TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Training for Complex Automated Systems

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SoS vs Air Defense Systems

System of Systems

- Multiple entity command and control
- Distributed information and communication networks
- Complex coordination
- Collective training

Air Defense Systems

- Joint command and control (Army-Air Force-Navy—and sometimes multinational)
- Network-enabled—and dependent
- Complex—an early “system of systems” configuration; many interacting components
- Knowledge-intensive
- Technical and tactical complexity “flow through” directly to operators
- Collective training

Patriot Vigilance

- MG Vane’s question in the Spring of 2004: “How do you establish vigilance at the proper time? 23’ 59” of boredom followed by 1” of panic”?

Tremendous Complexity Ahead

- Over the next four years SLAMRAAM, JLENS, and THAAD joining PATRIOT, SENTINEL, and AVENGER/MANPADS in the AMD arsenal
- Increasingly Complex Operating Environment
- Continuous System Improvements
- Joint Command and Control
- Network-Centric
- System of Systems
- Knowledge Intensive

"The Army's [and the ADA Branch's] ongoing transformation …. requires an unprecedented alliance of humans and machines."

ARI Report on FCS, November 2003

Implications for Our AMD Force

- Controlling engagements in a net-centric system of systems requires experts
- Automation does not eliminate human role, it changes the nature of the role
- We must be sure today's operators can decide when to override automation

"Technological advances are used to demand more from operators and meeting these demands requires 'exceptional human expertise.'"

The Lessons of Modern War, Cordesman & Wagner 1996

Success in OIF Dependent on Technological Advances

- Every TBM launched at defended assets was destroyed (9 for 9)
- A joint- and coalition-based integrated air and missile defense fight

A reporter on the scene wrote that the Soldiers of the 159th Aviation Brigade, 101st Airborne Division (Air Assault), gave the Patriot Soldiers a standing ovation. MG David Petraeus, the division's commander, later stated, "Patriot saved the 101st!"

Army, January 2004

Not All Was Reason to Celebrate

- Royal Air Force GR-4 misclassified as anti-radiation missile (ARM)
- U.S. Navy F-18 misclassified as a tactical ballistic missile
- U.S. Air Force F-16 fires an ARM at a Patriot Unit in Iraq

"… re-look the level of expertise required to operate such a lethal system on the modern battlefield."

DoD Board of Inquiry, OIF 2003

We Took a Hard Look Across All Domains

- Unacknowledged system fallibilities
- Fascination with and “blind faith” in technology
- Little regard in system design for the human performance consequences
- Rote crew drills vs. high-level judgment
- Lack of experience on the part of personnel in key crew positions
- Organizational Culture: “react quickly, engage early, and trust the system”

“Technological advances are used to demand more from operators and meeting these demands requires ‘exceptional human expertise.’”

The Lessons of Modern War, Cordesman & Wagner 1996

Patriot Vigilance Findings

1. Reexamine air defense battle command automation concepts to emphasize effective human supervisory control (HSC)
   - Examine ways to mitigate situation awareness problems resulting from undisciplined automation of Patriot control functions
   - Put operators back into the loop
2. Develop more effective battle command teams
   - Reexamine the level of expertise required to employ a system such as Patriot on the modern battlefield
     - Knowledge, skills, job-relevant experiences and time
   - Explore ways to develop and maintain the necessary expertise

Complex Systems

Training – Unit Table VIII Certified/ Preliminary Data Suggests Issues with Air Battle Operations

Source: ARL HRED's rating for Patriot PDB6 OTRR3

"Post-Deployment Build-6 (PDB-6) software increases operator workload and requires additional manpower. The level of expertise required for PAC-3 (Patriot Advanced Capability-3) PDB-6 operations exceeds the current Army training standard. … The operational impact of [these deficiencies] includes less robust and less effective defense of critical assets, an increased probability that operator error will lead to not engaging threatening targets and/or engaging friendly targets, and longer downtimes when reliability failures occur."

