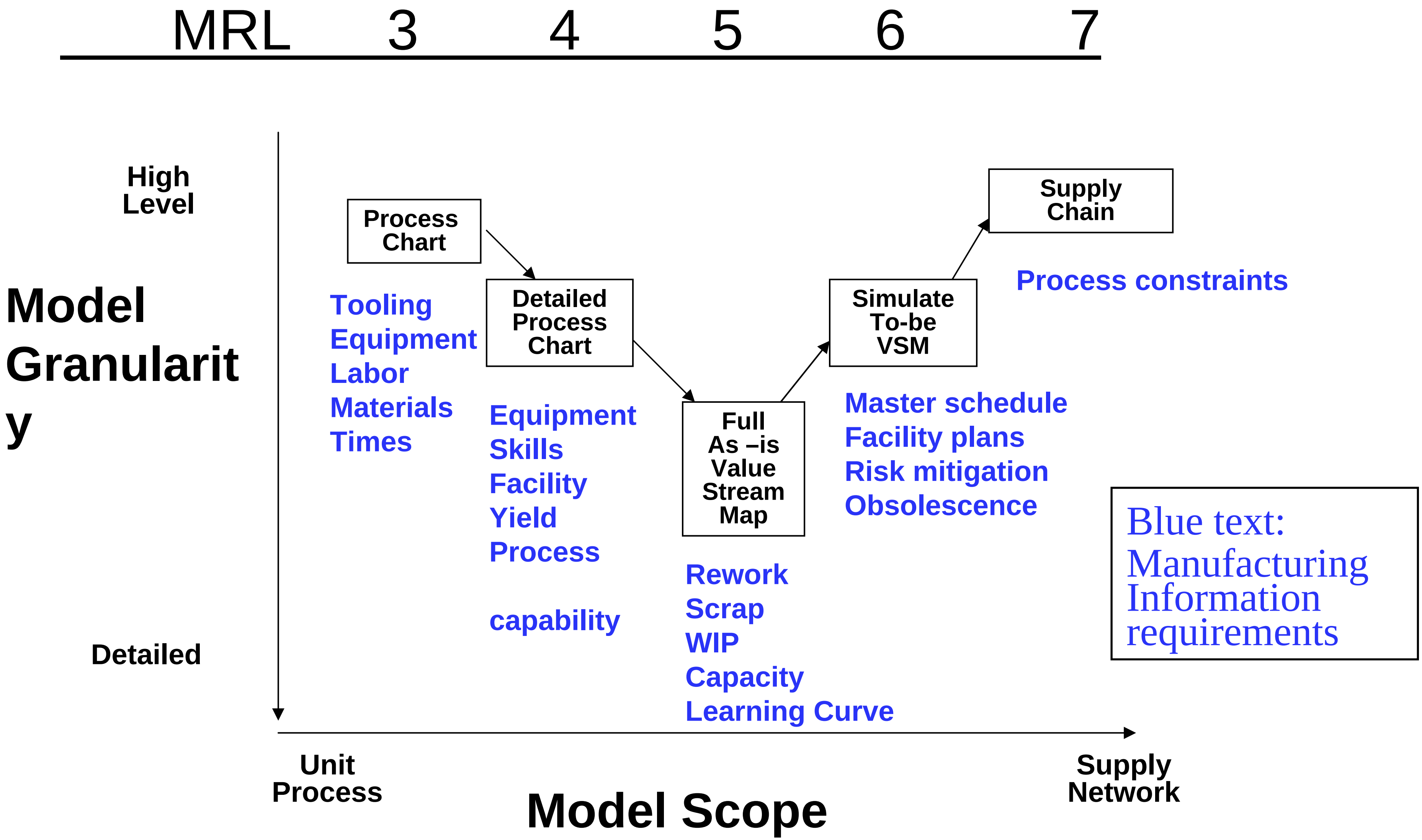
Benefits of Future State:

- DESs are easier to generate and more standard
- Enhanced communication between customer and LSI
- Predictive supply chain modeling
- Reduced intellectual property concerns

Complex Network



Process Modeling within the MRL Structure



Summary

- Manufacturing Readiness Levels assesses whether or not a design will be successful in production
- Model Based Manufacturing provides the ability to predict the performance of products and processes
- Information flow across boundaries requires standard data definition

Contact Information

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Science & Technology Program
16 April 2008

Dr. James Sheehy
Chief Scientist / Technology Officer
Human Systems, AIR-4.6T)
E-mail: james.sheehy@navy.mil
Phone: (301) 342-8480

NAVAIR Sites

TRAINING SYSTEMS DIVISION, ORLANDO, FL

Center for research, development, test and evaluation, acquisition and product support of training systems for the world.

AIRCRAFT DIVISION, LAKEHURST, NJ

Provides aircraft launch and recovery expertise to the fleet.

AIRCRAFT DIVISION, PATUXENT RIVER, MD

Provides acquisition management, research and development capabilities, air and ground test and evaluation, aircraft logistics and maintenance management for Naval aviation.

WEAPONS DIVISION, CHINA LAKE & PT MUGU, CA

Provides our forces with effective and affordable integrated warfare systems and life cycle support to ensure battlespace dominance.

NAVAIR DEPOT, NORTH ISLAND, CA

Provides comprehensive quality aviation support to the nation's warfighters.

Aircraft: F/A-18 Hornet; E-2C Hawkeye; C-2 Greyhound; S-3 Viking; H-60 Seahawk

NAVAIR DEPOT, CHERRY POINT, NC

Delivers on time quality products and services for Naval aviation as service to the fleet.

Aircraft: AV-8B, Harrier; H-53, Sea Stallion; C-130, Hercules; H-46, Sea Knight; V-22, Osprey; VH-3, Presidential Helicopter

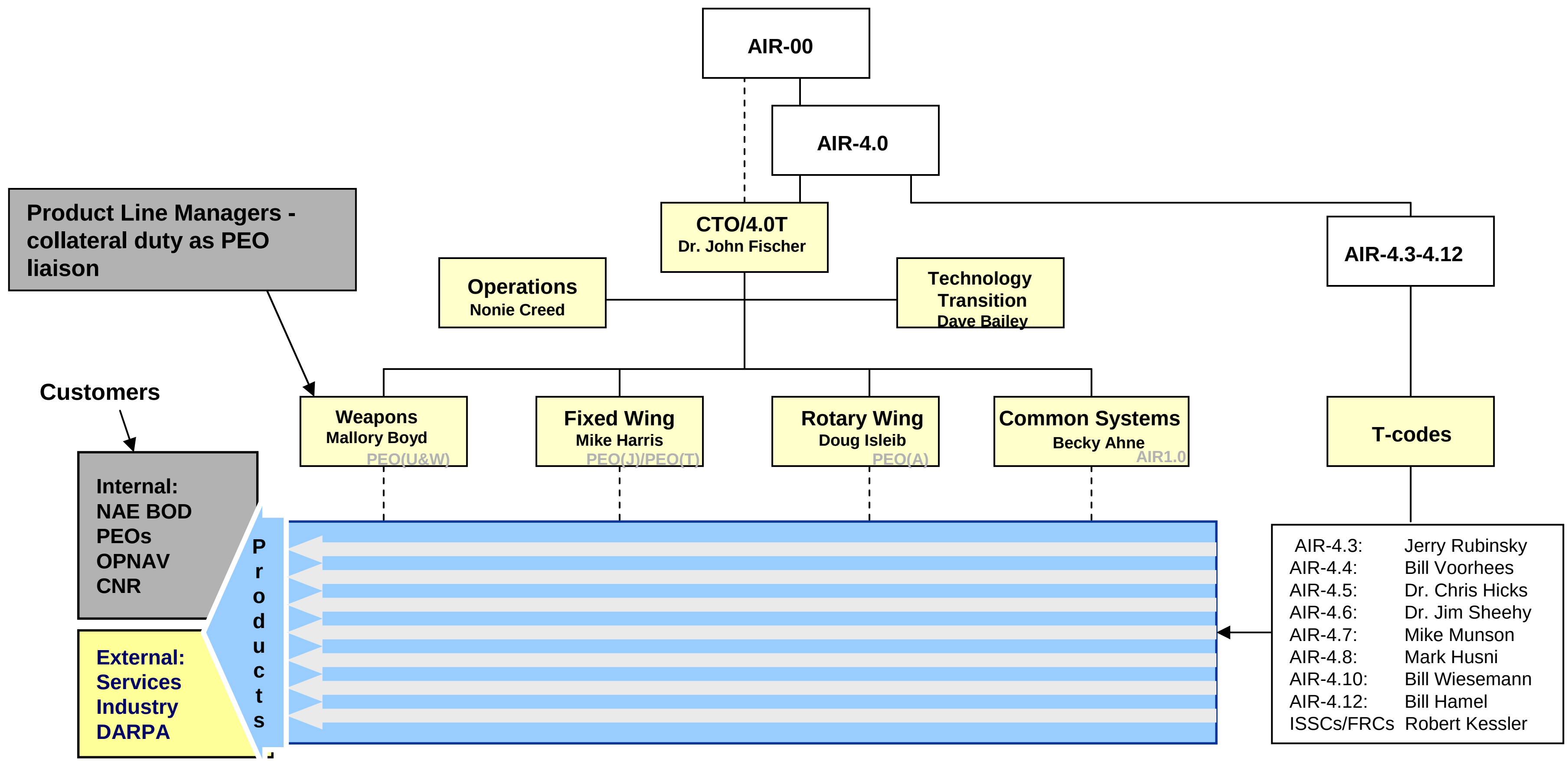
NAVAIR DEPOT, JACKSONVILLE, FL

Delivers high quality maintenance, engineering, logistics and support services to the fleet.

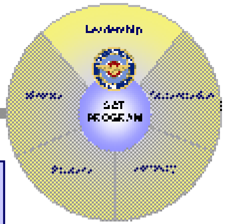
Aircraft: P-3 Orion; EA-6B Prowler, F-14 Tomcat, F/A-18 Hornet; S-3 Viking; SH-60 Seahawk

Science & Technology Organization

The S&T Program is managed by an Integrated Program Team of Product Line Managers and NAVAIR Technologists (T-codes)



Chief Technology Officer (CTO)



CTO engages internally and externally to develop an S&T Program that responds to capability needs with innovative technology solutions

External Focus

- Maintain knowledge of Naval Aviation needs through strong ties to the warfighting community
- Continually seek innovative solutions for warfighter needs. Champion for innovative ideas that do not address a specific need
- Foster relationships with potential technology providers (DoD, Industry, Academia, etc.)
- Support ASN(RDA), Chief of Naval Research and other Enterprise CTOs in planning and executing an effective Navy S&T Program

Internal Focus

- Primary advisor to AIR-00, Naval Aviation Enterprise (NAE) Board of Directors and Program Executive Officers for technology issues & investments
- Advisor to AIR-00 & AIR-4.0 for issues related to S&T workforce & infrastructure, including workforce revitalization efforts
- Monitors health of S&T portfolio and progress toward delivery of capability through the use of approved metrics & processes

NAVAIR

NAE S&T Objectives

- 32 NAE S&T Objectives
  - Represents the *goals* of the NAE S&T program. Used as the baseline for identifying, prioritizing, aligning, and synchronizing S&T efforts throughout the enterprise.
  - Derived from 340+ capability needs provided by warfighters
  - Developed by a Working Group comprised of warfighters
  - Coordinated throughout the enterprise
  - Aligned with ONR Focus Areas, Joint Capability Areas, and Sea Power 21 Pillars
  - Support scenarios contained in Naval Aviation Capability Needs 2030-2050
- **NAE STOs will be presented at 18 April NAE BOD meeting for approval/signature**
  - NAVAIR and CNAF already briefed, ready to approve STO Document

Naval Aviation Enterprise
Science and Technology Objectives

Commander Naval Air Forces

Commander Naval Air Systems Command

Director, Air Warfare Division

30 April 2008

VADM Thomas J. Kilcline, Jr.
Commander, Naval Air Forces

VADM David J. Venlet
Commander, Naval Air Systems Command

RADM Allen G. Myers
Director, Air Warfare Division

STO Distribution (by Capability Gap Area)

32 Total STOs

- Force Protection (FP) **(3)**
- Surface Warfare (SUW) **(1)**
- Under Sea Warfare (USW) **(3)**
- Theater Air and Missile Defense (TAMD) **(2)**
- Strike Operations (STK) **(7)**
- Deploy and Employ Forces (DEF) **(3)**
- Integrated Logistics Support (ILS) **(1)**
- Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) **(6)**
- Enterprise and Platform Enablers (EPE) **(1)**
- System Safety, Availability and Affordability (SSAA) **(2)**
- Naval Warrior Performance (NWP) **(3)**

# of STOs

Summary

- NAE is improving the way it plans and manages the S&T program
  - CTO organization
  - Processes
  - Metrics
- Developed 32 S&T Objectives (STOs)
  - Developed by warfighters, technologists and intelligence community
- Work closely with ONR to ensure that NAE objectives are communicated and advocated
- CTO office supports OPNAV efforts in science and technology
  - Identifying capability needs
  - Identifying appropriate funding venue
  - Update on programs/projects

Dr. John Fischer

Director, Systems Engineering (AIR-4.1)

Chief Technology Officer (AIR-4.0T)

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Phone: (301) 757-2328

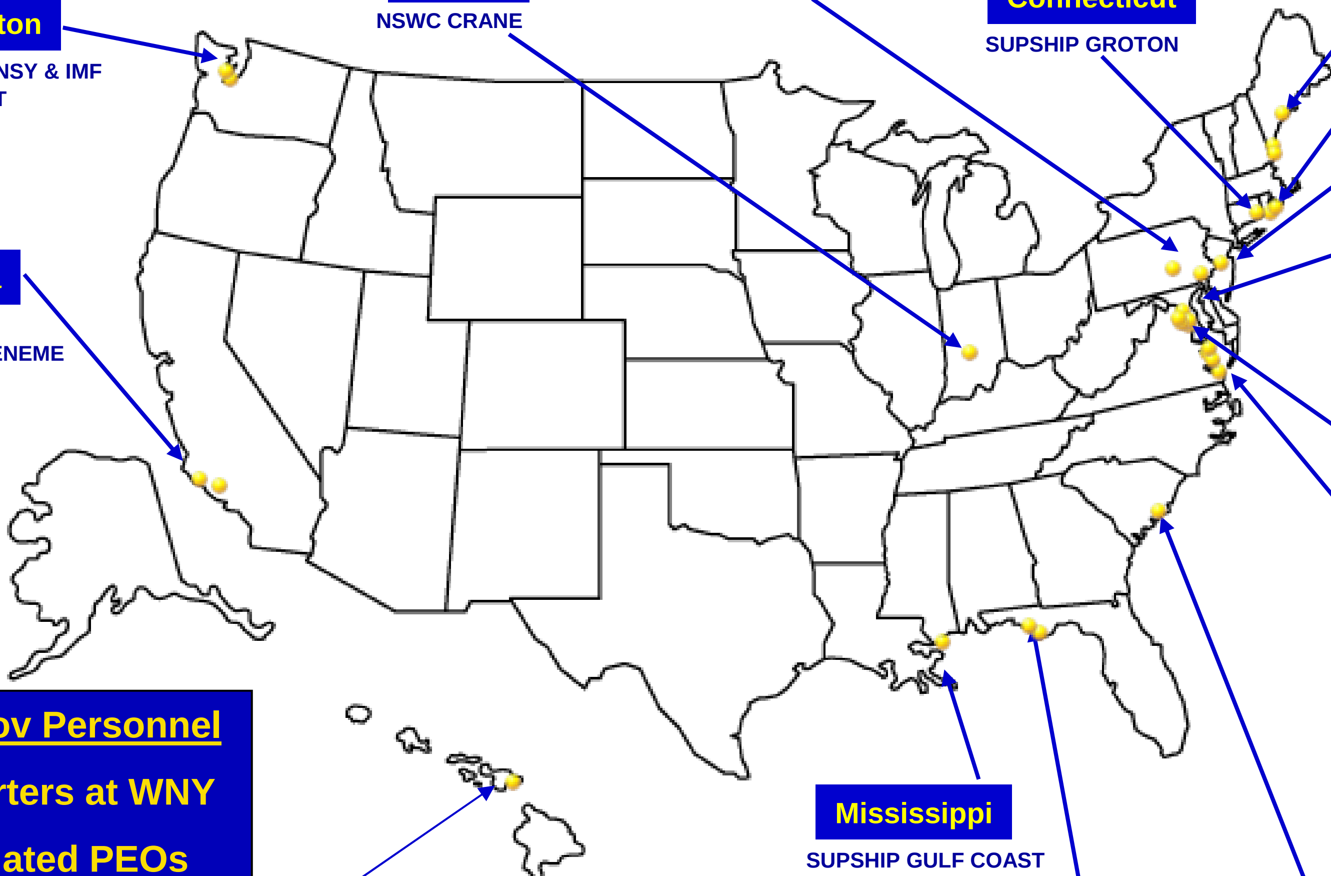
INNOVATIVE TECHNOLOGY INSERTION – NAVSEA'S PERSPECTIVE

9th ANNUAL NDIA SCIENCE & ENGINEERING TECHNOLOGY CONFERENCE

Brian J. Persons
Executive Director
Naval Systems Engineering Directorate (SEA 05)
& Corporate Chief Technology Officer
16 April 2008

NAVSEA
NAVAL SEA SYSTEMS COMMAND

GREATER NAVSEA/PEO ORGANIZATION



Washington
★ PUGET SOUND NSY & IMF
NUWC KEYPORT

Indiana
NSWC CRANE

Pennsylvania
NSWC Ship Systems Engineering Station
Naval Sea Logistics Center

Connecticut
SUPSHIP GROTON

Maine
★ PORTSMOUTH NSY
SUPSHIP BATH
Submarine Maintenance Engineering, Planning & Procurement

Rhode Island
NUWC HQ
NUWC NEWPORT

New Jersey
AEGIS Technical Rep

Maryland
NSWC CARDEROCK
NSWC INDIAN HEAD
Naval Ordnance Safety & Security Activity
Naval Explosive Ordnance Disposal Technology Div

California
NSWC CORONA
NSWC PORT HUENEME

Washington DC
NAVSEA DIR & PEOs
NSWC HQ

Virginia
★ NORFOLK NSY
SUPSHIP NEWPORT NEWS
NSWC DAHLGREN
NSWC Combat Direction Systems Activity
Surface Combat Systems Center
SEASPARROW Project Support Office
AEGIS Ballistic Missile Defense

Hawaii
★ PEARL HARBOR NSY & IMF

Mississippi
SUPSHIP GULF COAST

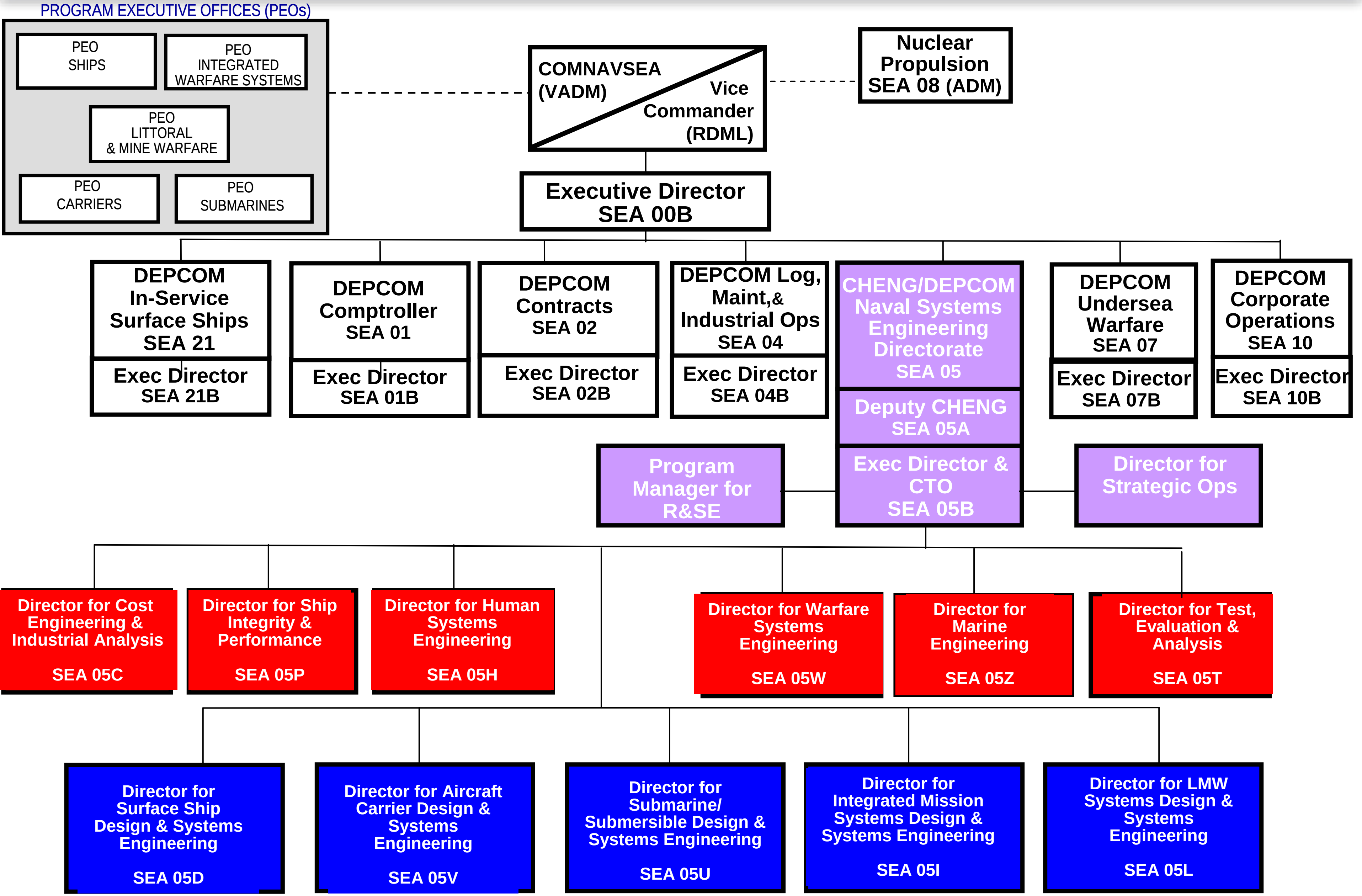
Florida
NSWC Coastal Systems Station
Naval Experimental Diving Unit

South Carolina
Naval Nuclear Power Training Unit

50,000 Gov Personnel
Headquarters at WNY
Five Affiliated PEOs
30+ Organizations

★ CFFC Claimancy/ NAVSEA Operator Tech Mgmt

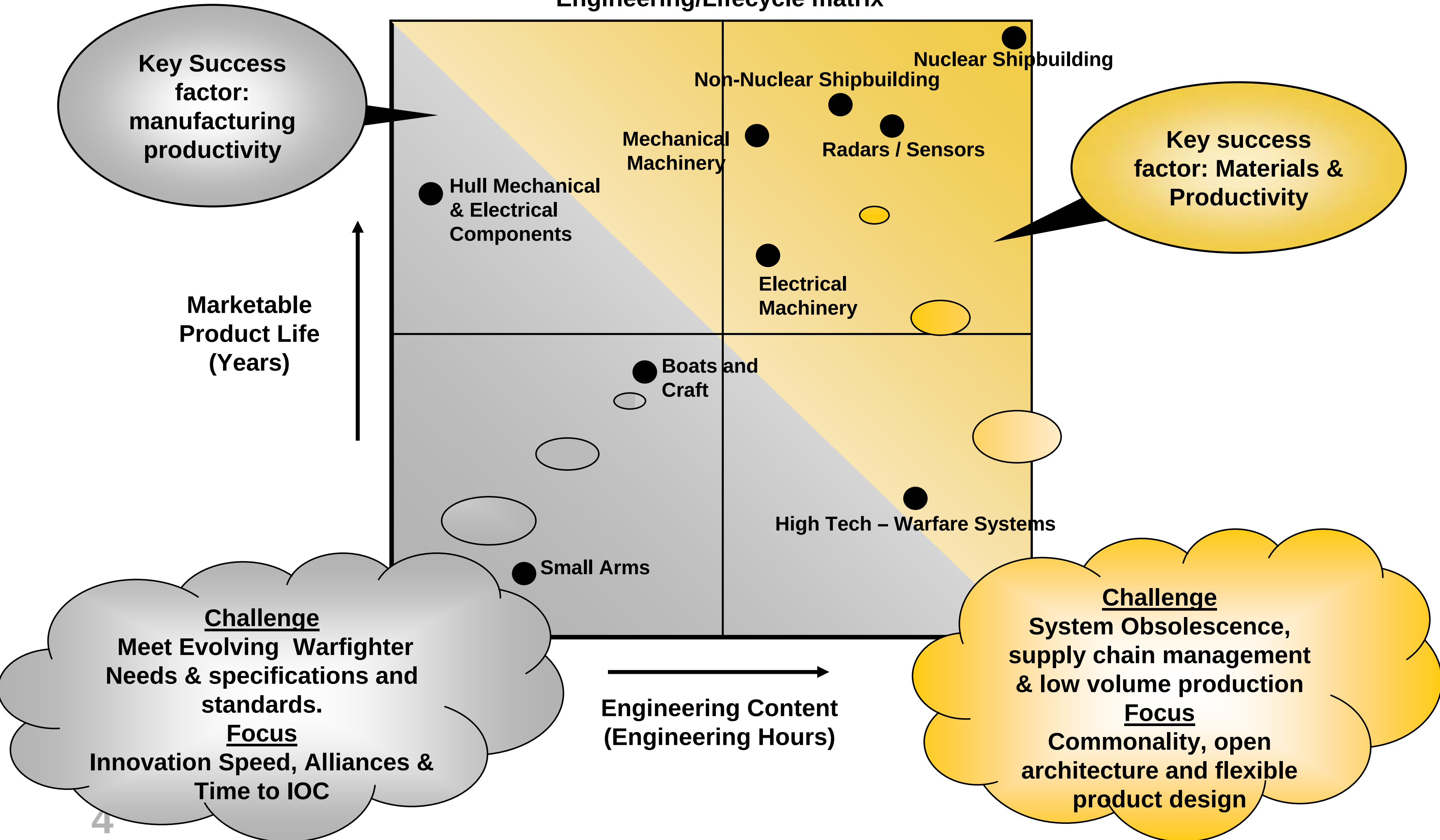
NAVSEA Headquarters



OUR CHALLENGE

Delivering A Diverse Portfolio of Products to War Fighter That Meet All of Their Expectations!

