Science, Technology and the Art of War

presented at

Potentially Disruptive Technologies Symposium

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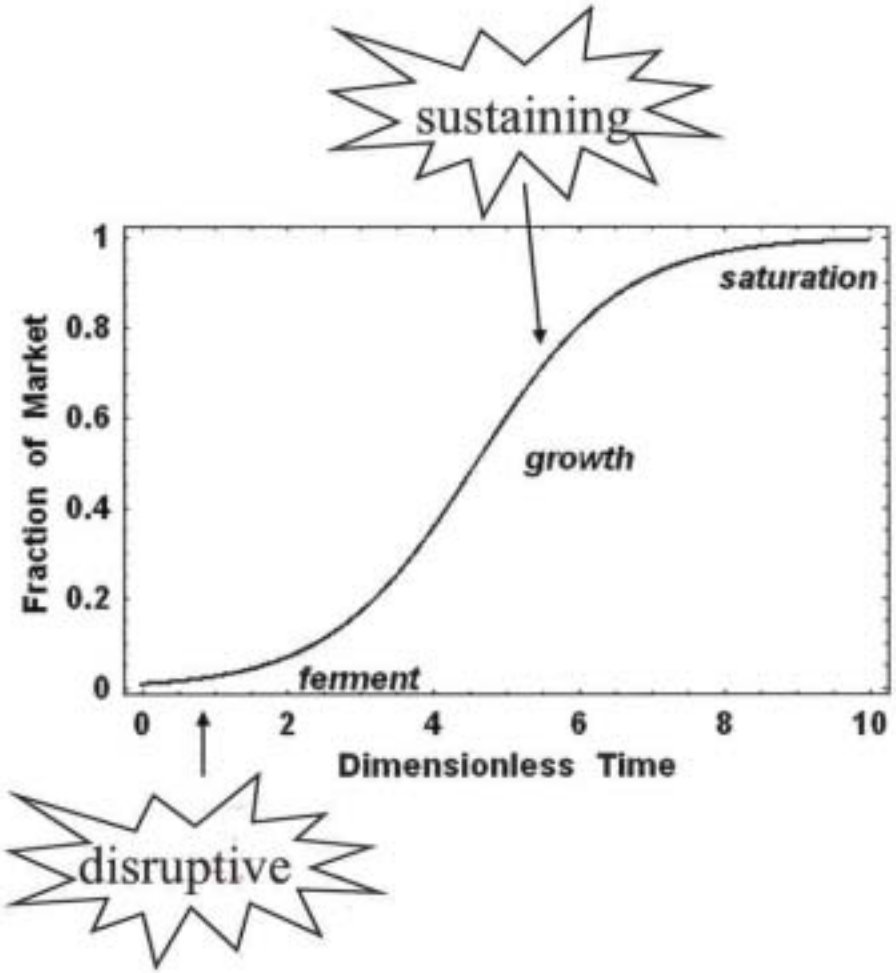
Things to come

- Introduction
- Performance and Perspective
- Systems of systems
- Modeling & Simulation
- Conclusions

Marketing Concept



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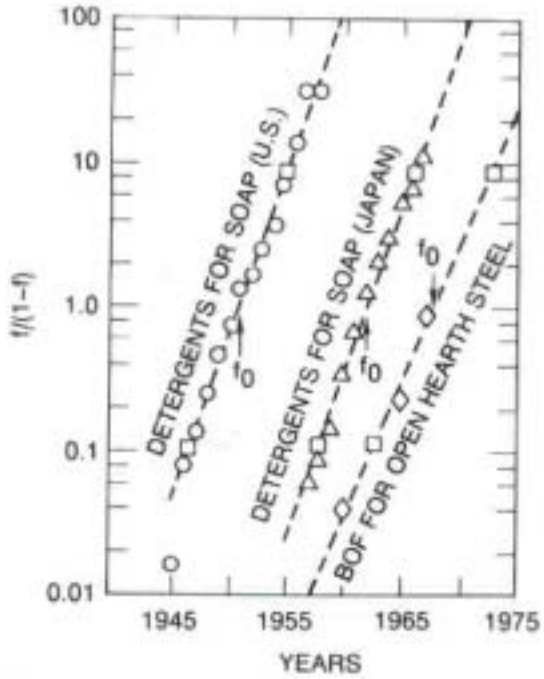


Montroll & West, 1972;
logistic growth

Cautionary Forecasts

- Predicting future technology from the past
  - Failure modes
    - too little importance

"The ordinary horseless carriage's is at present a luxury for the wealthy; and although its price will fall in the future, it will never, or course, come into as common use as the bicycle", The Literary Digest - 1899

    - too much importance

"That the automobile has practically reached the limit of its development is suggested by the fact that during the past year no improvements of a radical nature have been introduced." Scientific American - 1909

    - wrong branch

" The cinema is just a fad. It's canned drama. What audiences really want is flesh and blood on stage." Charlie Chaplin – 1916

  - We try to avoid these pitfalls using reasonable but optimistic extrapolations from today's potentially disruptive technologies.

