Annual Systems Engineering Research Center Research Review

15 October 2009

The Honorable Zachary J. Lemnios

Director, Defense Research and Engineering

Report Documentation Page

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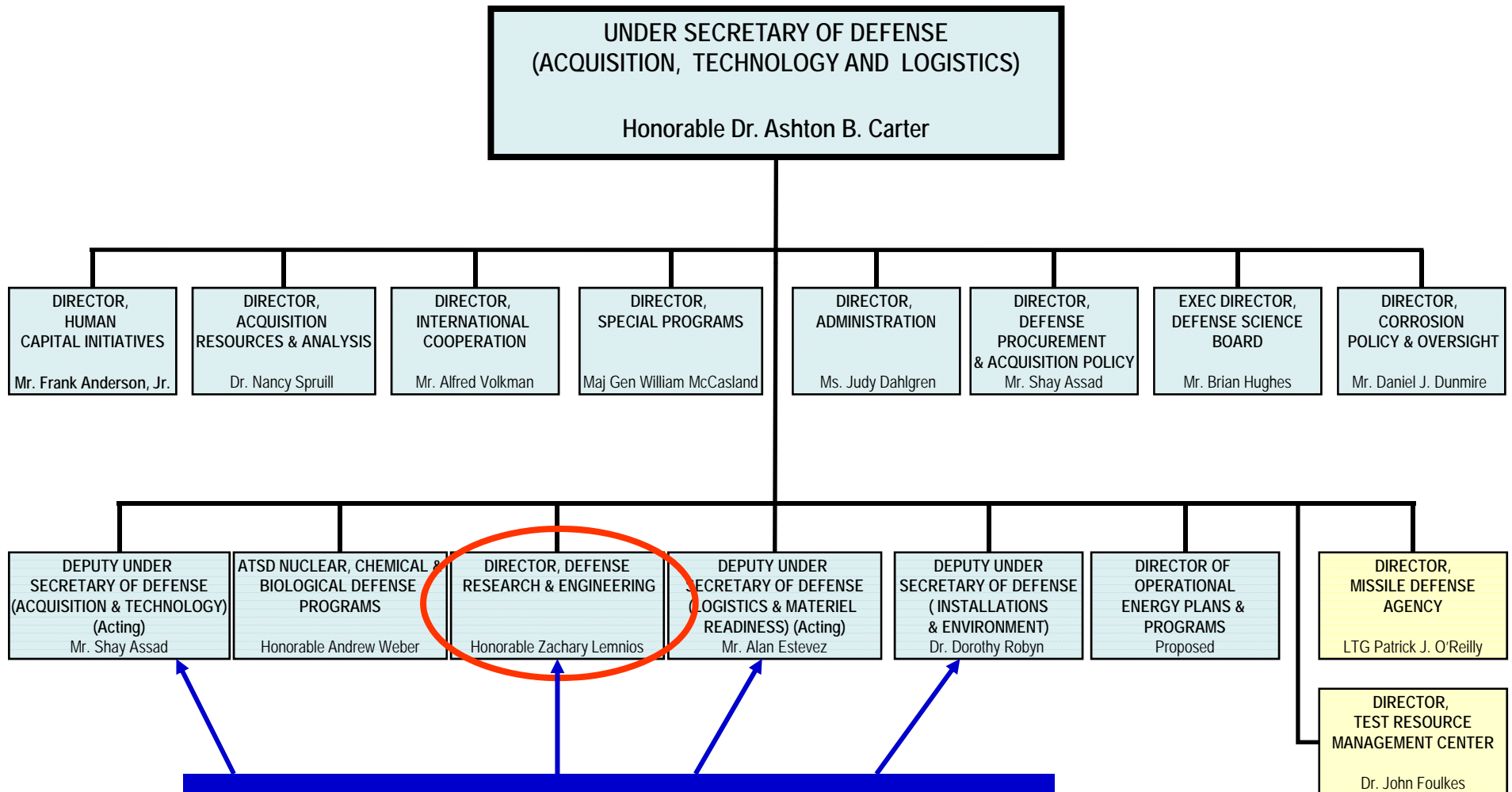| 16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
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Our Guidance

- **Defense Budget Recommendation Statement**
  Secretary of Defense Robert M. Gates, April 06, 2009

  - *reaffirm our commitment to take care of the all-volunteer force*

  - *rebalance this Department's programs*

  - *institutionalize and enhance our capabilities to fight the wars we are in today and the scenarios we are most likely to face in the years ahead*

  - *provide a hedge against other risks and contingencies*

  - *fundamental overhaul of our approach to procurement, acquisition, and contracting*

- **Economic Club of Chicago**
  Secretary of Defense Robert M. Gates, July 16, 2009