Engineering/Lifecycle matrix



Your Challenge: Who To Contact???

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  (202) 781-3072
  Michael.Bosworth@navy.mil

- Ms. Lisa King
  NAVSEA CTO Office
  (202) 781-1582
  Lisa.M.King.Ctr@navy.mil

- Mr. Dean Putnam
  NAVSEA SBIR Program Manager
  (202) 781-3261
  Dean.R.Putnam@navy.mil

- Dr. Delbert (Ace) l
  NAVSEA Warfare Center Science & Technology Executive
  (850) 234-4202
  Delbert.Summey@navy.mil

Integrating Innovative Battle Command Capabilities

15 April 2008

BG Nick Justice
Program Executive Officer,
PEO Command, Control, Communications Tactical

Agenda

- Understanding the Battle Command (BC) SoS Environment
- Translating S&T Understanding into BC SoS Solutions
- Integrating and Validating New BC Capabilities
- Emerging Innovative Battle Command Technology Examples

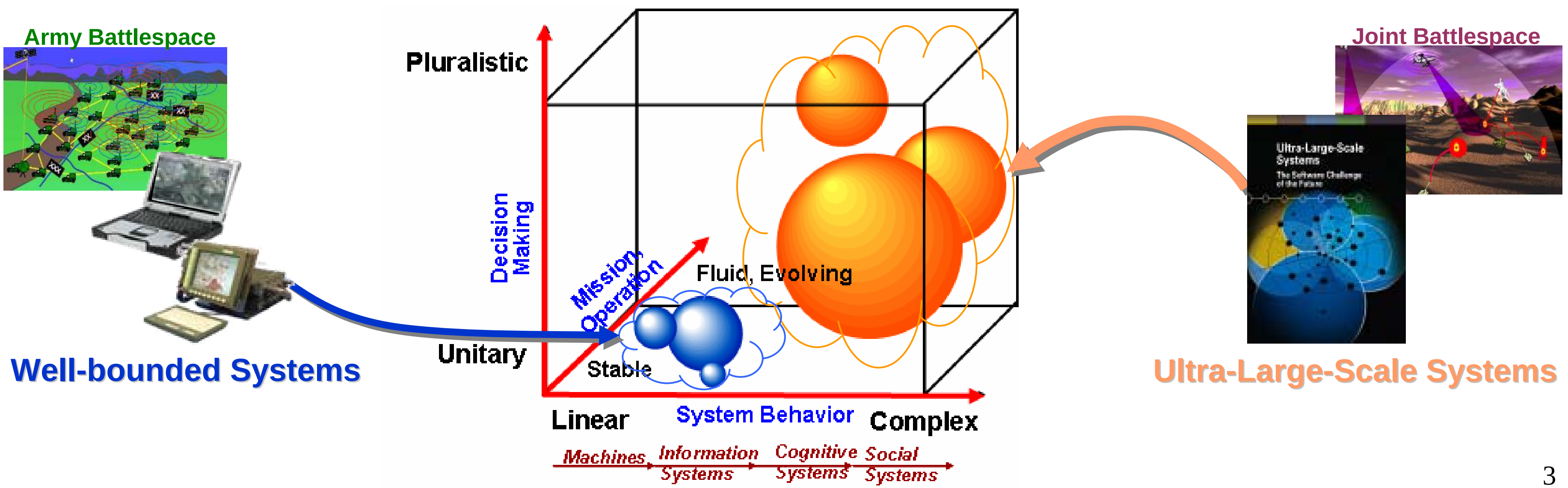
Understanding the Battle Command SoS Environment

Driving Factors

- Uncertain strategic environment demands *agile/adaptive responses*
- *Information as* competitive source of *power*
- Demand for enterprise and extended *enterprise-wide solutions*

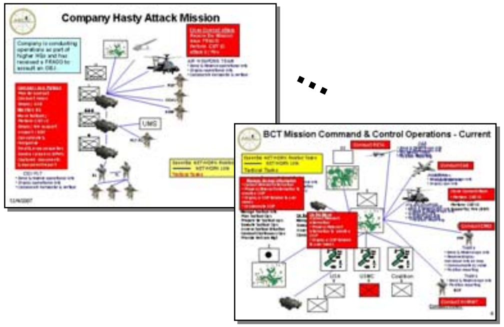
Solution Characteristics

- Richly *interconnected*; increasingly *interdependent*
- *Cross traditional boundaries…* functional, organizational, programmatic
- *Increasing scale/scope*
- *Increasing complexity*



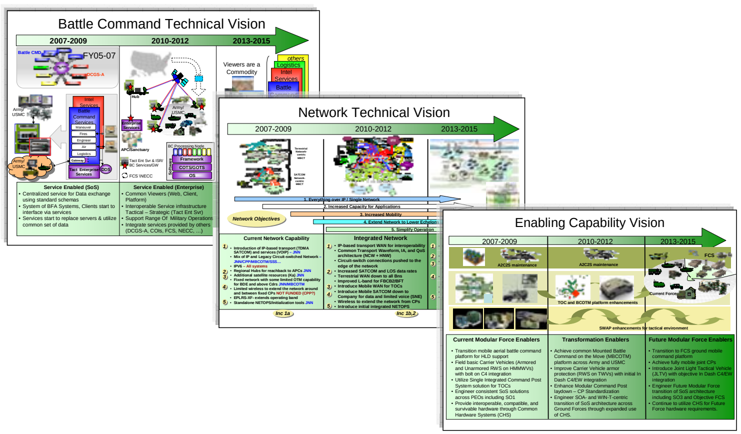
Army Service-Based Approach for Tactical BC Capabilities

Operational Capabilities



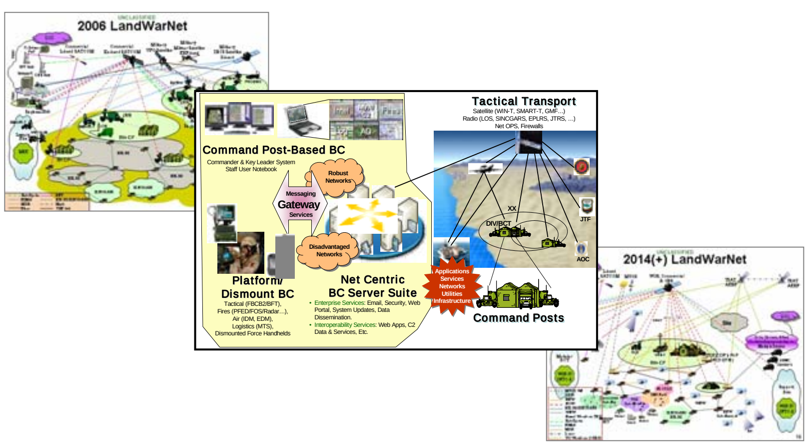
- Establish warfighter operational needs
  - *Currently reworking with "Good Enough Take 2"*

Services



- Translate a BC technical vision for Service implementation to operational capabilities
  - *Converging current and future force service strategies*

System of Systems



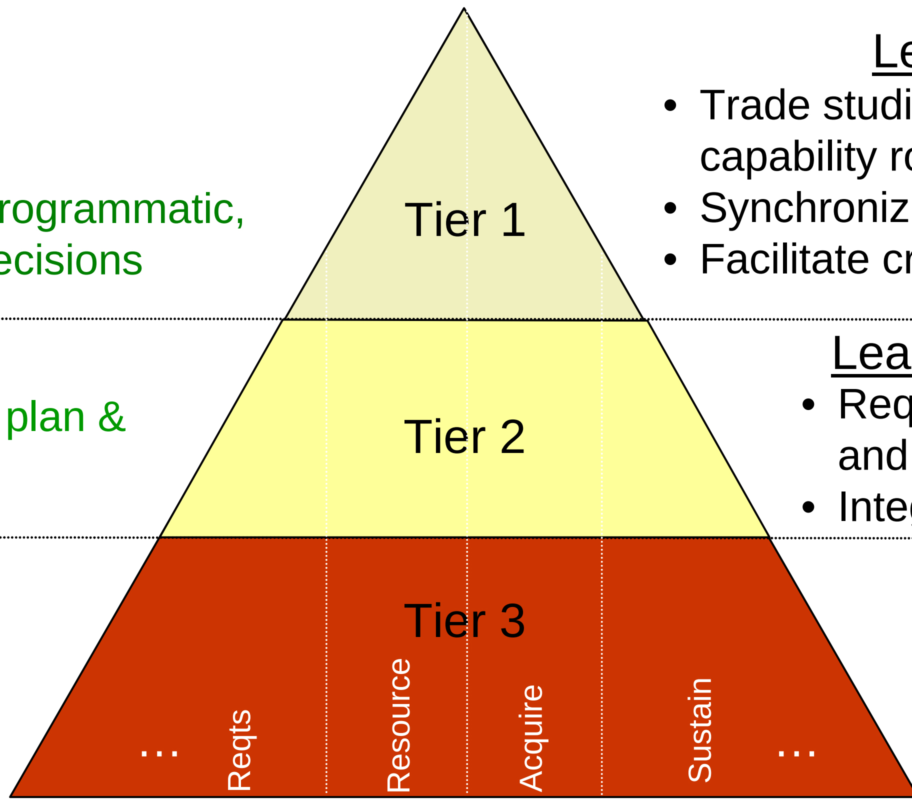
- Execute technical vision through a System of Systems engineering and integration approach
  - *Extending to an ASAALT-led cross Army approach*

Instituting Cross-Army SoS Engineering

Vision, programmatic, policy, decisions

Execution plan & resolution

Execution/ Solution



Lead: ASAALT

- Trade studies and analysis in support of capability roadmaps
- Synchronize enterprise level development
- Facilitate cross-portfolio issue resolution

Lead: ASAALT with PEO SoSE

- Requirements flow down, decomposition, and adjudication
- Integrated schedule and CM

Lead: PEOs

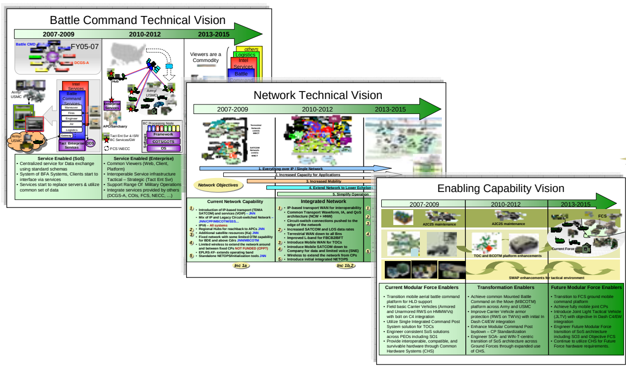
PEO/PM SoS Engineering Teams:

- Technical Execution, Implementation
- Trades supported by R&D Community

Managing depth and breadth of SoS Engineering issues vertically (within) and horizontally (between) C4ISR capability portfolios

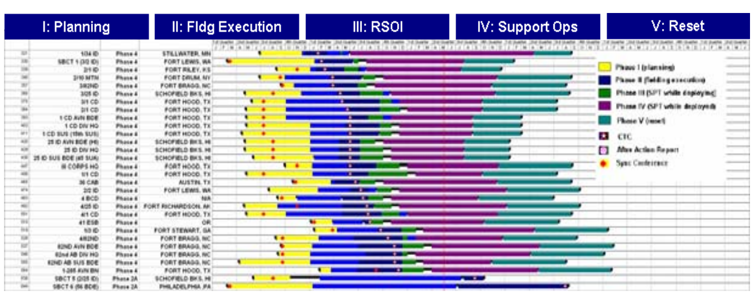
An S&T Innovator's Response

Adapting to the BC SoS Challenge



S&T Transition Challenge

- ***Establish a Shared Vision***
  - Demonstrate operational understanding of the Warfighting domain
- ***Create Product Partnerships***
  - Partner with high impact programs to fill critical technical/operational gaps

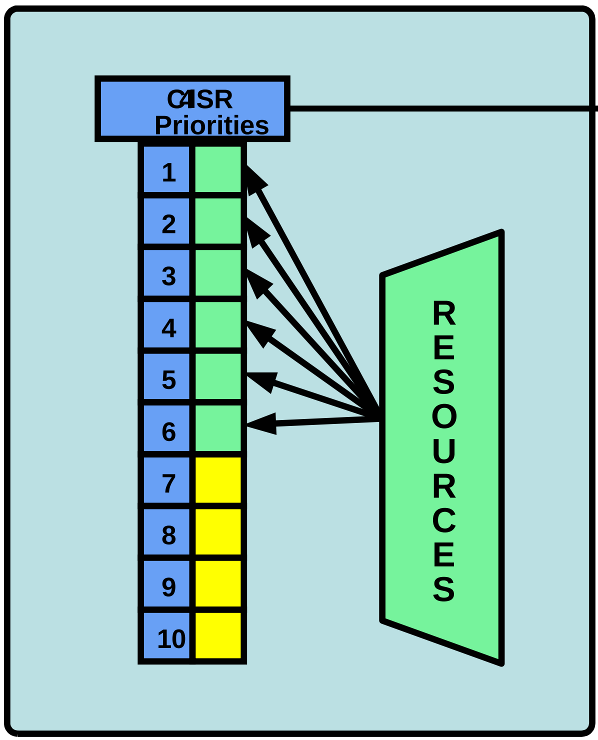


- ***Align Execution Processes***
  - Link S&T solution rollout with aggressive Modular Force capability block development and fielding

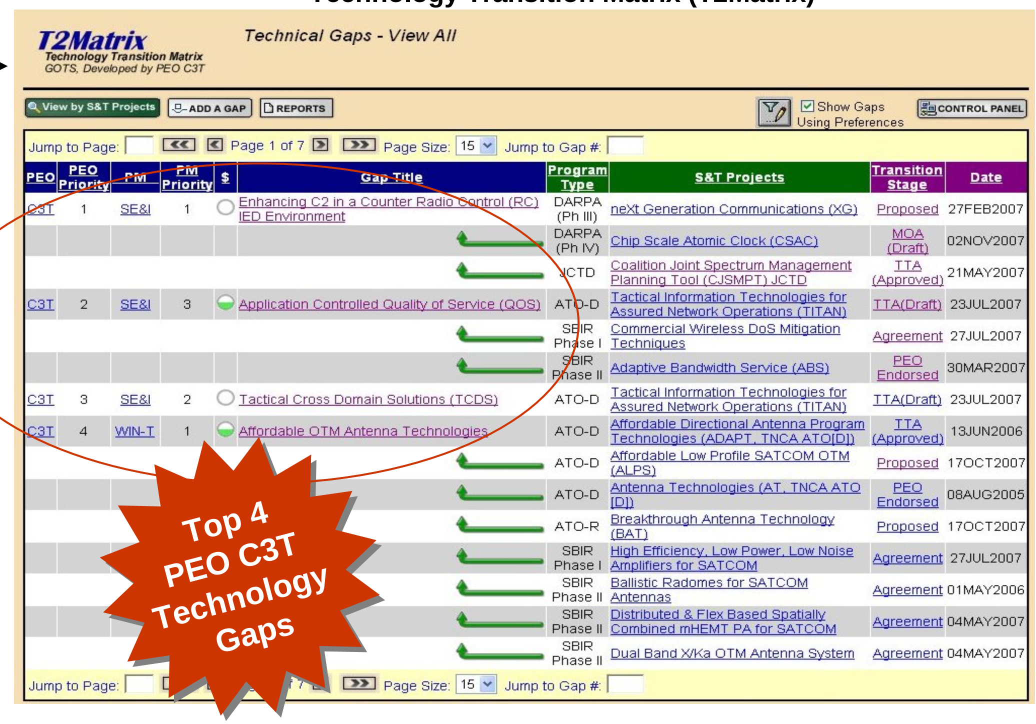
Evolution v. Revolution in fiscally constrained environment

Prioritizing Tactical C3 S&T Execution

PEO C3T Top 20 S&T Priorities



Technology Transition Matrix (T2Matrix)



PEO	PEO Priority	PM	PM Priority	$	Gap Title	Program Type	S&T Projects	Transition Stage	Date
C3T	1	SE&I	1		Enhancing C2 in a Counter Radio Control (RC) IED Environment	DARPA (Ph III)	neXt Generation Communications (XG)	Proposed	27FEB2007
						DARPA (Ph IV)	Chip Scale Atomic Clock (CSAC)	MOA (Draft)	02NOV2007
						JCTD	Coalition Joint Spectrum Management Planning Tool (CJSMPT) JCTD	TTA (Approved)	21MAY2007
C3T	2	SE&I	3		Application Controlled Quality of Service (QOS)	ATO-D	Tactical Information Technologies for Assured Network Operations (TITAN)	TTA(Draft)	23JUL2007
						SBIR Phase I	Commercial Wireless DoS Mitigation Techniques	Agreement	27JUL2007
						SBIR Phase II	Adaptive Bandwidth Service (ABS)	PEO Endorsed	30MAR2007
C3T	3	SE&I	2		Tactical Cross Domain Solutions (TCDS)	ATO-D	Tactical Information Technologies for Assured Network Operations (TITAN)	TTA(Draft)	23JUL2007
C3T	4	WIN-T	1		Affordable OTM Antenna Technologies	ATO-D	Affordable Directional Antenna Program Technologies (ADAPT, TNCA ATO[D])	TTA (Approved)	13JUN2006
						ATO-D	Affordable Low Profile SATCOM OTM (ALPS)	Proposed	17OCT2007
						ATO-D	Antenna Technologies (AT, TNCA ATO [D])	PEO Endorsed	08AUG2005
						ATO-R	Breakthrough Antenna Technology (BAT)	Proposed	17OCT2007
						SBIR Phase I	High Efficiency, Low Power, Low Noise Amplifiers for SATCOM	Agreement	27JUL2007
						SBIR Phase II	Ballistic Radomes for SATCOM Antennas	Agreement	01MAY2006
						SBIR Phase II	Distributed & Flex Based Spatially Combined mHEMT PA for SATCOM	Agreement	04MAY2007
						SBIR Phase II	Dual Band X/Ka OTM Antenna System	Agreement	04MAY2007

https://t2matrix.kc.us.army.mil

Institute an open process to align limited S&T resources with prioritized operational needs and increase transition successes

Transitioning S&T Solutions to PORs

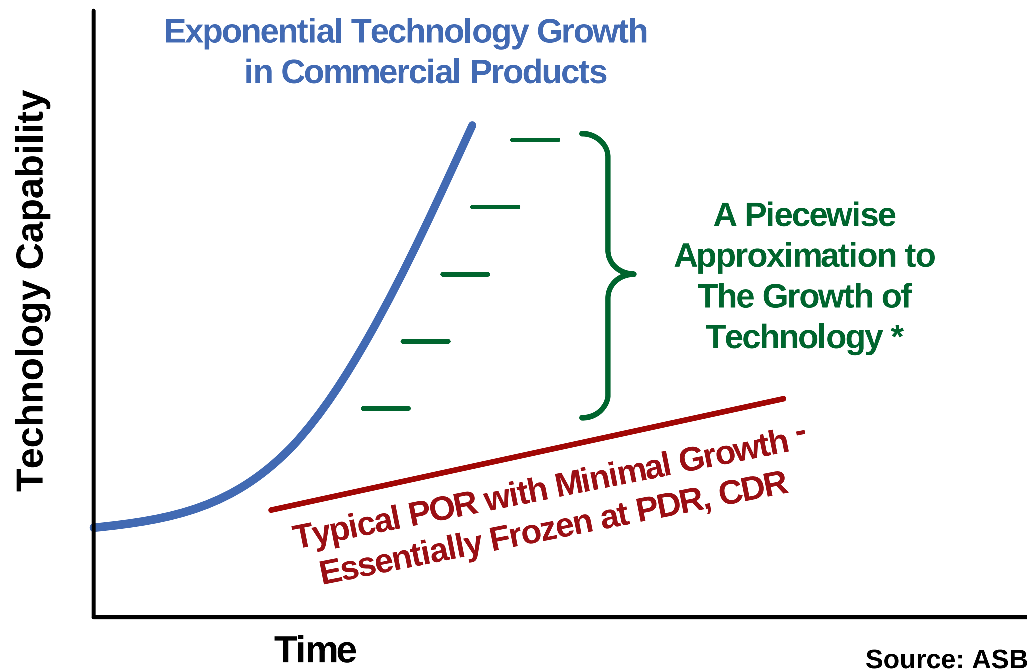
Challenges

– *"Operationalizing"*

- Delivering Warfighter-Focused v. Technology Policy-Driven Solutions

– *Execution Ownership*

- Strategizing with PMs early (and often) on S&T transition

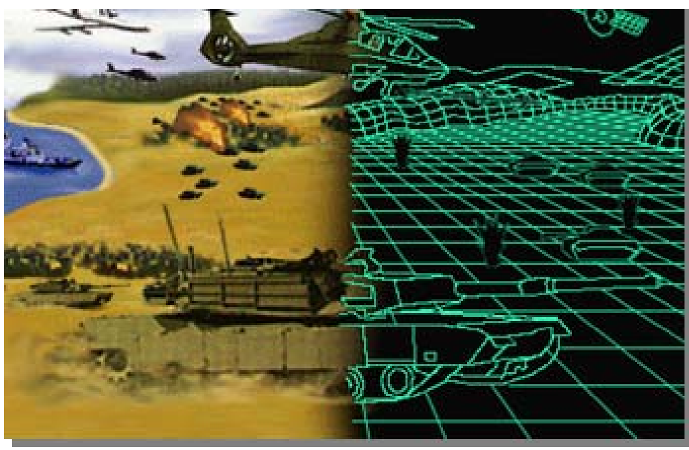


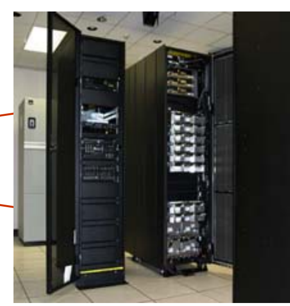
Source: ASB

Advancing C4ISR SoS M&S Capabilities

- Integrated C4ISR Live/Virtual/Constructive Demonstrations and Analyses
  - Enables C4ISR System of Systems Engineering analyses of greater scale and accuracy
  - Relevant across the spectrum of program life cycle
  - More quickly, more efficiently, resulting in significant cost savings/avoidance

Analysis of operational data collected in-theater and used in M&S enabled bandwidth assessments



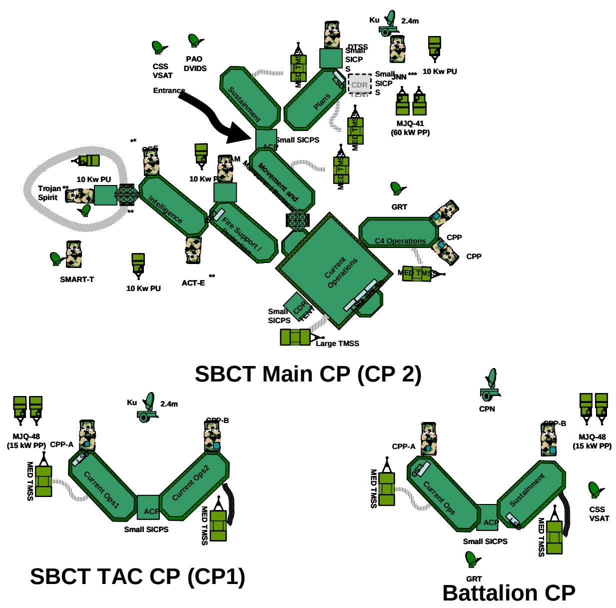


High-Performance-Computing Army Laboratory for Live/Virtual/Constructive Experimentation (H.A.L.L.E.)

