Globalization of Technology Impact on US Military

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April 19, 2007

Some Opening Thoughts

- ***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

- ***The future has a way of arriving unannounced***

  George Will

- ***Research is what I am doing when I don't know what I am doing***

  Werner Von Braun

- ***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

- ***If you don't know where you are going, you might end up someplace else***

  Yogi Berra

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.:**

Implications for:	Great Depression (1929)	Pearl Harbor (1941)	Atomic Revolution (1945-1955)	Sputnik (1957)	Fall of the Soviet Union (1989-1991)	9/11 Attacks (2001)	Katrina (2005)
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
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

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

FROM OUSD (Policy) – Future Shocks Study

Technology and the Modern World

- ***"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

- ***"The challenge of the defense planner and strategist is not to avoid being surprised. Rather, it is to plan against some of the more dire potential effects of surprise…'."***

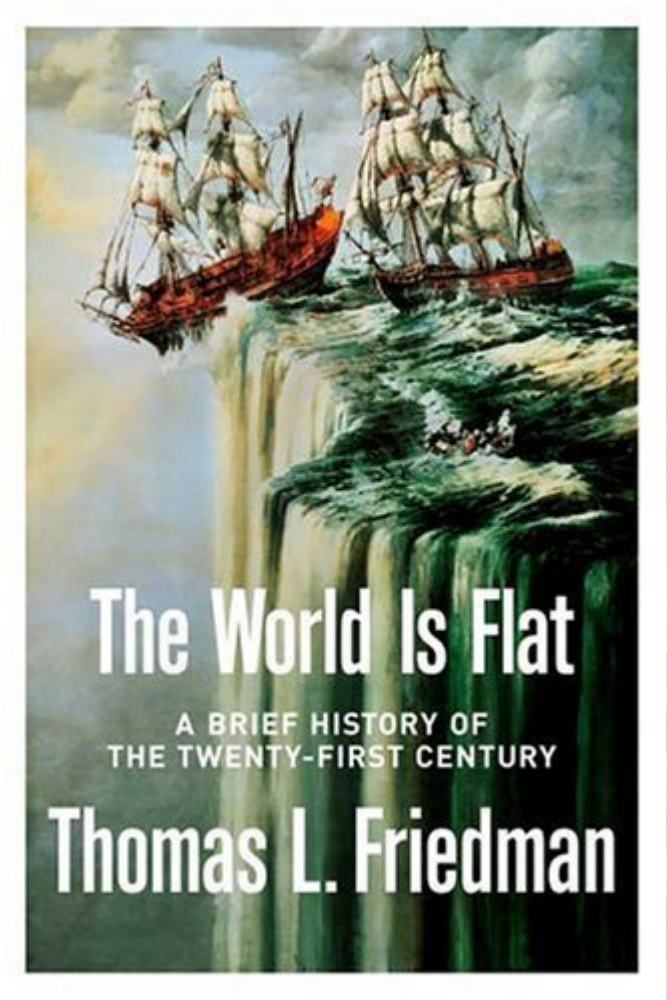
  Colin Gray, Transformation and Strategic Surprise

- ***"It is this convergence -- of new players, on a new playing field, developing new processes for horizontal collaboration -- that I believe is the most important force shaping global economics and politics in the early 21st century. Sure, not all three billion can collaborate and compete…but even if we're talking about only 10 percent, that's 300 million people -- about twice the size of the American work force. And be advised: the Indians and Chinese are not racing us to the bottom. They are racing us to the top."***

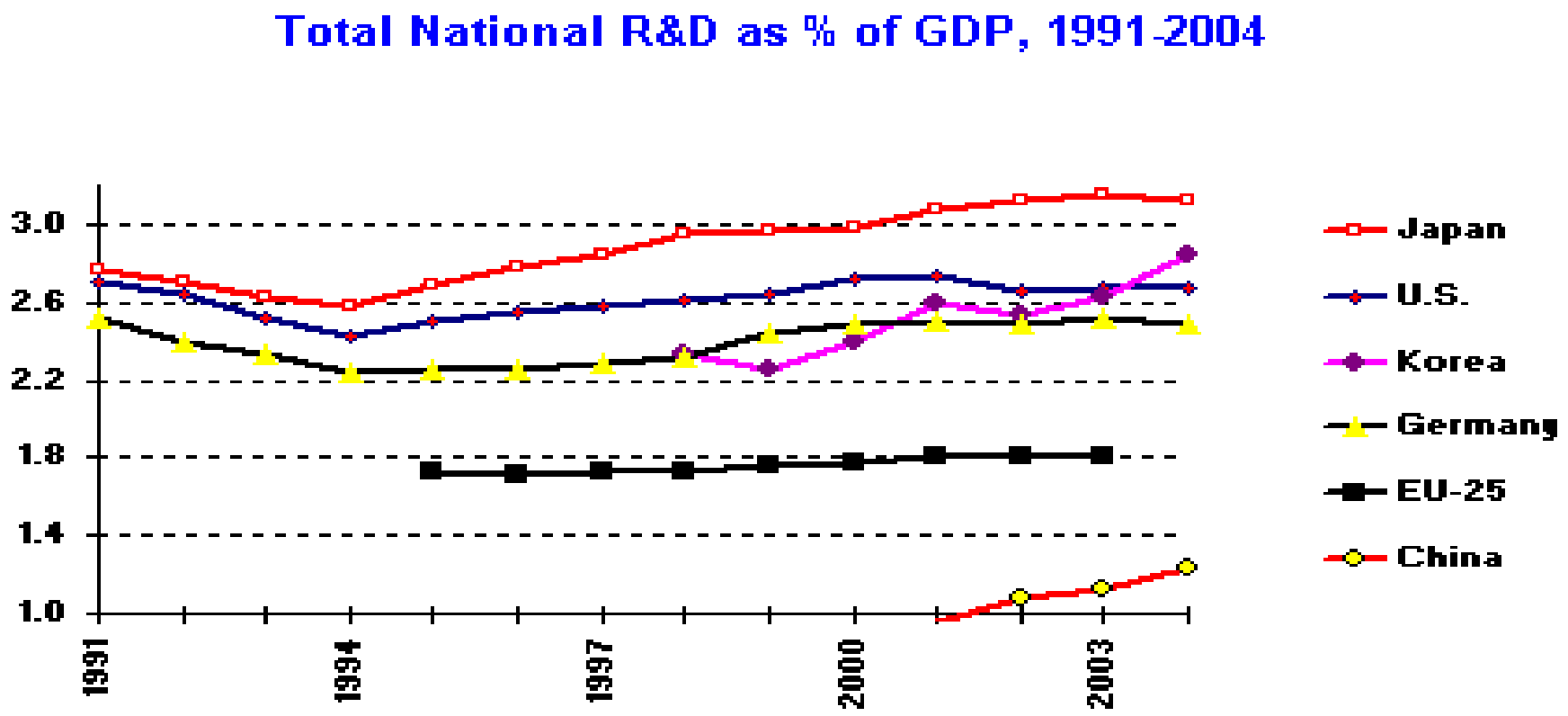
  Thomas Friedman, The World is Flat

Overview

- Global Technology Development Trends
- Technology Case Studies: Past, Present and Future
- Quadrennial Defense Review



