AFRL FIGHT'S ON!

THE AIR FORCE RESEARCH LABORATORY

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FALL 2020

THE NEW RHW

Warfighter Interactions and Readiness Division

THE AIR FORCE RESEARCH LABORATORY HAS A STRONG HISTORY OF EXPLORATION AND INVENTION, RELEVANT TO OPERATIONAL CAPABILITIES TODAY AND INDISPENSABLE TO OUR NATION'S FUTURE."

— Brigadier General Heather L. Pringle
USAF Commander, Air Force Research Laboratory

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Division Chief, 711 HPW/RHW

RHW

WARFIGHTER INTERACTIONS AND READINESS DIVISION

Wow – what a crazy, amazing year! I am super excited to be leading the new Warfighter Interactions & Readiness Division, RHW, with the ultra-talented team of researchers and support professionals. These are folks who went from working in their offices and labs last March to 100% teleworking in less than a week, managing to continue research and technology development. Since then we have merged the Warfighter Interfaces and Warfighter Readiness Research Divisions, stood up a new division front office, smoothly closed out the fiscal year, supported multiple exercises, organized and presented at conferences, conducted studies virtually, developed software, hit multiple scientific and technical transition milestones… "Hats off" to everyone on the RHW Team!

This merger brings together the two Airman Systems Directorate (RH) divisions that were focused on the Airmen's cognitive mission performance. In RH's enduring challenges of Enabling, Sustaining, Enhancing, and Restoring multi-domain capable Airmen and airman-machine operations, our mission lands squarely on Enable and Enhance: Enabling a more informed, agile, and lethal force by delivering revolutionary capabilities and Enhancing preparation and mission execution across the full range of military operations. While we have a long history of collaboration across organizations, we have already found multiple new touch points and have started leveraging new synergies that exist in our new division. As the Air Force and DoD move forward, Joint All Domain Ops and the demand for autonomy technologies bring the need for Airmen to be adaptable, efficiently trained, given decision-quality information, and have technologies that augment their strengths. This blurs the lines between training and operations and this new division has the people, expertise, and capabilities to address that need. I look forward to sharing the future successes of the Warfighter Interactions & Readiness Division. ☆

Dr. Louise Carter, Division Chief, 711 HPW/RHW

Graphic by Airman First Class Taylor Phifer

OUR MISSION LANDS SQUARELY ON ENABLE AND ENHANCE: ENABLING A MORE INFORMED, AGILE, AND LETHAL FORCE BY DELIVERING REVOLUTIONARY CAPABILITIES AND ENHANCING PREPARATION AND MISSION EXECUTION ACROSS THE FULL RANGE OF MILITARY OPERATIONS.

— Dr. Louise Carter
Division Chief, 711 HPW/RHW

Dr. Winston "Wink" Bennett
Readiness Product Line Lead, 711 HPW/RHW

READINESS

A hearty and virtual welcome to the 2020 vIITSEC Edition of "Fights On!" and to the Readiness Product Line for this year! As the continuing Readiness Product Line Lead for our Division, and in spite of all the global challenges this year, I am excited to share some of our work and great successes for the year. 2020 will go down in history as a year like no other and we are very hopeful 2021 will be a step away from the challenges we have had. This was a year of incredible change for the Airman Systems Directorate with a reorganization that affected our Warfighter Readiness Research Division and the Warfighter Interfaces Research Division. The two Divisions are now one under the new moniker of Warfighter Interactions and Readiness. This merger, while creating much turbulence, also opens new opportunities for collaboration and support.

The Division we are now a part of not only has the training and readiness mission and research portfolio you know so well, but it also has several relevant areas to connect to. These include adaptive warfighter interfaces, autonomous vehicles and control, human and machine teaming and trust, dynamic language interpretation and action, and Joint All Domain Command and Control interfaces for decision making. Many connections were already there before the reorg, but greatly enhanced as one Division. Stay tuned to future Fights On! For more on this as it matures!

"Our (new) Division is growing its already strong support of our international standards development and involvement in multinational research and technical groups."

— Dr. Winston "Wink" Bennett
Readiness Product Line Lead,
711 HPW/RHW

Although significantly impacted by the dynamics of 2020, our teams managed to get several new efforts started. One is a large multiyear, multidisciplinary effort to conduct research, development and integration of science and technologies supporting Headquarters Air Force and Air Combat Command. This effort provides research and engineering support for a variety of areas of need from the CAF. Examples include work to create rule sets for coalition DMO interoperability for tactical training, specifications for performance data and encryption of those data from live and simulator sources. It also supports 4th and 5th gen integrated training using the testbeds we have in the Division as well as integrating performance measurement and feedback technologies identified to support the CAF Future Training Concept into selected mission training center software integration labs. There is also support here for creating and transitioning live virtual and constructive technologies and tools into ops training and rehearsal.

We also started two efforts that were driven by General Mike Holmes during his tenure as COMACC. The first is one related to this effort is developing a web-based repository that will allow USAF training content developers, instructional designers, and instructors to share and reuse critical ARVR-related technologies (e.g., reusable models, source code, executable code, APIs, SDKs, performance measures and dashboards, etc.) with one another. This will facilitate tracking, integration, and fielding of ARVR-based solutions more quickly and cost-effectively by not having to "reinvent the wheel" every time a new application is developed or someone is looking for a policy precedence for software and hardware accreditation or certifications and related lessons learned and other data artifacts. The second of these is a collaboration with researchers at the Institute for Defense Analyses. This effort will develop an "effectiveness framework for AR/VR training" based on science and empirical findings. It is identifying and documenting current research and applications of the technologies in military education and training. We will be conducting

qualitative and quantitative reviews of the published literature and making recommendations for research and practice. We are also creating a training development, implementation and evaluation framework and integrating this effort into the state of the science, art, and practice in AR and VR in military education and training.

As one of our key activities, we hosted a major AFWERX challenge workshop related to Big Data and Data Lake innovation. The quantity and diversity of the training data we continue to harvest has led us to explore innovations and best practices in "big data" analytics. Very soon, we want to uses some of the innovations coming from the challenge workshop to standardize how we capture, store, retrieve and package our research data for a variety of applications, such as machine learning, mathematical modeling, and longitudinal trend analyses of training and readiness effects.

In collaboration with ACC and with AF Futures, we started a new project called Just In Time Multi-Mission Airmen/Warfighters (JIT MMA/W). This effort was developed in direct response to ops needs associated with Agile Combat Employment and mission performance at austere, deployed locations. The effort include integration and field demonstration of the enabling technologies that underpin just in time training and task performance support. The end state will enable Airmen to be capable of working across mission tasks through training, performance support and resilience monitoring and intervention to seamlessly adapt to changing operational needs and to provide a broader range of mission support in austere, deployed environments. We plan on iterative demonstrations that start in our virtual and constructive model-based systems engineering-based environment with SMEs and engineers evaluating the alternative capabilities and their prospective mission impacts first, then taking the best of this digital engineering-based approach to actual technology integration and evaluation for a series of live field tests.

In close partnership with our USAF collaborators at Air Combat Command, our Simulators Program Office, the Air Force Agency for Modeling and Simulation, and Air Education and Training Command, the Division and product line continues to create and transition proof-of-concept science and technology into ops. These transitions support the migration to proficiency-based training and encompassing learning management and performance measurement technologies, game-based applications for aircraft maintenance and medical training, and low-cost options for realistic fifth-generation tactical training.

Finally, our academic, industry and the international partners continue to grow their interest and involvement in collaborations with us. We have a number of new agreements, partnerships and contract activities underway. Our (new) Division is growing its already strong support of our international standards development and involvement in multinational research and technical groups.

