Department of Defense
HUMAN SYSTEMS OVERVIEW

July 2012
Roadmaps Tuned to Strategic Guidance of January, 2012

- **President**
  - ... focus on ... Asia Pacific .... deepening partnerships
  - ... military is agile, flexible, and ready for the full range of contingencies

- **DepSecDef**
  - ... Joint Force of the future that will be smaller and leaner, but will be agile, flexible, ready, and technologically advanced.
  - ... led by the highest quality, battle-tested professionals

- **Primary Missions**
  - Counter Terrorism and Irregular Warfare
  - Deter and Defeat Aggression
  - Provide a Stabilizing Presence
  - Conduct Stability and Counterinsurgency Operations
  - Conduct Humanitarian, Disaster Relief, and Other Operations

- **Joint Force**
  - ... resist the temptation to sacrifice readiness
  - ... limited resources may better tuned to their requirements
  - ... encourage innovation in concepts of operation
Summary – Human Systems

• Big Ideas

– Enable Engineering and Assessment for Joint Mission Effectiveness
  – Baseline Effectiveness Using Realistic Mission Training Scenarios
  – Extend Mission Training Scenarios to Joint Missions
  – Provide Synthetic Environments for Collaboration with Industry, Others

– Natural interfaces to manage multiple scale multiple role systems
  – Develop common representation schemes for system/data interaction
  – Develop natural language and gestural system interaction
  – Develop operator state monitoring technology
Problem: Complex Evolving Threats Outpace Readiness Training

- Warriors train for tomorrow’s fight using yesterday’s technology, methods, and strategies
- Current training scenarios not matched to evolving mission complexity and dynamics
- Warfighters are trained to doctrine -- fight strategically and dynamically to meet new threats
- Training is costly
  - Live systems deplete inventory, consume fuel, require maintenance & wear out
  - Ranges & role players are expensive – lack fast responsiveness to changing scenarios
  - Training ranges not designed for flexible scenarios and throughput is inadequate

Human Systems
Training for Readiness
- Seamless Virtual/Constructive training
- C2 with tactical players
- Quantified human system performance with mission effectiveness metrics
- Safe, live virtual constructive training
- Individual adaptive team training
- Increased Complexity
- Increased players

- Timely and effective training reflecting dynamic operational insights/challenges
- Personalized, adaptable, point of need training
- Integrated regional ally mission preparation
- Credible synthetic players: persistent, generative, robust
- Continuous, real time, high fidelity training with LVC multinational partnering – when and where needed

Mission Effectiveness (% Current)

Years

Speed to Train for Full Mission Effectiveness

Mission Effectiveness (Years away)

0 3 5 7 10 10+

Hours

0 3 5 7 10 10+
Human Systems Training Technical Challenges

Challenge 1: First Principles for Training Design
- **Validated tools to optimize** training outcomes across individuals and teams
- Characterizing and exploiting the “science of learning” and developing performance measures for effectiveness prediction
- Techniques to automatically capture operationally relevant measures of performance

Challenge 2: Realistic, Adaptive and Interactive Scenario Based Training
- **Persistent integration** of real world events and content into scenarios and syllabi
- Demonstrated and validated for the full range of warfighter capabilities reflecting recent lessons learned
- Training that adapts to warfighters’ individual needs in near real-time

Challenge 3: Persistent, Affordable, Integrated Training
- **Mission-focused training simulations** that enhance individual and collective training
- **Seamless, secure** integration of training systems across services and coalition partners
# Training Challenges

<table>
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<th>#1 – First Principles for Training Design</th>
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<td><strong>Gaps</strong></td>
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<td>- Estimated operational effectiveness via training scenarios</td>
<td>- Automated, adaptive, and individualized tutors</td>
<td>- Training systems which adapt to individual needs</td>
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<td>- Verification &amp; Validation of advanced training models</td>
<td>- Automated knowledge elicitation to develop responsive instructional content</td>
<td>- Standardized data protocols for operation in multi-level classified environments</td>
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<td>- Measures and assessment of long term (life long) performance</td>
<td>- “On the fly” assessment in dynamic environments</td>
<td>- Scalability across increasingly complex domains</td>
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Training Roadmap – First Principles for Training Design

Integrated Live, Virtual, Constructive (LVC) Environments With Real Time Assessment For Joint and Coalition Individuals, and Teams

**End States**

1. Integrated LVC Training and Assessment (F-18, F22, JSF, UAS)
2. Discovery engines to model individual expert behaviors
3. ITSs for Intell Analysts & STEM
4. Scalable Agents for Teams
5. Agent-driven Aiding & Trng for C2
6. Persistent Models & Environments

**Technical Capability**

1. Higher fidelity behavior models (individual and teams)
2. Training authoring tools
3. Generalized Intelligent Framework for Tutoring
4. High resolution, validated metrics for performance measurement
5. Computational models of human cognitive performance
6. Automated Knowledge Elicitation / Engineering