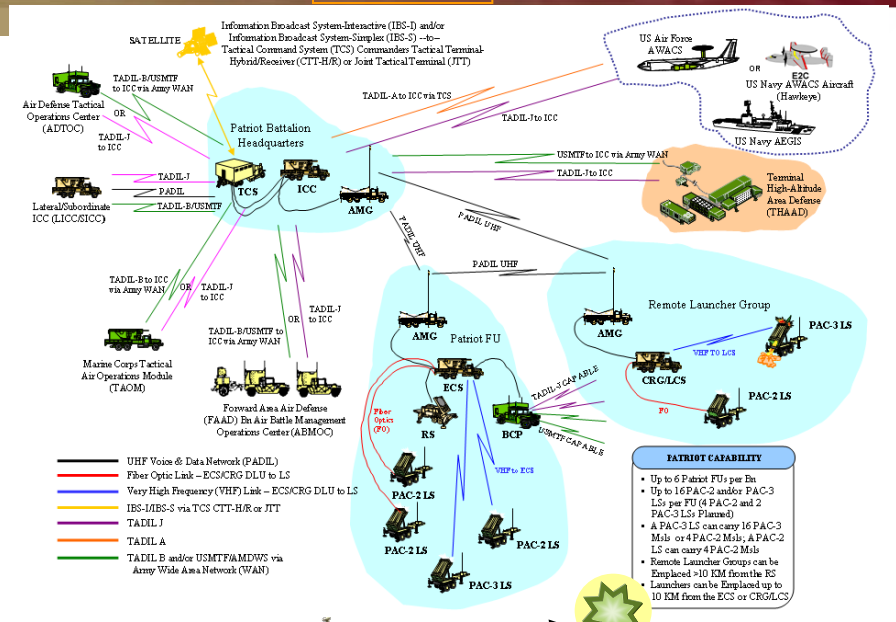
Source: Director, Operational Test and Evaluation. FY 2007 Assessment of the Ballistic Missile Defense System, February 2008

The “Catch-22” of Human System Control

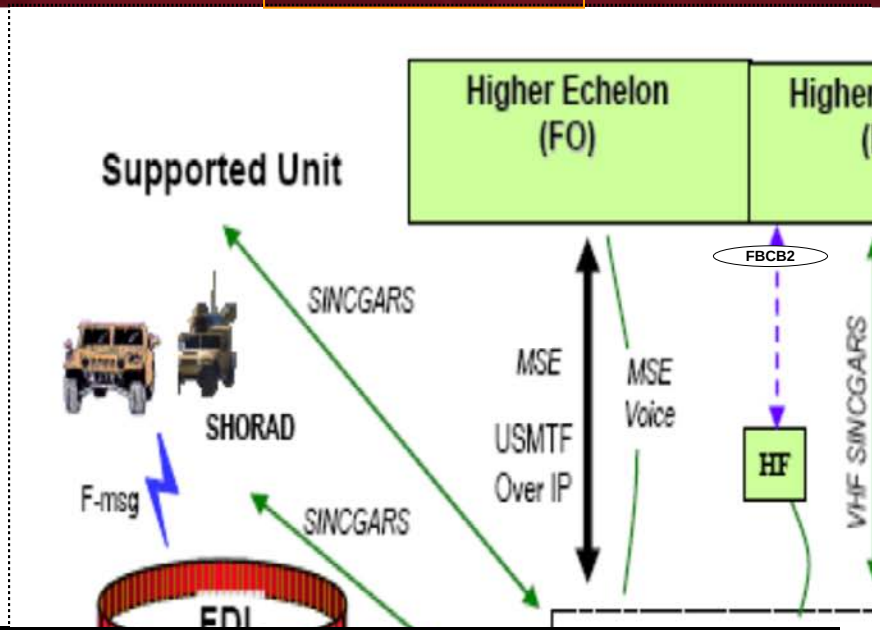
- Automation has been introduced because it can do the job better than a human operator
- Humans have been left in the control loop to “monitor” that the automated system is performing correctly and override the automation when it is “wrong”
- Tacit assumption: Operators can properly decide when the automation’s decisions should be overridden
- Humans are expected to compensate for machine unreliability
- Humans suffer from a variety of cognitive limitations that make it difficult to meet this expectation
- Undisciplined automation can make the operator’s situation more challenging