I invite you to contact me or any of our team members to explore opportunities for collaboration and partnership. ☆

Dr. Winston "Wink" Bennett, Readiness Product Line Lead, 711 HPW/RHW

OUR WORK

Advances the state-of-the art in learning, performance and modeling

Drives "innovation at the speed of Ops"

Develops solutions/capabilities and informing Air Force vision and investment

Aligns with academia, acquisition and industry to transition effective and efficient methods and technologies

Contributes to the operational readiness of our Airmen

Dr. Deirdre Mahle
Airman-Machine Integration Lead,
711 HPW/RHW

THE PRIMARY CAPABILITIES DELIVERED BY THE AMI PRODUCTS ARE:

Pilot Vehicle Interface (PVI) controls tailored for swarm SUAS lethal attacks

ABMS interfaces for force protection, planning & execution of distributed nodes

MDC2 - distributed play-calling and dynamic course-of-action real-time analytic toolkit

SA Suite for JADC2 – adaptive and intelligent C2 interfaces for mission execution

AIRMAN-MACHINE INTEGRATION (AMI)

Welcome to the latest edition of "Fight's On!" I am new to the Warfighter Interactions and Readiness Division, as well as to the Airman-Machine Integration Product Line (AMI PL) but no less excited to champion this team's unique capabilities that bring human factors and human systems integration to the fight. Human machine teams combine the ingenuity, creativity and intuitiveness of the human brain with the speed, autonomy and capacity of AI/ML systems to achieve accelerated and resilient decision-making in all domains that is essential to the fight in highly contested environments. "These human-machine teams are the real advantage of a JADC2 capability" (DAF JADC2 Concept). The AMI PL is focused on the development of operator-centric interfaces that increase the Airman's combat capabilities through integrated solutions. AMI develops advanced, situationally-adaptive interface technology and decision aiding tools for more rapid and accurate battlefield awareness and management, decision making, and maximized collaborative team performance. These operator-centric interfaces manage Airman cognitive workload in complex, distributed and uncertain environments to increase combat power while decreasing physical and cognitive workloads. If that sounds like an ABMS/JADC2 'buzzword smoothie' (to quote Dr. Will Roper), then I'm hitting on the buy-in to the culture change that data are more valuable than bullets on the battlefield. Key attributes of the technologies in the AMI PL include the ability to disrupt and operate inside the enemy's Observe-Orient-Decide-Act (OODA) loop, provide decisive shared battlespace awareness across multiple domains and enhance Airman decision-making via AI behaviors & COA analysis. The primary capabilities delivered by the AMI products are:

- Pilot Vehicle Interface (PVI) controls tailored for swarm SUAS lethal attacks
- ABMS interfaces for force protection, planning & execution of distributed nodes
- MDC2 - distributed play-calling and dynamic course-of-action real-time analytic toolkit
- SA Suite for JADC2 – adaptive and intelligent C2 interfaces for mission execution

The AMI PL currently serves ACC, AETC, AFLCMC/WISN, AFLCMC HBU and the Army. Multiple efforts support collaboration and transitions with Industry & International partners. ☆

Dr. Deirdre Mahle, Airman-Machine Integration Lead, 711 HPW/RHW

> **"These human-machine teams are the real advantage of a JADC2 capability."**
>
> **—Dr. Deirdre Mahle**
> Airman-Machine Integration Lead, 711 HPW/RHW

ANALYTIC TOOLS

Who among us is not inundated with a barrage of information from sunrise to sunset? Whether it is our ever-growing email backlog, the dopamine-inducing social media applications that consume our attention and influence our decisions, or the terabytes of uncorrelated data generated by a host of digital sensors onboard an Unmanned Air Vehicle, there is no doubt that we struggle to deal with the exponential growth of data in our environment. Indeed, as the DoD shifts to build Joint All Domain Operations (JADO) and Great Power Competition (GPC) capabilities in a data-saturated world, it is even more critical that we are able to rapidly identify, analyze, shape, and operationalize all types of information… without succumbing to analysis paralysis.

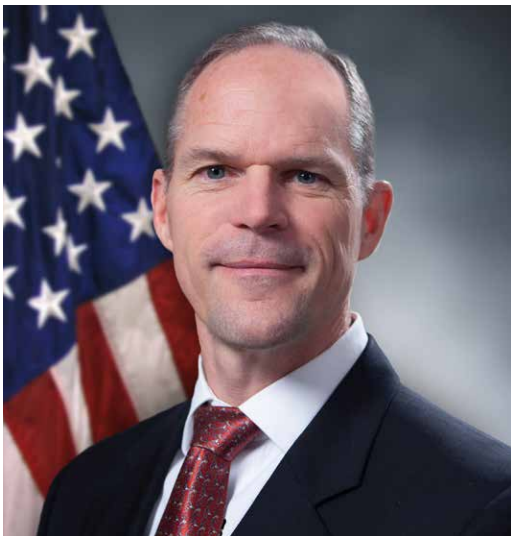
The Analytic Tools Product Line (AT PL), in collaboration with the CTCs and CRAs, is focused on developing and fielding products that assist others in dealing with data-related problems. The PL has two active products, CEREBRO and R2D2, as well as two candidate products, Haystack/DAN and JADCM. Most, but not all, of the deliverables that flow out of these products are classified software tools used by the Air Force, Space Force, Special Operations Community, and the Intelligence Community.

For example, to assist human analysts with the time-consuming tasks of updating and verifying an "order of battle" target list, the R2D2 product team worked with an operational customer to build an Artificial Intelligence (AI) software program to autonomously scan and fuse multiple data sources to generate an up-to-date target list in seconds rather than hours. As another example, the team developed an AI software program to discover "hidden" and unknown targets of interest in communications data, exploiting previously unused sensor data to rapidly and automatically nominate new potential targets of interest. Although these examples support a military mission, it is easy to see how the solutions could apply to adjacencies in markets that require other forms of "targeting", such as Disaster Management, Border Security, or Precision Agriculture.

Similar to a Product Line Manager in industry, the function of a government PL Lead is to develop a differentiated set of products that is relevant to target customers. Unlike industry, however, the main goal is not to generate a profit; rather, it is to transition products to a military end user, to a government Program Office, or to private industry. And, unlike traditional big-service acquisition that can take many years, a PL is expected to transition products within a few years. This drive to transition products is important because, within the context of an R&D Laboratory, it demonstrates the ability to remain relevant by consistently delivering capabilities that meet or exceed those of our enemy.

But, before getting too self-righteous about solving the world's data problem, I try to ground myself with a simple question: Am I applying this mindset to the smaller problems that cripple me every day? To, say, managing something as "simple" as my email Inbox… ☆

Mr. Greg Beister, Analytic Tools Lead, 711 HPW/RHW



Mr. Greg Beister
Analytic Tools Lead, 711 HPW/RHW

> **"… It is even more critical that we are able to rapidly identify, analyze, shape, and operationalize all types of information… without succumbing to analysis paralysis."**
>
> **— Mr. Greg Beister**
> Analytic Tools Lead, 711 HPW/RHW

TRAINING

“OUR AIRMEN MUST BE MULTI-CAPABLE AND ADAPTABLE TEAM BUILDERS, AS WELL AS INNOVATIVE AND COURAGEOUS PROBLEM-SOLVERS.”

— Gen. Charles Brown
Air Force Chief of Staff

Dr. Glenn Gunzelmann
Training Core Technical Competency Lead,
711 HPW/RHW

This edition of “Fight’s On!” reflects research conducted prior to November 2020. Dr. Leslie Blaha is Acting Training CTC Lead as of December 2020.

PERSISTENT, GLOBAL, PROFICIENCY-BASED TEAM TRAINING FOR HUMANS AND MACHINES

Welcome to the 2020 Fall Edition of "Fight's ON!" I began my introduction to the Training CTC a year ago with the famous quote from Heraclitus – "The only constant is change." Little did I know that change would not only persist, but that it would become the key consideration for the Air Force as we look to the future. General Charles Q. Brown, Jr., made change the focus of his initial message to Airmen after becoming the 22nd Chief of Staff of the Air Force in August. His message, Accelerate Change or Lose, refocuses the Air Force on preparing for rapidly evolving, dynamic environments that will test our ability to adapt.

The Chief of Staff's message resonates especially well with the Air Force Research Laboratory's Training Core Technical Competency (CTC). We have emphasized adaptivity in our training environments and cognitive agility in our Airmen for many years. Now, as we pivot to the future, these requirements become increasingly important for our national defense. At the highest level, we know that future operations will be complex, dynamic, and integrated, with heavy reliance on machine systems with varying degrees of autonomy. However, we will also have to accept that the advantages that specific capabilities provide may be fleeting, as our adversaries rapidly counter with equally sophisticated systems and algorithms. Not only do we have to accelerate change to adapt to this new reality, but we must accept that continual change will be a key feature of successful operations.

