Creating Capability Surprise

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The Surprise Exemplar: 4 October 1957

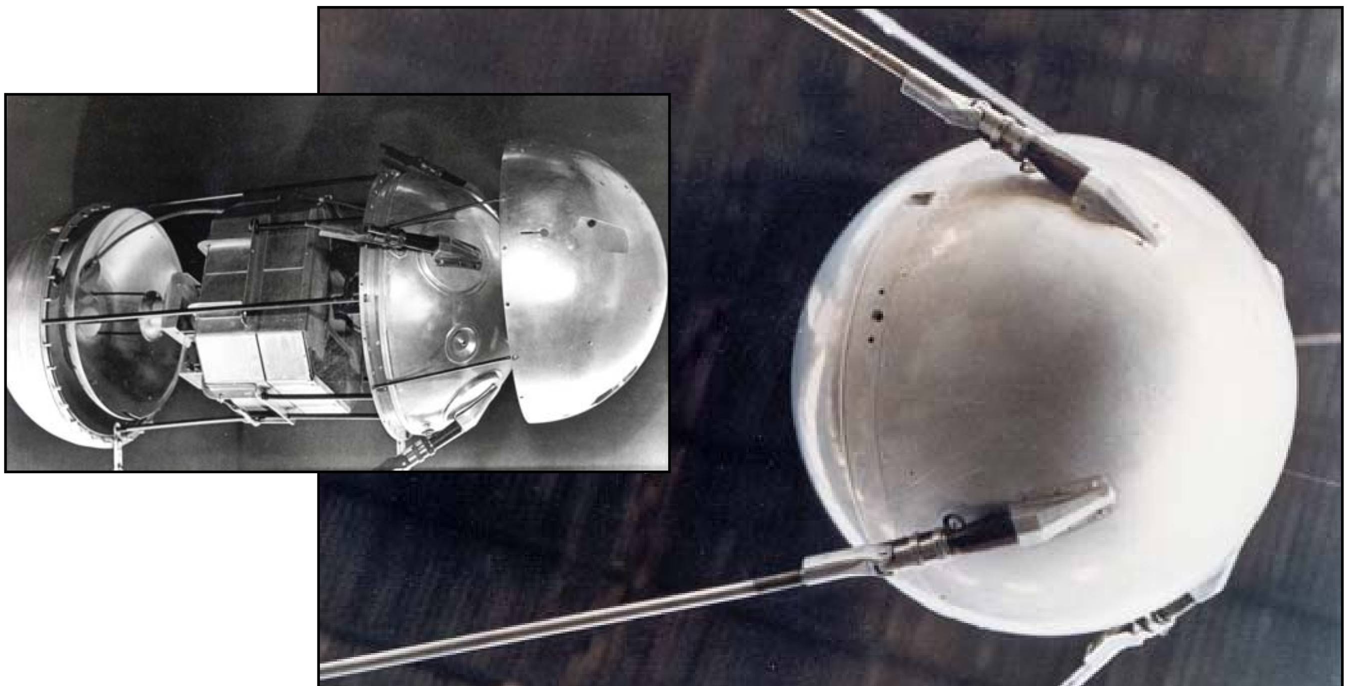
"All the News That's Fit to Print"

The New York Times.

LATE CITY EDITION

NEW YORK, SATURDAY, OCTOBER 5, 1957 FIVE CENTS

SOVIET FIRES EARTH SATELLITE INTO SPACE; IT IS CIRCLING THE GLOBE AT 18,000 M. P. H.; SPHERE TRACKED IN 4 CROSSINGS OVER U. S.



—Dallas News Staff Photo.

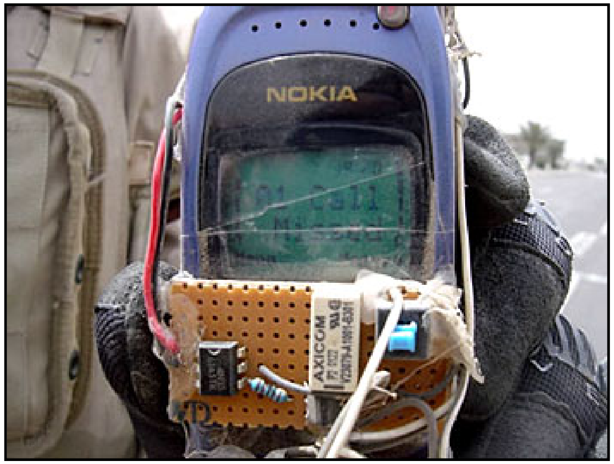
SIGNALS FROM THE SATELLITE
Ham operator Roy Welch of Dallas, seated, plays a tape-recorded signal from the Russian space satellite for fellow hams at the State Fair of Texas. Welch recorded the signals on a receiver at his home.

The Extension of Asymmetric Surprise

Terrorist Attack

Suicide Vest

Explosive Cell Phone



Vehicle-Borne IED

Using existing systems in radically new and asymmetrical ways can have enormous impact

Examples Abound

Pearl Harbor

Kamikazes

Bay of Pigs

China enters Korea

Sputnik

Cuban Missile Crisis

Iran Hostages

Tet Offensive

Victor 3/Akula Quieting

Beirut Barracks Bombing

Soviet Bio-weapons Program

Khobar, Cole, Nairobi

Kuwait Invasion

’93 WTC

9/11

PRC ASAT

IEDs in OIF

PRC Force-down of EP-3

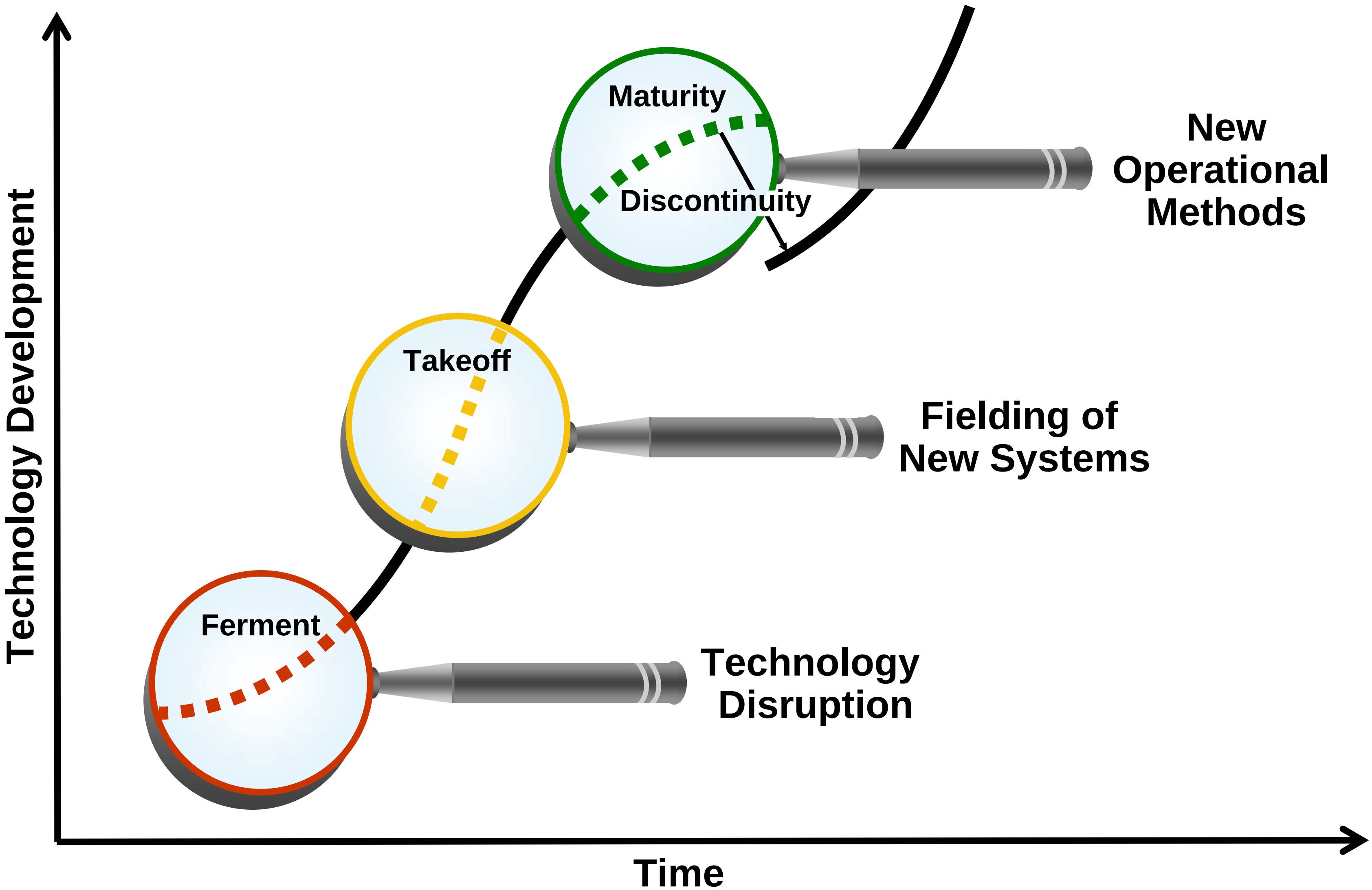
...and happened for a variety of reasons