National R&D Funding Levels

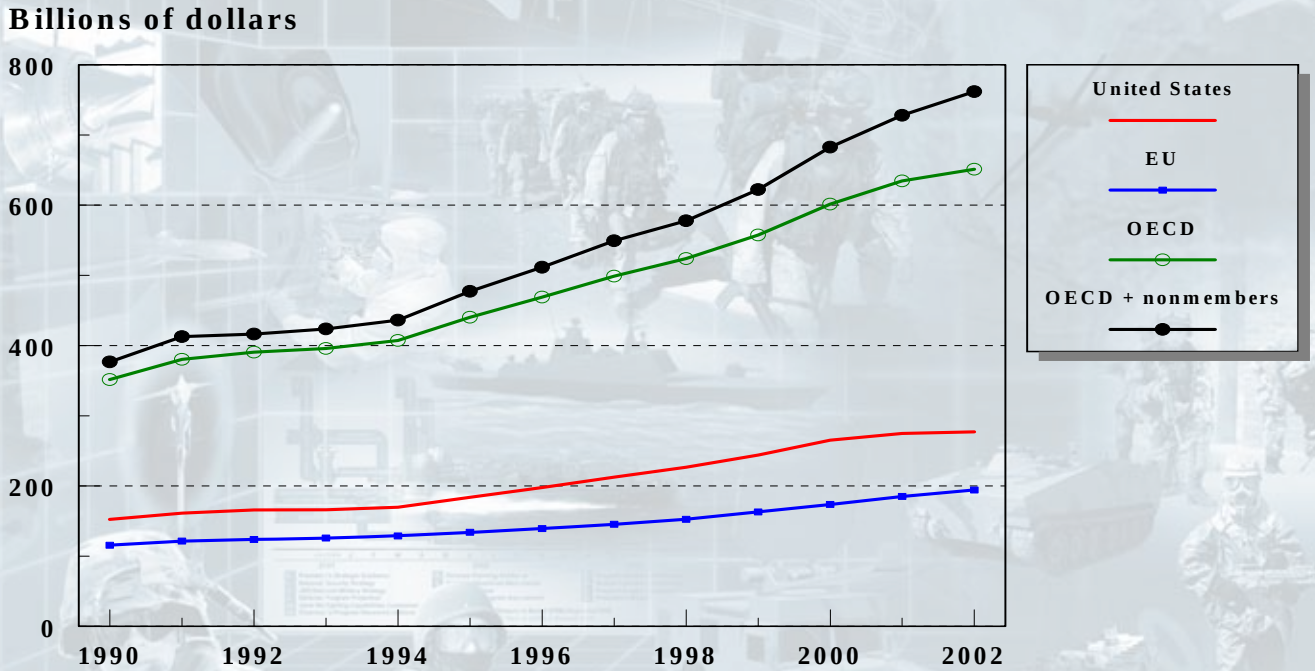


Source: National Science Foundation, National Patterns of R&D Resources and OECD, Main Science and Technology Indicators. Data not available for all nations for all years. SEPTEMBER '06 © 2006 AAAS

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



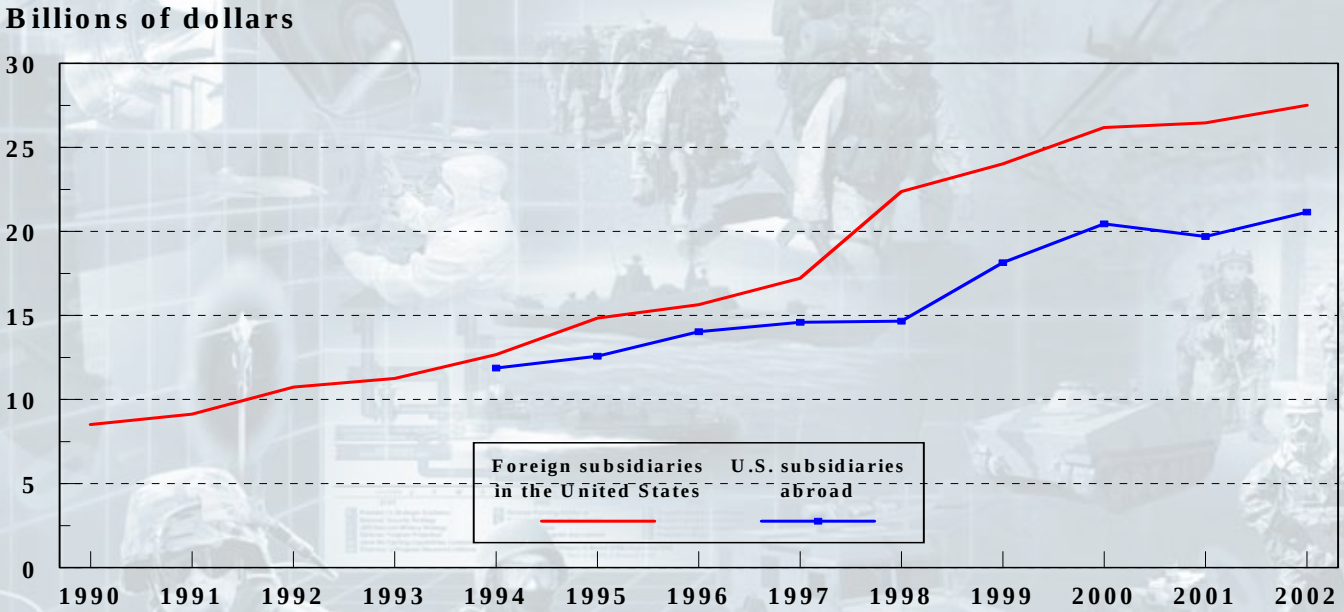
NOTE: Billions of current dollars converted with purchasing power parities.
EU data since 1998 include 10 new member countries.
SOURCE: OECD, Main Science and Technology Indicators database, November 2004

Source: National Science Foundation, S&E Indicators 2006

Internationalization of R&D

- **Firms' cross-border R&D investments are on the increase.**

Figure 3. R&D expenditures of foreign-owned firms in the United States and of U.S.-owned firms abroad: 1990-2002



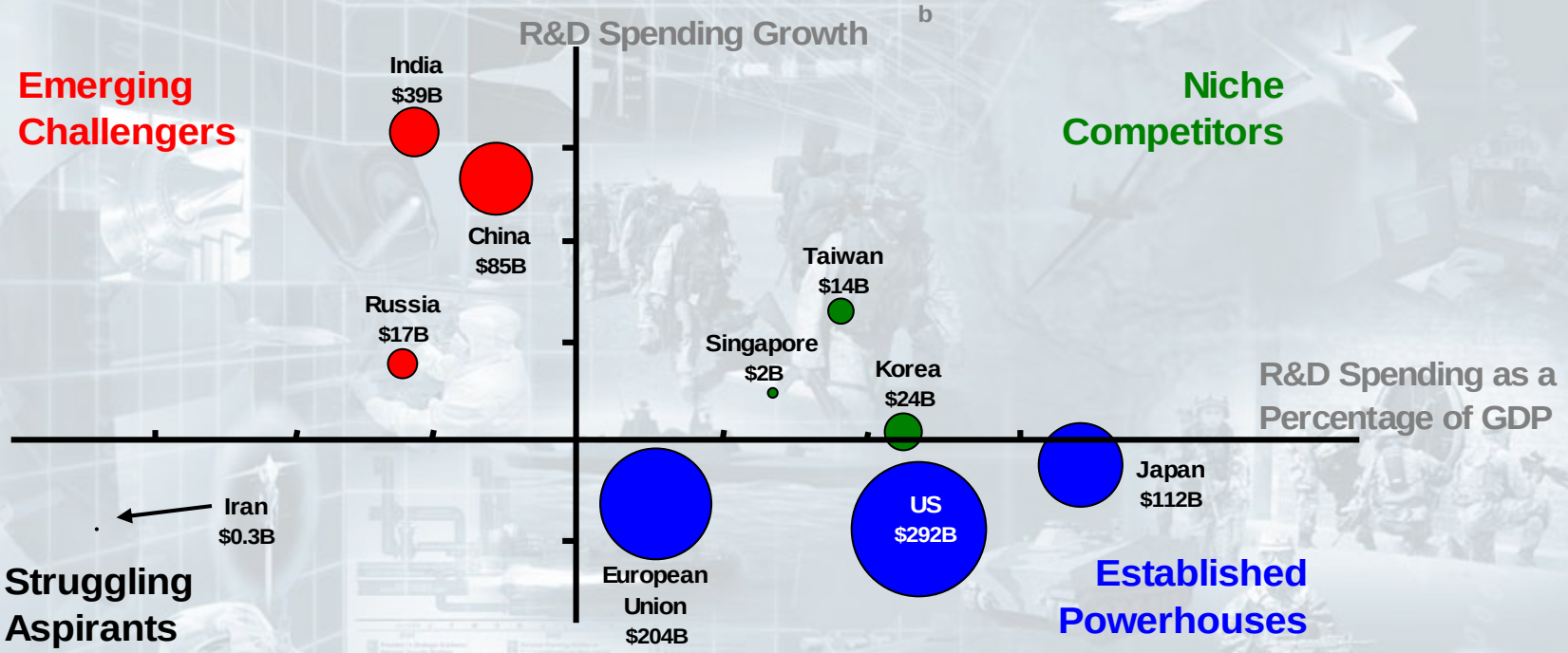
SOURCE: U.S. Department of Commerce, BEA, Surveys of Foreign Direct Investment in the United States and U.S. Direct Investment Abroad; and National Science Board, Science & Engineering Indicators 2006, appendix tables 4-49 and 4-51.