  - *What is needed is a portfolio of military capabilities with maximum versatility across the widest possible spectrum of conflict*
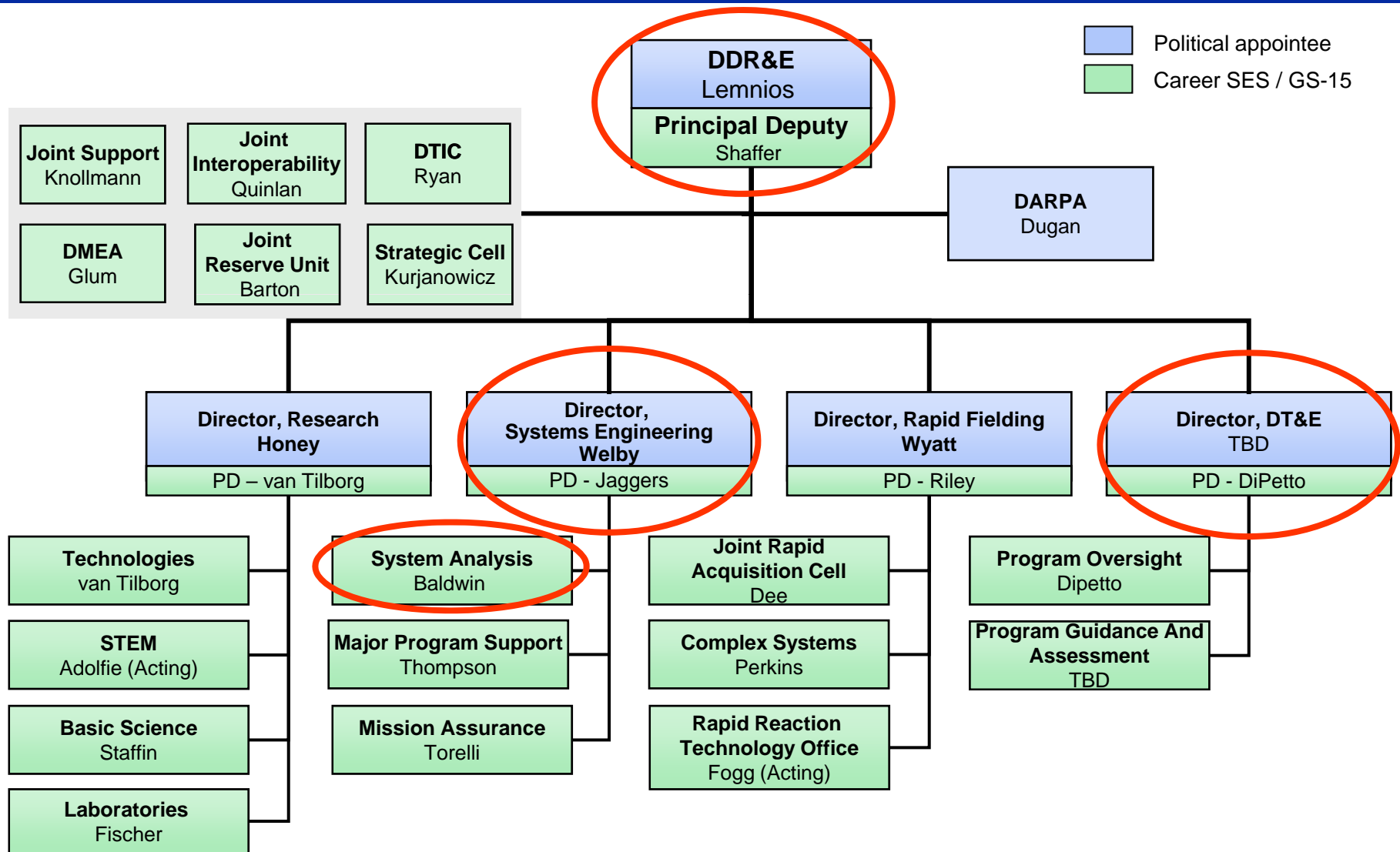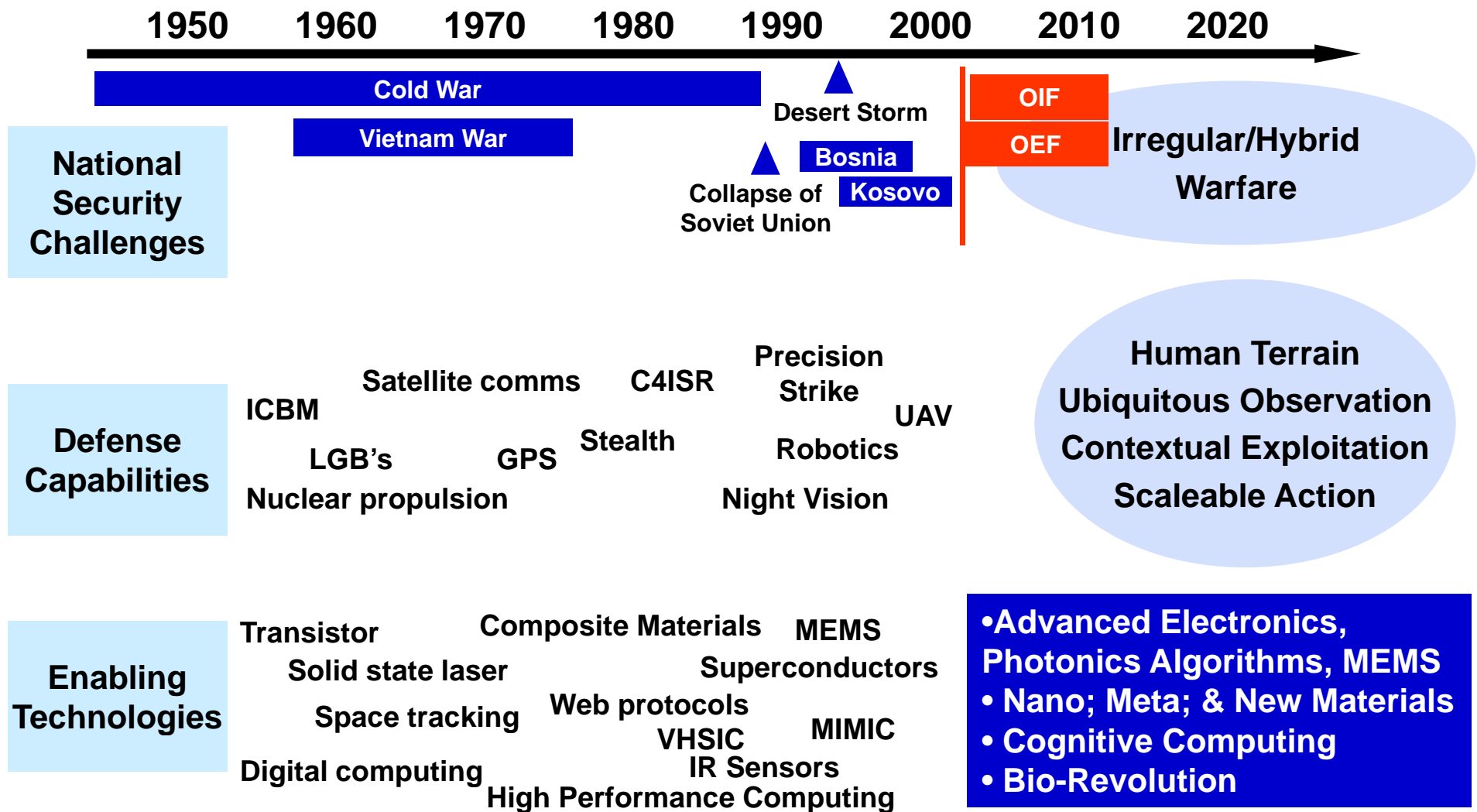
AT&L Organization