Insertion of realistic C4ISR effects into live experimentation environments

Instituting Operational Design Reviews

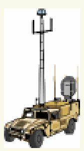
- TOCFEST
  - Team C4ISR engineering field study to validate the current Command Post SoS from 11 Mar to 13 Apr 2008 at Fort Indiantown Gap, PA (FTIG)

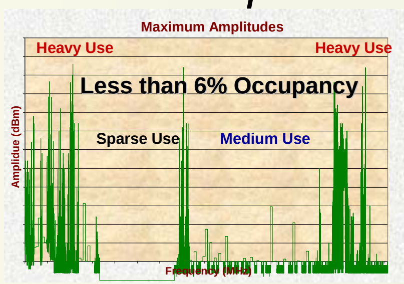


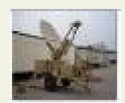
Standardizing Command Post baseline architecture – *physical and logical*
Evaluating technical and operational effects of configuration changes
Setting conditions for ongoing C4ISR SoS operational design reviews

Selected BC Enabling Technologies

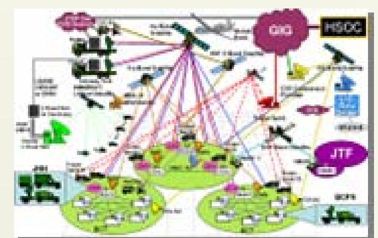
- **neXt Generation Communications (XG) Dynamic Spectrum Access Technology**
  - *Maximize access to and use of required tactical spectrum*

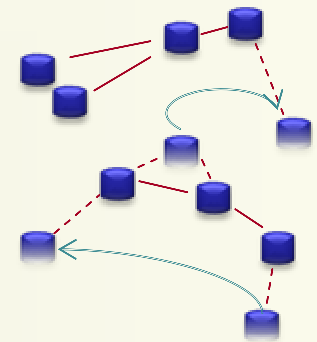




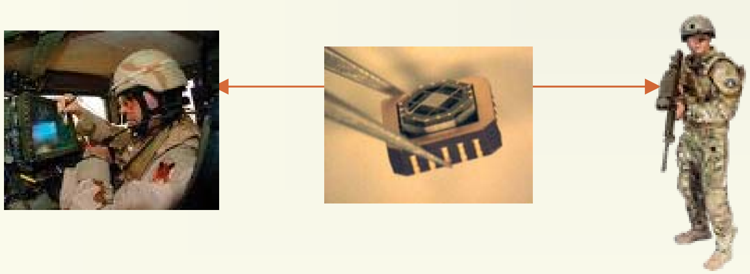


- **Disruption Tolerant Networking (DTN)**
  - *Assure tactical C2 info delivery when no network path exists*



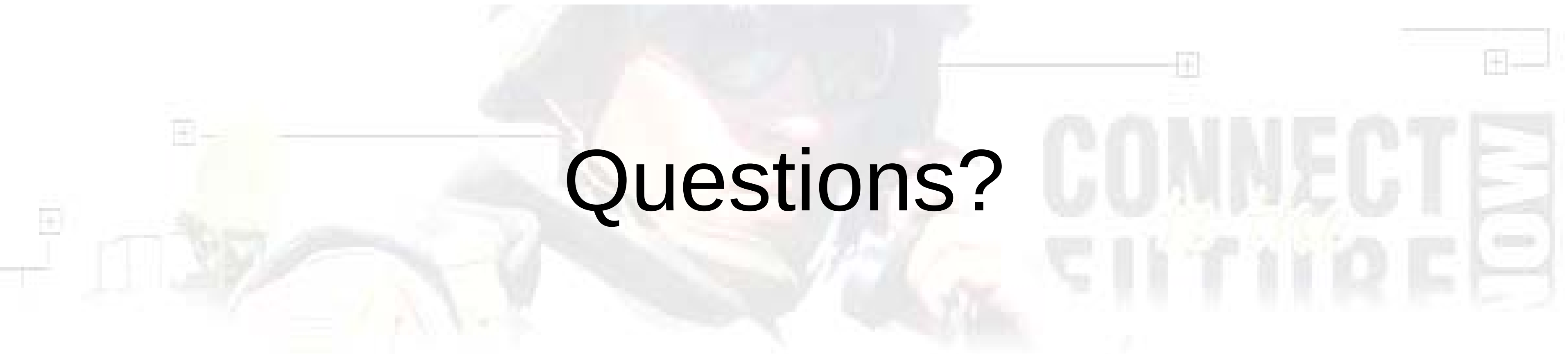


- **Chip Scale Atomic Clock**
  - *Deliver precise timing and positioning for the "last tactical mile"*

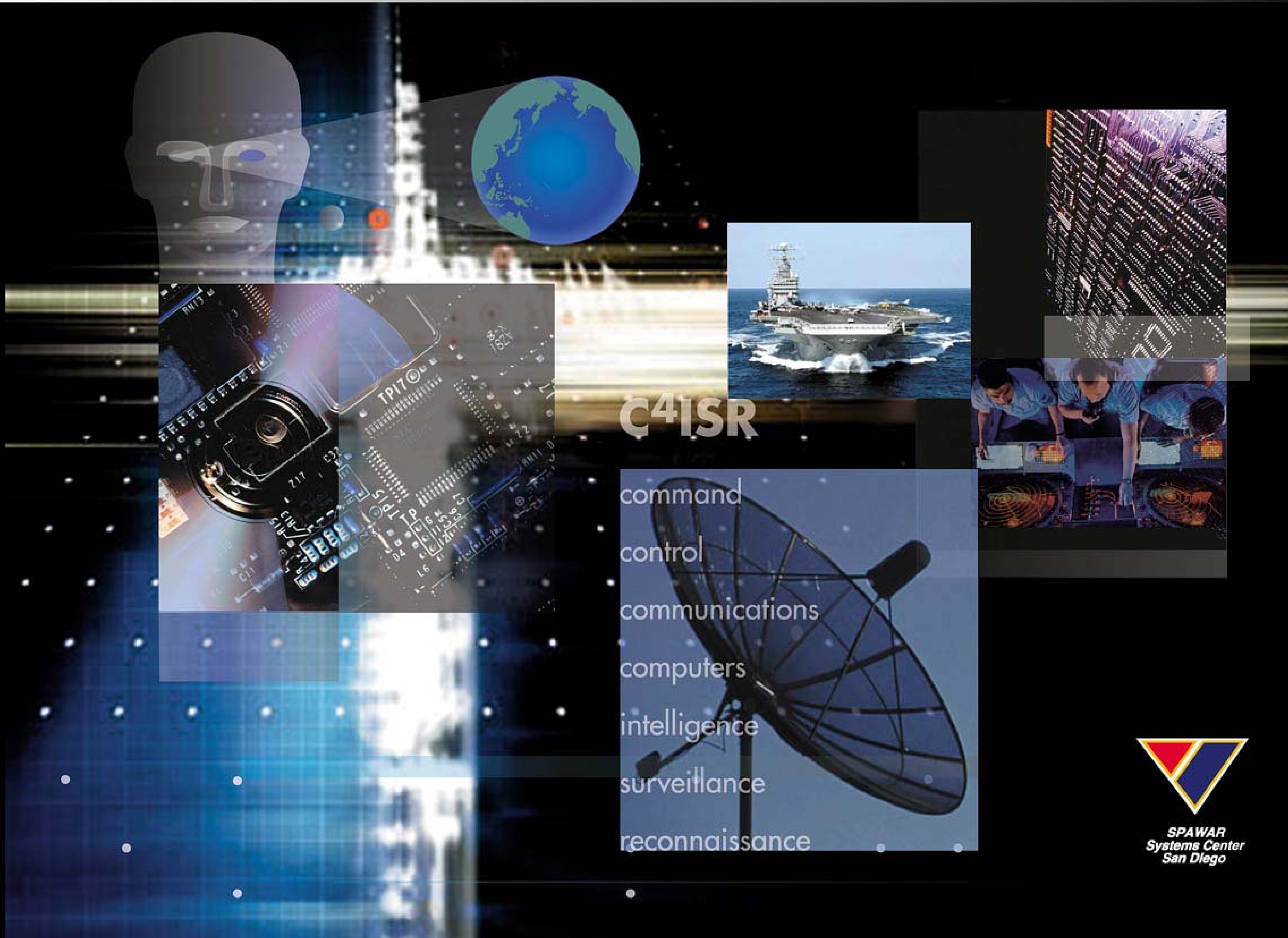


- **Serious Gaming**
  - *Enhance C4ISR training environments, linking Command Post capability usage with realistic tactical scenarios*

Questions?



COMMAND OVERVIEW



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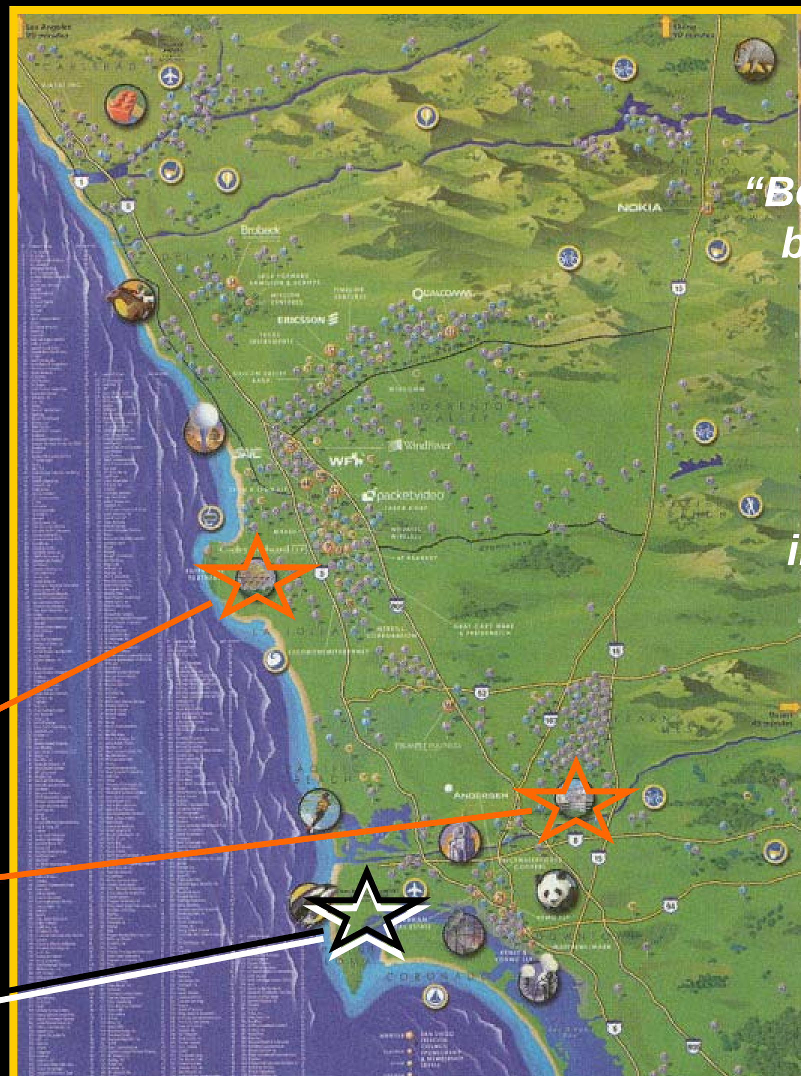
Systems Center
San Diego

San Diego/ IT Research Hub

- **Qualcomm, Inc**
- **SAIC**
- **Nokia Mobile Phones**
- **ViaSat**
- **Leap Wireless**
- **Kyocera America**
- **Titan Wireless**
- **Applied Micro Circuits Corp.**
- **Wireless Facilities**
- **Siemens…**



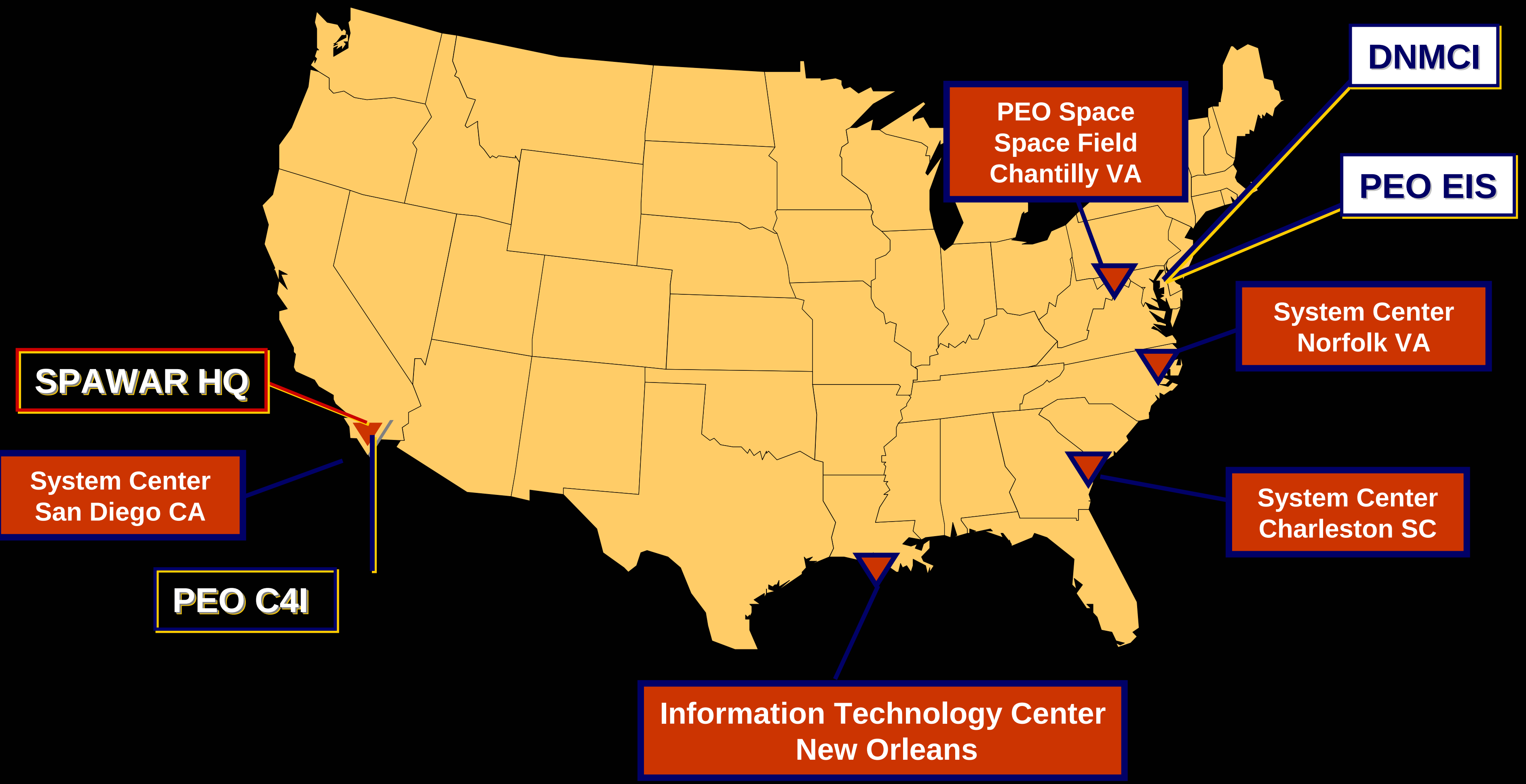
UCSD

SDSU

"Best place in country for business and careers"
- Forbes magazine

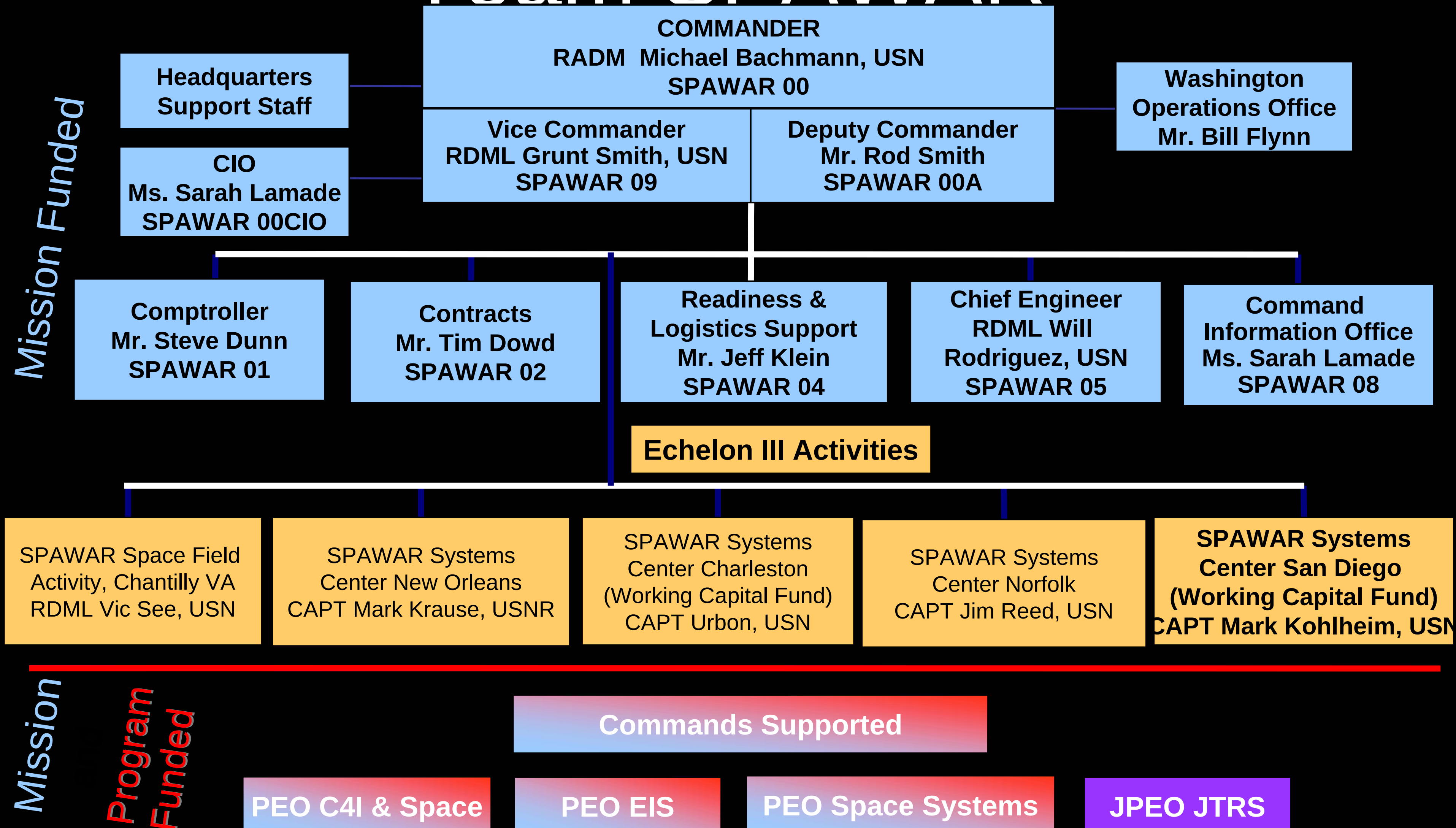
San Diego is the hot spot for careers in information technology"
-Kaplan Newsweek Careers

TEAM SPAWAR


DNMCI
PEO Space
Space Field
Chantilly VA
PEO EIS
System Center
Norfolk VA
SPAWAR HQ
System Center
San Diego CA
System Center
Charleston SC
PEO C4I
Information Technology Center
New Orleans

Co-Located with the Fleet, Industry and Academia

Team SPAWAR


Mission Funded
COMMANDER
RADM Michael Bachmann, USN
SPAWAR 00
Headquarters Support Staff
CIO
Ms. Sarah Lamade
SPAWAR 00CIO
Vice Commander
RDML Grunt Smith, USN
SPAWAR 09
Deputy Commander
Mr. Rod Smith
SPAWAR 00A
Washington Operations Office
Mr. Bill Flynn
Comptroller
Mr. Steve Dunn
SPAWAR 01
Contracts
Mr. Tim Dowd
SPAWAR 02
Readiness & Logistics Support
Mr. Jeff Klein
SPAWAR 04
Chief Engineer
RDML Will Rodriguez, USN
SPAWAR 05
Command Information Office
Ms. Sarah Lamade
SPAWAR 08
Echelon III Activities
SPAWAR Space Field Activity, Chantilly VA
RDML Vic See, USN
SPAWAR Systems Center New Orleans
CAPT Mark Krause, USNR
SPAWAR Systems Center Charleston
(Working Capital Fund)
CAPT Urbon, USN
SPAWAR Systems Center Norfolk
CAPT Jim Reed, USN
SPAWAR Systems Center San Diego
(Working Capital Fund)
CAPT Mark Kohlheim, USN
Mission
Program Funded
Commands Supported
PEO C4I & Space
PEO EIS
PEO Space Systems
JPEO JTRS

SPAWAR Systems Center San Diego
TEAM SPAWAR Chief Technology Officer
"Leadership and Innovation"

SPAWAR S&T OPPORTUNITIES

17 Apr 2008

Mr. Gary Wang
Code 73
(619) 553-2010
gary.wang@navy.mil

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Systems Center
San Diego

S & T OPPORTUNITIES

- **Industry and Government Teaming**
  - **CCAT (Center for Commercialization of Advanced Technologies)** Commercialization of emerging technologies (private and government) / Stephen Lieberman, stephen.lieberman (553-2778); http://www.ccatsandiego.org/
  - **CRADAS (Cooperative Research & Development Agreement)** Means to perform research with industry Stephen Lieberman, stephen.lieberman (553-2778); Roger Boss, roger.boss (553-1606)
  - **Commercial Sales Agreement (U.S. Code 2539B) and Work for Private Parties (U.S. Code 2563)** Laws & policies to increase private sector access to defense-unique capabilities Raj Samuel, raj.samuel (767-4156)
  - **SBIR (Small Business Innovation Research)** Contracts awarded to small businesses for innovative research through congressionally mandated federal program. Steve Stewart, steve.stewart (553-2546)
  - **MP (Mentor Protégé)** Small business partnering with large companies in developing innovative technologies Cliff Hudson, cliff.hudson (553-7442)