- **Thought we could respond without doing anything new**
- **Knew it was likely, understood the magnitude of the implications, but didn't pursue it appropriately**
- **Believed they were not up to it**
- **Believed they wouldn't dare**
- **Knew it might happen, but were trapped in our own paradigms**
- **Didn't imagine or anticipate the strategic impact**
- **Lost in the "signal to noise" of other possibilities**
- **Imagined it, but thought it was years away**
- **Were willing to take the risk that it wouldn't happen**

In most cases the indications were there, but with nothing to differentiate a given possibility from others and compel a decision to act

Adapted from 2008 Defense Science Board Study on Capability Surprise

Three Tiers of Technology Innovation

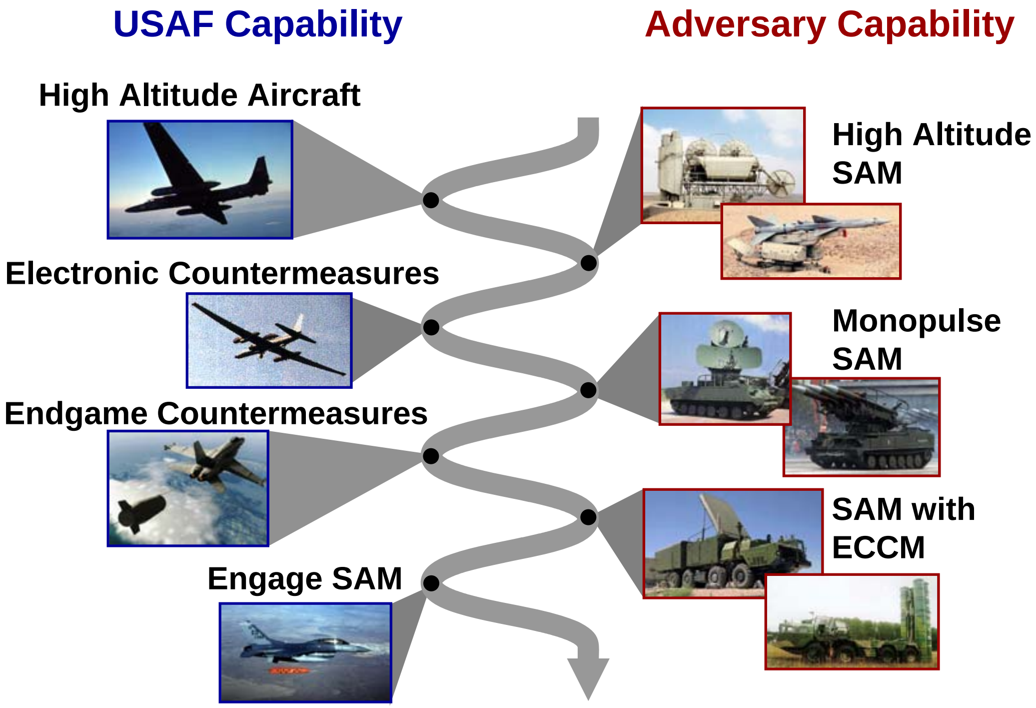


Outline

- **Introduction**
- **Sources of Technology Capability Surprise**
  - – New operational methods
  - – Transition and fielding
  - – Adaption of new technologies
- **Summary**

The Symmetric Timeline

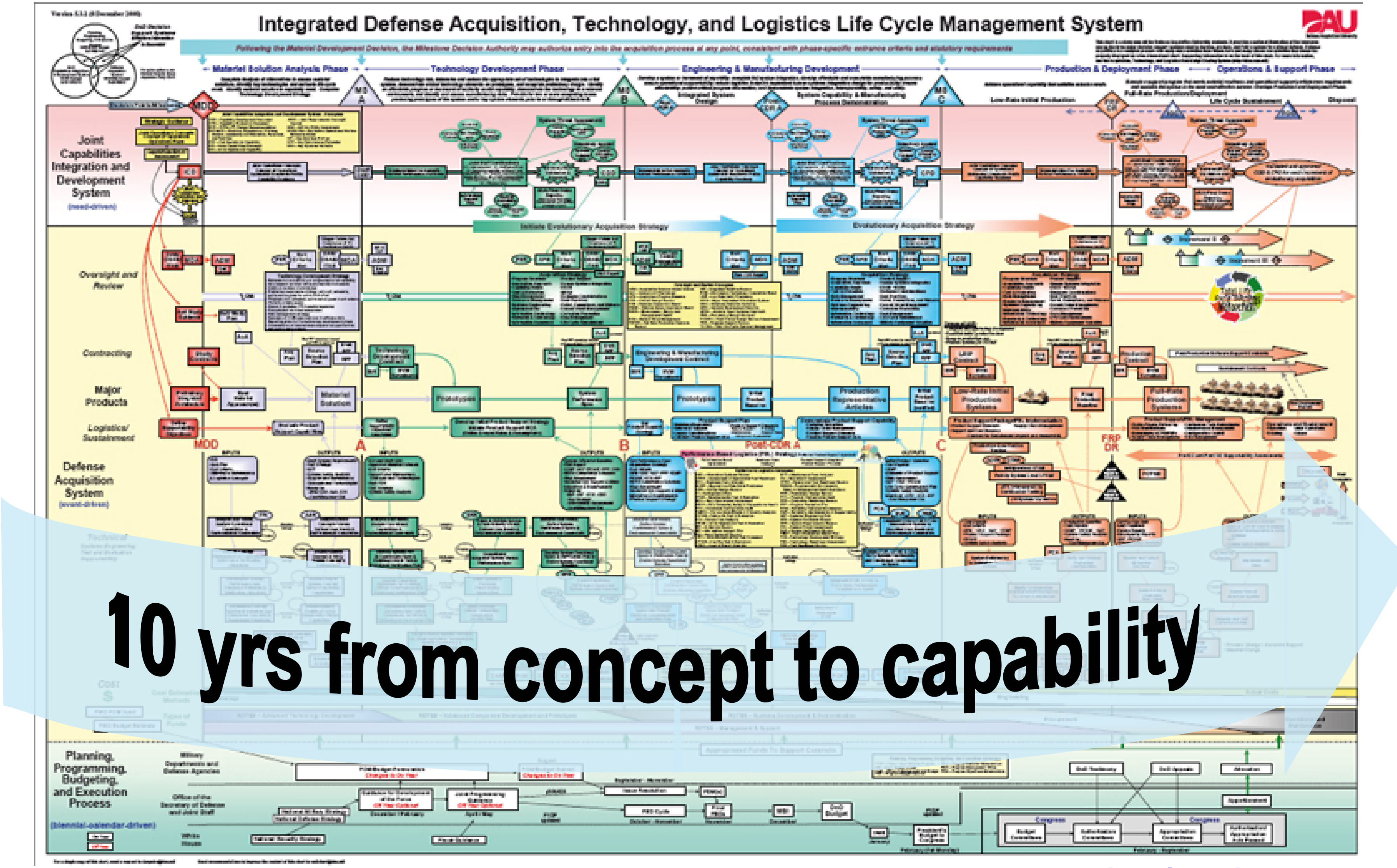
Conventional Warfare
SEAD / DEAD Example



Response loop measured in years

- Suppression of enemy air defense (SEAD)
- Destruction of enemy air defense (DEAD)

The DoD 5000 Integrated Defense Acquisition, Technology and Logistics Life Cycle Management Process



Changing Political and Economic Landscape

- Connectivity growth (CNN, internet)
- Ease of global transportation

- Emergence of US as sole superpower

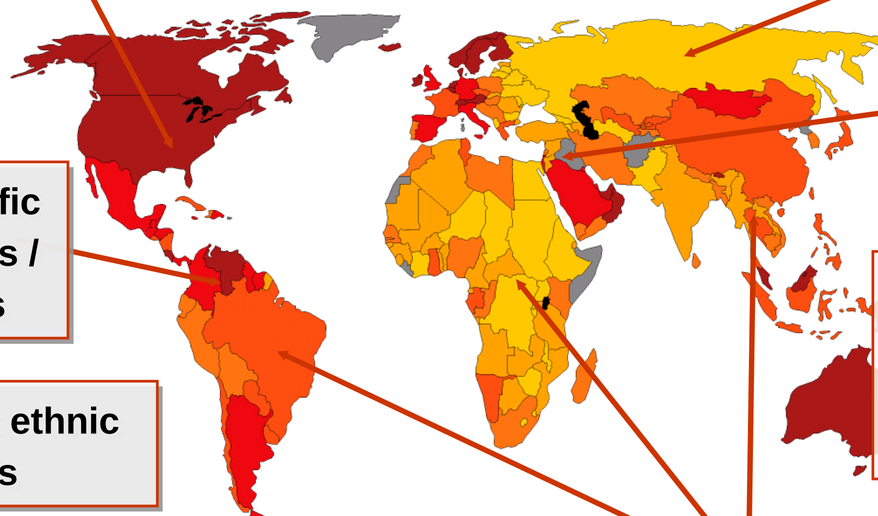
- Disintegration of Soviet Union

- Insertion / maintenance of US military in Middle East

- Explosion of drug traffic
- Partnering of narcotics / terrorist organizations

- Worsening income inequity
- Declining standard of living
- Clash over religious influence in third world

