Urbanization and Global Biosecurity: A Dangerously Neglected Dimension in DOD Doctrine and National Security Policy

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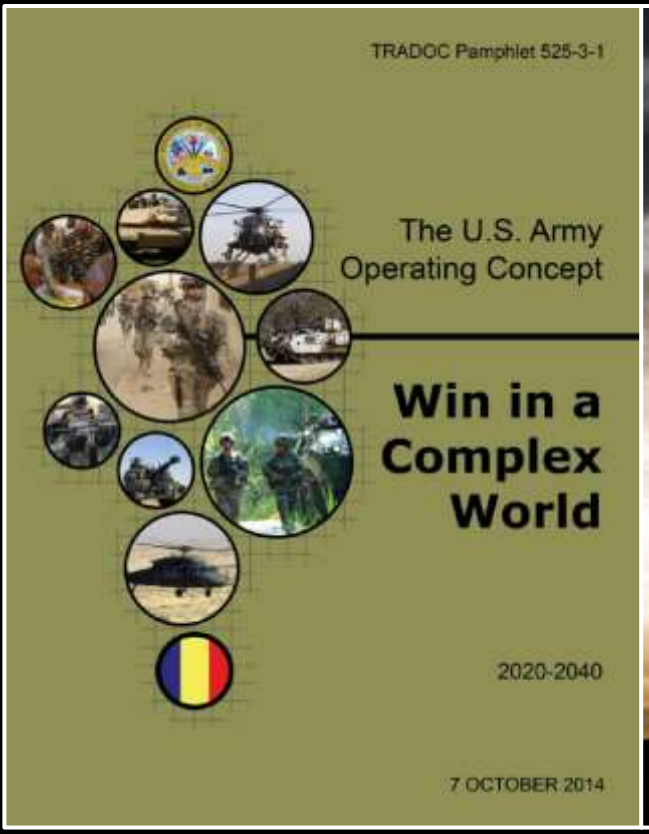
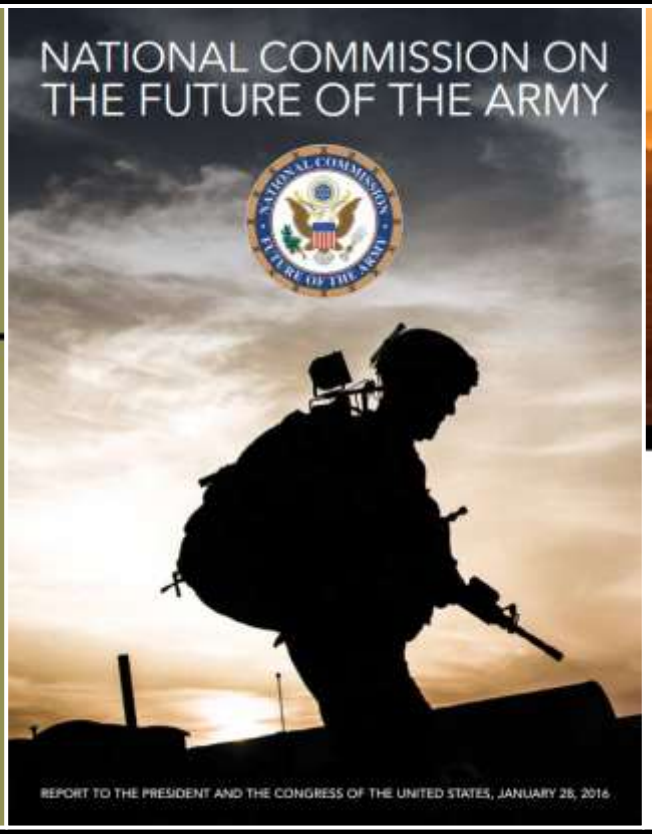
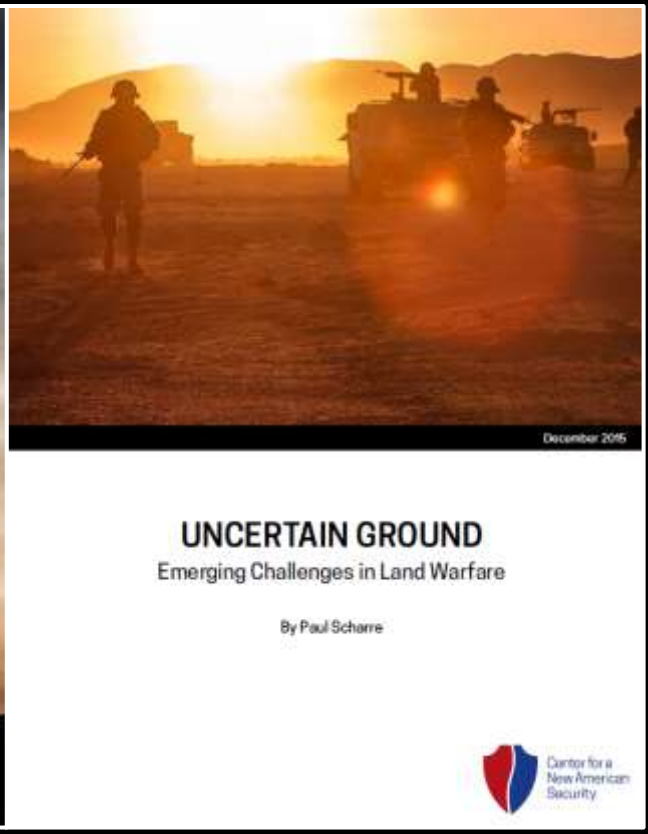
MAD SCIENTIST 2016: MEGACITIES AND DENSE URBAN AREAS IN 2025 AND BEYOND
Arizona State University, Tempe, Arizona
21-22 April 2016

The Changing Strategic Environment

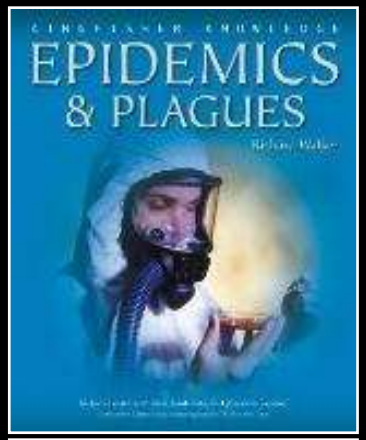


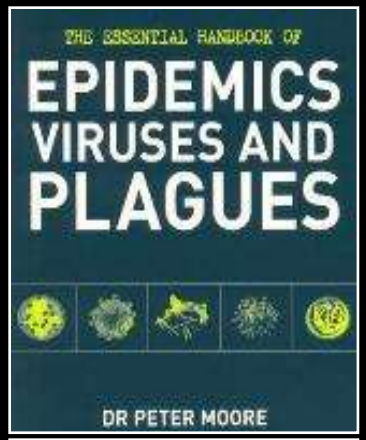


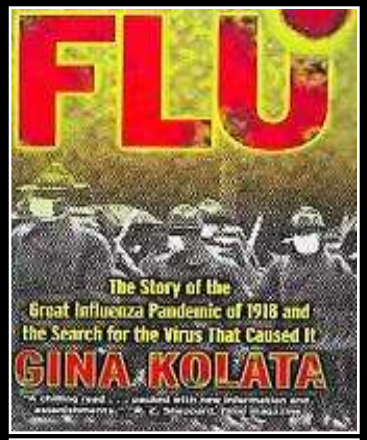


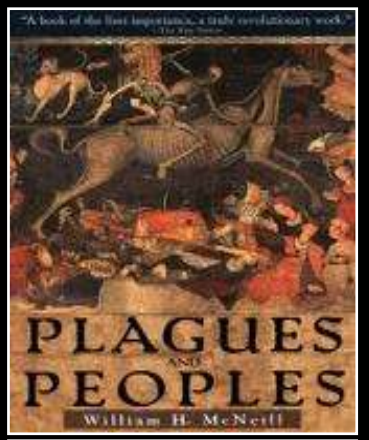
demographics and operations among populations in mega-cities, dense urban areas and complex terrain

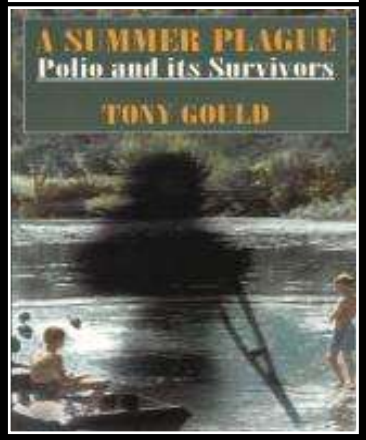
Infectious Disease: A Powerful Force in Human History

