Primary Army S&T Organizations: Executing HS R&D

Personnel
- G-1

Medical
- MEDCOM

Infrastructure/Environmental
- USACE

Materiel
- AMC

Strategic Missile Defense
- SMDC

Test & Evaluation
- ATEC

ATEC

ARDEC

CERDEC

ECBC

NSRDEC

TARDEC

ARI

AMSAA

RDECOM

ARL
Human Systems Science & Technology Scope

**System Interfaces**
- Human-Machine Interfaces
- Human cognitive process modeling
- Decision-making models
- Human state modeling
- Applied Neuroscience
- Trust
- Metrics & measures of effectiveness

**Personnel & Training**
- Force management & modeling
- Selection & Classification
- Theory of learning
- Adaptive, tailored instruction
- Live, virtual, constructive sims
- Realistic immersive training
- Training methods, tech, & media
- Education & training strategies
- Innovative leader development
- Metrics & measures of effectiveness

**Social & Cultural Understanding**
- Cultural situation awareness
- Socio-cultural models & synthetic entities
- Socio-cultural data in denied areas
- Social network analysis
- Building partnerships
- Metrics & measures of effectiveness

**Protection & Sustainment**
- Extreme environment protection
- Combat clothing & protective equipment
- Extended combat rations & field feeding equipment
- Physical aiding
- Performance enhancement
- Vehicle escape & crash safety
- Survival & rescue
- Aerial delivery
- Warrior-System integration
- Metrics & measures of effectiveness
RDECOM Human Systems S&T Areas

Soldier Perception, Cognition, & Physical Performance
- Visual & auditory perception
- Multi-sensory integration
- Cognitive & motor interaction

Translational Neuroscience
- Neurocognitive performance
- Advanced computation
- Neuro-technologies

Human Robot Interaction
- Intuitive interface concepts
- Soldier-robot teaming
- Cognitive robotics

Equipment Integration, Assessment, and Demonstration
- Human, equipment, & technology operational integration
- Equipment/technology experimentation, assessment, & demonstration

Social-Cognitive Network Science
- Sociotechnical network operations
- Network-enabled cognition

Methods, Models, and Analysis
- Soldier centered analysis
- M&S tool development
- Social cultural modeling

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
RDECOM Simulation & Training Technology
S&T Areas

Intelligent and Adaptive Technologies for Training

- Readiness to Learn Modeling & Prediction
- Virtual Humans

Training Application Environments

- Dismounted Soldier
- Live Training/Instrumentation
- Medical Simulation

Immersive Learning

- Authoring & Infrastructure
- Interface Technologies

Synthetic Environments

- Dynamic Effects

Advanced Distributed Simulation

- System Design & Engineering
- Authoring

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
Personnel Assessment

*Measures and models to assess:*
- Potential
- Competencies
- Attitude/opinions (6.6)

Unit-Focused Training

*Methods and measures for:*
- Collective (unit) training
- Training difficult tasks
- Unit training assessment

Institutional Training

*Training methods for:*
- Individual (Soldier) skills
- Instructors and training developers

Leader Development

*Accelerate leader skills for:*
- Strategic Thinking
- Influence
- Mission command
- Building Partnerships

Technology-Based Training

*Effective methods for:*
- Emerging training technologies
- Adaptive learning tools

Basic Research (6.1)

*Scientific advances in:*
- Personnel measures
- Training effectiveness
- Leader development
# ARI S&T Program Strategy