- Resurgence of violent ethnic and ideological groups



Demographic Stress

Moderate — Severe

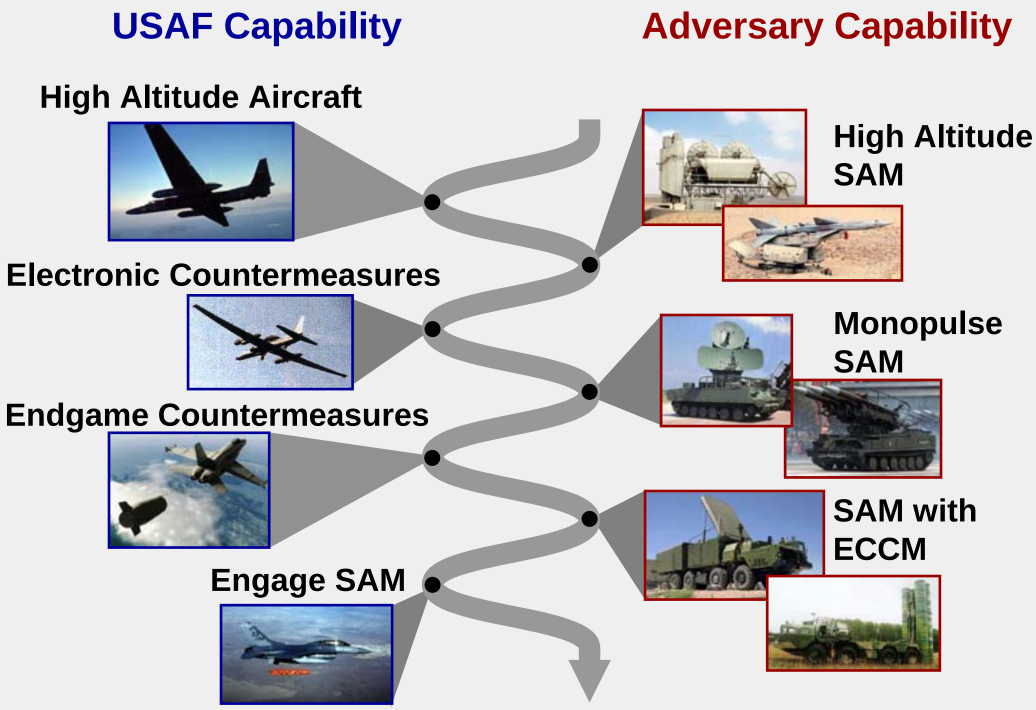
- Safe havens in Africa, Asia, South America
- Readily available small arms & weapons

Variety of socio-economic and political conditions providing "kindling" for likely explosion of 4th generation warfare

† Map by Adrian White, University of Leicester (2006)

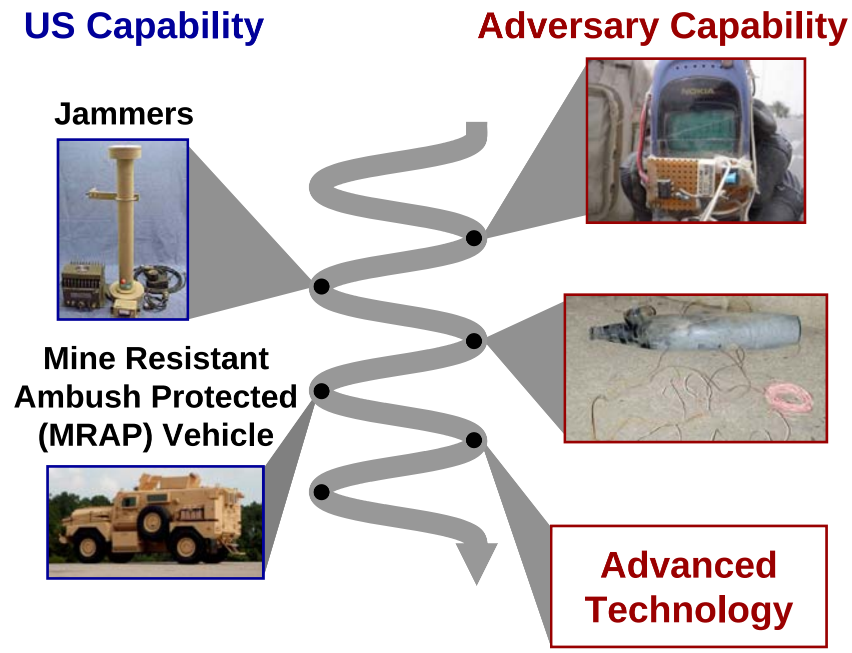
The Timeline Has Collapsed!