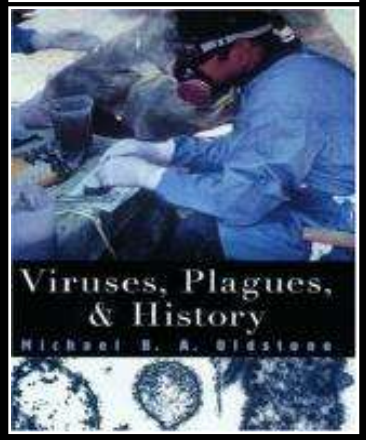


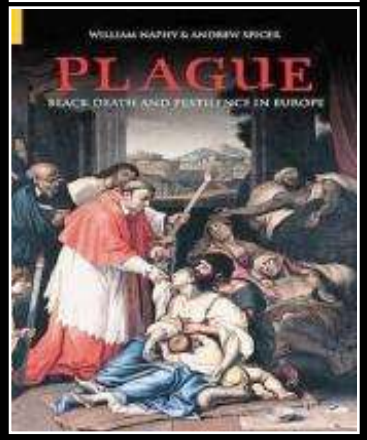


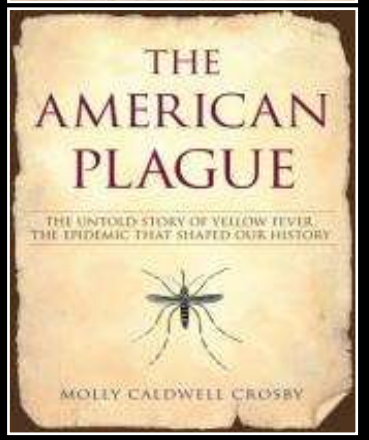


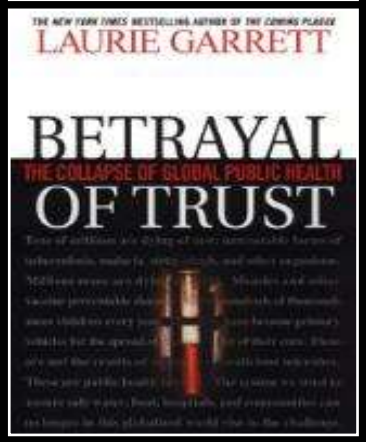


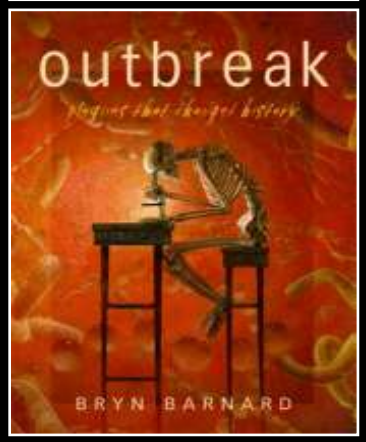


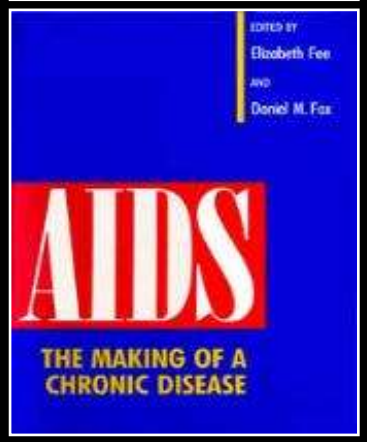


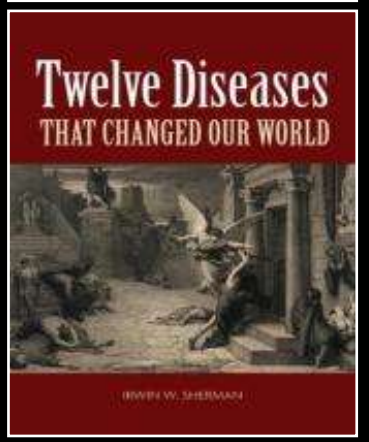










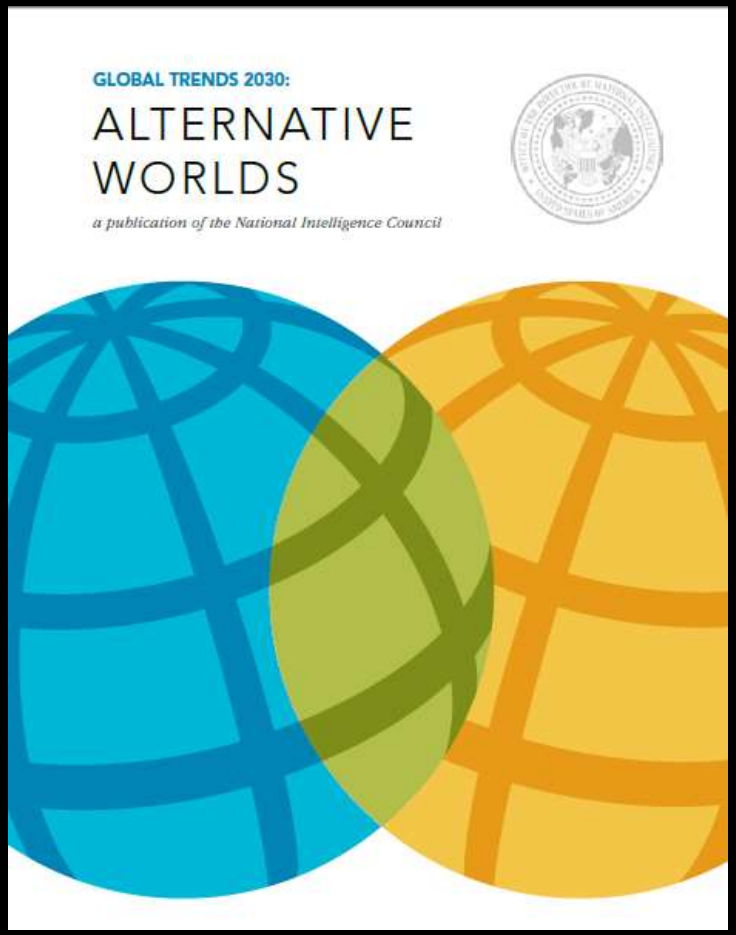


Biosecurity Is More Than Preparedness Against Infectious Diseases: Understanding the Implications of Major Economic Disparities and Environmental Dislocations

Biosecurity Is More Than Preparedness Against Infectious Diseases

- understanding how changes in complex biological systems threaten health and societal stability
  - directly and indirectly
  - infectious disease, sanitation and clean water, food production
  - ecosystem shifts and new patterns of disease
  - natural disasters
- disruption of transport and supply chains, economic loss and risk of civil disorder
- chronic social and economic instabilities as triggers of political turmoil and conflict
  - probability of future military and humanitarian missions

Global Urbanization



- 28 megacities in 2016 (populations greater than 10 million)
- Projected 41 megacities by 2030
- 850 cities with populations of 500,000 projected by 2030, majority in Africa and Asia
- estimated 60% of global population in urban areas by 2030
- 70% projected megacities in countries with Global Conflict Risk Index (GCRI) probability for conflict within 10 years

Global Urbanization

- estimated 180,000 people migrate to cities every day
- unprecedented demands (stresses) on infrastructure and services by 2030
  - food (35%↑), water (40%↑), energy (50%↑)
  - new housing demands equal to entire worldwide construction to date
- susceptibility of megacities to extreme weather events/natural disasters
  - littoral locations of 8/10 top megacities
  - vulnerability of vertical structures and slum zones

Global Urbanization: Deficits in Infrastructure and Services and Destabilization of Governance Systems

- diaspora from 'youth bulge' countries and refugee migrations from failing nations/conflict zones
- expansion of acute and extreme poverty
  - poor education, unemployment, xenophobic tensions
  - perceived disenfranchisement, civil unrest and appeal of extremist/religious ideologies
- breakdown of national governance and rise of local power-brokers hostile to US/coalition presence

MEGACITIES AND THE UNITED STATES ARMY

PREPARING FOR A COMPLEX AND UNCERTAIN FUTURE

Chief of Staff of the Army, Strategic Studies Group

Megacities Concept Team:

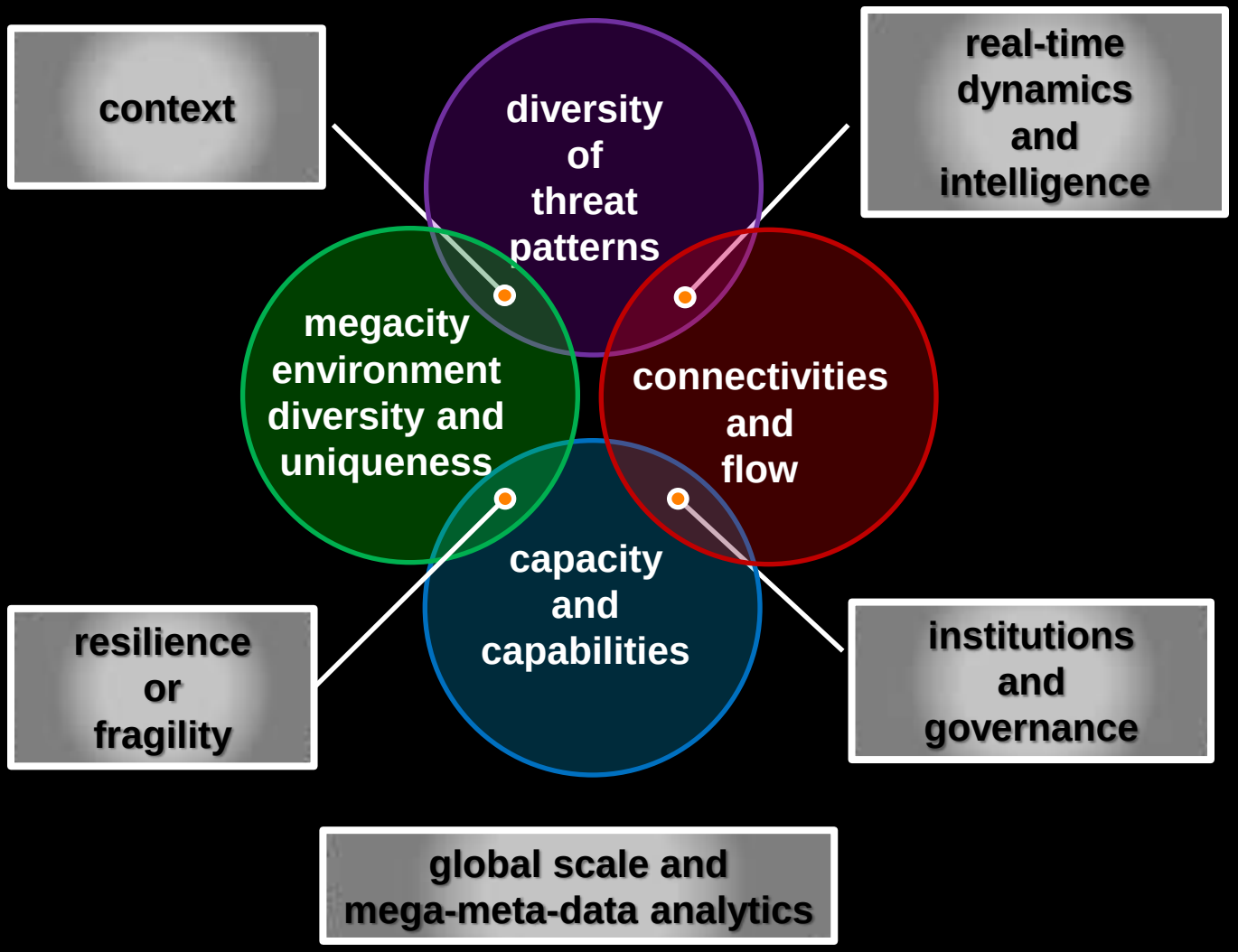
Colonel Marc Harris, Lieutenant Colonel Robert Dixon, Major Nicholas Melin,
Command Sergeant Major Daniel Hendrex, Sergeant Major Richard Russo
and Mr. Michael Bailey

June 2014

Resilience:
Typology of Levels of Integration of Services, Integration and Governance in Megacities and Dense Urban Areas

high	intermediate	low

The Complexity Matrix for Strategy Development and Intelligence for Missions in Dense Urban Area and Complex Terrain Operational Environments



Data Layers for Intelligence and Mission Operations in Dense Urban Areas and Complex Terrain

- terrain
- weather
- threat
- civil considerations

- political
- military
- economic
- sociological
- infrastructure
- information
- physical
- environment
- time

