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# ***Two Macro Revolutions and the Battle for Control & Prosperity in the Digital World***

***Reflecting on Historical Trends to offer a Framework for  
Thinking about Today and the Future***

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North Dakota State University  
Fargo, ND**

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# ***Bottom Line Up Front: Cyber Problem is the “First among Equals” in a dynamic time***

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- Two Macro Technological Revolutions underway:
  - Intelligent Machines in motion....in human space
  - Intelligent Machines at Rest: Digital information processing at home, and across the planet
- Tech Leaders have three tasks: C<sup>3</sup>
  - Create the technology, it is a competitive race (e.g., robots, routers, internet art, businesses, services)
  - Control the Technology (**the main topic here today**)
  - Civilize the Technology (eg., law, policy, sociology, .... Leaders in these fields must all shoulder a load)

*But at this point in history.... **Control (the Cyber problem)**, is the first among equals: what if you can't control what you create?*

# Technological Change as *THE* Driver of our Time

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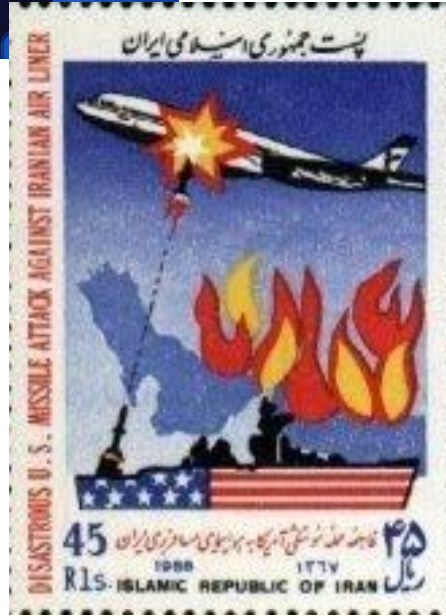
- ❑ Mazarr, “Un-Modern Men in the Modern World”
- ❑ Kelly, “What Technology Wants”
- ❑ McAfee/Brynjolfsson, “Race Against the Machine”
- ❑ Beniger, “The Control Revolution”
  
- ❑ ***Significance of Robotics, Information, and Cyber?***
- ❑ Singer, “Wired for War”, “Cyber Security and Cyberwar”
  
- ❑ If you have time... Olson, “We are Anonymous” (for the human factor); Gleick, “The Information”
- ❑ And... Kasson, “Civilizing the Machine” (to inspire the lawyers/humanists/religious leaders in the group)

Unclassified





# My personal misunderstanding of the Emerging Nexus of the Human, Machine, and Information



I served on the sister ship of VINCENNES after it shot down the airbus...was in OSD when insurgencies broke out in Iraq & Afghanistan



# Theory 1: Tech Change is three stage, and “late stage” changes are dangerous

- ❑ **Early**: society exerts most influence. Change is easy.
- ❑ **Middle**: momentum accumulates around the invention (e.g., capital, labor, political)... change is harder.
- ❑ **Late**: technology appears “beyond social control”, or “technology out of control”...change all but precluded...
- ❑ **Change in “Late Stage” can come with Near Disaster**
  - Cuban Missile Crisis energized nuclear arms talks
  - Fukushima stopped nuclear power trajectory in Japan

**Our Challenge is Greater because of the momentum of Internet Design made 40 years ago!!!**



## ***Theory 2: Human innovation seeks to improve the “Sensing-Thinking-Acting” cycle... a force of nature?***

### □ Sensing

- Human Senses (sight, hearing, taste, feel, smell)
- Machine sensing: Radar, Sonar, Infrared etc

**Signal** →  
**Entropy**

(COMMUNICATION LINKS)

### □ Thinking

- Human Decision maker (brain)
- Computer/Computation (early analog, now digital)

**Signal** →  
**Entropy**

(COMMUNICATION LINKS)

### □ Acting

- Human body (limbs...walking, holding, etc)
- Human-Machine integration (cars, planes, ships)
- Machine (unmanned air systems... robots)

## *Theory 3: Dual Macro Revolutions*

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- As distinct from multiple, preceding and coincident micro-techno revolutions... the **“Macro”** revolutions are combinations of multiple technologies which create an entirely **new**, never before seen, **structure of economic/social/military activity**.

## **3a. Macro Revolution: Autonomous technology creates a 'Machine Realm' of Econ/Social/Mil Activity...**

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- In pursuit of S-T-A advantage, third Realm emerges
  - 1<sup>st</sup>: Social-Human Realm
    - (apprx 10,000 BC-
  - 2<sup>nd</sup>: Integrated Human-Machine Realm
    - (apprx 1588AD-
  - **3<sup>rd</sup>: autonomous, intelligent Machine Realm**
    - (apprx 2014-??)

# 3b. Macro Revolution: Critical Mass of Communication, Thinking, and Knowledge goes Online... the Internet

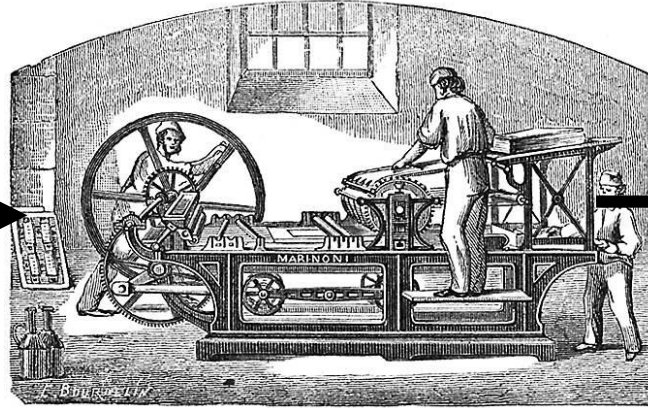
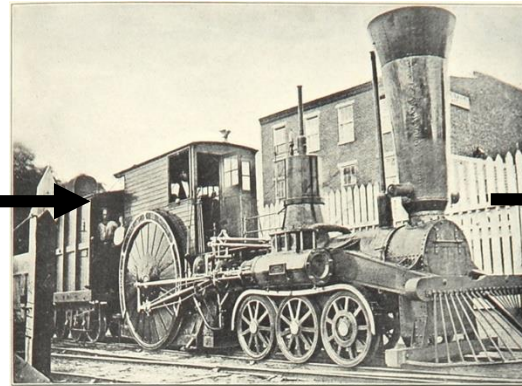
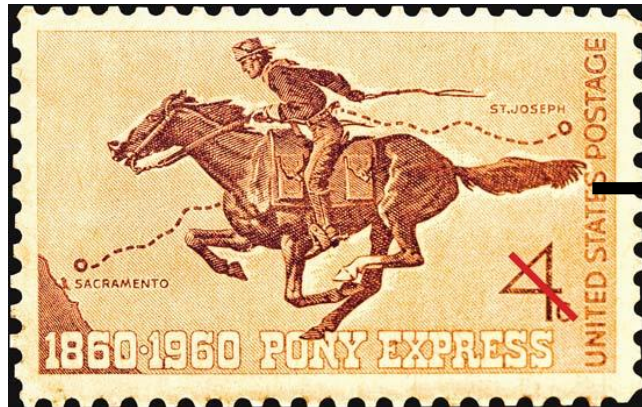
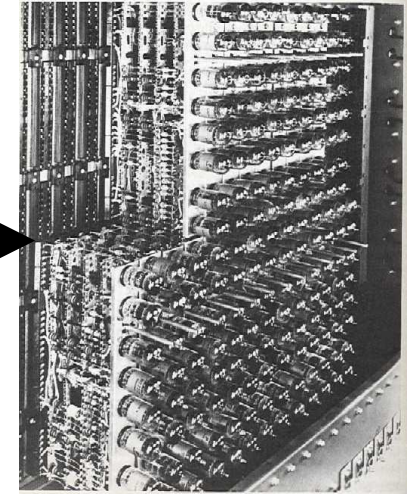


Fig. 3. Machine simple.

oldbookillustrations.com



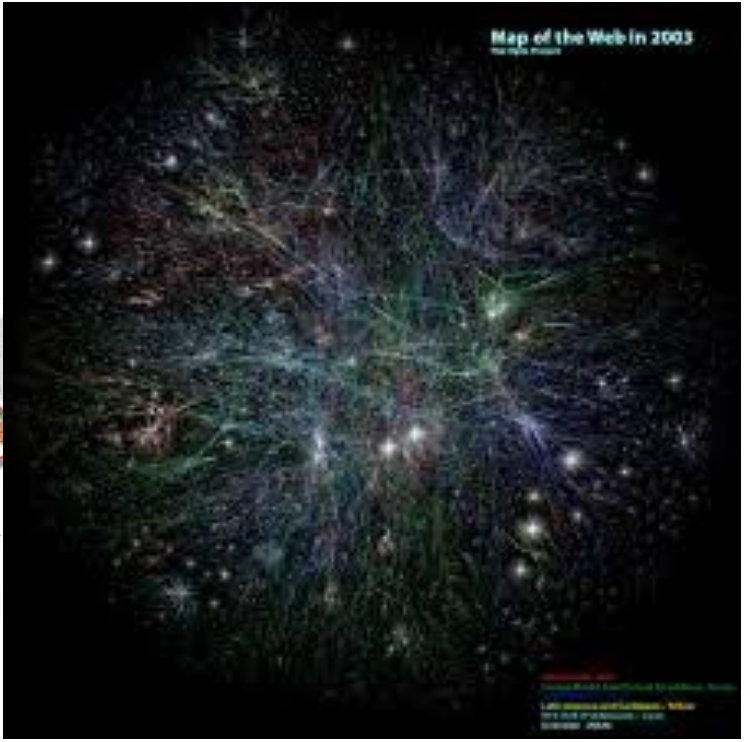
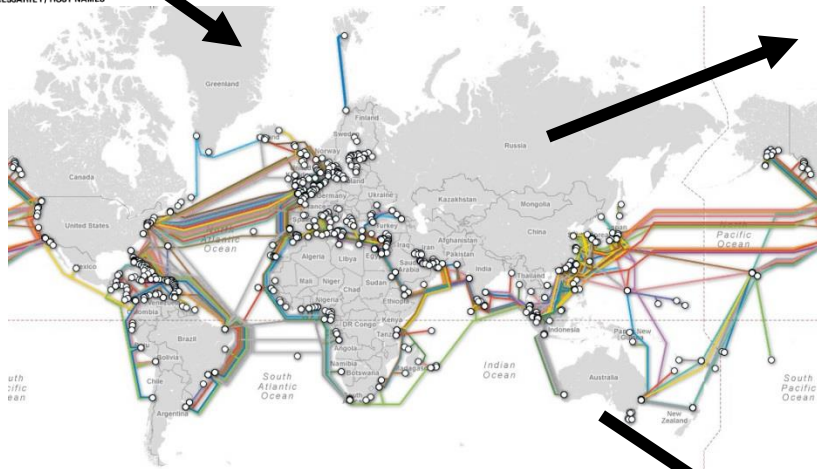
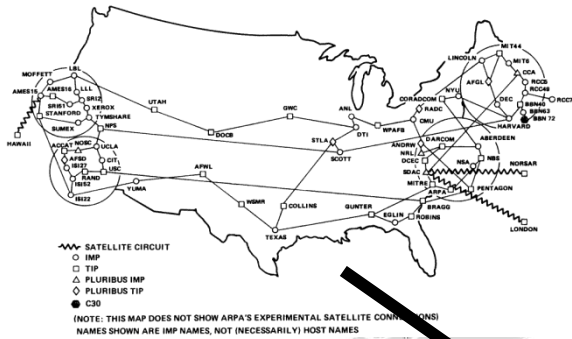
AN EARLY LOCOMOTIVE BUILT BY WILLIAM NORRIS FOR THE PHILADELPHIA & READING RAILROAD



