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The UAS & Big Data Revolutions and the Cyber Challenge:

A Framework and Progress Report for Educating our People and Diversifying our Economy

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Economic Impact Committee

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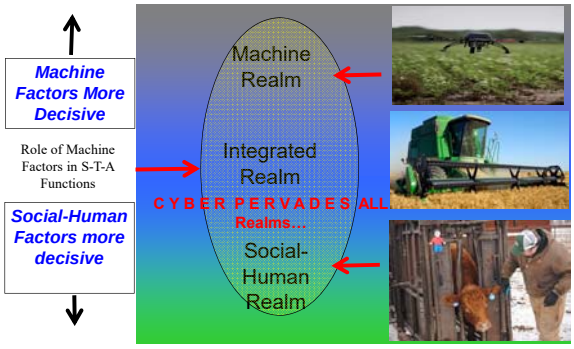
Framework Applied to Agriculture



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NexusND = Opportunity ND

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Bottom Line Up Front: North Dakota Uniquely Positioned to Prosper

- Two Macro Technological Revolutions underway:
  - Intelligent Machines in motion: Robots and UAS
  - Intelligent Machines at Rest: Big Data
  -
- Tech Leaders have three tasks: C^3
  - Create the technology, it is a competitive race (e.g., robots, routers, internet art, businesses, services)
  - Control the Technology (**the Cyber Problem)**
  - Civilize the Technology (eg., law, policy, sociology, …. work for our law schools and humanities depts)

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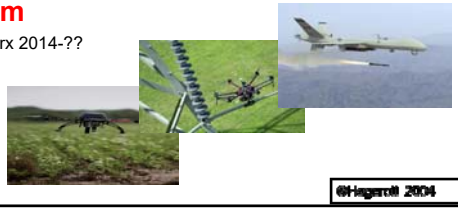
Macro Revolution: Autonomous/Robot tech creates a mobile 'Machine Realm' of Econ/Social/Mil Activity…

- In pursuit of S-T-A advantage, third Realm emerges
  - 1st: Social-Human Realm
    - (apprx10,000 BC-
  - 2nd: Integrated Human-Machine Realm
    - (apprx 1588AD-
  - **3rd: autonomous, intelligent Machine Realm**
    - (apprx 2014-??



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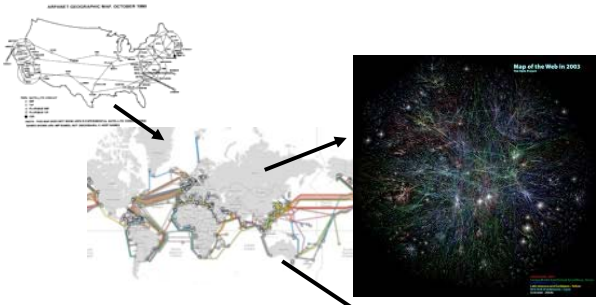
Macro Revolution: Knowledge and Communication at Speed of Light…the Internet …Big Data



Internet of Things (IOT)

But the "Kicker": all three Realms of physical action & Big Data/IoT can be attacked…

- 1st: Social-Human Realm
- 2nd: Integrated Human-Machine Realm
- **3rd: Autonomous Machine Realm**

'Cyber Power' can be exerted across the Three Realms and the Global Info System/Big Data… resulting in a North Dakota of 'at risk' people, data, and machines

A Tool and Framework for Thinking…

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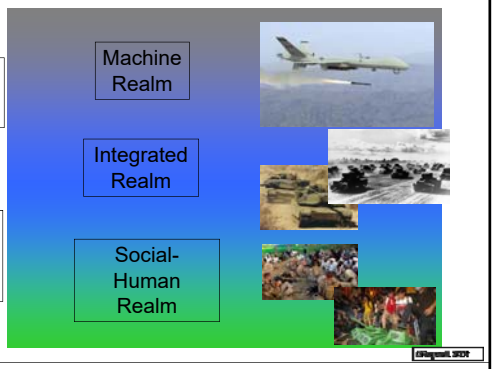
A New Reality… Three Realms of Physical Activity on the planet…Three Realms of Warfare

