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NDIA 19th Annual Science & Engineering Technology Conference C4I COI

21 March 2018

Dr. Stephen Russell
Co-Chair, C4I CoI

C4I COI: State of Technology

Personnel Changes:

- Dr. Ranjeev Mittu (Navy) - New Steering Group Representative
- Mr. Chuck Hoppe (Army) - New Steering Group Representative
- Dr. Kevin Gluck (Air Force) – New Working Group Chair
- Dr. Morgan Bishop (Air Force) – New Working Group Chair

Taxonomy Sub Areas / Roadmap Changes:

- Information Collection/Management and Computing Software Technologies refocused to Information Systems Technology
- Systems/Analysis/Decision Tools refocused to Algorithmic Warfare
- HCI for Decision Making refocused to Optimizing Human Decision Making

Roadmap Trends:

- Information Systems Technology (IST) focused on mechanics of information access, supporting architectures, hardware and software
- Algorithmic Warfare (AW) focused on AI/ML and higher level fusion and synthesis to support autonomous reasoning and decision making (planning, execution and assessment)
- User context modeling a key focus for Optimized Human Decision Making in order to leverage expected efficiencies in IST and AW
- Increased efforts in Artificial Intelligence, Machine Learning, Autonomy at Rest, C2 Space Domain, Rapid Prototyping, Internet of Things (IoT)

C4I COI: Tier 2 & 3 Taxonomy

Information System Technology

- Acquire, Transform & Access
  - Collection management
  - Aggregation & inference
  - Info discovery, ontologies & provenance
  - Trust & access control
- System Architectures
  - Tactical cloud architectures
  - Policy-based information exchange
  - Composable software systems
  - System simulation and emulation
- Computing Hardware
  - High performance computing
  - Distributed & energy-efficient tactical computing
  - Advanced computing architectures
  - Advanced memory and storage technologies
- Software
  - Programming languages
  - Formal methods & trust
  - Parallel OS / scalable algorithms
  - Software architectures & engineering

Algorithmic Warfare

- Data Extraction, Analysis & Synthesis
  - Unstructured-to-structured extraction
  - Speech & text data analysis & synthesis
  - Information Operations
  - Data conditioning & uncertainty quantification
- Autonomous Reasoning and Decision Making
  - Artificial Intelligence & Machine learning
  - Cooperative teaming
  - Automated planning
  - Closed loop resource management
- Sensor Data Fusion and Analysis
  - Object/anomaly detection & attribute recognition
  - Scene reconstruction / understanding
  - Object / entity tracking & assessment
  - Situation & Impact Assessment
- Planning, Execution & Assessment
  - Course of action development and analysis
  - Cross-domain synchronized effects
  - Dynamic re-allocation and tasking
  - Presentation of forces & Operational assessment

Optimized Human Decision Making

- User Interaction
  - Cognitive work analysis
  - Understanding nonverbal behavior
  - Natural task & content interaction
  - Bio-psychometrics
- Collaboration
  - Distributed collaboration
  - Facilitated shared awareness
  - Virtual human behavior modeling
  - Collaboration with autonomous systems (advanced supervisory control)
- Information Presentation
  - Innovative display technologies
  - Presentation aware information derivatives
  - Task/decision based information abstraction
- Display Management
  - Task & display-aware adaptive info displays & routing
  - Progressive information disclosure
  - Spatial localization cueing
  - Adaptive aesthetics

Networks and Communications

- Radios & Apertures
  - Software defined RF
  - Spatial multiplexing & directional beamforming
  - Quantum, Optical, THz communications
  - Components
- Waveforms
  - Spectrum sensing/sharing/management
  - MAC, Link/network protocols, modulation, & coding
  - Physical layer security
- Networks
  - Software-defined networking
  - Network coding & disruption tolerant networking
  - Routing protocols & network interfaces
  - Network assurance
- Information
  - Transport protocols/services/applications
  - Data/message standards (e.g., MIBS, IFDL)
  - Managed information flows (e.g., meta-data tagging)
  - On-demand QoS-based services & prioritization

