Bugs, Bits and Engineering Bioforms: Good and Bad Applications and Actors

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Presentation at New America Foundation Symposium:
Warring Futures: Transforming Today’s Military
24 May 2010
“Every age has its own kind of war, its own limiting conditions and its own peculiar preconceptions.”

Claus von Clausewitz

- security policy is determined by the threats and their deployment
- there is no single security policy that serves all needs equally well
Navigating a World of Increasingly Complex and Diverse Threats
“The old concentration of force is likely to be replaced by an intangibly ubiquitous distribution of force - pressing everywhere, yet assailable nowhere”

B.H. Liddell Hart (1935)
British Historian: Biography of T.E. Lawrence
Quadrupennia DEFENSE REVIEW REPORT

- prevail in today’s wars
- prevent and deter conflict
- prepare for and defeat disruptive high-tech capabilities being developed by other nations
- preserve and enhance all-volunteer force
- reform the acquisition process
<table>
<thead>
<tr>
<th>Company</th>
<th>Industry</th>
<th>Country</th>
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<tbody>
<tr>
<td>Samsung</td>
<td>flash memories, hard disks, flat screen monitors</td>
<td>South Korea</td>
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<tr>
<td>Aracruz</td>
<td>market pulp for paper products</td>
<td>Brazil</td>
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<td>Sasol</td>
<td>synthetic fuels</td>
<td>South Africa</td>
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<td>TSMC</td>
<td>logic semiconductors</td>
<td>Taiwan</td>
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<td>Misc</td>
<td>liquified natural gas shipping</td>
<td>Malaysia</td>
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<tr>
<td>Gazprom</td>
<td>natural gas</td>
<td>Russia</td>
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<td>Tenaris</td>
<td>oil pipes</td>
<td>Argentina</td>
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“Sustaining The Global Commons”:
A Broader Conceptualization of National Security
The Principal Determinants of Global Order in the Early 21st Century

New Intelligence and Military Capabilities
- Asymmetric warfare and counter-terrorism

Biosecurity
- Mitigation of natural and malevolent risks to populations and the environment

Global Governance and Global Commerce
- Mitigation of economic, social and political instabilities
“The Poverty of Imagination”: An Enduring Theme in the History of Technology

- The myopia of individuals, companies, and nations in recognizing novel disruptive technologies:
  - complacency, risk aversion

- Disruptive technologies are created disproportionately by individuals/companies operating at the mainstream margins:
  - risky topics, investor timidity, claustrophobic corporate hierarchies/cultures
  - precautionary principle
The New Strategic “Spaces” in Military Affairs and National Security

Systems and Synthetic Biology

Ubiquitous Sensing

Brain: Machine Interactions

Infocosm and the Metaverse

Militarization of Space

“Biospace”

“Connected Space”

“Smart Space”

“Cyberspace”

“Outer Space”

Constantly Emerging and Evolving Multi-Dimensional Matrices of Knowledge Ecologies

Global Challenges

Systems of Innovation
Transcending Boundaries: Emergent Domains Arising from Technology Convergence

<table>
<thead>
<tr>
<th>Systems and Synthetic Biology</th>
<th>Targeted Rx</th>
<th>Regenerative Medicine</th>
<th>HPO</th>
<th>Genetic Identity</th>
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![Images representing different domains](image1.jpg)
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<tr>
<th>Molecular Foundries</th>
<th>Novel Materials</th>
<th>Micro-Devices</th>
<th>Ubiquitous Sensing</th>
<th>Robotics</th>
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<td><img src="image2" alt="Novel Materials" /></td>
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<td><img src="image4" alt="Ubiquitous Sensing" /></td>
<td><img src="image5" alt="Robotics" /></td>
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<th>Intelligent Machines</th>
<th>Competition and Espionage</th>
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<td><img src="image7" alt="Digital Anthropology" /></td>
<td><img src="image8" alt="Cogint" /></td>
<td><img src="image9" alt="Intelligent Machines" /></td>
<td><img src="image10" alt="Competition and Espionage" /></td>
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**Massive Computing Power and Analytical Parsing**
Comprehending Biological Design: The Design of Complex, Adaptive Networks of Increasingly Higher Structural Order
Regenerative Medicine