Our training infrastructure must prepare Airmen for that new reality by producing and sustaining multi-capable airman that can adopt and employ new technologies in real time. **The Training CTC is focused on enabling that future through these interrelated emphases:**

First, we are leading the push to proficiency-based assessments based on quantitative data. This is the foundation required to shift to personalized readiness that tailors training and operational experiences to ensure that every Airmen can effectively execute their mission when called upon.

Second, we continue to push toward a global, integrated Live-Virtual-Constructive (LVC) training infrastructure to enable training whenever and wherever its needed. This capability will become increasingly important as change becomes a fundamental part of our operations. Highly trained airmen with deep expertise in single system operations will no longer suffice. As stated by General Brown, "We must place value in multi-capable and adaptable team builders, and courageous problem solvers that demonstrate value in diversity of thought, ingenuity, and initiative." This requires a robust and adaptive training infrastructure, which can provide just-in-time training to facilitate adaptation to novel operational contexts in real time.

Finally, we are emphasizing training capabilities to support team training for humans and machines. Because the roles of autonomy and artificial intelligence will be increasing, we must be able to integrate new technologies with speed and agility to best leverage them to our advantage. We will have to adapt to operational environments where the technologies of war are constantly changing. The systems our airmen fly with on one day may have new or different capabilities the next. We must be able to integrate new capabilities into operations faster than our adversaries can counter them to ensure our operational advantage.

We are pursuing these goals with a diverse collection of basic and applied research activities. In conjunction with the Readiness Product Line, the Training CTC is leading the next revolution in Air Force training. You can read about the impressive array of research efforts underway in the remainder of this issue. We all welcome your comments on our work and I invite you to contact me or any of our team members to explore opportunities for collaboration and partnership. ☆

Dr. Glenn Gunzelmann, Training Core Technical Competency Lead, 711 HPW/RHW

THE TRAINING CTC EMPHASIZES

Leading the push to proficiency-based assessments based on quantitative data

Continuing the push toward a global, integrated Live-Virtual-Constructive (LVC) training infrastructure to enable training whenever and wherever its needed

Emphasizing training capabilities to support team training for humans and machines

COGNITIVE MODELING (CM) CORE RESEARCH AREA

Dr. Glenn Gunzelmann
Training Core Technical Competency Lead and Cognitive Models Core Research Area Lead (Acting), 711 HPW/RHW

TWO PROJECT AREAS

- **Teachable Models for Training**
- **Multiscale Models of Cognitive of Performance**

This edition of "Fight's On!" reflects research conducted prior to November 2020. Dr. Megan Morris is the Cognitive Models CRA Lead as of December 2020.

This research area is built on foundational research to understand the representations and processes that underlie human cognitive performance, the capacities and limitations of cognitive processing, and how those mechanisms can be represented in mathematical and computational form. The Cognitive Modeling Core Research Area (CRA) contributes to that foundation, and leverages it in applied research to create technologies that enable on-demand training and support continuous readiness monitoring.

Training support comes in the form or intelligent teammates and adversaries that create a more realistic and valuable training experience, or software-based instruction to automatically assess trainee performance and recommend future training experiences to maximize readiness. A central objective in this area is developing capabilities to greatly reduce the costs associated with producing models that provide these capabilities.

Readiness monitoring emphasizes capabilities for understanding and predicting performance based on the interaction between knowledge and skill on the one hand, and various situational factors that put various kinds of pressure on the cognitive system on the other hand. There are many such factors (e.g., toxins, oxygen deprivation, fatigue, workload, etc.). We seek to both understand how they impact cognitive performance and how to best manage and mitigate any potentially negative effects to maximize mission effectiveness.

There are two project areas within the Cognitive Modeling CRA:

- Teachable Models for Training
- Multiscale Models of Cognitive of Performance

Descriptions of each of those projects is provided next, along with background and details on the specific lines of effort being pursued within each. ☆

Dr. Glenn Gunzelmann, Training Core Technical Competency Lead and Cognitive Models Core Research Area Lead (Acting), 711 HPW/RHW

TEACHABLE MODELS FOR TRAINING

COGNITIVE SCIENCE, MODELS, & AGENTS BRANCH

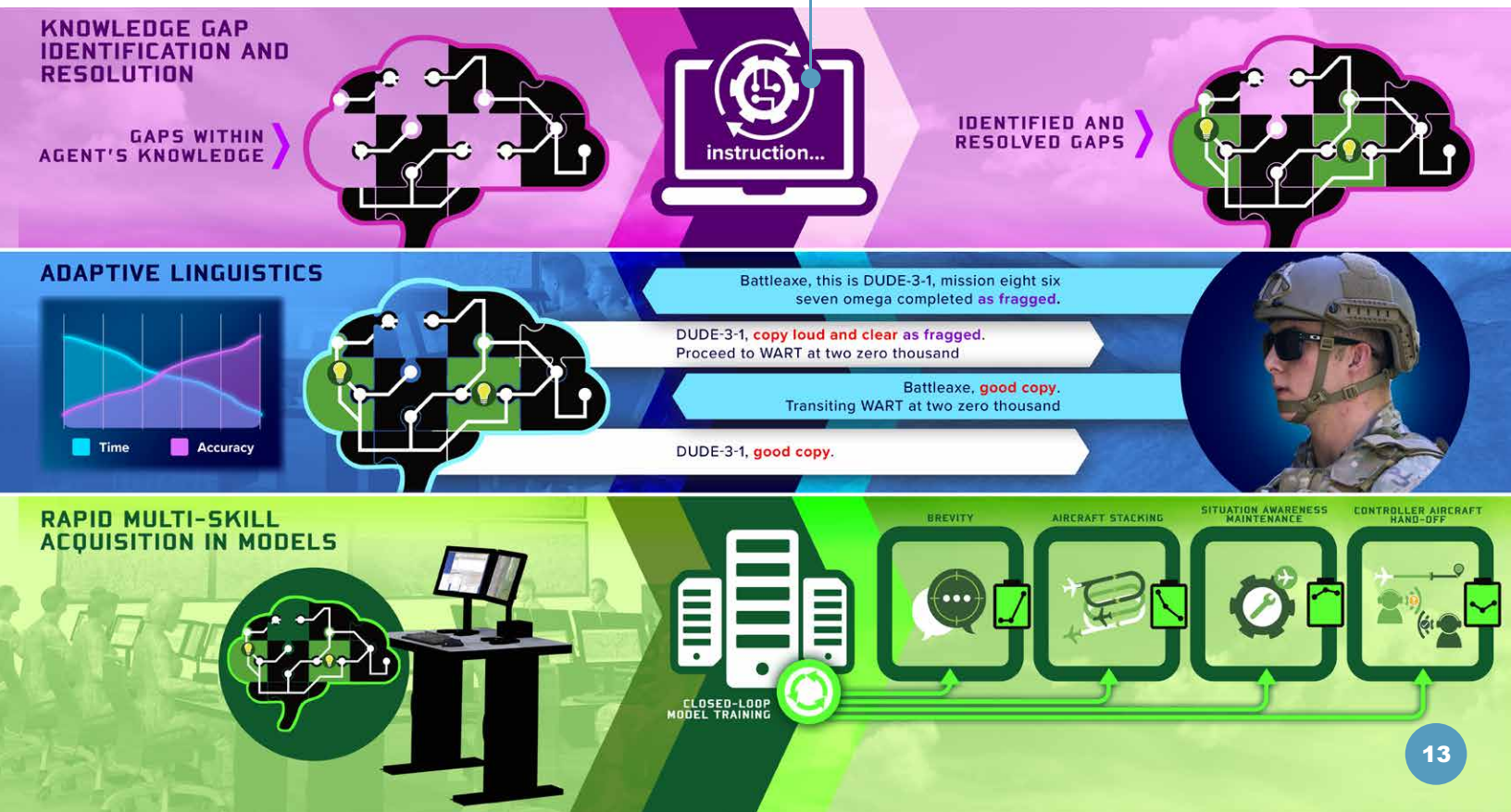
The development of intelligent systems capable of operating as team members, adversaries, or tutors within team training scenarios is costly and time consuming. At issue is the requirement for developers to analyze, organize, and integrate task knowledge within a modeling and simulation framework, often referred to as the knowledge engineering bottleneck. To widen the knowledge engineering bottleneck for greater efficiency in intelligent agent development, we are leveraging our understanding of human cognition formalized in executable models that can learn from instruction. Three related lines of effort have been instantiated to make progress and achieve the goal of teachable models: (1) knowledge gap detection, identification & resolution, (2) adaptive linguistics, and (3) rapid multi-skill acquisition in models. Each line of effort is covered in greater detail in the following pages.☆

Dr. Christopher Myers, Senior Cognitive Scientist, 711 HPW/RHWM

OV OVERVIEW

The nature of the research and development within Teachable Models for Training requires a multidisciplinary approach. Across the three lines of effort, contributions are provided from computer science, machine learning, cognitive science, computer science, and modeling and simulation.