- sewage
- water
- energy
- trash
- medical
- safety
- others

- flow-area
- structure
- capabilities
- organizations
- people
- events

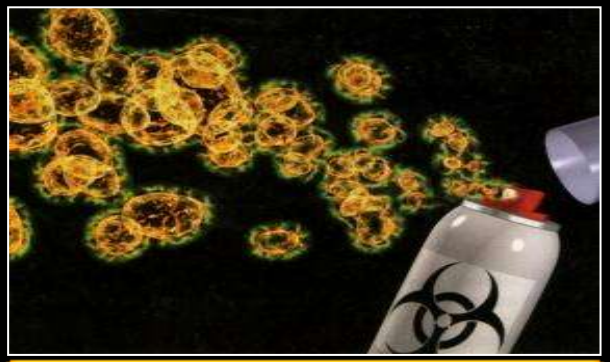
- information (from) denied access communities

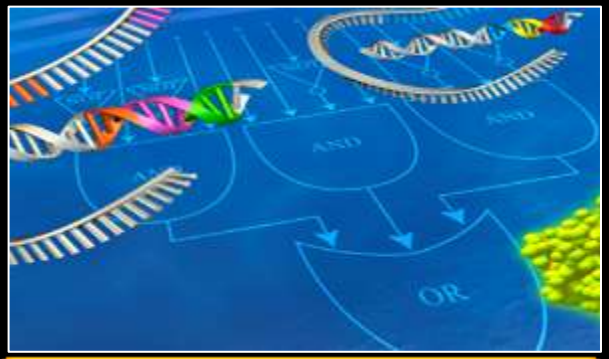
The Relentless Changing Dynamics of Infectious Diseases

old foes:
resurgent drug – resistance

omnipresent
pandemic threats

new foes:
emerging infectious diseases





global connectivities
and faster spread

bioterrorism and
dual-use technologies

new technologies: genomics
and synthetic organisms

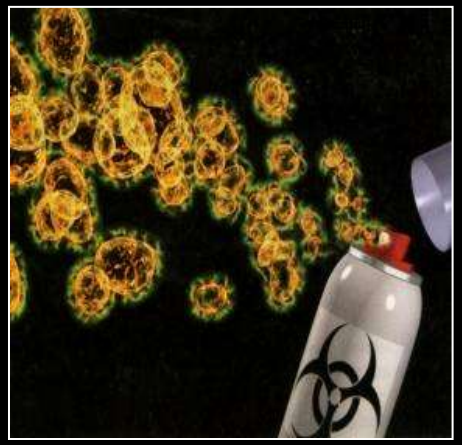
The Biosecurity Quartet

Infectious Diseases of Natural Origin

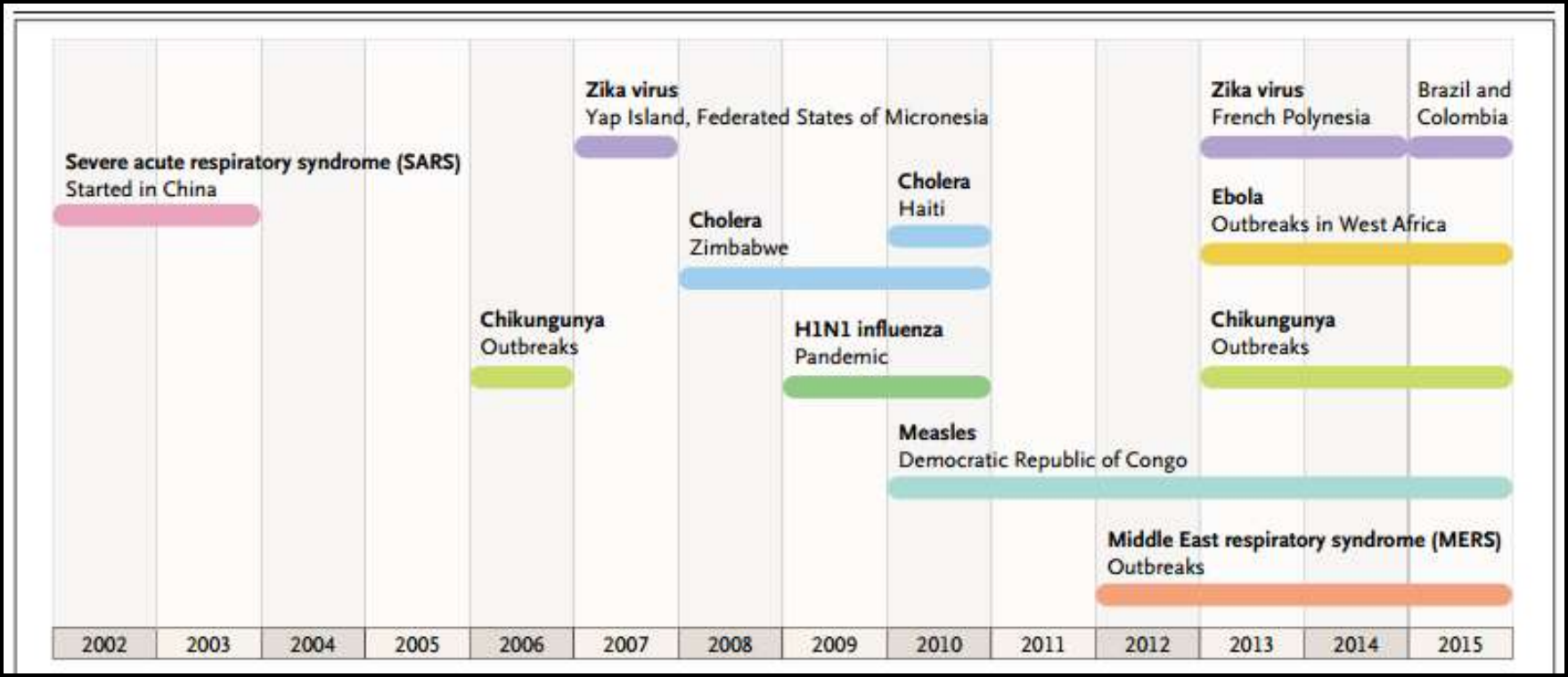
Urbanization, Environmental and Ecological Impacts on Disease Emergence and Health

Military and/or Humanitarian Missions in Dense Urban Areas

Bioterrorism, New Dual-Use Technologies and an Expanded Threat Pattern



Emerging and Reemerging Infectious Diseases (2002-2005)



pubhlth | P. Sands et al. (2016) New England Journal of Medicine 374, 1281

JOOST DE RAEYMAEKER/EPA

Locals wait in line for vaccinations in the Angolan capital Luanda after an outbreak of yellow fever.

Nature (2016) 532, 155

PUBLIC HEALTH

Fears rise over yellow fever's next move

Scientists warn vaccine stocks would be overwhelmed in the event of large urban outbreaks.

5,804,475 people vaccinated in Luanda in the past two months

Rapid Growth of Dense Urban Areas in Developing Countries: The Increased Threat of Zoonotic Diseases

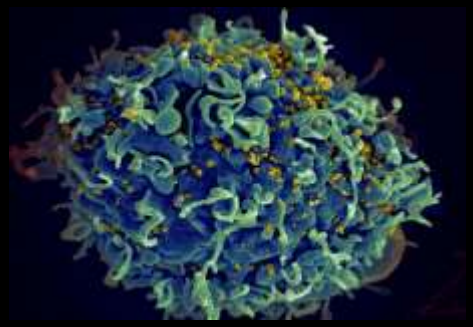
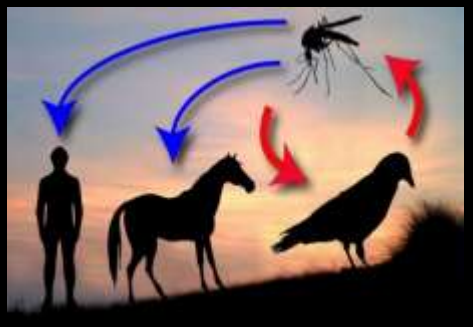
High Population Density With Inadequate Biosurveillance/Containment

Major Gaps in Health Infrastructure and Disease Reporting

Expanded Eco-niches and New Zoonotic Exposures/Risks

The Dominant Role of Zoonoses In Emerging Infectious Disease

One Health:
Recognition of the Importance of Zoonotic Diseases as Human Health Threats

pandemic (avian) influenza	HIV	West Nile virus	MERS
			
Ebola virus	**bush meat food chain**	**Zika virus**	**what's out there?**

Pandemic Influenza: Still the Largest EID Threat?

- H1N1: high transmissibility - low virulence/mortality
- H5N1: low transmissibility – high virulence/mortality
- H5N1 x (H1N1) or (X): potential for devastating pandemic

Biosecurity Implications of the Rise of Intensive Agriculture in BRIC Countries

- disruption of global food chain via diversion of grain to animal feed
- new famine risks in DCs

- intensive agriculture and proximity of large avian and pig populations in urban centers
- increased zoonotic influenza risk via bird-pig-human transmission chain

Biosecurity: The 'One Health' Concept

The Health of People, Animals, Plants and Ecosystems Are Inextricably Linked

zoonotic disease threats	feeding 9 billion	dirty water	no water
			World Health Organization
depletion of non-renewable resources	intensive agriculture and new disease patterns	climate change and new vector ranges	fragile global biosurveillance and response infrastructure

The Need for Major Reform in Global Response Capabilities to Epidemic/Pandemic/Epizootic Threats

- critical shortcomings in mobilizing and leveraging public and private sector resources
- major socio-economic impact
- need for new “network of networks”
  - surveillance, education, training
  - coalition coordination
  - private sector incentives

Ebola: West Africa 2014-2015

A Glimpse of the On-Ground Challenge of Managing Epidemic Disease In Locations With Inadequate Infrastructure and Frightened Populations

Still a Small Scale Epidemic and Relative Easily Contained Versus Challenge of Global Pandemic Incident(s)

DOD Mobilization in Ebola Virus Epidemic: West Africa 2014

Ugly Daily Scenes in Managing a Mounting Death Toll
Ebola: West Africa 2014

Denial, Fear and “Shadow Zones”: Ebola Virus Epidemic W. Africa 2014

- many of the few available treatment centers and clinics closed
- shortage of biohazard control materials
- families hide stricken individuals
- corpses buried in rural villages without adequate containment
- health workers attacked as perceived Ebola carriers
- community resistance, lack of personnel hinder both investigation and containment in the “shadow zones”

Fear and Distrust:
Proliferation of Myth and Misinformation

- deliberate spread by Governments
  - delay elections
  - genocidal assault on Kissi tribe
- deliberate spread by healthcare workers (HCW)
- treatment centers as organ harvesting operations for western countries
- attacks on HCW and contact tracers

Amplifying Fears and Resentment

forceful capture of individual who fled from treatment center

military enforcement of quarantine zone and public hostility

Shortage of Critical Biocontainment Resources = Rubber Boots on the Ground

Decontamination

The Logistics (and Risks) of Waste Disposal

Life in High Level Personnel Protection Suits in Hot and Humid Conditions: A One Hour Exercise In Exhaustion

Ebola and Managing Communications: A Critical Competency

- both a biological plague and a psychological one
- not nearly as contagious as many viruses but high lethality generated fear and irrational behavior
- fear spread faster than the disease
- myth and misinformation (local) and media sensationalism (USA) fueled fear and stigmatization

Media Sensationalism, Public Fear and Irrational Populist Decisions by Political Leadership

Ebola In Lagos 2014:
A Bullet Dodged

- fear of unchecked spread in urban slums and rapid global dissemination
- arrival of infected individual from Liberia (Patrick Sawyer)
- city's doctors on strike and refusal of Nigerian Medical Association to terminate
- rapid reaction by Nigerian government, NGOs (Gates, MSF), CDC to trace 891 at risk individuals
- advantages of high internet connectivity in contact tracing
- contained to 20 cases and 8 deaths

A Complex Choreography:
Logistics, Integration, Turf and Local National Pride

Biosurveillance and Accurate Diagnosis: Early Detection Saves Lives!