<table>
<thead>
<tr>
<th>Personnel</th>
<th>FY12-13</th>
<th>FY14-18</th>
<th>Critical Gaps (not programmed)</th>
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</table>
| Selection of Candidates | • Enlisted  
• Officers | Classification and Assignment | • Soldier job classification  
• Officer branch/career selection | Social Science | • Well-being  
• Talent management  
• Human relations  
• Culture of Respect | Future Force | • Agile  
• Cyber |
| Training & Leader Development | Measures and training methods for:  
• Achieve proficiency faster  
• Cross-cultural leadership  
• Mission command skills  
• Rapid training development  
• Training emerging tasks | Effective methods for individuals and small units to develop:  
• Individual (Soldier) skills  
• Collective (unit) skills  
• Collaborative strategic thinking  
• Training manned-unmanned teaming skills  
• Adaptive training | Training methods to achieve Decisive Action for:  
• Lifelong learning  
• Active + Reserve effectiveness  
• Functional/ multi-functional Brigades  
• Military Info Support Ops & HumINT  
• Cyber warfare |
| Basic Research | • Theory linking emotion & cognition  
• Team leadership strategies  
• Self-learning strategies  
• Measures of emotional intelligence | • Learning from experiences  
• Multi-echelon leadership  
• Models to predict training effectiveness  
• Unbiased measures of cognitive ability | • Multi-disciplinary approach to human measurement  
• Modeling human behavior in organizations  
• Computational learning model |
Information and communication networks allow diverse and geographically separated military units the potential to leverage available relevant information to maximize mission effectiveness.

The tenets of network-enabled operations:

• A robustly networked force improves information sharing.
• Information sharing enhances the quality of information and shared situational awareness.
• Shared situational awareness enables collaboration and self-synchronization; and enhances sustainability and speed of command.
• These, in turn, dramatically increase mission effectiveness.

Information and communication networks allow diverse and geographically separated military units the potential to leverage available relevant information to maximize mission effectiveness.

Social-Cognitive Network Considerations:

• Information load
• Information uncertainty, quality (completeness, accuracy), ambiguity, timeliness
• Display issues
• Multitasking requirements
• Time stress
• Distributed team communication
• Team situational awareness
• Trust
• Multinational team collaboration
• Cultural environment
• Resiliency to node failure

Is more better …?
We have access to more information than we can process
**System Interfaces: Social-Cognitive Network Science**

**Purpose:** Study the interconnections of the network genre (information, communication, and social-cognitive) with an emphasis on the role that behavior, cognition, and relationships play in governing network behavior.

**Products:**
- Models and methods to support distributed coalition information processing for decision making at the tactical and operational levels
- Decision support tools for enhanced cognitive performance
- Documented principles of organizational design
- Network metrics and advanced analysis techniques
- Enhanced network information flow task modeling
- Work/information flow analyses

**Results:**
- Lab-based scenario-driven experimentation of Army mission command collaboration and communication
- Rapid operational analysis capability of blue forces in the field

**Payoff:**
- Better alignment of current and future Soldier and system capabilities such that cognitive workload will be reduced, situation understanding will be enhanced, and fast and accurate decisions will be made
- Decision aids will help integrate information management for Soldiers to rapidly and efficiently process information from sources at multiple levels

**MILESTONES**

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Milestone Indicators: TRL or SRL: Milestone Timeline:
Vision: Conduct research aimed at improving Soldier performance through understanding the effects of equipment and technology on the interaction of perceptual, cognitive, and physical performance.
System Interfaces: Soldier Perception, Cognition, & Physical Performance

**Purpose:**
- Understand, predict, and improve Soldier perception, cognition, and physical performance in current and future operational environments

**Products/Results:**
- Operationally relevant metrics of perception, cognition, and physical performance and their interaction
- Innovative data collection techniques and facilities for collecting perceptual, cognitive, and physical performance data on operationally relevant tasks with appropriate Warfighter context
- Data demonstrating the effects of physical load on cognitive performance and vice versa
- Algorithms to predict Soldier-system performance for modeling, system design
- Model of the effects of protective equipment on auditory performance
- Validated techniques for enhancing spatial cognitive performance under dynamic combat environments
- Validation of algorithms to enhance target identification with night vision devices.
- Guidance for small arms weapon design and marksmanship technique to improve shooting performance