Embryonic Stem Cells

Tissue Engineering

Xenografts

A Distant Future
Enhancing Extreme Performance

Novel Materials

Bioenergetics

“Hassle-free” Sensors

Optimizing Physiological Performance

Total System Monitoring

Full Spectrum Performance

Novel Integration of performance enhancing tools
Novel Materials

- Flexible superfast electronics
- Non-reflective coatings
- Black body materials
- Metamaterials
- Switchable materials
Novel Materials for Warfighter Protection and Performance Enhancement

- Medical management capabilities
- Minimize kinetic injuries
- Shock management
- Traumatic brain injury

- Light weight composites
- Novel power sources
- Organic photovoltaics

- Rapid detection CBW
- Interface with networked sensors

- Switchable surfaces
- Metamaterials
- Tag signature for MOUT
Robotic Jobs: Dull, Dirty, Detailed, and Dangerous
Bioterrorism

Infectious Diseases of Natural Origin

Environmental Sustainability
Assessing the Threat from Infectious Diseases

**Bioterrorism**
- low probability, high consequence

**Natural Epidemics and Pandemics**
- high probability, high consequence

- HIV
- TB
- Malaria
- Influenza

- EIDs
- Urbanization
- Rx Resistance
- Incentives
The Global Public Health Challenge Posed by Rapid Urbanization in Developing Countries

- High Disease Transmission
- Lack of Safe Water
- Toxic Waste
- Major Deficits in Health Infrastructure
- Expanded Eco-niches and Increased Zoonotic Risks
**The Expanded Dimension of the Chem-Bio (CB) Challenge**

- thinking beyond ‘bio’ as just infectious agents (bugs)

- systems biology
  - targeted disruption of ANY body function
  - novel CB threats

- synthetic biology
  - exploring biospace: designing new life forms
  - designer organisms to attack materials/infrastructure
Synthetic Biology: Engineering Novel Organisms with Novel Functions
Synthetic Biology:
Genetic Modification of Living Cells to Produce Biofuels or Other Complex or Scarce Materials
Researchers start up cell with synthetic genome

A fully synthesized genome transforms one species of bacterium into another.

Alla Katsnelson

Scientists have built a bacterial genome from scratch and used it to 'reboot' a cell from a different species of bacterium.

Daniel Gibson and his colleagues at the J. Craig Venter Institute in Rockville, Maryland, synthesized the genome of the bacterium *Mycoplasma mycoides*, consisting of about 1.1 million base pairs. Having assembled the genome inside a yeast cell, they transplanted it into a cell from a closely related species, *Mycoplasma capricolum*. After the newly made cell had divided, the cells of the bacterial colony that it formed contained only proteins characteristic of *M. mycoides*.

A chemical marker (blue) shows the ability of a single bacterium with synthesized genome to spawn a viable colony.

Science/AAAS
Biohackers: An Emerging Challenge
The Infocosm: Emerging Networks of Global Connectivity
• everything will become a reporter
• everything will move faster
• everything can go everywhere
• everything carries a signature
The Increasing Importance of Geodemographic Information Systems (GIS)
It's all about signatures…

Who's been using explosives?

Who's handled a biothreat?

Is this someone I'm looking for?

Who's lying?

Who's been inoculated against an agent?