- **Ebola: West Africa**
  - **December 2013 to March 21 2014**
  - **IHE not declared until August 2014**

Every Local Event is a Potential Global Event

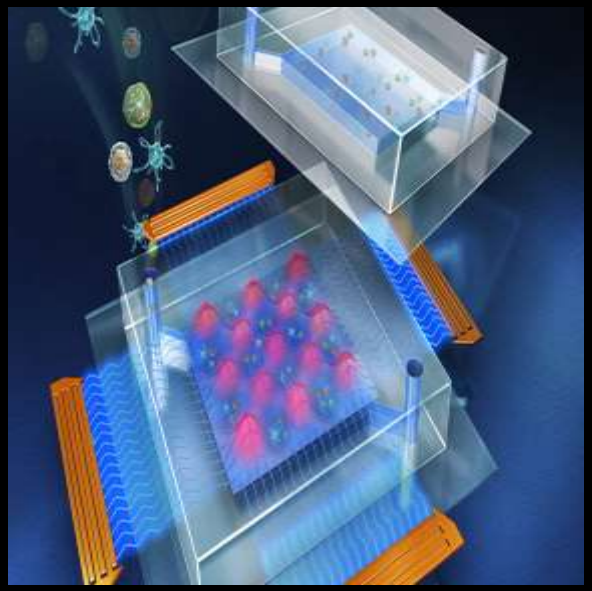
Super-Vectors

Billion Cross-Border Travelers/Year

Rapid Global Spread: Chikungunya (and Dengue)

Global Biosurveillance Capabilities

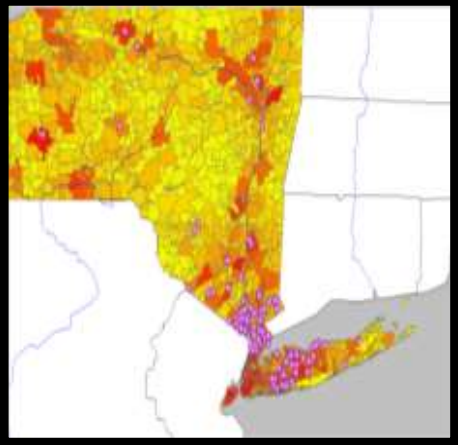
Biosurveillance - Faster Diagnosis Saves Lives:
The Primacy of Early Detection and Preparedness Mobilization

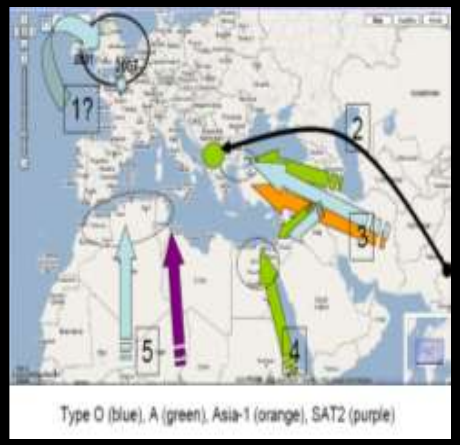
Profile	Detect	Act
		
Genetic Signatures of Infectious Agents	Distributed Rapid Automated Point-of-Need Diagnostic Tests	Real-time Situation Awareness and Decision Authority

Geodemographic Information Systems: Mapping Disease Patterns and Modeling Trends

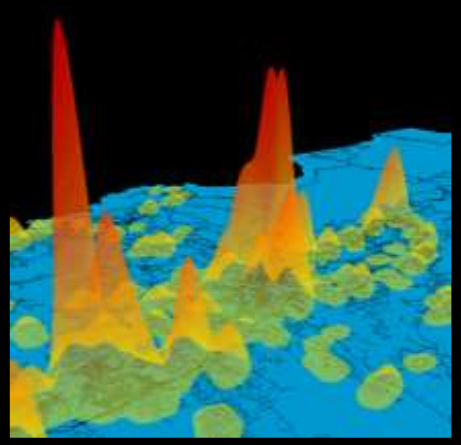
Anomaly Detection and Early Alert

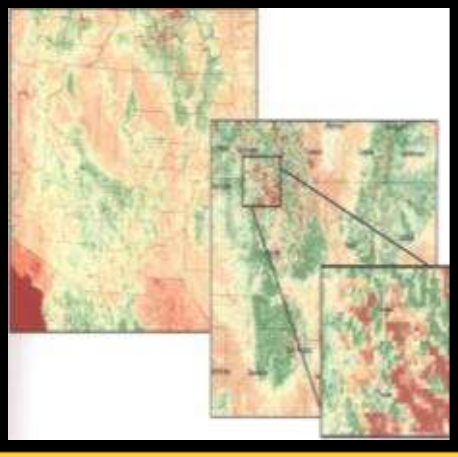
Disease Progression

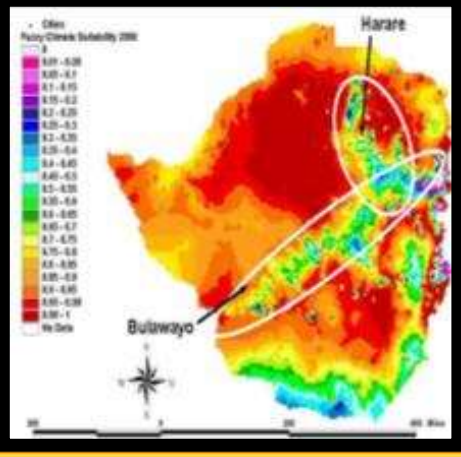




Type O (blue), A (green), Asia-1 (orange), SAT2 (purple)







Satellite Surveillance and Predictive Modeling of Disease Trends

Geodemographic Information Systems (GIS): Ground Zero Data

Comprehensive Front Line Sampling of Sentinel Species

Real-time Intelligence and Faster Preparedness

Global Disease Surveillance

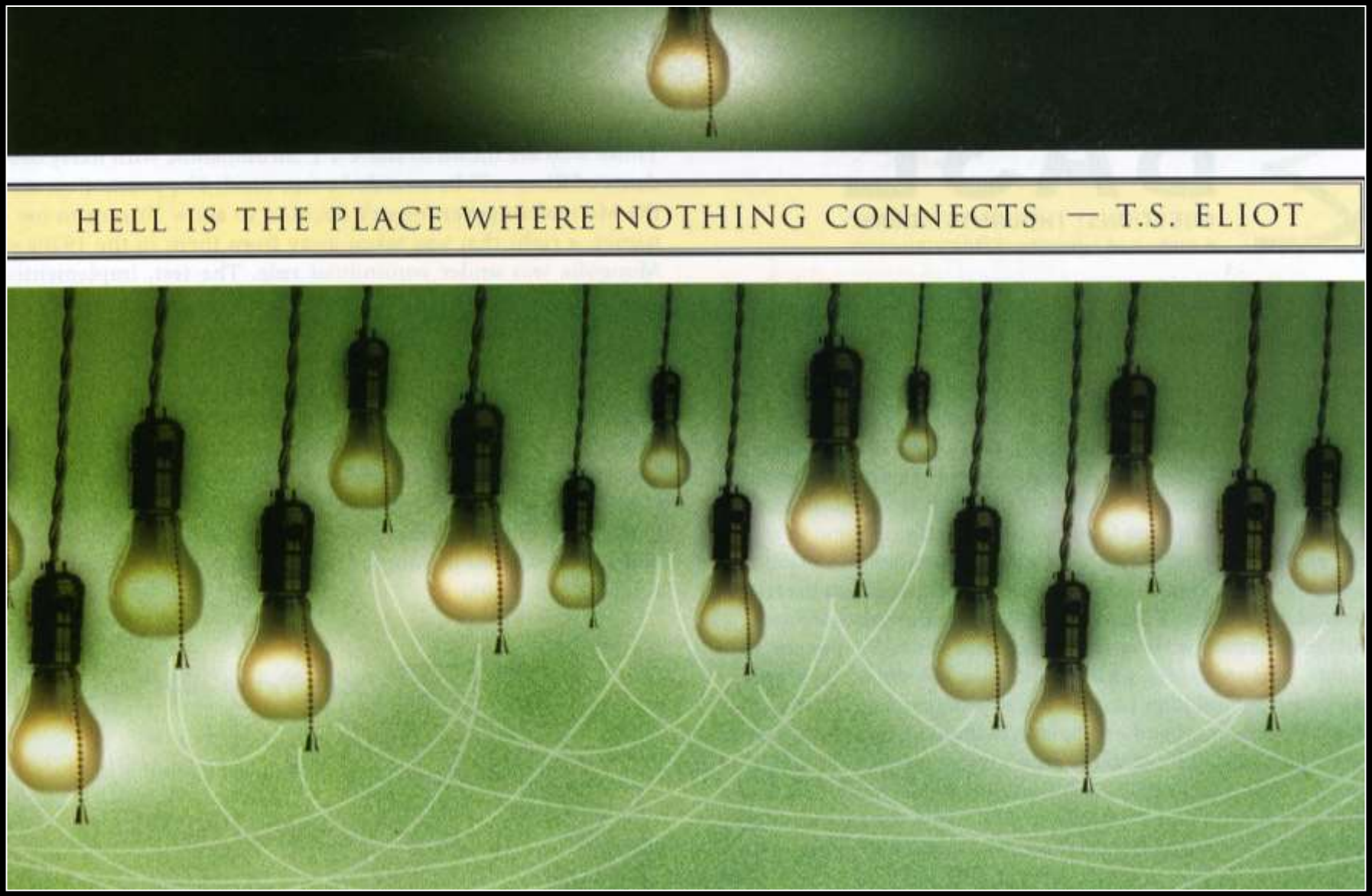
EMERGEncy ID NET

Public Health Department's Surveillance

U.S. Influenza Sentinel Provider Surveillance Network

Quarantine Activity Reporting System (QARS).