wiseGEEK

# 3b. Knowledge Storage and Communication at Speed of Light...the Internet ...across the Globe

ARPANET GEOGRAPHIC MAP, OCTOBER 1980



**Internet of Things (IOT)**

***But the “Kicker”:* all three Realms of physical action as well as the Global Info System/IoT can be attacked...**

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- 1<sup>st</sup>: Social-Human Realm (est 10,000 BCE-
- 2<sup>nd</sup>: Integrated Human-Machine Realm (est 1588-
- **3<sup>rd</sup>: Autonomous Machine Realm (2015-**



**‘Cyber Power’ can be exerted across the Three Realms and the Global Info System/IoT... resulting in a world of contested ‘netted’ humans and machines**

# *Recent Evidence of Accelerating Change*

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- ❑ Electronic/Computer systems under siege
  - Only 12 computer viruses in 1988...now in 2015, approximately 200,000,000 (200 million)
- ❑ Robotic Revolution
  - Countries producing or designing unmanned systems: 2001, <10, now 2015, approximately 80+
- ❑ Social Media a Disruptive Force
  - Middle East turmoil following a “Twittered” Arab Spring 2011
- ❑ Big Data/High Performance computing/AI
  - “Watson” beats the human in Jeopardy 2011

# *Review Thesis: Two Macro Revol and Cyber Battle for control will be a Generational Challenge*

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- ❑ 1. Emergence of a New Realm of action: Autonomous Machine activity that is ambulatory intelligent actors in our physical world
- ❑ 2. Electronic Netting of the World of Humans and Machines...intelligence (brain) at 'rest'.
- ❑ Challenge: 'cyber' security ... battle for control...who or what will exercise power?

**What is Historical evidence? How to “Frame” and Display these Revolutions? Cyber?**



## ***Gain Perspective: step back and look at the historical trajectory/trend of technology....***

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- “ ... because our teachers ...focus their attention only on the present or at the most on the very recent past, they find the present more and more difficult to explain. They are like oceanographers who refuse to look at the stars because they are too remote from the sea, and consequently are unable to discover the causes of the tides.” Marc Bloch, French historian and veteran of WWI and WWII, tortured and killed by the Gestapo while fighting as part of the French Resistance

# ***A Tool and Framework for Thinking...***

# At first...there existed one realm of warfare/activity: the Social-Human Realm

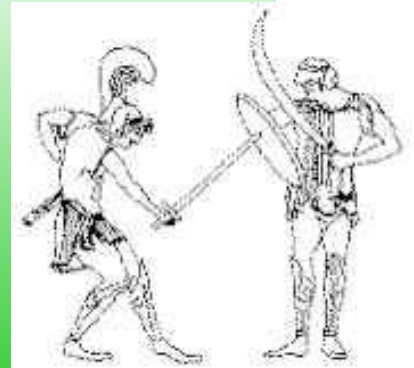
- Most of history and pre-history, the social-human factor was decisive action in war:
  - Human wit, will, strength, and ability to persuade....
  - Tools magnified or leveraged human strength, or protected the human body.
  - Humans dominated the **Sense-Think-Act** sequence



# One Realm of Warfare.... 'Social-Human' factors dominate Sensing-Thinking-Acting

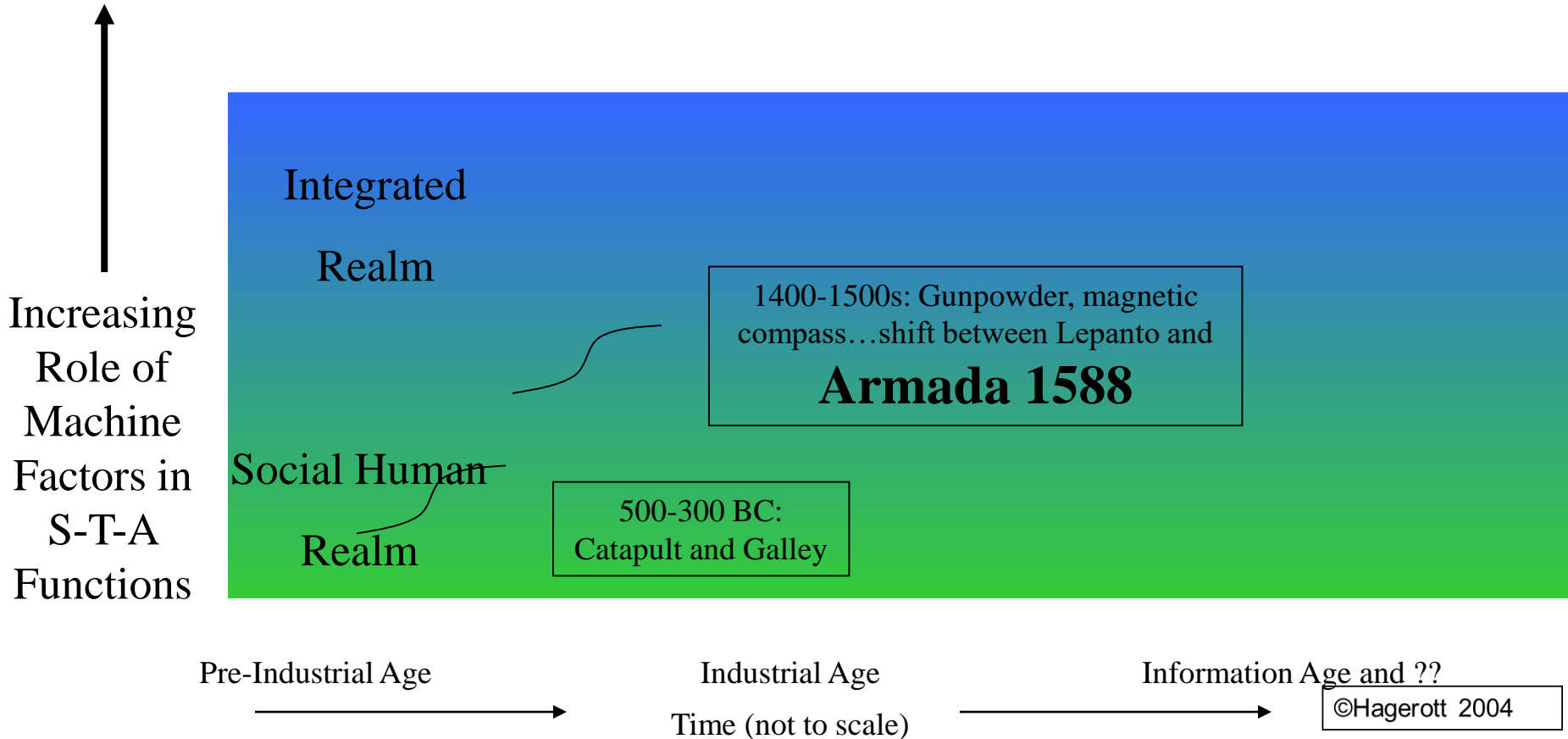
Social-  
Human  
Factors  
Dominate  
S-T-A

Social- Human  
Realm



Enter Accelerating Technological Innovation,  
Increasing Complexity, and the more tools to  
better Sense-Think-Act (S-T-A)