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.

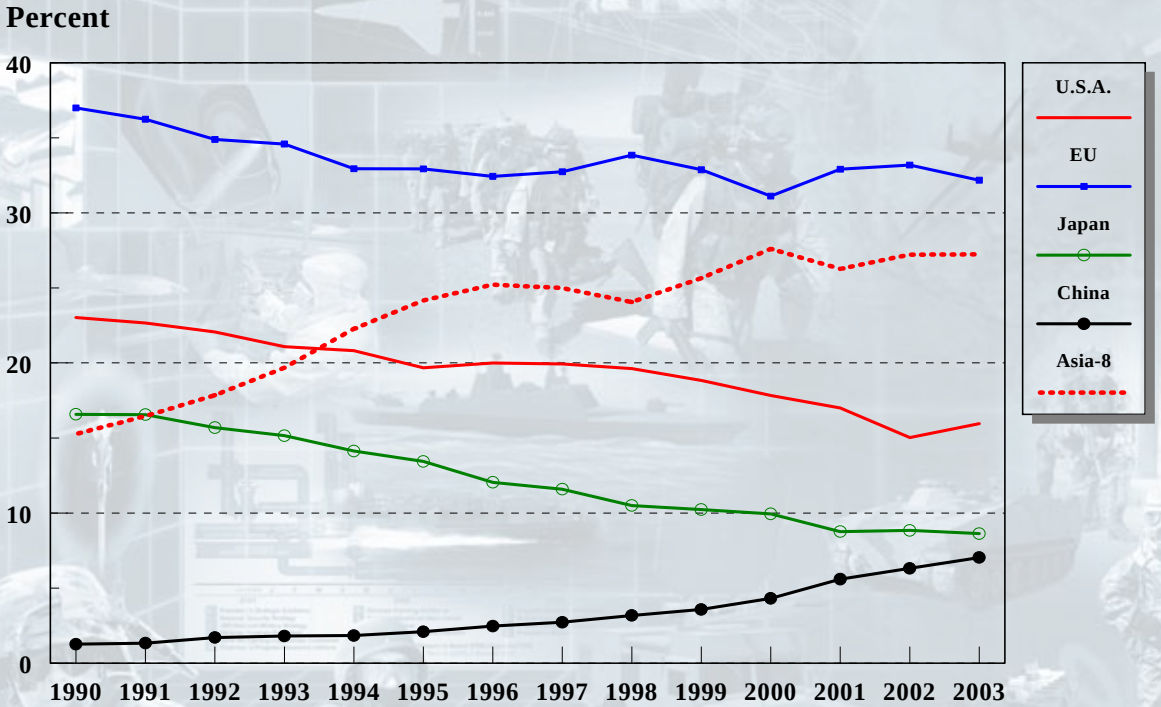
[b]Growth rates are calculated since 2000, except for Russia, which was calculated since 1992 due to high uncertainty in the regression since 2000.

Sources: OECD, Main Science and Technology Indicators Volume 2005; UNESCO, Science Report 2005; Indian Ministry of Science and Technology, Science and Technology 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.

High technology exports

- **High technology exports are expanding, but European, Japanese, and U.S. export shares are shrinking as those of China and other Asian exporters are rising.**

Figure 11. Export market shares in high technology goods: 1990-2003



NOTE: Asia-8 includes South Korea, India, Indonesia, Malaysia, Philippines, Singapore, Taiwan, and Thailand.
SOURCE: Global Insight and S&E Indicators 2006

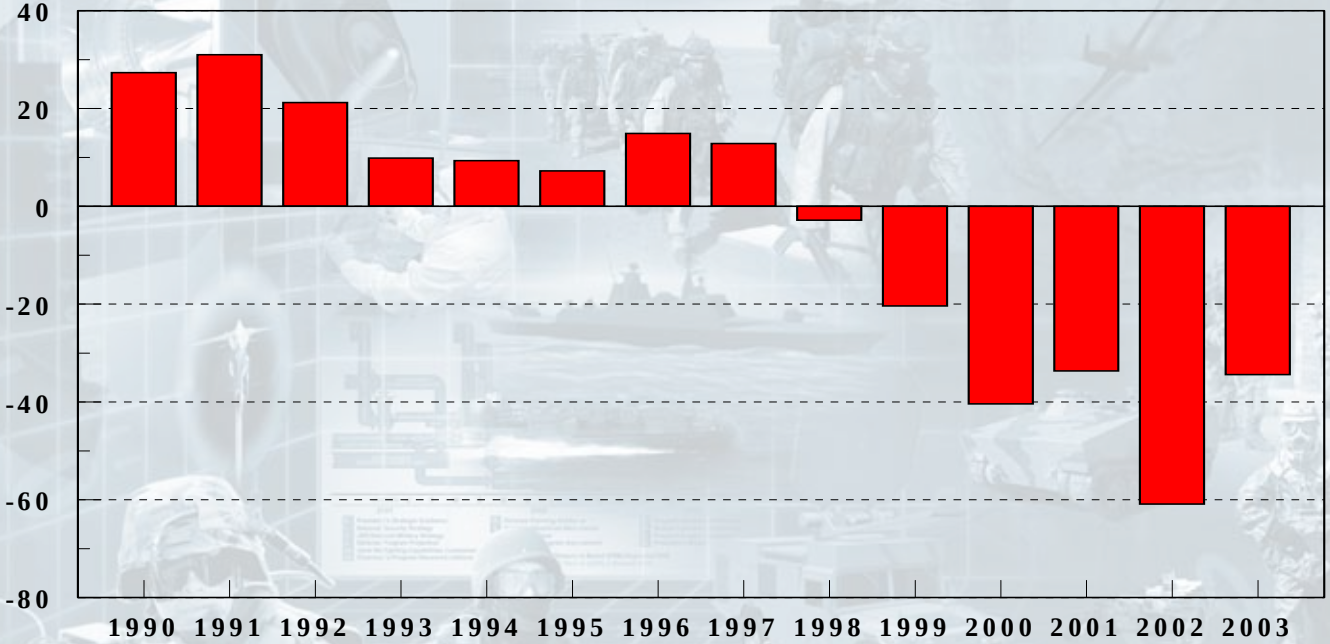
Source: National Science Foundation, S&E Indicators 2006