Graphic by 711 HPW/RHW



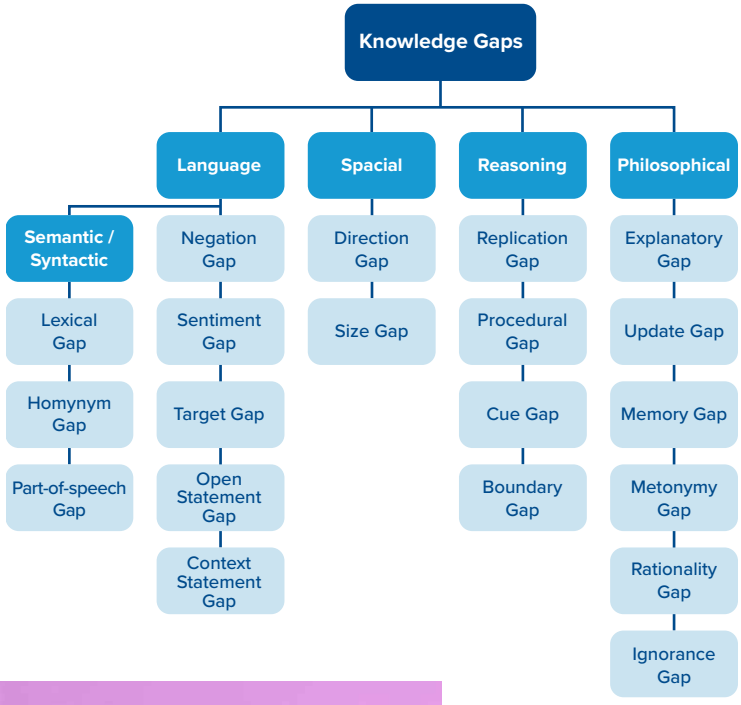
KNOWLEDGE GAP DETECTION, IDENTIFICATION AND RESOLUTION

As the ability for machines to learn from instruction and experience increases, their ability to identify and resolve gaps in their newly acquired knowledge will become increasingly important. The ability to detect, identify, and resolve gaps in knowledge required to successfully execute at mission will help to reduce autonomy failures and mistakes. This line of effort takes the approach that it is preferable to identify inconsistencies and absences within a knowledge base early, rather than to assume that a system's knowledge is correct and complete. To this end, the ability to detect knowledge gaps is critical. Informally, knowledge gaps arise when the information or capabilities available to an agent or autonomous system are inconsistent or missing. This leads to inefficiency in performing a task, or even failure to perform it outright. Knowledge gap detection, then, is the ability to recognize when there are inconsistencies in knowledge which may cause a knowledge gap to arise. Knowledge gap identification consists of the ability to classify the gap as belonging to a certain category of knowledge gap. Once a gap is identified, it becomes possible to resolve it through knowledge gap resolution, either automated or with a human or other trainer's assistance.

The goal of the knowledge gap detection, identification, and resolution (KGDIR) line of effort is to develop a system or set of systems for agents or autonomous systems to automatically identify and resolve as many knowledge gaps as possible without human intervention. In order to properly categorize and deal with gaps, it is necessary to understand the different categories of gaps; consequently, a knowledge gap taxonomy has been derived and is being used as a backdrop against which knowledge gap categorization can be applied (see below). Additionally, at this time, a prototype focused on linguistic gaps has been developed, and a derivative of this prototype to improve agents' learning from instruction is being integrated into the agent framework. Further, a collaborating research team at The Ohio State University is working on a Visual Question Answering system which includes a knowledge gap detection, identification, & resolution component used to better evaluate scenes and when a question is unanswerable as opposed to just missing necessary information which can be independently acquired; a variation on the aforementioned prototype is in use there as well. The next steps for this project primarily revolve around continuing development of these applications of the prototype, as well as expansion of both the prototype and the knowledge gap taxonomy. ☆

Mr. Daniel Schmidt, Associate Research Computer Scientist, 711 HPW/RHWM

Dr. Christopher Myers, Senior Cognitive Scientist, 711 HPW/RHWM



Graphics by 711 HPW/RHW

Graphic by 711 HPW/RHW

RAPID MULTI-SKILL ACQUISITION IN MODELS

Imagine your unit will be participating in a training exercise next week. Your unit is ready, but there is a wrinkle in the preparations: two members of your unit will not be able to attend the exercise, one is ill and another suffers a death in the family. Now imagine that you can use intelligent agents to participate in the exercise, effectively playing the roles of your missing team members. As your unit leader, you want your surrogate teammates to have different levels of proficiency across a set of skills required for performing their tasks (e.g., communications, workload management, coordination, etc.) to ensure realism in the training exercise, to improve specific deficiencies you have observed in your team, or both. A critical component of teachable models for training is their ability to train agents to desired levels of proficiency across multiple skills. Achieving this goal requires two key components: the ability to track the different targeted skills and to rapidly tailor training for models to bring those skills to the desired proficiency levels.

RHW researchers are developing a new line of research to more thoroughly understand and evaluate potential tradeoffs and cascades of implications involved in multi-skill acquisition, in order to identify and prescribe agent training regimens across the full set of desired skills/competencies. This research leverages 711HPW Chief Scientist seedling-awarded work that successfully demonstrates the integrated value of ensemble modeling approaches integrating cognitive models with machine learning algorithms. Results from that effort reveal minimized data requirements and enhanced predictive validity for both cognition-inspired artificial intelligence, and machine learning-enhanced cognitive modeling. These ensemble modeling formalisms will be brought to bear in this new line of effort, specifically aimed at 1) rapidly training targeted skills to desired levels of model proficiency, 2) tracking learning and forgetting across different skills in cognitively plausible ways, and 3) assessing the impact of one skill on another in light of additional learning gains or decay of other skills. This work will afford the ability for skills to be rapidly trained for synthetic teammate use, allow for the evaluation of the impacts of training to be quantified as they relate to other required skills, and be of service in the development of intelligent tutoring systems aimed at optimizing the interleaving of skills to for enhanced acquisition and sustainment across the full set of desired skills of interest. Furthermore, the use of MindModeling resources provides functionality targeted to agent development, exploration, and training all while reducing technical debt for faster development. ☆

Dr. Tiffany Jastrzembski, Senior Cognitive Scientist, 711HPW/RHWS

Ms. Olivia Leung, Research Computer Scientist, 711HPW/RHWM

ADAPTIVE LINGUISTICS

For decades, research on human-computer interaction has occurred where the focus was on identifying barriers and paths to optimal human-machine performance. With the increasing capabilities within intelligent machines, human-machine teaming has emerged as a critical area for advancing DoD goals. The ability to seamlessly team with intelligent machines requires advancements in machines' capabilities to adapt to changes in communications. The Adaptive Linguistics line of effort is focused on research investigating how to expand the language capabilities of current cognitive models and synthetic teammates toward the ability to incorporate novel linguistic items or novel uses of known linguistic items. Further, the research efforts are addressing how to enable machines to tailor language to particular task contexts and teammates. This new line of effort will include novel empirical investigations with all-human teams to achieve foundational knowledge in how humans adapt language use to each other to accomplish a particular task, as well as leverage high fidelity mission-relevant testbeds (e.g., Mission Planning and Debrief) as a way to develop and test cognitive models of adaptive task-based language use. Expected results include identifying the best candidate linguistic structures for cognitive models and synthetic teammates to adapt, based on which structure(s) humans adapt and which contribute to improved team performance. Impacts for the warfighter include more naturalistic interactions with synthetic teammates and intelligent tutors, less cognitive load from needing to learn and apply restrictive communications with synthetic teammates, and improved coordination between human teammates and synthetic systems. This work fits into the larger collaborative program of Percepts to Proficiency, which includes research in the Personalized Learning and Readiness Sciences and Multisensory Perception and Communication CRAs. The full path from a percept (speech, visual displays, gestures) to proficiency (accomplishing a task, working well as a team) has many steps, from being able to process the input, to interpreting the input and linking it to an actionable step in the task environment, to actually taking such an action. Adaptive Linguistics focuses on taking a linguistic signal (acoustic or text) that has already been pre-processed and mapping it onto a symbolic representation which is grounded in a model of a task environment, as well as models of the teammate(s). This research also focuses on selecting the appropriate linguistic signal to send back to the human teammate(s). ☆