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(ACQUISITION, TECHNOLOGY AND LOGISTICS)

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DIRECTOR, TEST RESOURCE MANAGEMENT CENTER

Dr. John Foulkes

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DDR&E Organization

Political appointee
Career SES / GS-15

DDR&E
Lemnios
Principal Deputy
Shaffer

DARPA
Dugan

Joint Support Knollmann	**Joint Interoperability** Quinlan	**DTIC** Ryan
DMEA Glum	**Joint Reserve Unit** Barton	**Strategic Cell** Kurjanowicz

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Honey
PD – van Tilborg

Director, Systems Engineering
Welby
PD - Jaggers

Director, Rapid Fielding
Wyatt
PD - Riley

Director, DT&E
TBD
PD - DiPetto

Technologies
van Tilborg

STEM
Adolfie (Acting)

Basic Science
Staffin

Laboratories
Fischer

System Analysis
Baldwin

Major Program Support
Thompson

Mission Assurance
Torelli

Joint Rapid Acquisition Cell
Dee

Complex Systems
Perkins

Rapid Reaction Technology Office
Fogg (Acting)

Program Oversight
Dipetto

Program Guidance And Assessment
TBD

DDR&E Imperatives

1. Accelerate delivery of technical capabilities to win the current fight.

2. Prepare for an uncertain future.

3. Reduce the cost, acquisition time and risk of our major defense acquisition programs.

4. Develop world class science, technology, engineering, and mathematics capabilities for the DoD and the Nation.

Perspective
for the Next Decade

| 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | 2010 | 2020 |

National Security Challenges

Cold War

Vietnam War

Desert Storm

Collapse of Soviet Union

Bosnia

Kosovo

OIF

OEF

Irregular/Hybrid Warfare

Defense Capabilities

ICBM

Satellite comms

C4ISR

Precision Strike

UAV

LGB's

GPS

Stealth

Robotics

Nuclear propulsion

Night Vision

Human Terrain
Ubiquitous Observation
Contextual Exploitation
Scaleable Action

Enabling Technologies

Transistor

Composite Materials

MEMS

Solid state laser

Superconductors

Space tracking

Web protocols

MIMIC

VHSIC

Digital computing

IR Sensors

High Performance Computing

- Advanced Electronics, Photonics Algorithms, MEMS
- Nano; Meta; & New Materials
- Cognitive Computing
- Bio-Revolution

Forces of Change…
Irregular and Hybrid Warfare

Operations in Austere Locations → **Defense S&T for Persistent / Irregular Warfare** ← **Humanitarian Assistance / Provincial Reconstruction Teams**

NEW TECHNOLOGY NEEDED
Affecting the Hearts and Minds…

The Timeline has Collapsed!

Conventional Warfare

USAF Capability

Adversary Capability

High Altitude Aircraft

High Altitude SAM

Electronic Countermeasures

Monopulse SAM

Endgame Countermeasures

Engage SAM

SAM with ECCM
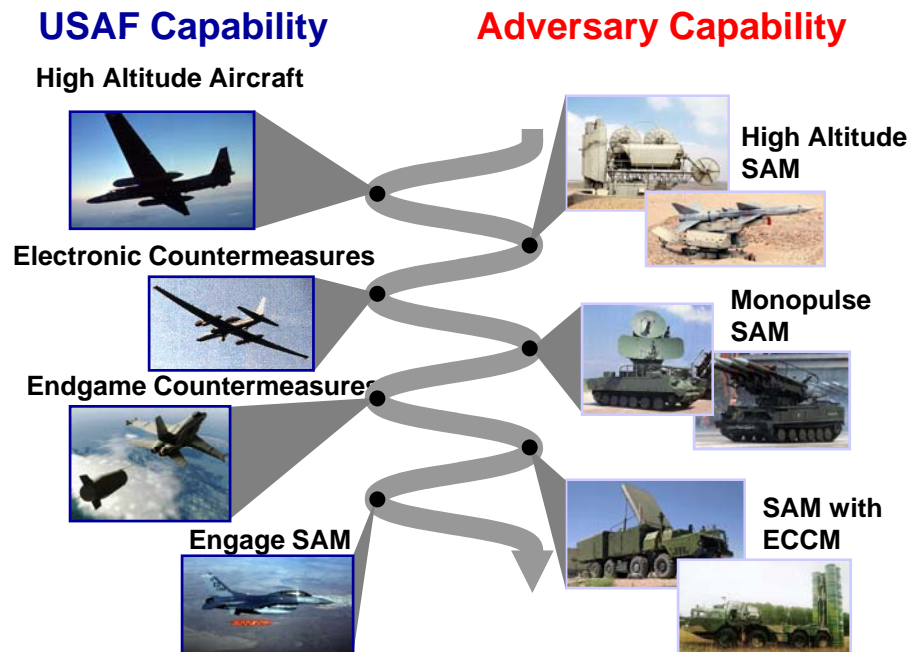
Response loop measured in years

Counter-Insurgency Warfare

US Capability

Adversary Capability

Jammers

Mine Resistant Ambush Protected (MRAP)