# Waves of Innovation increases Human-Machine S/T/A integration in war...evolving the 2<sup>nd</sup> Realm



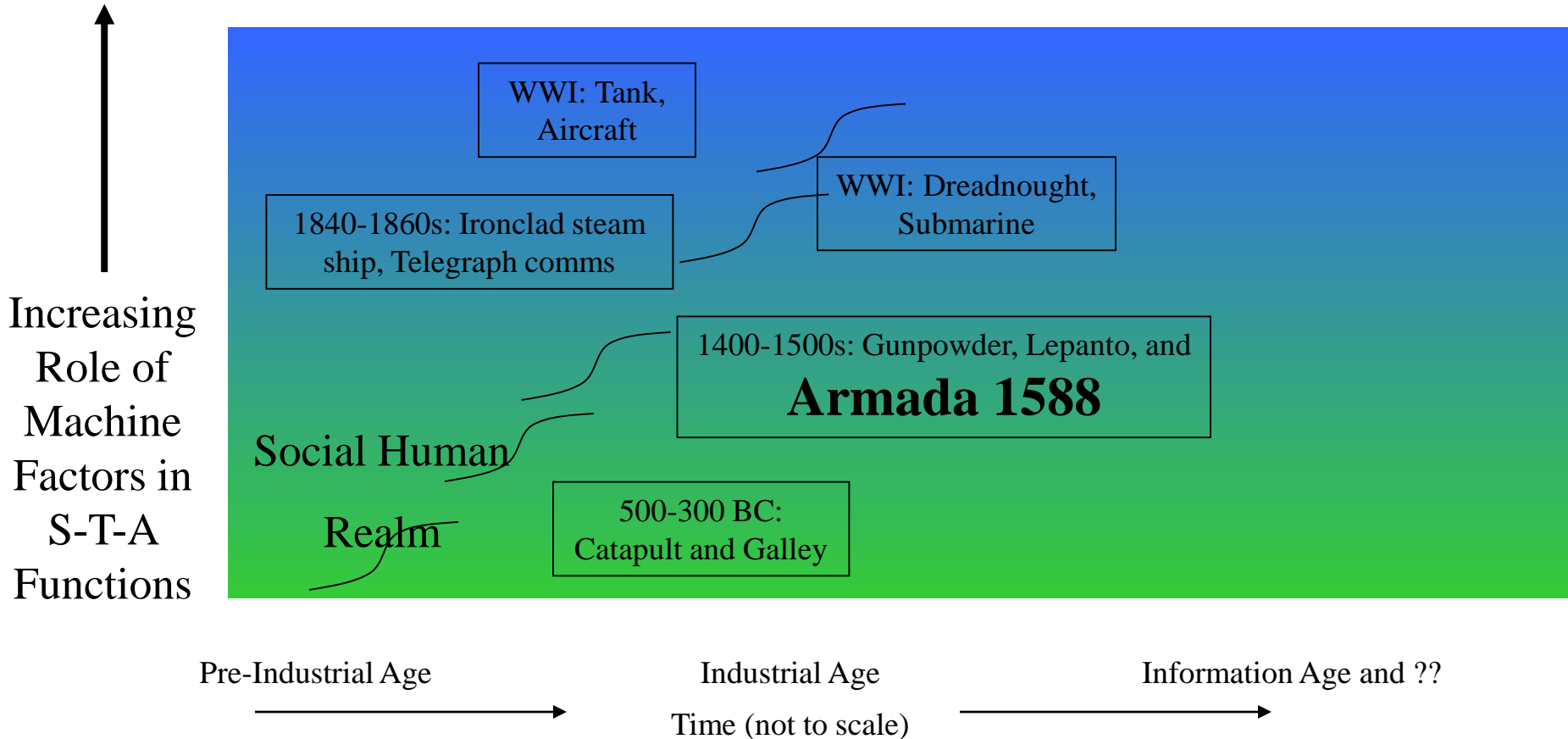
# “Integrated Realm” emerges...Machines and specialists replace human mass...first at sea



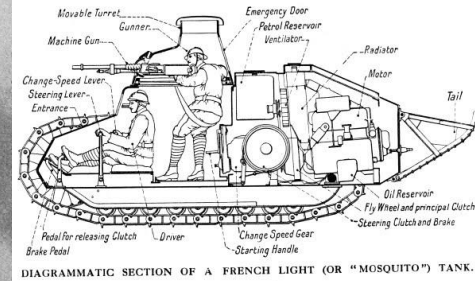
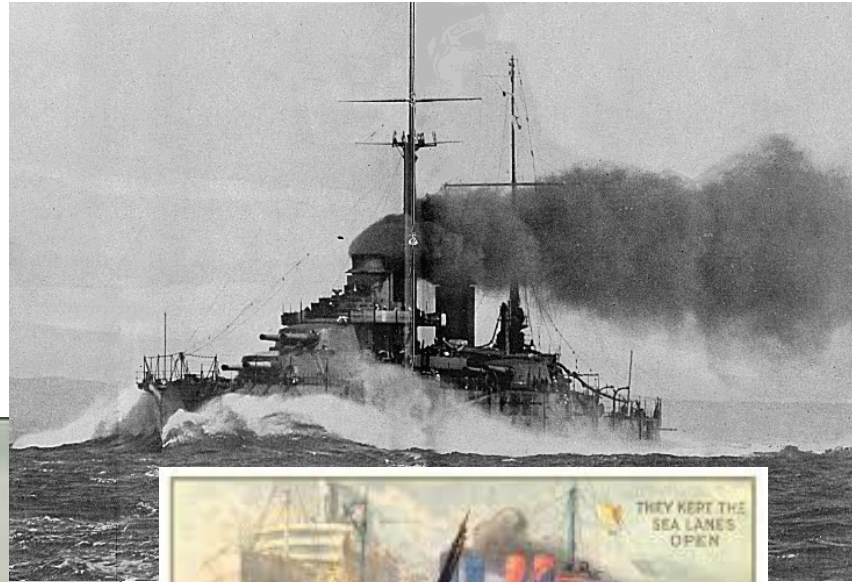
Social-Human Realm: 1571 Battle of Lepanto dominated by mass infantry battles fought on/across fleets of galleys....

To Integrated Realm: 1588 Battle of Armada the English embark **ZERO INFANTRY** and fight an artillery duel at sea on ‘ships of the line’

# Waves of micro-Innovations... create an Integrated Realm of human & machine on Land and in the Air



# Human & Machine team up to create “Integrated Realm” of war, but confused leaders produce disaster of WWI



**INVEST IN THE  
VICTORY LIBERTY LOAN**



“Artillery men with their cold blooded mathematics seemed subversive of all that made a soldiers life heroic, admirable, worthy.” William McNeill, Pursuit of Power)



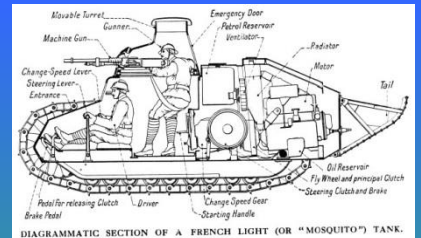
# Now...two Realms of warfare co-exist...



Increasing  
Role of  
Machine  
Factors in  
S-T-A  
Functions

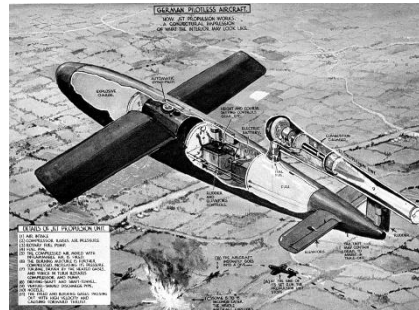
Integrated  
Realm

Social- Human  
Realm



# 20<sup>th</sup> century Scientific Engineering creating the third Realm of activity/warfare: “Machine Realm”

- ❑ With the increased complexity came an increased machine capacity for sensing, thinking, acting at higher speeds...the ‘MACHINE Realm’ emerges



“...modern warfare is more a matter of machines than of men.” Thomas Edison, 1913

# Micro-waves of Innovation push into the Third Realm of Autonomous and Ambulatory Machines...

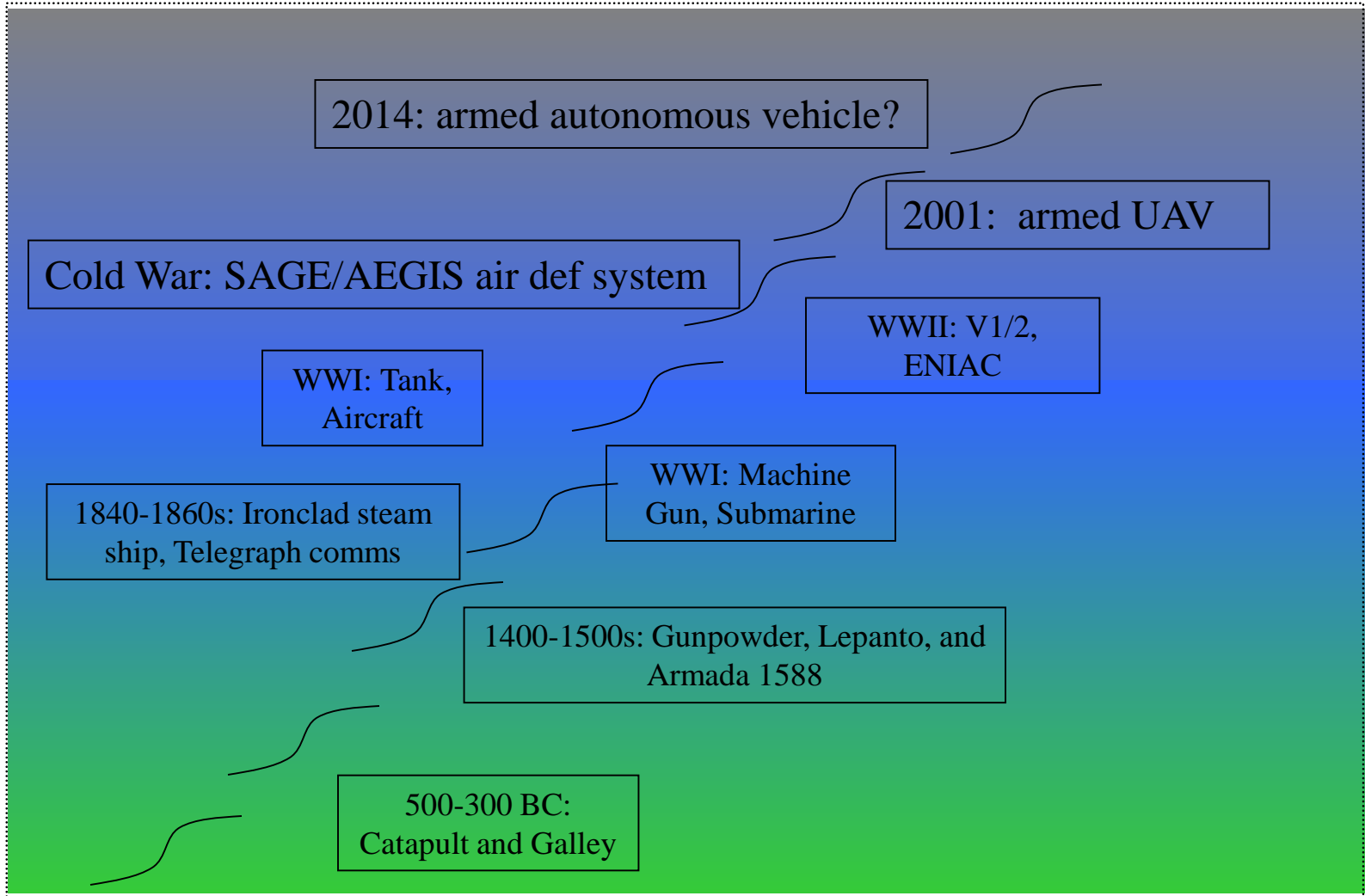
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Machine

Integrated

Social

Human



Pre-Industrial Age

Industrial Age

Information Age and ??