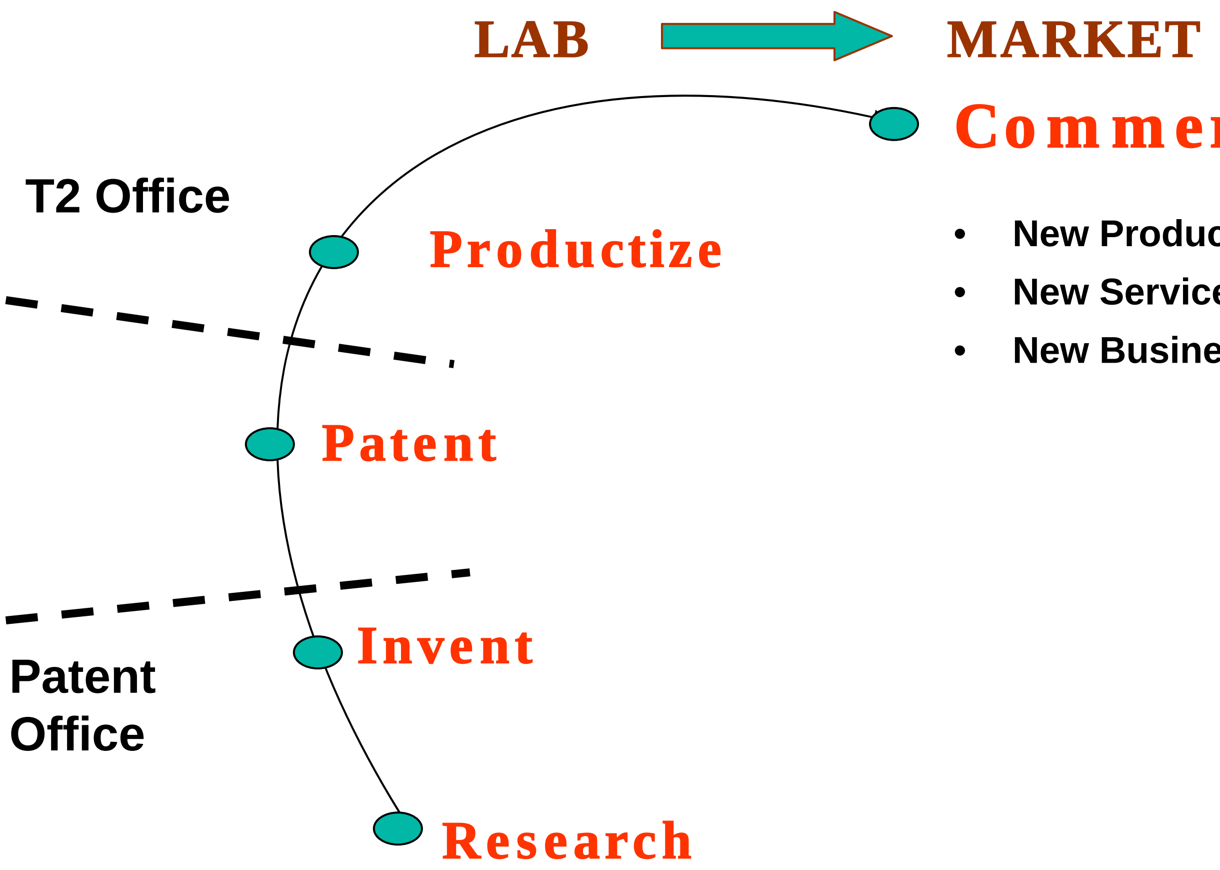
S & T OPPORTUNITIES (cont)

- **CTO Services for Transition, Technology Strategies, and Forecasting**
  - **ILIR (In-House Laboratory Independent Research)** Internal discretionary 6.1 funds from ONR emphasizing basic research / Roger Boss, roger.boss (x31606) https://donst.nrl.navy.mil/cgi-bin/login-form.cgi
  - **IAR (Independent Applied Research)** Internal discretionary 6.2 funds from ONR emphasizing revitalization and transition / Roger Boss, (x31606) https://donst.nrl.navy.mil/cgi-bin/login-form.cgi
  - **S&T Capabilities Initiative** Internal G&A funding emphasizing 6.2-6.3 transitions / Roger Boss, roger.boss (x31606)
  - **S&T Challenges** Internal funding used to support for about 5 yrs a team of researchers building a 6.1-6.3 S&T capability vital to the Center's mission / Eric Hendricks, eric.hendricks (x31624) / Roger Boss, roger.boss (x31606)

Outline

- What is T2
- Why do we do T2
- How do we do T2
- What's in it for you? for the Navy?

What is T2

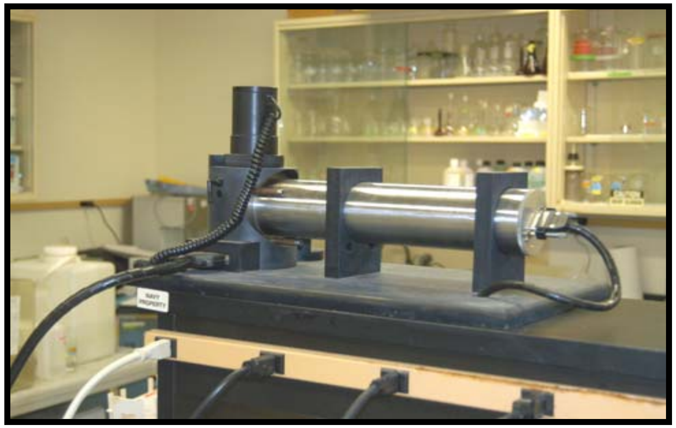


Commercialize:

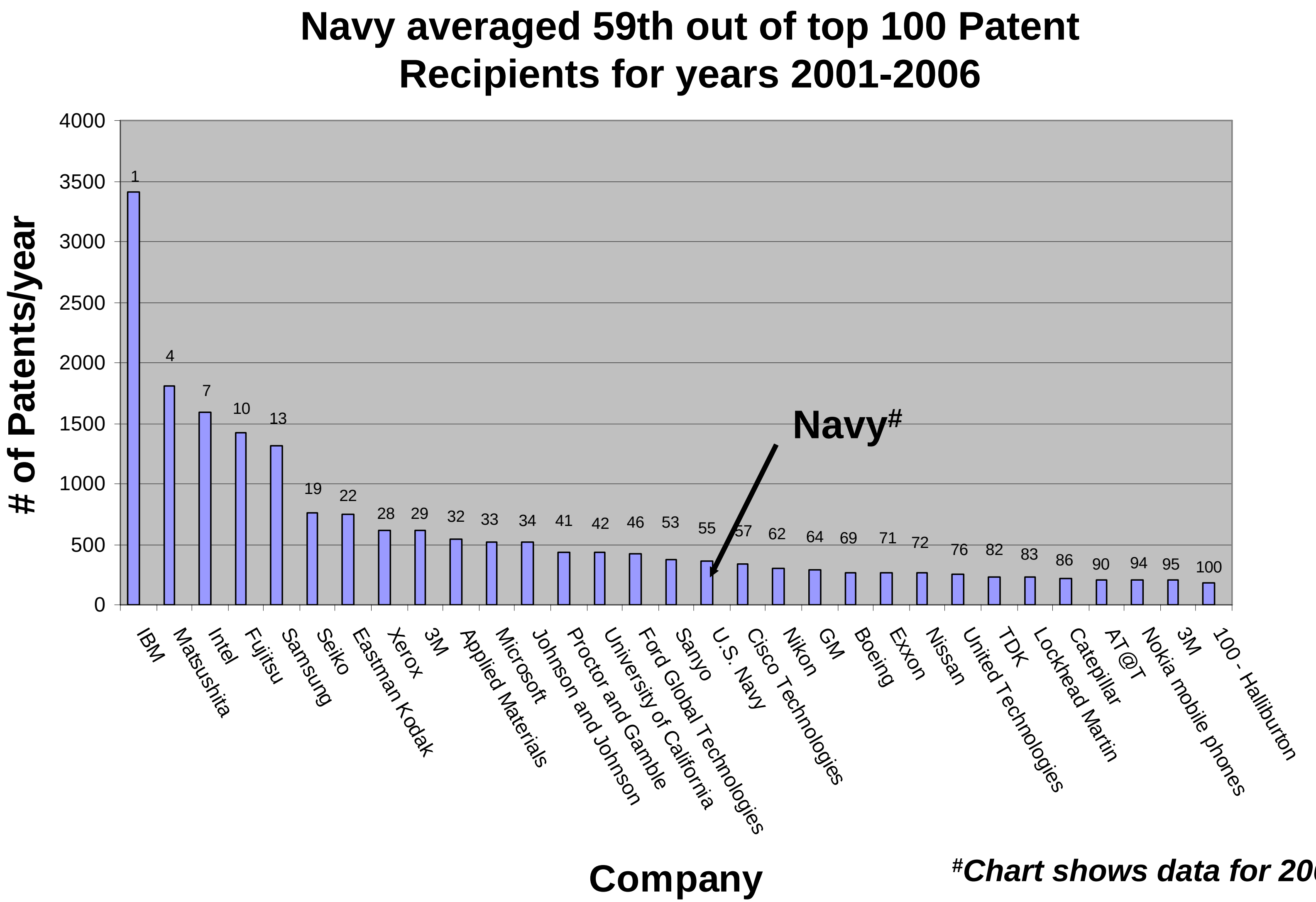
- New Products (Features)
- New Services
- New Businesses

Adapted from Ricardo dos Santos, Sr. Director of New Business Development, Qualcomm, Inc.

Lab to Market
Example: QwikLite Technology



Background
Top 100 USPTO Patent Recipients



#Chart shows data for 2003

Background
SSC San Diego vs. San Diego Based Companies

SSC San Diego ranked 5th compared to San Diego based corporate patent recipients in 2006

Rank/Company	Number of Patents
1. Qualcomm	200
2. Kyocera Wireless	32
3. Applied Micro Circuits Corp.	30
4. Science Applications Int.	24
5. SSC San Diego	21
6. Agouron Pharmaceuticals	19
7. Cymer	18
8. Genral Atomics	14
9. Gen-Probe	14
10. Diversa	11
11. Amylin Pharmaceuticals	9

Data from San Diego Union, 25 Jan 2006 -- SSC SD data added. (Does not include data from local Universities)

Why do T2

- Facilitate the transfer of SSC San Diego innovations for the benefit of public and warfighter
- Enhance the research experience of SSC San Diego scientists and engineers through technology transfer
- Promote economic development by leveraging SSC San Diego innovations
- Provide financial incentives to SSC San Diego scientists and engineers to stimulate technological innovations

SPAWAR Systems Center San Diego

How: T2 Vehicles

- Patent License Agreements (PLAs)
- Cooperative Research and Development Agreements (CRADAs)

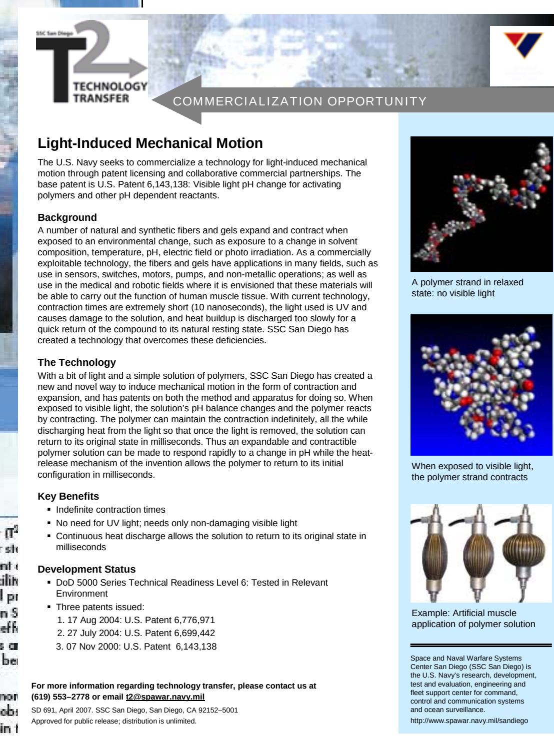
Licensing
Guiding Principles

- **Benefit the public and the warfighter.**
- **Licensee should be capable of bringing the invention to the marketplace.**
- **Timely development, marketing, and deployment of the invention.**
- **Fair consideration in exchange for the grant of commercial licensing rights.**

Technology Transfer: How

T2 Brochures

T2 TIP Sheets



TECHNOLOGY TRANSFER

COMMERCIALIZATION OPPORTUNITY

Light-Induced Mechanical Motion

The U.S. Navy seeks to commercialize a technology for light-induced mechanical motion through patent licensing and collaborative commercial partnerships. The base patent is U.S. Patent 6,143,138: Visible light pH change for activating polymers and other pH dependent reactants.

Background

A number of natural and synthetic fibers and gels expand and contract when exposed to an environmental change, such as exposure to a change in solvent composition, temperature, pH, electric field or photo irradiation. As a commercially exploitable technology, the fibers and gels have applications in many fields, such as use in sensors, switches, motors, pumps, and non-metallic operations; as well as use in the medical and robotic fields where it is envisioned that these materials will be able to carry out the function of human muscle tissue. With current technology, contraction times are extremely short (10 nanoseconds), the light used is UV and causes damage to the solution, and heat buildup is discharged too slowly for a quick return of the compound to its natural resting state. SSC San Diego has created a technology that overcomes these deficiencies.

The Technology

With a bit of light and a simple solution of polymers, SSC San Diego has created a new and novel way to induce mechanical motion in the form of contraction and expansion, and has patents on both the method and apparatus for doing so. When exposed to visible light, the solution's pH balance changes and the polymer reacts by contracting. The polymer can maintain the contraction indefinitely, all the while discharging heat from the light so that once the light is removed, the solution can return to its original state in milliseconds. Thus an expandable and contractible polymer solution can be made to respond rapidly to a change in pH while the heat-release mechanism of the invention allows the polymer to return to its initial configuration in milliseconds.

Key Benefits

- Indefinite contraction times
- No need for UV light; needs only non-damaging visible light
- Continuous heat discharge allows the solution to return to its original state in milliseconds

Development Status

- DoD 5000 Series Technical Readiness Level 6: Tested in Relevant Environment
- Three patents issued:
  1. 17 Aug 2004: U.S. Patent 6,776,971
  2. 27 July 2004: U.S. Patent 6,699,442
  3. 07 Nov 2000: U.S. Patent 6,143,138

A polymer strand in relaxed state: no visible light

When exposed to visible light, the polymer strand contracts

Example: Artificial muscle application of polymer solution

Space and Naval Warfare Systems Center San Diego (SSC San Diego) is the U.S. Navy's research, development, test and evaluation, engineering and fleet support center for command, control and communication systems and ocean surveillance.

http://www.spawar.navy.mil/sandiego

For more information regarding technology transfer, please contact us at (619) 553–2778 or email t2@spawar.navy.mil

SD 691, April 2007. SSC San Diego, San Diego, CA 92152–5001

Approved for public release; distribution is unlimited.

T2 Web Site

SPAWAR

Home | Contact Us

SSC San Diego – Technology Transfer

Links

About Us
Available Technologies
Contact Us
Licensing
News Releases
Partnerships
Technology Transfer

Home

Technology Transfer

Space and Naval Warfare Systems Center San Diego (SSC San Diego) is the U.S. Navy's research, development, test and evaluation, engineering and fleet support center for command, control and communication systems and ocean surveillance. The Office for Technology Transfer makes it easy for commercial businesses or start-up companies to access and implement our innovative technologies. Our mission is to facilitate and enhance the transfer of intellectual property resources and information between SSC San Diego and the business community in an effort to improve the commercial value of inventions and creative work.

The Government's interest in patents parallels that of private industry although the Government does not compete in the commercial market. One reason the Government obtains patents is to transfer technology developed with Government research and development funds to the public and private sector. Intellectual property, such as patent applications, patents and other forms of protection that the Government receives, may be licensed to interested parties on a royalty-bearing basis who agree to commercialize the invention for the benefit of the general public.

For more information regarding technology transfer or to join our mailing list, to be alerted of newly issued patents, please contact us at: T2@spawar.navy.mil

http://enterprise.spawar.navy.mil/body.cfm?type=c&category=29&subcat=211

SPAWAR Systems Center San Diego

Technology Transfer: How
Marketing Cont.

Subject: SSC San Diego Technology Transfer Email Alerts

SSC SAN DIEGO TECHNOLOGY TRANSFER EMAIL ALERT - Message (HTML)

File Edit View Insert Format Tools Actions Help

Reply | Reply to All | Forward

From: Vincent Crowley [vcrowley@spawar.navy.mil] <vcrowley@spawar.navy.mil>

Sent: Thu 1/17/2008 5:01 PM

To: Undisclosed-Recipient:;

Cc:

Subject: SSC SAN DIEGO TECHNOLOGY TRANSFER EMAIL ALERT

Greetings from the Technology Transfer office at Space & Naval Warfare System Center, San Diego! (SSC San Diego)

We are pleased to announce the launching of a new periodic email alert to notify you of new technologies as they become available for licensing and/or collaborative commercial partnerships. In addition we have a new Technology Transfer website located at http://enterprise.spawar.navy.mil/techtransfer.

Here are two recent technologies:

TECHNOLOGY 1: Intelligent Decision Support System

Scientist Stuart Rubin has developed an intelligent decision support system which outperforms contemporary expert systems by allowing for user-controlled creativity in the decision making process. This vastly reduces the primary cost of acquiring and maintaining knowledge for a decision support system. Applications include: helpdesks that support telephone callers, medical and automotive diagnosis, etc.

For more information on this technology, click here

TECHNOLOGY 2: Electroactive Polymer Biaxial Braid

SSC San Diego researcher Michael Blackburn has developed an electroactive polymer (EAP) biaxial braid which revolutionizes current EAP structures. The benefits of the biaxial braid over current technologies are: decreased bulk and mass, increased flexibility and local shape control, and the technology can be utilized in unconventional settings. Shapes can be woven to create necessary structures depending on application, allowing for snake-like movements to climb or swim. Potential markets include: robotics, industrial, medical/surgical devices and nano electrical devices.

For more information on this technology, click here

SSC San Diego is actively seeking industry partners interested in licensing or initiating a Cooperative Research and Development Agreement (CRADA). The Office for Technology Transfer makes it easy for commercial businesses or start-up companies to access and implement our innovative technologies. Our mission is to facilitate and enhance the transfer of intellectual property resources and information between SSC San Diego and the business community in an effort to improve the commercial value of inventions and creative work.

For more information regarding these technologies or any of the other technologies we have available check out http://enterprise.spawar.navy.mil/techtransfer or contact Dr. Stephen Lieberman at (619) 553-2778, email: T2@spawar.navy.mil.

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San Diego

Technology Transfer: How
Marketing Cont.

- **Partner with Navy, DoD, Federal T2 organizations, Entrepreneurial groups, industry trade organizations, State, Local Economic Development Groups**

TechLink

ONR Office of Naval Research
Science & Technology
Office of Transition (Code 03T)

Federal Laboratory Consortium
FLC
for Technology Transfer

ccat[SM]
Innovation for a Safer Nation

Connectory.com
The California Network

DoD TechMatch

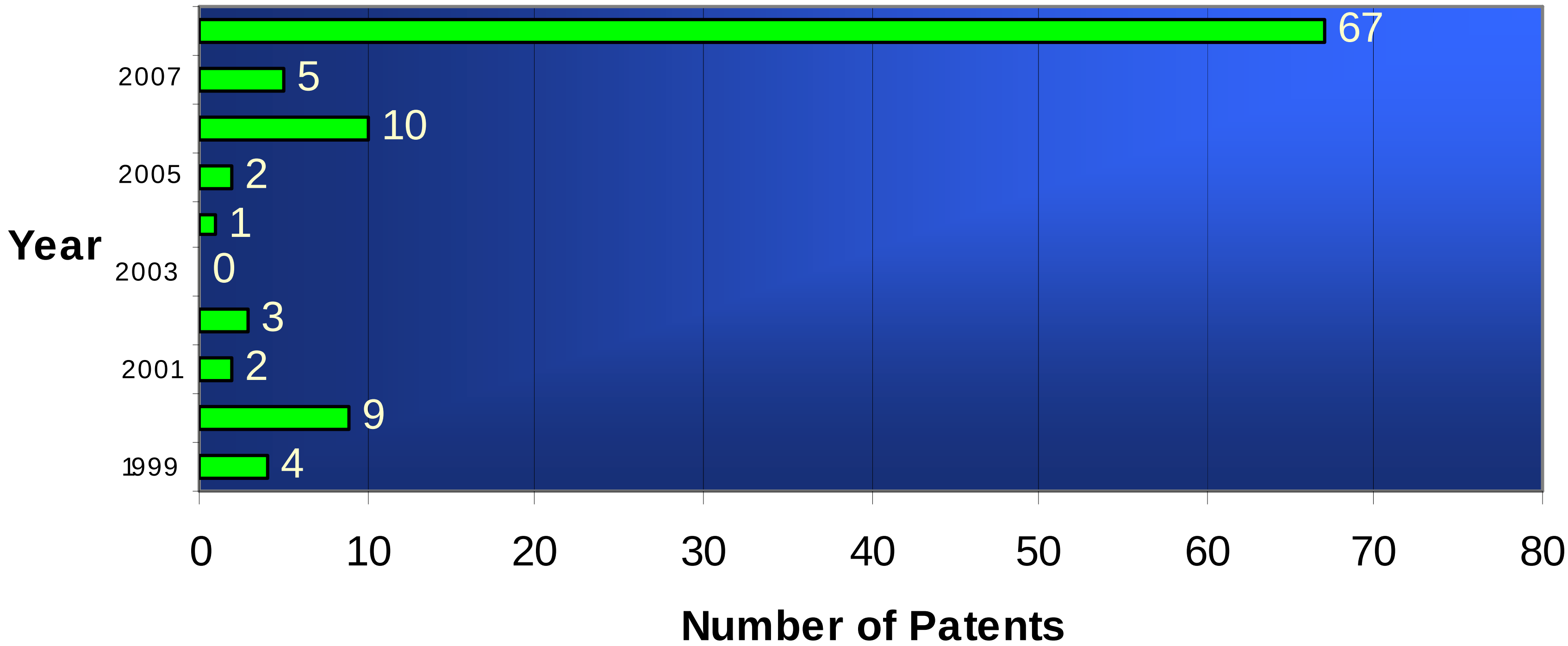
SDSIC Network
San Diego Software Industry Council

CONNECT

FirstLink

San Diego
DEFCOMM
A Defense and Space Technology Consortium

Number of Patents Licensed/Year



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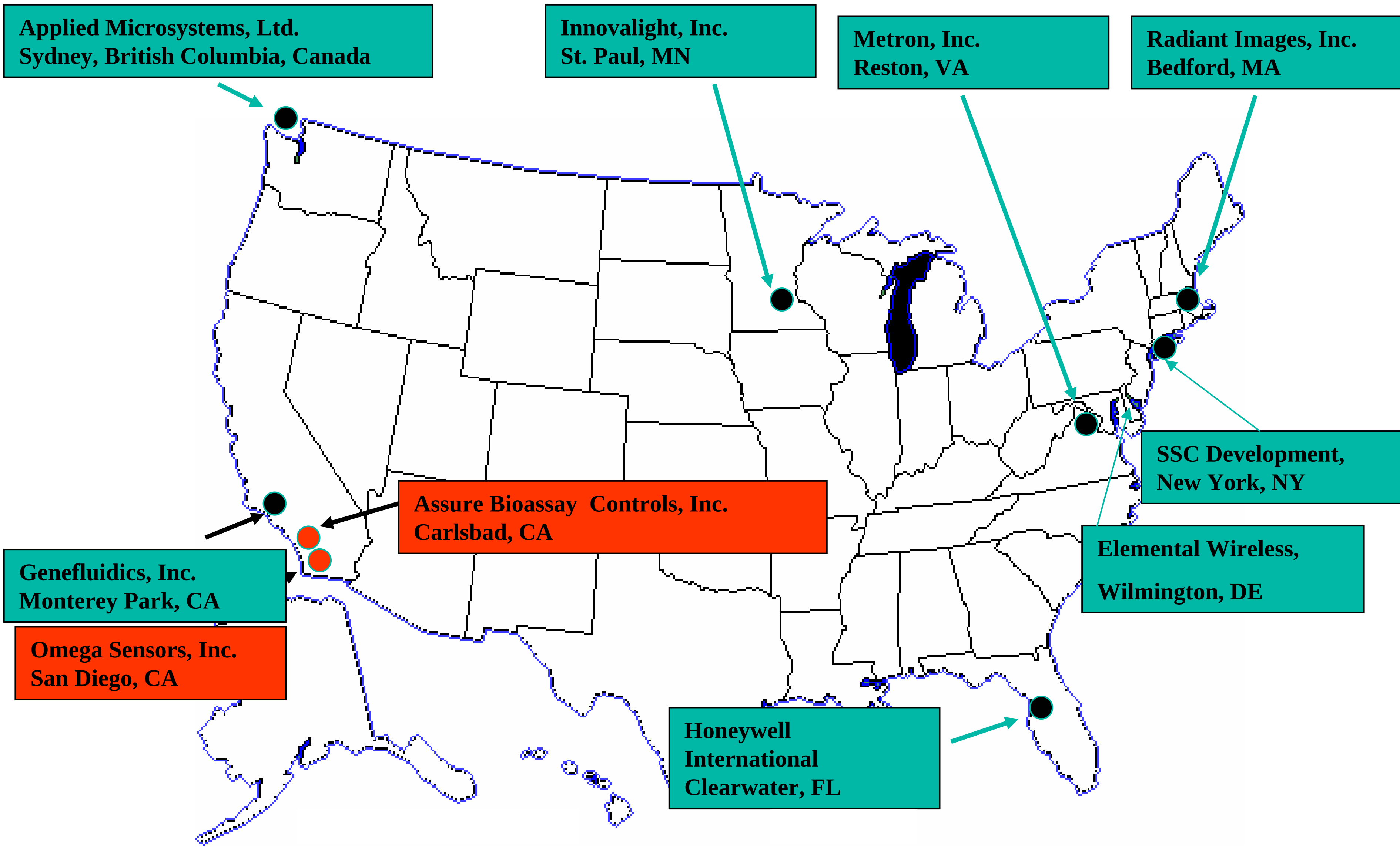
San Diego

SSC San Diego Licensee Distribution



Benefit to Small Business

- Gov't. developed technologies can:
  - Provide technology for new start-up companies
  - Provide enhancement to existing product lines
- Industry can partner with the govt. to gain access to facilities, equipment, and personnel in specific technical areas consistent with laboratory mission

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Benefit to the Navy

- Provides ROI to Navy's for investment in patent process
- Important path to move Navy innovations from lab to product
- Promotes economic development
  - » **Make US more competitive in global marketplace**

Cooperative Research and Development Agreements (CRADA)

- What is a CRADA
  - **Legal agreement between a government R&D laboratory and interested partners**
  - **Allows partners to collaborate in mutually beneficial R&D in specific technical areas consistent with laboratory mission**
  - **Pre-determines all intellectual property rights**

CRADA cont.

