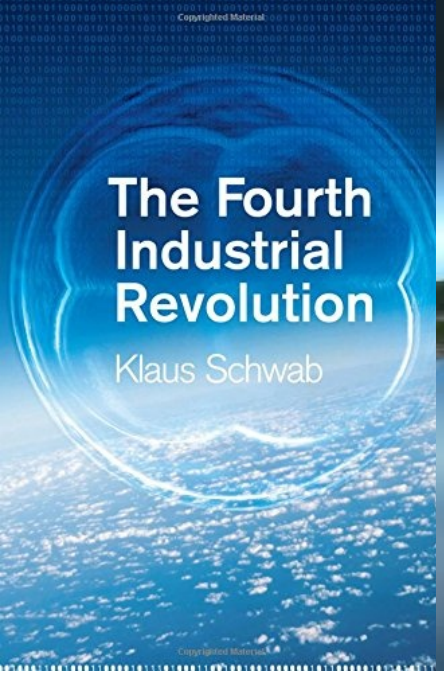



C4I & CYBER CENTER

Wicked Problems: National Security Implications of the Fourth Industrial Revolution

Linton Wells II

C4I & Cyber Center Seminar

April 10, 2017

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Overview

- Definition of Wicked Problems
- Four Industrial Revolutions
- Intersections with Current Military Developments
- International Challenges
- Implications of Converging Trends
- Challenges for National Security Decision-Makers & Research

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Security Definition

Freedom from want and freedom from fear

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Broad Classes of Problems

- Simple (or Tame or Well-Structured) Problems
  - Problem is well-defined and how to solve it is generally known, even though executing may be hard
  - See slide 6
- Complicated (or Medium-Structured) Problems
  - General agreement on problem definition, but not on the solution
- Wicked (or Complex or Ill-Structured) Problems
  - No agreement on problem definition, much less on solution. See slides 7-8

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Tame Problems

- Have a relatively well-defined and stable problem statement.
- Have a definite stopping point, i.e. we know when the solution or a solution is reached.
- Have a solution which can be objectively evaluated as being right or wrong.
- Belong to a class of similar problems which can be solved in a similar manner.
- Have solutions which can be tried and abandoned.

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Criteria for Wicked Problems (1)

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***Rittel and Webber**, 1973, as amplified by United States **Army**. "Commander's Appreciation and Campaign Design" Version 1.0, 28 January 2008. Pages 4-12.*

Wicked (or Complex, or Ill-Structured) Problems

- **There is no definitive way to formulate a wicked problem**
- **Wicked problems have no "stopping rule"**
- Solutions to wicked problems are better or worse, not right or wrong
- There is no immediate, nor ultimate, test of a solution to a wicked problem
- **Every solution to a wicked problem is a one-shot operation**
- Every wicked problem is essentially unique and novel
- **Wicked problems are interactively complex**
- Every wicked problem is a symptom of another problem
- We cannot understand a wicked problem without proposing a solution
- Wicked problems have no fixed set of potential solutions
- **The problem-solver has no right to be wrong**

Criteria for Wicked Problems (2)

Wicked Problems: A class of problems "that defy solution, even with our most sophisticated analytical tools"

(Roberts, 2001, p. 1)

Characterized by:

- No definitive problem statement: in fact, there is **broad disagreement on what 'the problem' is**
- An open-ended search for solutions
- Stakeholders champion alternative solutions and compete with one another in ways that directly connects their preferred solution and their preferred problem definition
- Problem solving process is complex since constraints are constantly changing
- Constraints also change because numerous interested parties change the problem-solving rules

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Examples

- Terrorism
- Nuclear Proliferation
- Cyber Security
- Climate Change
- Border Security

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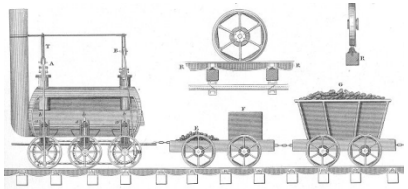
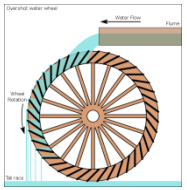
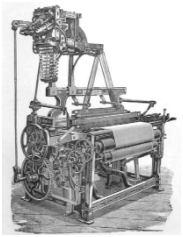
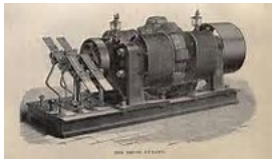
Four Industrial Revolutions

