Always a Step Ahead

ARDEC
ARMAMENTS

A Mad Scientist's Lab for Bio-Convergence Research

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UNPARALLELED
COMMITMENT
& SOLUTIONS
Act like someone's life depends on what we do.

U.S. ARMY
RDECOM

**U.S. ARMY ARMAMENT
RESEARCH, DEVELOPMENT
& ENGINEERING CENTER**

BIO-CONVERGENCE RESEARCH QUESTIONS

- The Mad Scientist bio-convergence conference will explore four aspects of bio-convergence: 1) bio and operational environment attributes (bio-inspired materials, biotechnology tools, man-machine interface), 2) the coming pandemic, 3) democratization of bio improvements, and 4) Soldier enhancement.

- The following research questions will drive presentations:

  1) What does co-evolution of humans and their technologies look like and how does it change warfare?

  2) How available will bio capabilities (including weapons) be to non-state groups and individuals?

  3) What Soldier enhancements will be needed to operate in the faster more lethal battlefield?

  4) What are the future technology breakthroughs that could speed the co-evolution of humans and what are the projected timeframes?

- Empirical answers to these questions require a laboratory that is experienced in human research
    - Valid research designs for human
    - construct test beds
    - gain human research approvals
    - collect, and analyze human data

" SHOW ME THE DATA"

- Purpose of this presentation is to
    - Introduce the TBRL as a human research laboratory to support DoD studies and research questions relevant to BioConvergence.
    - Give an overview of two BioConvergence projects underway at the TBRL
        - Human Electrophysiology for Soldier-Armament Integration
        - Armament Virtual Collaboratory Environment
    - Give an overview of planned projects in Artificial Intelligence and Remote Autonomous/Armament Systems

Tactical Behavior Research Laboratory

- Human research for ARDEC

  – User interactions with armament systems

  – Non Lethal Weapon effectiveness

- Staffed by S&E experts in Psychology, Neuroscience, Biomedical Engineering

- Validation & Verification throughout the lifecycle

  – Concepts, Requirements

  – Designs, Effectiveness
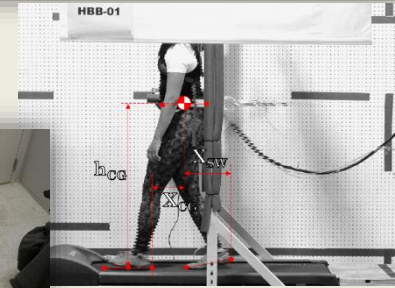
TACTICAL BEHAVIOR RESEARCH LAB

MISSION

- Measure and analyze the interaction between humans and armament systems to evaluate and validate the human aspects of armament performance.

CORE COMPETENCY

- Human and Systems Effectiveness Research & Evaluation using Behavior and Performance Analysis with Psycho-Social Paradigms in:

  - Armament / Soldier Integration
    - Virtual Reality Simulation
    - Squad Performance
  - Counter-Terrorism Technology Evaluation
  - Non-Lethal Weapons Effectiveness Research

BACKGROUND

- Over **14 years** conducting **human research**, testing and evaluation with ~ **2,000 volunteers**.

- Expertise in Neurosciences, Social Behavior Psychology, Biomedical, Mechanical and Electrical Engineering fields.

- Validation of **effectiveness in performance** of **Weapons, Systems, Users and Targets** to aid decision making.

- Evaluate an armament system's effectiveness by measuring performance of human with the system.
  - Does the **Soldier** performance improve with the materiel solution?
  - Does the **Target's** performance degrade when engaged by the non-lethal weapon?