Work System

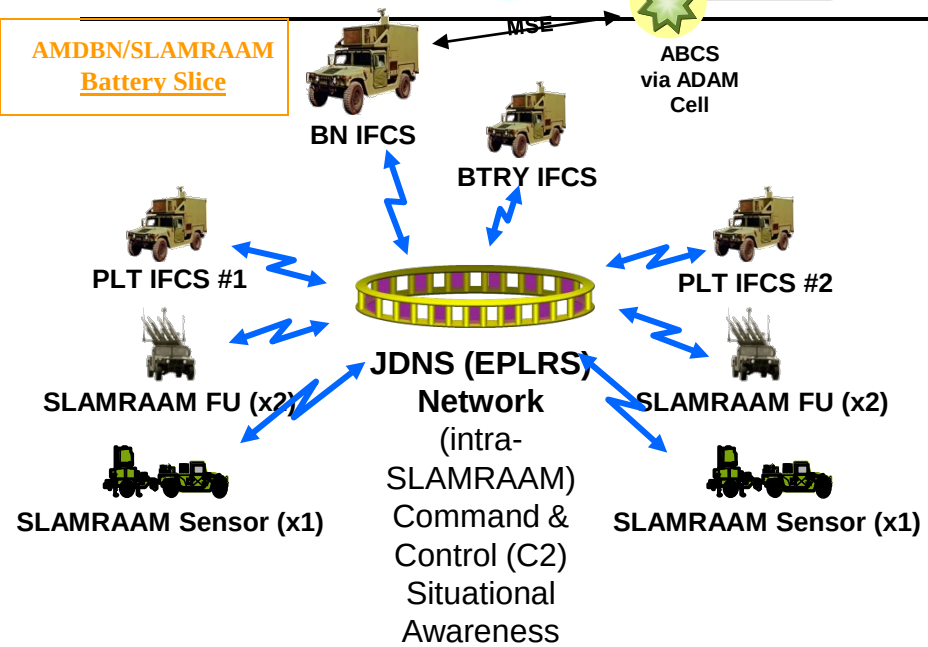
Patriot



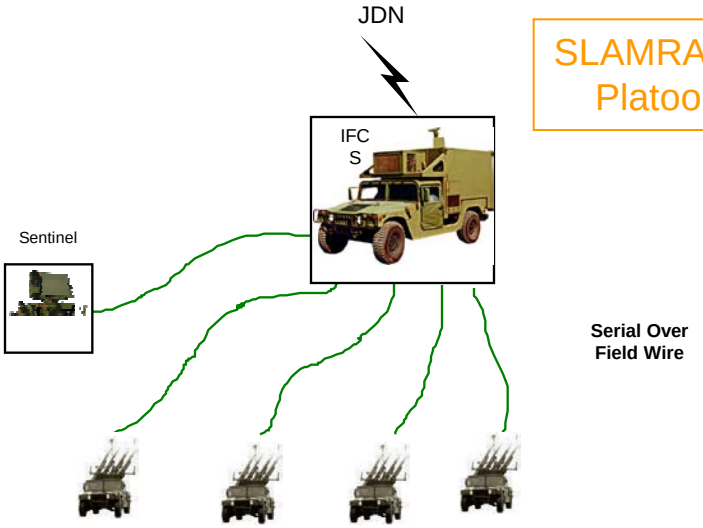
SLAMRAAM



AMDBN/SLAMRAAM Battery Slice



SLAMRAAM Platoon



Current Acquisition System Training

- No Training Effectiveness Analysis (TEA) early on in the programs
- Training devices funded by MS B.
- No training course validation
- Institutional Training focus on 25% of Critical Tasks
- No consideration for training at all levels, Joint, Brigade, Battalion, and Battery
- New Equipment Training
  - NET not translated into 19.5 weeks of Institutional Training
  - Various qualities of NET
  - Instructors are important
  - Rote drills emphasized, high-level decision making not trained

Training Itself Must Change

- Training must be qualitatively different: “Current training does not prepare individuals or units for new, dynamic cognitive demands.” (Defense Science Board)
- Many emerging systems are knowledge-based (Rasmussen, 1986; Dekker, 2002)
- Much current Army training stresses skill- and rule-based performances but gives short-shrift to knowledge-based performance requirements
  - OIF BOIs criticized Patriot training for emphasizing “rote drills vs. high-level judgment”
  - What distinguishes “good” decision makers from “bad” decision makers most is their ability to make sense of situations by using a *highly organized experience base of relevant knowledge (Dekker, 2002)*
- Knowledge-based systems place a premium on user expertise

Automation does not simplify training, it changes training requirements and often makes job preparation more demanding.

How can we influence training improvement?

- ✓ MOS Adequacy
- ✓ Test players must be trained to Army standard
- ✓ Test scenarios must be realistic
- ✓ A training strategy needs to be developed early in the process
- ✓ Training devices for all levels of training
- ✓ Valid training content