New Thinking

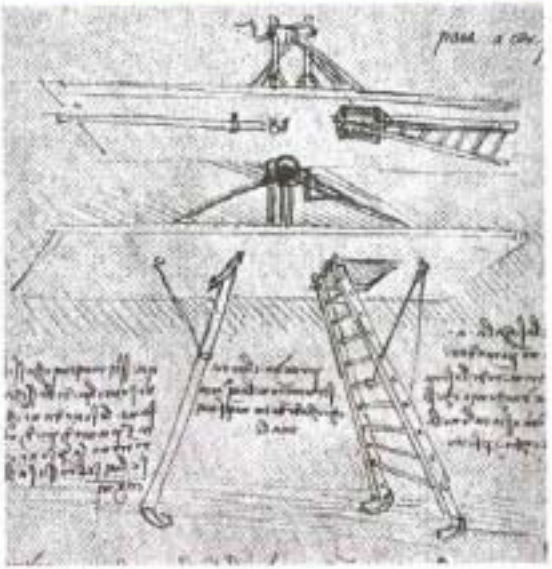
- What science contributes to the military (historically):
  - research and development of new technology
  - building and fielding prototype technology
  - teaching the warfighter to use new technology

  } armament, communications, sensors, vehicles, weapons

- Science has an additional role
  - evolutionary research (sustaining)
    - new things
  - revolutionary research (disruptive)
    - new thinking
- Revolutionary research or disruptive innovation leads to new ways of thinking in peace and in war.

Evolutionary vs Revolutionary

Evolutionary Research



Revolutionary Research

Ripple Effect

tive Technolo

Tsunami Effect

Performance and Perspective

- **Human Performance**
  - monitoring the warrior
  - synthesis of sciences
  - education and training (ICT)
  - nanotechnolgy (ISN)
  - biotechnology (ICB)
  - communication with command
- **Thought-driven systems**
  - man-machine interface
  - thought-driven systems

Monitoring the Warrior

Sensors/Measurements

1. Headband EEG and Oximetry
2. Acoustic (Voice stress and content analysis)
3. Dead reckoning module (3-axis accelerometer, GPS, magnetometer, altimeter)
4. EKG, EMG and Thoracic impedence cardiography
5. Body core and skin temperature
6. Near-infrared (or other) technology tissue pH, glucose and lactate
7. Wrist-worn actigraph
8. Boot-to-boot impedence
9. Foot contact (weight/locomotion)
10. Wireless inter-module communication

What/Why?