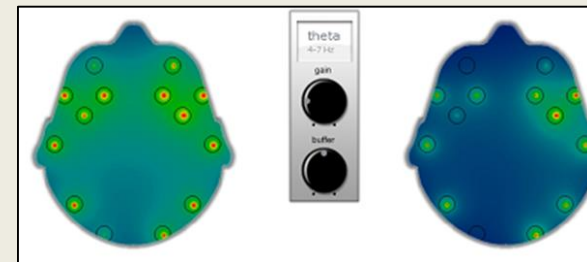## COLLABORATORS & CONSULTANTS

- ARL/HRED, NSRDEC, Academia

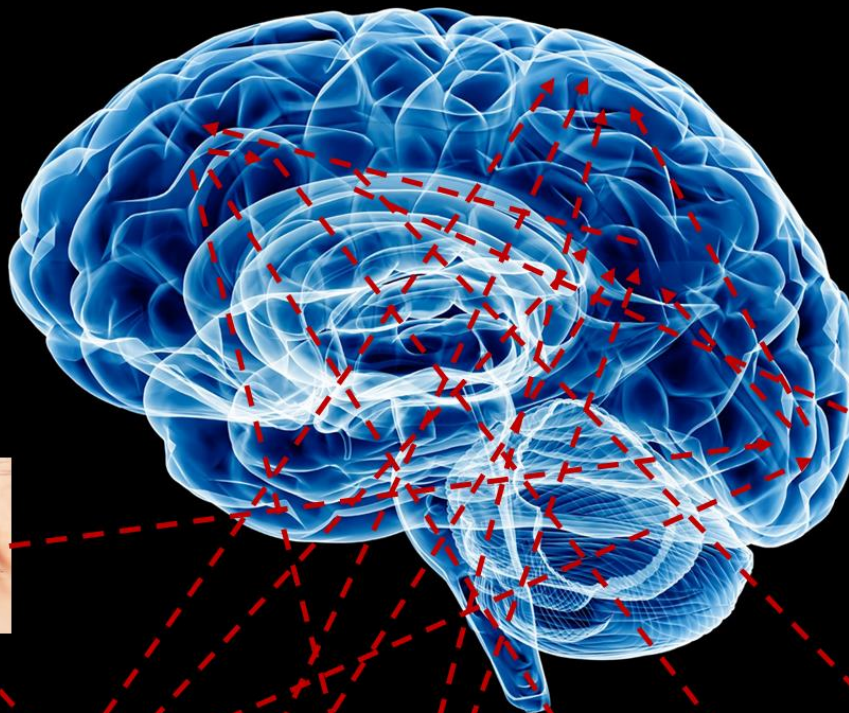# BRAIN, HEART, NERVOUS SYSTEM, AND MUSCLE RECORDINGS WHILE TARGETING

- **"Human Electrophysiology for Soldier-Armament Integration"**
- Currently working on using bio-sensors to look for psychophysiological markers that have a high correlation to tactical events.
- Art of the Possible:
  - Weapon systems that are controlled by a Soldier's mind.
  - Weapons systems that are smart enough to interpret the Soldier's state and adjust accordingly (i.e. using the human brain as a co-processor to the machine).
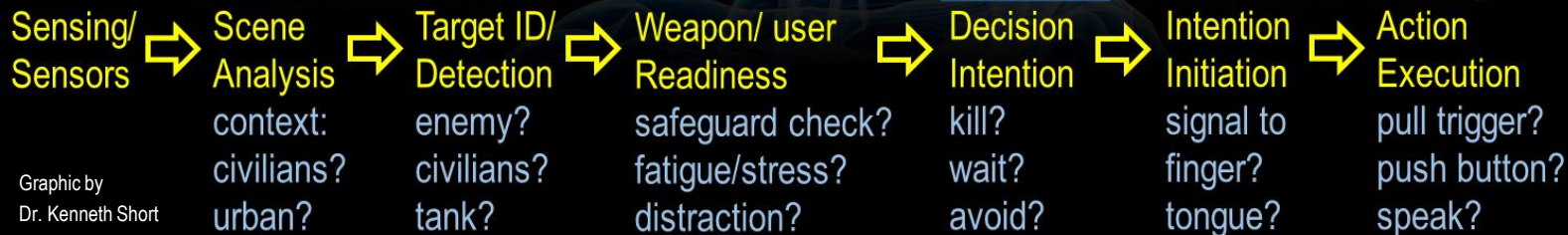
HOW SHOOT DECISIONS ARE MADE

Graphic by
Dr. Kenneth Short

3000.09 Decision Space (now)

3000.09
(goal)

Sensing/ Sensors	→	Scene Analysis	→	Target ID/ Detection	→	Weapon/ user Readiness	→	Decision Intention	→	Intention Initiation	→	Action Execution
		context: civilians? urban?		enemy? civilians? tank?		safeguard check? fatigue/stress? distraction?		kill? wait? avoid?		signal to finger? tongue?		pull trigger? push button? speak?