Time (not to scale)

# A New Reality...3a. Three Realms of Physical Activity on the planet...Three Realms of Warfare



**Machine Factors More Decisive**

Role of Machine Factors in S-T-A Functions

**Social-Human Factors more decisive**



Machine Realm



Integrated Realm



Social-Human Realm



Direct implications for law enforcement, business/human security

# Three Realms of Policing at Sea



**Machine  
Factors More  
Decisive**

Role of Machine  
Factors in S-T-A  
Functions

**Social-Human  
Factors more  
decisive**



Machine  
Realm

Integrated  
Realm

Social-  
Human  
Realm



# Apply the Three Realms to Agriculture



**Machine  
Factors More  
Decisive**

Role of Machine  
Factors in S-T-A  
Functions

**Social-Human  
Factors more  
decisive**



Machine  
Realm



Integrated  
Realm



Social-  
Human  
Realm



But with global networks, global supply chains....

# Apply Three Realms Framework to Power Grid/Energy

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**Machine Factors More Decisive**

Role of Machine Factors in S-T-A Functions

**Social-Human Factors more decisive**



Machine Realm



Integrated Realm



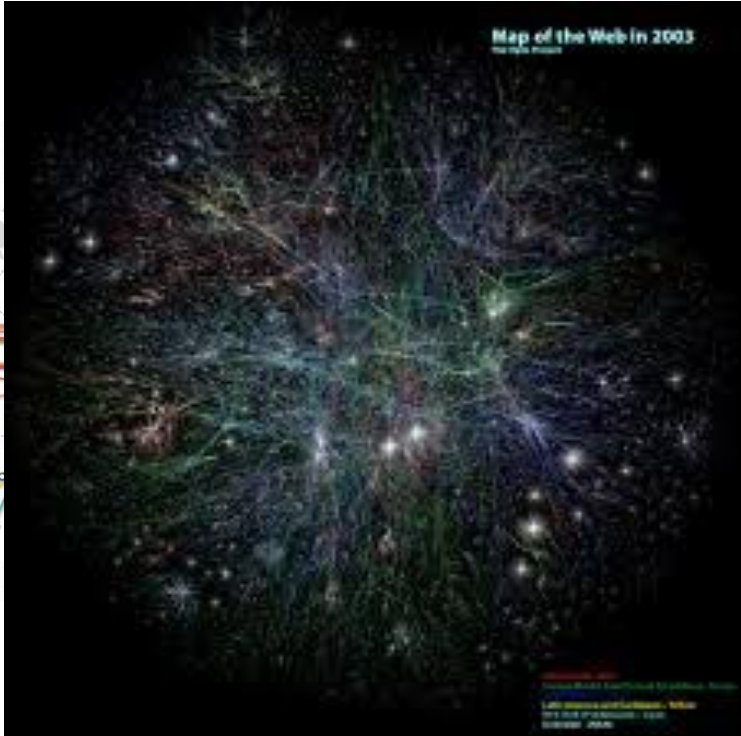
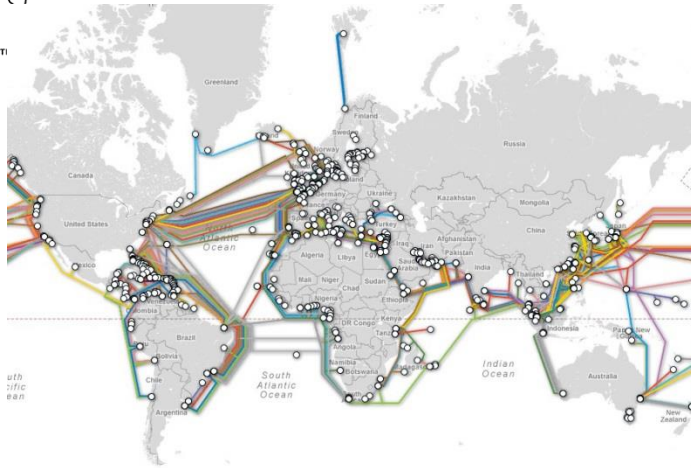
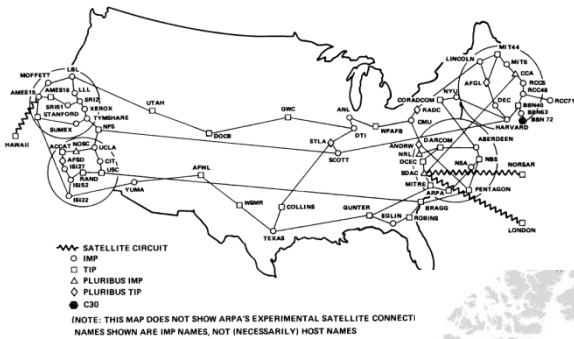
Social-Human Realm



Range of Cyber tools can be limited by tech... or lack of tech

# 3b. Knowledge Storage and Communication...Internet Growth...across all Realms of Activity and the Globe

ARPANET GEOGRAPHIC MAP, OCTOBER 1980



**Cyberspace** comes into existence...But this global information entity becomes both a Vector and Target for Cyber Attack...

Internet of Things (IOT)



# *Struggle for Cyber Power and control*

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- ❑ National borders: Russian cyb-physical invasion of Georgia/Ukraine
- ❑ Defense forces: US Navy cyber safe; NK nuke arsenal
- ❑ National govt functioning: Estonia
- ❑ Electoral processes: Ukraine election 2014, almost corrupted.
- ❑ Personal info: OPM; ND govt
- ❑ Credit card transactions: Target Corp
- ❑ Banks: from Wall Street to local credit unions
- ❑ Transport: Chrysler hack
- ❑ Utilities: Shodan; Russian attack on Ukraine grid Dec 2015
- ❑ IoT: refrigs and baby monitors, home security; pace makers
- ❑ Research institutions: Penn state; Rutgers
- ❑ Social media: Twitter flash crash; FB attack (DDOS)
- ❑ Online identity and state of mind: Cornell FB study
- ❑ Energy Production: SHAMOON attack in Saudi Aramco

Cyber power alone destroys physical facility...STUXNET

# A New Reality...DoD example, Cyber insecurity across the Three Realms

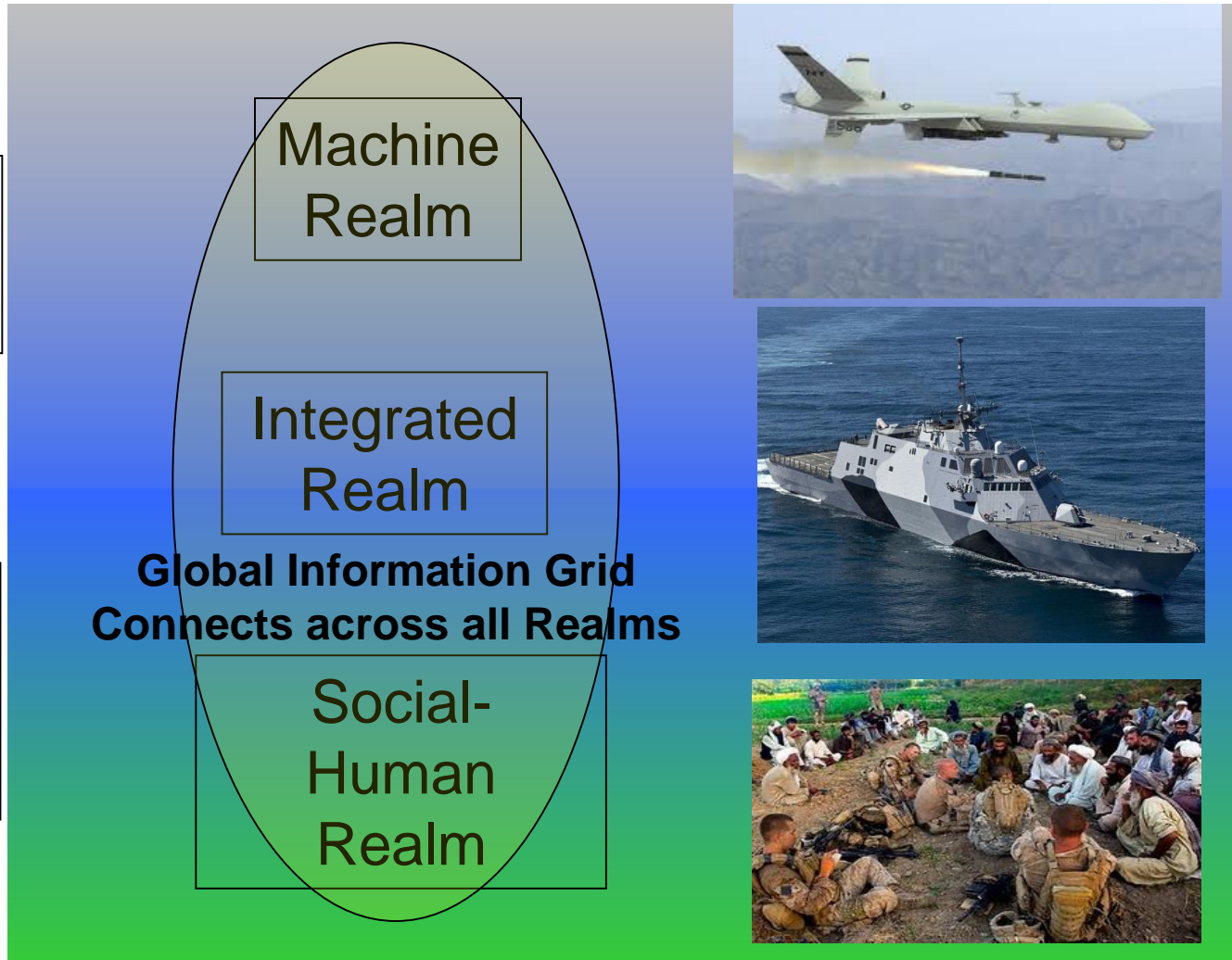
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**Machine Factors More Decisive**