Dr. Sarah Bibyk, Research Psychologist, 711 HPW/RHWM

Graphic by 711 HPW/RHW

MULTISCALE MODELS FOR COGNITIVE PERFORMANCE

Today's warfighter faces environments and operations that challenge both their bodies and their minds. The mission of the Multiscale Models for Cognitive Performance team is to integrate models of cognition with models of physiology to better understand their complex interactions. These combined models make it possible to predict how environmental and biological perturbations will affect a warfighter's cognitive performance. In general, we use computational cognitive models to represent cognition. These models are theories of cognition implemented as computer software. Thus it is possible to observe these models interacting with task environments to produce predictions of behavior. The workings of these models can be influenced via parameters that control the flow of cognition. These include speed of memory retrieval, rate of decay of information in working memory, and speed of attention shifts. We use physiological models to simulate the state of an individual at a given moment in time, and use that state to influence model parameters. The updated model then produces new behavioral predictions based on these new parameter values. In this way, we can link physiological events to behavioral outcomes.

In our fatigue and sustained attention line of effort, we link biological models of circadian rhythms to cognitive models to predict cognitive performance as a function of fatigue. In our physiocognitive modeling line of effort, we use models of chemical absorption and circulation to predict how chemicals will diffuse into the brain and, in turn, influence cognition. In a third line of effort, individualized cognitive load profiling, we are investigating methods for inferring a warfighter's cognitive state from physiological indicators. We are combining cognitive models that can update in real-time based upon a person's task performance with machine-learning technologies to draw conclusions about a warfighter's workload level as well as the cognitive capacities affected by that workload (e.g. memory). Together, these technologies allow us to quantify the performance risk associated with changes in a warfighter's physiological state. This, in turn, will help drive decisions that will protect warfighter safety and enhance readiness even in difficult missions and environments. ☆

Dr. Christopher Stevens, Research Psychologist, 711 HPW/RHWM

PARAMETERS THAT CONTROL THE FLOW OF COGNITION:

Speed of memory retrieval

Rate of decay of information in working memory

Speed of attention shifts

FATIGUE AND SUSTAINED ATTENTION PERFORMANCE IMPACTS

The fatigue and sustained attention line of effort focuses on advancing modeling of human fatigue and sustained attention in operational settings to increase the efficacy and efficiency of fatigue risk management tools in the Air Force. This effort supports the Sense and Assess and Readiness product lines, and includes four primary research lanes.

The first lane includes studies examining the prevalence of fatigue within Air Force mishaps and incidents, as well as trends of fatigue and fatigue mitigation strategies within a range of aircrew squadrons (e.g., Air Mobility, Airborne Warning and Control Systems, Combat Search and Rescue) in operational settings. The research produced authoritative reports used across the Wing suggesting that in a recent 15 year period fatigue was associated with about 4% of mishaps and incidents and led to $2.1B in direct costs to the Air Force. Additionally, key collaborative research with Air Mobility Command has demonstrated that fatigue continues to be a serious issue for aircrews and current fatigue assessment and mitigation technologies have limitations that must be addressed to increase operator performance and mission safety.

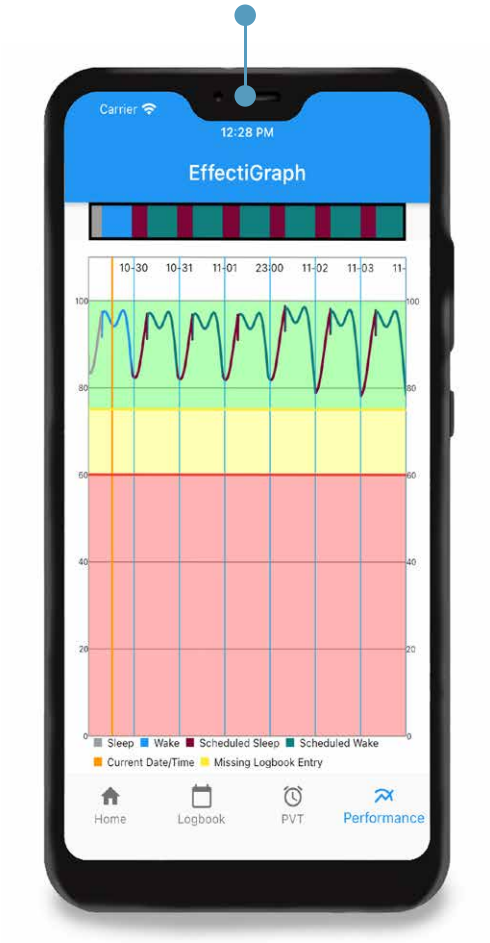
In order to address these limitations, the research group is leading advancements in integrating biomathematical fatigue models, computational cognitive models, and other innovative methods to provide real-time, individualized predictions of specific performance outcomes in relevant operational settings. The group recently developed an initial integrative fatigue model of C-17 approach and landing performance and is working on further development and validation of the model. The group also recently received funding for two different projects. The first project received funding from the 711 Human Performance Wing (HPW) Studies and Analysis Intramural program ($342K) to individualize biomathematical fatigue model predictions based on reaction time task performance using Bayesian modeling. The second received funding from the Joint Program Commitee-5 Fatigue Working Group: Fatigue Mechanisms and Countermeasures (FY21: $463K; FY21 – 23: $1.401M total) to collaborate with Naval Surface Forces at Naval Amphibious Base Coronado and the Naval Medical Research Unit Dayton to conduct simulator studies with C-17 mobility aircrew and Naval bridge crew and develop a cognitive modeling capability aimed at predicting individualized performance degradations in operations across military domains due to fatigue and workload. These technologies will improve aircrew fatigue risk management by better characterizing individual operator and mission risk, allowing commanders to make more informed decisions that balance safety with mission requirements.

In order to put these technological advancements into the hands of the Airman, the group is developing a mobile fatigue application capable of taking in user inputs and habits, exploiting these modeling advancements, and producing individualized fatigue assessments and predictions for the specific Airman. A prototype of this application is available on Android and iOS and is currently being further tested and validated.