Seamless Communication Networks: A Key Success Factor in Bioincident Management



Seamless Communication Networks: A Key Success Factor in Bioincident Management

Notice the Resemblance?
Hygiene and Quarantine as the Only Controls
Absent Drugs or Vaccines

Bubonic Plague
Physician 15th Century

Ebola, Liberia
21st Century

DOD and Epidemic/Pandemic Disease

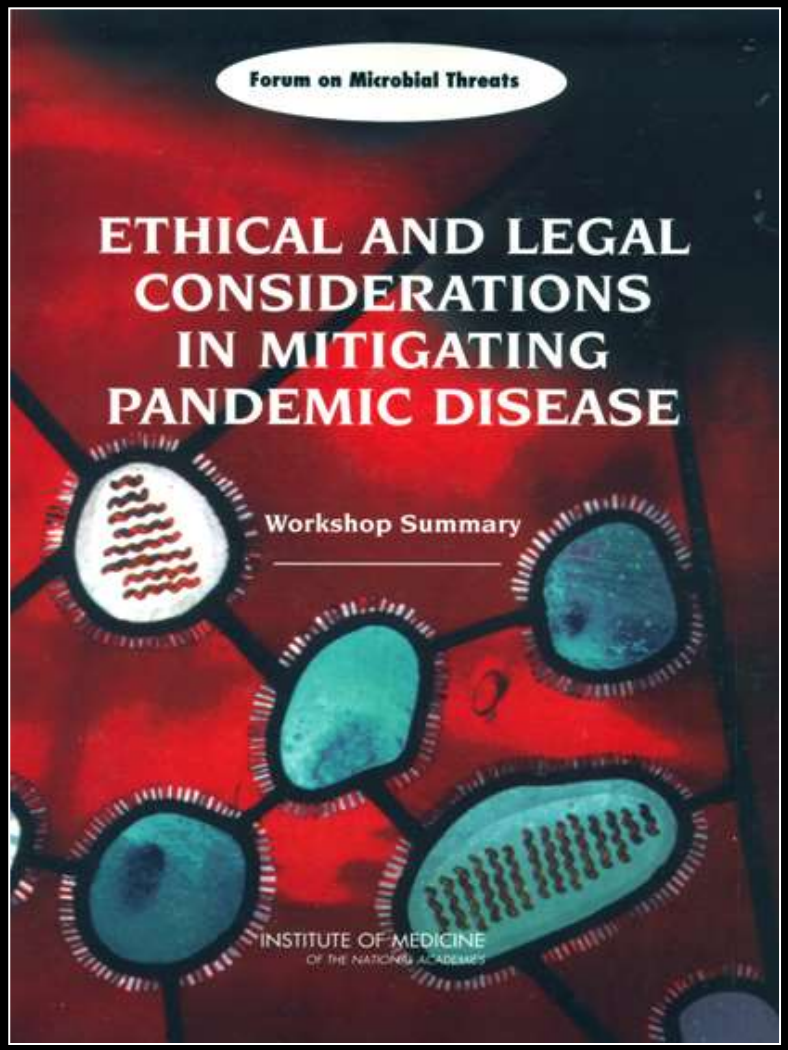
Risk in the Homeland

Posse Comitatus Applies But DOD as the Only USG Agency with the Logistical Resources to Coordinate a Robust Response to a Major Bioincident

The ‘Fog of Disaster’: Crisis Standards of Care and Proliferation of Unanticipated Events and Consequences

Control of Population Movement and Supply Chain Networks

Legal Aspects of Public Health and Counter-Terrorism Actions to Contain Bioincidents



- suspension of civil liberties
- imposition of quarantine
- triage decisions and rationing
- mandatory medical examination and treatment
- mandatory treatment with unapproved drugs and vaccines
  - informed consent
  - indemnification
  - special populations

Provision of Health Services and Force Protection in Dense Urban Area Hot Zones in Fragile and Failed States

Escalated Complexity if Combat/Counter-insurgency and Public Health/Disaster Missions Need to be Conducted Simultaneously

Constrained Mobility

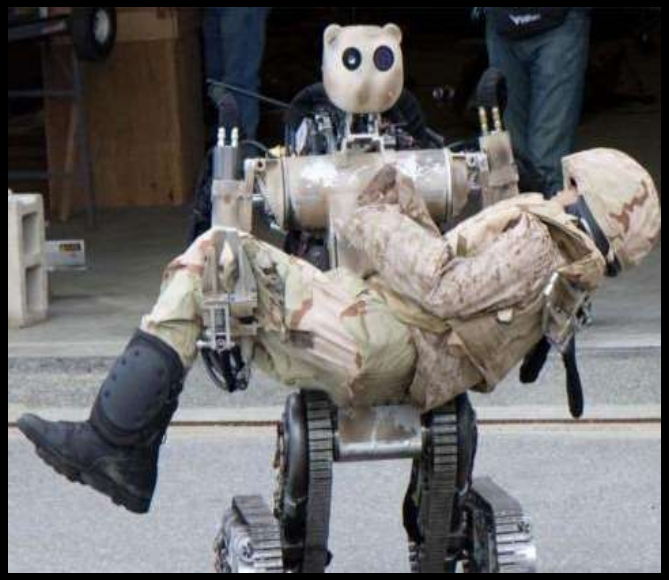
Denial of Access

Limiting Physical Infrastructure Destruction and Alienation of Previously Supportive Non-Combatants

- non-lethal weapons and riot control
- stun guns
- temporary immobilizing sensory/cognitive modalities
- new see-through capabilities for buildings and subterranean structures
- unmanned systems

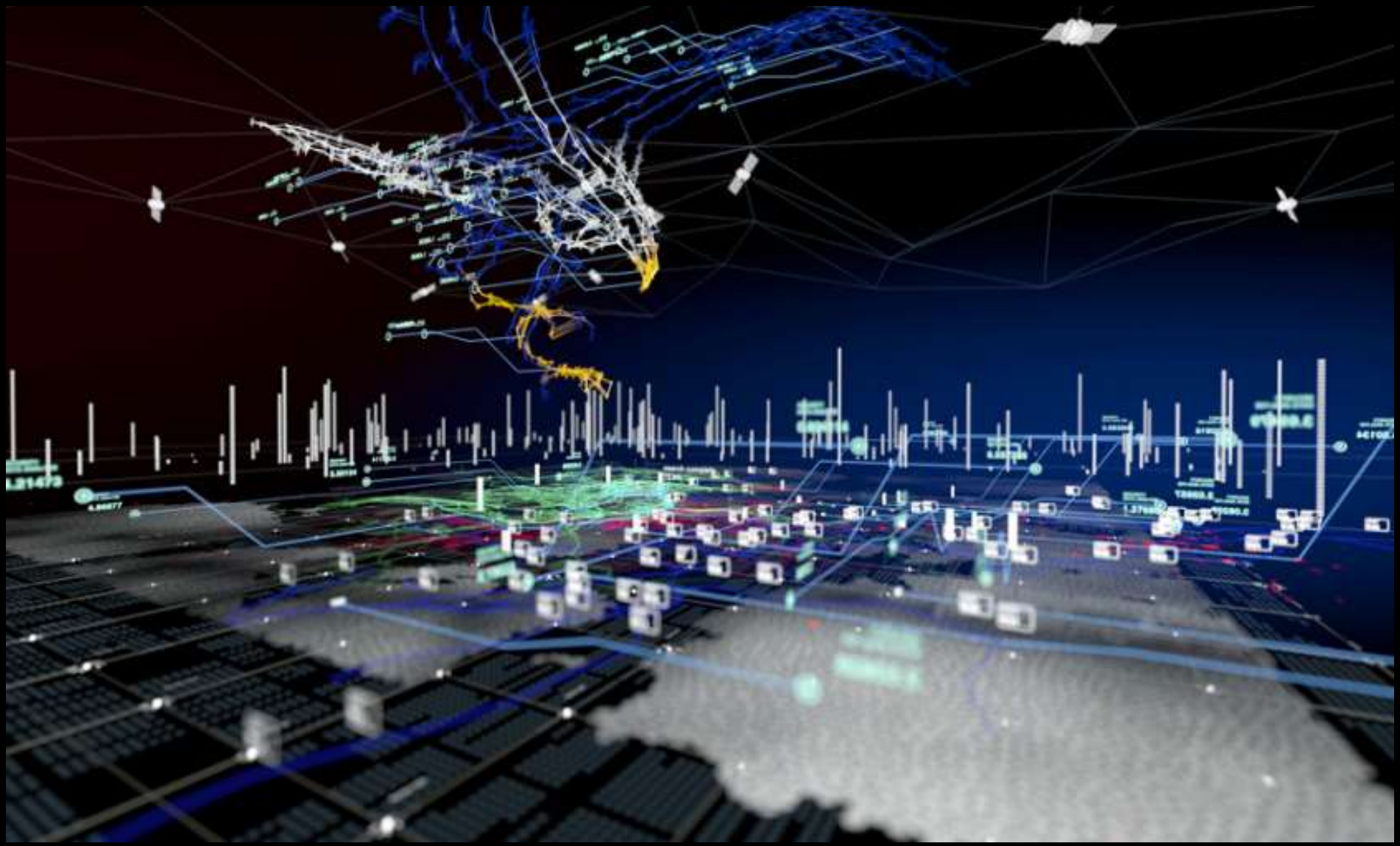
‘The Golden Hour’ and the ‘Platinum Ten Minutes’ Casualty Care and Extraction

Unmanned Systems (UMS) in Support of Medical Operations in Dense Urban Environments and Complex Terrain