Role of Machine Factors in S-T-A Functions

**Social-Human Factors more decisive**



Cyber Pervades Portions of all Three Realms

*Super A.I.  
breakthru?....  
Worth  
discussion*

# Cyber Attack/Defense across the Three Realms

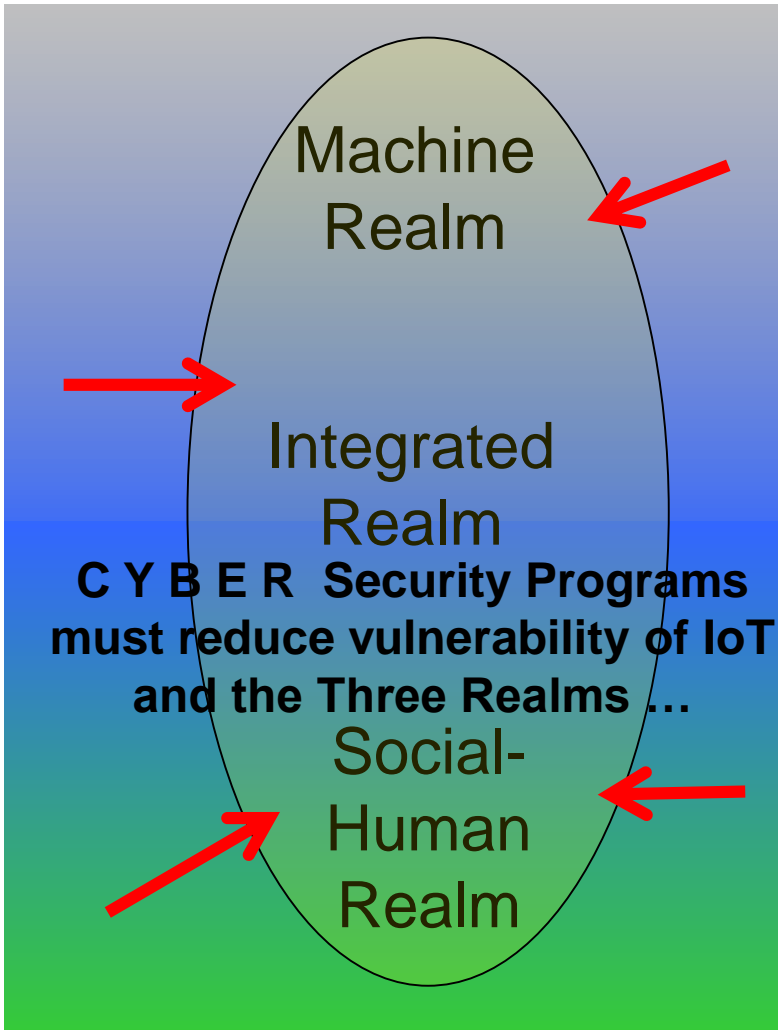
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**Machine Factors More Decisive**