Machine Factors More Decisive

Role of Machine Factors in S-T-A Functions

Social-Human Factors more decisive



Direct implications for law enforcement, business/human security

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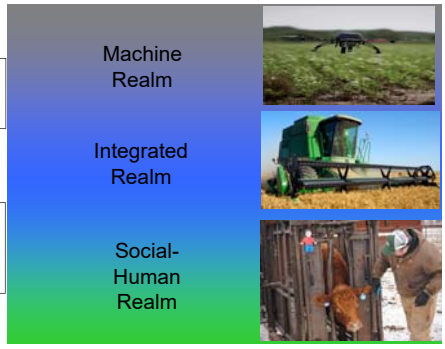
Apply the Three Realms to Agriculture

Machine Factors More Decisive

Role of Machine Factors in S-T-A Functions

Social-Human Factors more decisive



But with global networks, global supply chains…

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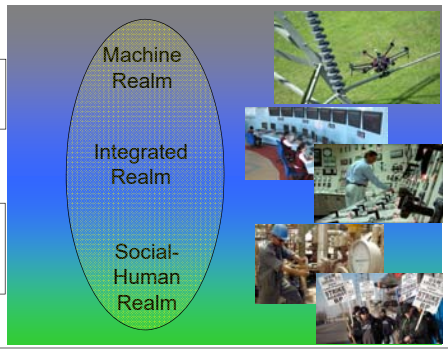
Big Data overlays the Three Realms Framework to Power Grid/Energy

Machine Factors More Decisive

Role of Machine Factors in S-T-A Functions

Social-Human Factors more decisive



All these systems and work forces are connected digitally…

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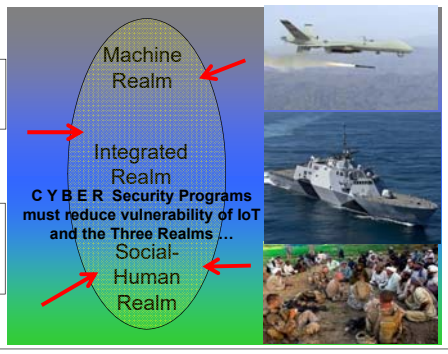
Cyber Attack/Defense across the Three Physical Realms and Data

Machine Factors More Decisive

Role of Machine Factors in S-T-A Functions

Social-Human Factors more decisive



Cyber Security Pervades all Three Realms

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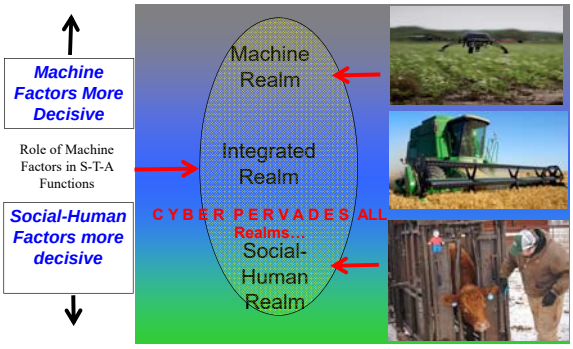
Apply the Framework to Agriculture



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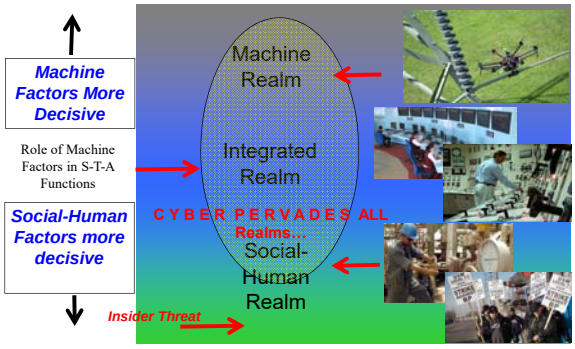
Apply the Framework to Energy



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Bottom Line Up Front

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

North Dakota govt, Legislature, ND Biz, and University System are uniquely positioned to diversify our economy… IF we can maintain momentum.