Hypothermia

Hyperthermia

Hypoxia

Metabolic fatigue

Vigilance lapses

Dehydration

Psychological Stress

Inadequate restorative sleep

Desynchronization of Circadian function

Jolt, blast, and repeated impact exposure

Toxic substance exposure

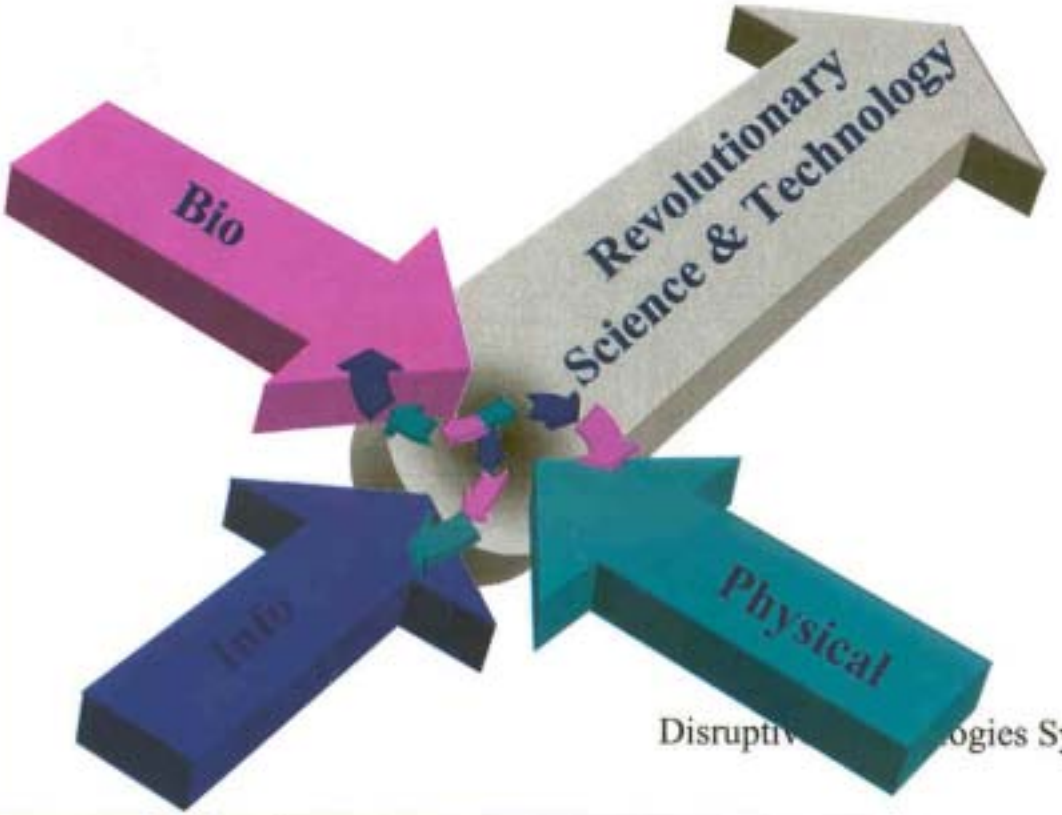
LEARNING

METRICS

COMPLEXITY

Synthesis of Sciences

- **Transdisciplinary**
  - Essential mixing
  - Focused interactions
  - Leverage opportunities



- **Discipline Interfaces**

Now

- Controlled biomemtics
- Tissue-based biosensors
- DNA computing
- Electronic Dog's nose
- Microfluidics
- BW diagnostics

Future

- Hybrid computing
- Bio-physical interface
- Bio-complexity algorithms
- Bio-control information
- Bio-mathematics
- Biotechnology Center

Defense Research Centers

Project Objective: Establish Army extramural biotechnology research center in high payoff focussed areas - coordination with ISN and ICT Centers - creating and maintaining a pool of highly trained and knowledgeable, Army-focused disruptive innovators

Biotechnology

ICB, (2003)

USC

Soldier Survivability

Immersive Environments

States with additional Army-supported centers

Institute for Soldier Nanotechnologies (ISN)

- Technical Program
  - Three founding Industrial Partners
    - Strong involvement in proposal
    - Will add more industrial partners later in programme
- 130-140+ Research Personnel
  - 36 faculty
  - 65-80 grad students
  - 20-25 post-doc
  - 6 professional staff
- Facility
  - ~24,000 ft² net in Tech Square on/near MIT campus

Institute for Creative Technologies (ICT)