Role of Machine Factors in S-T-A Functions

**Social-Human Factors more decisive**

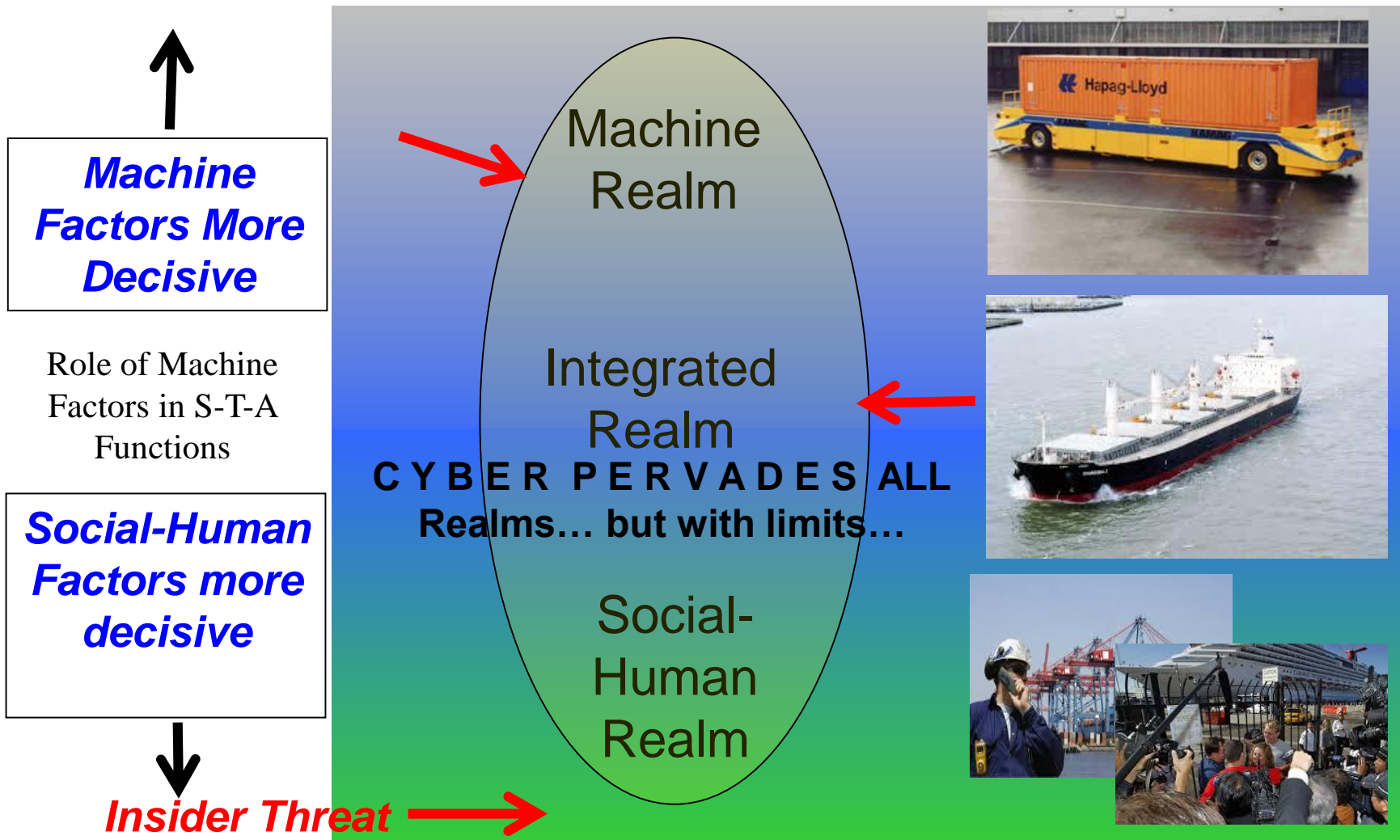


Cyber Security can be limited by lack of technology or workforce

Unclassified

# Cyber Attack/Defense across the Three Realms

## Applied to Industry (this case, Maritime)



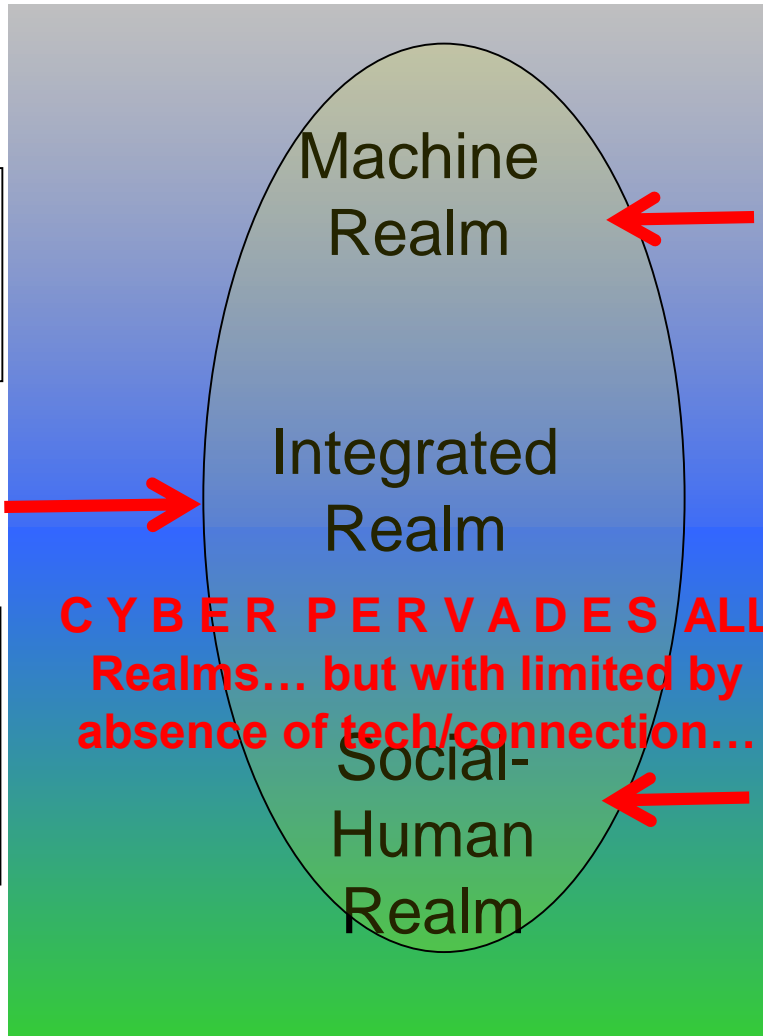
# Apply the Framework to Agriculture



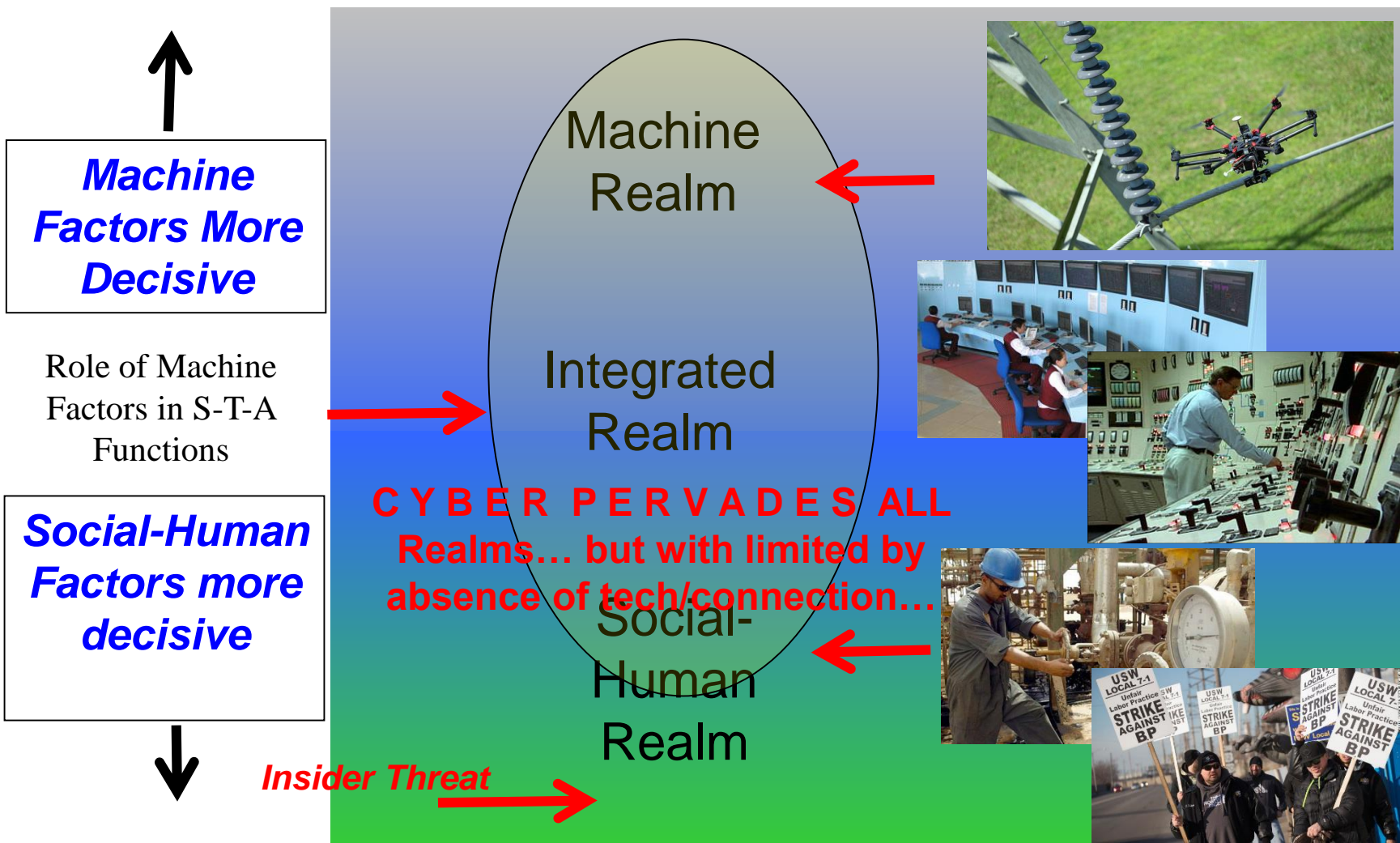
**Machine Factors More Decisive**

Role of Machine Factors in S-T-A Functions

**Social-Human Factors more decisive**



# Apply the Framework to Energy



# Global Internet: Snapshot of cyberspace attacks

Unclassified



Video, Chinese DDOS attacks on FB:

<https://www.youtube.com/watch?v=efmJsENgG-o>

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# **Citizenry/Commerce/State/Infrastructure**

- ❑ Personal safety/security/privacy (ND “Securing the Human” training)
- ❑ Big Data companies (MSFT, third largest campus is in North Dakota )
- ❑ Energy Extraction/Distribution (ND is the nation’s 2<sup>nd</sup> leading oil producing state)
- ❑ Research Institutions (UAS, ND a leading center)
- ❑ Any organization that has digitized or gone on-line... individual, small to medium sized businesses are target

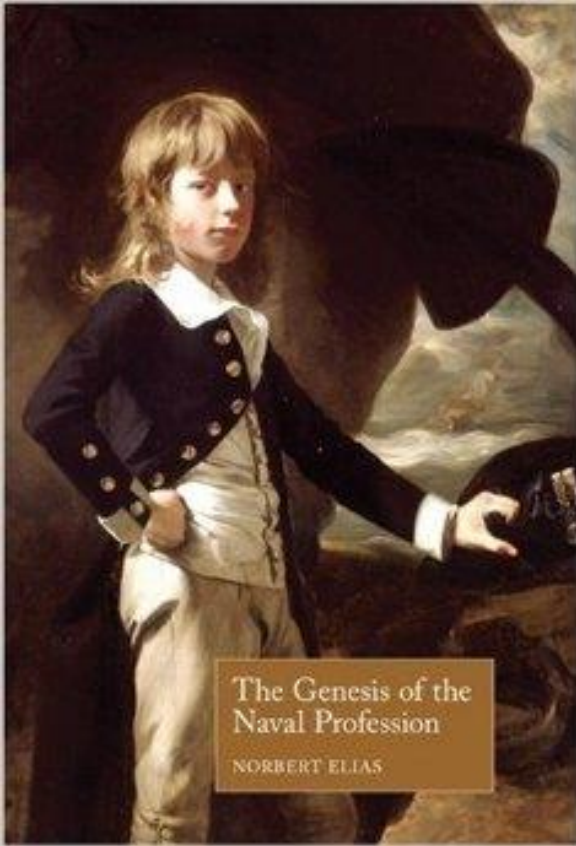


# Implications for Your workforce Education/Training...your Future as Leaders??

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- ❑ Center of Gravity Shifts Across the Three Realms...Cyber Attack is Cross-Realm/Domain
  - Human Realm (global insurgency, insider threat)
  - Integrated Realm (man and machine/platform)
  - Machine Realm (autonomous/robotic)
  
- ❑ Old forms of competition for control/power will persist... security is additive... renewed need for Integrative Knowledge
  
- ❑ Yet, Cyber will also require specialists...how to balance?
  
- ❑ Without an aware work force/electorate... we may not be in control of our business our govt or our lives.... Major push on cyber education by NDUS, led by NDSU.

# Cyber... disrupting DoD Education



# When Paradigms Change...what type of Work Force is needed?

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- Civilian Models... IT specialist? CISO? Entrepreneurs?



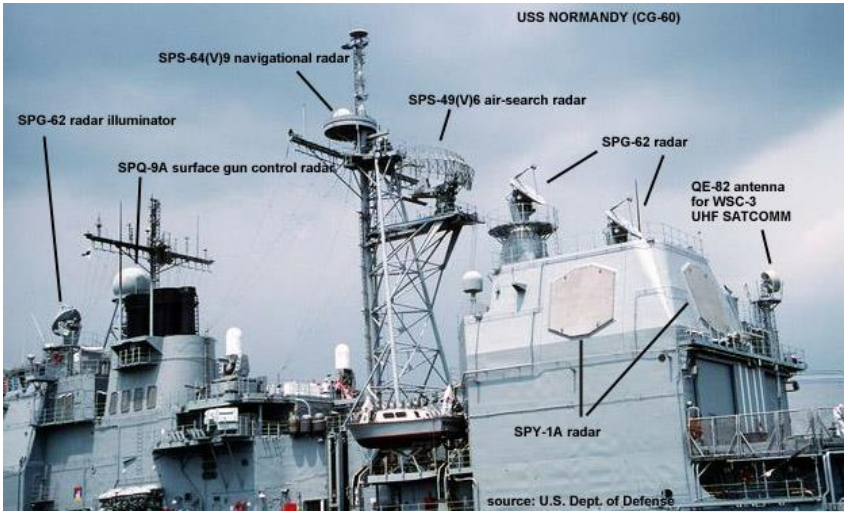
# Cyber... disrupting Military Career Paths, Creating New Organizations

Unclassified



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# Massive Disruption of DoD, Federal and State Gov't Budgets/Programs...



# *Disrupting How We Provide Security and Policing at the intersection of our virtual and physical lives...*

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# *This and Next Generation Leaders must understand the human...the machine... the code...but a caveat...*

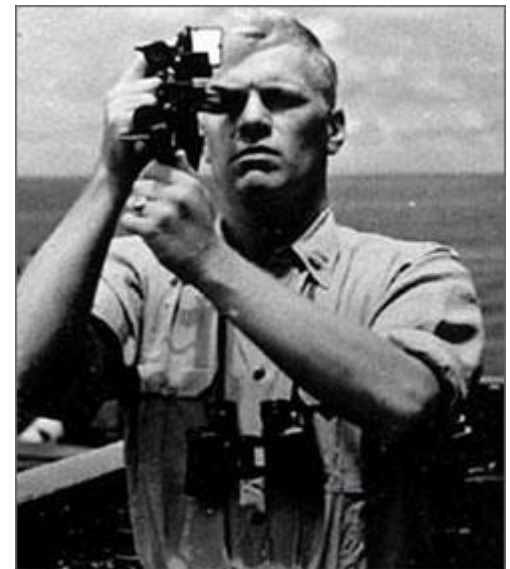
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- ❑ Crossing Two Thresholds Simultaneously:
  - Emerging the Machine Realm of AI
  - Emergence of the IoT
  
- ❑ Epic Battle for Control:
  - Penetration of Cyber tools of crime, reconnaissance, conflict, and war... across all Realms...
  