Empatica E4

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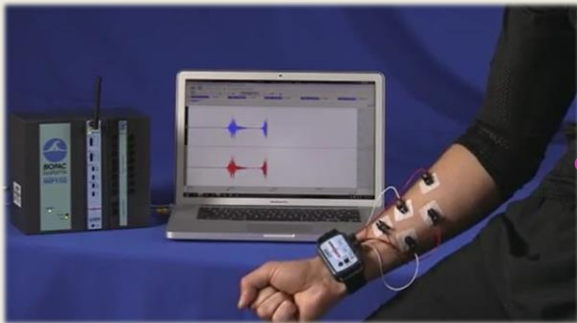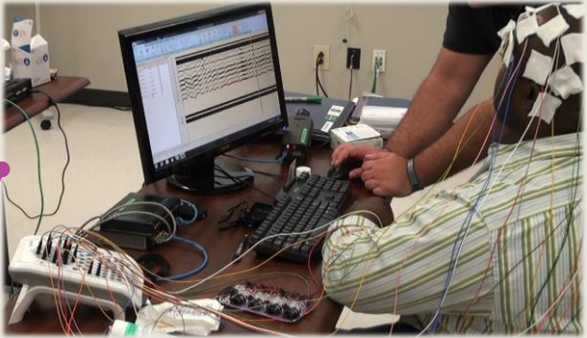
Biopac Nomadix

Emotiv EPOC+

Delsys Trigno Wireless

ELECTROPHYSIOLOGICAL SIGNALS
FOR FIRE CONTROL
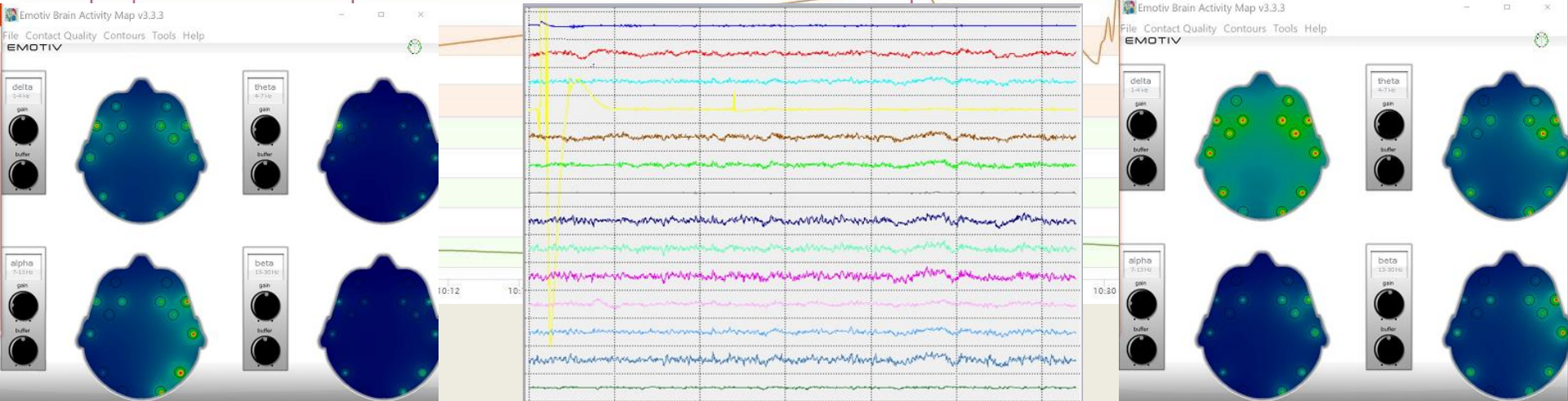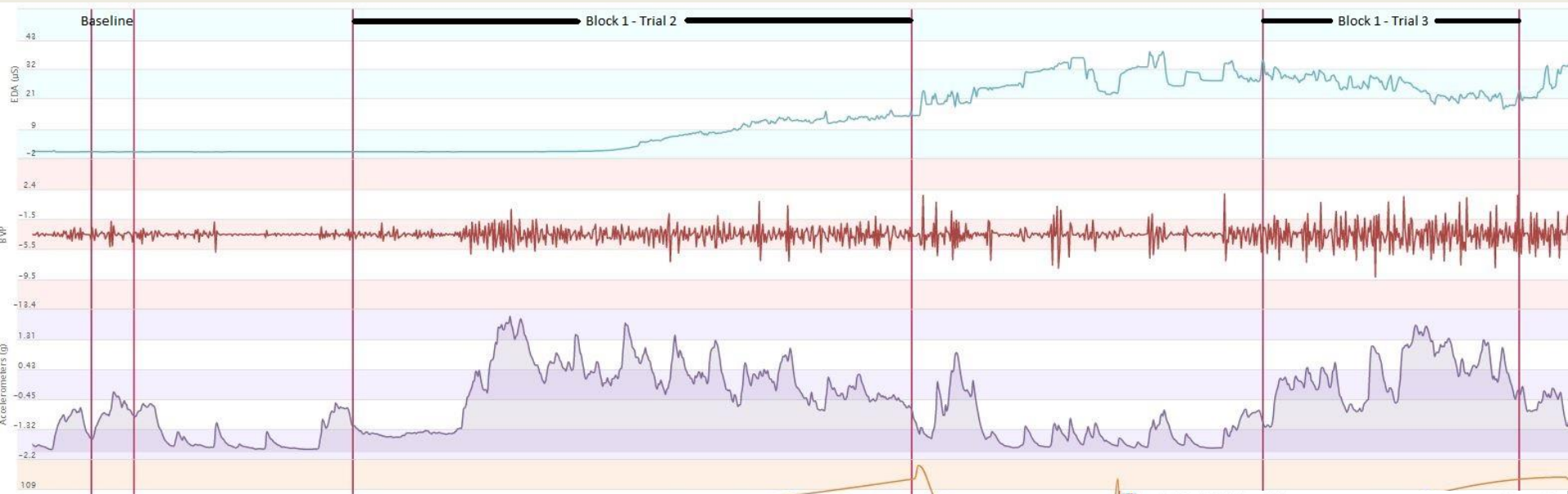
- We know that there is an inevitable chain of events between a decision and the physical action.