Advanced Technology
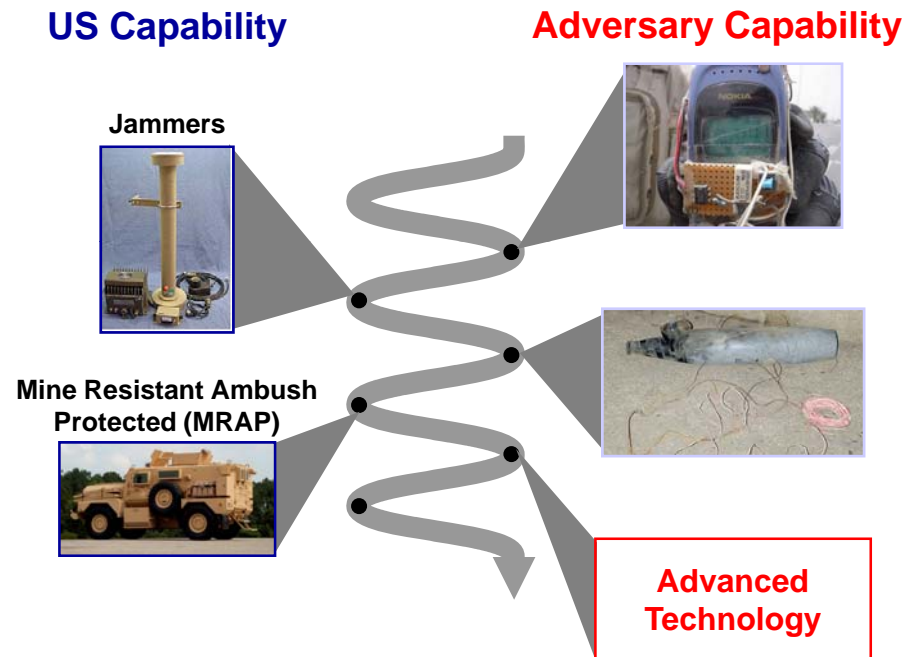
Response loop measured in months or weeks

Four Key Challenges
to our Technical Base
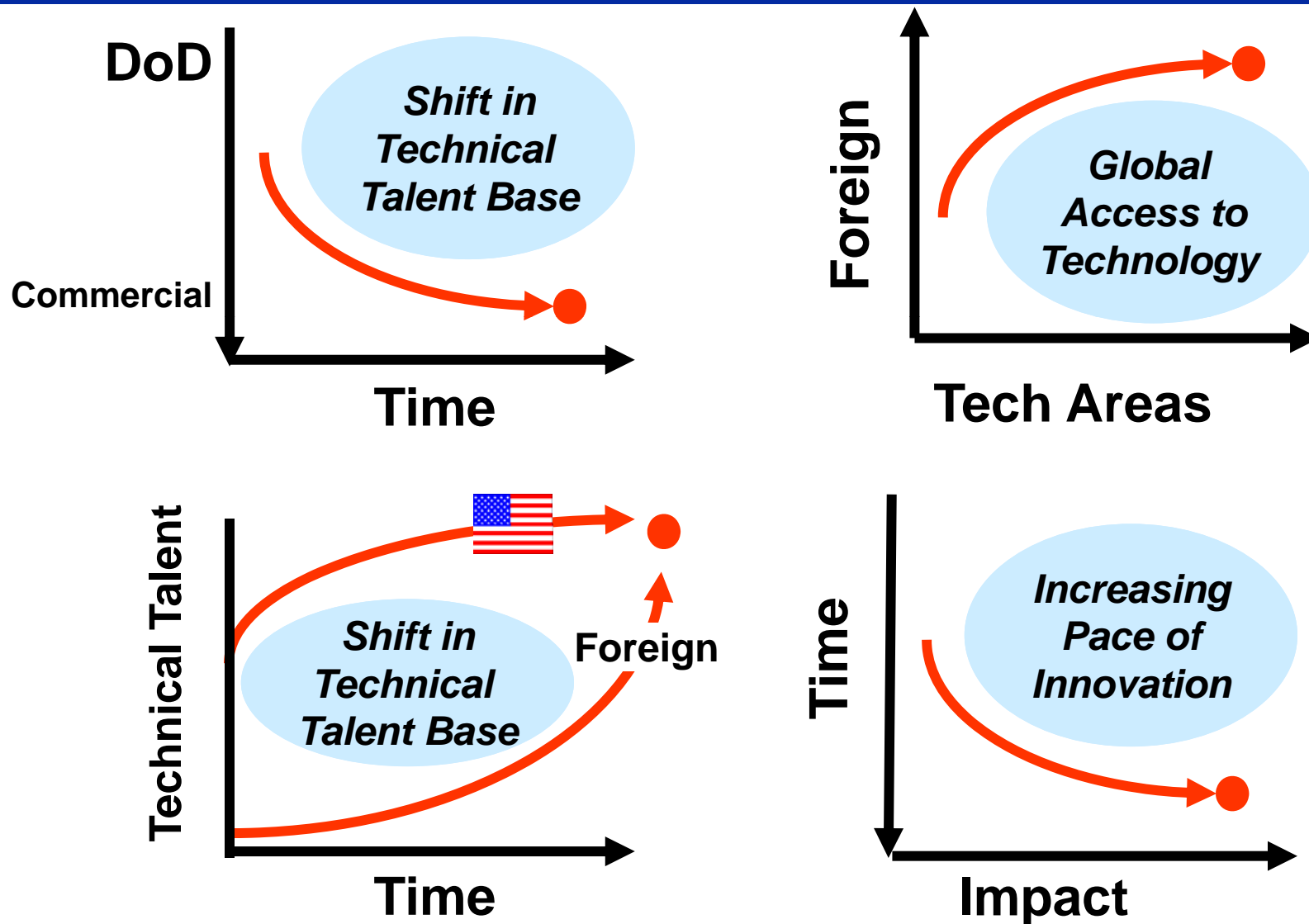
We are in a competition for the best technical talent

Thousands of graduates

China

Japan

U.S.