Can a biosignature tell me where someone has been and whom they interacted with?
Reframing Robert Frost

“Good fences make good neighbors”

“Good sensors make good fences”
Biosignatures: A High Value Under-leveraged Component of National Security

- signatures of disease exposure
- signatures associated with inoculation
- signatures associated with environmental exposure
- signature patterns among separate individuals
- signature changes – both subtle and significant
- induced signatures

from the battlefield
to the visa line?
Natural Signatures Research

- what signatures (or combinations of signatures) are individually unique?
  - can they be read at distance?
  - can they be amplified or modulated?
  - can novel signatures be induced?
Commensal Microorganisms, Viruses and Parasites as Sensors and Taggants

- engineered tag insertion into carrier organism/materials
  - constitutive or induced expression of tag
  - activatable tags

- variable standoff detection range
  - magnetic, metallic, spectral tags

- induction of biomarkers by exposure as evidence of presence in red location
“Hell is the Place Where Nothing Connects”
T. S. Eliot
Mr. Spock: “Insufficient data, Captain”

Captain Kirk: “Insufficient data is not sufficient, Mr. Spock. You’re the Science Officer. You’re supposed to have sufficient data all the time”

Star Trek
The Immunity Syndrome
Great Expectations:
Intelligent Monitoring Systems for Improved Analysis of National Security Threats and Their Implications

- dramatic expansion in ‘signatures for interest’
- formidable data mining and context analytics
- new tradecraft
- new open sources (OSINT)
- new ways to validate sources
- new technical competencies
- new knowledge integration tools
- new behaviors
Cyber-Attacks and Vulnerable Infrastructure: Compromising Critical Systems
Trends in Cyberwarfare

AI and Cybersystems

Technology Maturation

Humans and Human Societies

Combatants

AI and Cybersystems

- singularity engagement
- cyber-enhanced engagement and advanced robotics
- human-human conflict
Cyberwar

- relentless probing of defenses and acquisition of source codes
- serious exfiltration of key security and commercial data
- malware: vulnerability to outsourced software and hardware
- little likelihood of international treaty to ban

A Return to a Cold War Strategy?
MAD: Mutually Assured Destruction
Big SIS is Watching You
● estimated 7 trillion wirelessly connected devices and objects by 2017 (c.1000/person)
● mobile devices and monitoring consumer habits
  – behavioral targeting
  – contextual targeting
  – social network profiling
● the politics of privacy
  – growing pressure for legislative oversight
  – US Energy and Commerce Internet Subcommittee
  – EU Article 29 Working Party
● two-thirds of new products now come with some electronic component or tracking potential
Virtual Worlds: The Largest Design Space in Technology Today

- avatar-inhabited, multi-user on-line worlds
- immersive spaces in web-based ecosystems
- accommodate complexity, dynamism, diversity and selection
- the emergent synthesis of the global collaboratory
- irreversible, symbiotic (?) interaction with the human nervous system
maintaining more than one viable identity in the infocosm will be virtually impossible

being off-grid will be suspicious

vital vehicle for winning the ‘deep battle’: the war of ideas for victory against jihadist ideology
Enhancing Human Capabilities to Use the Increased Volume, Diversity and Complexity of Information Flows
Cognitive Biology, Customized Data Formats and Visualization for Improved Decision-Making
Q (Bus. Week):
   “Is Google really creating a true artificial intelligence or thinking machine, as Google’s founders have set up as a goal?”

A (Eric E. Schmidt, CEO, Google)
   “In the next few years, cognition, or real understanding, remains a research goal”

Bus. Week 9 April 2007
High Resolution MRI Imaging and Computational ‘Unfolding’ of the Hippocampus Medial Temporal Lobe During Encoding and Retrieval of Face-Name Pairs
“Cogint”

- mapping neurocircuitry: the ‘signatures’ of motor, sensory and cognitive states
- coupled feedback from attentive computer interface and on-body: in-body sensors
- language translation
- inter-memetic engineering: sharing concepts
  - specialized knowledge
  - cultural fusion
  - conflict reduction
The Neurobiology of Decision

choice  risk reward  rational (?) economics  religion
Expansion and Democratization of Human Cognitive Capacities

\[ c_\tau = S \frac{N(h) - Xe^{-\kappa t}}{\tau} N(h - \sigma \sqrt{\tau}) \]

where

\[ h = \left[ \ln \left( \frac{S}{X} \right) + r \tau + \frac{\sigma^2 \tau}{2} \right] / \sigma \sqrt{\tau} \]

Cognitive Enhancement
“Mental health is the ultimate competitive weapon. Even if just a few people choose to use neuro-enhancements, their choice will change the basis of business competition for the rest of us”

(and nations too . . . . . . . . . .?)