- ❑ But if Cyber stalls improvements in IT or the functioning of your network... What humans can still operate the enterprise?
  
- ❑ Our families and young workforce?...If the IoT/Cyber/Social Media conveys more *disinformation* than truth to our children... what do we do?

# *Human Caveat 1: retain modicum of human skills and functionality to preserve RESILIENT organizations*

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- ❑ If the automated cyber security systems become matched? Does machine stalemate result?
- ❑ If so, does advantage shift to the HUMAN workforce...
- ❑ Who can 'manually' debug/restore the system faster than the other guy?
- ❑ Who can navigate with degraded electronics... without GPS?





## ***Human Caveat 2: For social scientists...the Urgent Need for Resilient, Morally-Ethically Grounded Youth***

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- ❑ The most advanced information infrastructure in history... but does it convey truth to our youth?
- ❑ What happens to the young when their value frameworks are disrupted... “Anomie”...



# Bottom Line Up Front

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- Two Macro Technological Revolutions
  - Robotic/AI guided digital machines
  - Global Information Nexus spreading across the planet (digital information flows)
- The United States has three tasks: C<sup>3</sup>
  - Create the technology, it is a competitive race (e.g., robots, routers, internet art, businesses, services)
  - Control the Technology (**the main topic here today**)
  - Civilize the Technology (eg., law, policy, sociology, .... Leaders in these fields must all shoulder a load)

*North Dakota University System is making a major push in these fields. We will be welcoming partners in business and government.*



ACCESS. INNOVATION. EXCELLENCE.

# NexusND

**CONNECTING EMERGING ECONOMIC OPPORTUNITIES  
TO NORTH DAKOTA'S FUTURE**

# NexusND

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## *Success Through Collaboration*

**NexusND** leverages the resources of all 11 NDUS institutions to prepare North Dakota's future workforce and create new economic growth sectors for the state.

**NexusND** is an organic integration of 3 emerging industries:

- Unmanned Aircraft Systems (UAS)
- High Performance Computing and Big Data
- Cybersecurity



***These 3 industries directly contribute to North Dakota's ability to maintain a lead role in other industries like Energy, Ag, and Healthcare.***

# NexusND

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## *Unmanned Aircraft Systems*

UAS has and will continue to be, under this plan, one of the Red River Valley's points of prestige and economic growth potential.

**Competition in other places:** Although UND was among the first, today, many institutions across the country are focusing on UAS research.

For example, the University of Florida and Oregon State University are employing **UAS and Big Data** to bolster their respective state's position in **Precision Ag**.

*The economic impact of UAS technological research can be found in more places than just the skies.*

# NexusND

## *Obama announces \$3.9B for autonomous corridors, North Dakota first in line*

The vision is to use Highway 83 as a corridor for unmanned vehicles to transport goods for commerce.

The highway is over 1,885 miles long, stretching through North Dakota, South Dakota, Nebraska, Kansas, Oklahoma and Texas, even crossing into Manitoba and Mexico.

The corridor will allow for unmanned vehicles in commerce to mingle with other drivers using the road.

There is potential for the airspace above the corridor, about 15-20 miles wide, to be designated for unmanned aerial vehicles (UAVs, or drones) in commerce as well.



## *Big Data = Big ROI*

High Performance Computing and Big Data investments yield big ROI.

According to the University of Houston and a research analysis conducted by the Department of Energy, **for every dollar spent** on high performance computing, the **investor receives \$356.5** in revenue.

**Competition in other places:** The state of Wyoming recently erected an enormous supercomputing facility in collaboration with federal agencies, private area businesses, and the University of Wyoming.

# NexusND

## *Big Data = Big ROI*

### Competition in other places:

The state of Wyoming's NCAR is a supercomputing partnership between the state, University of Wyoming, and several area private businesses **sponsored by the National Science Foundation.**





# NexusND

## *Big Data = Big ROI*

The HPC component of **NexusND** will establish North Dakota as a major destination for research and education pertaining to Big Data.

By housing its own data, North Dakota will also be more able to safeguard its lead role in Precision Healthcare.

Beyond improving profits and cutting down on wasted overhead, **Big Data in Healthcare** is being used to predict epidemics, cure disease, improve quality of life and avoid preventable deaths.



The 'big data'  
revolution in healthcare

# NexusND

## *Big Data = Big ROI*

**NexusND** will actualize the SBHE's goals for the NDUS Collaborative Center for Computation and Data, which will be a key player for the region's economic development.

Because of this mandate, one of the largest expenses in developing HPC computing capability has already been addressed by the facility near UND's main campus.



# NexusND

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## *Taking the Lead in Cybersecurity*

Cybersecurity is no longer just a computer science problem for programmers; this is an issue that now touches every area of society.

Forbes estimates that there are currently **one million job vacancies** for cybersecurity professionals in the United States.

It is the responsibility of top research U.S. higher education institutions to address this massive workforce shortage in cybersecurity.

# NexusND

## *Taking the Lead in Cybersecurity*

In the News: The **U.S. Army Cyber Command** unit is currently in the process of relocating from Fort Belvoir, Virginia to Fort Gordon, Augusta, Georgia.

### **Competition in other places:**

Georgia Regents University is launching its Cyber Institute to develop research, new curriculum and outreach opportunities in cybersecurity starting this summer.



# NexusND

## *Taking the Lead in Cybersecurity*

In the News: US Navy Needs Help to Defeat UAS Cyber Threats.

Navy kicks off project to collaborate with outside scientists on R&D that will help protect the branch's UAS fleet.



# NexusND

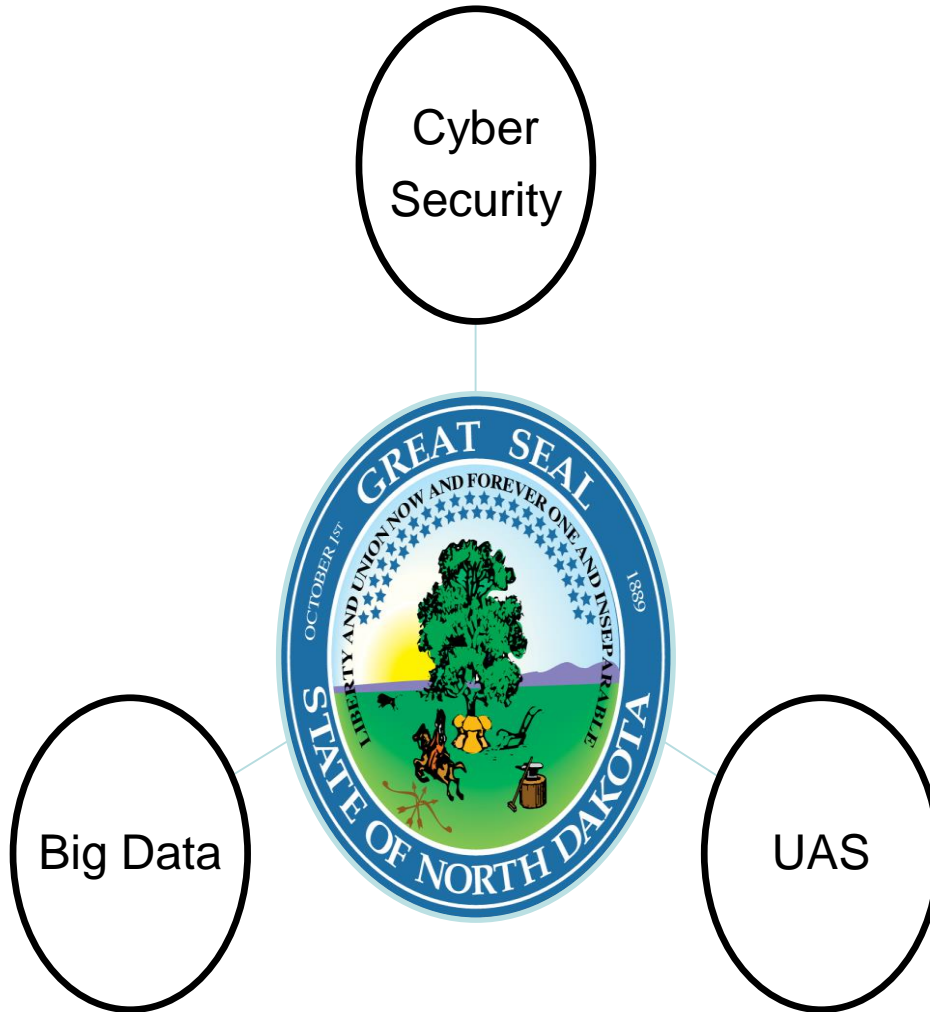
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## *Taking the Lead in Cybersecurity*

- North Dakota's research institutions have access to an FAA-certified unmanned aerial systems test site, the UAS Center of Excellence, two air bases with UAS activity, and public-private partnerships through the Grand Sky and Research ND initiatives.
- By using North Dakota's existing strength in unmanned aerial systems and pairing it with the major labor shortage of data analysts and cybersecurity professionals, North Dakota can diversify its economy and grow its prestige.