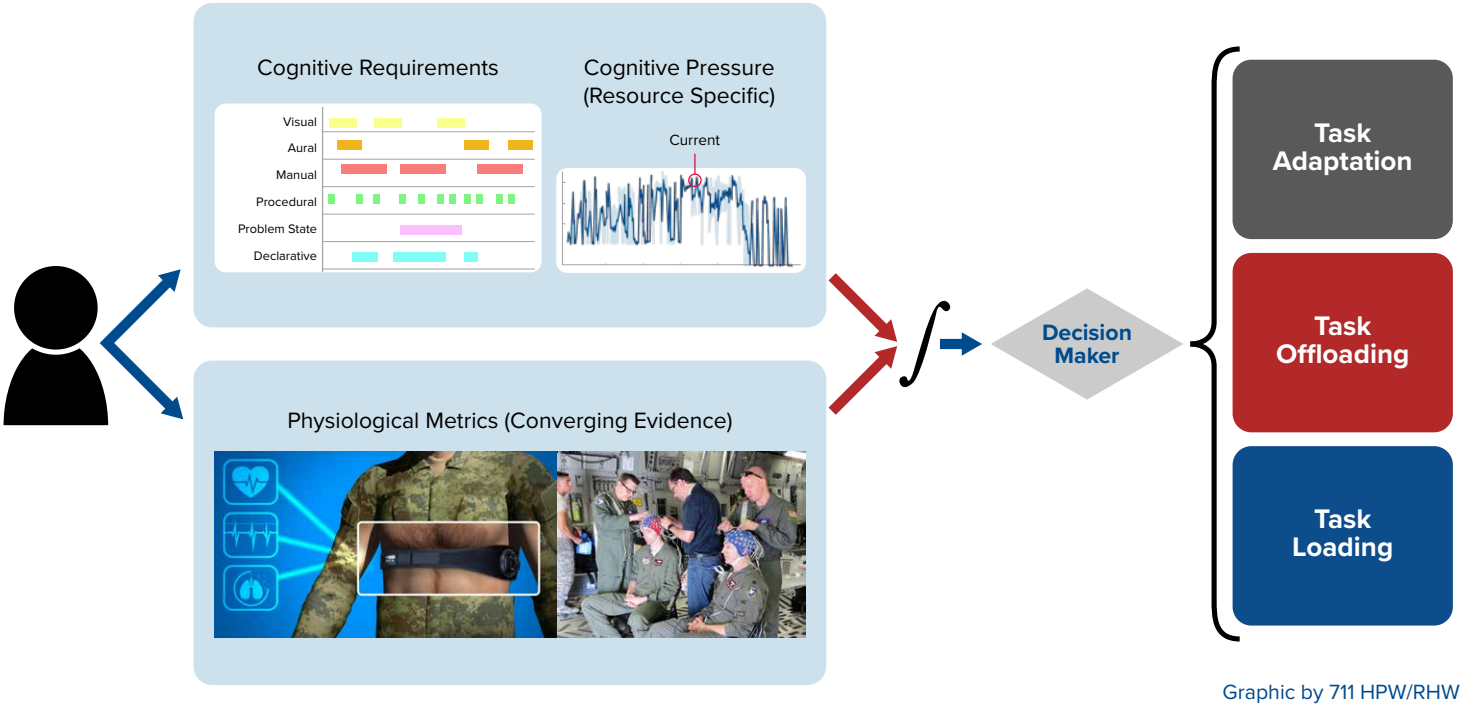
Lastly, the research group is conducting basic research examining the underlying cognitive mechanisms of fatigue from sustained attention, sleep deprivation, and circadian disruption to inform work on these integrative modeling advancements and ultimately transition to fatigue risk management technologies. ☆

Dr. Megan Morris, Research Psychologist, 711 HPW/RHWM

Below is a screengrab of the Android/iOS mobile fatigue application prototype that will be capable of taking in user inputs and habits, exploiting these modeling advancements, and producing individualized fatigue assessments and predictions for the specific Airman.



Graphic by Ms. Shania Horner



Graphic by 711 HPW/RHW

INDIVIDUALIZED COGNITIVE LOAD PROFILING

Warfighters must execute missions in increasingly complex and uncertain environments. They must be able to quickly digest information from a variety of sources, maintain awareness of evolving situations, and make sound decisions under stress. The cognitive workload experienced by warfighters can be very high, and can lead to errors and performance degradation if not properly managed. In the Individualized Cognitive Load Profiling line of effort, we aim to develop technologies to predict and detect workload spikes before they result in a loss of performance.

It is well known that increases in physiological actuation (increased heart rate, decreased heart rate variability, and increases in EEG signals of alertness) are associated with increases in workload. However, there is a high degree of variability in these signals that can sometimes make it difficult to adequately infer workload. Moreover, it is often unclear how to interpret increases in these signals, or at what point an operator should be considered "overloaded." Therefore, we augment physiological indicators with computational cognitive models. Computational cognitive models are theories of cognition implemented as software. These models interact with task environments or emulations of them to produce moment-to-moment simulations of behavior.

Cognitive models allow us to incorporate information about individual differences (e.g. personality, cognitive processing speed, working memory) and task demands to make predictions about workload and performance. Moreover, these models can be adapted in real-time by updating them with information about an individual's current performance, potentially allowing for improved prediction accuracy (Stevens et al., 2020). Finally, these models give insights into which cognitive resources (e.g. memory, time-estimation, situation awareness, visual processing, etc.) are being taxed most heavily by the current scenario. This information could inform insights into how to mitigate the cognitive workload (e.g., by providing external information support when memory resources are overtaxed). We believe the output of these models can be combined in real-time with the output of pattern classification algorithms of physiological data to inform automated task mitigation efforts, such as automatic task reallocation algorithms (Frame et al., 2019).

This modeling approach is broadly applicable, and we are developing and testing it in a variety of contexts. These include command and control (Stevens et al., 2019a; 2019b), intelligence, surveillance, and reconnaissance (ISR) (Frame et al., 2019), aerial refueling, and driving. We have demonstrated previously that our model estimates of workload have good convergent validity with known physiological indicators of workload (Stevens et al., 2019). We have developed an ISR isomorph and cognitive models that can simulate performance within it. We have a planned upcoming experiment for collecting human performance data for model validation. Finally, we have developed a low-fidelity cognitive model representing important cognitive skills associated with aerial refueling (e.g. collision avoidance and movement planning). We plan to expand this model and link its outputs to physiological metrics to produce a more valid prediction of workload in this task context.☆

Dr. Christopher Stevens, Research Psychologist, 711 HPW/RHWM

PHYSIOCOGNITIVE MODELING

Warfighters are continuously exposed to compounds from their mission environments. The ability to detect compound levels in real-time and predict their effects on downstream cognitive performance would provide opportunities to intervene *before* cognitive performance drops enough to hinder task performance and possibly produce catastrophe. The goal of the *phsysiocognitive* modeling line of effort is to derive such predictions through the integration of computational models of physiology with computational cognitive process models.

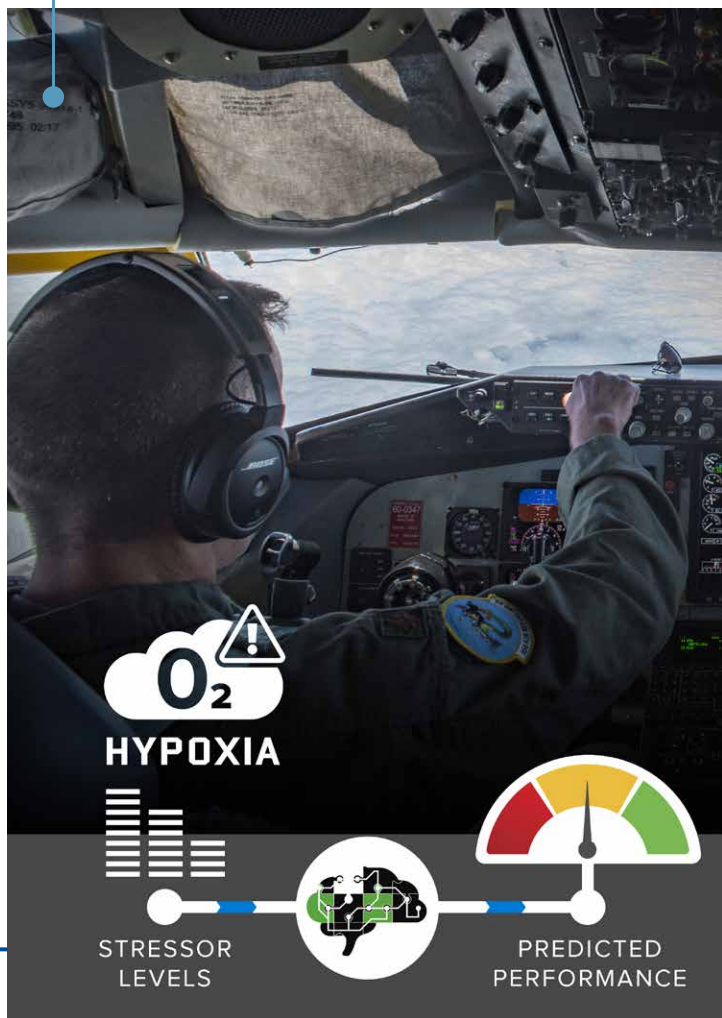
Environmental compounds can be controlled by the warfighter (e.g., caffeine intake during long-duration missions) and some cannot (hypoxic conditions during flight, toxin exposure during aircraft maintenance). The ability to predict cognitive performance improvements given different stimulant ingestion times would facilitate ensuring maximum performance for long-haul flights or late-night cyber operations. Further, accurate cognitive performance predictions given increasing, decreasing, or stable toxin levels would provide critical information to the warfighter on whether to continue or abandon the mission based on safety and effectiveness considerations.