Conventional Warfare
SEAD / DEAD Example



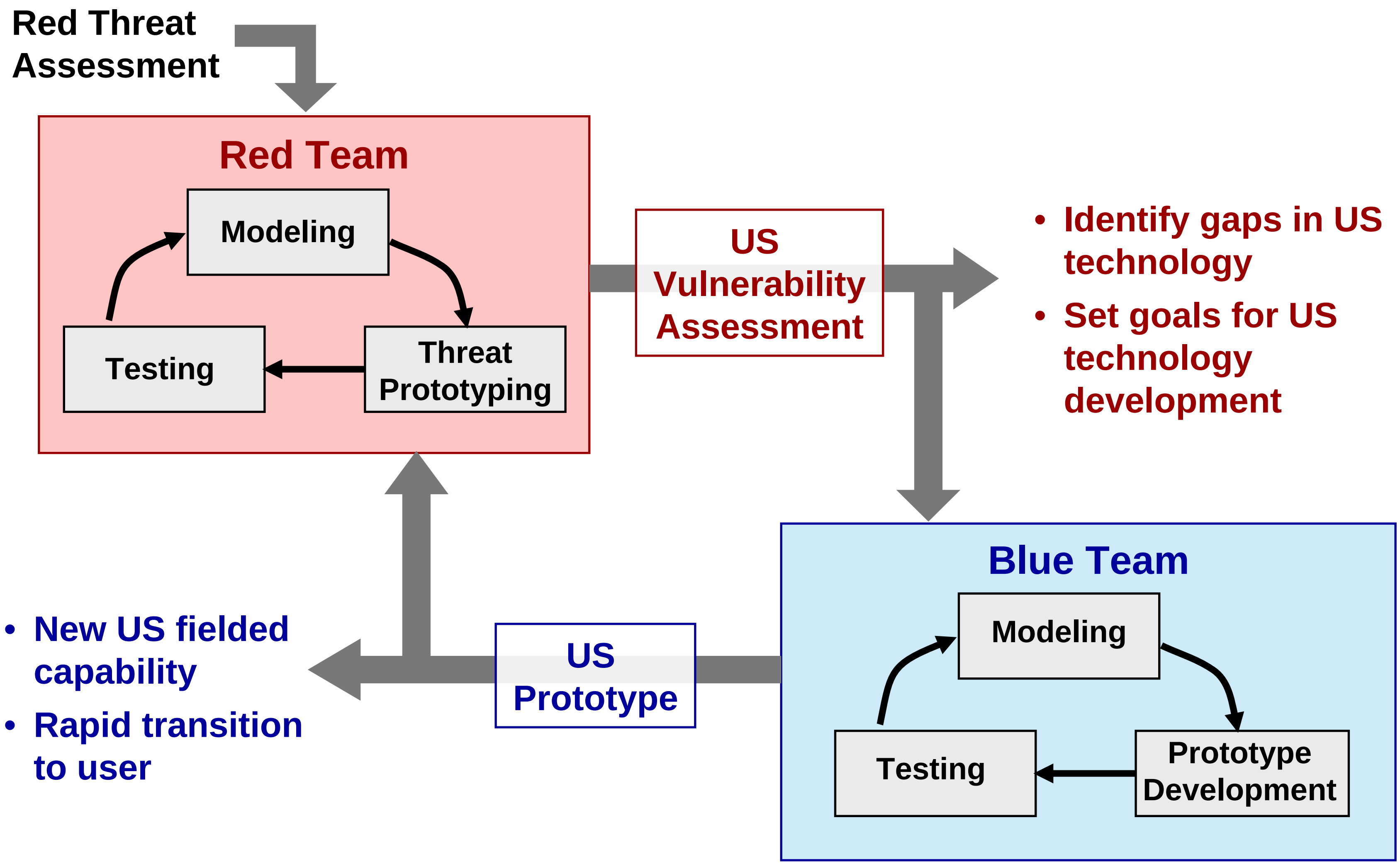
Response loop measured in years

Counter-Insurgency Warfare
Iraq Example

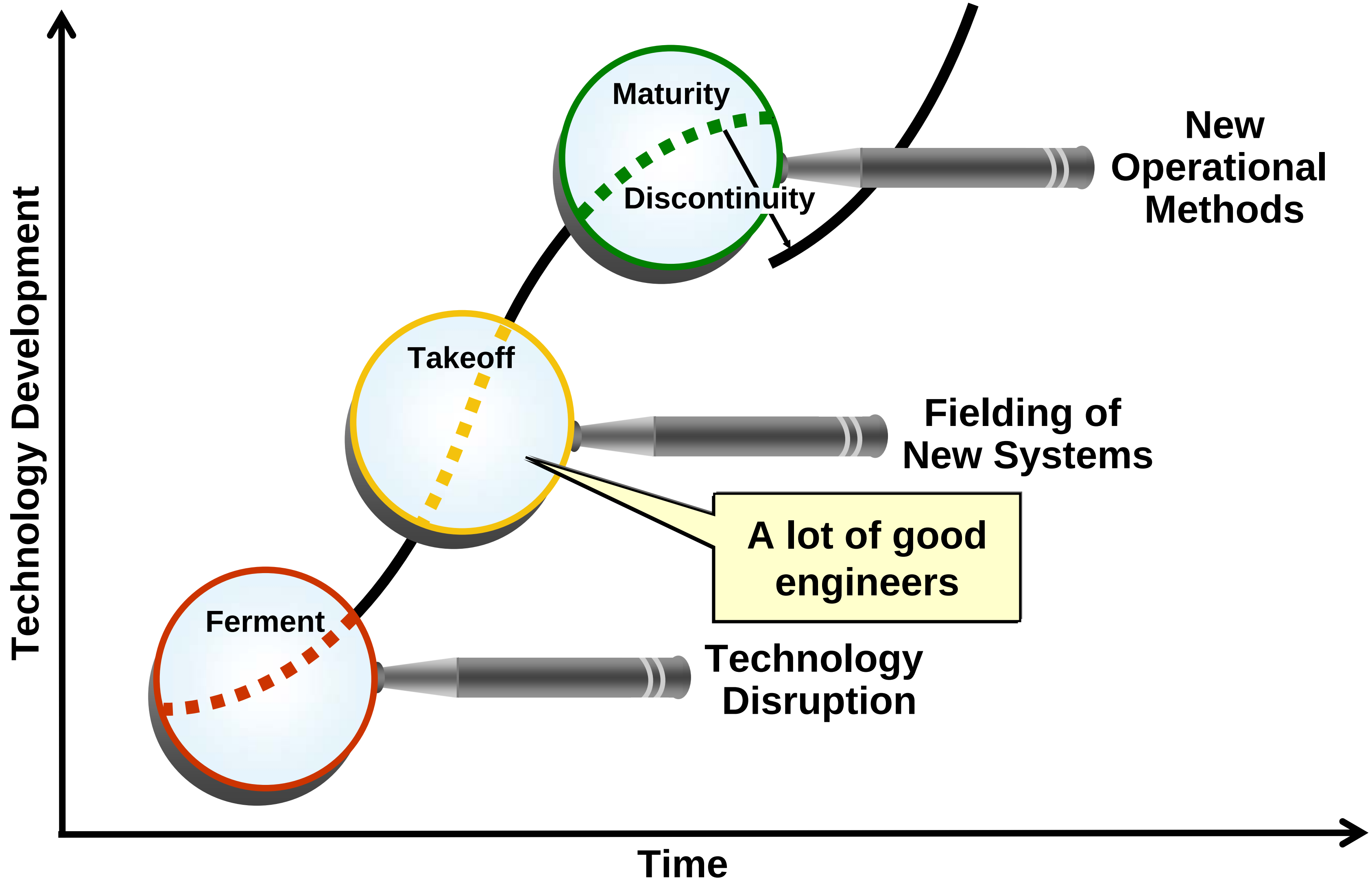


Response loop measured in months or weeks

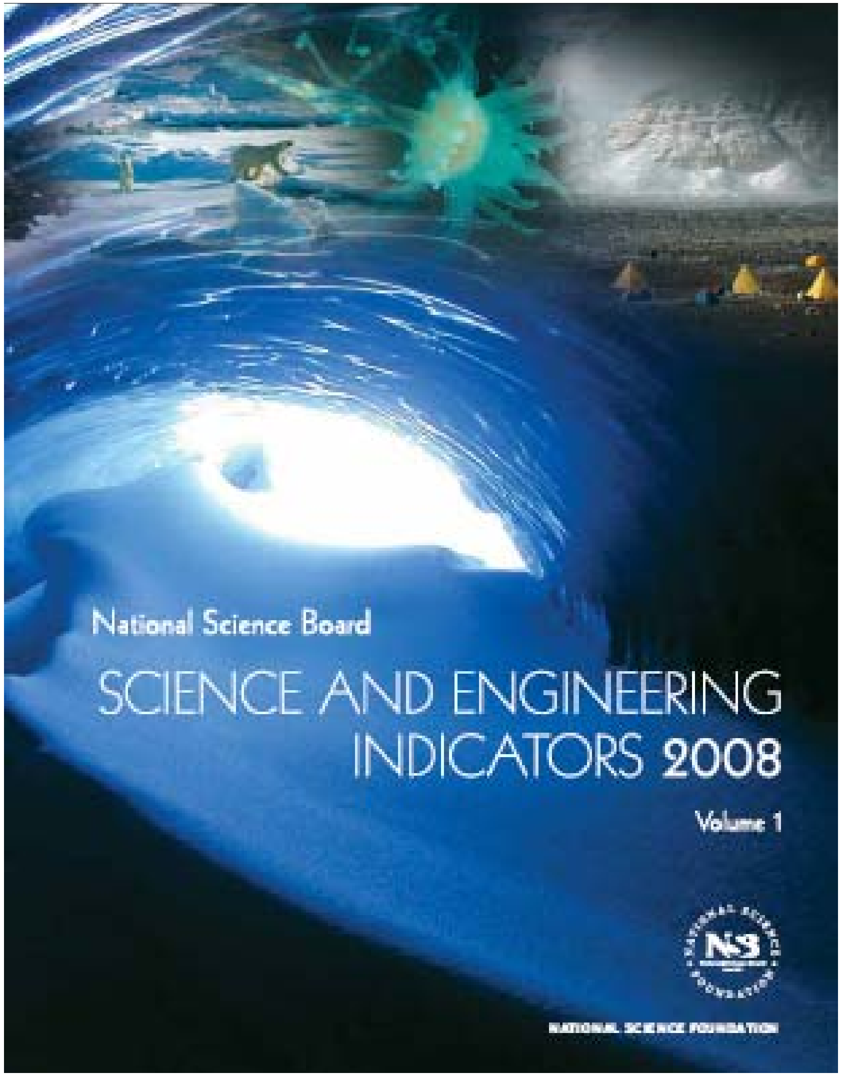
Red Team / Blue Team Process



Three Tiers of Technology Innovation

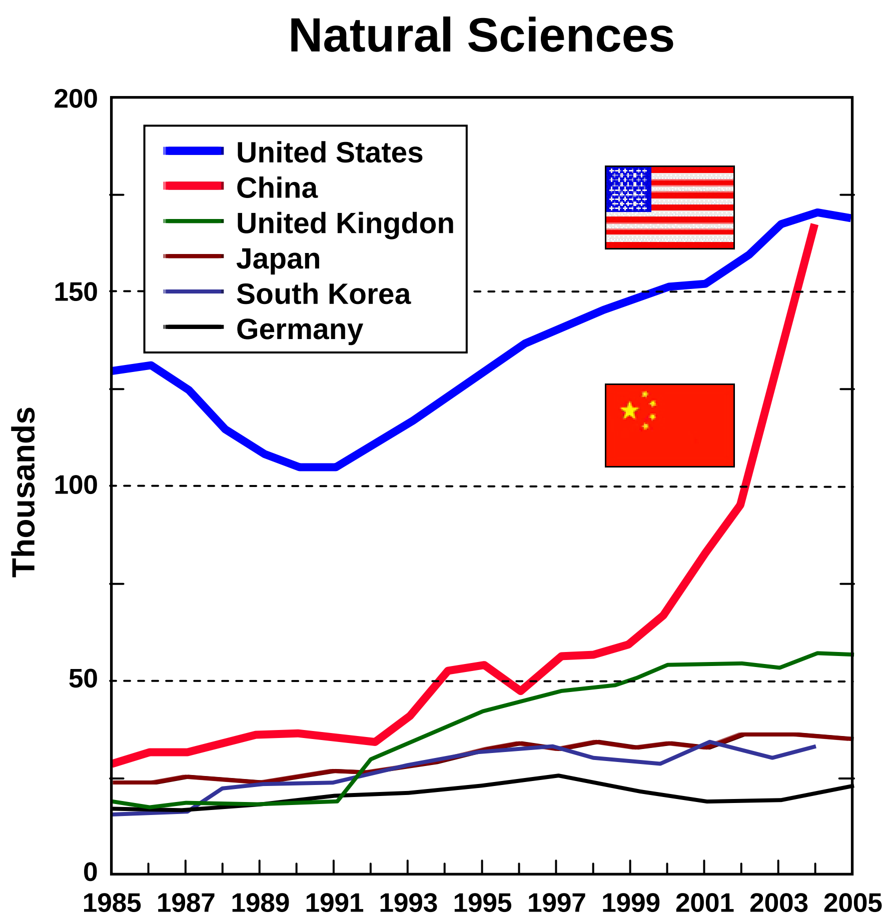


Concerning Trends

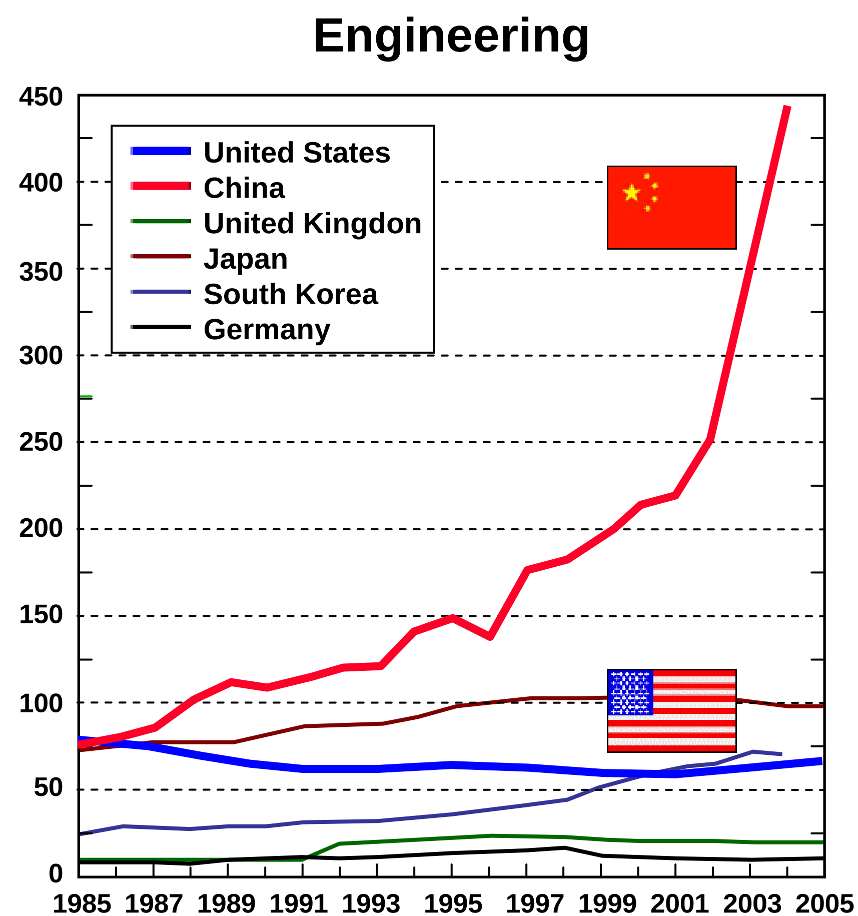


- Knowledge-intensive industries are reshaping the world economy
- Industry R&D in manufacturing and services is expanding and increasingly crossing borders
- R&D in the United States is robust and dominated by industry
- Advanced training in natural sciences and engineering is becoming widespread, eroding the US advantage

First University Degrees, by Selected Country: 1985–2005



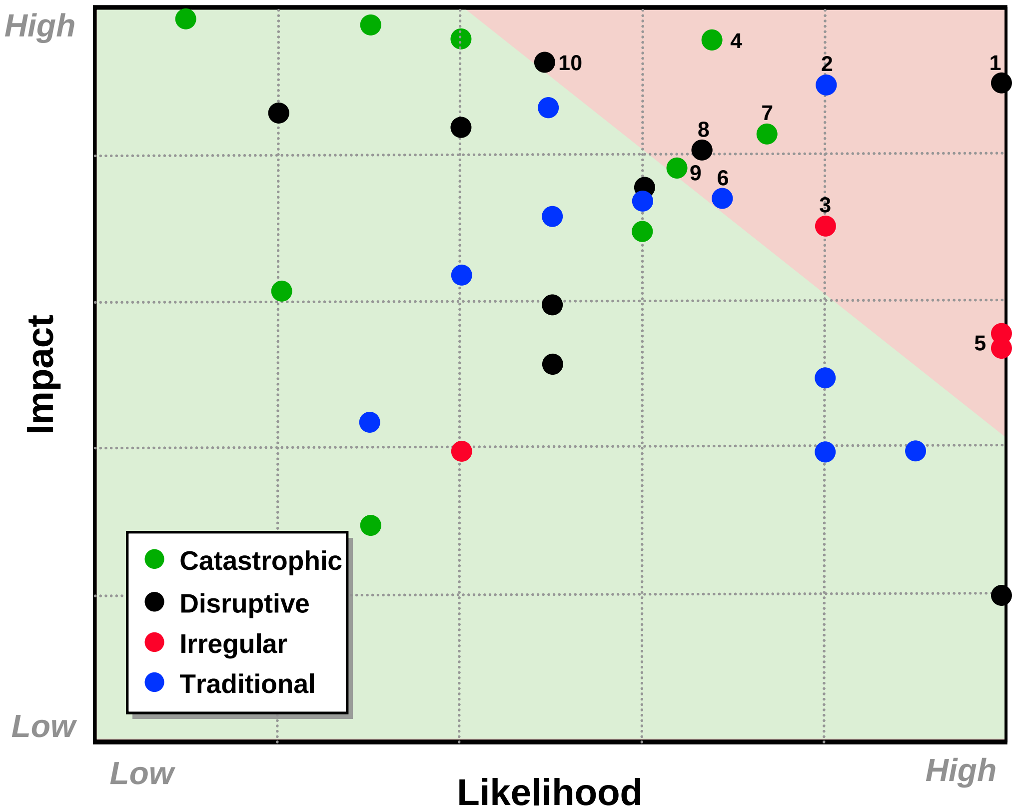