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Some Examples other Universities or Organizations are Responding,too…

- Army National Guard
- Defense Science Board
- US Air Force and US Navy
- Department of Transportation
- Department of Energy
- Georgia/Florida/Oregon/WY University Systems
- State of Colorado
- State of Maryland
- State of Iowa (recent Governors Cyber Strategy had major component to fund Higher Education)

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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.

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.

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**.

Societal/Work Force Gaps 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.

National initiatives ("NIST"/"NICE") in place to help U.S. higher education institutions to help with this massive workforce shortage in cybersecurity…. But many states are augmenting this effort.

ND National Guard tasked to help Lead in Cybersecurity in upper Midwest…

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 = *Opportunity ND*

Success Through Collaboration, Efficiencies, Scale….otherwise not achievable by single campuses

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, and to help our US Air Force and Homeland Security make America safe.

Quick Overview of NexusND

Integration of 3 emerging industries, with emphasis on DATA:

Unmanned Systems …creating massive amounts of data sets

Advanced Computing …required to store and process the massive data sets

Cybersecurity ….to secure the data; keep it safe from bad actors

Data Overview of NexusND

Integration of 3 emerging industries:

Advanced Computing

- NDUS opportunity to make impact

Advanced Computing: NDUS Role

Actualize SBHE's goals for the NDUS Collaborative Center for Computation and Data

- Provide human capital
  - Analyze problem
  - Write software
  - Test software
- Maintain adequate technical infrastructure
- Create solutions to drive economic development for the state

Excel Energy Natural Disaster Response

Problem to solve:

- Reach, inspect, assess infrastructure after storms, floods, tornadoes

Solution:

- UAS to capture data
- UND/Research ND Project to create solution(s) from the data

Excel Energy Natural Disaster Response

Multi-terabytes of raw data from UAS

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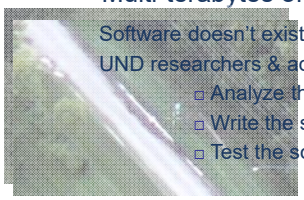

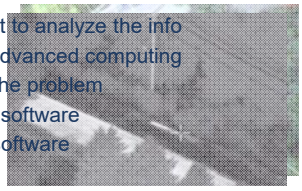

Software doesn't exist to analyze the info

UND researchers & advanced computing

- Analyze the problem
- Write the software
- Test the software

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Excel Energy Natural Disaster Response

Multi-terabytes of raw data from UAS

Software doesn't exist to analyze the info

UND researchers & advanced computing

- Analyze the problem
- Write the software
- Test the software

Implement the solution

Model solution for other opportunities

Field Crop Management

Problem to solve:

- Increase crop production efficiency - world population continues to grow while farm acres continue to decline

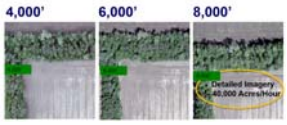
Solution:

- UAS to capture data
- NDSU/Research ND Project to create solution(s) from the data

Field Crop Management

Multi-terabytes of raw data from UAS

Imagery at Various Elevations:



Field Crop Management

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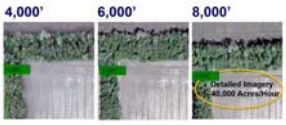
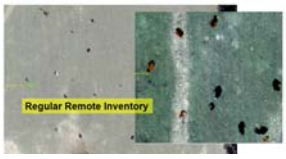


Analysis from Imagery: Cattle from 8,000'



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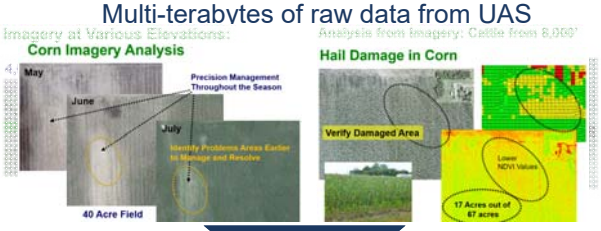