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

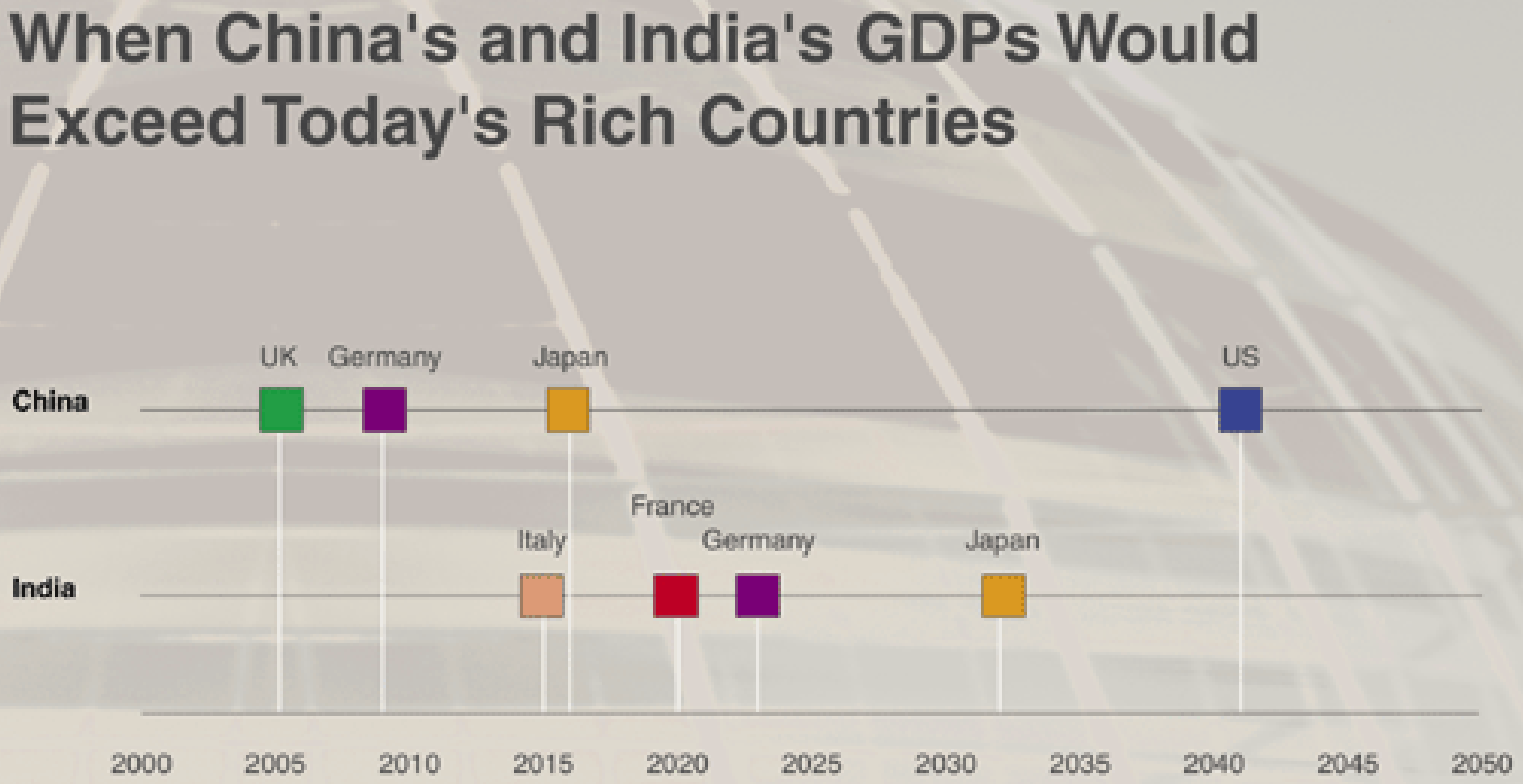


NOTE: Includes aerospace; pharmaceuticals; office and computing equipment; communication equipment; and scientific instruments.

SOURCE: Global Insight and S&E Indicators 2006

Source: National Science Foundation, S&E Indicators 2006

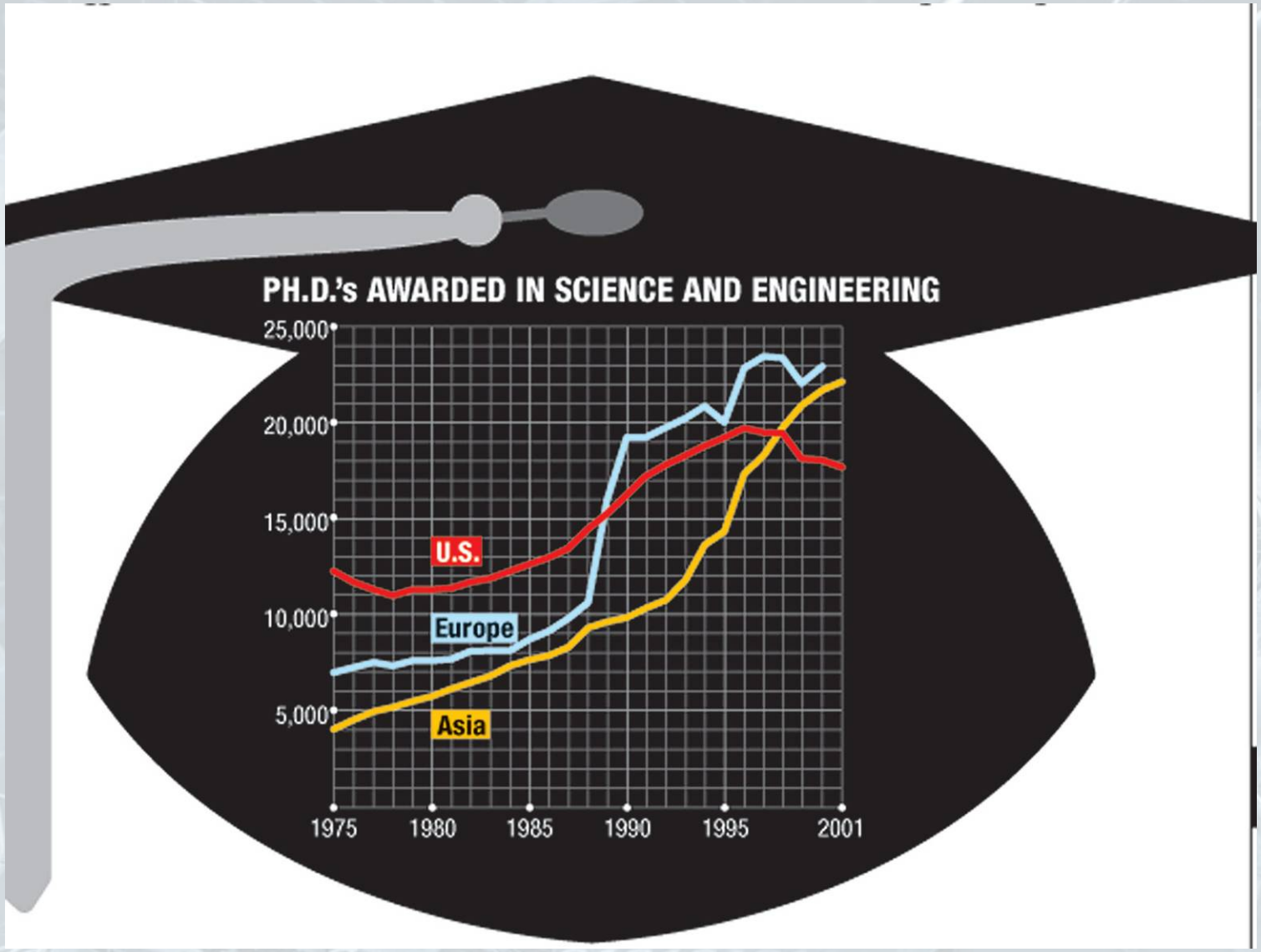
Rising Powers: The Changing Geopolitical Landscape



Globalization Changes Everything

Source: Goldman Sachs, *Global Economics Paper No: 99*, October 2003.