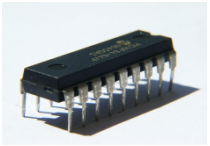
- 1st ~1780s:

- 2nd ~1870:




- 3rd ~1969:



- 4th just beginning: fuse technologies "blur lines between physical, digital and biological spheres"




Source: Klaus Schwab, "The Fourth Industrial Revolution: what it means, how to respond," 14 January 2016 http://www.weforum.org/agenda/2016/01/, accessed February 16, 2016

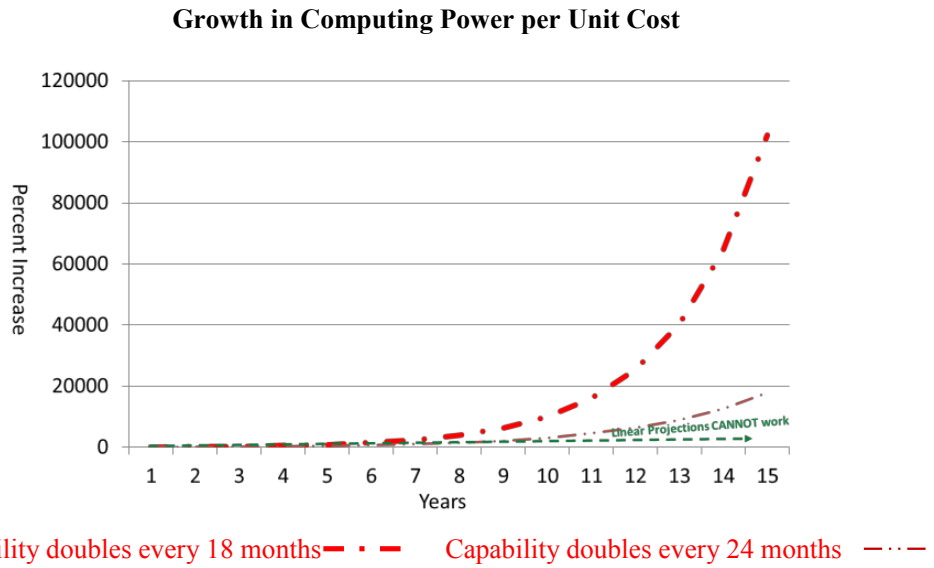
4th Industrial Revolution (4th IR)

- Key distinctions between 3rd & 4th revolutions:
  - Velocity of change, scope, and systems-wide impact
    - **Massively disruptive**, and accelerating
    - **Transforming management**, as well as production and distribution
    - Can provide very **important collective benefits** to society, but also **negatively affect many individuals**
      - Loss of jobs and pace of social change
      - Machine learning and artificial intelligence

- Responses must engage public-private, whole-of-society, and trans-national stakeholders
  - In comprehensive, integrated ways

Velocity of Tech Change

If a factor, e.g. computing power/unit cost, doubles every 18 mo, 5 yr increase is 900%, 10 yr 10,000%, 15 yr ~100,000%



Biotech even faster, robotics ubiquitous, nano poised breakout, energy impacts are global

- Think BRINE (bio-robo-info-nano-energy) + Additive Manufacturing

Interactions complicate things

Linear projections CAN'T work

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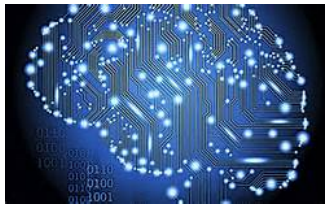
U.S. Third Offset Strategy (3rd OS)

- Leverages many similar technologies as 4IR
- 5 main building blocks:
  - **Learning machines**:
  - **Human-machine collaboration**:
  - **Advanced human-machine combat teaming**:
  - **Assisted human operations**:
  - **Autonomous weapons**:



Focused on potential adversary capabilities, not just intentions

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Third Offset Strategy (2)