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Advanced Computing and Possible Data Center

Exploring public/private partnerships

- Coordinating effort with ND Dept. of Commerce
- Univ. of MN tour in early November
- Possible collaboration with Grand Sky
- Possible collaboration with Northrup Grumman
- Alliance with Oak Ridge National Lab, Midwest Big Data Hub

Cyber Overview of NexusND

Integration of 3 emerging industries:

Cyber Security

- Update

Cybersecurity Graduate level…

Graduate certificate in cybersecurity

- Offered at UND, NDSU, and Minot State
- Collaborative program model
- Minimal resources

Cybersecurity Undergrad level

Pending Undergraduate minor in cybersecurity

- Offered across the System
- Collaborative program model

Cybersecurity Certificates…

Non-credit professional certificate in cybersecurity

- Short course offerings to business and industry
- Will take effort to develop
- Collaborative program model
- Good potential

nexusND

Cybersecurity…keeping the momentum of computer sciences…

- NDSU: 120 new CS freshmen, possible record
- UND: Solid enrollment; rise in students transferring into CS
- MiSU: 64% growth in CS enrollment during the past three years

- Students polled on interests
  - Many anticipate good jobs in CS field
  - Many recognize opportunities in cybersecurity

nexusND

nexusND = Opportunity ND

Center for Computationally Assisted Science and Technology (CCAST)
North Dakota State University

CCAST operates 4 high-performance computing (HPC) systems. CCAST also operates database, graphics rendering, and General-Purpose on Graphics Processing units (GPGPU) servers.

The HPC clusters provide the aggregate of more than 31 million schedulable processor-hours per year to NDSU researchers and their collaborators (nearly 23 million processor-hours per year not counting the Intel MIC Phi co-processors).

Available aggregate global storage in the CCAST environment is ~1.05 Petabytes on magnetic disks and ~4 petabyes on tape, assuming all slots are populated by media (this excludes local solid state/hard disk drive storage on individual servers). Currently, only 695 TB of magnetic disk and 667 TB of tape are populated (1 petabyte = 1,000 terabytes).

Among CCAST's four distributed memory computer clusters, one system is dedicated to serial and high-throughput computational workloads, another system is dedicated to massively parallel simulational workloads, a third system is dedicated to data intensive and simulational workloads (both high-throughput and massively parallel), and the fourth system is dedicated to export controlled and other sensitive workloads.

CCAST is currently limited by available power and cooling in its Research 1 computing room. To remove this constrain CCAST is fitting out an existing computer room in Research 2 to adapt it to the demands of modern high- density HPC equipment. When completed, this fit-out will provide CCAST with additional 500 kW of cooled IT power with a path for further upgrade to 1000 kW (fitout scheduled for completion end of CY).

Computational Research Center
University of North Dakota

The UND Computational Research Center (CRC) hosts three HPC cluster environments, a Hyper-V Virtual Machine farm, and a number of ancillary server systems.

The Computational Research Center HPC clusters provide the aggregate of more than 2.5M schedulable processor-hours per year, 8.9M schedulable Xeon Phi co-processor-hours per year, and 437M schedulable GPU-hours per year to UND researchers and their collaborators.

Not counting local drives, the CRC provides 288TB of raw storage through a High-Availability NFS Storage Solution (HA-NSS) appliance, for a total of 220TB of usable storage space. Tape backup services is also provided.

The HPC clusters supported by CRC are all general-use HPC systems, and are not optimized for any specific type of HPC workloads.

Wide Area Network and Local Area Network
Between NDSU and UND HPCs

The HPC network environment at UND and NDSU is currently 10 Gigabits per second (Gbps) end to end. In both locations, the HPC is connected via 10 Gbps dedicated links to the respective campus cores. The campus cores are then connected to StageNet with a 10 Gigabit wave that carries StageNet (HPC traffic between UND and NDSU would be StageNet) and Internet 1 traffic. Current utilization of the connections to StageNet are shown below and indicate a peak usage at UND of 1.2 Gbps and a peak usage of 1.0 Gbps at NDSU.