**R&D Programs**

1. Mechanisms of Cognitive Processing
2. Cognitive Model and Scale Integration
3. Integrated LVC Training and Assessment (F-18, F22, JSF, UAS)

Shading Legend

- Dark: Funded
- Light: Not/partially funded
Training Roadmap – Persistent, Affordable, Integrated Training

End States

- Reduced tutor development time/cost
- Integrated Live, Virtual, Constructive (LVC) Environments With Real Time Assessment For Individuals, and Teams
- Persistent Readiness Assessment, Tracking, Prediction
- Personalized, adaptive, persistent, scalable training

Military Capability

- Higher fidelity behavior models (individual and teams)
- Common Instructional Strategies across Domains
- Persistent, Generative Models and Agents
- Persistent, Globally Distributed Knowledge Bases

Technical Capability

- Robust Functional Synthetic Teammates
- Agent-Based Training Enterprise Management
- Persistent, Generative Models and Agents
- Common Instructional Strategies across Domains

R&D Programs

- Augmented Immersive Training for Infantry
- Perceptual Training Systems and Tools
- Everyday (not stressful) Environments 24/7/365 training
- Virtual World for Post Deployment Soldier Support
- Small Unit (Leader & Individual) Adaptive Tutoring Research

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Training Techniques

2013 2016 2018 2020 2023

Distribution A: Approved for Public Release
Human Systems Interface for Effectiveness

Problem: Current system operation is rigidly data-centric vice flexibly information-centric

- Modern technologies exacerbate critical manning and talent pool deficiencies by ignoring role of Mission, Task & Context – Moving & presenting data vice information
- Current adaptive planning tools do not allow rapid “course of action” analysis and generation
- Information displays typically non-interactive, adapting little to changing needs
- Data quantity will continue to increase nonlinearly

Virtual lab

Actual lab
Interface
Technology End States

- Task-centric interfaces for increased speed and accuracy of decisions
- Model context and decision space
- Situation sensitive adaptive interface

- Mission-centric automated information analyses (e.g. prioritized COA recommendations)
- Operator state driven tailored information

- Context sensitivity to Commander’s intent
- Common control station for UxS
- Tactically believable agents

- Natural language dialogue
- Influence operator state

- Social Cognitive Architectures for synthetic teammate development
- Hybrid force demonstration for multiple UxVs via natural man-machine interactions

Mission Effectiveness (Re: Current)

Interaction Quality

Number of years away

1 3 5 7 10 10+

Distribution A: Approved for Public Release
Human Systems Interface Technical Challenges

Challenge 1: Human-Machine Teaming
- Developing representation and inference frameworks that capture and reason over the beliefs, goals, intentions and obligations of the human user
- Integrating low-level operator state modeling with representations of human user’s estimated mental states (see below)

Challenge 2: Intelligent, Adaptive Aiding
- Measuring, assessing, and modifying operator’s mental and physical state
- Adapting estimates of user’s mental states via successful and unsuccessful interactions
- Iteratively learning user model via natural, multi-modal interfaces (E.g. gesture, natural language dialogue)

Challenge 3: Intuitive Interaction
- Natural, anticipatory interaction
- Trust
# Interface Challenges

## #1 – Human-Machine Teaming

**Gaps**

- Non-verbal cue understanding between the interface and the operator
- Natural interfaces to manage multiple scale (one to many), multiple role systems

## #2 – Intelligent, Adaptive Aiding

**Gaps**

- Metrics (systematic, scalable, relevant) for free form interactions
- Interfaces which adapt to the user’s mental state
- Heuristics to determine relevant information to be exchanged during operations

## #3 – Intuitive Interaction

**Gaps**

- Human-centric parameters for management of autonomous systems
- Goal-oriented interfaces for simultaneous multiple domain operations
Interface Roadmap – Human-Machine Teaming

End States

Military Capability

Human-Robot Teaming
Gesture/Limited Dialogue-enabled UGV for Logistics Connector Missions

Technical Capability

Combined Speech/Gesture Interfaces
Natural User-System Interactions: Reactive interfaces

Natural Language Dialogue

Natural User-System Interactions: Trustworthy Proactive interfaces

Human-Robot Interaction

Socio-Cognitive Architectures

Cognitive Architectures and Integrated Intelligent Systems
Unrestricted Natural Language Dialogue

Mission-Specific Natural Language Dialogue

Gesture/non-verbal interaction

R&D Programs

SUMET Logistics UGV Vehicle Control Demo

Future Carrier Deck UCAV

AAGUS Cargo UAV

Damage Control 21

Human – Robot Cooperative Shipboard Demo (Damage Control 21)