**Payoff:**
- Increased Soldier situational awareness, lethality, and survivability
- Improved Soldier-system performance on operational tasks

**MILESTONES**

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**TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.**
Highest Priority Research

- Neuroimaging tool development is within the top four research priorities (White House)
- Understanding the brain’s structure and function is a top three foundational research theme (White House)
- Cognitive neuroscience is a top six disruptive basic research area (ASDRE)

Neurotechnology industry invests >$140 billion annually

Broad Implications of 6.1 Efforts

Neuroscience-based approaches have the potential to provide revolutionary advances that address Army needs (National Research Council)

Cognitive Performance: Enhanced or altered Soldier/combatant cognitive performance. Army payoffs range from training to faster, more effective operations to enhanced recovery and rehabilitation

Communications Technologies: Faster, more accurate, more informative bi-directional communication. Army payoffs range from enhanced information understanding by Soldiers to deception detection
Over ½ million citable documents produced over the past 14 years

Widely acknowledged that neuroscience has had difficulty in “translating” basic research into applications

Solution requires we move beyond the laboratory setting

ARL focuses on creating and executing a capability to translate neuroscience from a laboratory science to innovative technologies that provide revolutionary solutions for the Army

- Enhancing and creating technologies to effectively understand brain function in real-world settings
- Accessing unique, military relevant, and often one-of-a-kind data and data collection opportunities
- Interweaving a deep knowledge of basic neuroscience, technology development, and military environments and situations
- Creating a translational pathway between science and technology development organizations
NEUROIMAGING TOOLS for interpreting complex brain dynamics within real-world environments

Understand the relationships among brain STRUCTURE, neurocognitive FUNCTION, and Soldier BEHAVIOR in military-relevant tasks

Enable mutually-adaptive BRAIN-COMPUTER INTERACTION technologies for improving Soldier-system performance

Research Objectives

FY10

Low-Resolution Wireless Sensor Systems

High-Resolution Wireless Sensor Systems

Robust Neural Processing Software

Integrated, Wearable, Fieldable Multi-Aspect Solutions

Improved Brain Connectivity Metrics And Algorithms

Models Linking Structure and Function

Armor that Minimizes Brain Injury

Proof-of-Concept Performance Predictors

Bi-Directional Increased Bandwidth Communication Tools

Real-Time Collaborative Cognitive Status Predictors

Payoff

Enhanced Human-Systems Interface Research and Development Effectiveness

Robust Tools for Real-Time Integration of Soldier Readiness and Capability

Individualized Models Predicting Soldier Neurocognitive Performance

Enhanced Armor and Survivability

Shorter, More Effective Training

Enhanced Soldier-System Performance

Improved Soldier-System and Soldier-Soldier Communication
Purpose:
- Leverage a multidisciplinary approach to enable advances in Soldier-System performance by exploiting the capabilities of the nervous system, optimizing across Soldier and system, and accounting for individual differences

Products:
- Hardware and software components and tools for real-world neuroimaging
- Neural processing algorithms and software
- High-resolution and real-time models of neural behavior and Soldier performance
- Proof-of-concept and brain-computer interaction technologies
- Scientific papers and presentations

Payoff:
- Improved Soldier neurocognitive performance
- Enhanced Soldier-System integrated performance (e.g., faster, more accurate, more informative communications)

Milestone Indicators: TRL or SRL: Milestone Timeline: 6.1 Research 6.2 Research
**Intuitive Interfaces**
“Communicate”
- Multimodal displays and controls to reduce task burden
- Decrease Soldier cognitive & physical workload
- Human-like interaction with intelligent systems

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“Communicate”
- Multimodal displays and controls to reduce task burden
- Decrease Soldier cognitive & physical workload
- Human-like interaction with intelligent systems

**Shared Cognition**
“Think”
- Model human abilities (perception, learning, cognition)
- Develop “common ground”
- Collaborate on computational approaches to modeling shared mental models