- Ground Rules
  - Partners can provide facilities, equipment, and personnel in support of CRADA
  - Government labs can enter into CRADAs with private sector, universities, and state and local governments
  - The non-government partner can provide funds to the government laboratory to perform tasks under the CRADA
  - The Government laboratory CANNOT provide funds to their partners

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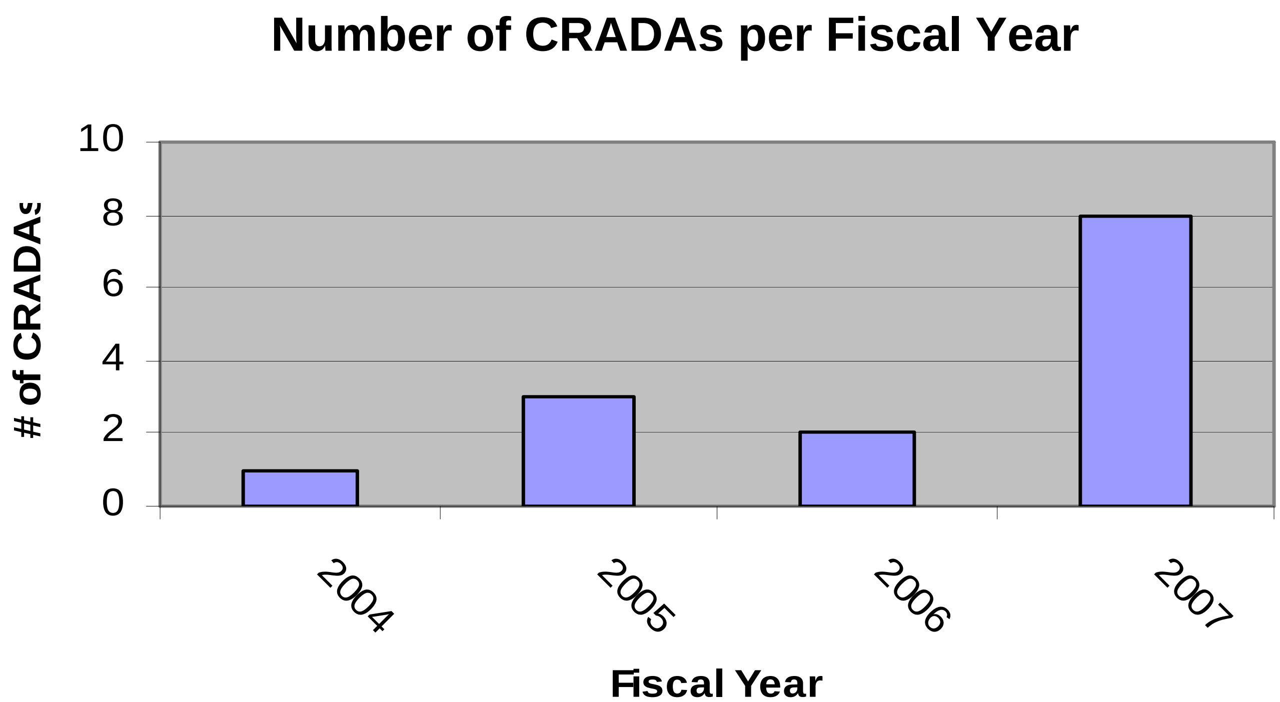
Recent CRADA Activity



Lumedyne Technologies

Mesa Robotics

XILINX

AAI

STAR Cryoelectronics

Advanced Systems Engineering Group

GENERAL DYNAMICS Strength On Your Side

Secure Rugged Portable Systems

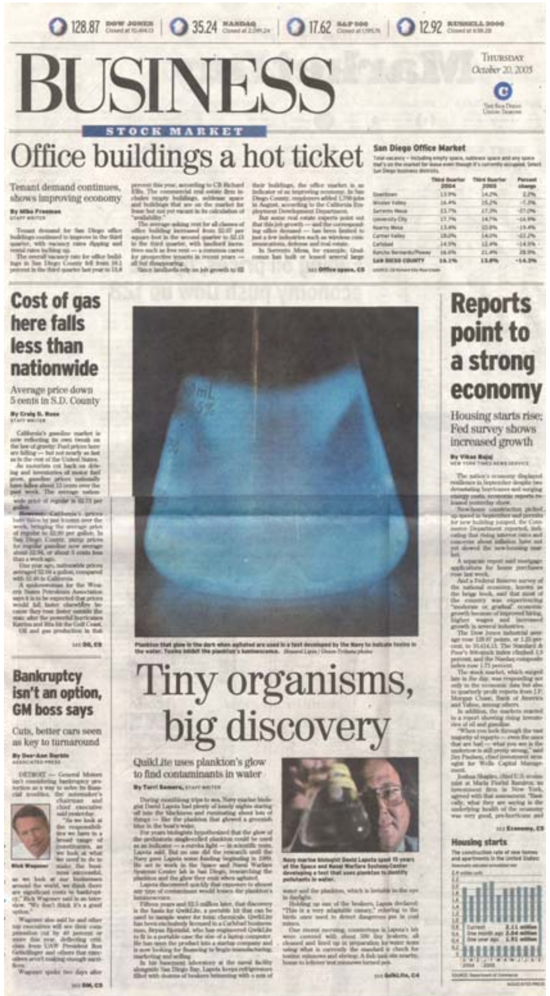
LOCKHEED MARTIN

assure CONTROLS

softmax

NORTEL

SSC San Diego Technologies in the News



128.87 DOW JONES | 35.24 NASDAQ | 17.62 S&P 500 | 12.92 RUSSELL 2000

BUSINESS

Thursday
October 20, 2005

STOCK MARKET

Office buildings a hot ticket

Tenant demand continues, shows improving economy

San Diego Office Market

Cost of gas here falls less than nationwide

Average price down 5 cents in S.D. County

Reports point to a strong economy

Housing starts rise; Fed survey shows increased growth

Bankruptcy isn't an option, GM boss says

Cuts, better cars seen as key to turnaround

Tiny organisms, big discovery

QuikLite uses plankton's glow to find contaminants in water

Housing starts

**San Diego Union-Tribune
Page 1: Business Section**

Brad Chisum, CEO Lumedyne technologies (formerly Omega Sensors Inc.) rings the opening bell on NASDAQ, August 2007

Contact Info

Stephen H. Lieberman, Ph.D.
619-553-2778
Email: T2@spawar.navy.mil

SSC San Diego - Teaming with Industry

Raj Samuel

Science & Technology

raj.samuel@navy.mil

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Systems Center
San Diego

SECOND PRIORITY : Add value to SSC San Diego.

Teaming with Industry

- **Objective**
  - **Efficient transition of the DoD technologies to the warfighter**

- **Supported by**
  - **Congress, the Secretary of Defense, and the Secretary of the Navy**

- **Vehicles**
  - **Laws & policies to increase private sector access to defense-unique capabilities**
  - **10 U.S.C. §2539B … Sale of testing services outside the DoD**
  - **10 U.S.C. §2563 … Sale of Articles & services outside the DoD**

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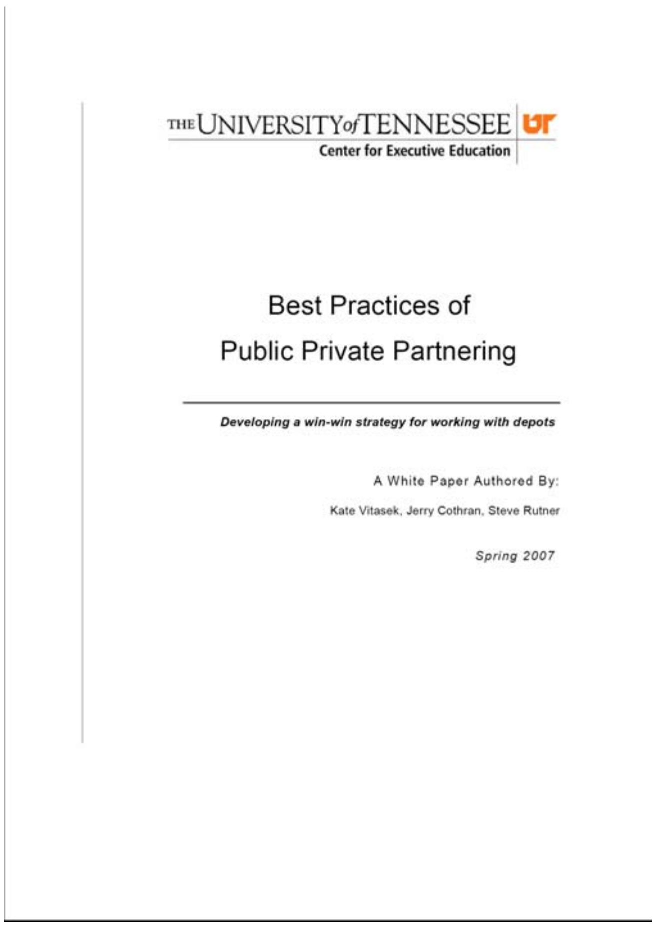
San Diego

Advantages to the Industry Partner


THE UNIVERSITY of TENNESSEE UT
Center for Executive Education

Best Practices of
Public Private Partnering

Developing a win-win strategy for working with depots

A White Paper Authored By:
Kate Vitasek, Jerry Cothran, Steve Rutner

Spring 2007

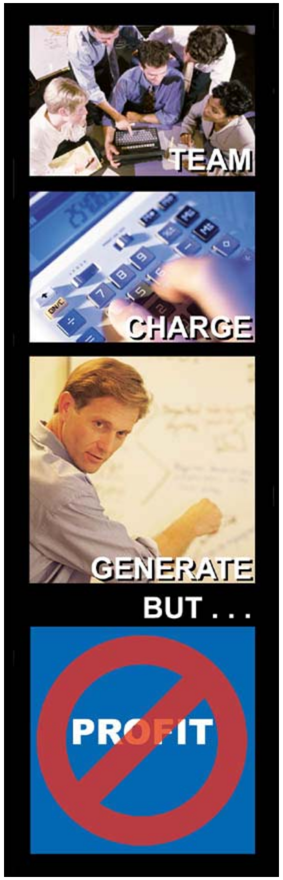
- **Leverage Center’s capabilities**
- **Access to knowledgeable workforce**
- **Use of existing facilities & equipment**
- **Minimize process flows**
- **Avoid investment in duplicate capabilities**
- **Compliance with Government regulations**
- **Increase profits**
- **Reputation associated with partnerships**

Working Capital Fund

Works like private industry

- **We team to do the work**
- **We charge our salaries & expenses to the project**
- **We generate overhead to pay operating expenses**

But we cannot make a profit



10 U.S.C. §2539B

Authorizes the Secretary of Defense to allow the military departments to

(1) **sell, rent, lend, or give samples, drawings, and manufacturing or other information to any person or entity;**

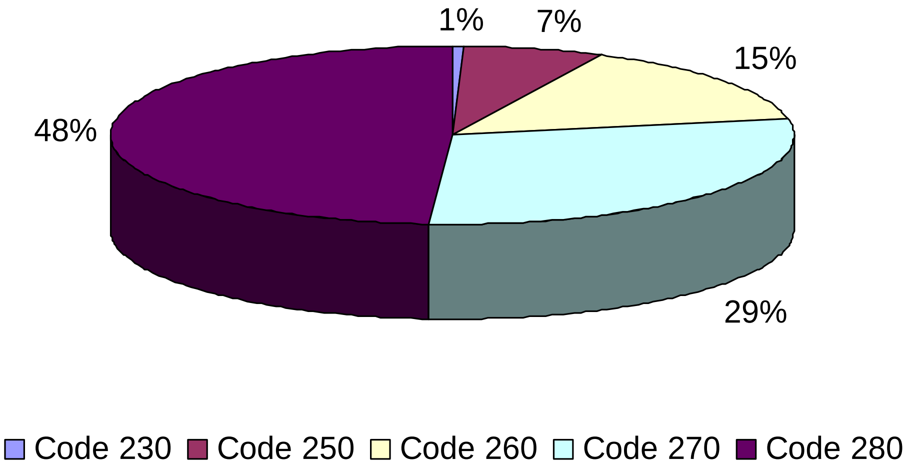
(2) **sell, rent, or lend government equipment or materials to any person or entity**

(3) **make available to any person or entity, at an appropriate fee, the services of any government laboratory, center, range, or other testing facility for the testing of materials, equipment, models, computer software, and other items.**

10 U.S.C. 2539B

74 executed FY03 thru FY07

Total value $4.1M



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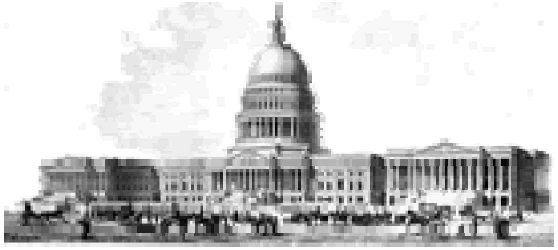
10 U.S.C. 2539B

Deep Silence Engineering Lab & Test Facilities
Medium Weight Shock Test (MWST)
Acoustic Testing and Evaluation
Acoustic Evaluation of Hydrophones
TRANSDEC - Acoustic Evaluation of Hydrophones
Antenna and Radome Testing
Acoustic Evaluation of Hydrophones
TRANSDEC - Acoustic Evaluation of Hydrophones
Joint Tactical Radio System Test & Evaluation Lab
High Assurance Internet Protocol Encryptor (HAIPE)
HAIPE - Falcon III Manpack Radio (RF-300M-MP)
Deepwater National Security Cutter Antenna Test

10 U.S.C. §2563



Authorizes the Secretary of Defense to sell ***articles and services*** **that are manufactured or performed by any DoD working capital funded facility of the armed forces (e.g.** ***SSC San Diego*****) to parties outside of the DOD (*****Industry*****).**

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10 U.S.C. §2563 Statute Criteria

Sale of Articles & Services outside of DOD

10 USC 2563

No other U.S. Commercial Source

Indemnify U.S.

Burdened Rate

Fixed Price or Cost Reimbursable

≤ $1M

COMSPAWAR

> $1M

ASN RDA

Funds from Industry

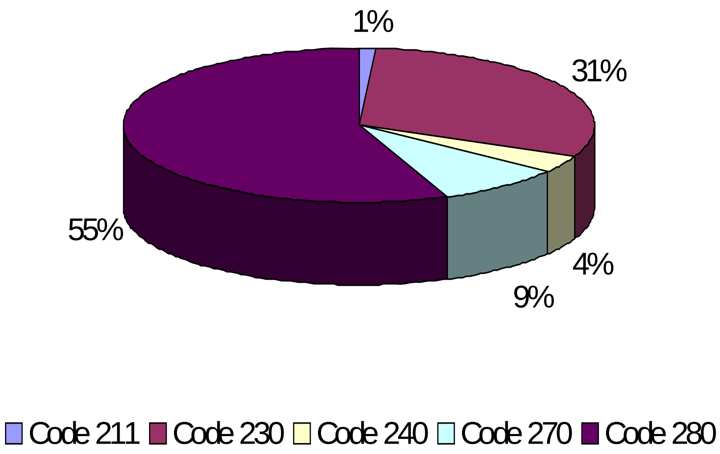
10 U.S.C. §2563 Elements

- **Non Availability Letter**
  - **Indicating that required articles or services are unavailable from a U.S. commercial source**

- **Sale of Articles or Services Agreement**

- **Statement of Work**
  - **Defining tasking, costs, period of performance, deliverables & reporting requirements**

10 U.S.C. § 2563



24 executed FY03 through FY07

Total $25.5M

10 U.S.C. § 2563

AS-4614 / URD Antennas
CLS for Minuteman Program
Data Link Gateway System
VLF / LF High Voltage Testing
AS-4614 & AS-4623 Antennas

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San Diego

Sample of Partners

Agreements have involved both major corporations as well as small businesses.

Conclusion

2539B and 2563 are excellent vehicles for Industry to acquire DoD technology / assets for transition

The agreements are easily adaptable

SSC San Diego

- is the pre-eminent provider of C4ISR solutions
- has a successful track record with 2539B and 2563 agreements
- is actively engaged in Best In Class processes & Continuous Improvement

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Systems Center
San Diego

SSC San Diego - Teaming with Academia

Raj Samuel

Science & Technology

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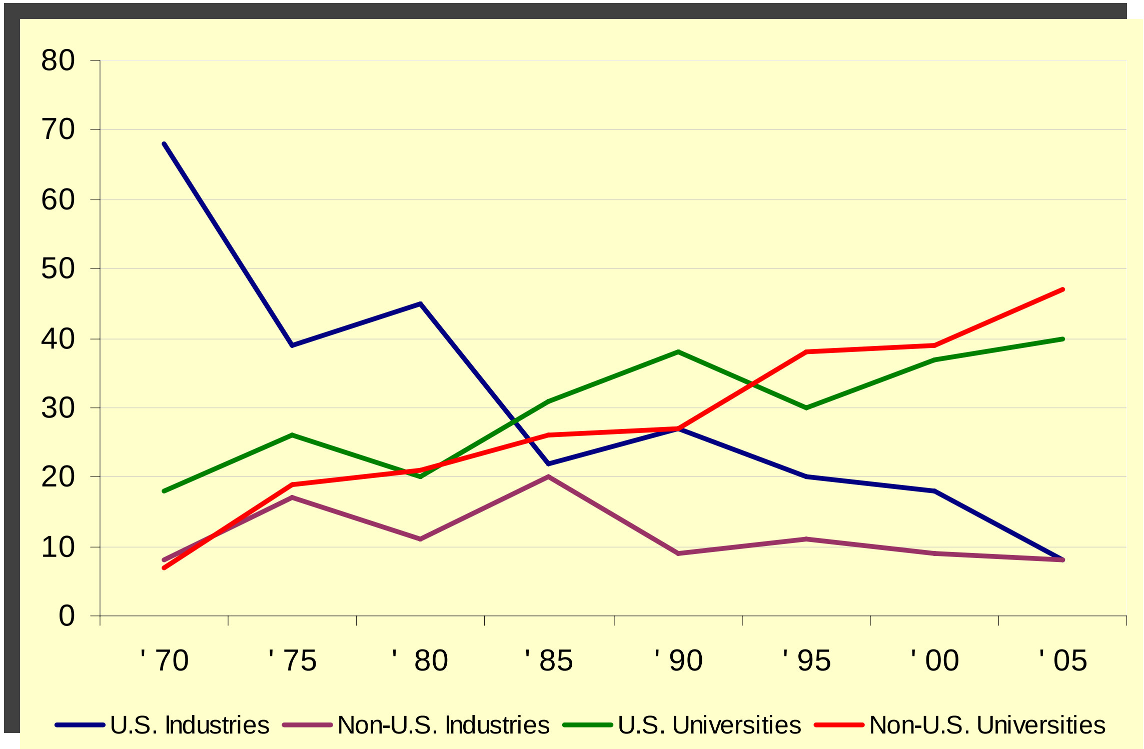
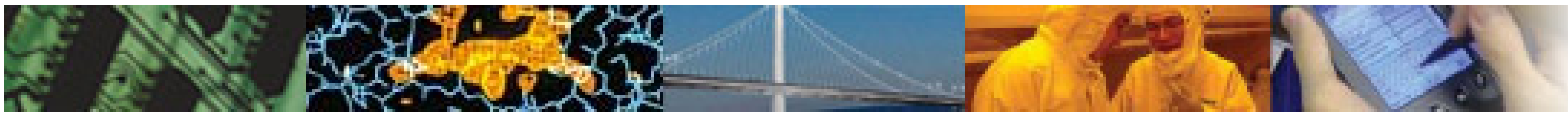
Shift in Comms Research….. % of IEEE papers published



Source: Bob Lucky, Telcordia / SAIC

Cal ISI ..

California Institutes for Science & Innovation



- **Launched in 2000 to support multi disciplinary research in biomedicine, bioengineering, nano systems, telecommunications and information technology**
- **$400M funded by state of California … 2X matching funds by Institutes**
- **The 4 research centers operate as a partnership among the University, state government, and industry,**
  - Calit2 (**California Institute for Telecommunications and Information Technology)**
    - » UC San Diego & UC Irvine
  - QB3 (**California Institute for Quantitative Biomedical Research)**
    - » UC San Francisco, UC Berkeley & UC Santa Cruz;
  - CNSI **(California Nanosystems Institute)**
    - » UCLA & UC Santa Barbara
  - CITRIS **(the Center for Information Technology Research in the Interest of Society)**
    - » UC Berkeley, UC Davis, UC Merced, &UC Santa Cruz.