The process applied to achieve model-based predictions of compounds' effects on cognitive performance first requires computing simulated blood concentrations of a targeted compound using *physiologically-based pharmacokinetic* (PBPK) models. Next, the blood concentrations are mapped to computational cognitive process model parameters associated with specific cognitive capacities (e.g., attention, memory, executive control, motor responses, etc). It is this mapping that is the focus of much of the empirical and modeling research. Once a blood concentration-to-parameter mapping has been identified, cognitive performance across a set of different cognitive tasks that target the different capacities can be computed to determine which capacities show performance changes. The summary of performance changes across capacities can then be used by to inform the warfighter's commanding officer (e.g., readiness metrics) or the warfighter directly (e.g., alarms and warnings).

To date, we have developed models of the effects of a common solvent on cognitive processing (toluene; Fisher, et al, 2017) and caffeine effects interacting with fatigue. Further, we have developed a cognitive task battery that targets different cognitive capacities for deployment in exposure studies. Data collected from these studies will facilitate model development by helping to determine if, and to what extent, cognitive capacities are affected differently by exposure to different compounds. We are currently collaborating with the 711th Human Performance Wing's Airman Biosciences Division to collect data from airman exposed to isopropanol in isolation, and plan to collect data on G-forces and hypoxia's effects on cognitive capacities. ☆

Dr. Christopher Myers, Senior Cognitive Scientist, 711 HPW/RHWM

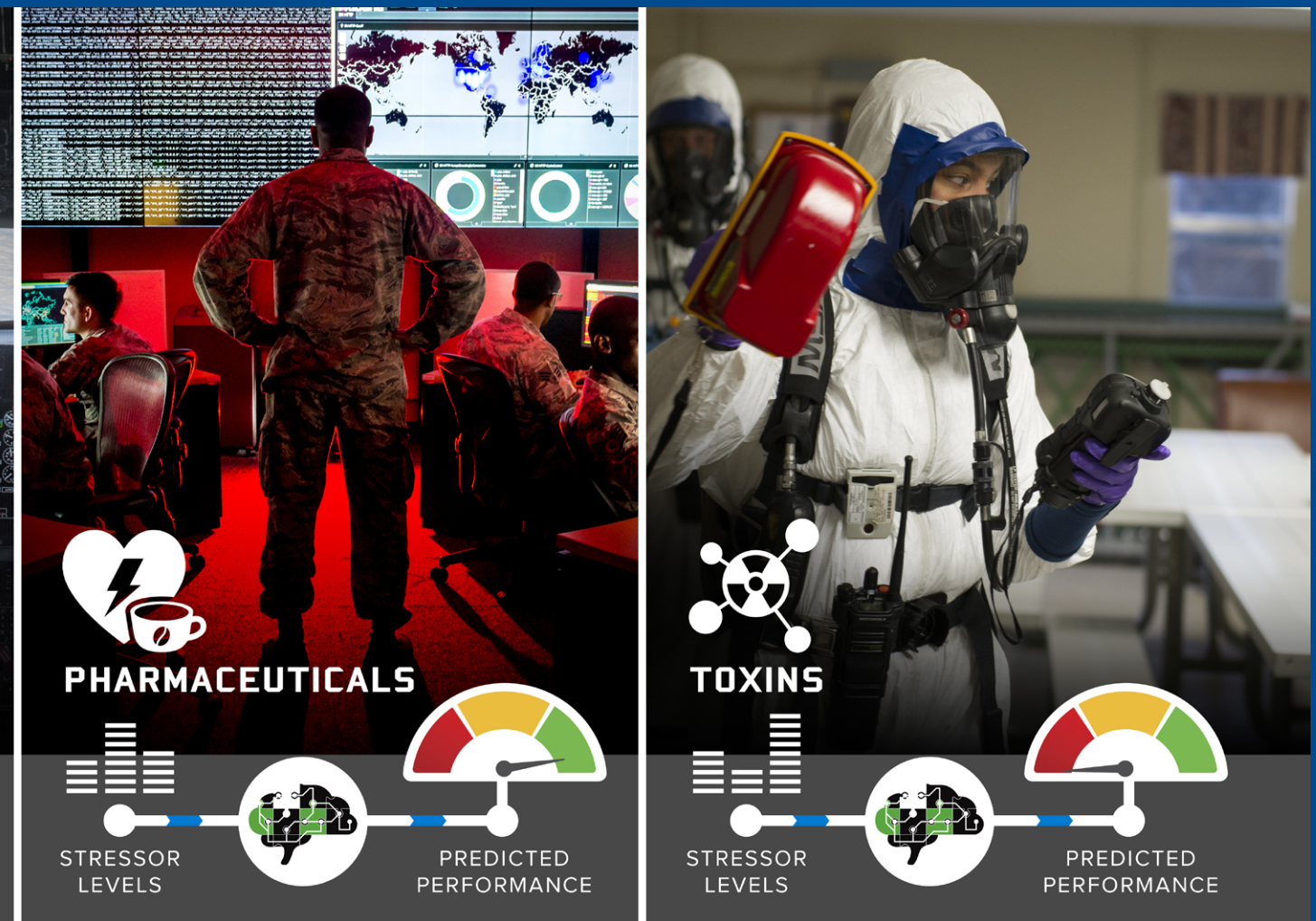
The graphic below depicts several compounds that can and cannot be controlled by the warfighter. Measuring these compounds help predict the cognitive performance improvements to ensure maximum performance.



THE GOAL... IS TO DERIVE SUCH PREDICTIONS OF COMPOUND-INDUCED COGNITIVE DECLINE THROUGH THE INTEGRATION OF COMPUTATIONAL MODELS OF PHYSIOLOGY WITH COMPUTATIONAL COGNITIVE PROCESS MODELS."

— Dr. Christopher Myers
Senior Cognitive Scientist, 711 HPW/RHWM

Graphic by 711 HPW/RHW



THE GAMING RESEARCH INTEGRATION FOR LEARNING LABORATORY®

The Gaming Research Integration for Learning Laboratory (GRILL®)—under the Air Force Research Laboratory, 711th Human Performance Wing, Airman Systems Directorate, Warfighter Readiness Research Division—leverages low-cost high-fidelity commercial-off-the-shelf technology solutions for a variety of Department of Defense customers.

Since the GRILL's inception in 2007, our team has worked successfully on achieving near- and long-term objectives. These objectives include the following.

- Create and validate a new and flexible generation of synthetic task environments for research
- Use game-based technologies to develop STEM (science, technology, engineering, mathematics) modeling and simulation content and exemplars
- Develop and evaluate virtual-reality and autonomous technologies and ad-hoc networks
- Create methods and tools to demonstrate and evaluate a "family of complimentary trainers" that can share content (i.e., interfaces, databases, models, metrics) via virtual-reality, part-task trainers, high-fidelity simulations and live operational systems
- Conduct university and operational collaborative research

In pursuing these objectives, our team evaluates and exploits commercial-off-the-shelf gaming technology to fill Air Force gaps and requirements and also conducts STEM outreach (on behalf of the Air Force Research Laboratory and the United States Air Force). Our team's vision is to serve as an authoritative resource for the integration and application of game-based technology to address United States Air Force education and training requirements. Together with our local, regional and national partners, our team supports the development of a highly qualified technical and scientific workforce for the future. ☆

Lt Dave Clement, Program Manager, RHWM
Mr. Jon Diemunsch, Software Engineer, RHWM
Mr. Quintin Oliver, Development Engineer, RHWM
Dr. Winston "Wink" Bennett, Product Line Lead and GRILL Team Lead, RHW

STUDENT SUMMER SHOWCASE

The Gaming Research Integration for Learning Laboratory® (GRILL®) evaluates, innovates and conducts science, technology, engineering and mathematics (STEM) outreach through a variety of projects.

The 2020 Student Summer Showcase is a perfect example of the outreach that the GRILL demonstrates. Due to COVID-19, the GRILL had to take necessary safety precautions but students were still able to deliver satisfactory results to their clients.