- We want to find identifiable signatures in the bio-signals we can detect from the brain…

- …and use it to control a weapon system.

In other words:
If we can detect that the first domino has been pushed,
don't wait for the last one to fall – just activate the weapon.

- **"Armament Virtual Collaboratory Environment"**
- Collaboration between ARDEC's Gaming, Interactive Technologies and Multimedia (GITM), Operational Analysis Branch, and TBRL.
- Purpose is to:
  - Develop the architecture to test individual Soldier targeting and shooting performance in a simulated environment and the individual's effects on brigade level mission performance
  - Establish interoperability between the high resolution graphics engine, the Virtual Reality Test Bed, and the OneSAF simulation
  - Test individual Soldiers given novel armaments in VR test bed where performance is then inputted into OneSAF to generate battle level results
  - Collect human data to submit to machine learning efforts to support development of artificial intelligence to aid dismounted Soldiers
    - Research target characteristics that lead to Soldier shoot decisions in virtual reality scenarios
      - Speed, posture, velocity of approaching person
      - Clothing (uniform/non-uniform
      - Objects that are carried (i.e., gun, shovel, etc.)
      - Gender, age
    - Research electrophysiological signatures for cognitive processes underlying shoot decisions
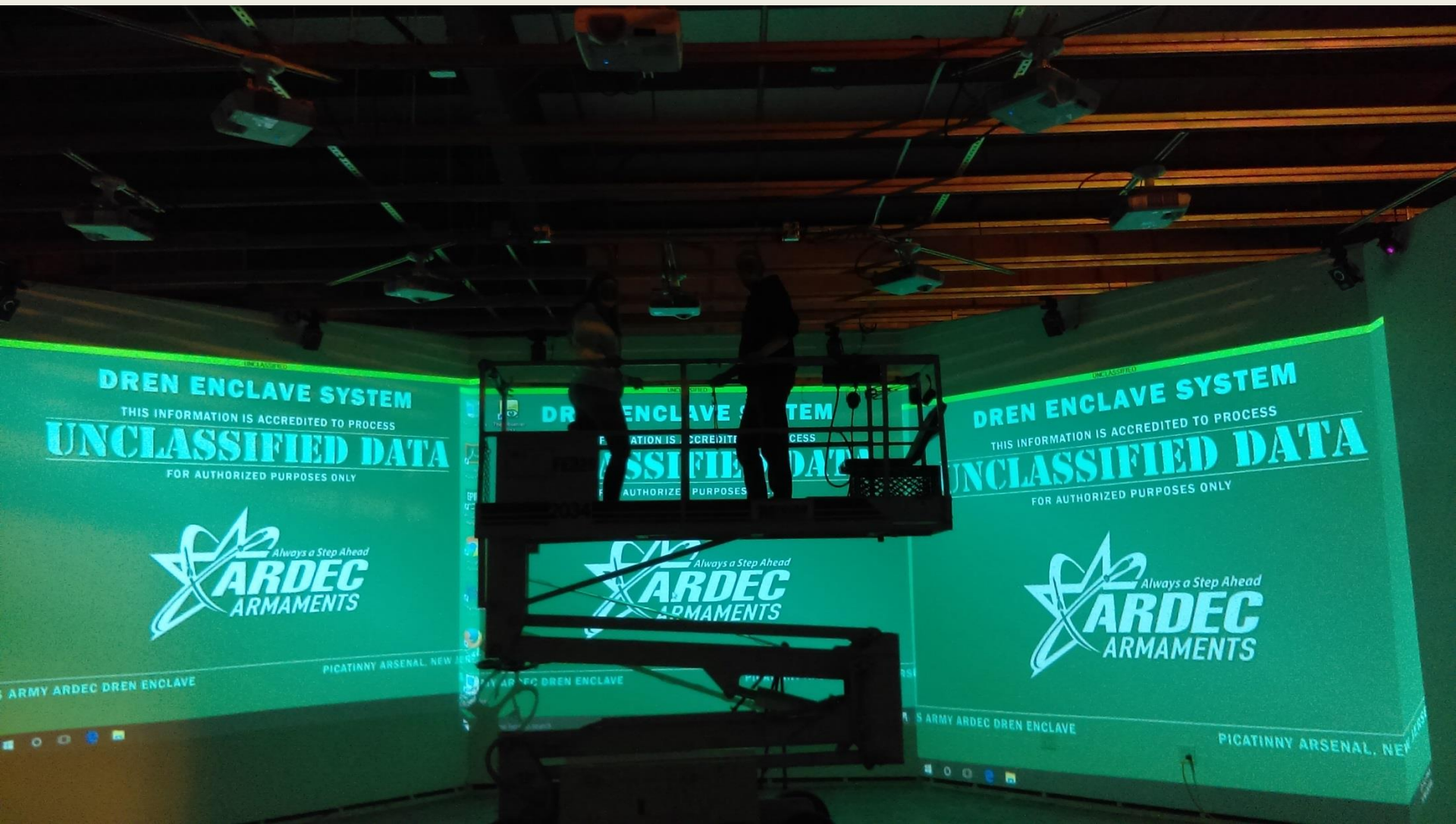
VETB Next Generation