**Situational Awareness**
“Understand surroundings”
- Effective local situational awareness
- Rapid development of battlespace awareness for dismounts
- Safe maneuvering with indirect vision

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**Teaming**
“Work together”
- Effective Soldier & robot teams
- Manned-unmanned teaming (MUM-T)
- Supervisory control
- Trust & transparency

**Teaming**
“Work together”
- Effective Soldier & robot teams
- Manned-unmanned teaming (MUM-T)
- Supervisory control
- Trust & transparency
System Interfaces: Human-Robot Interaction

Purpose:
- Effective Soldier-robot teaming
- Develop human-centered approaches and design principles that:
  - improve overall Soldier-robot performance in military operations
  - enhance the Soldier interface with robots
  - establish “common ground”
  - increase situational awareness, e.g., spatial SA
  - increase span of control by Soldiers
  - support manned-unmanned teaming (MUM-T)

Results/Products:
- Human-centered design principles for multimodal, speech, and gesture interfaces
- Documented methodologies to enable human-like interactions and establishing “common ground”
- Design principles reports for 360° local situational awareness for vehicles via configurable displays
- Validated and documented display design principles for enhancing spatial awareness in dismounting infantry
- Documented methods for MUM-T, including control of unmanned air systems (UAS) through delegation
- Documented design principles for trust and transparency in Soldier-robot interactions

Payoff:
- Improved Soldier performance with unmanned systems by managing cognitive and physical burden:
  - Reduced workload
  - Increased situational awareness
  - Human-like interactions
- Fewer Soldiers, with greater standoff distances

Schedule & Cost

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Milestone Indicators: TRL or SRL

Milestone Timeline: [Green Bar]
Looking across DOTMLPF domains to integrate and standardize a suite of laboratory-based measures of performance linked to measures of effectiveness in field experiments and demonstrations:

- Linking human, equipment, Soldier, Small Unit
- Linking laboratory to field (i.e., operationally relevant environment)
- Addresses holistic Soldier performance and optimization

Equipment / Technology Integration:
- Mission-based Load Planning Aids & training /education aids
- Human augmentation devices
- Human-based protective equipment design concepts
- Information portrayal in cockpit displays for degraded visual environments (DVE)

Equipment / Technology Experimentation, Assessment, Demonstration:
- Supporting Technology Enabled Capability Demo (TECD) Integration & Demonstration
- Supporting multiple crew station working groups
- Supporting gaps and risk reduction for PEO-Soldier, PEO-Aviation, and PEO-C3T

React to Contact

Capable

Non-Capable
Purpose:
• Influence Soldier System designs
• Develop collaborative understanding of the relationships that link performance measures of: human, equipment, Soldier, and Small Unit
• Quantify how changes in one measure trace to the others, from lab to field

Products:
• Mission Planning Aids that incorporate Soldier performance predictions on unit task performance
• Unified suite of linked laboratory and field performance measures, experiments, and demonstrations in varying conditions
• Helicopter cockpit display design to enable safe operations
• Reports that quantify effects of human and/or equipment performance on Soldier and/or Small Unit performance

Results:
• Repeatable, data-driven design criteria
• Balance of human and equipment performance tolerances and parameters

Payoff:
• Informed decision-making regarding Soldier System capabilities development and investment
Provide quantitative data to inform trade-off decisions early in acquisition process

Human Performance R&D provides basis for soldier modeling & simulation

Soldier centered analysis gaps inform human performance R&D

Modeling and simulation enable early analysis

Infantry Warrior Simulation (IWARS)

JACK

Improved Performance Research Integration Tool (IMPRINT)

Command, Control, and Communication: Techniques for Reliable Assessment of Concept Execution (C3TRACE)

Defense Acquisition Lifecycle
Purpose:
• Develop models and techniques to support the early analysis and design of Warfighter systems and equipment to enhance mission performance