- Goal of 3rd OS is to "make humans more effective in combat" Much in common with 4th IR
  - In both areas people must be empowered to address most serious challenges
  - Tech is important, but both involve adaption and, ideally anticipation, across Organizations, People, and Processes, as well as Technology
- **NOT JUST TECH**

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Convergence of Commercial Trends will Affect C4ISR*

- Velocity of Tech Change
- Explosion of Sensors—many-non-government
- Cyber and EW—Kinetic and Non-Kinetic Fires
- Info Sharing & Security
- Data Visualization/Virtual Reality
- OODA Loop & Decision Cycles

*Command, Control, Communications, Computing, Intelligence, Surveillance, Reconnaissance

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Explosion of Sensors

- Open Source ISR-GIS

- UASs

- IV4 (Info Volume, Velocity, Veracity, Value)

- Mobile, Wearable

- Internet of Things (IoT)

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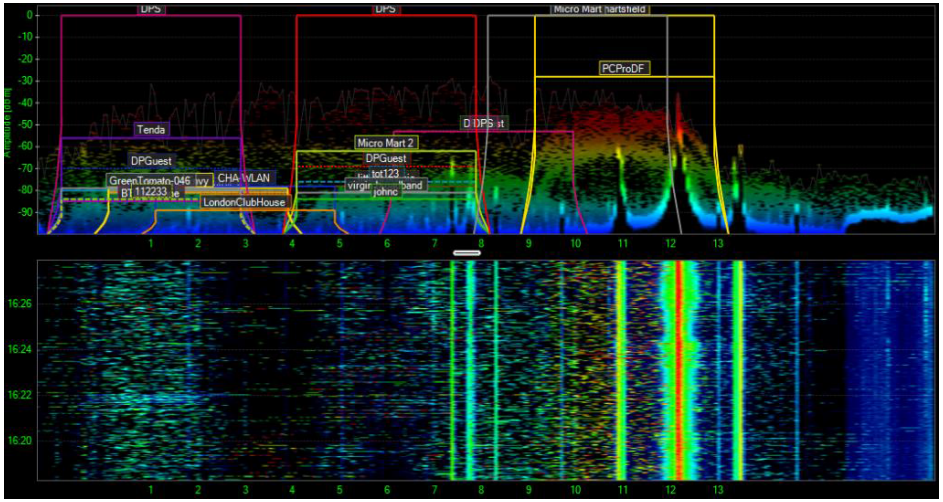
Cyber and EW Convergence
Kinetic & Non-Kinetic Fires

- Maneuver in Electromagnetic Spectrum (EMS) Space
  - Navy Electromagnetic Maneuver Warfare (EMW)
  - Army Cyber Electromagnetic Activities (CEMA)
    - EW Planning & Management Tool (EWPMT)
  - Marine Corps Cyber EW Coordination Cell (CEWCC)
  - USAF
- C4ISR Implications