China
Japan
S. Korea
U.S.
U.K.
Germany

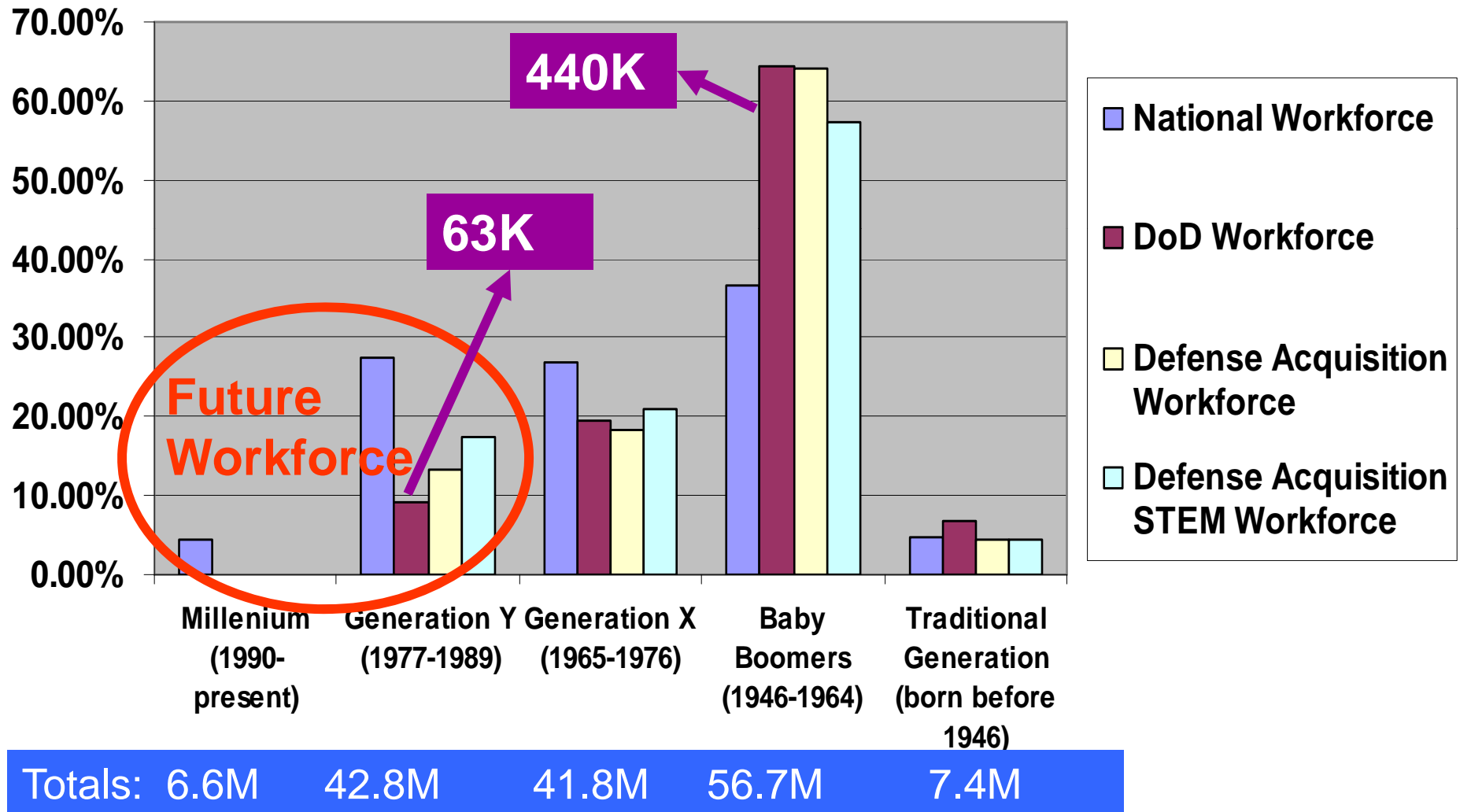S&E Indicators, 2008
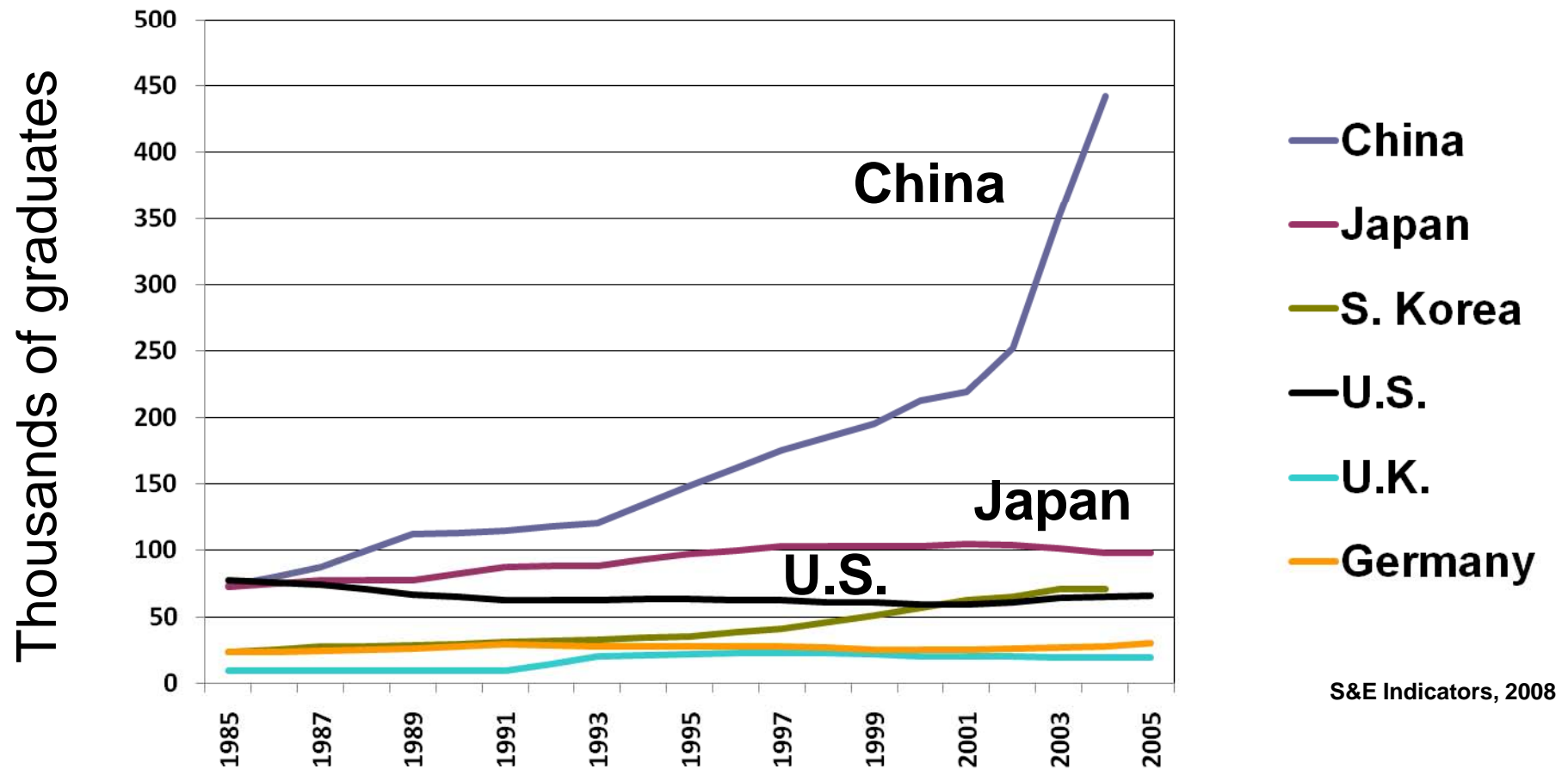
The Shifting Research Base