Results/Products:
• Human performance modeling (HPM) tools, force-on-force constructive simulation and analysis techniques at Soldier, small unit and large force levels
• Statistically optimized models for sizing of combat clothing/equipment and design of aircraft, ground vehicles, & workstations

Payoff:
• Modeling and simulation (M&S) tools that support early analysis of military technology, equipment and systems lead to cost savings and more efficient design to support Soldier performance
• Reduced risk of human factors failures in acquisitions means better systems for Soldiers
• Robust and innovative exploratory development for new Soldier capabilities
Improved Performance Research Integration Tool

400+ users supporting Army, Navy, Air Force, Marines, NASA, Department of Homeland Security (DHS), Department of Transportation (DoT), Joint and other organizations across the country

http://www.arl.army.mil/IMPRINT
IMPRINT can be used to:

- Set realistic system requirements
- Identify future manpower & personnel constraints
- Evaluate operator & crew workload
- Test alternate system-crew function allocations
- Assess required maintenance manhours
- Assess performance during extreme conditions
- Examine performance as a function of personnel characteristics and training frequency & recency
- Identify areas to focus test and evaluation resources
- Quantify human system integration risks in mission performance terms to support milestone review
- Represent humans in federated simulations

IMPRINT is a trade-off analysis tool
IMPRINT Modules

WARFIGHTERS
Personnel Modeling

MISSIONS
Operations Modeling

EQUIPMENT
Maintenance Modeling

FORCES
Manpower Modeling

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
Progressive Insertion of Human Figure Modeling (HFM)

- operationalize requirements
- pretest with HFM
- add clothing models to figures
- consider workspace & ensemble design interaction
- multivariate vs univariate analysis
- draft reqs vetted against models
- reqs in RFP to support claims w/modeling
- easier to test requirements
- HFM used during design IPTs
- aircrew clothing & equipment models
- clothing layers and equipment, dynamic space claims
- boundary mannequins
- models more accurate than test rig
- subpopulation accommodation but laborious
- images, limited files
- offerors back off blanket claims
- transportability analysis
- eliminated invalid univariate analysis
- designs based on 90% accommodation with clothing & equip
- requests for boundary figures on other programs

Air Warrior
- clothing layers and equipment, dynamic space claims

Comanche
- boundary mannequins
- models more accurate than test rig
- subpopulation accommodation but laborious

Stryker
- images, limited files
- offerors back off blanket claims
- transportability analysis

Future Combat System
- eliminated invalid univariate analysis
- designs based on 90% accommodation with clothing & equip
- requests for boundary figures on other programs

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
• apply HFM to COTS program
• standardize analysis across vendors

• encumbered boundary dimensions in RFP
• bidders provide Jack files

• pre-milestone A requirements determination

• link with survivability
• standardize approach in guidelines or military standard

Mine Resistant Ambush Protected (trucks)
• analysis turnaround sufficient
• supported priority design changes (seats)

Ground Combat Vehicle
• received Pro-E files of prototypes
• evaluated design details before prototypes built

Joint MultiRole (helicopter)
• TBD

Occupant Centric Platform
• TBD
Social & Cultural Understanding: Collaborative Socio-Cultural Research Effort

U.S. Army Research Institute (ARI)
Cross Cultural Competency

U.S. Army Research Laboratory (ARL)
Understanding and modeling cognitive aspects of socio-cultural influences on Soldier/Commander decision making to enhance mission performance

Decision Support Tools
Cognitive model, guiding principles, decision support tool concepts

U.S. Engineer Research and Development Center (ERDC)
Mission Planning & Analysis Tools

Image from: http://citizensandsoldiers.wordpress.com/
Personnel & Training: Simulation and Training - The Army Niche

Experimentation @ USMA

Computer-Mediated Training

Virtual Human Toolkit

Embodied Conversational Agents

Academia and International

Computer-based Tutors

Games for Mission Planning and Operational Training

EDGE

Commercial Gaming and Smart Phone/Tablet Industry

Game Engines

TC3

Games for Medical Training

Mobile Training Apps

Other Agencies (e.g. DARPA)