Notes: Natural sciences include physical, biological, earth, atmospheric, ocean, agricultural, and computer sciences and mathematics. German degrees include only long university degrees required for further study.



Notes: German degrees include only long university degrees required for further study.

Source: National Science Board, Science and Engineering Indicators 2008

MIT LL National Security Technology Study
Threat Ranking



Critical National Security Threats

(1) Computer Network Attack/Exploit

(2) Quiet Submarines

(3) Unguided Battlefield Rockets

(4) Chemical/Biological Attack

(5) IED/Insurgents

(6) Maneuvering Ballistic Missile (MaRV) Against Carrier Battle Group (CBG)

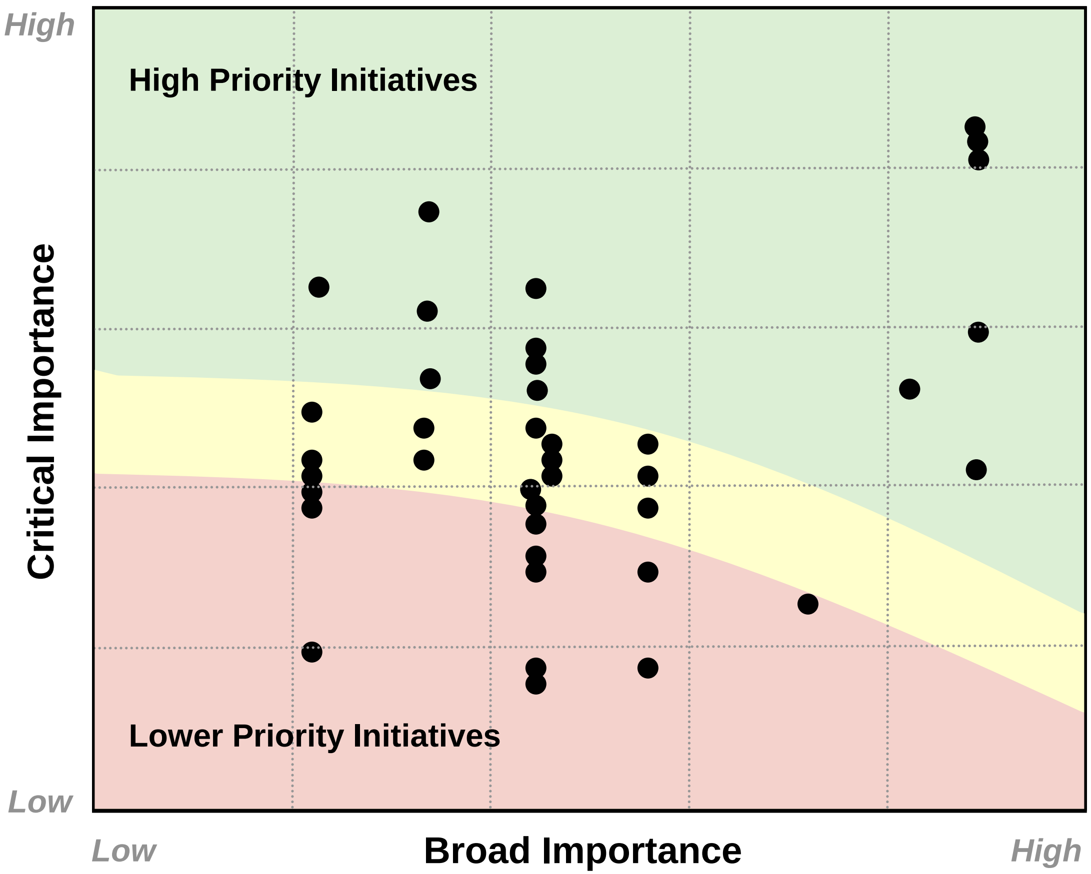
(7) Containerized Nuclear Weapon

(8) Anti-Satellite (ASAT)

(9) Cruise or Short-Range Ballistic Missile Launch off Barge

(10) Anti-cryptography (QC)