Jacobs School of Engineering

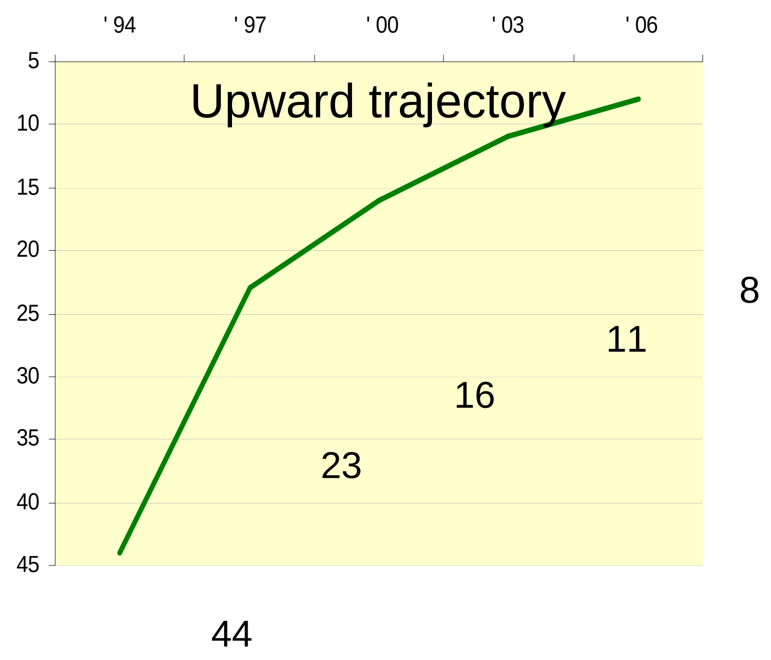
Youngest & fastest rising engineering school

2 in total research $ per faculty

925K per faculty

5 in the nation for federal R&D

$ 110M by Irwin Jacobs

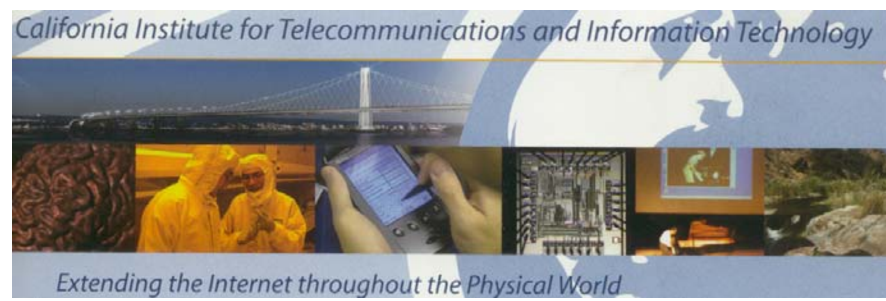


SSC – Calit2 Strategic Partnership

SSC San Diego … on Point and at the Center of C4ISR

- **Calit2 "Lives in the Future" by:**
  - **Building Systems of Emerging Disruptive Technologies**
  - **Integration of Technology Consumers and Producers**

- **To be the Nation's pre-eminent provider of integrated C4ISR solutions for warfighter decision superiority**



Provide collaborative and better solutions to the Fleet & Joint Warfighter

SPAWAR Systems Center San Diego

SSC SD _ Calit2 Strategic Partnership

Strategic

DoD, DTRA etc Strategic Groups

Net-Centric Technology Objectives

DTRA Transformational Countermeasures Technology Initiative

JTRS JPEO

Seminars

Collaborative Proposals & Projects

Cooperative Agreement

Tactical

SPAWAR
Systems Center
San Diego

Collaborative work

- **Co-operative Agreement**
  - **the Federal Grant and Cooperative Agreement Act of 1977**
  - **assistance agreements in which substantial involvement between the DoD and the recipient is anticipated**
  - **awards to universities to support research studies in subject areas consistent with the awarding agency's mission**

- **Agreement thru September 2009**

- **Graduate Seminar**
  - **CSE 290: Service Composition in Ultra-Large Scale Systems**
  - **Speakers (via VTC) from MIT, NCSU, NPS, SRI, SSC SD & Charleston, Vanderbilt & UCSD**
- **JTRS Project .. FY08**
  - **Increment 3 networks and radios**
- **DARPA .. BAA .. LANdroids Proposal ..Aug ’07**
- **ONR .. BEAMS Network Comms Gathering .. May ’07**
- **DARPA .. RFI .. Feb 07**
  - **Assurable Global Networking**

SPAWAR
Systems Center
San Diego

Conclusion

SSC & Calit2 are developing key strategic partnership to

- **provide the best solutions to the warfighter**
- **grow workforce competencies**
- **develop a highly credentialed workforce**

Plan is to continue to nurture this partnership and collaborate with additional partners

Improving Developmental & Operational Test Integration via Technology

Brian M. Simmons

Director
US Army Evaluation Center

15 April 2008

Agenda

- ATEC Mission
- OSD & Army Acquisition Initiatives
- Benefits of DT/OT Integration
- DT/OT Integration in the Army and Technologies that May Help

ATEC Mission

- Plan, conduct, and report the results of tests, simulations, experiments, and evaluations to Acquisition decision makers in order to ensure our Army's Warfighters have the right capabilities for success across the entire spectrum of operations.

- Conduct rapid testing in direct support of the GWOT warfighter in order to provide capabilities and limitations of weapon systems issued directly to Soldiers conducting combat operations (Iraq/Afghanistan).

OSD T&E Initiatives

- **Focus on measuring improvements to capability and operational support**
- **Experiment to learn strengths & weaknesses - impact on capabilities**
- **Integrate Developmental Testing & Operational Testing**
- **Start early, be operationally realistic, continue throughout the life cycle**
- **Evaluate in mission context at time of fielding**
- **Compare to current mission capabilities**
- **Use all available information**
- **Exploit benefits of Modeling & Simulation**

Source: DoD Report to Congress, DUSD (AT&L), 8 Aug 07

Army Acquisition Initiative

Reliability Improvements

- Significant number of U.S. Army systems are failing to demonstrate established reliability requirements during operational testing

Effective Immediately:

- A System Development and Demonstration (SDD) reliability test threshold will be established
- Applies to programs in pre-MS B phase
- Applies to Information Technology systems that include hardware development
- Threshold to be established before entrance into MS B
- Must detect and report threshold breaches
- Must implement Reliability Best Practices

Excerpts from ASA(ALT) memo, dated 6 Dec 07, “Reliability of U.S. Army Materiel Systems”
Claude M. Bolton, Jr. ASA(ALT)

Army T&E

Developmental Testing

- to find faults, implement corrective actions, and mature the design
- to confirm technical capabilities/functionality and manufacturability

Operational Testing

- to provide information on integration of the Soldier, the support system, training & doctrine, and materiel in an operational environment
- to confirm/demonstrate operational suitability requirements

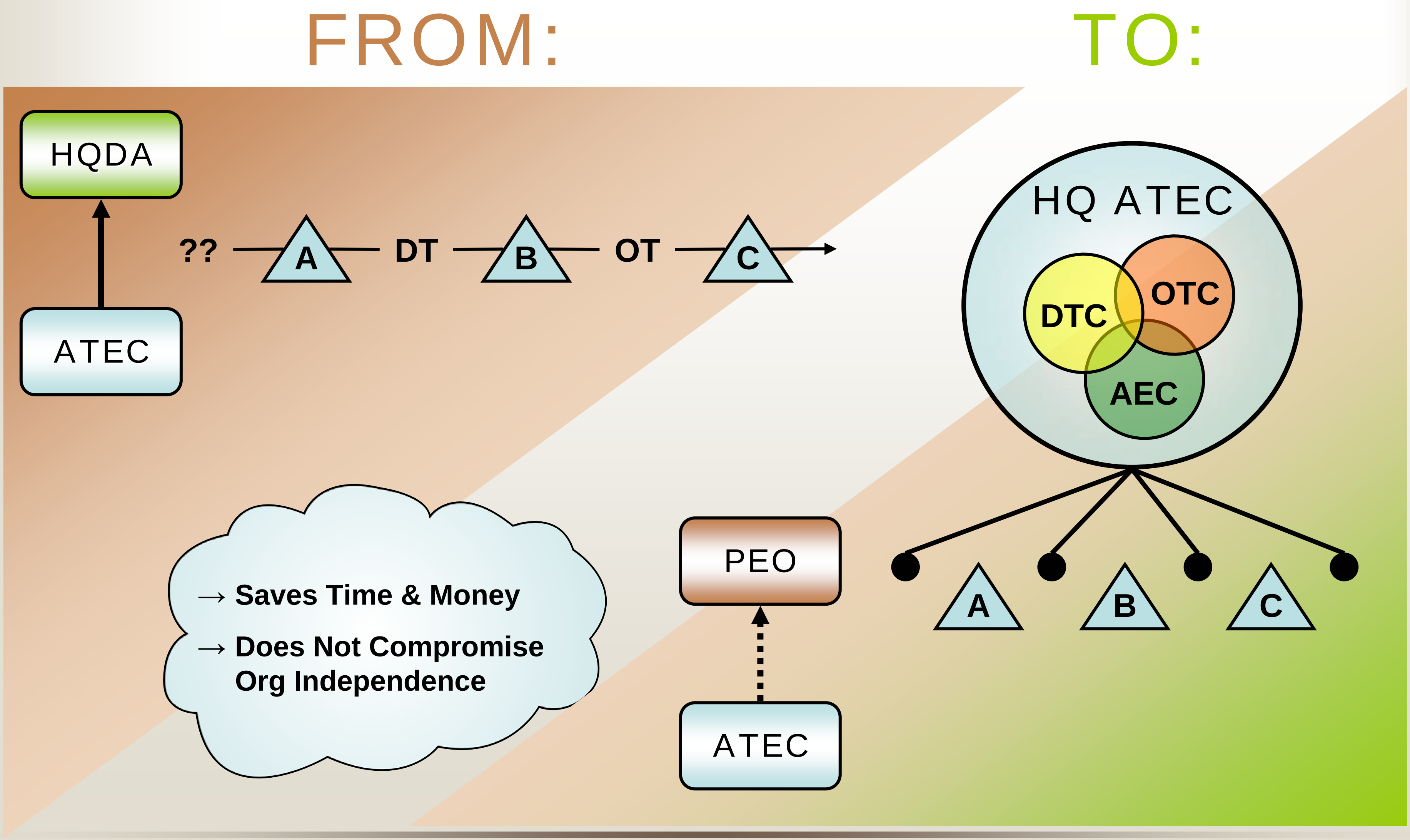
Benefits of DT/OT Integration

- **Reduced Risk**
  - Ensure capabilities are tied to mission
  - Systems deficiencies identified
  - Test data is shared

- **Reduced Cost**
  - Sharing resources
  - Eliminate duplicative testing
  - Early deficiency identification and correction

- **Reduced Acquisition Timeline**
  - Combined vs. sequential testing
  - Sharing of high-demand testing assets

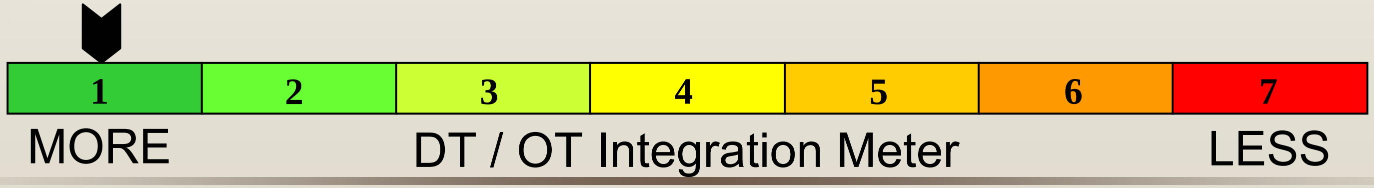
Strategic Organizational Construct



DT/OT Integration in the Army

Ballistic Missile Defense

- DT/OT Integration is widely used, but not in “traditional” definition
- DT is all planned, executed, and reports written by the PM (not ATEC/DTC); has significant system contractor influence/input
- No planned IOT, BMDS OTA arranges for Warfighter participation during DT events, using operationally realistic scenarios and DIA threat representation in HWIL and digital M&S
- Warfighter participation in flight and ground test events
- Proposed end-of-block OT will likely include contractor involvement



Technology That May Improve DT/OT Integration

Ballistic Missile Defense

- Screen capture / frame-grabbing devices
- Automated data capture and transfer; data reduction
- Shared analysis tools

DT/OT Integration in the Army

Medical / Business Information Technology (IT) Systems

• A "hybrid DT/OT" usually, depends on product size, system complexity, software maturity

• Developer Integration Testing in laboratory test bed using production-representative hardware

• Not "ad hoc" – firm processes and procedures

• More Commercial Off The Shelf (COTS) - based products in use

• DOT&E process for determining level of OT – ranges from ATEC looking over shoulder of DT tester to a full operational test

1	2	3	4	5	6	7

MORE DT / OT Integration Meter LESS

Technology That May Improve DT/OT Integration

Medical / Business Information Technology (IT) Systems

- Improve Modeling of networks (currently using none)
- Better Data Management and sharing

DT/OT Integration in the Army

Chemical / Biological Defense

- All live BWA & actual CWA testing is done in chamber in DT

- For Oversight systems Chem/Bio Policy defines this as DT-OT

- Many OTs are conducted in partnership with DT Community on outdoor ranges (mostly DPG) that operates and manages instrumentation to determine simulant concentration

- Key effectiveness evaluation hinges on integrating results from chamber testing with actual agent and operational testing

1	2	3	4	5	6	7

MORE DT / OT Integration Meter LESS

Technology That May Improve DT/OT Integration

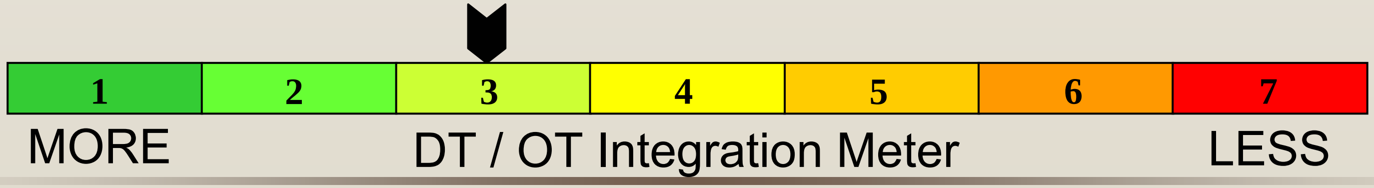
Chemical / Biological Defense

- Increase use of HWIL to stimulate detector sensors
- Real need for more accurate simulants of live agents; ALO (Agent-Like Organism)
- Better Data Management and sharing

DT/OT Integration in the Army

Aviation

- DT/OT widely used for subsystem evaluation (i.e. CMWS)
- Hardware-in-the-Loop Simulations
- Soldiers used in DT, especially moving from component level to subsystem level tests
- Combined test teams - Air Worthiness Release restricts introducing operational pilots early on.
- Operational Testing conducted at DT ranges



Technology That May Improve DT/OT Integration

Aviation

- Improved models and simulations; cockpit simulators
- Automated instrumentation for Real Time Casualty Assessments
- GPS- (or other geometric pairing) based RTCA systems
- Collaborative tools / personal communicators

DT/OT Integration in the Army

Infantry Weapons and Soldier Systems

- Non-oversight ACAT III systems: usually integrated DT/OT in a single location
- DT done first for safety/performance check; OT phase with Soldiers follows
- Rapid Acquisition systems: usually just DT, then theater
- Some OT at technical test sites (hot/cold regions,etc)
- OT = Soldiers in lanes

1	2	3	4	5	6	7

MORE DT / OT Integration Meter LESS

Technology That May Improve DT/OT Integration

Infantry Weapons and Soldier Systems

- Improved commonality of instrumentation
- Common data reduction protocols at all test sites

DT/OT Integration in the Army

Unmanned Aerial Vehicles (UAV)

- DT always for component-level building and assessment and Air Worthiness Release
- Soldiers used in DT, especially moving to subsystem level tests to obtain early user feedback
- DOTE requires greater operational realism in OT – tactical personnel using approved doctrine

1	2	3	4	5	6	7

MORE — DT / OT Integration Meter — LESS

Technology That May Improve DT/OT Integration

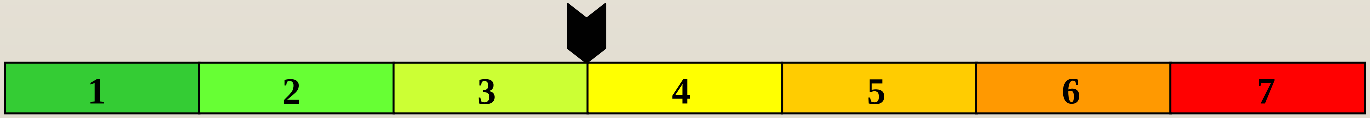
Unnamed Aerial Vehicles (UAV)

- Improved availability of models
- Improved Operator simulators
- Improved communication equipment to keep Combined Test Team in the loop
- Develop common instrumentation and data reduction protocols at all sites

DT/OT Integration in the Army

Missiles (Direct / Indirect Fire)

- Extensive firings early without operators
- Extensive Developmental Testing
- Extensive HWIL
- Extensive M & S
- Formal OT’s



MORE DT / OT Integration Meter LESS

Technology That May Improve DT/OT Integration

Missiles (Direct / Indirect Fire)

- Continued heavy emphasis on M&S and HWIL

- Improved data collection, data reduction to speed up test reports to the evaluator

- Better threat replication (consistency between DT & OT) and usage in virtual environment

DT/OT Integration in the Army

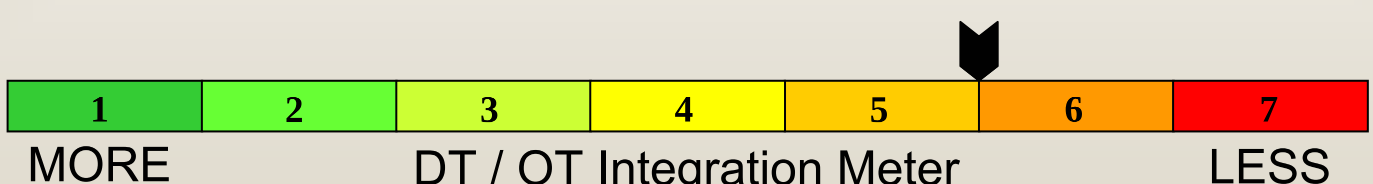
C4 Systems

• Limited Gov't DT – shock, vibration testing, interoperability; message completion rates

• Communications systems – performance centers on stress testing and operational environment

• Field testing is most useful integrated event – soldiers and developers working together to establish system configuration and achieve optimization

• Field tests are cost prohibitive – need for architecture for system to create the environment



DT / OT Integration Meter

Technology That May Improve DT/OT Integration

C4 Systems

- Improve available models and simulations
- Invest in jammers / Electro-Magnetic Environment generators
- Improved data management (storage, retrieval, sharing)

DT/OT Integration in the Army

Counter IED

- non-typical development process

- from Laboratory to DT Ranges to Theater – fielding decisions based on DT results and production timelines

- for Jammers – DTs are technical tests on instrumented ranges; PM data considered when available

- DOT&E has not been involved in this commodity area

1	2	3	4	5	6	7

MORE DT / OT Integration Meter LESS

Technology That May Improve DT/OT Integration

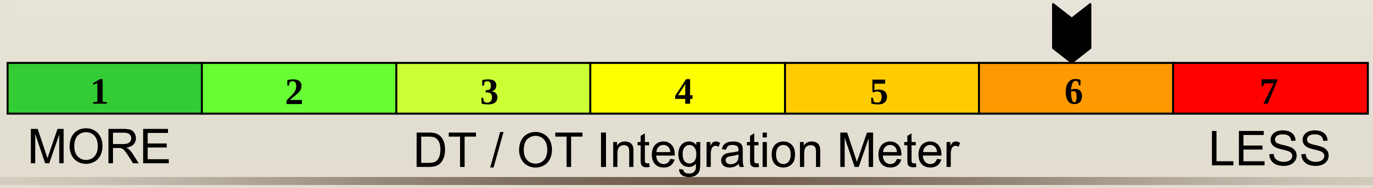
Counter IED

- Increase investment in S&T / R&D before T&E
- Invest in in-line jammers / Electro-Magnetic Environment generators
- Better threat replication (consistency between DT & OT)
- Commonality of instrumentation
- Instrumentation sharing between DT & OT organizations

DT/OT Integration in the Army

Tracked & Wheeled Vehicles

- Usually Separate DTs and OTs; higher risk – more oversight
- OMS/MP miles driven by contract, over known, precise courses
- Extensive data collection in DT
- DOT&E wants “free play” in OT; freedom of maneuver, much of which can be done at Soldiers’ home station



Technology That May Improve DT/OT Integration

Tracked & Wheeled Vehicles

- Increase number of instrumented test articles
- Embedded instrumentation
- Common instrumentation and data reduction protocols at all sites
- Technology for tracking in GPS-denied environments

Integration Roll-Up

Ballistic Missile Defense

Medical/Business IT Systems

Chemical/Biological Defense

Aviation

Infantry Weapons/Soldier Systems

Missiles (Dir/Indirect Fire)

Unmanned Aerial Vehicles

C4 Systems

Counter IED

Tracked/Wheeled Vehicles

1	2	3	4	5	6	7

MORE — DT / OT Integration Meter — LESS

Summary

To further improve DT & OT integration, T&E technology needs include:

- Data management (repository, reference models)
- M&S advances (physical system models, simulations, networks)
- Network Models
- Distributed operations & systems
- Embedded / common instrumentation

Brian M. Simmons
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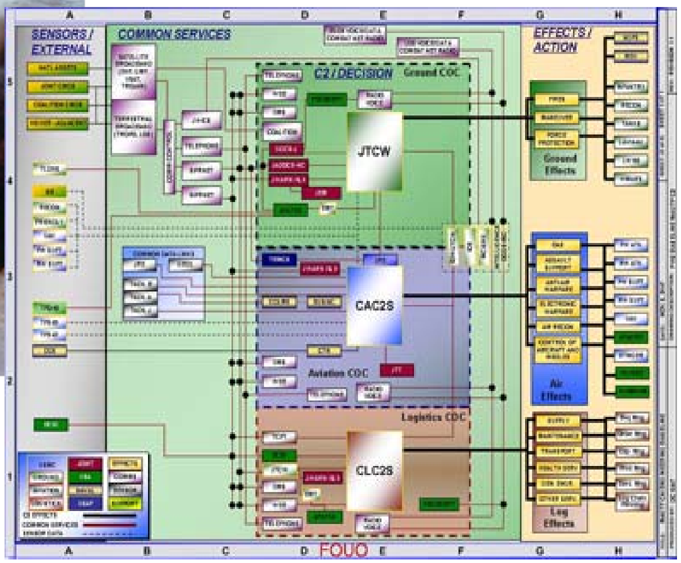
Marine Corps Systems Command Brief to NDIA



April 16, 2008

Dave Ungar

Director Program Engineering & Technology

MARINE CORPS SYSTEMS COMMAND

EQUIPPING THE WARFIGHTER TO WIN

Organization Chart

COMMANDER

EXECUTIVE DIRECTOR *

Special Staff
- International Programs
- Counter-Improvised Explosive Devices
- Corporate Communications
- Counsel
- OSBP
- Strategic Change Management Center

Chief of Staff
- CIO
- Facilities & Services
- Operations Cell
- Reserve Affairs
- Security

Sergeant Major

PEO Land Systems
- PM Expeditionary Fighting Vehicle
- PM JPMO, Lightweight 155
- PM Light Armored Vehicle MPC
- PM LVSR, PM JLTV
- PM MTVR, PM GATOR, PM CAC2S
- PM CAC2S

Deputy Commander Resource Management *^
- Resource Mgmt Competency Domain/ Competency Leaders
- Director, Financial Management
- Director, Workforce Management and Development

Deputy Commander SIAT *^
- Systems Engineering Competency Domain/ Competency Leaders
- Director, M&JI
- Director, IA & JC
- Commanding Officer MCTSSA Camp Pendleton, CA
- Director, PE&T

Product Groups
- Product Group 09 Director, Operational Forces Systems
- Product Group 10 Director, Information Systems & Infrastructure
- Product Group 11 Director, MAGTF C2, Weapons & Sensors Development & Integration
- Product Group 12 Director, Communications, Intelligence, & Networking Systems
- Product Group 13 Director, Infantry Weapons Systems
- Product Group 14 Director, Armor &Fire Support Systems
- Product Group 15 Director, Ground Transportation & Engineer Systems
- Product Group 16 Director, Combat Equipment and Support Systems

Program Managers
- Program Manager, Ammunition
- Program Manager, Global Combat Support System-Marine Corps
- Program Manager, Training Systems Orlando, FL
- Program Manager, Robotic Systems Huntsville, AL
- Program Manager, Mine Resistant Ambush Protected
- Program Manager, Light Armored Vehicle Warren, MI
- Deputy JPEO, Chemical & Biological Defense Arlington, VA

Assistant Commander Contracts ^
- Contracts Competency Domain/ Competency Leaders

Assistant Commander Life Cycle Logistics ^
- Life Cycle Logistics Competency Domain/ Competency Leaders

Assistant Commander Programs^
- Program Mgmt Competency Domain/ Competency Leaders

* = SES Position
^ = Competency Director

Industry Access

Industry Forums

- Briefs to Industry (Open) 13-14 May 2008
- Modern Day Marine   Sept
- Force Protection Equipment Demonstration
- POC Gloria Prior (703) 432-3930

Technology Transitions

- Hundreds of Programs
- Established Technology Leads
- POC Jim Johnson

(703) 432-3327

Assault Breaching System Technologies

Revolutionary Research . . . Relevant Results

Presented to
9th Annual Science & Engineering Technology Conference / DoD Tech Exposition
15-17 April 2008

Mr. Brian Almquist
Ocean Engineering & Marine Systems
Office of Naval Research
(703) 696-3351   almquib@onr.navy.mil

LtCol Tim McLaughlin
APM for ABS
PMS 495 Mine Warfare Program Office
(202) 781-4457   tim.j.mclaughlin@navy.mil

Mine Warfare Research Area
Strategic Vision

Provide rapid, standoff mine countermeasures capability to support the <u>unencumbered maneuver</u> of combatants throughout the littoral penetration area (<u>sea shield</u>), to enable <u>sea strike</u> operations in the littorals from the sea (i.e. STOM), and to assure access to the <u>sea base</u>, intermediate staging bases, and Sea Ports of Debarkation (SPOD) to ensure strategic mobility and sustainment.