Today

ARO

AMC

UNI

- S&E training module for Army Officers
- Uniformed Army S&E program

2025

- people who understand soldiering and technology

2050

- A true symbiosis of man and machine

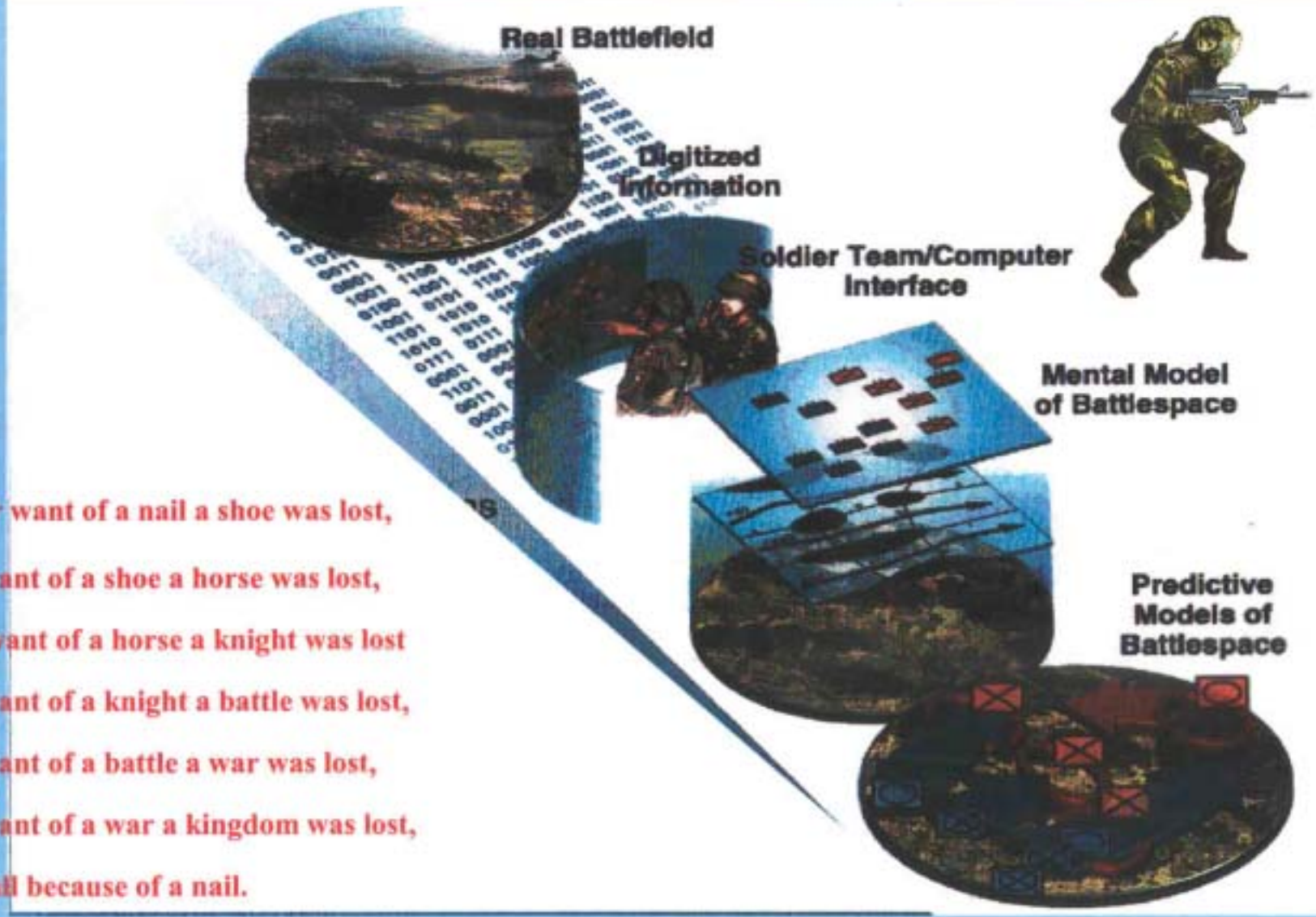
Institute Collaborative Biotechnology (ICB)

- Cross-disciplinary Biotechnology
  1. Sensors, electronics and photonics
  2. Soldier health and performance
- Technical - Foundations
  3. Tools to enable discovery, construction & characterization
  4. Complex multi-scale dynamic and predictive models
- Programmatic

$ 5M/yr, 6.1 UARC, > 5 yrs
Primary user facility
Cost & resource sharing

- Industrial partner(s)
- Integrate research solutions
  - Cost sharing required
  - Many commercial spin-offs
  - Army 6.2 funding likely
  - Outreach & other information