Comparison of Scientists & Engineers (S&Es)

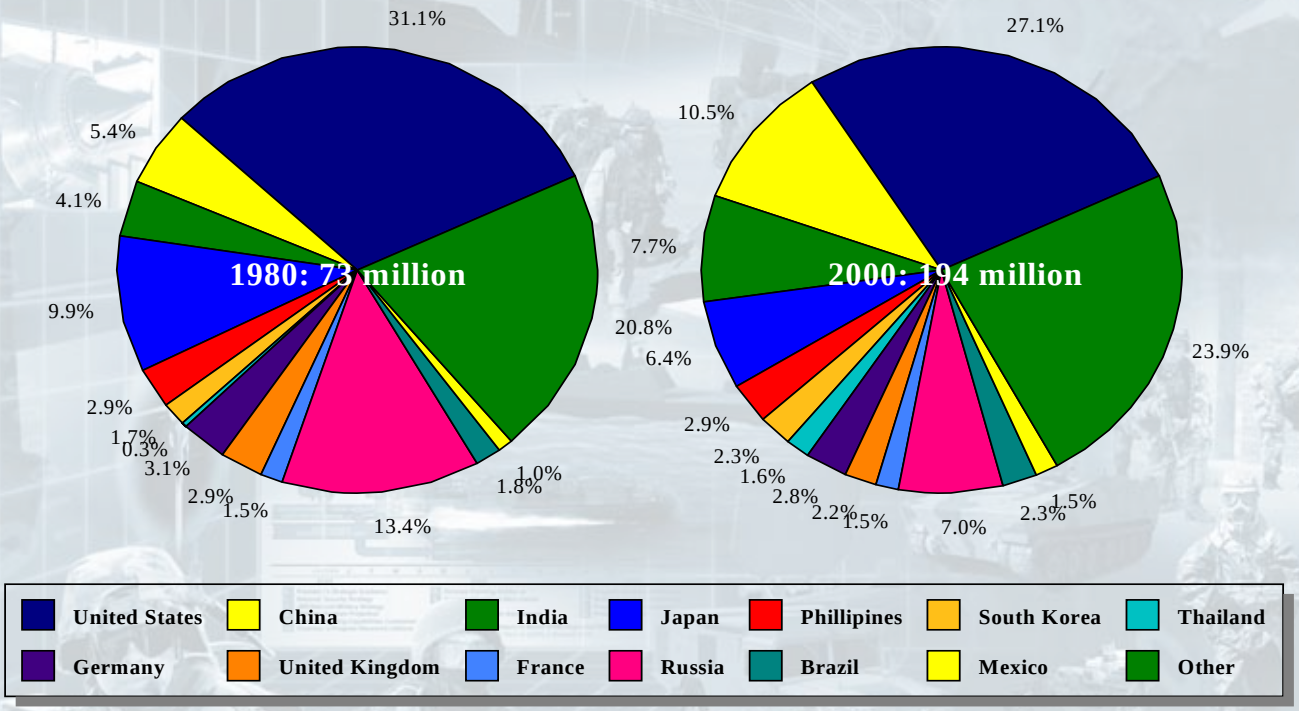


Source: Money Magazine: 2005

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



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

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**
- **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

Overview

- Global Technology Development Trends
- Technology Case Studies: Past, Present and Future
  - Rand 2006
  - Office of Secretary of Defense (Policy) Future Shocks
- Quadrennial Defense Review

2006 Rand Study
The Global Technology Revolution

- Not a DoD Study, but a Study of the Future Technology "Shocks"
- Looked at Technology Growth, Needs and Opportunities
- Assessed Which Nations are Poised to Adapt, Lead

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

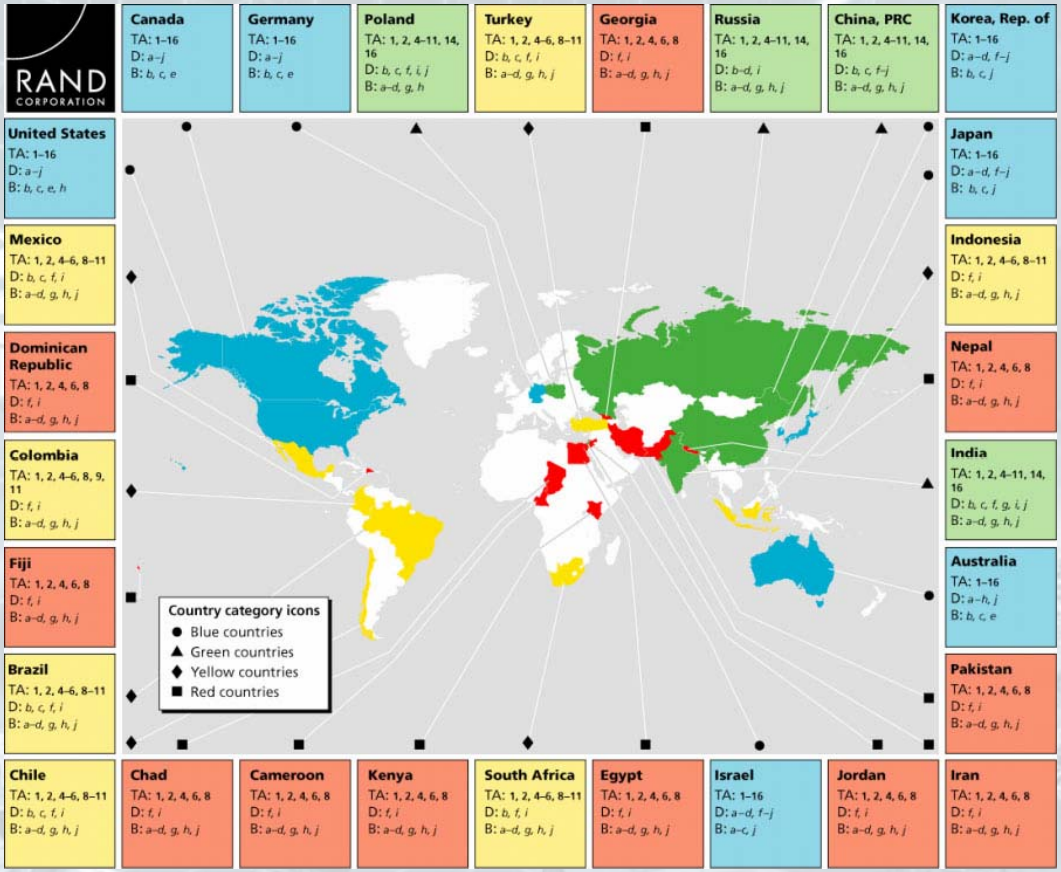
✓ *Direct Military Application*

⇒ *Indirect Military Application*

• *No Military Application*

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

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***

OUSD(Policy): Strategic Futures Effort

- **Assess the defense implications of long-term "trends" and potential "strategic shocks" to:**
  - **Generate defense strategies to <u>shape</u> the strategic environment over the next two decades.**
  - **Predispose the national security establishment toward defense strategies that can help us <u>hedge</u> against a range of plausible alternative futures**

Generate forward-looking proposals for changes in the roles, mission, and capability needs of the military

Initial Findings: DoD Future Technology Shocks Study

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

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

Biotechnology

Nanotechnology

Information Technology

Potential Military Applications:

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

Genomics: Development Timeline

US Bio-Tech Science & Technology Good

Genetic Engineering and Research Applications Very Strong in Europe, Korea, Singapore…