Automated Tasking Management for Autonomous Systems

Seamless teaming of autonomous UAV with manned systems

Hybrid Force Demonstration: Combined Air-Sea-Land Engagement

2013
2016
2018
2020
2023

Shading Legend
Dark: Funded
Light: Not funded
Interface Roadmap – Intelligent, Adaptive Aiding

End states:
- Soldier System State Assessment
- Soldier System State Prediction
- Mission & Task Driven Adaptive Aiding

Military Capability:
- Task and Behavior-Driven Assessment Systems
- Dynamic- UAV Mission Mgmt.
- Socially-Guided Machine Learning

Technical Capability:
- Models of Cognition, Performance and Physiology
- Neurally Informed Displays with Individual Differences
- Natural User-System Interactions: Trustworthy Proactive interfaces

R&D Programs:
- Cognition, Performance and Individual Differences
- Computational Models of Operators’ Beliefs, Desires, Intentions and other Mental States
- Human-System Co-Adaptation
- Applied Neuroscience
- Gesture/non-verbal interaction

Shading Legend:
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*Processing, Exploitation, Dissemination
Interface Roadmap – Intuitive Interaction

End States
- Submarine 360 Full-Azimuth Synthetic periscope
  - Multi-Modal interfaces
  - Synthetic Displays for Spatial Awareness
  - Cognitively based visualization techniques
- Common UxV Control Station
  - Interoperable UxV control stations
  - Advances Interfaces for Team Coordination
  - Virtual Environments for C²
- LCS UxV Mission Control
  - Neurally Informed Displays
  - Visualization and Decision Support for Agile C² and Cyber
- Future Carrier Deck UCAV
  - UxV Control Station
  - Multisensory Perception and Interfaces
  - Interfaces to C2 Information Systems
  - Mission Planning and Scheduling Tools
- AACUS Cargo UAV
  - U2CI UUV
  - Multi-AOR based Analysis Tools
  - Fusion Exploitation Tool Suite
  - Distributed Intelligent Interfaces for Human-Centric Info Systems
- Agile Decision Support for Autonomy Management
  - Mission & Task Driven Adaptive Aiding
  - Intrinsic PED
  - Enterprise level decision systems (social and cultural parameters)

Military Capability
- Multi-Modal interfaces
- Synthetic Displays for Spatial Awareness
- Cognitively based visualization techniques

Technical Capability
- Virtual Environments for C²
- Schema for Dynamic Management of Heterogeneous Autonomous Systems
- Advances Interfaces for Team Coordination
- UxV Control Station
- Multisensory Perception and Interfaces
- Interfaces to C2 Information Systems
- Mission Planning and Scheduling Tools

R&D Programs
- Visualization and Decision Support for Agile C² and Cyber
- Neurally Informed Displays
- Agile Decision Support for Autonomy Management
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2013 2016 2018 2020 2023
Summary

• Engineering and Assessment for Joint Mission Effectiveness
• Natural interfaces to manage multiple scale multiple role systems
Interfaces and Training
End States

Continually Updated
Training Regimen

Up to date, synergistic training

Lessons Learned from the field

Today

The Future:
Human Systems - Autonomy

LVC with Current Tactics
Adaptive Tutoring / Training
Home-based Combat Training
Mission Rehearsal

Training & Tactics

“Instrumented” Operator

Cognitive Processing, Visualization, Neuroscience,
System State Adaptation, Continuous Learning

“Instrumented” System

Operator-State Adaptation, Autonomous Intent, Cognitive Modeling

Training & Tactics
Training Vision

Realistic Mission Rehearsal
Interface Vision

Constant, reciprocal state awareness between humans, machines, and information sources
Human Systems
Training Measures of Success

Challenge 1: First Principles for Training Design

- At least one sigma performance improvement of trainees across domains / applications
- Automated measurement capability that produces meaningful feedback for individual and/or collective performance in live and virtual training exercises

Challenge 2: Realistic, Adaptive and Interactive Scenario Based Training

- Automatic players in training scenarios indistinguishable from live players (‘Turing Test’)
- Improved performance resulting from training that automatically adapts in near real time
- 25% reduction in time and cost to develop training scenarios

Challenge 3: Persistent, Affordable, Integrated Training

- Capability to deliver training to any internet-capable device
- Affordable, turnkey capability to link simulations across services for joint training exercises
Human Systems Measures of Success

Challenge 1: Human-Machine Teaming
- Number of UxVs controlled by single operator
- Number of warfighters and UxVs supported in roles
- Per cent of operator requests anticipated
- Latency for machine-generated alternative courses of action

Challenge 2: Intelligent, Adaptive Aiding
- Speed and accuracy of decisions X scope
- Transaction rate of relevant information
- Increased situation awareness

Challenge 3: Intuitive Interaction
- Accuracy of operator state assessment
- Effectiveness of natural language dialogue
- Ease of interaction, time to achieve full competency