Mine Countermeasures Research Area

Investments Address Critical Capability Gaps

- Supports Development of an Organic Capability
- Supports Sea Shield Undersea Warfare (MIW) Gap Analysis

Goal is to Decrease the MCM Timeline & Eliminate the Requirement for Manned Ops in Minefields

- Highly Cluttered, Littoral Environment Provides Challenge
- Sensors, Automated Processing, Unmanned Systems Focus
- Air Deployable Mine and Obstacle Breaching System

  - Unique effort in support of amphibious assault

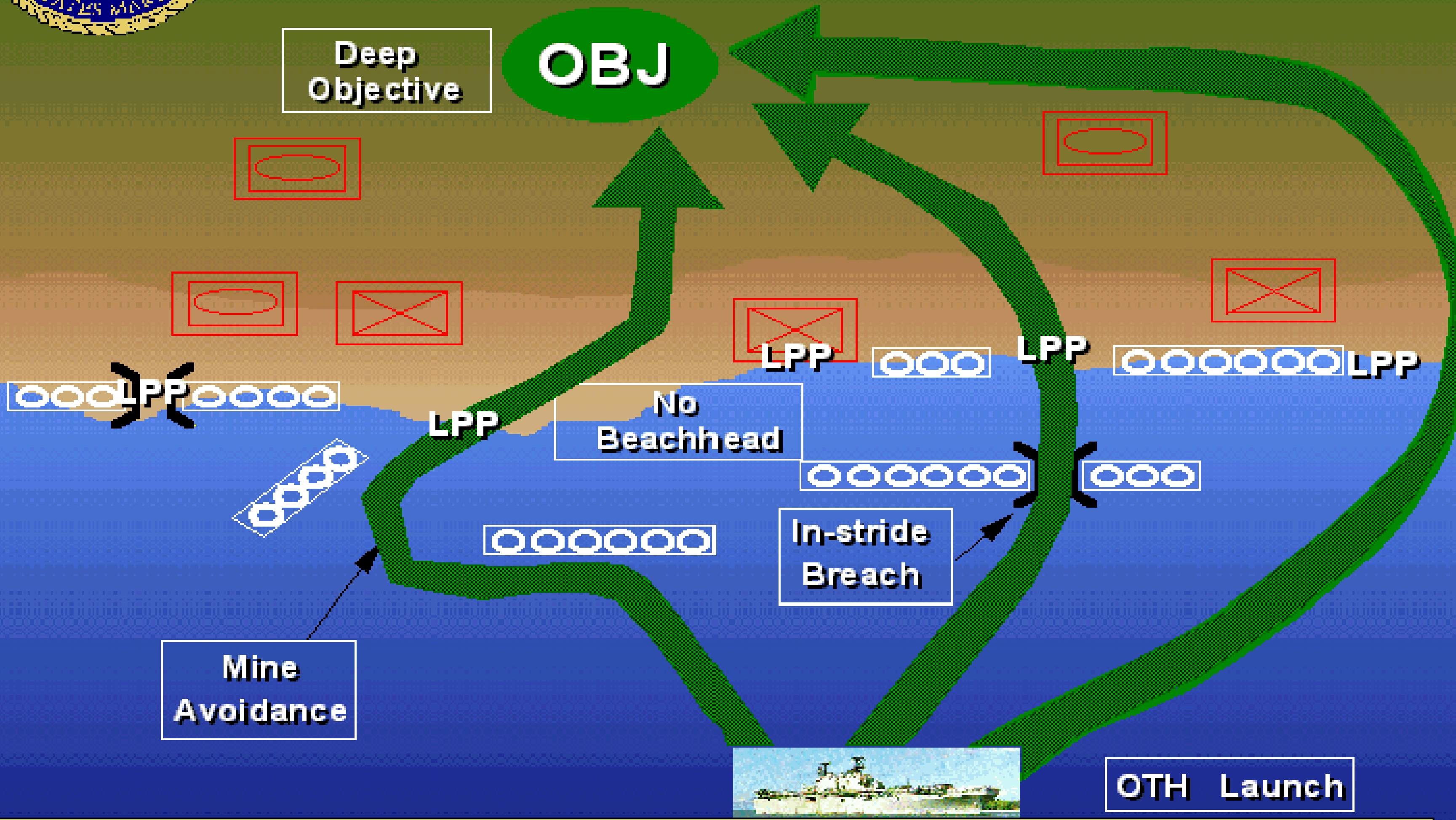
Organic Mine Counter Measures FNC Program

POM 06 / PR07 / POM08 Capability Gaps

- **Gap 1:** Capacity to clear large areas of mines without cued ISR

- **Gap 2:** Destruction of mines in areas through which Marine Corps and Joint Forces must maneuver, ranging from deep water through the surf and beach exit zone.

Ship-to-Objective Maneuver



Assured Access to Enable OMFTS/STOM

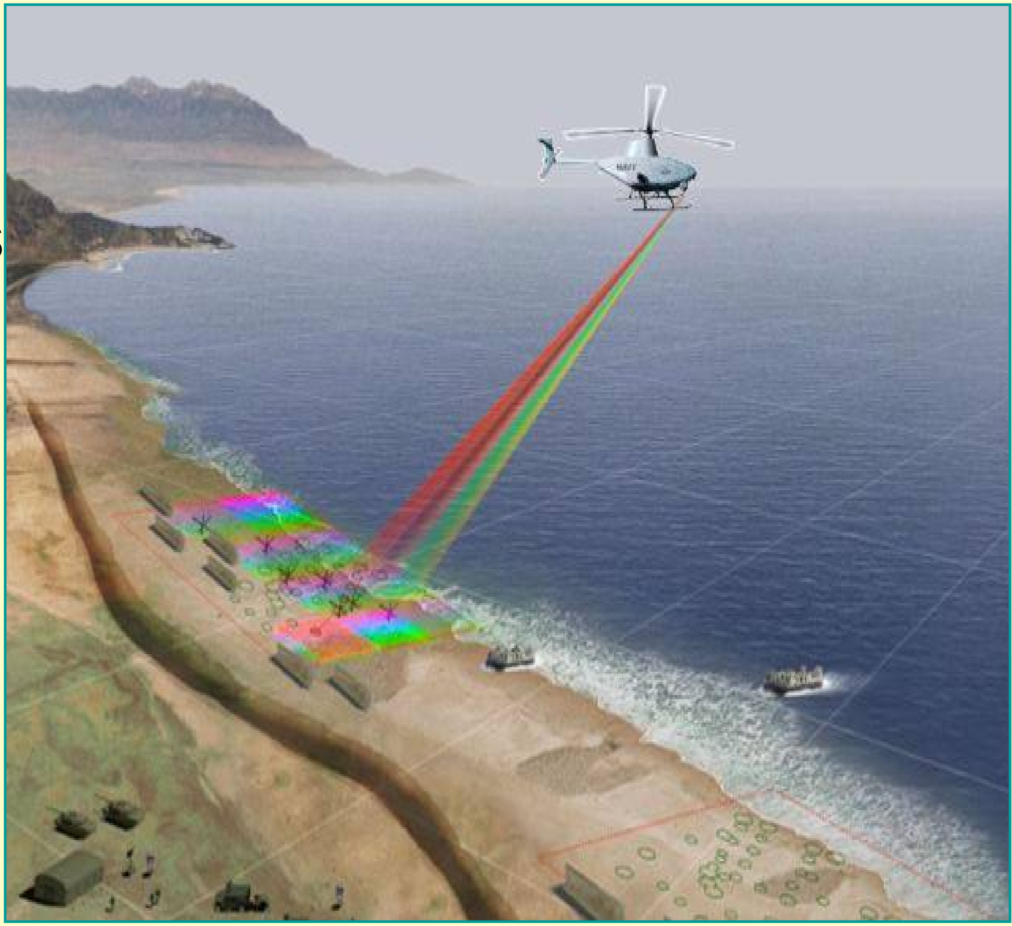
Ship To Objective Maneuver

Capabilities:

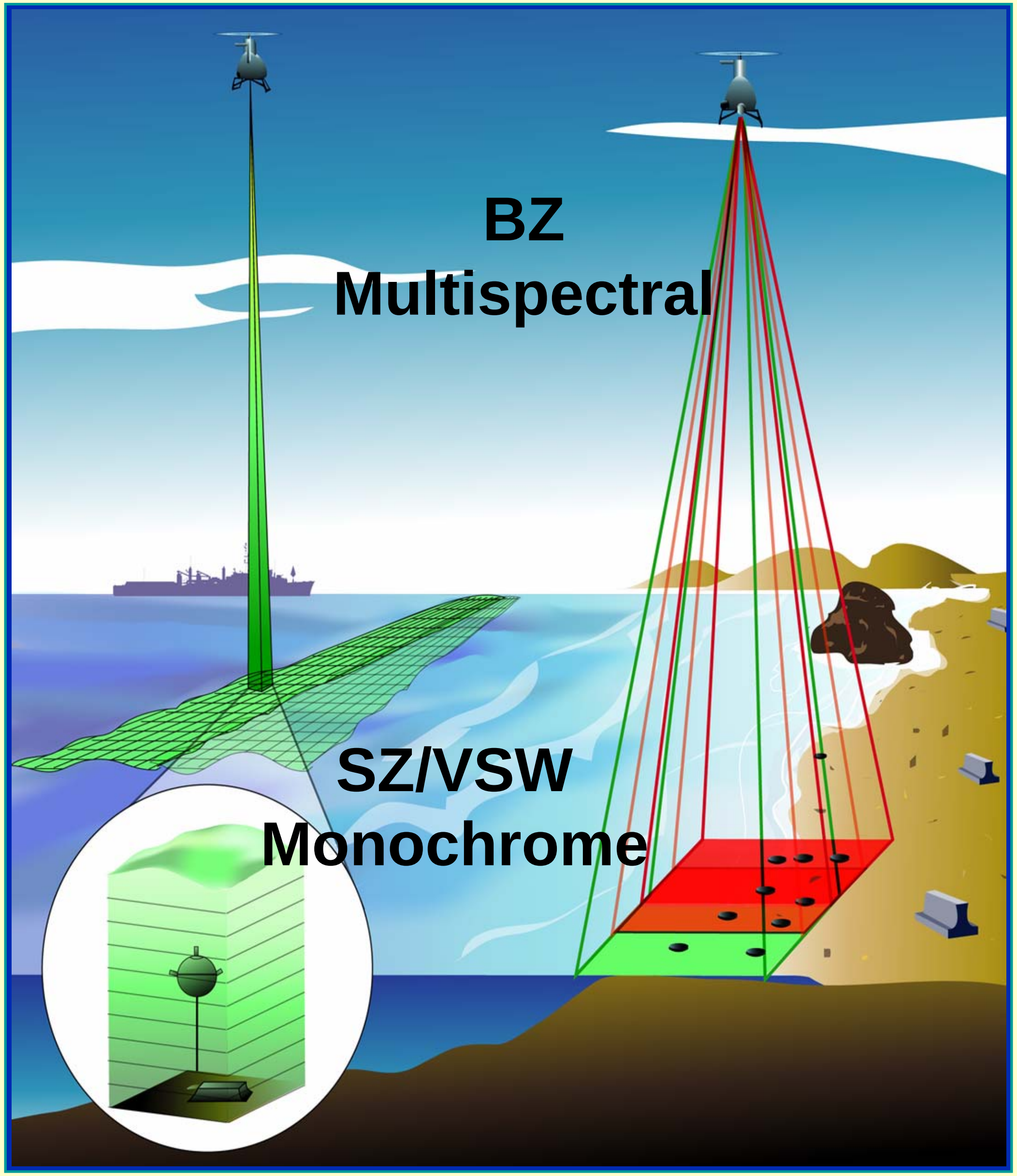
- Wide area surveillance to enable maneuver
- Clandestine reconnaissance to prepare the battlespace
- Rapid overt mine and obstacle reconnaissance
- Data Fusion to accelerate the planning process
- Timely MCM Common Tactical Picture to enable maneuver
- Stand-off neutralization of individual mines in VSW
- Stand-off breaching of mines and obstacles
- Autonomous, high speed compact influence sweep
- Precision localization and navigation from VSW to BEZ
- Rapid Follow On Clearance

Spiral Development of COBRA

- **Block I (FY09) limited:**
  - Daytime operations
  - Surface mines & obstacles
  - Detection in BZ
- **Block II (FY13)**
  - Night operations
  - Full detection in surf zone
- **Block III (FY16)**
  - Buried mine line detection
  - Near real-time processing



Rapid, Overt, Airborne, Reconnaissance (ROAR)



General

- Day / Night Operation
- Altitude: 3,000 feet
- Speed: 75 knots
- Swath: 200 meters

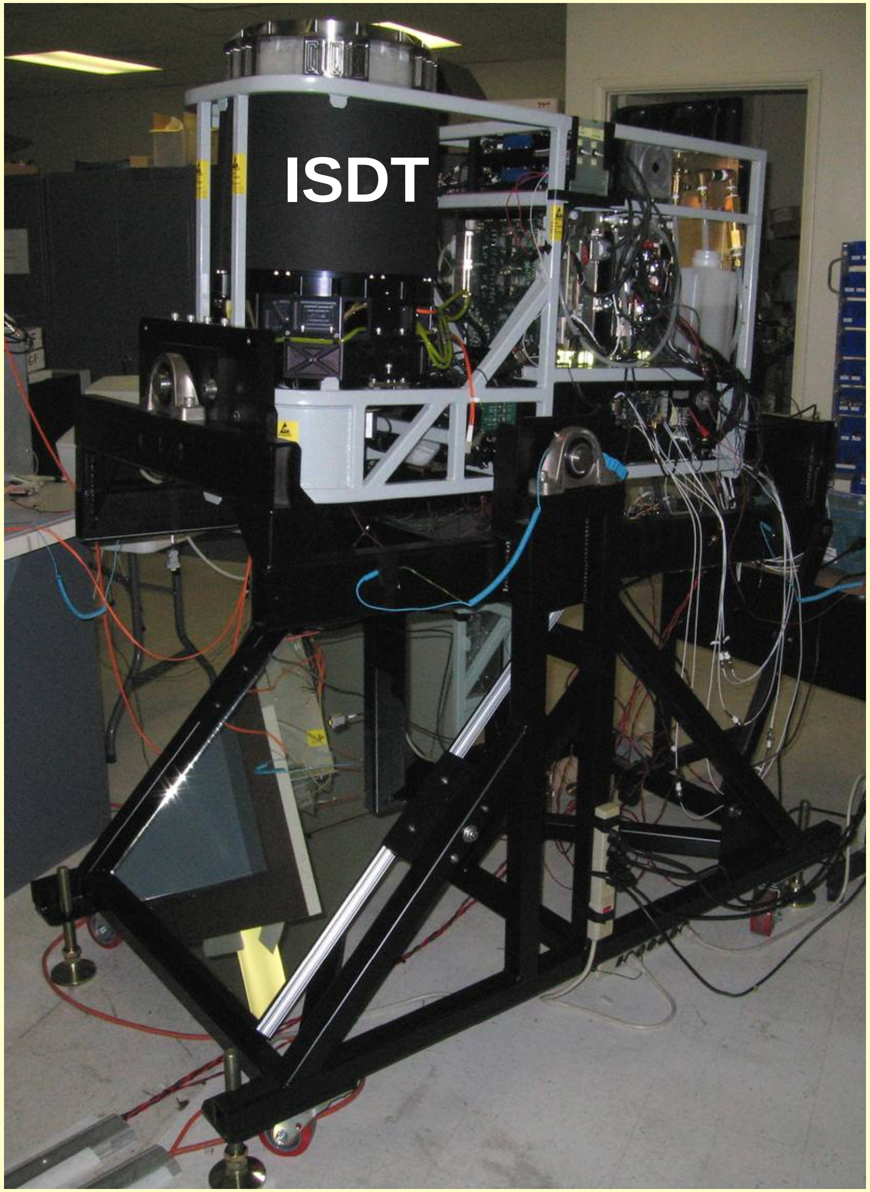
Surf Zone (SZ)

- 44 Range Gates
- Multiple Looks
- Track-and-Revisit Mode

Beach Zone (BZ)

- 3-Color Active MSI
- 70% Spectral Overlap

ROAR Technology Advances



- Integrated camera, scanner, receiver, and laser system in compact design for UAV
- True 3-D LIDAR system
- Multi-look scan pattern
- Active multi-spectral provides day / night capability
- Optimized for Surf Zone

Tactical UAV Sensor for Detection of Minefields (Buried) in the BZ / SZ

Description

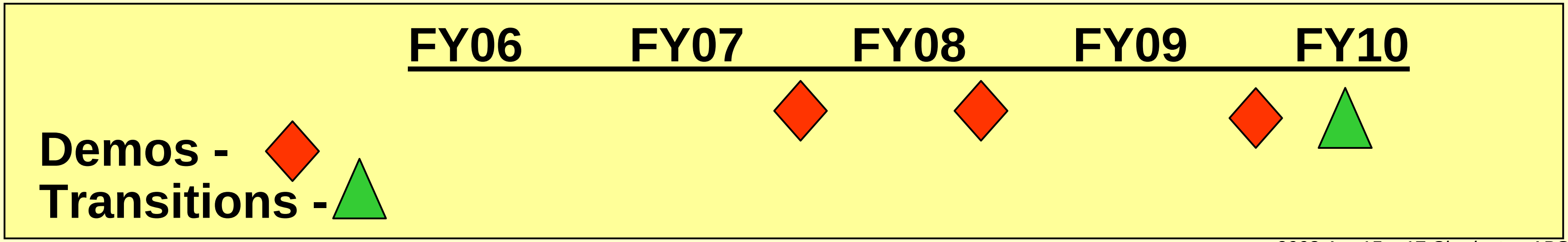
- Detection of buried minefields
- Technical Approaches
  - Active and passive imagers
  - Synthetic Aperture GPR
  - Laser Interferometric Sensor
  - High Resolution 3-D Imaging
  - Resonant Radio Freq Location

Demos / Transitions

- PMS 495 COBRA BLOCK III

Warfighting Payoff

- Rapid recon, day and night
- Supports targeting for ABS



Mine & Obstacle Breaching S&T Strategy

Develop a Precision Breaching Capability

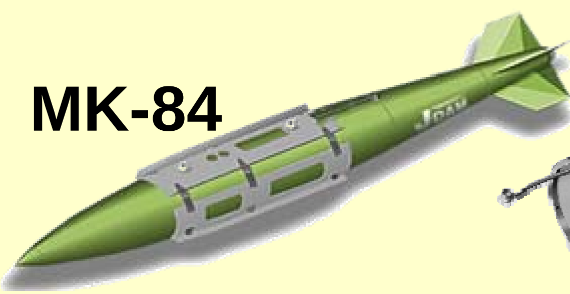
- Enabled by ISR and Weapon Precision Guidance
- Delivery by Naval TACAIR, USAF Bombers

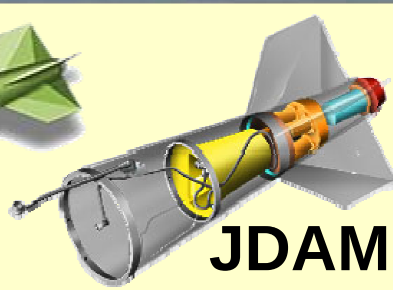
Spiral Development Approach

- JDAM Assault Breaching System (JABS): Exploit existing precision guided bombs for surface laid BZ/SZ mines and obstacles; VSW Mines
- Advanced Warhead Development: Countermine darts with greater kill radius & effectiveness vs. buried BZ / SZ mines in water and on land

JDAM Assault Breaching System (JABS)

MK-84





JDAM
Tail Kit

GBU-31(V)2/B
Precision Guidance

- **Requirements**
  - OPNAV Letter
  - Threshold and Objective
- **System Level Demos**
  - Beach Zone
  - Beach Zone / Surf Zone
- **Mission Planner**
- **Transitioned to PMS-495**

VIDEO VIDEO

Mine and Obstacle Defeat System (MODS)

- **Requirements**
  - MCIA Mine Threat Letter
  - ABS IPT Mine Matrix
  - Mine "Kill" Criteria
- **Component Tests**
  - Chemical and HE Darts
  - Sled Tests
- **System Level Demos**
  - Flight Tests with Darts
- **Transitioned to PMS-495**

Dispenser

CM Darts

SLED TEST

LIVE DEMO

Standoff Assault Breaching Weapon Fuze Improvement

Description

- Demo JABS vs. VSW mines
- Program will address:
  – Weapon Trajectory in VSW
  – Time of weapon detonation
  – Lethality against VSW mines
  – Fuze options