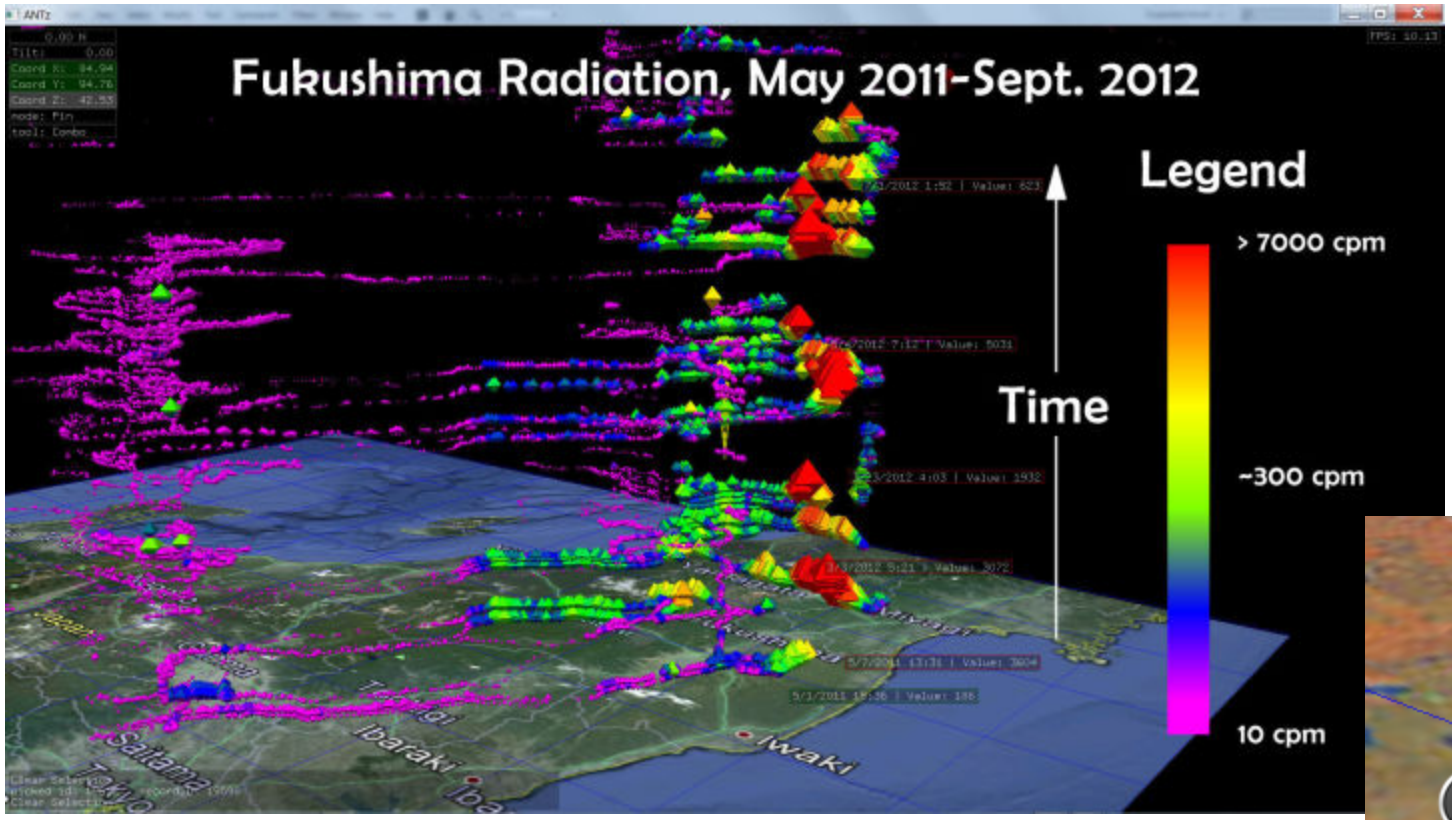
Info Sharing and Security

- Info Sharing Rules
- Alternative approaches to cybersecurity
  - Big data
  - NRT anomaly detection
  - Supply chain, blockchain
- Major policy, legal, moral, ethical, privacy issues

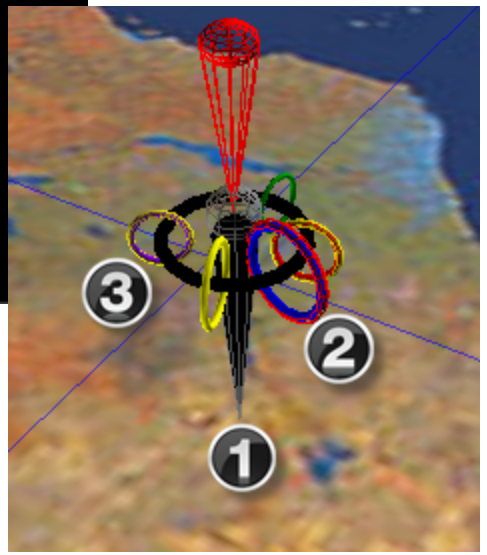
Command and Control/Sensemaking/ Decision Support

How to achieve "**Unity of Action**" when there's **no** "**Unity of Control**?"