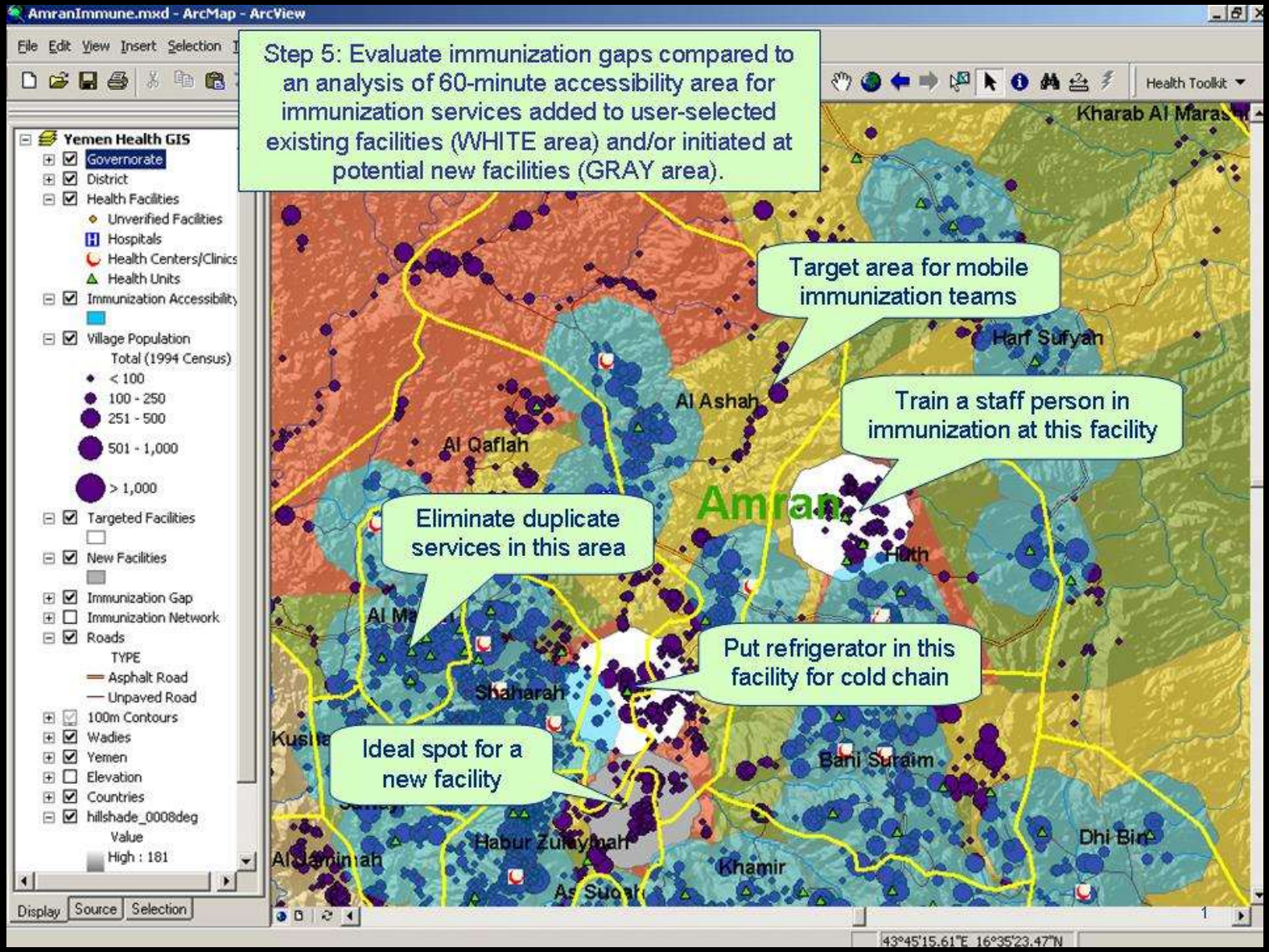


- UMS as force multiplier for wide range of missions including medical logistics
- area denial challenges and restrictions on air and ground MEDEVAC/CASEVAC platforms
- DARPA's Aerial Reconfigurable Embedded System concept includes a detachable module for CASEVAC
- Uncertain capacity to deal with mass (civilian) casualties

Big Data and Analytics: Integration of Diverse Data Streams for Comprehensive Situational Awareness of Health Status and Biosecurity Risks



Mapping Epidemic Disease and Targeting Hot Spots for Immunization



JUNE
2014

Creative Disruption
Technology, Strategy and the Future of the Global Defense Industry

By Ben FitzGerald and Kelley Sayler

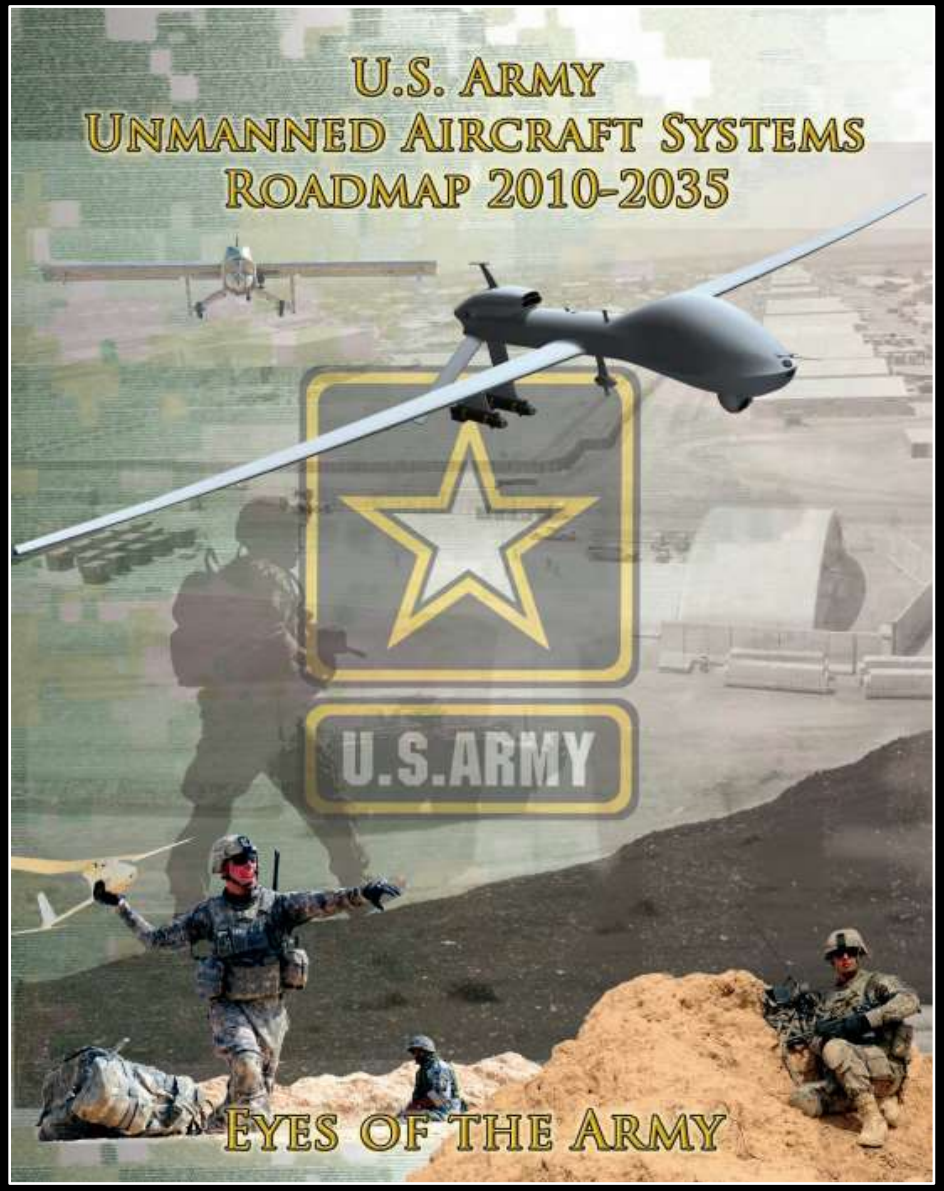
Foreword by the Honorable William J. Lynn III
and ADM James Stavridis, USN (Ret.)