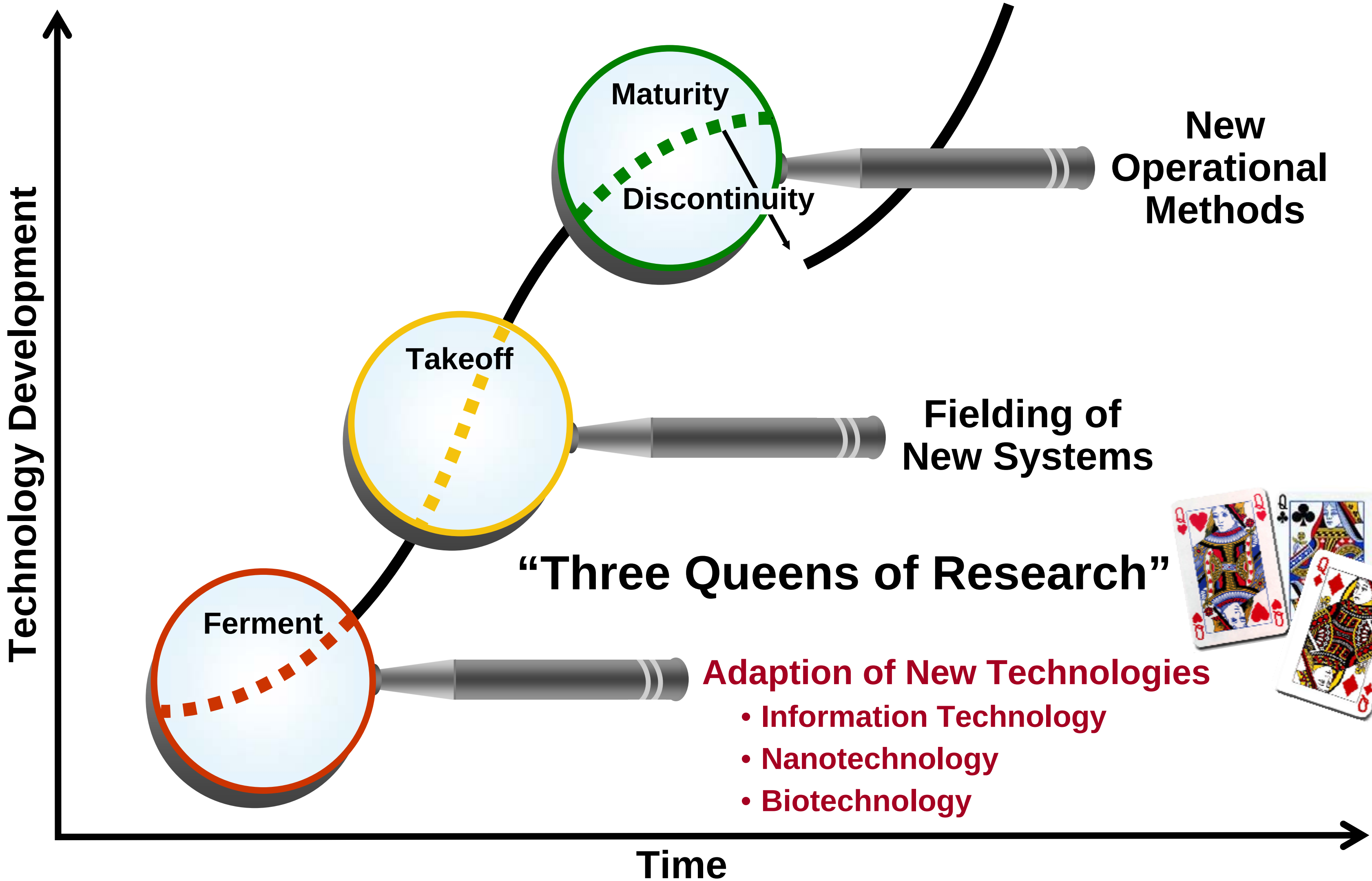
S&T Initiatives to Address Top National Security Threats



High Priority Initiatives

- Early Warning
- Medical Treatments
- Speed-of-Light Weapons
- Container Monitoring/Tracking
- Active Radiological Detection
- Pre-detonation
- Cultural Training
- Persistent Surveillance
- Counter-media
- Authentication, Trust, Access
- Network Attack
- Attack Detection & Response
- Network Hardening
- Platform Hardening

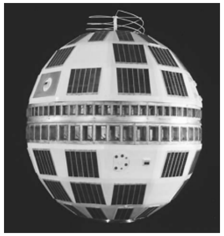
Three Tiers of Technology Innovation

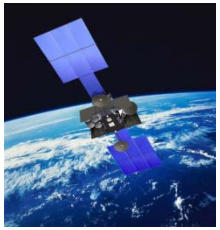


"Three Queens of Research"

Adaption of New Technologies
- Information Technology
- Nanotechnology
- Biotechnology

Defense Technology Timeline

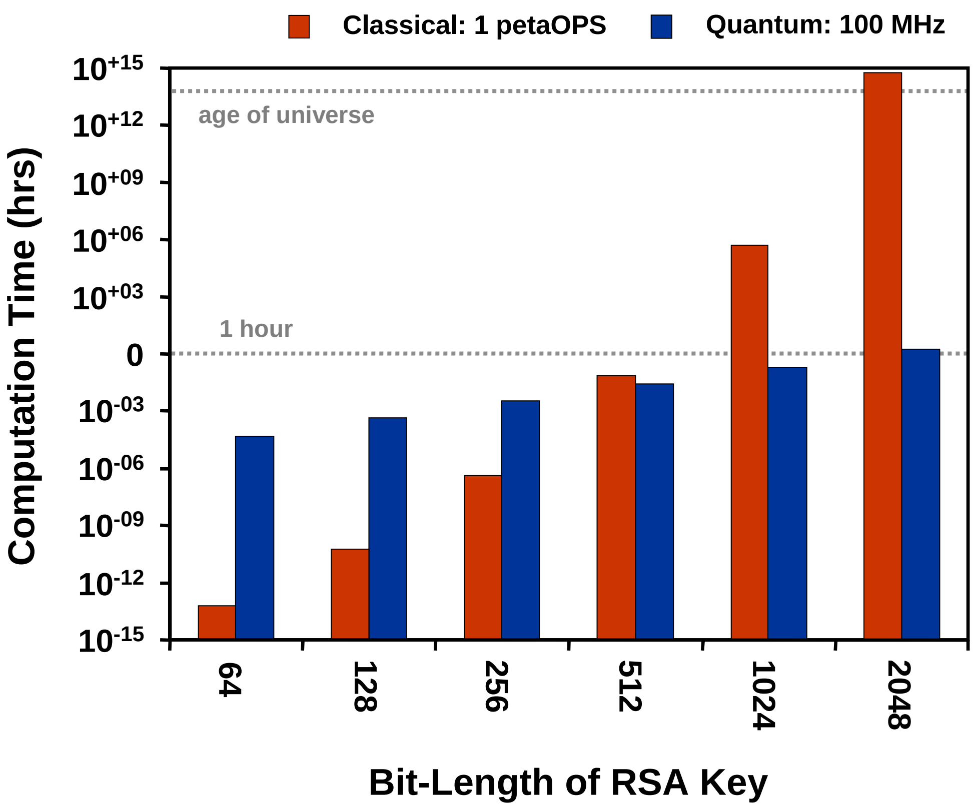




40s	50s	60s	70s	80s	90s	00s
• Nuclear weapons	• Digital computer	• Satellite comm.	• Airborne GMTI/SAR	• GPS	• Wideband networks	• GIG
• Radar	• ICBM	• Integrated circuits	• Stealth	• UAVs	• Web protocols	• Armed UAVs
• Proximity fuze	• Transistor	• Phased-array radar	• Strategic CMs	• Night vision	• Precision munitions	• Optical SATCOM
• Sonar	• Laser technology	• Defense networks	• IR search and track	• Personal computing	• Solid state radar	• Data mining
• Jet engine	• Nuclear propulsion	• Airborne surv.	• Space track network	• Counter-stealth	• Advanced robotics	• Advanced seekers
• LORAN	• Digital comm.	• MIRV	• C2 networks	• BMD hit-to-kill	• Speech recognition	• Decision support