TBRL Augmented/Virtual Reality Testbed (to be completed in 2019)
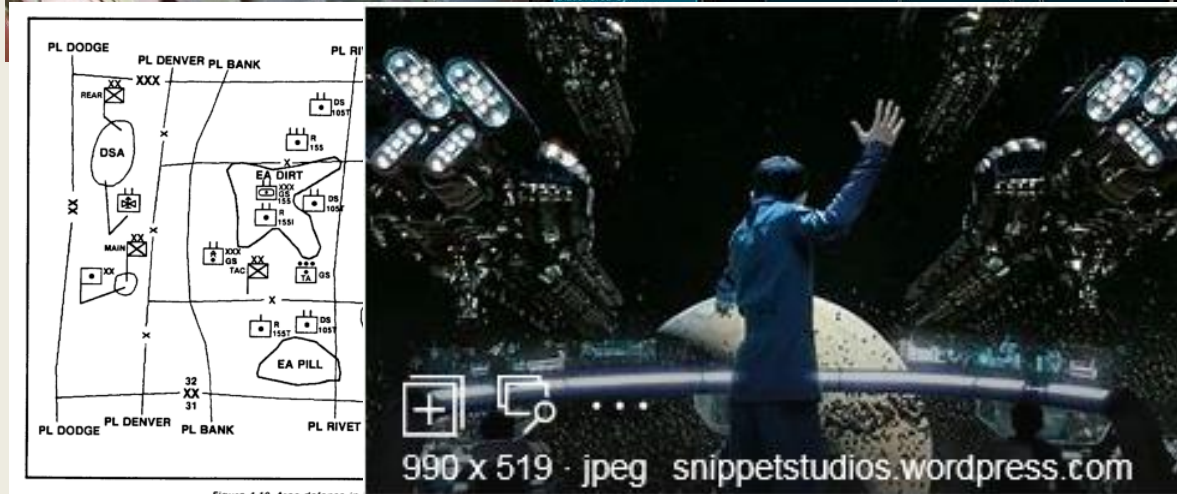
ADVANCED ARMAMENT CONTROL

Figure 4-10. Area defense in sector: fire support

A study of how people think and make decisions, in order to develop intelligent machines, resulting in increased combat power per human, and leaving only the most important decisions to the human.

- Comparison of Human vs Autonomous System Error Rates
  - Knowing human error rates sets a requirement for autonomous systems.
  - Understanding how human's make error's will help autonomous systems make better decisions.

- Levels of Human Control
  - Every individual trigger pull approved by a human
  - Human decides when and where to open fire, and the weapon picks out individual targets and engages (Squad/Platoon leader control)
  - Human decides on mission parameters and selects the engagement area and weapon control measures throughout the mission. Weapon system then executes the mission orders, finds and selects targets and reacts within parameters. (BN/BDE+ command & control)

From this

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To this

QUESTIONS?

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