Full-Time Equivalent (FTE) Researchers
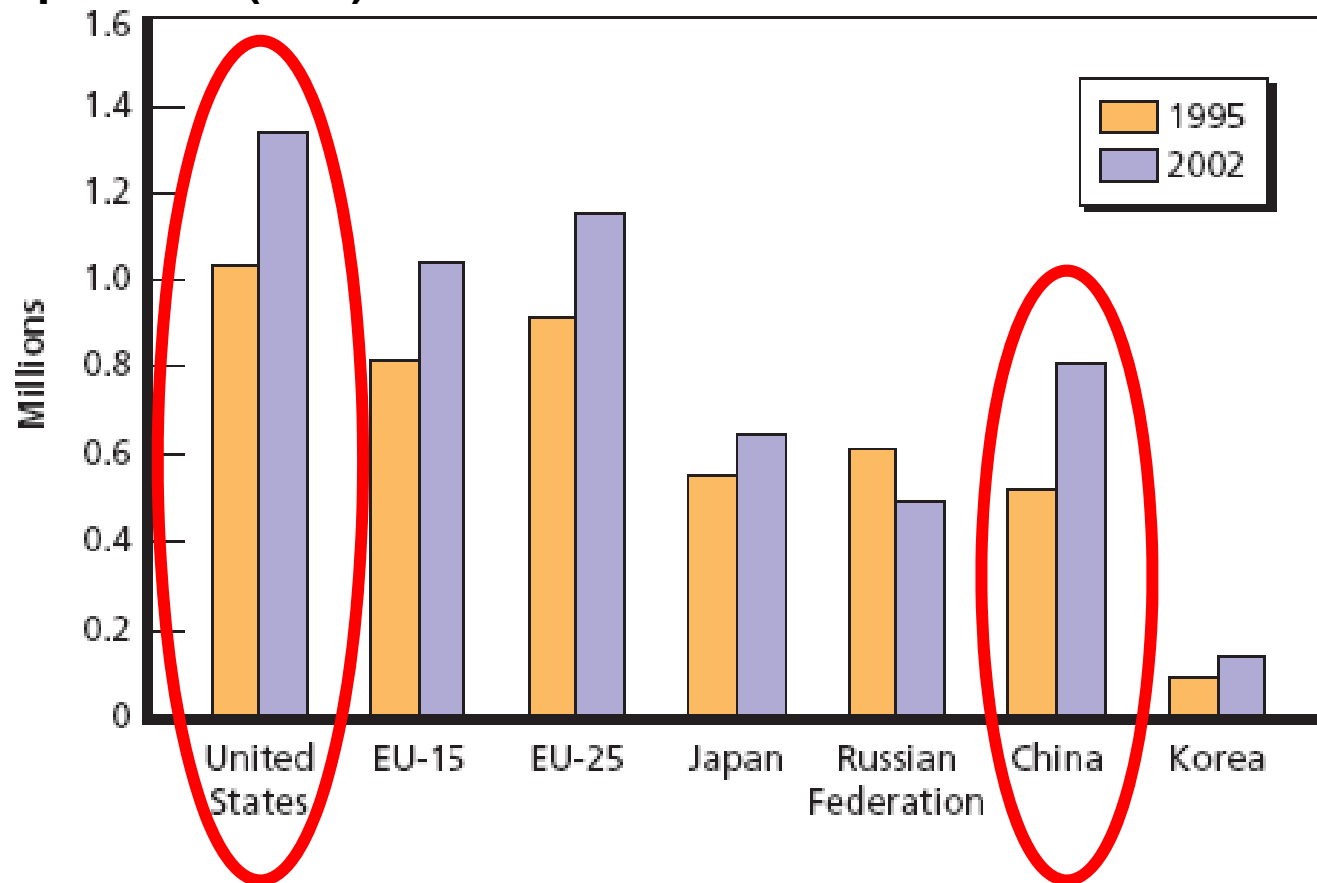
Source: OECD Science, Technology and Industry Outlook (2006)

Workforce Breakdown by Generation

The Big Three

Innovation

Speed

Agility

Comments from COCOMs

"We need to detect IED's at range… I am willing to test technologies in the field… We need persistent communications on the move…"

"I need the 70% solution today, rather than the 100% solution in 5-8 years…"

"…we are concerned about our technological edge against a near peer competitor…"

"It took us 10 years to get to the Moon, we are 8 years into our research efforts for defeating IED's…we need to find a solution to reliably detect and defeat IED's at range…