- Quantum
- Nanoscale
- Engineered Bio

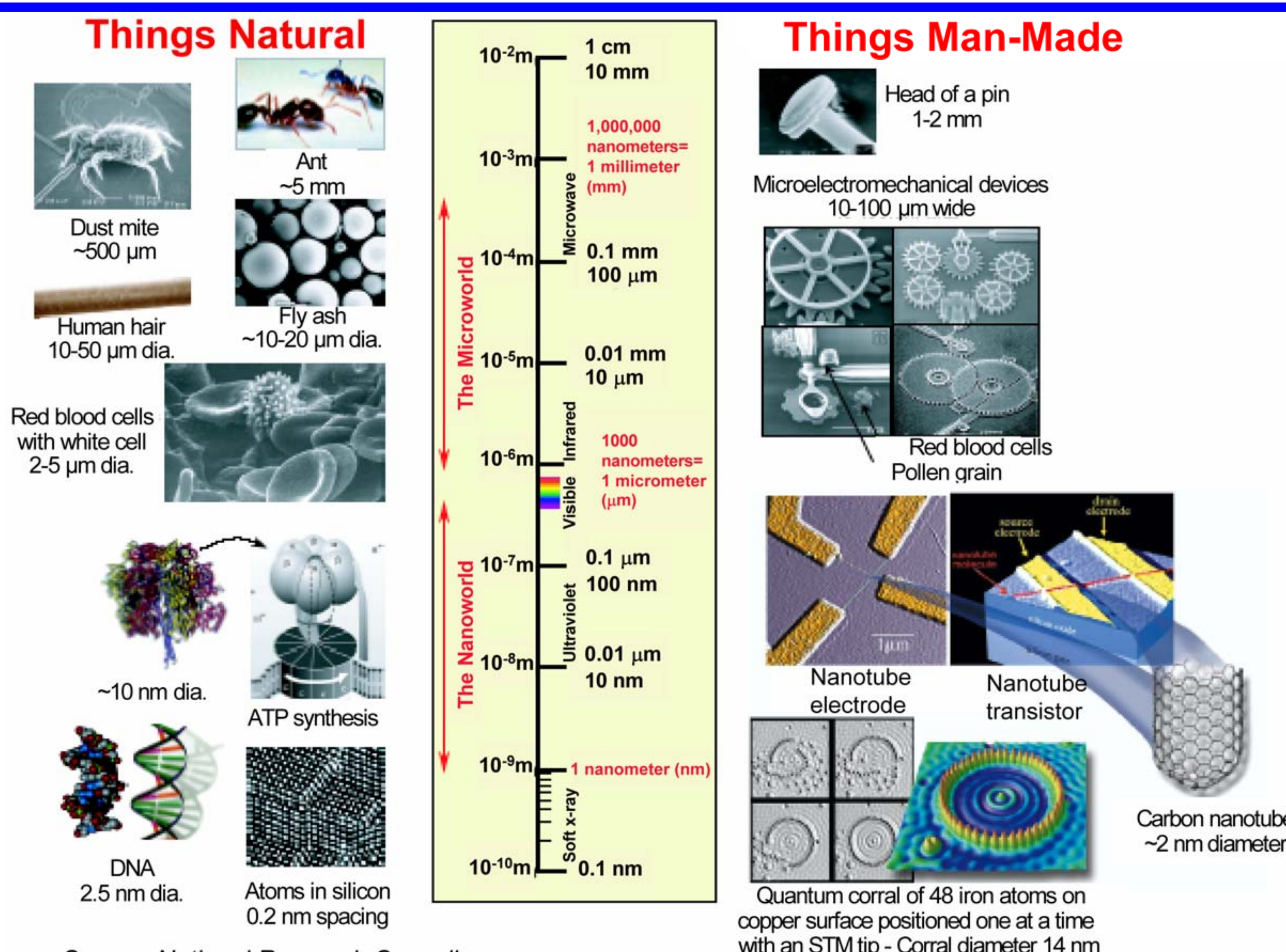
Quantum Computing



- **Cryptanalysis**
  - **Factorization of prime numbers**
  - **Unsorted database searches**
- **Simulation**
  - **Fluid flow problems**
  - **Atomic interactions**
  - **Material Sciences**
  - **Modeling quantum systems**
- **Nobody knows whether we can build one big enough to be useful**

Quantum computers are significantly faster than classical computers for certain classes of problems

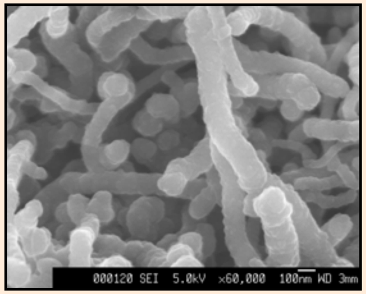
The Nanometer Scale



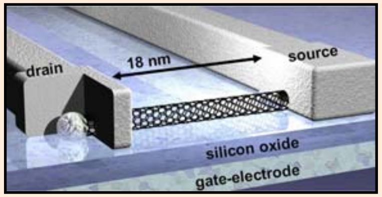
Source: National Research Council

Nanotechnology Classes

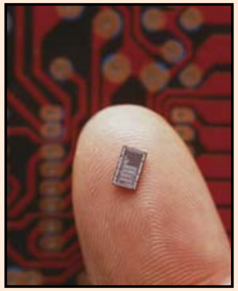
Nano-Structures



Nano-Devices



Nano-Enabled Systems



Sensors	Functionalized plasmonic structures	Chemical nanosensors	Distributed nanosensor arrays
Computing	Graphene films	Graphene transistors	Ultrafast computers
Electronics	Carbon nanotubes	Field emitting devices	High-efficiency displays
Energy	Semiconductor nanodots	Thermoelectric materials	Efficient thermoelectric generators
Biotechnology	Protein nanotubes	Drug-containing nanotubes	Drug delivery systems
Materials	Metallic-dielectric nanostructures	Negative-index metamaterials	Cloaking coatings

Explosion of Biological Capability*

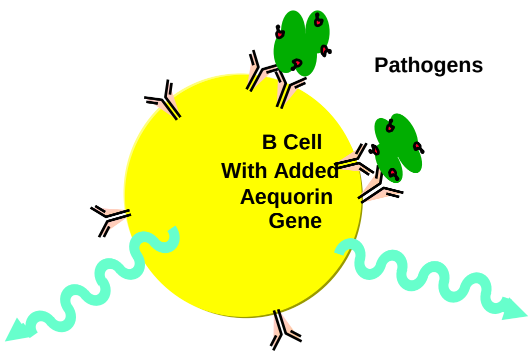
- *E. Coli* was the first bacterial genome sequenced, in 1997
- The Human Genome was sequenced in 2003; it took 10 years and $3 billion
- In 2007 the genome of James Watson (co-discoverer of DNA) was sequenced; it took 2 months and $1 million
- The $1000 genome is imminent, and it is projected to become a common diagnostic procedure.
- In 2006, a patent application was filed for the first synthetic organism
- In 2007 recombinant genetic methods were used to alter the species of a bacterial strain

There are many "Moore's Law" equivalencies for DNA and synthetic biology, and we are just at the beginning of the curves

*Courtesy D. Galloway, DTRA JSTO

Enabling Technology: Engineered Organisms

- A range of organisms (bacteria, fungi, yeast, eukaryotic cells) have been engineered in a variety of ways
  - Biosensors (ex. CANARY)
  - Protein production (ex. insulin from yeast and bacteria)
- How is this done?
  - Selection under stringent conditions (predominantly used for bioremediation applications)
  - Genetic engineering – insert desired genes into genome of organism (ex. CANARY)



(1) Pathogens crosslink antibodies

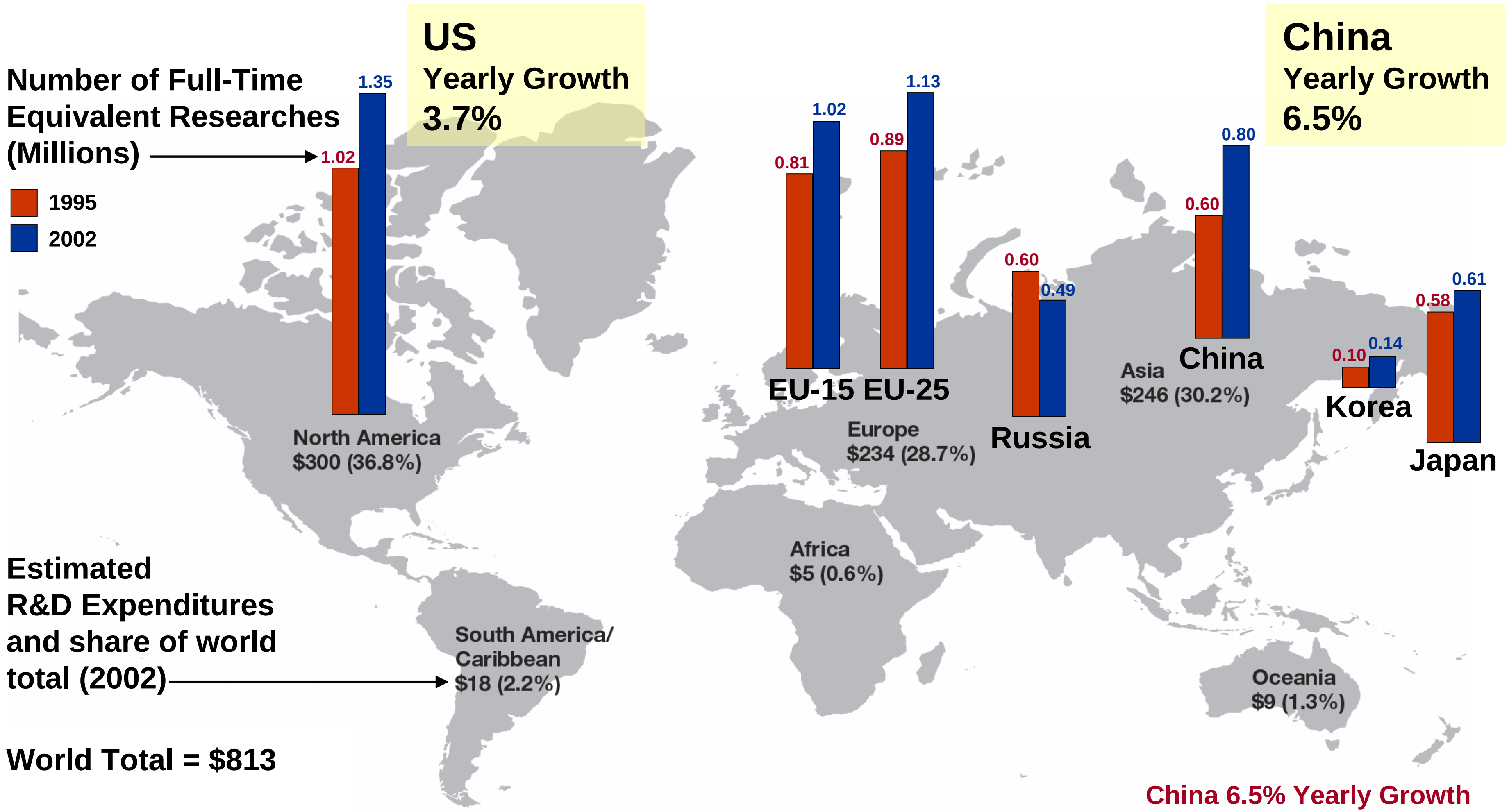
(2) Biochemical signal amplification releases Ca^{2+}