Data Visualization/Virtual Reality



Graphics by SynglyphX



OODA Loop & Decision Cycles

- "Observe" and "Orient" phases increasingly electromagnetic
- "Decide" and "Act" supported by information processing
- Cyber can dominate OODA loop in any domain
- Tech changes
  - Processing power
  - Machine learning
  - Sensor proliferation
  - Army 2050 battlefield—can you move?
- Speed of decisions
  - "Man-on-the-loop," vice "Man-in-the-loop"

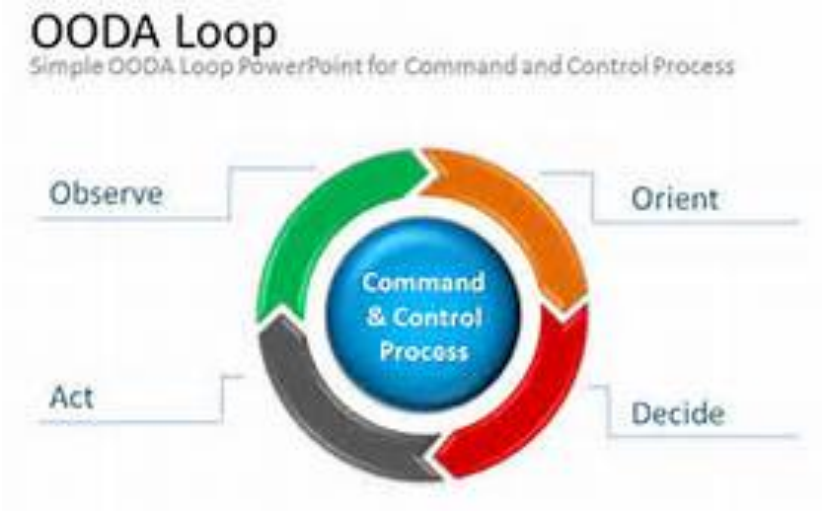


Image courtesy successing.com

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Cheap Tech Challenges U.S. Tactical Dominance

- Evolving Tech
  - Additive Manufacturing—drones, EFPs
  - Nanotech—nanoexplosives and nanomaterials
  - Space-like capabilities—GIS, ORS, Aerial Layer
  - AI—convergence of tech to make cheap, widely available, autonomous weapons
- Implications for Modern Battlefield
  - Irregular Warfare, Conventional Warfare (Ground, Sea, Air, Space, Cyber)

- Strategic Implications—cost of intervention rises
  - "Small, smart and many"* represent excellent investments for adversaries
  - US may be underinvesting in evolving 4IR tech that's changing nature of warfare

*TX Hammes, JFQ 81

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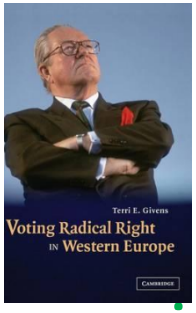
4th IR Job-Related Security Issues (1)

- 4th IR can raise global incomes and improve quality of lives
  - More unequal and disrupted labor markets
  - Loss of jobs, "low-skill/low-pay" and "high-skill/high pay" groups
  - Societal inequalities and social tensions

- **Service jobs particularly vulnerable** to automation
  - Services are some 80% of developed world employment, growing role in developing economies
  - McKinsey Global Institute (MGI) 2017 study:
    - less than 5 percent of all occupations can be automated entirely
    - **"about 60% of all occupations have at least 30% of constituent activities that could be automated**." [with present tech]

Job-Related Security Implications (2)

- Impacts likely to be more severe in **youth bulge** areas
  - Parts of Islamic world, South Asia and sub-Saharan Africa, plus megacities and under-served parts of developed world
  - Pressures for migration & radicalization if NO entry level jobs
    - Hence **no stake in international system**
- Many types of security problems:
  - Impact of a million refugees on Europe in 2015
  - Many times more likely in future
  - High potential for domestic unrest, scapegoat-finding, radical nationalism and protectionism
    - Unless governments and the private sector "are really skillful in managing these changes" -- **track record not encouraging**



The *Economist* has been especially good in reporting on these topics

Job-Related Security Implications (3)

- 4th IR challenges are beyond 3rd OS's intended focus
  - Unrest in developing (and developed) world
  - Potential threats to existing security structures
    - Political, social and economic **issues threaten true center of gravity of future conflicts: resilience of populations of engaged nations**
    - Can challenge social compacts
- Also threaten possible de-globalization*
    - **Local production** of manufacturing and services
    - Installed **new energy production** is now dominated by **local** sources -- solar, wind, hydro, and fracked natural gas.
    - Explosion of productivity in **urban and indoor agriculture**
    - **Voter anger** over trade pacts
    - **Balkanization of Internet**