"I like the 1 year acquisition cycle rather than the standard 5-8 year cycle, get the prototypes into the hands of the warfighters, turn the feedback into a quick redesign and deliver relevant capability now…"
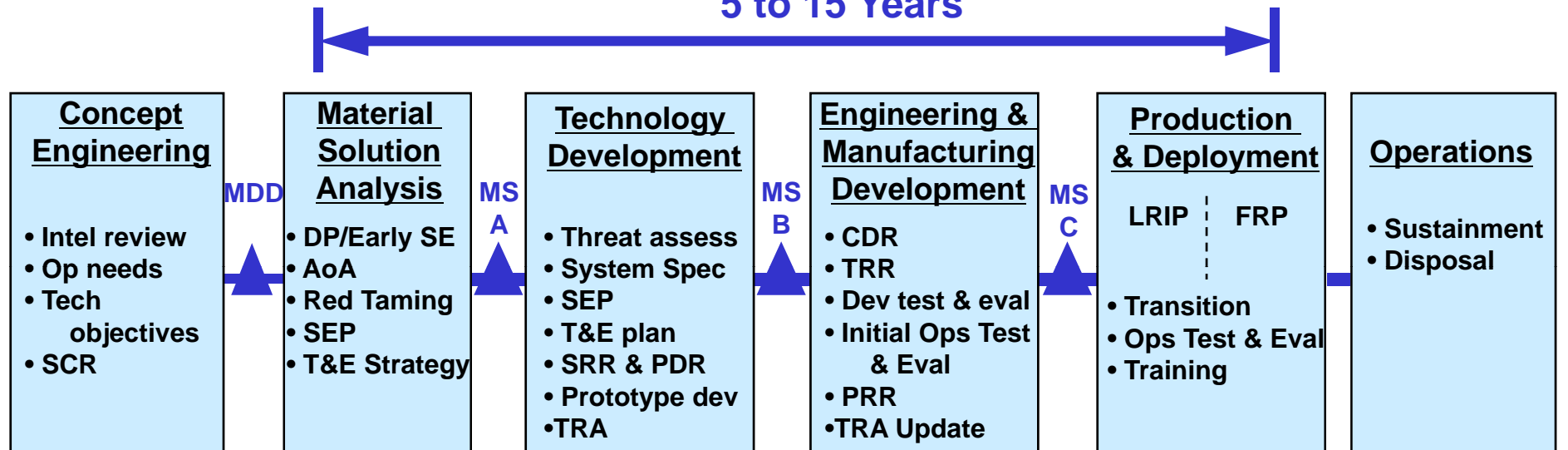
"Often times we fail due to shortage of imagination…"

An Effective Process for Major Defense Systems – but not very agile

Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management System

Defense Acquisition Approach
Systems Engineering is key discipline

5 to 15 Years

Concept Engineering		Material Solution Analysis		Technology Development		Engineering & Manufacturing Development		Production & Deployment	Operations
• Intel review • Op needs • Tech objectives • SCR	**MDD**	• DP/Early SE • AoA • Red Taming • SEP • T&E Strategy	**MS A**	• Threat assess • System Spec • SEP • T&E plan • SRR & PDR • Prototype dev •TRA	**MS B**	• CDR • TRR • Dev test & eval • Initial Ops Test & Eval • PRR •TRA Update	**MS C**	LRIP ┊ FRP • Transition • Ops Test & Eval • Training	• Sustainment • Disposal

Technology and Risk Reduction
- Technology "push" investment
- Technology maturation
- Phenomenology measurements

AoA – Assessment of Alternatives
DP – Developmental Planning
MDD – Material Development Decision
SCR – System Concept Review
SRR – System Requirements Review
SEP – System Engineering Plan
PDR – Preliminary Design Review
CDR – Critical Design Review
TRR – Test Readiness Review
PRR – Production Readiness Review
LRIP – Low-Rate Initial Production
FRP – Full Rate Production

70-75% of Cost Decisions Made Prior to Milestone A
Impact 72% of Total Life Cycle Costs

Scope of DDR&E Acquisition Program Oversight Efforts*

Program Category	Increasing cost/risk	SE	DT&E	TMA
ACAT ID**	$$$ MDA = AT&L	93	93	70
ACAT IC**	$$$ MDA = CAE	29	29	52
Special Interest**	Any $s Risk	17	17	19
MAIS, ACAT IA	$-$$$, AIS	15	15	30
Pre-MDAP	$$$ pre-MS B	44	44	53
Pre-MAIS	$-$$$, AIS pre-MS B	9	9	10
ACAT II	$$ < ACAT I	0	8	0
ACAT III	$ < ACAT II	0	3	0
Total		207	218	234

DABs in next 90 days

- **BAMS IPR**
- **MUOS DAE Review**
- **FCS Follow-on**
- **EA-18G FRP**
- **JTRS MIDS MS C**
- **WIN-T Increment II MS-C**
- **SSN 774 Virginia Class MS III**
- **Global Hawk IPR**
- **HC/MC-130 MS C**
- **SBIRS DAE Review**
- **JTRS HMS MS C**
- **JHSV (pre-MDAP)**
- **JSF (F-35) LRIP**

*Based on 2009 T&E Oversight List (Jan 5, 2009)
**Major Defense Acquisition Program (MDAP)
+Major Automated Information System (MAIS)