(3) Ca^{2+} makes aequorin emit photons

(4) Detect photons

As we learn more about cellular systems and "-omics", we can engineer more elaborate systems

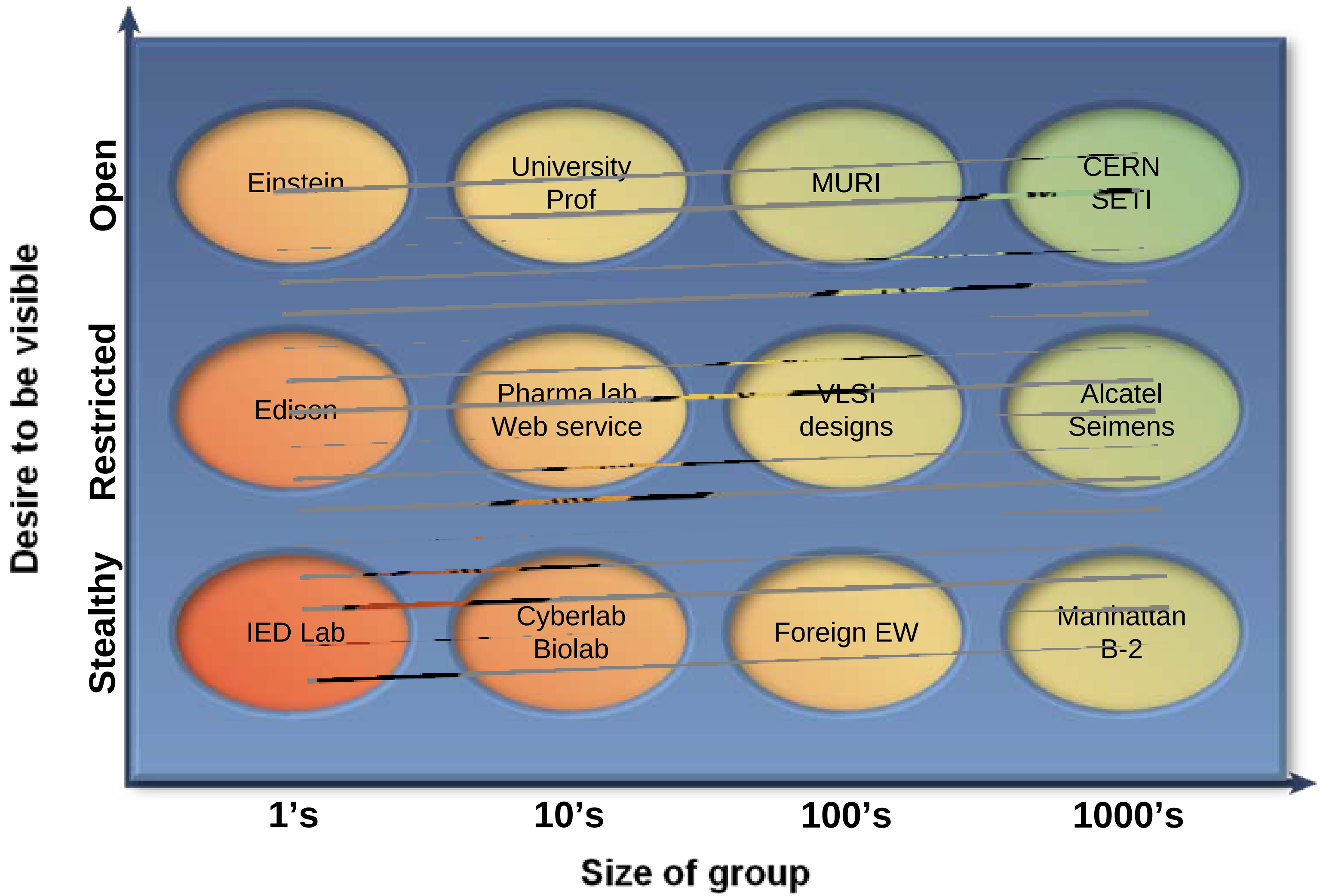
The Shifting Research Base



Notes: R&D estimates from 91 countries in billions of purchasing power parity dollars. Percentages may not add to 100 because of rounding.

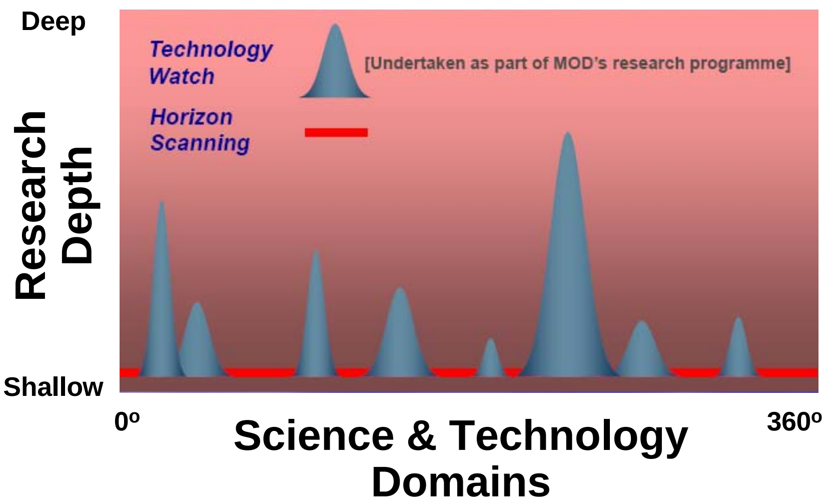
Sources: OECD Science, Technology and Industry Outlook (2006)
National Science Board, Science and Engineering Indicators 2008

Monitoring People in Research Communities is Also Important



Adapted from 2008 Defense Science Board Study on Capability Surprise

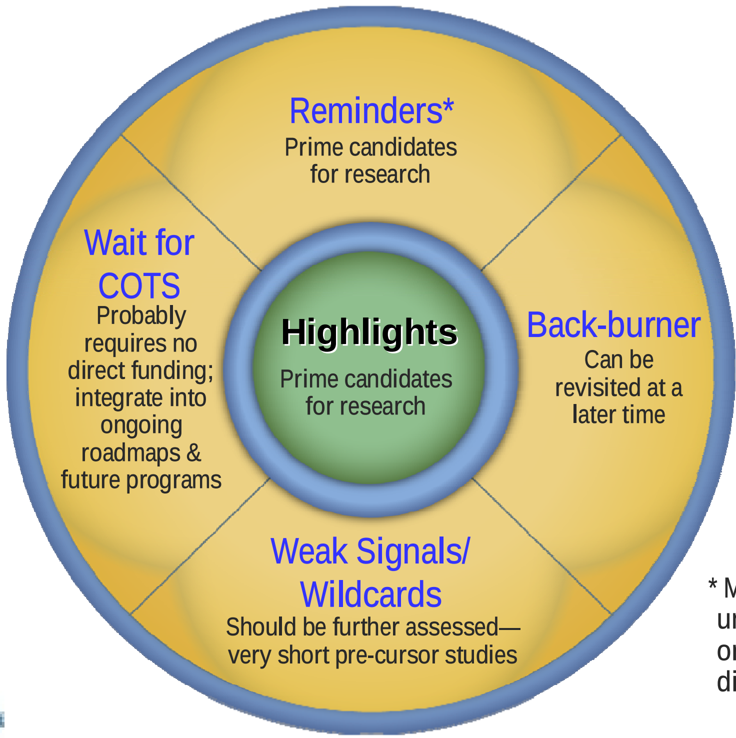
Tech Watch / Horizon Scan



- Scientometric analysis of published work
- Identify emerging technical communities
- Identify movement of authors
- Detect new technical concepts

UK Office of Science and Innovation (OSI)

DOD Techipedia



* May already be under consideration or have been discounted

Adapted from 2008 Defense Science Board Study on Capability Surprise

Summary

- **Capability surprise results from both "known surprises" and "surprising surprises"**

- **The changing landscape is likely to result in more capability surprises**
  - **Growing strength of foreign S&T enterprise**
  - **Global diffusion of technology**
  - **Global pull on US S&T ideas and workforce**
  - **Changing nature of innovation**

- **Sources, examples, and methods for countering each of the technology surprise categories were presented**