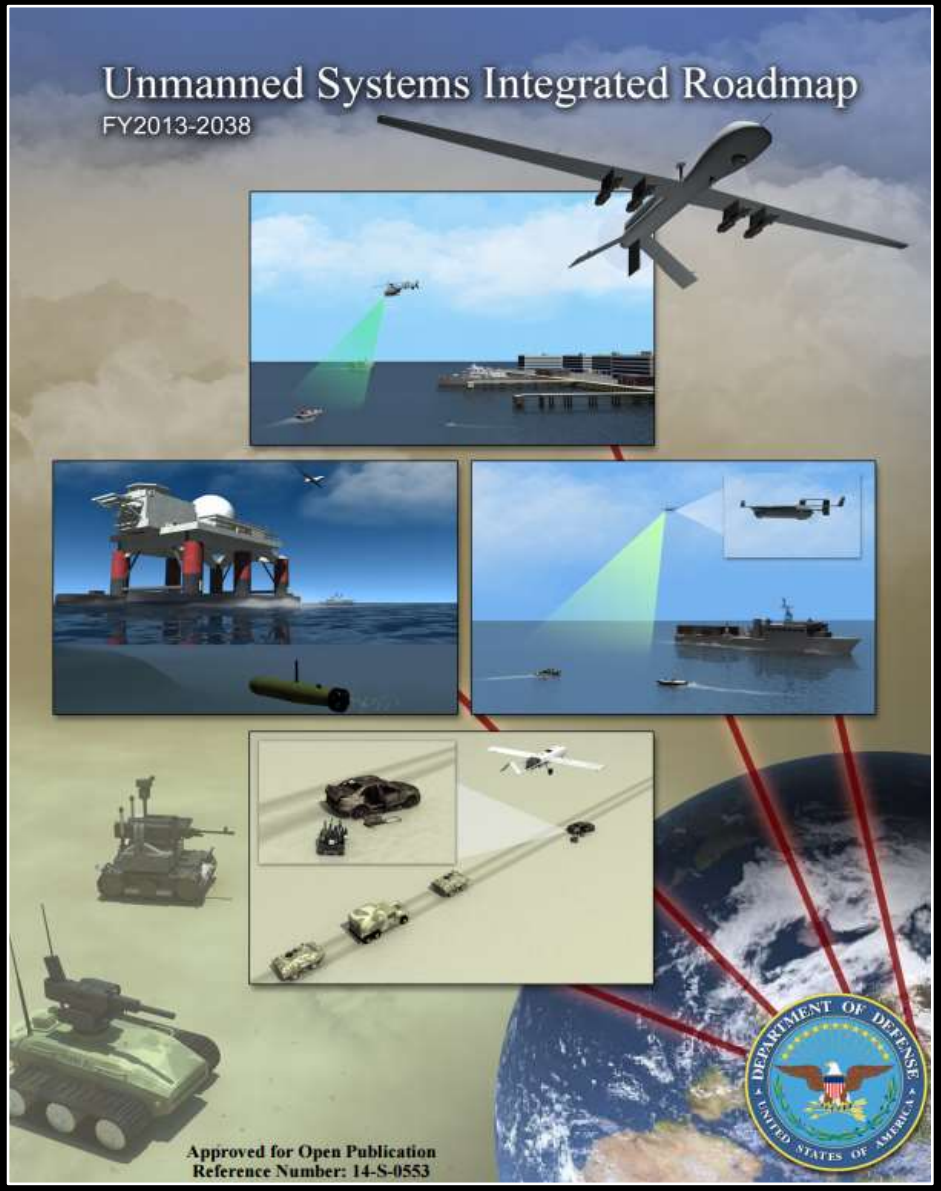
Center for a
New American
Security

THE DEFENSE SCIENCE BOARD REPORT ON

Technology and Innovation Enablers for Superiority in 2030

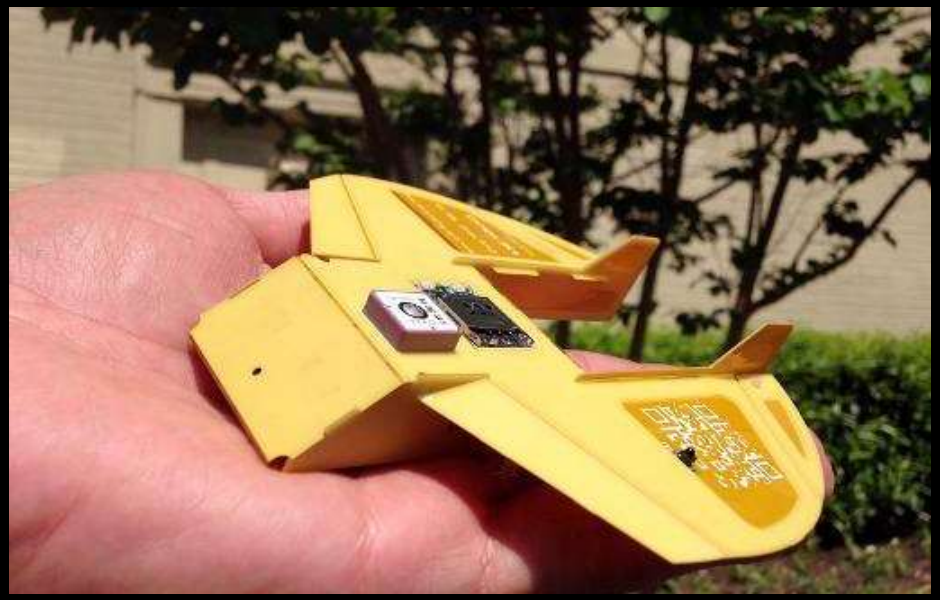
OCTOBER 2013


U.S. ARMY
UNMANNED AIRCRAFT SYSTEMS
ROADMAP 2010-2035
U.S.ARMY
EYES OF THE ARMY


Unmanned Systems Integrated Roadmap
FY2013-2038
DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA
Approved for Open Publication
Reference Number: 14-S-0553

amazon
PrimeAir

Cicada: Covert Autonomous Disposable Aircraft



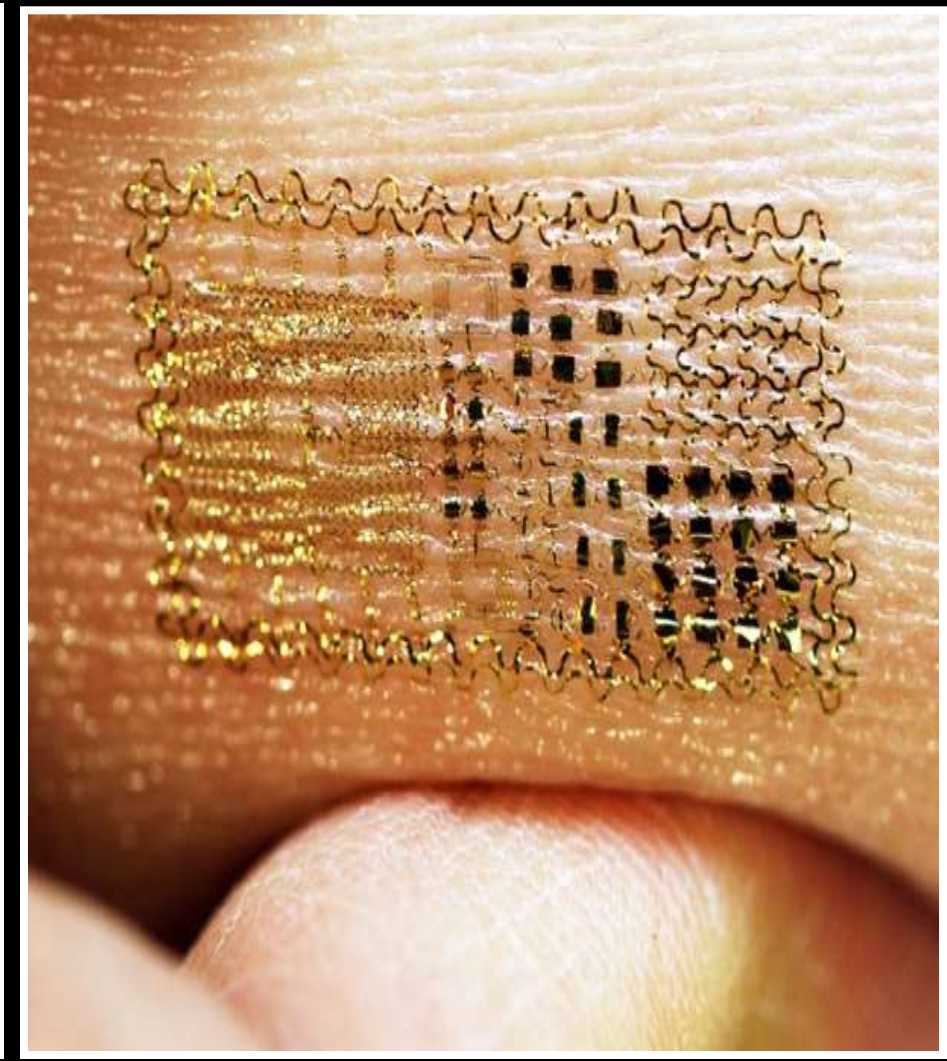
Teaming, Interoperability and Human-Robot Interfaces in the Evolution of Unmanned Systems (UMS)

- projected proliferation of UMS and functionalities
- integration of manned-unmanned systems
- current limited interoperability for command and control of disparate UMS
- almost no current UMS to UMS direct communication capabilities
- development of UAS Control Segment (UCS) as common framework for operator:UMS interactions
- future realization of DARPA's 'Gremlins' program?

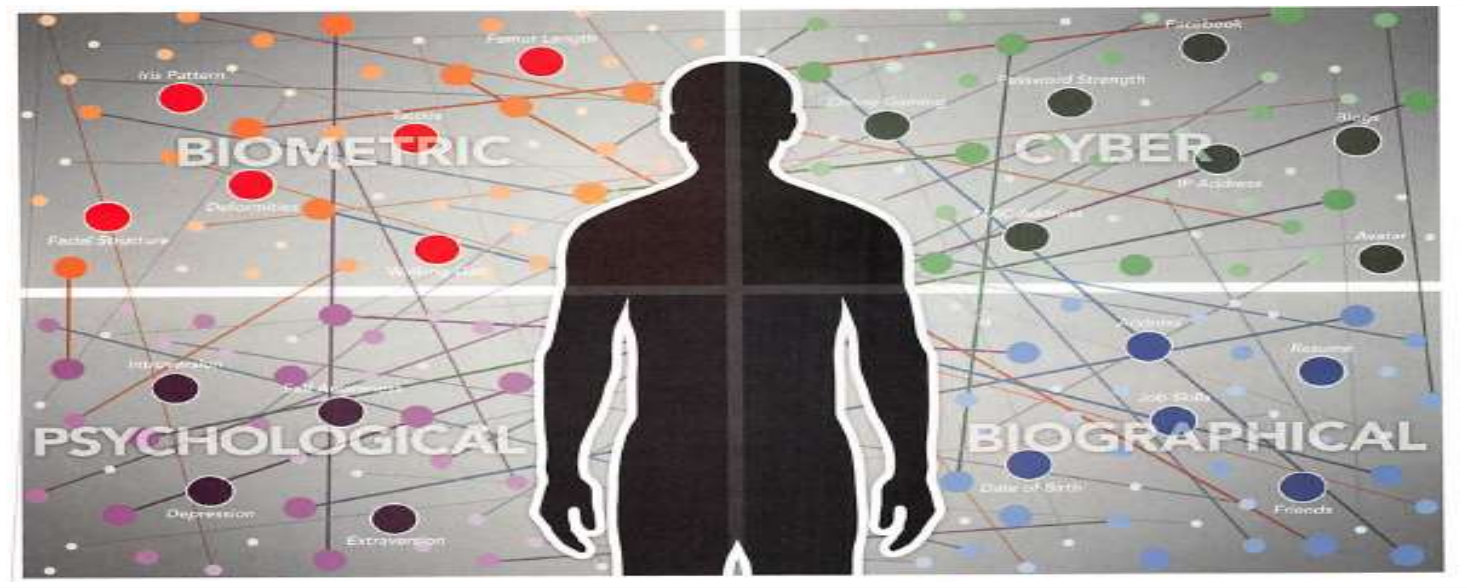
Sensor Webs and the Internet-of-Things (IoT)

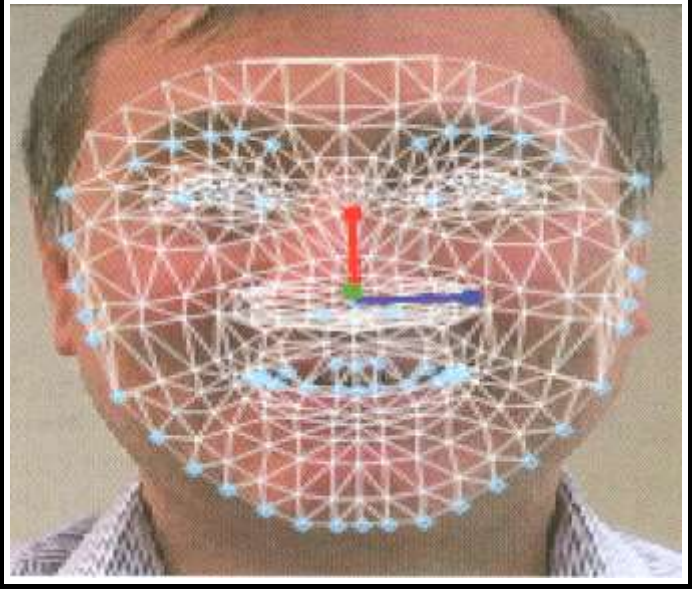
- instrumented, interconnected, interactive and intelligent network(s) of sensors and devices
- pervasive/ubiquitous sensing of diverse environments/analytes
- critical features
  - sense-compute-actuate (SCA) loops
- next-generation features/traits
  - reconfiguration, repair and regeneration
  - intelligence and evolvability