C4I COI: State of Technology Accomplishments

- **C4I COI**
- Tier 2 & 3 Taxonomy Updated / Supporting OSD AI Strategy
- Numerous technologies demonstrated / transitioned (i.e. Android Tactical Assault Kit/TAK Server Technology; Open Standards for Unattended Sensors (OSUS) to PdM EOIR; Tactical Cloud Reference Implementation transitioned to CANES PoR and deployed; Secure Cross-domain Orchestration Engine; …)
- Behavioral Cyber (Integrates human and sensor observations by illustrating cognition and behaviors of friendly/adversary actors): Emerging Partnerships (ARL, CYBERCOM, AFRL, Army Cyber Institute, Naval Surface Warfare Center-Crane, …)
- Autonomy Research Pilot Initiative (C4I-Autonomy) (ARL-AFRL-SPAWAR) resulted in two brain-computer interface demonstrations in ARL MIND Lab
- Air Force/Navy Cross Domain Solution (CDS) for Distributed Interactive Simulation (DIS) and Link-16 Protocol Integration
- Army/Navy extensions to Marine Corps Tactical Service Oriented Architecture (TSOA) Program
- Army/Navy Scientist Exchange (ARL/NRL) to define Internet of Things Collaborative Research Alliance

- **Cross-COI Collaborations**
- DoD & DoE Artificial Intelligence and Machine Learning TEM (C4I & HS COI) Sept 2017, McLean, VA
- Autonomy & Sensors COIs Automatic Target Recognition WG Meeting, December 2017, Suitland, MD
- Establishing Autonomy at Rest portfolio for near-term autonomy capabilities for warfighters (in collaboration with Autonomy COI)
- HAOME Joint Proposal (ARL, AFRL, CERDEC, NRL, ONR, DTRA J9CXQ, and MIT-LL)
- Machine Learning Centers (Army & Navy), AI/ML TEM, Feb 2018, San Diego, CA

C4I COI: State of Technology Highest Focus Areas

Information Systems Technology

Data Access, Architectures, HW, and SW

- Acquisition of information from all sources.
- Tools, algorithms and methods to convert inputs from heterogeneous sources to machine and human useable forms.
- Ubiquitous search and retrieval, information discovery, and trust and access control.

Optimized Human Decision Making

Effective, Natural Human-Machine Collaboration

- Exploit emerging HCI technologies to create an intuitive & effective collaboration environment.
- Focus on mission and task context and the efficient / effective sharing of information across commands.

Algorithmic Warfare

Complex Data Processing, Decision Making and Reasoning for Planning, Execution & Assessment

- Transform sparse, unstructured, limited data in constrained environments to actionable information.
- Use language artifacts to define ontologies & design algorithms that capture knowledge of relevant behaviors, events, tasks & mission.

- Use social media platforms, user groups, & machine learning to train software agents that derive intent for human action.

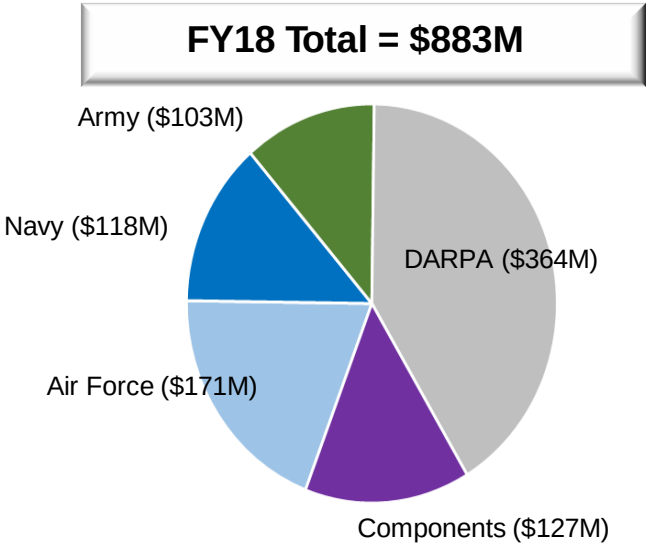
Networks and Communications

Adaptive and Resilient Infrastructure

- Improvement to network agility and resiliency across all domains.
- Enhancements to improve AJ, LPI, LPD.
- Spectrum Management.
- Advancement of high layer networking technology areas.