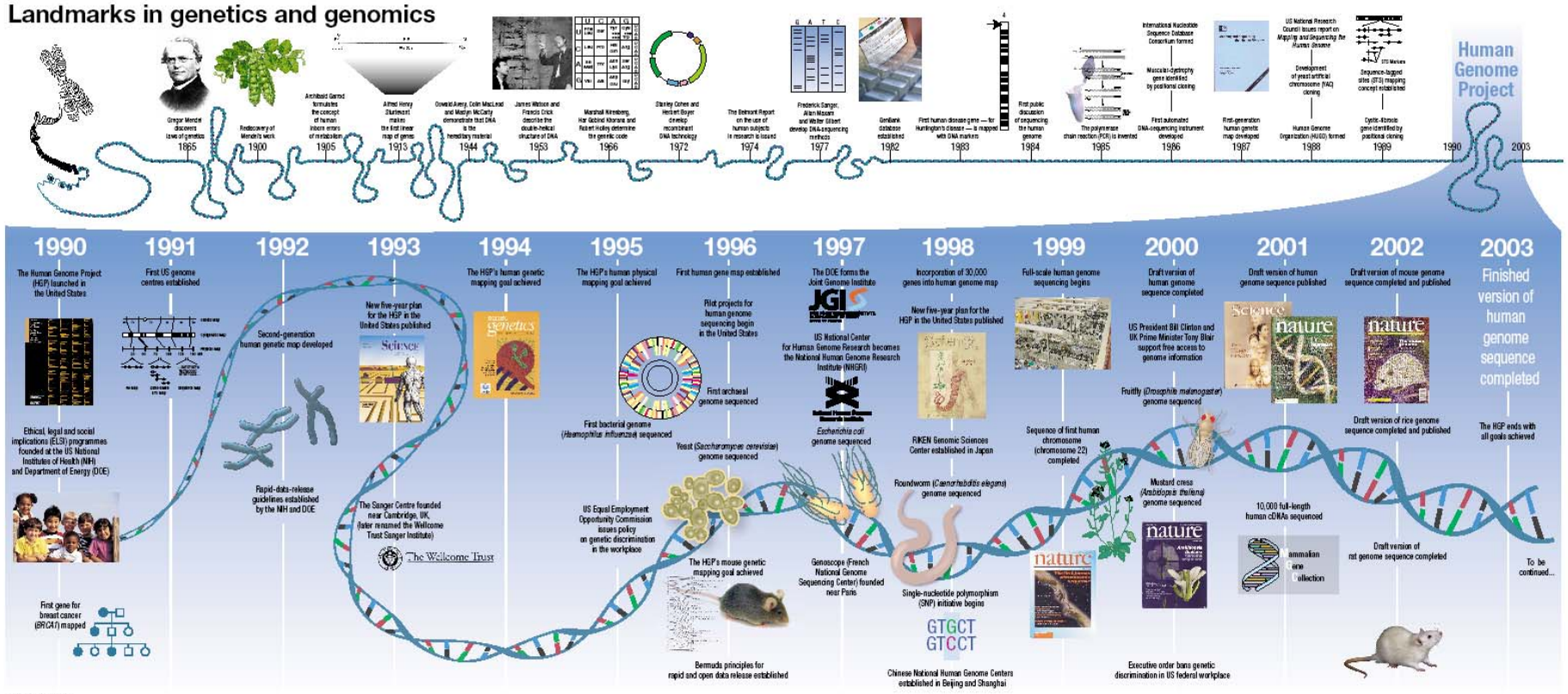
1865: Gregor Mendel discovers laws of genetics

1953: Double-helical structure of DNA described

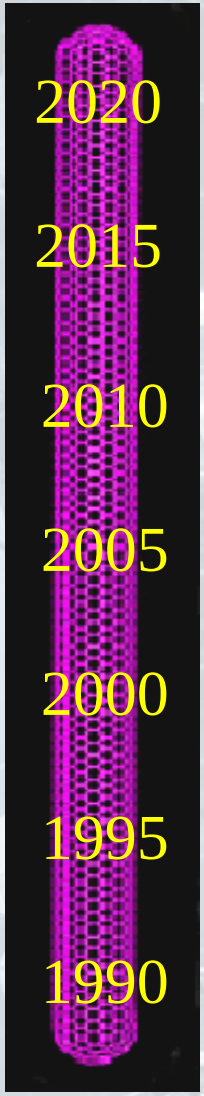
1984: First public discussion of mapping the human genome

1988: Human Genome Organization formed

2003: Human Genome Project completed



Nanotube Timeline Projection



2020 } Molecular electronics, NEMS, Composite materials

2015 } Textiles, CBR filters, biomedical

2010 } Batteries, fuel cells, H_2 storage, ultra-capacitors, RAM, MEMS, microelectronics, FED

2005 ✸ Volume Production MWNT (SWNT?)

✓ Japanese pilot plant: 100 g/hr (MWNT)

2000 ✓ Netherlands – nanotube transistor concept

✓ Chinese – 3mm long nanotube

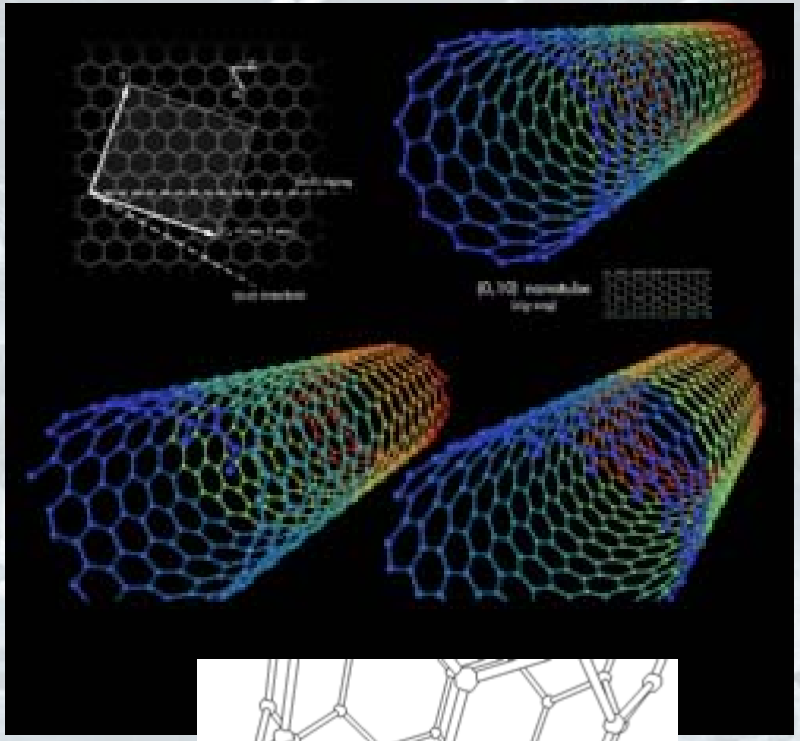
1995 ✓ Experimental demo - H_2 storage, FED

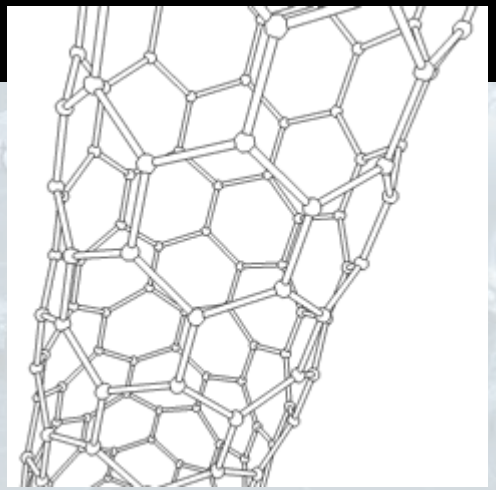
1990 ✓ Japanese discovery (1991)