Communication with command



- For want of a nail a shoe was lost,

for want of a shoe a horse was lost,

for want of a horse a knight was lost

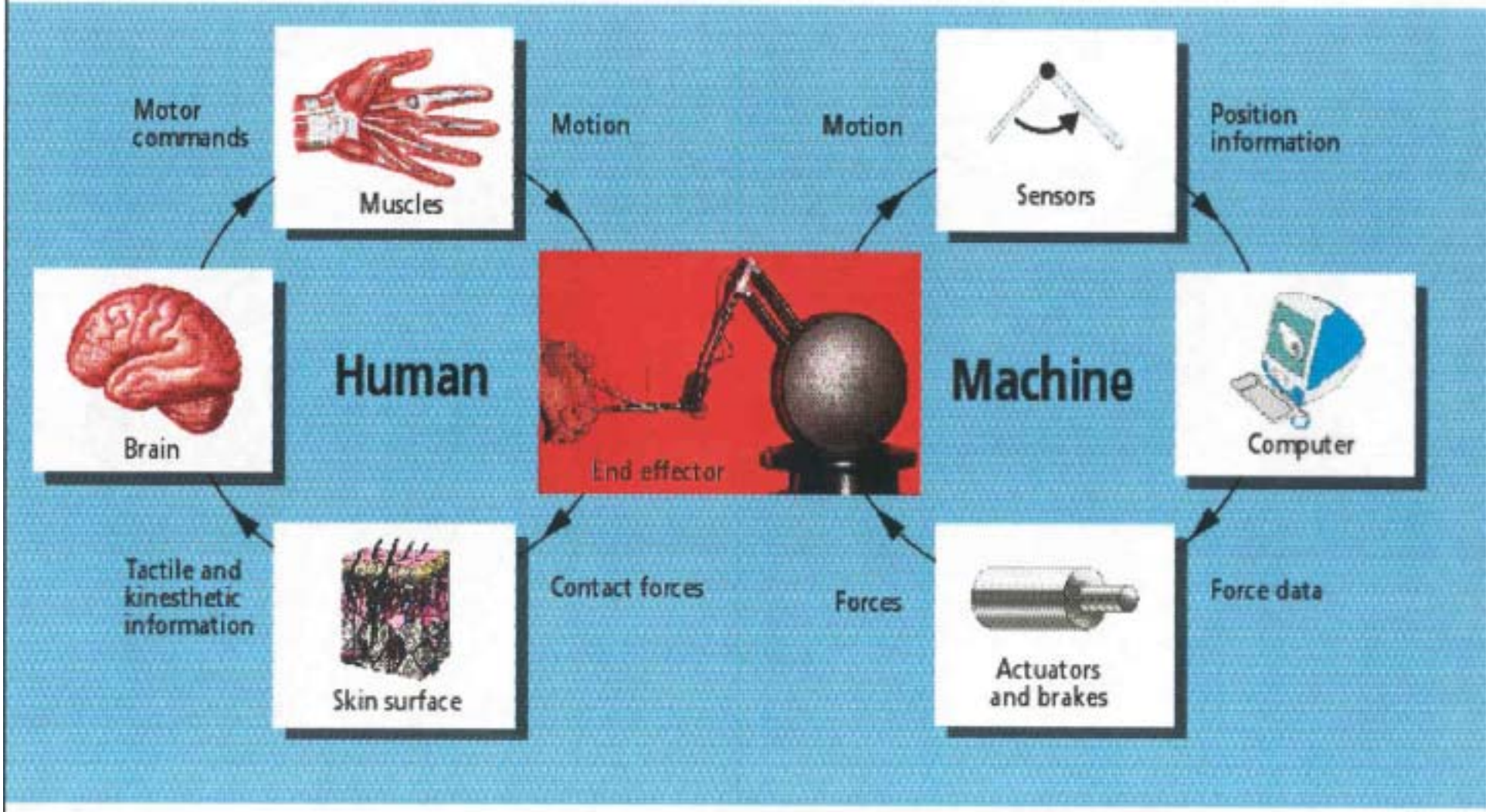