Demos / Transitions

- ABS Program / PMS-495

Payoff

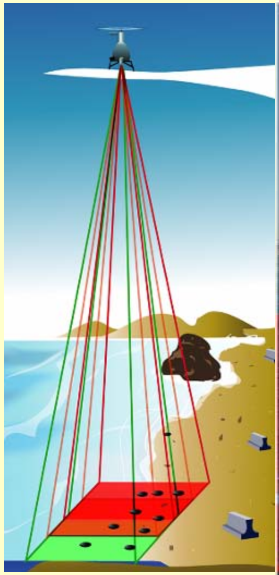
- Standoff clearance of VSW mines

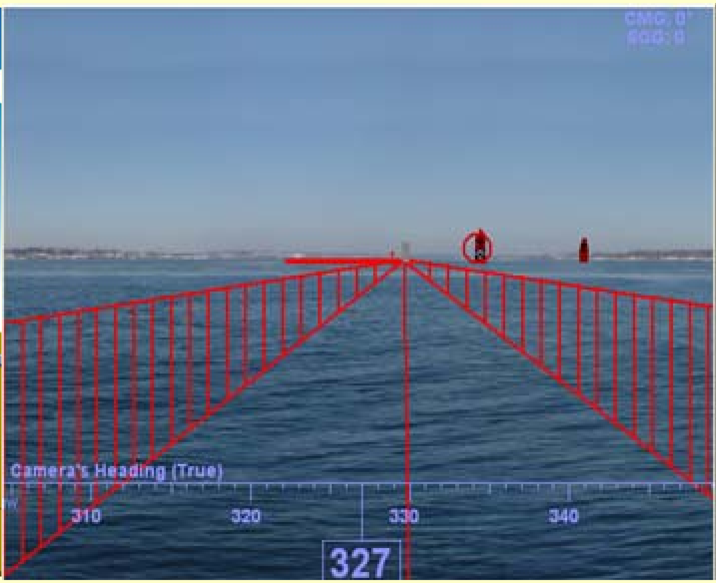
	FY06	FY07	FY08	FY09	FY10	Technical Risk
Demos - ◆			◆ ◆	◆ ◆		
Transitions - ▲					▲	●

Precision Assault Navigation in Mined Environments and Assault Lane Marking

Description

- Ensure Location Accuracy
  - GPS Augmentation
  - Zero Age of Data (ZOAD)
- Virtual Marking of Lanes
  - ARVCOP
  - Situational awareness
  - Virtual representation



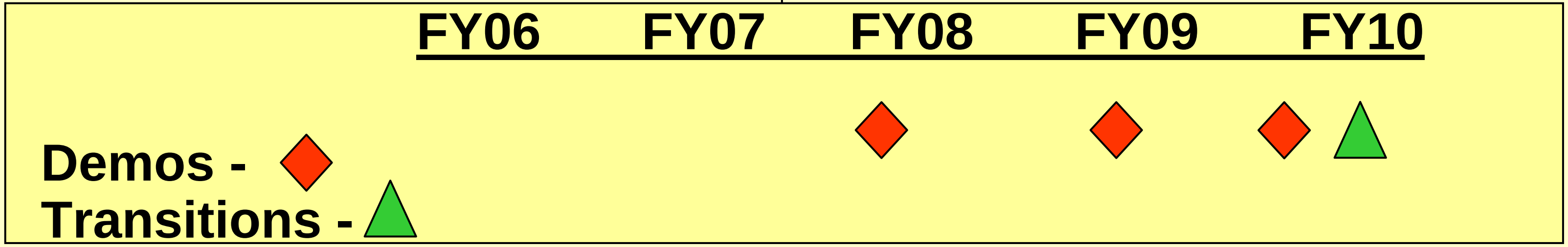


Demos / Transitions

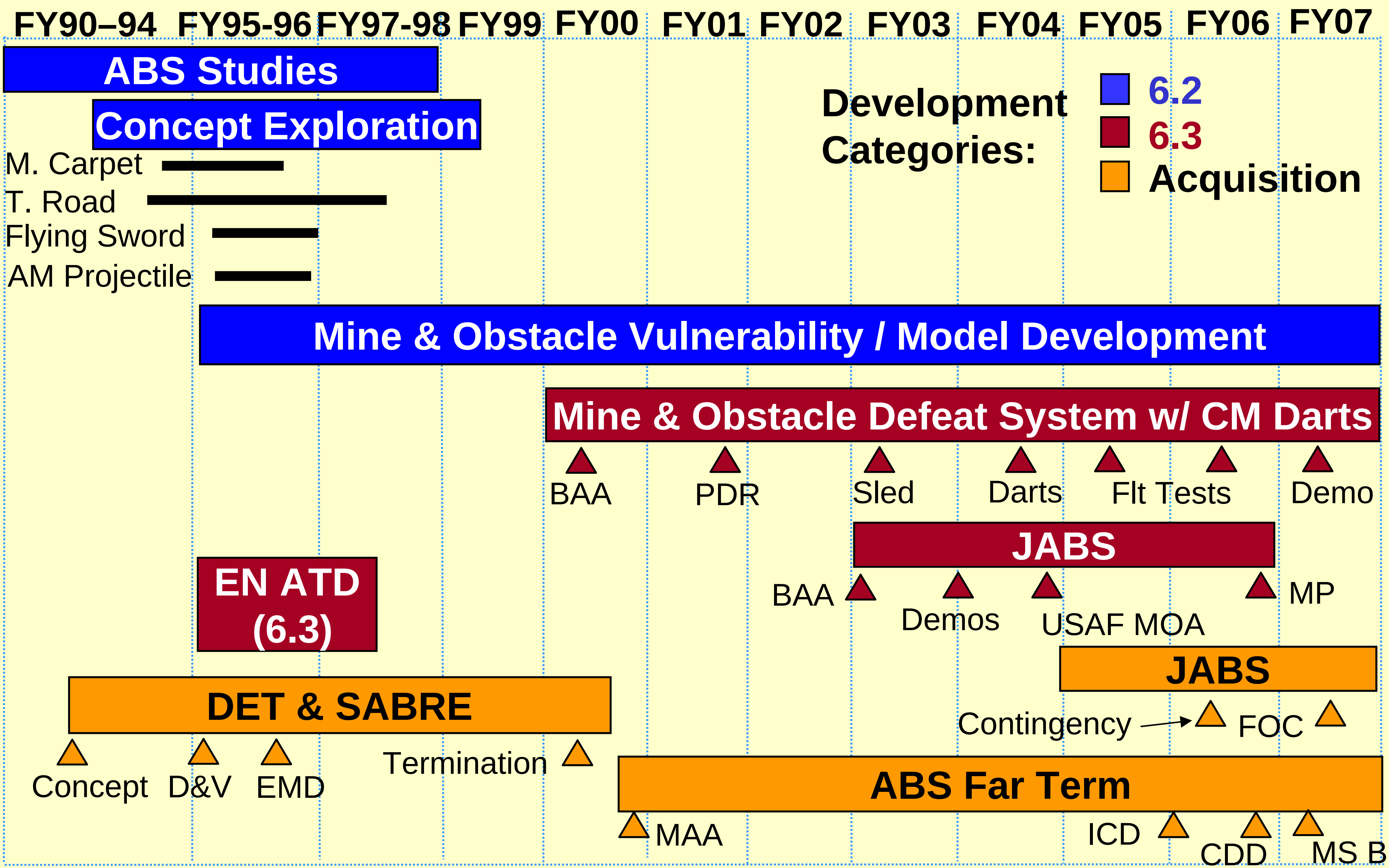
- ABS Program / PMS-495

Warfighting Payoff

- Location accuracy for assets
- Improve TLE

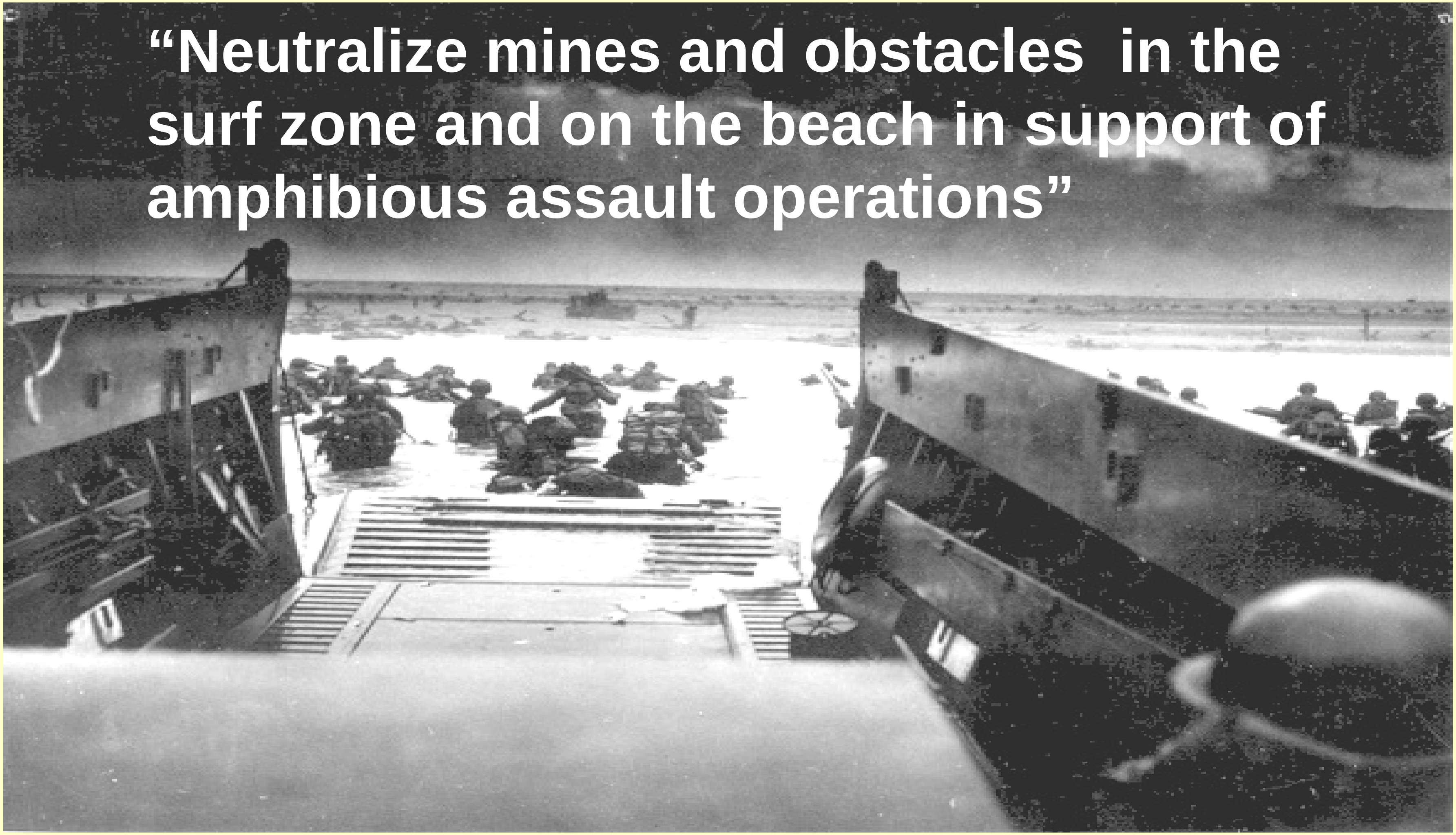


Mine and Obstacle Breaching Concept, Development, Transition



Assault Breaching Systems (ABS) Program

Assault Breaching Systems Mission Statement



Mission Need

“We can ill afford to move 3,000 miles to theater and be stymied by mines and obstacles in the last 3,000 yards.”

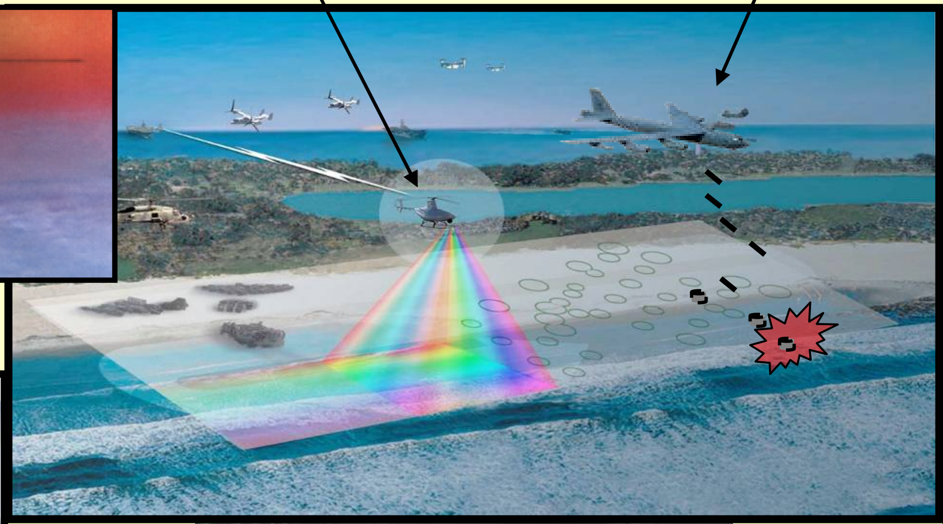
- General John Rhodes,
Marine Corps Combat
Development Command

ABS System-of-Systems

COBRA Sensor on Fire Scout

Counter Mine/ Counter Obstacle (CMCO)

ISR&T Capabilities



JABS

Precision Navigation / Lane Marking

MODS

COASTAL BATTLEFIELD RECONNAISSANCE AND ANALYSIS

COBRA

AN/DVS-1

PMS 495
MINE WARFARE

COBRA Block I

Processing and Data Storage

Step Stare Gimbal with MSI Camera

Access Panels to Remove Mission Data

COBRA System Description
Block I, Spiral B

Ground Control Station

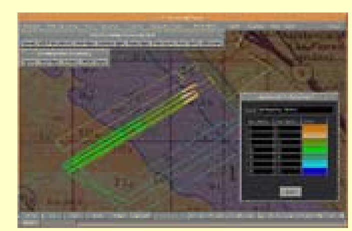
Tactical UAV

Airborne Control Processor (ACP)

Payload Housing Group (PHG)

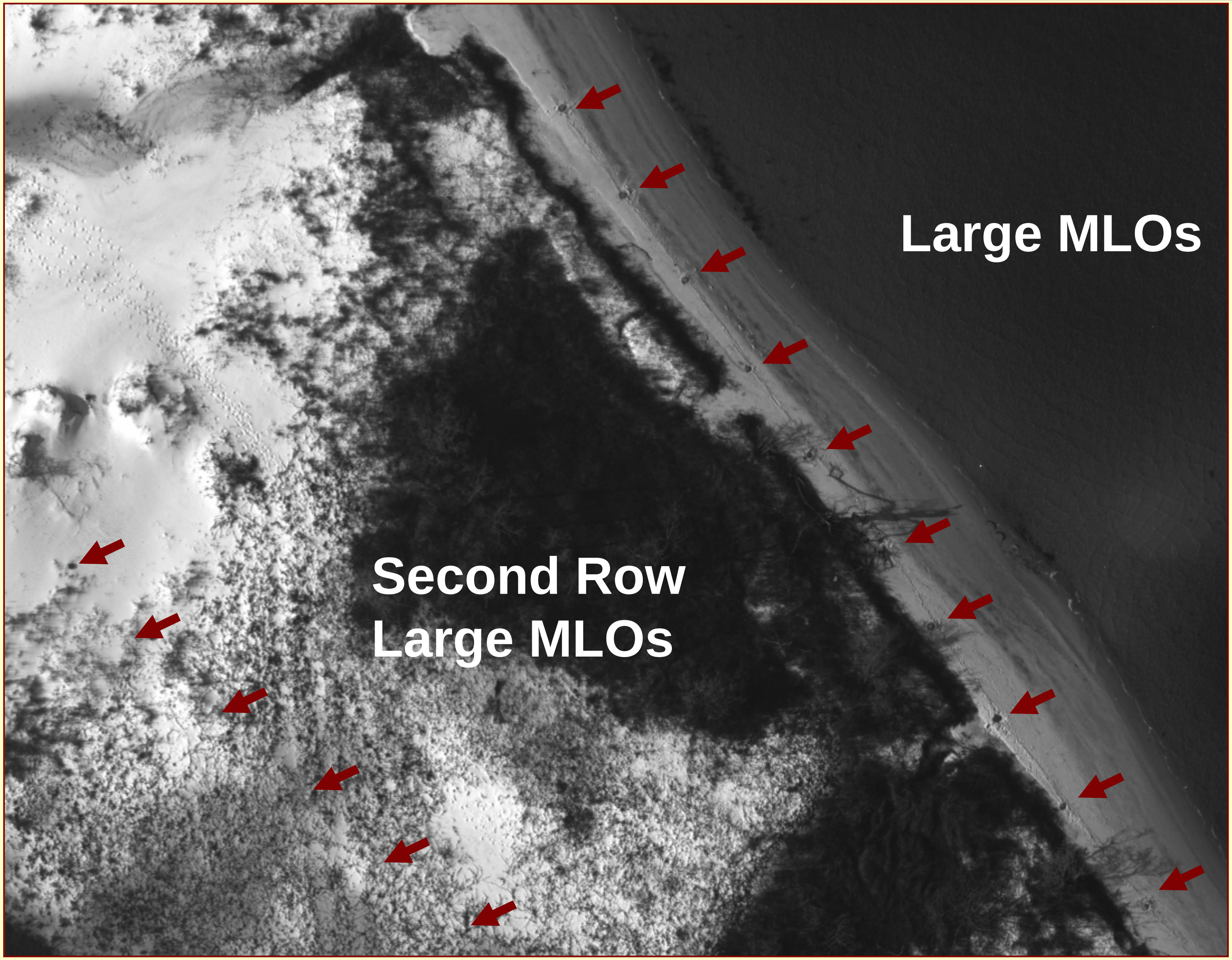
COBRA PMA Station

MEDAL



Airborne Sensor Group (ASG)

Eglin Sound Area A15 Target Fields

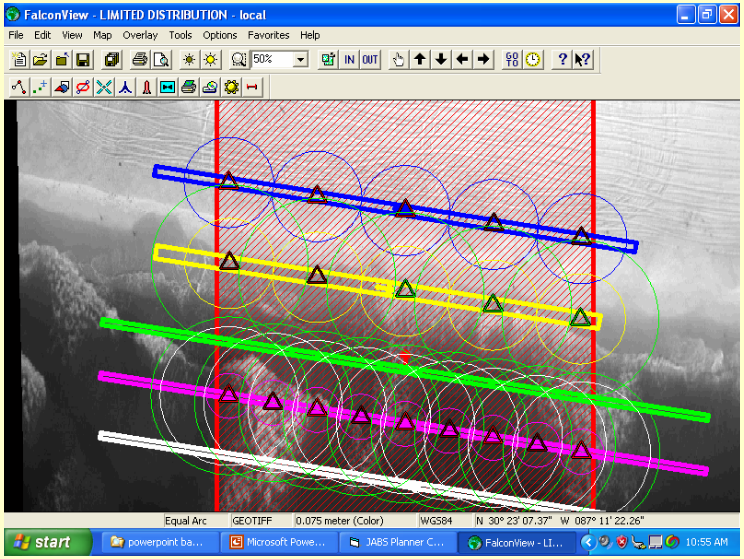


JDAM Assault Breaching System (JABS)

JABS Capabilities

- JABS leverages fielded JDAM weapon:
  - Effective vs. unburied mines / obstacles in the SZ & BZ
  - Limited lethality against buried mines
  - Day/Night Capability
  - Man out of the minefield
- MOA between USN-USAF
- JABS capability fielded through DOTMLPF Change Recommendation (DCR), approved by JROC May 06
- With accurate targeting information, JABS is the surf zone/beach zone breaching capability of today

Aim Points Sent to Air Force



Air Force Executes Mission

Countermine System (CMS)

Countermine System (CMS)

Description

The CMS consists of a precision guided weapon and mission planning software. The weapon will be delivered by USAF bombers and Navy TACAIR. The CMS will be effective against surface laid and buried mines in the surf zone (SZ) and beach zone (BZ).

Status

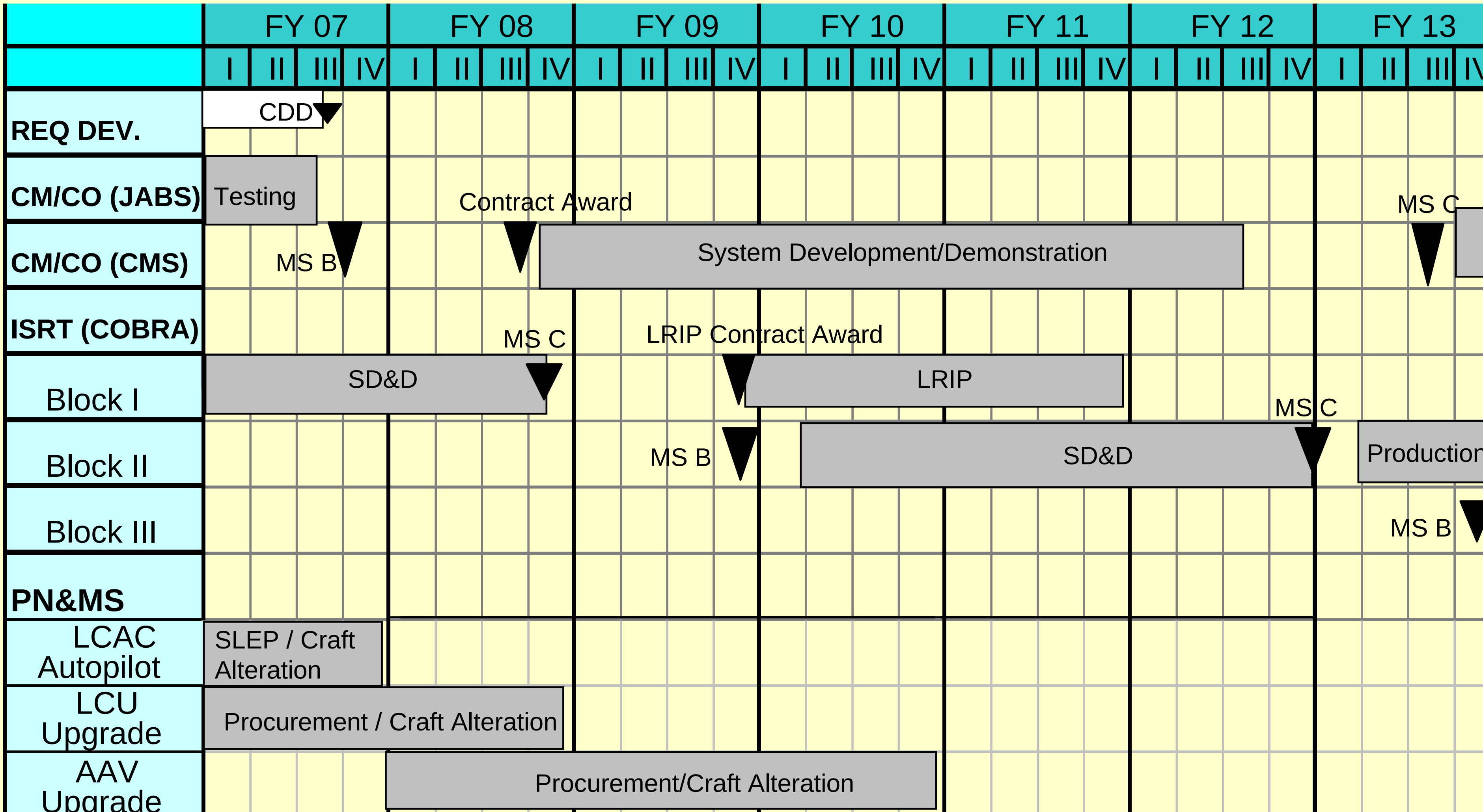
- Request for Proposals: 30 April 2007
- Proposals Received: 14 June 2007
- Contract Award Pending: May/June 2008

Precision Navigation and Marking

Precision Navigation and Marking System

Improve survivability and reduce the required lane size by visually / electronically marking lanes and providing electronic aids to facilitate maneuver.

ABS Schedule



Summary

- **Transitions Have Contributed to Closing Gap**
  - Minefield Breaching Weapons JABS & MODS
- **Current Technology Transition Agreements**
  - UAV-Based Mine Sensors
  - GPS Augmentation & Augmented Reality
- **Keys to Successful Transitions**
  - Close Coordination between OPNAV / ONR / PMS-495, Industry, Laboratory, and Academia
  - Clearly defined exit criteria
  - System-level demonstrations

Assault Breaching System Technologies

Revolutionary Research . . . Relevant Results

Presented to
9th Annual Science & Engineering Technology Conference / DoD Tech Exposition
15-17 April 2008

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JABS Flight Test

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JABS Surf and Beach Flight Test

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MODS Live Demo

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Sled Test

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