Nanotechnology – Rapid Technology Evolution/Application Cycle

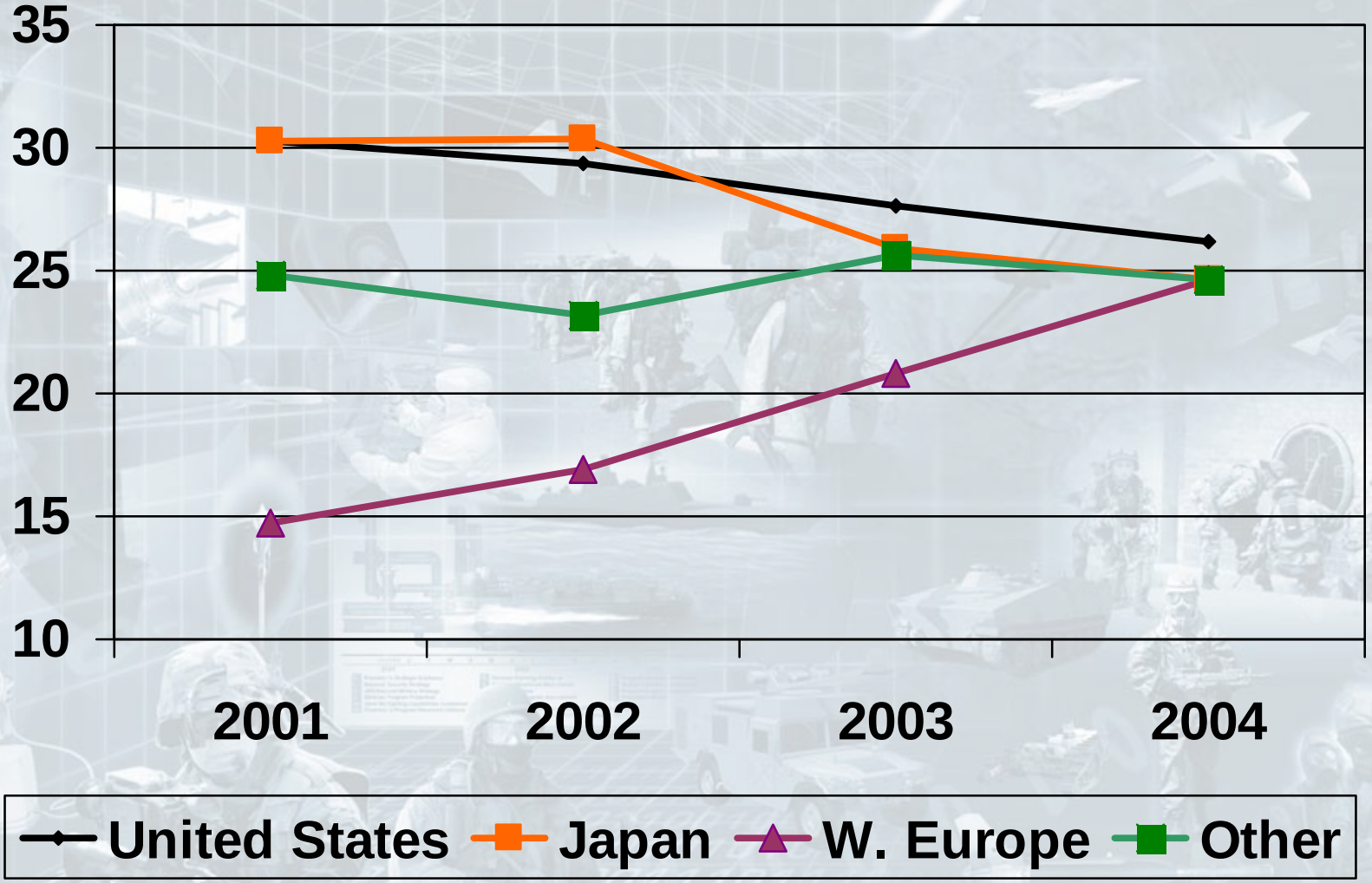
- **The carbon nanotube—was discovered by Sumio Iijima (Japan) in 1991**
  - **1995, researchers recognized carbon nanotubes were excellent sources of field-emitted electrons**
  - **By 2000, the "jumbotron lamp," a nanotube-based light source was available as a commercial product**

- **By contrast, the period of time between the modeling of the semiconducting property of germanium in 1931 and the first commercial product (the transistor radio) was 23 years.**





Nanotechnology World Investment (%)



Source: Sean Murdock, Testimony before the Research Subcommittee of US, June 29, 2005

The Communication Revolution

--The Pace of IT Development is Accelerating--

- **Fifteen years ago, only scientists were using (or had even heard about) the Internet, the World Wide Web was not up and running….**

- **Twenty years ago the use of desktop personal computers was still limited to a fairly small number of technologically advanced people. The overwhelming majority of people still produced documents with typewriters….**

- **Fifteen years ago, large and bulky mobile telephones were carried only by a small number of users in just a few U.S. cities…..**

…… *And these technologies are not the domain of a few countries*

Globalization 101.org website

Overview

- **Global Technology Development Trends**
- **Technology Case Studies: Past, Present and Future**
- **Quadrennial Defense Review**
  - **Change in DoD Strategic Framework**
  - **Implications for DoD Technology**

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

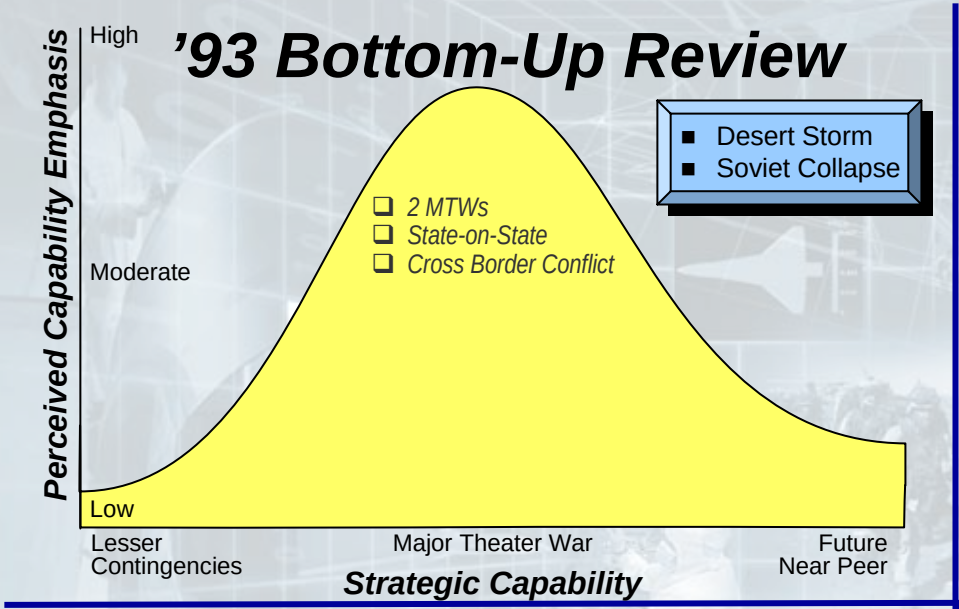
Science and Technology Enabling Technology Priorities

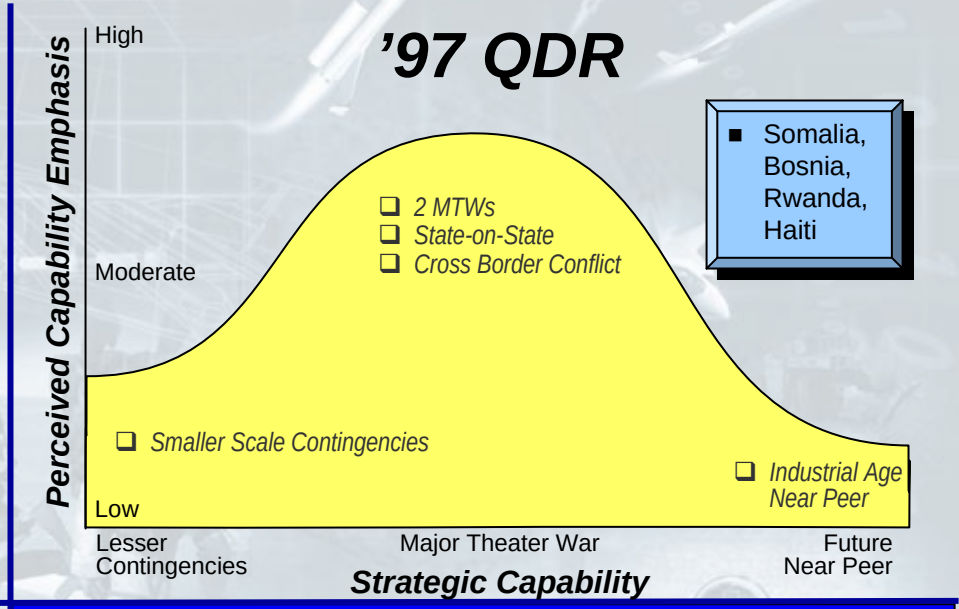
- **Potential technology focus areas:**
  - **Biometrics and Biological exploitation**
  - **Information technology and applications**
  - **Persistent Surveillance Technology**
  - **Networks and Communication**
  - **Human, Social, Cultural, and Behavioral Modeling**
  - **Language**
  - **Cognitive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