# NexusND

= *Opportunity ND*

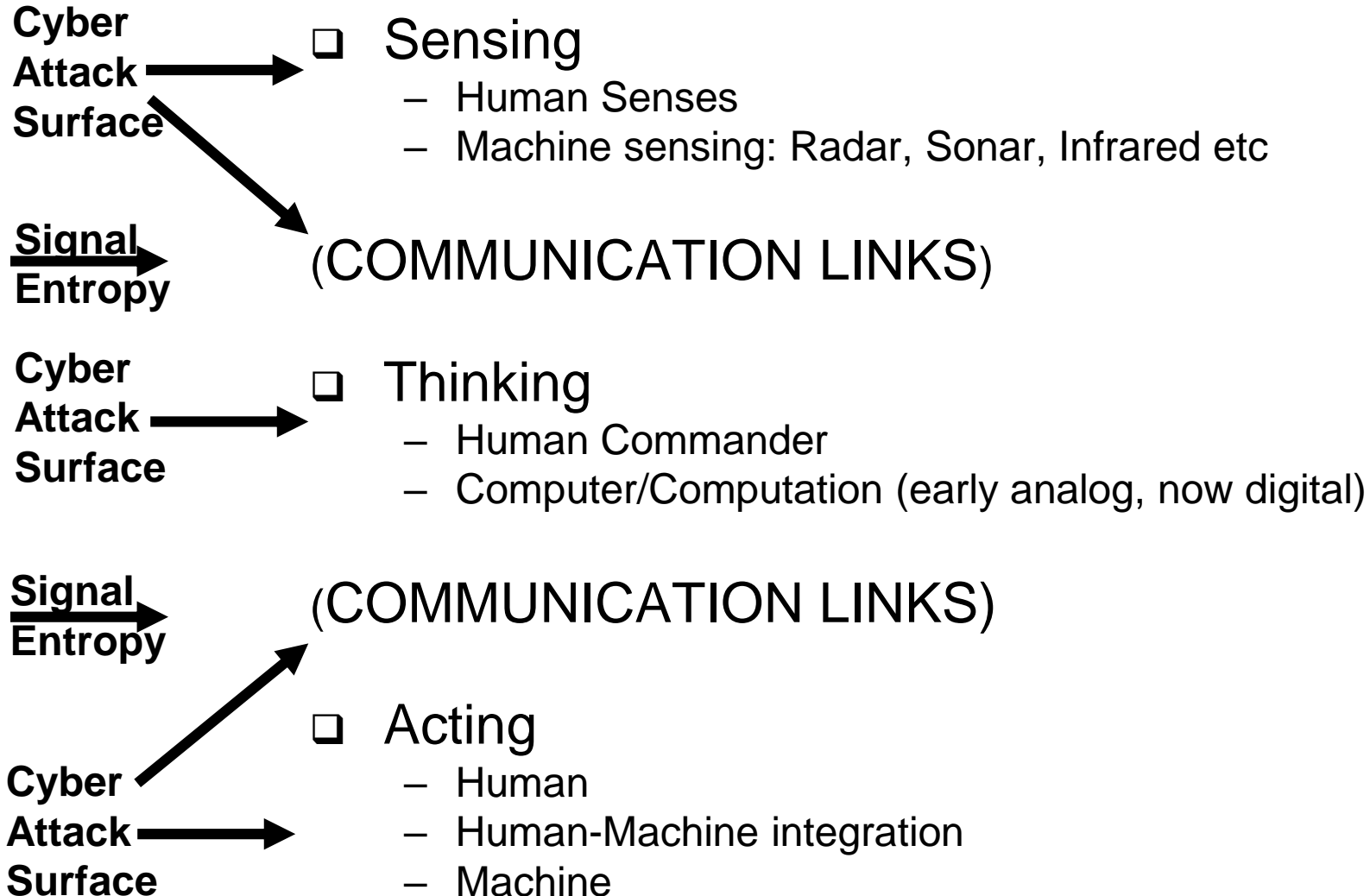


# *Back up*

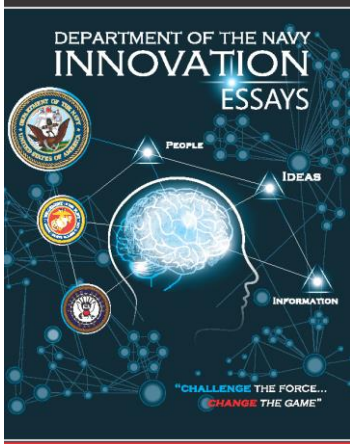
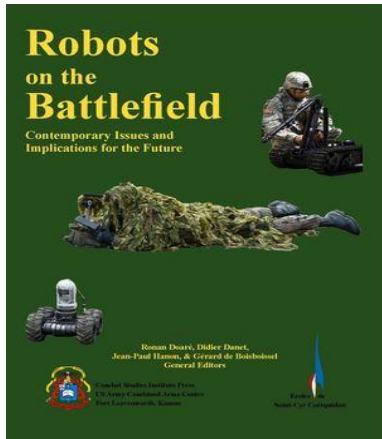
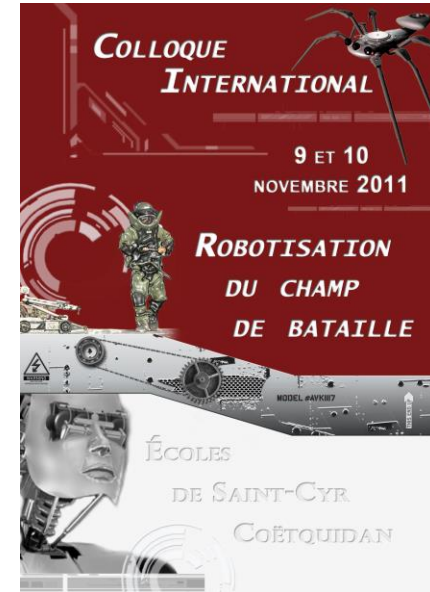
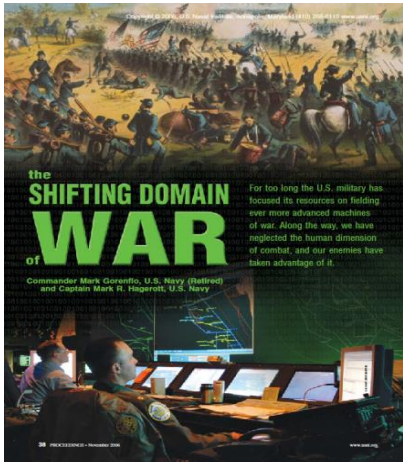




# Theory 2 Surprise: “Sensing-Thinking-Acting” cycle (or loop) faces both signal entropy and now Cyber Attack

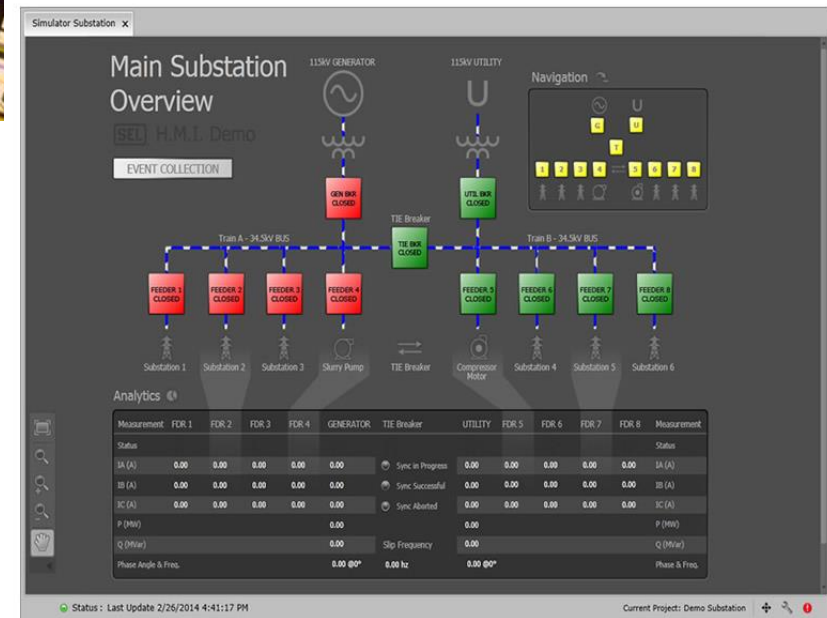
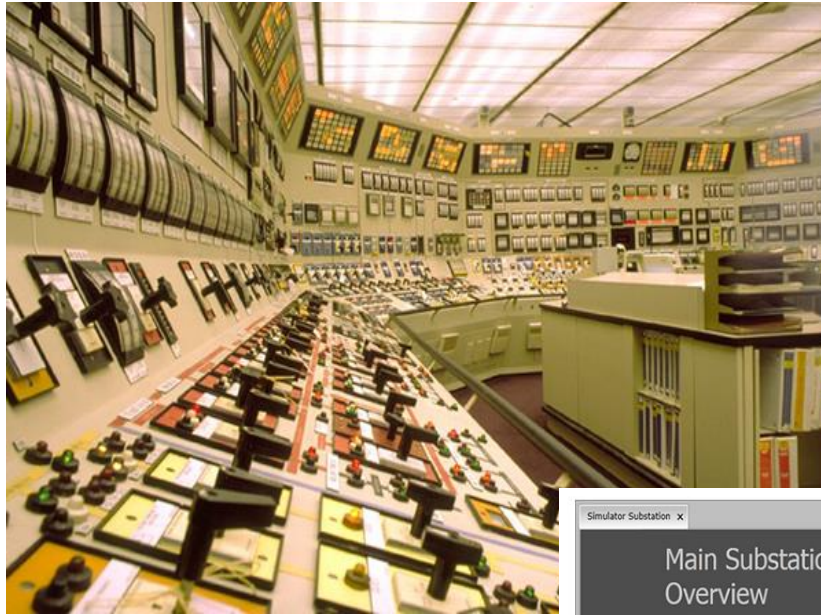


# Grappling with a Framework/Theory



[A Future in Denial](#)  
Slate Magazine

# Disrupting how we control and Extract, Convert, and Distribute Energy



# **Summary: Confluence of Two Macro Techno-Revolutions will Challenge most everything....**

- ❑ Two near simultaneous challenges:
  - ❑ 1. Emergence of a Third Realm: Autonomous intelligent machines moving in physical space (note: the older 'Realms' of Social-Human, and Integrated Human-Machine exist, too)
  - ❑ 2. Electronic Netting of the World of Humans and Machines...Machine intelligence "at rest".
  - ❑ **The Big Surprise: Battle for Control of the Machines and of Information... the 'Cyber' battle...made harder by the previous techno-momentum of past 40 years.**