*TX Hammes, "3-D Printing Will Disrupt the World in Ways We Can Barely Imagine," http://warontherocks.com/2015/12/3-d-printing-will-disrupt-the-world-in-ways-we-can-barely-imagine/

The BROCADE Concept

Building Resilient Opportunities in Culturally Aligned, Diverse Environments

Reducing Pressures for Migration, Radicalization and Marginalization Through "Collaborative Economy" Initiatives

www.brocaderesilience.org

BROCADE RESILIENCE

BROCADE

Shift Focus from THREAT to Opportunity

Provides a framework to:

- Build resilience in under-served communities
- By reducing risk and
- Providing collaborative economic opportunities ("Peers, Inc." model)
  - Airbnb reached 650,000 beds in 4 years

Apply multi-sector approaches that integrate changes in People, Organizations, Processes & Technology

"Make hope possible, rather than fear convincing"-- Raymond Wilson

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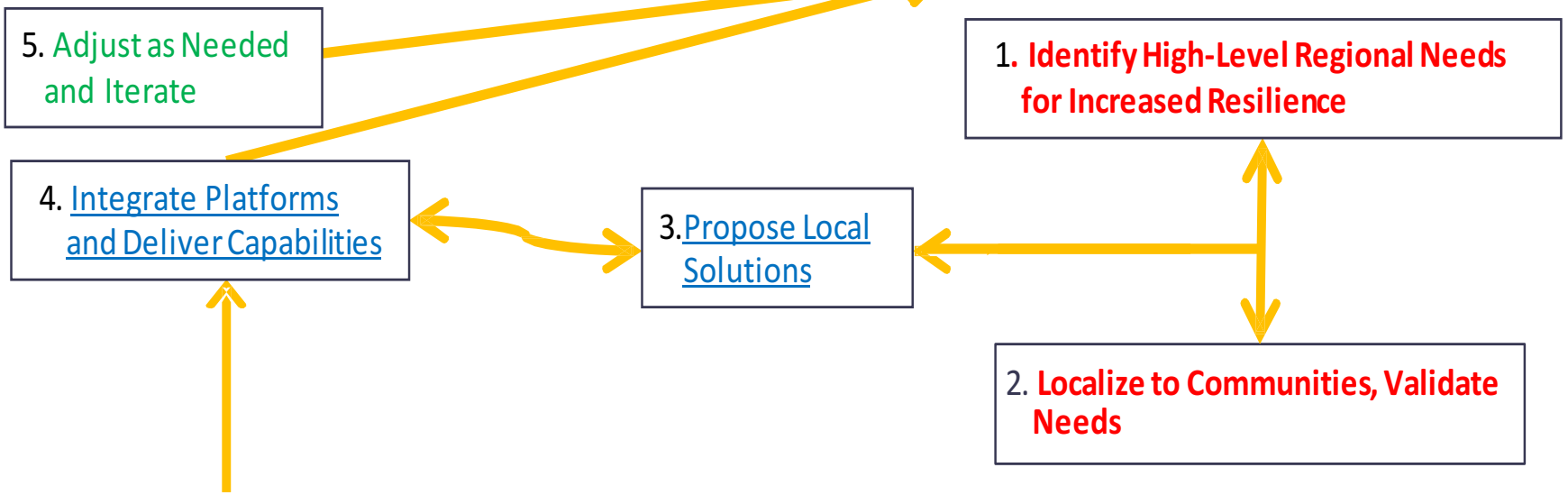
Potential "Platforms" for BROCADE (the "Inc." from "Peers, Inc.")