for want of a knight a battle was lost,

for want of a battle a war was lost,

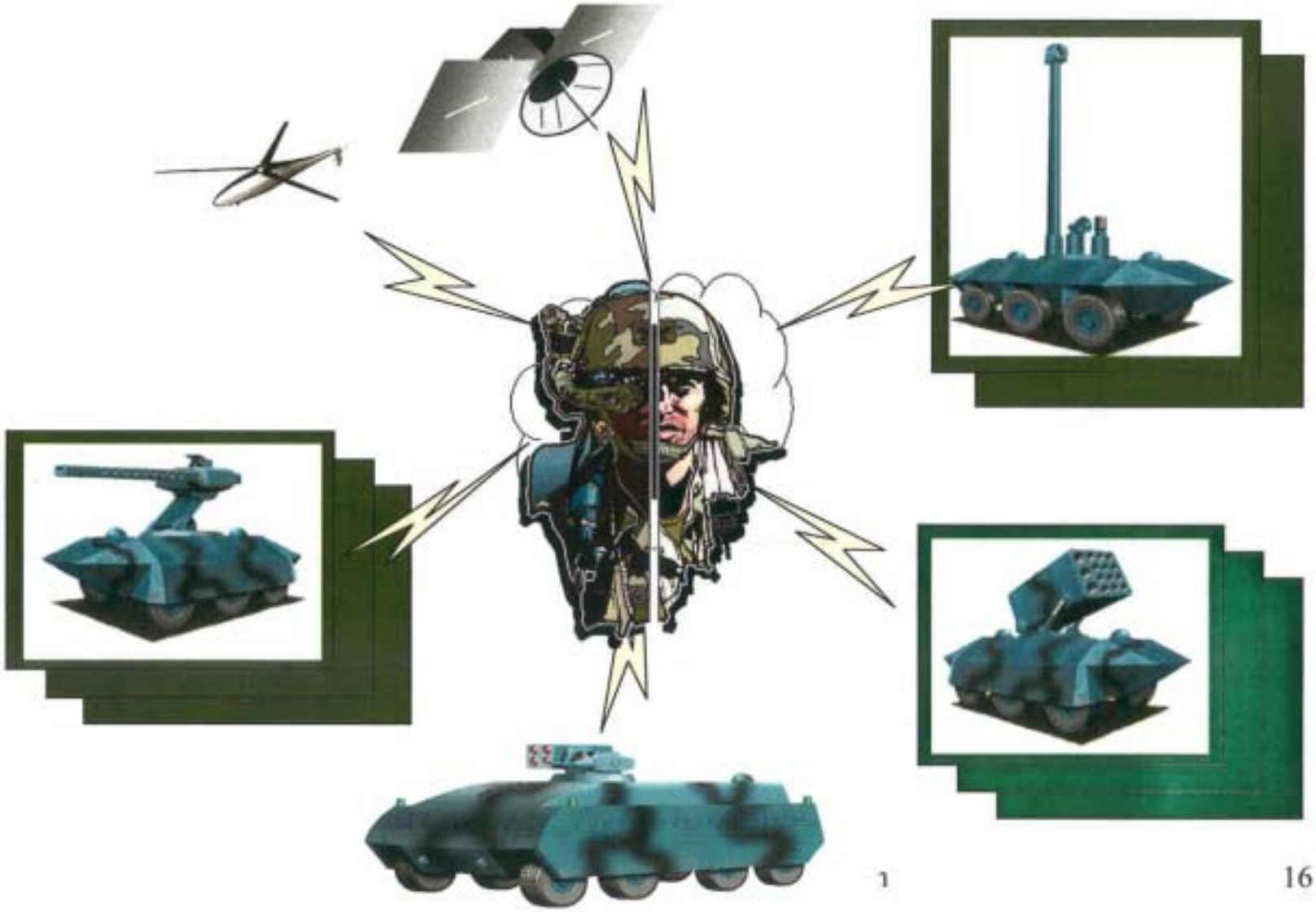
for want of a war a kingdom was lost,

and all because of a nail.