Zack Lynch
Managing Director, NeuroInsights
AAAS Symposium on Impact of Human Enhancement
Intelligent Adaptive Neural Systems and Devices for Circumventing Disability

Neural Signatures of Motor and Cognitive Functions

Neuro-Controlled Robotics

Intelligent Prosthetics
Control of Bull with Implanted ‘Stimoceiver’
Jose Manuel Rodriguez Delgado 1963

Sci. Am. Oct 2005
Behavioral Genetics: A Non-PC But Unavoidable Domain of Cognitive Neurosciences
Is the human species inherently violent and are ethnic and theological differences the inevitable drivers of violent confrontation?
Touch the Future:
Computing Platforms as Socio-Biological Systems

- modification of social patterns
- modification of cognitive structures
- memes as selection agents
- “the brain(s) in the cloud”
Social Network Analysis of al-Qaeda Cells
Islamist militiaman take pictures on their mobile telephones of some of the casualties of the heavy fighting in Somalia’s capital Mogadishu on 17 June 2009.
The Marriage of the Hard and Soft Sciences
New Networks of Intellectual Fusion

Behavioral Economic and Social Technologies (BEST)

- massive data sets
- open source networks
- new analytical models/tools for non-linear systems
- multi-scale networks

Acceleration and Convergence in Science and Technology
anonymity, connectivity and ‘virality’
- strengths and weaknesses

- catalyst for building digital spaces for dissent, prodemocracy activism and a digital civic culture?

or

powerful new tools for surveillance, propaganda and manipulation by authoritarian regimes?
are children the best new targets for intelligence gathering and ideological channeling?
new patterns of electronic connectivity at progressively younger ages
‘poly-Ender’ talents
- friend and foe
- uninhibited are already displaying them!
complex ELSI questions
• “deception cannot succeed in wartime without developing theory and doctrine in peacetime”
• “understanding the enemy culture, standing beliefs and intelligence-gathering process and decision cycle”
• “reliant on running agents (and double-agents) and creating stories that adversaries will readily believe”
rapid proliferation of dual-use technologies

rapid diffusion and ubiquity of new technologies

global connectivity and convergence

military and national security implications

economic, socio-cultural and political implications

impact on human identity

MANAGEMENT OF COMPLEX ADAPTIVE SYSTEMS
American Progress: Manifest Destiny by John Gast (1872)
“But I must go and meet the danger there, or it will seek me in another place, and find me worse provided.”

- William Shakespeare, Henry IV
“For most of us design is invisible Until it fails”:
Bruce Mau. Massive Change. 2004
The Curse of Contemporary Governance: ‘Quick Fixes’ and the Retreat from Complexity

- public complacency and political populism as major policy barriers
- unidimensional, short term policies to address multidimensional complexity with long term consequences
- influence of media in shaping public opinion, policy and operational constraints
- the retreat from complexity
rising
to the
Challenges

Understanding Complexity

Building Systems of Innovation

Adaptive Flexibility
The Retreat from Complexity: The Insularity and Risk-Aversion of USG Analytical and Decision Frameworks

- ‘too hard’ problems
- denial, avoidance, paralysis
- sustained focus/funding on ‘the familiar’ and the ‘usual suspects’
- growing and dangerous deficits in USG expertise in next generation “disruptive technologies”
The Retreat from Complexity

BIG IDEAS GO UNEXPLORED AND UNFUNDED

TIMIDITY AND PRESERVATION OF STATUS QUO
TRUMP BOLDNESS AND DISRUPTIVE INNOVATION
Meeting Previous Grand Challenges
“Science is a tool against despotism and feudal barbarisms. I rejoice that the American mind is already too much opened to retreat from it’s commitment to science.”

Thomas Jefferson, 1799
“Politics is the art of the possible, the calculated science of survival”

Prince Otto von Bismarck

“Survival owes little to the art of politics, but everything to the calculated application of science”.

Professor Rudolph Virchow (in reply)