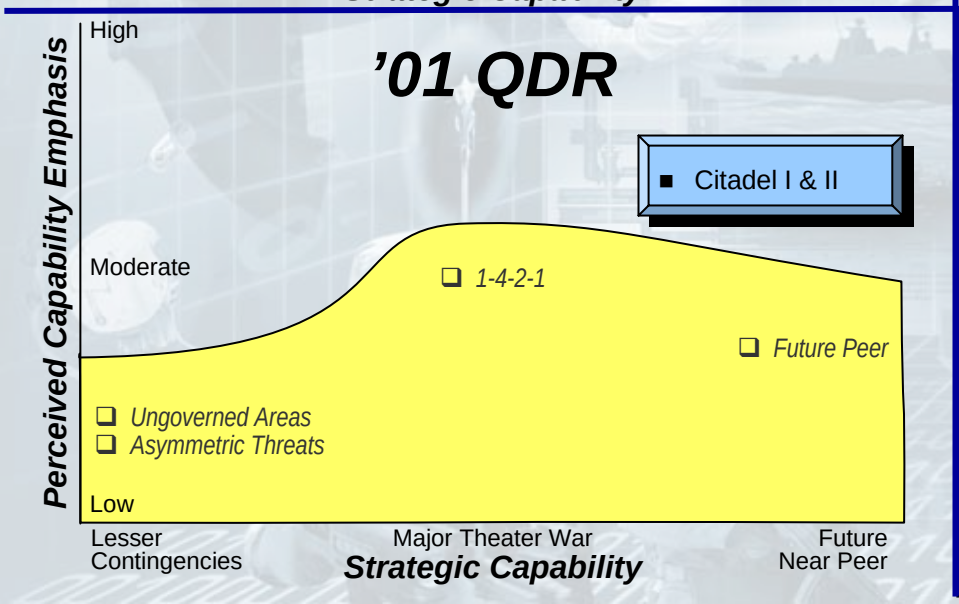
Summary

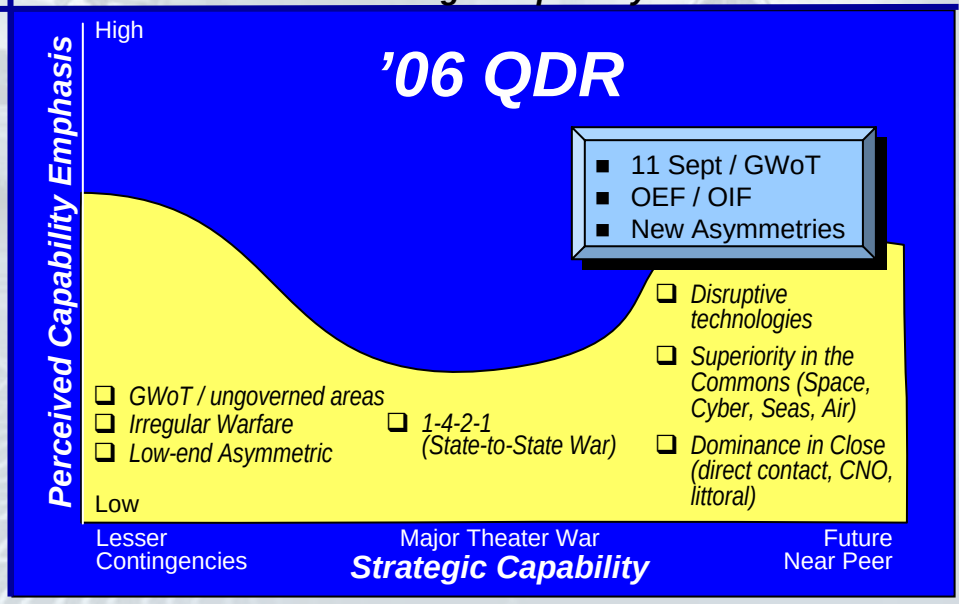
- Rest of world is getting smarter and the rate of technology change is increasing
- Entire US technical structure needs to work closely, as a team
- More Needs for System Engineering
- Need exists to stretch conventional wisdom
- DoD technical efforts migrating for new US strategic framework

Decade of Strategic Evolution

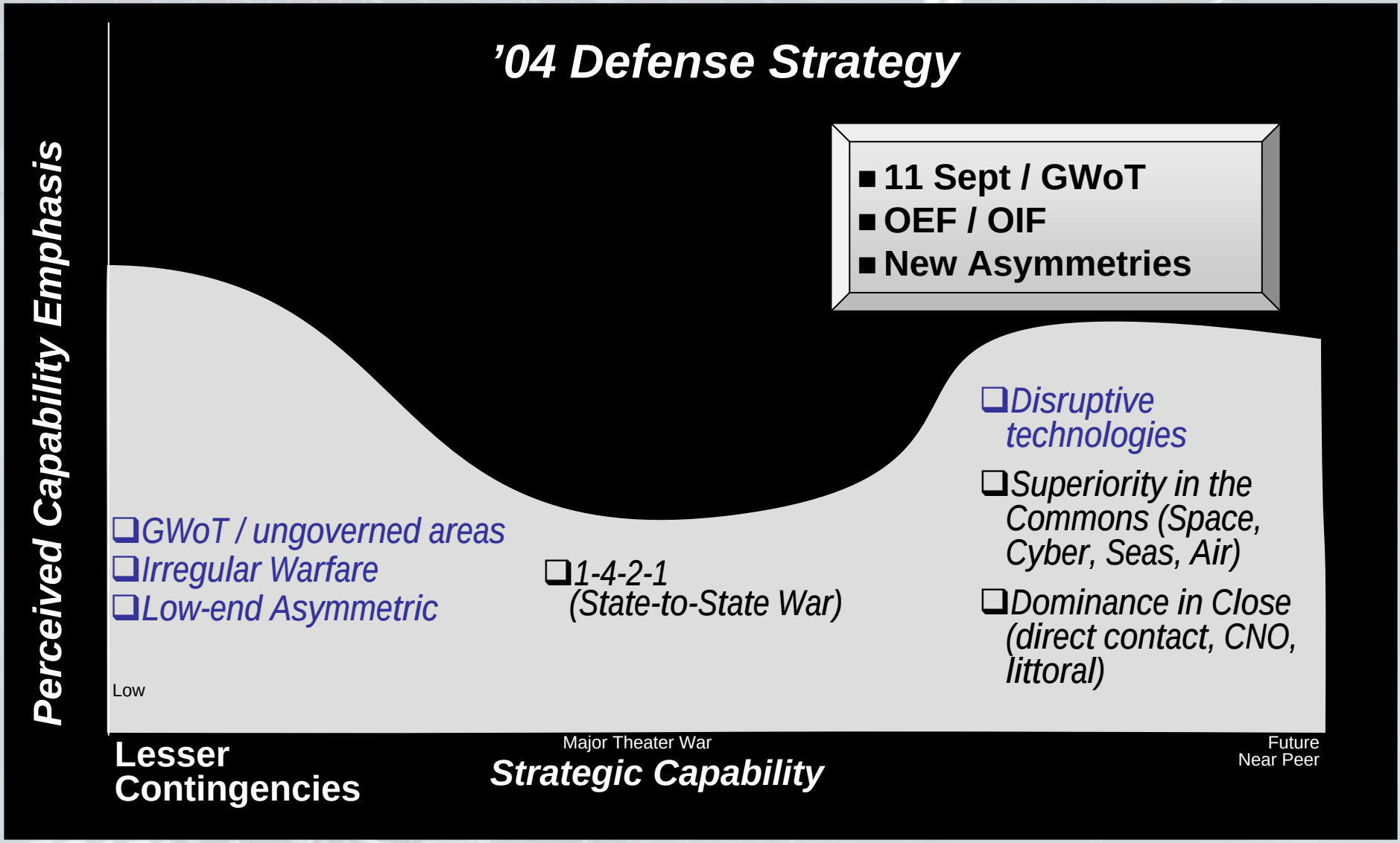








Decade of Strategic Evolution



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