Man-machine interface



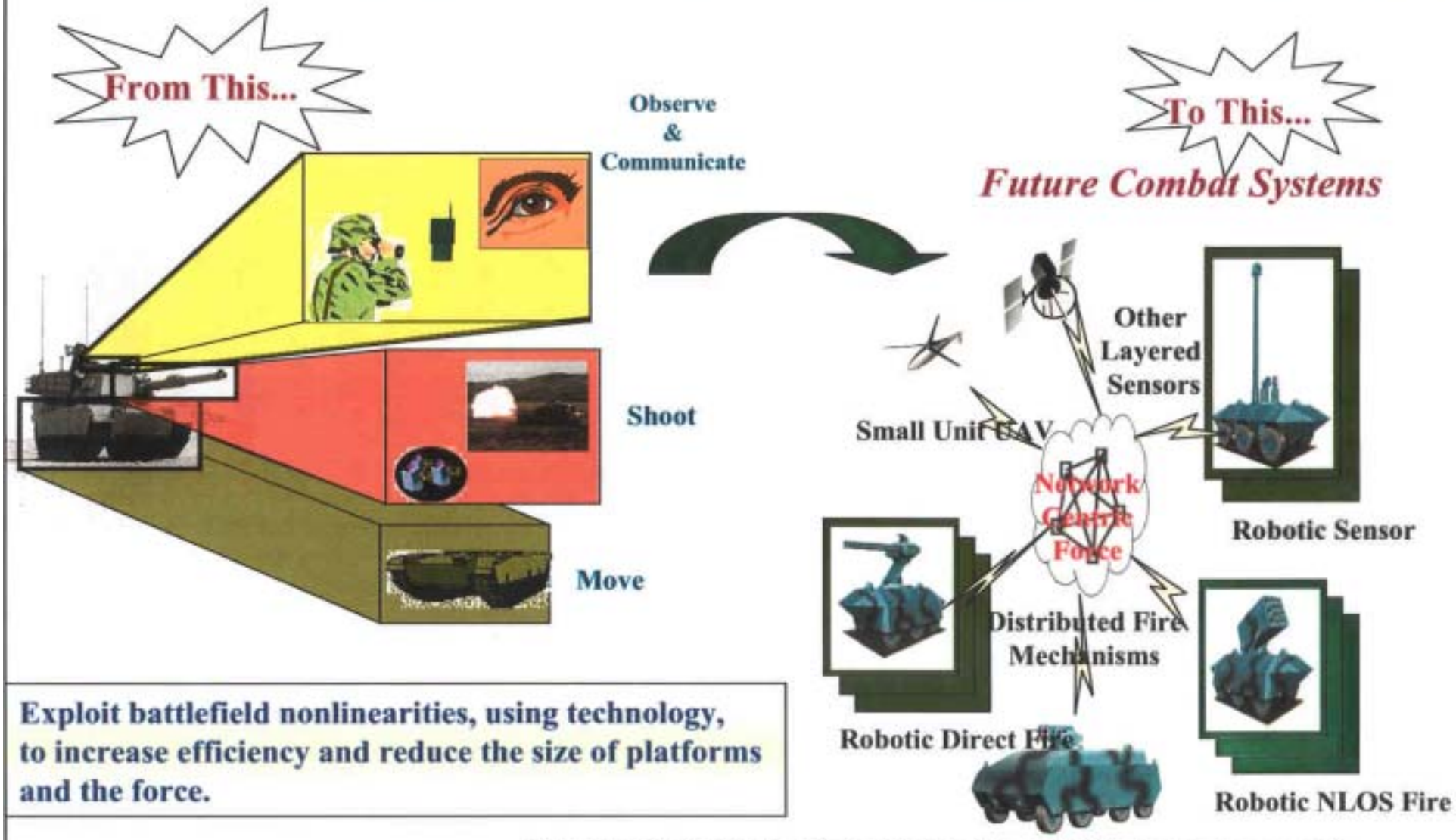
Thought-driven systems



System of Systems

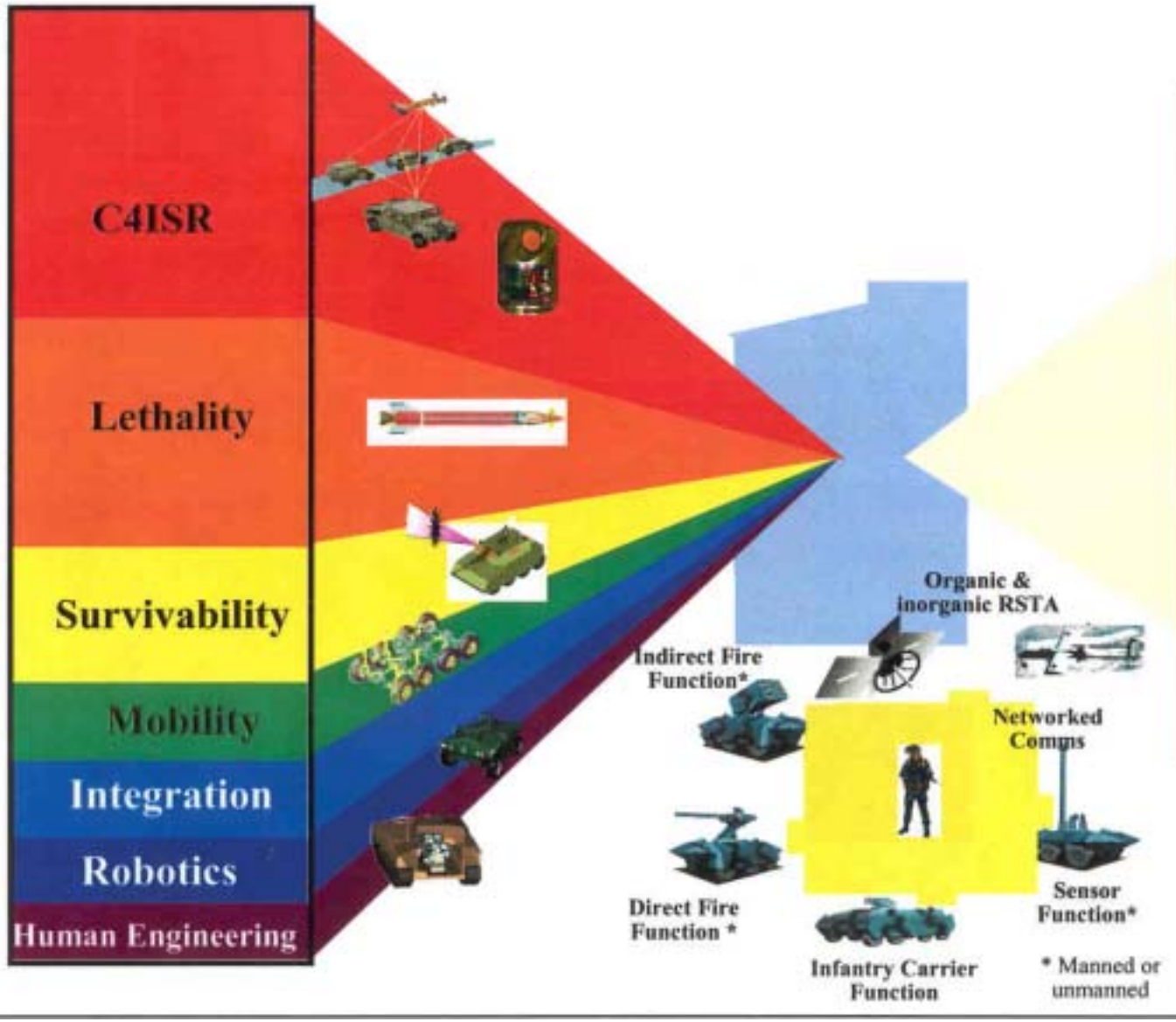
- **Network Distributed Platforms**
  - see, shoot, kill, move
  - network-centric vision of combat
- **Force Transformation**
  - the *–ilities*
  - system of systems
  - Future Combat Systems
  - information fusion

Network Distributed Platforms



Exploit battlefield nonlinearities, using technology, to increase efficiency and reduce the size of platforms and the force.

Force Transformation



FCS Characteristics

- Comprehensive Situational Awareness
- Networked Fires - Extended range lethality
- Survive first engagement
- Manned/Unmanned Integration
- C-130-like Transportable
- Reduced Logistics

System of Systems

Modeling and Simulation

- **Hard Science versus Soft Science**
  - the warrior as a complex systems
  - the –ilities and the individual
- **Mathematics for Understanding**
  - metrics in complex phenomena
  - ICT
  - ISN
  - ICB
  - transdisciplinary nature of metrics
- **New Mathematics**
  - modeling and simulation as enablers
  - mathematics of complexity

Synthesis of the sciences

Hard Science

biology, chemistry & physics

Soft Science

anthropology, psychology & sociology

(large investment)

(small investment)

The ultimate multidisciplinary system

Purpose: go beyond equipment and apparatus by integrating the soft sciences into the warfighter's development and support.

- Sustainability is achieved through an in-depth understanding of the psychology, physiology and chemistry of the warfighter.
- Deployability is amplified through knowing where people/things are and how to move them with the greatest agility using all available information.
- Lethality dominates the enemy with the most versatile, accurate and smartest weapon systems in the hands of committed warfighters.
- Mobility is enhanced by developing the fastest, lightest and most efficient soldiers and vehicles.
- Survivability is maintained by developing the most extensive protection and communication systems for the warfighter, along with the most innovative medical support network.

A new mathematics

New Mathematics ⇒ **New Thinking**

- Determinism does not imply predictability
- Qualitative is sometimes more important than quantitative
- Many phenomena are singular, with no analytic representation
- Many phenomena do not possess a fundamental scale (scaling)
- Most phenomena do not superpose

Conclusions

- ARO is investing its resources in 6.1 research of both an evolutionary (sustaining) and revolutionary (disruptive) nature.
- This research leads to the development of new technologies (ripple effect), but even more importantly, for the long term, to new ways of thinking (tsunami effect).
- Part of this new way of thinking is phenomena-driven problem solving, rather than the traditional discipline-driven problem solving.
- These new ways of thinking can contribute significantly to the Army of the future