Joint & Coalition Training Research

RAID

Digital Emily

Virtual Humans to serve as role players (e.g. mentors, peers, adversaries)

MCIT

Recognition and Defeat of IEDs Training

3D Holography

Tactical Holograms Fielded in Iraq and Afghanistan

MCIT

Virtual Human Toolkit

Graphics

Entertainment “Hollywood” Industry

Story Telling

Predictive Software

Integrated with DCGS-A

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
• Research and prototype a computer-based tutoring framework to evaluate adaptive tutoring concepts, models, authoring capabilities, and instructional strategies across various populations, training tasks and conditions, thus enabling summative and formative evaluations including between system evaluations

• empirically assess Computer-based tutoring systems (CBTS), CBTS models, methods, and components using GIFT
• use results to build CBTS standards
**PURPOSE:** Lower the barrier of entry to the use of powerful, complex simulations through a single user interface that accounts for systems engineering complexity while providing launch and execution management of a distributed computing environment.

**OBJECTIVES:** Research, develop, and demonstrate an M&S-focused executable architecture based on systems engineering design linking high-level analytical needs with M&S execution through an automated data-driven system to reduce execution time of complex distributed simulation environments.

**TECHNICAL CHALLENGES:**
- Determining linkage from high-level analytical requirements to system implementations represented by different M&S components
- Simplifying ingestion of simulation data into EASE

**PLANNED ACCOMPLISHMENTS (FY13):**
- Demonstrate refined EASE in a relevant environment to quantify advantages
- Document results in conference papers

POC: Chris Gaughan
407.208.3323
Overview

Generalized Intelligent Framework for Tutoring (GIFT)

Description | Background | Research Goals | Requesting GIFT | Features | Releases

Description

GIFT is an empirically-based, service-oriented framework of tools, methods and standards to make it easier to author computer-based tutoring systems (CBTS), manage instruction and assess the effect of CBTS, components and methodologies. GIFT is being developed under the Adaptive Tutoring Research Science & Technology project at the Learning in Intelligent Tutoring Environments (LITE) Laboratory, part of the U.S. Army Research Laboratory - Human Research and Engineering Directorate (ARL-HRED).

Background

The technology gap for a reusable CBTS framework to support individual and small team tutoring was identified through a review of the intelligent tutoring systems (ITS) literature in 2009-2010 and the Training and Doctrine Command (TRADOC) formalized the Army requirement for GIFT in their Army Learning Concept (2011). GIFT was brought to practice in 2011 by the LITE Lab team. The first public demonstration of GIFT was conducted at the Interservice/Industry Training Systems and Education Conference (I/ITSEC) in December 2011. The first release of GIFT was completed in May 2012.

While GIFT is being developed to facilitate the use of CBTS by the U.S. Army, the intent is to collaboratively develop GIFT and have it function as a "nexus" for CBTS research being conducted within government, industry and academia.

Research Goals

Adaptive Tutoring research goals that are driving future GIFT development include:
<table>
<thead>
<tr>
<th>Research Thrusts</th>
<th>Goals</th>
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| Neuroergonomics                                      | • Enable tailoring of human-system interaction for operational effectiveness  
  • Sensors & analysis for joint, real-time human-system calibration and optimization  
  • Intelligent tutors that adapt to moment-to-moment & lifetime individual differences |
| Soldier Perception and Performance: The Invincible Soldier | • Use Soldier capabilities to ensure dominance on the ground  
  • Novel stealth technologies to “fool” enemy senses via sound, appearance, expectation  
  • Total Soldier measures—physical & mental—for design, analysis, and training |
| Social-cognitive Network Science: Soldier-driven data for decisions | • Enable Soldiers to exploit data and info across the battlefield to the edge  
  • Decision quality metrics as a function of network and team properties  
  • Soldier-commander-driven networks and info requirements within workload constraints |
| Virtual Humans and Immersive Learning: Technology to enable learning at the point of need | • Enable cost-effective and maximally immersive training where and when needed  
  • Simulation dimensions matched to user/learner expectation and intent  
  • Interactive and reactive simulations and virtual humans  
  • Mobile applications |
| Advanced Distributed Simulation: Standardized databases for analysis, training, & mission rehearsal | • Develop M&S architectures for true “plug and play”  
  • Authoring capability for diverse modeling & simulation (M&S) users  
  • Advanced computing approaches for data synchronization and update  
  • Scaling for end-devices from home station to the battlefield |
- **Human System Interface**
  - Characteristics of the displays and controls