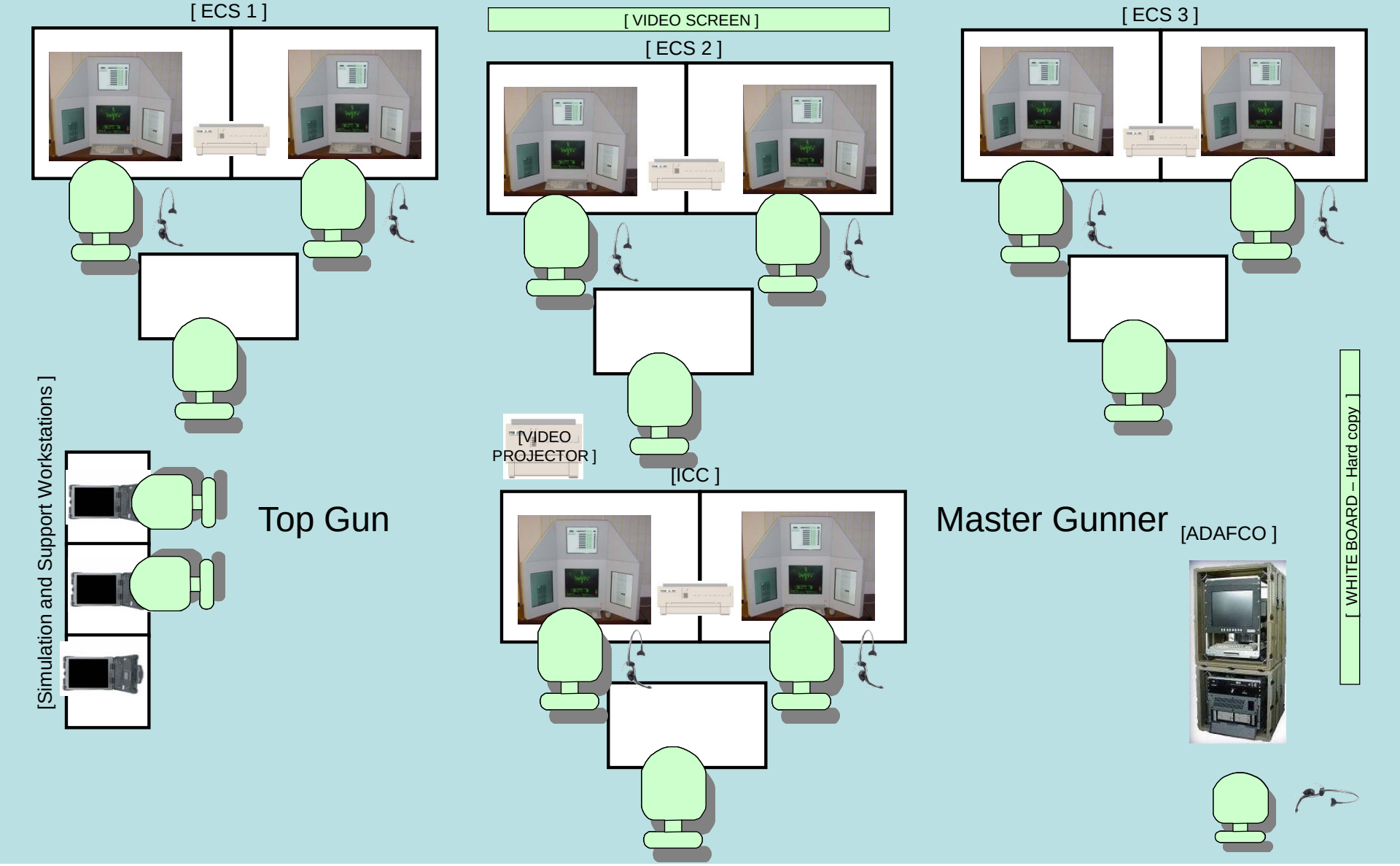
Why is training so important?

- Uncertain test player capabilities will result in a compromised test
- The most common form of compromise is *confounding* between test outcomes and pre-test proficiency levels
- It is not possible to determine unambiguously whether test outcomes reflect system capabilities and features, test player proficiency levels, or some interaction between the two
  - You can not disentangle observed system performance from test player proficiency
- Interpretation and generalization of test results could be risky
- But…we would like to generalize from the operational test setting to a future operational environment

Training Evaluation

- Multi-stage training evaluation prior to testing is essential
  - Preliminary assessment of training plans to determine whether planned training events will produce desired test player competencies
  - Performance-based evaluation (PBE) of test player proficiency prior to starting testing: Can test players actually perform as required?
  - Both stages critical to avoiding “late-cycle churn” in pre-test training program: Test player performance flaws discovered late in the train-up process
    - Very expensive to correct
    - May be too late to be adequately corrected
- Use objective, outcome-based metrics—derived from training objectives—as the basis for performance-based training evaluation

To evaluate training we have to test what people have learned, and not just find out if they liked the training.



"… simulators by themselves do not train. They are tools used by good instructors operating within a well-designed instructional strategy to achieve training objectives."

Hawley, Mares, Fallin, and Wallet, RTOS OPDEMO 2007

“Risk exists that training failure will negate hardware [and technology] promise.”

(Defense Science Board)