MDA – Milestone Decision Authority
TMA – Technology Maturity Assessment
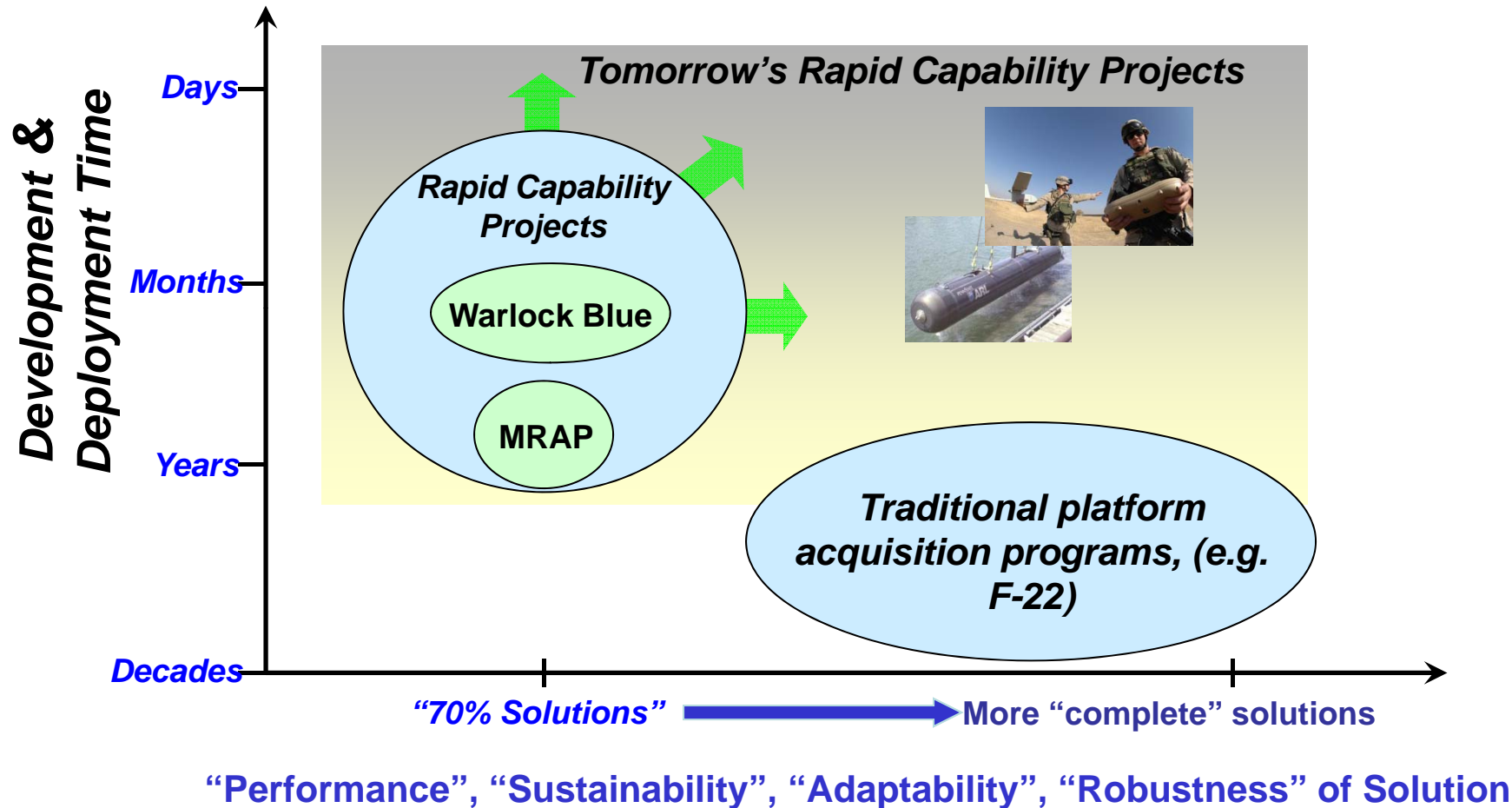CAE – Component Acquisition Executive

The Current SE Environment

Systems Engineers confront a spectrum of issues that challenge "traditional" systems engineering

- **Complexity**
  - Scope & Scale: number and diversity of elements
  - Connectivity: interdependencies among the disparate elements
  - Emergent behaviors: nonlinear stochastic response functions
  - Effects of non-technical attributes and characteristics
- **Criticality**
  - Systems to be continuously available
  - Able to deal with Security, Privacy, Authenticity, Accuracy, requirements "seamlessly" & without performance degradation
- **Compatibility**
  - Integrate the newest/fastest with the oldest/slowest
- **Chronology**
  - "Idea" to "IOC" measured in weeks/months versus years/decades
- **Competency**
  - Can the workforce develop the knowledge and abilities to adapt & survive?

Rapid Capability "Toolbox"

Development & Deployment Time

- Days
- Months
- Years
- Decades

Tomorrow's Rapid Capability Projects

Rapid Capability Projects

Warlock Blue

MRAP

Traditional platform acquisition programs, (e.g. F-22)

"70% Solutions" → More "complete" solutions

"Performance", "Sustainability", "Adaptability", "Robustness" of Solution

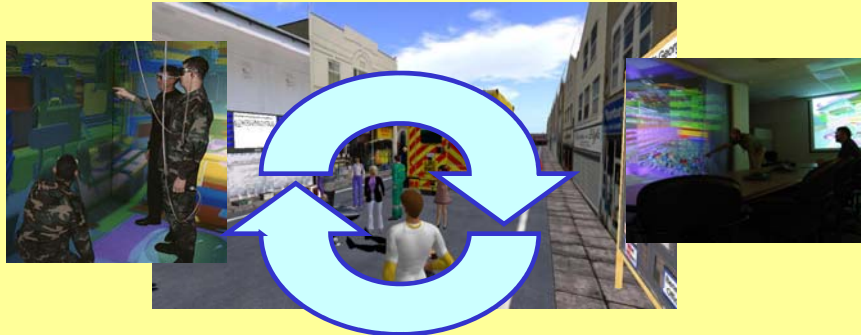**DDR&E Rapid Capabilities Toolbox study will identify tools to enable more rapid, adaptive, robust, and sustainable solutions to the warfighter**

A New Generation of Concept Engineering Tools

Warfighter Needs

Anticipatory Opportunities

Accelerated Concept Engineering Environment

Iterative Virtual and Real Prototyping

- Conceptual Designs
- CONOPs
- TTPs
- Detailed Design Models

- **Immersive Virtual Environments**
- **Rapid Virtual Environment generation**
- **Virtual Environment to CAD tool translation**
- **Rapid Prototyping fabrication tools**
- **"Human-Centered Design" principles and tools**
- **Integrated engineering and virtual M&S**

Immerse Users/Developers in a Rapidly-Configured Environment with Real and Virtual Prototypes: *Accelerated Concept Engineering*

How the SERC Adds Value

- **Brings focus and synergy across the broad technical / engineering community to address complex challenges**

- **Develops engineering methods, tools to reduce risk in acquisition**

- **Inspires and advances a national competency for Systems Engineering**

- **Provide direct supports the DoD and Intelligence Communities**
  - **To do this effectively, SE Research must be *Engaged* —*this is a "Contact Sport"***

Summary: Challenges Ahead

- **Create the tools to enable Rapid Capability Delivery**
  - Shorten the time to deliver life-saving and war-winning technologies – without compromising SE integrity

- **Evolve SE to design systems for adaptability**
  - Capture agility, adaptability, responsiveness as design attributes

- **Expand the aperture of SE to address 21st century technical challenges**
  - Security, software-intensive, etc…

- **Embrace complexity**
  - Systems of Systems / Complex Adaptive Systems / Emergent behaviors

- **Expand the SE human capital resource base**
  - Reflect new insights in the curriculum to grow the next "crop" of SE