- **Human System Interaction**
  - Interdisciplinary field focused on the interactions between human users and systems, including the user interface and the underlying processes which produce the interactions.

- **Human System Integration: DoD Instruction, 5000.02**
  - A multidisciplinary field of study that emphasizes human considerations as the top priority in systems design and acquisition to reduce life cycle costs and optimize system performance.

- **Human Factors (or Ergonomics)**
  - The scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and other methods to design in order to optimize human well-being and overall system performance.
Manpower and Personnel Integration (MANPRINT)

- The US Army’s instantiation and implementation of HSI. As in HSI, the goal is to optimize total system performance, reduce life cycle costs, and minimize risk of Soldier loss or injury by ensuring a systematic consideration of the impact of materiel design on Soldiers throughout the system development process.
Updating Military Standard 1472, Human Engineering

Department of Defense
Design Criteria Standard
Human Engineering

METRIC
MIL-STD-1472G
11 January 2012
SUPERSEDING
MIL-STD-1472F
23 August 1999

AMSC N/A
AREA HFAC

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**International Technology Alliance (ITA):**
*Alliance of UK MoD, academic & industry*
Focus on information and network sciences to enhance decision making for coalition, and enhance capabilities to conduct coalition warfare.

**Network Science CTA:**
*Alliance with academia and industry*
Cross-cutting research for a fundamental understanding of interactions, interdependencies, and common underlying science among networks.

**Robotics CTA:**
*Alliance with academia & industry*
Research to enable the creation of future highly autonomous unmanned systems and permit those systems to effectively conduct military operations in mixed environments.

**Institute for Creative Technologies (ICT):**
*Alliance with academia*
Research to capture human appearance and behavior in virtual or simulated humans for effective interaction.

**Cognition and Neuroergonomics CTA:**
*Alliance with academia & industry*
Research to demonstrate fundamental translational principles of the application of neuroscience-based research and theory to complex operational settings.

**Inst for Collaborative Biotechnologies (ICB):**
*Alliance with academic & industry*
Interdisciplinary, powerful alliance of academia, industry & Army researchers to transform biological inspiration into technological innovations.

These partnerships facilitate collaborative research with top researchers in government, academia, and industry to solve Army-specific problems.
Crew Safety Technologies - In FY12 TARDEC and ARL-HRED conducted a study to determine if cognitive load leads to performance decrements in critical crewmember tasks such as rollover avoidance or IED detection. Results for crew safety technologies.

Enhanced Secure Mobility through Experimentation and System Design - In FY12 ARL-HRED and RDECS transitioned the Improved Mobility and Operational Performance through Autonomous Technologies Digital Video Architecture with Digital Video Recorder to PEO-GCS and PM-GCV

Load Carriage Effects - Competitive 2012 DA ILIR awarded to NSRDEC to identify neuromechanical variables affected by load carriage during transitional phases of Soldier specific movements.

IMPRINT - Developed and implemented Tri-Service human performance modeling software to conduct analyses that support the system design process.

Enhanced Performance of Commanders and Collaborative Teams - Methods for measurement of information brokerage & social transactions shed new light on situation awareness and mission effectiveness