On Body: In-Body Sensor Systems for Real-Time Remote Monitoring and Evaluation of Health Status



Large Scale Integration of Diverse Data Streams for Situational Awareness of Health Status and Biosecurity Risks





Mobile Devices, Disease Tracking, Contact-Tracing and Education

IOT, Social Networks and Social Media: Real-Time Data on EIDs and Environmental Threats

- rich data streams at ground zero and point-of-need (PON), point-of-care (POC)
- continuous surveillance and data for risk communication, operational status planning and bio-incident modeling
- valuable force health multiplier in forward deployed environments with limited human resources, laboratory support, bandwidth and time
- new bioinformatics analytics to reduce uncertainty quantification for decision support
  - DTRA, LANL (EpiEarly, EpiRapid, EpiAgent, BARD, SWAP, EPIC)

Social Media Flash Mobs and Social Swarming
"The Revolution Will Be Tweeted"

Arab Spring	Occupy Wall Street Movement	London Rioters

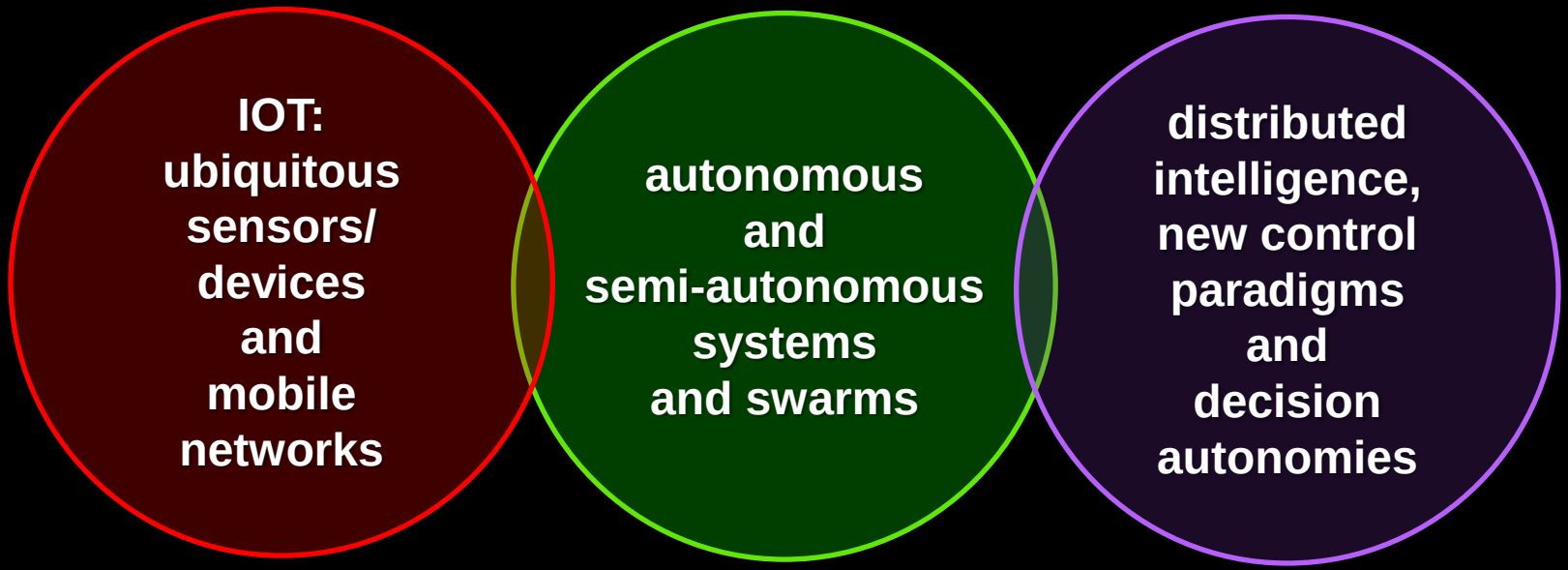
Radical Transparency:
Where Every Action by US Military/Law Enforcement/Disaster Responders Will Be Recorded and Tweeted

New Categories of Real-Time Intelligence Data

- every on ground individual and every device is a potential information node
  - self reported (friendly) or surveilled (neutral or hostile)
  - source, recipient or both
- integration with traditional standoff ISR assets

Geospatial Identification of Structures and Individuals and Real-Time Monitoring of On-Ground Events

Intelligent Systems and Extended ISR Reach



- persistent surveillance
- data diversity, integration and analytics
- machine learning and intelligence at ingestion
- decision support systems

Biotechnology and Synthetic Biology:
The Rapid Growth of New Dual-Use Technology Threads

Synthetic Biology, Genome Editing and National Security: The Ultimate Dual-Use Technology for Modification of Biological Systems?

Statement for the Record

Worldwide Threat Assessment
of the
US Intelligence Community

Senate Select Committee on Intelligence

James R. Clapper

Director of National Intelligence

February 9, 2016

Genome Editing Listed In The Top Six Threats

Technology Diffusion, Automation and Simplification

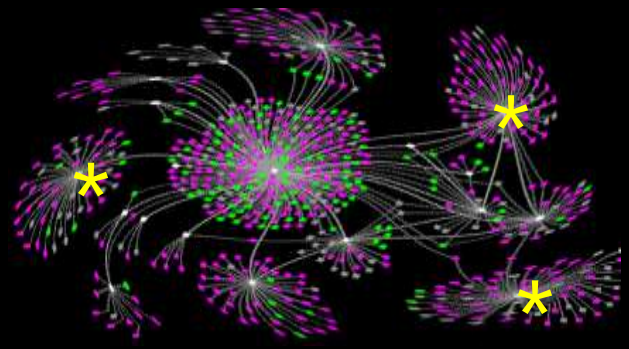
Outdated CBW Convention: New International Oversight Needed

New Technologies and Increased Complexity of Dual-Use Issues in Biosecurity: Synthetic Biology, Genome Editing and Manipulation of Biological Circuits

digital biology: "it from bits"

de novo synthesis of organisms

engineered virulence



华大基因学院
BGI college
华大基因研究院
BGI research

targeted modification of any biological circuit in any organ

mapping neural circuitry and brain – machine interfaces

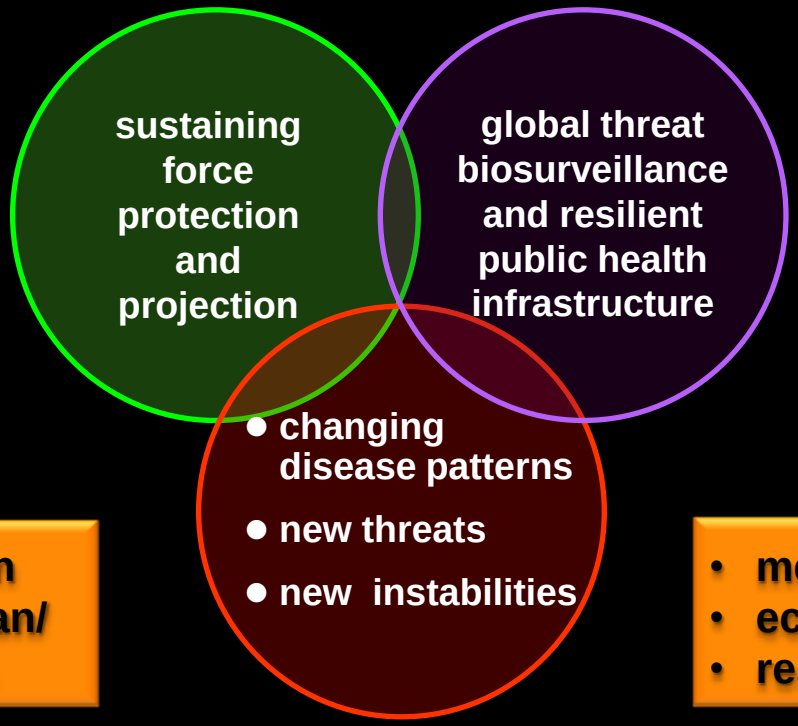
accelerating technological diffusion

Biosecurity: Health Matters!

military: strategy/conops

civilian sector: global public health

- **operations in dense urban terrain**



- **global connectivities and potential rapid spread of zoonotic EIDs**

- **changing balance in combat/humanitarian/ stability operations**

- **megacities and DUAs**
- **ecosystem deterioration**
- **resources depletion**

- **bioterrorism**
- **dual-use technologies**

(Re)Building Robust Global Public Health Preparedness and Resilient 'All Hazards' Capabilities

- major vulnerabilities exist across the full spectrum of biosecurity
  - pre-emptive detection and interdiction
  - rapid diagnosis at point-of-need
  - healthcare resources for mass casualty management
  - drug and vaccine coverage (quantitative and qualitative)
  - outdated public health laws (national/international)
  - emergency control of media/commerce
- stark inadequacies in international mobilization and cooperation

Dangerous Vulnerabilities in the Homeland

United States Government Accountability Office

GAO

Testimony
Before the Committee on Homeland Security and Governmental Affairs
U.S. Senate

For Release on Delivery
Expected at 10 a.m. ET
Thursday, April 14, 2016

BIODEFENSE

The Nation Faces Multiple Challenges in Building and Maintaining Biodefense and Biosurveillance

Statement of Chris Currie, Director, Homeland Security and Justice

GAO-16-547T

A NATIONAL BLUEPRINT FOR BIODEFENSE:

LEADERSHIP AND MAJOR REFORM NEEDED TO OPTIMIZE EFFORTS

BIPARTISAN REPORT OF THE BLUE RIBBON STUDY PANEL ON BIODEFENSE

October 2015

Institutional Sponsors: Hudson Institute

Ugly Realities

- minimal to no prospect of building suitably robust urban ecosystems and comprehensive public health services in most DCs over next 10 years
- scale of deficits in infrastructure, educational, social, economic and political systems as major barriers to adoption of solutions from developed countries
- persistent asymmetries and inequities will escalate the probability of DOD engagements in both combat and non-combat missions in dense urban areas, many with major risks to force protection

Biosecurity:
A Neglected Dimension in DOD Doctrine and National Security Policy

- accelerate new military capabilities and training for increasingly diverse missions in unstable/anarchic dense urban environments, including infectious disease “hot zones”
  - combat, counter-insurgency, terrorist-criminal nexus
  - global health and humanitarian missions in same OE’s
  - new complex logistics needs
  - increased use of robotics and unmanned autonomous systems
  - big data analytics and machine intelligence
  - training facilities and preparedness
  - coalition coordination capabilities
- more proactive analysis of new national security risks and intelligence requirements arising from technology acceleration and convergence in the life sciences

Slides available @ http://casi.asu.edu/