C4I COI: State of Technology Investments

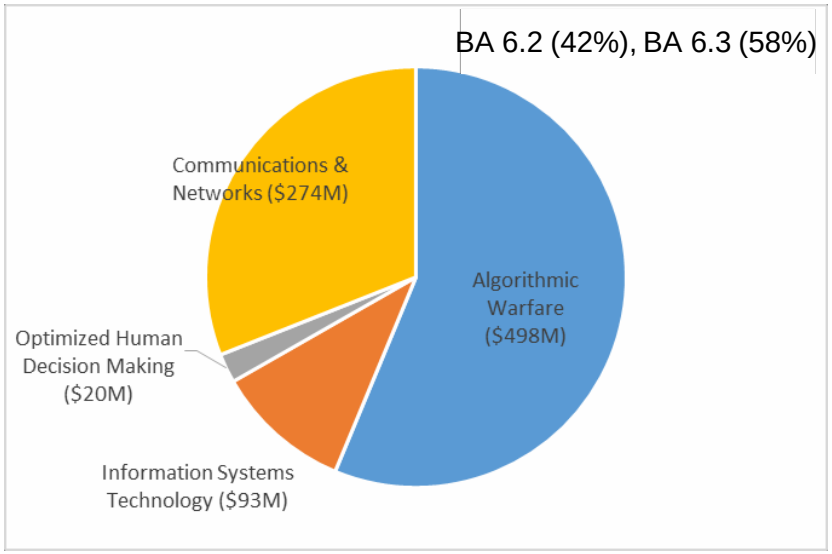
- **C4I Investment Portfolio Leaders**
  - DARPA major investor in BA 6.2 & BA 6.3 (41% of Total)
  - Algorithmic Warfare (DARPA, Air Force)
  - Optimized Human Decision Making (OSD, Navy)
  - Information Systems Technology (OSD, Army, DARPA)
  - Networks & Communications (DARPA, Navy, Air Force)

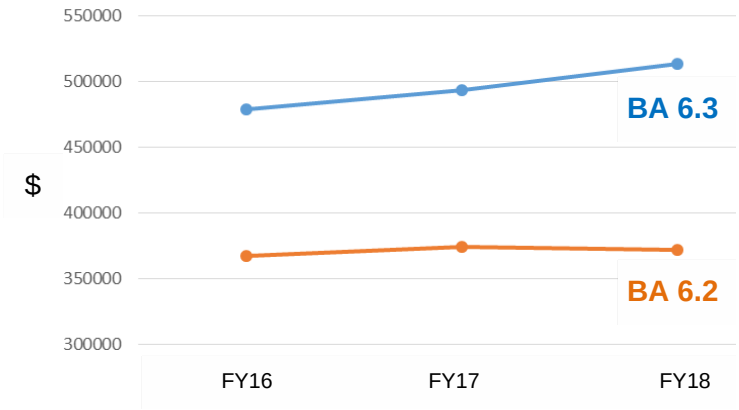


- **Risk Areas / Investment Gaps**
  - AI/ML in Command Centers as Virtual Assistants
  - AI/ML User Context Modeling for Information Filtering and Explainable AI
  - Validated M&S with Labeled Data for AI/ML
  - Autonomy at Rest (Cyber Defense)
  - Resilient Tactical Network Architectures
  - Distributed Low-Power Computing Hardware / Software Co-Design
  - EM Spectrum Operations (e.g. Quantum, Optical, mmW, THz communications and sensing)
  - Counter-C4I

C4I COI: State of Technology Investments

FY18 Total = $885M





Lead:

- Tactical Architectures / Interfaces
- User Interaction / Collaboration
- Data Extraction, Analysis & Synthesis
- Information Operations
- Spectrum Management

Leverage:

- Commercial AI/ML
- Commercial IT Systems
- Software Defined Networking

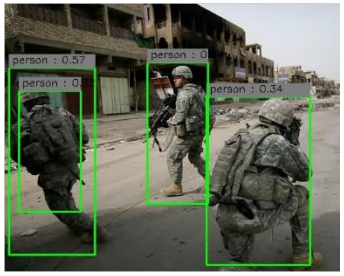
Watch:

- Information Presentation, AR/VR
- Trust & Access Control

C4I COI: Future Directions

- **Cross-COI, industry, academia opportunities for collaboration**
  - Human-Agent Planning, Teaming and Execution (HAPTE) Initiative (C4I, HS, Autonomy, ATRWG)
  - C4I/Cyber COI TEM Feb. 21-22, 2018 San Diego, CA
  - ASBREM COI – Cross-COI Air Platforms, Autonomy, C4I, Energy & Power, Ground & Sea Platforms, Human Systems, and Sensors, March 2018, National Capital Region
- **Initiatives or best practices to accelerate R&D process**
  - Rapid Prototyping: Agile software/algorithm development in DevOps environments / Hardware Additive Manufacturing
  - Leveraging Visiting Researchers: Cross-Service e.g. NRL/ARL and with Coalition Partners
  - Networked Testbeds: Common or complementary
- **Take-Aways**
  - S&T / Acquisition emphasis on agility, rapid prototyping, and quickly delivering warfighting capabilities
  - Accelerated warfighter demand has produced an increased demand for BA 6.3/6.4 resources
  - Warfighter gaps drive innovation needs at basic (BA 6.1) and applied (BA 6.2) research levels not addressed by commercial products

Video Analysis



Visualization

Data Ingest and Processing