High Efficiency Urban **Agriculture**/Farming/Food Security
Local Production and Logistics: 3-D printing, etc.
Energy and Energy Storage
Clean Water
Information and Communications Technology (ICT): Ubiquitous Connectivity via SkyFi; Innovative Learning; Conversational User Interfaces (CUI); Include Appropriate **Cybersecurity** from the Start
Health: Telemedicine; Cheap, Widely Deployable Sanitation, Environmental Medicine
Low Cost, Culturally Aligned **Shelters**
Heating and Cooling
Governance, Security, Community Design & Management: Sensors; Geospatial Information System (**GIS**) data; Blockchains for Secure Land Titles and Transparent Transactions
Public-Private Partnerships/Cooperation
Innovative **Financial** Arrangements: e.g., M-Pesa, Micro-Loans

Transitioning BROCADE's *Strategy* to *Framework* to Locally Focused *Projects*

Region	MENA, Sub-Saharan Africa, Underserved People in the Developed World, etc.
Possible Projects	Community (separate name for each project)



Apply framework to **local** conditions by integrating several "platforms" to deliver capabilities to meet **local** needs through projects

GMU's Large Role in BROCADE

- Lead project in Appalachia with Shepherd U
- Other projects developing in:
  - Morocco
  - Ghana
  - Japan
  - Philippines
- STAR-TIDES tech demo at GMU Sept 12-15
  - Near Johnson Center
  - STAR-TIDES (www.star-tides.net) accumulates tech for BROCADE
- Join us!

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Converging 4th IR Trends (1)

- Trends can't be controlled by governments, only influenced
  - May need to "restructure our national security strategy, culture, and organizations accordingly"
    - **How to do better with** foresight & strategic futures?
- 4th IR will affect business, government, and people
  - Challenge very feasibility of governing by "systems of public policy and decision-making [that] evolved alongside the Second Industrial Revolution"
    - "When decision-makers had time to study a specific issue and develop the necessary response or appropriate regulatory framework"

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Converging 4th IR Trends (2)

- Trends support:
  - **Hybridization** of warfare,
  - **Empowerment** of individuals and non-state actors (especially through cyber, autonomous and biological weapons), and
  - Further **blurring of lines** between combatants and non-combatants
- Impact likely to be most profound on people
  - Will change "not only what we do, but also who we are"
  - Privacy issues will be key, but also biotech and AI revolutions

    "which are re-defining what it means to be human by pushing back the current thresholds of life span, health, cognition, and capabilities, will **compel us to redefine our moral and ethical boundaries**"

Do 4th IR Issues Meet Wicked Problems Criteria?

- No definitive problem statement: broad disagreement on what 'the problem' is
- An open-ended search for solutions—no stopping rule
- Stakeholders champion alternative solutions and compete with one another
- Constraints are constantly changing
  - Pace of technology
  - Economic impacts and resource availability
  - Numerous interested parties change the problem-solving rules
- Interactively complex—**need iterative approaches**
- The problem-solver has no right to be wrong

4th IR Challenges for Decision-Makers

- Projections range from pessimistic to optimistic
  - Insufficient data now for major public policy decisions
- Don't accept passively: **shape** "a future that reflects common objectives and values"
- Work to develop comprehensive view of how tech is affecting our lives and all our environments
- Break free of linear thinking—"there is no box"
  - Think strategically to turn threats into opportunities
  - Such as Diamandis & Kotler *Abundance*
  - Innovate! Improve! Repeat!

Implications for Research

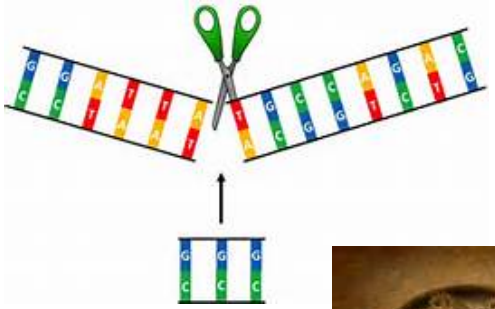
- Research opportunities in many areas
  - C4I & Cyber, Engineering, Science, Conflict Analysis and Resolution, Public Policy, also Business & Education
  - **Focus at Policy-Technology-Sociology-Economy** interface
- Promote change in how Organizations, People, Processes and Technology come together
  - Link security and sustainability goals, public-private, trans-national mechanisms & regional cooperation
- Organizations in Europe and the Gulf are building knowledge development resource centers with
  - Analytics & visualization component
  - Training modules and a vibrant community of interest
- All could be tied together. **Who will lead?**

Questions for Students

What technologies will your children use to befuddle you the way you befuddle you parents? Perhaps:

- Cyborgization of the human body

- Trans-generational perception differences



- Genome modification
- Networked minds

- What else?

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QUESTIONS?

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