To the right are the highlights of projects that students were able to complete under the GRILL's guidance and resources.

> **My most rewarding experience at the GRILL is watching students' excitement over solving a problem as a team and their eventual completion of the problem that they are given."**
>
> **—Ms. Gretchen Capogna**
> **STEM Outreach Coordinator**

WANT TO COLLABORATE?

If you are interested in opportunities to collaborate, we invite you to contact us at:

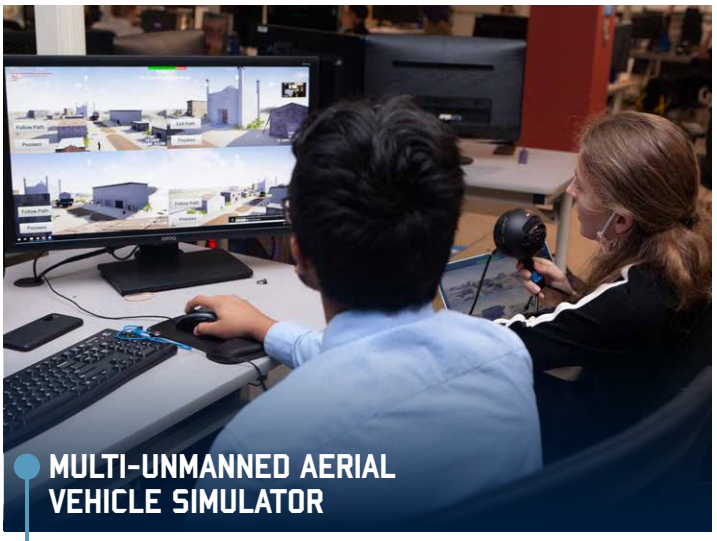
http://gamingresearchintegrationforlearninglab.com/contact-us/

Photos by Mr. Will Graver

AUGMENTED REALITY MAINTENANCE TRAINER

Task:
The AR Maintenance Trainer needed to assist users as they perform a maintenance routine on a physical object through providing various forms of guidance.

Result:
In the software, a user first selects the maintenance routine to perform and then scans a physical target image to place the virtual object. Then the user steps through their chosen routine which provides animations and step-by-step instructions on how to perform their routine.



MULTI-UNMANNED AERIAL VEHICLE SIMULATOR

Task:
The Multi-UAV Sumulator was required to show different levels of drone automation, explore the impacts of various distractors, evaluate and analyze human machine teaming.

Result:
- A fully functional level with four independent UAVs in a unique custom map
- A Friendly/Enemy recognition
- The simulator design allows it to have high cognitive fidelity while also allowing for flexibility

VIRTUAL REALITY LASER DAZZLE

Task:
Laser dazzles distract and harm airmen while performing their duties. This group's was tasked with making a more accurate, cheaper, and safer alternative to test human performance when impaired by a laser dazzle.

Result:
Students and staff created a safe, quick, and cost-effective prototype for researchers to measure the effects of a laser dazzle upon test subjects. Additionally, VR measurements provided researchers with new data such as head and hand positions so researchers could better understand human reactions with greater accuracy.

VIRTUAL REALITY TRAUMA TRAINER

Task:
The VR Reality Trauma Trainer group's task was to replicate eFAST exam in virtual reality.

Result:
- Vive tracker and probe
- Virtual mannequin placement
- Organs on ultrasound display
- Organs move when the mannequin "breathes"
- Calibration feature

PERSONALIZED LEARNING & READINESS SCIENCES (PLRS)

Dr. Kevin Gluck
Core Research Area Lead for Personalized Learning and Readiness Sciences and Principal Cognitive Scientist, 711 HPW/RHWL

TWO PROJECT AREAS

- **Adaptive Proficiency Technologies**
- **Interactive Task Learning**

Both projects involve multiple lines of effort, each with its unique and complementary role to play in creating new capabilities for the future fight.

This edition of "Fight's On!" reflects research conducted prior to November 2020. Ms. Jennifer Winner is the Cognitive Models CRA Lead as of January 2021.

The DoD identifies readiness as a key objective and has called for innovative new ways to ensure it. If we can maximize the effectiveness, efficiency, and durability of education and training for all personnel, then we can ensure readiness across all mission areas. Accomplishing this requires adopting a multi-disciplinary approach both to improving our fundamental understanding of human readiness and also to developing novel personalization technologies that are useful in complex, uncertain, dynamic environments.

The PLRS (pronounced "pillars") mission is scientific discovery and exploratory application of adaptive personalization capabilities for more effective and efficient learning, improved knowledge and skill retention, and more robust mission readiness.

PLRS personnel are leading the development of mission-relevant proficiency measures, models for personalized scheduling of instruction, the integration and field testing of readiness technologies, advancing the science of understanding, the creation of joint human-machine learning and performance capabilities, and novel measures and methods for robustness evaluation. Although we have our lead roles to play in this space, we know we can't do it alone. We're engaged in multiple ways across the enterprise, with several multi-CRA R&D activities, our AFRL-level engagement in the Robust and Secure Machine Learning Commander's Research and Development Fund Initiative (CRDF), a seedling from the Office of the Secretary of Defense, and international engagements with visits to the Asia-Pacific region and negotiations underway with the Netherlands and Sweden. Additionally, we have a large and diverse set of more than three dozen R&D partners and collaborators, across gov't, industry, and academia.

The result of all this is a high degree of S&T productivity, with dozens of journal articles, conference papers, and technical workshop contributions each year. We are engaged with Major Commands and our sister services and other departments and agencies. We use the core investments in PLRS as a foundation on which to build a broader portfolio with other sources of funding. Finally, we are actively involved with the larger scientific community by reviewing for conferences and journals, and through leadership positions on the boards of multiple professional societies. ☆

Dr. Kevin Gluck, Core Research Area Lead for Personalized Learning and Readiness Sciences and Principal Cognitive Scientist, 711 HPW/RHWL

ADAPTIVE PROFICIENCY TECHNOLOGIES

UNOBTRUSIVE NETWORKED INTEGRATED COMBAT OPERATIONAL RESEARCH INSTRUMENTATION (UNICORN)

The UNICORN line of effort focuses on capturing existing performance measure methodologies, performance capture technologies, and data governance solutions within government and industry then utilizing them for unobtrusive performance measurement. The program has identified the JTAC (Joint Terminal Attack Controller) community as an effective use case as it strives to develop and provide an unobtrusive proficiency based training system. In addition to baselining and beginning to assess current methodologies and technologies, UNICORN has supported two CAS (Close Air Support) training exercises at the 75th Ranger Regiment in Ft. Benning, Georgia. The relationship with this operational customer has grown to year-round research support and provides ample opportunity to evaluate the development of performance measurement and assessment tools.

UNICORN is working to increase the common operational picture of available capabilities across the Warfighter Readiness & Interactions Division as well as developing requirements for a comprehensive data governance solution. In addition, the team is working closely with the JTAC WIC (Weapons Instructor Course) to directly progress the development of subjective measurement capture in the specialized combat training environment.

Capturing operational measurements unobtrusively requires robust technological solutions in both hardware and software. The goal of these solutions is to capture objective and subjective measurements developed by performance measurement methodologies in a way that is inherently unnoticed by subjects during experimentation. In addition, the technological solutions must be able to process and analyze performance data in near real time, while seamlessly integrating with data governance technologies to enable longitudinal proficiency analysis and provide persistent access to all captured data in a relevant and organized manner, irrelevant of geographic limitations.

The UNICORN team seeks to discover and champion world class data storage and analysis solutions to be used by warfighters and scientists to gain a greater edge over the enemy when it comes to training, proficiency, and innovation. We will provide needs driven data storage and analysis solutions that will become faster, more intuitive, and smarter over time. ☆

Dr. Rachel Vickhouse, Principal Investigator and Team Lead, RHWL

Lt. Kyle Bucklew, Program Manager, RHWM

Lt. Tyler Lucas, Data Analyst, RHWL

Lt. Chao Pan, Data Analyst, RHWM

Lt. Lauren Gallego, Researcher, RHWL

Mr. Lon Hopson, JTAGGS Program Manager, RHWL

Ms. Montana Woolley, Researcher, Leidos

Dr. Caitlin Rizzardo, TO Lead, Aptima

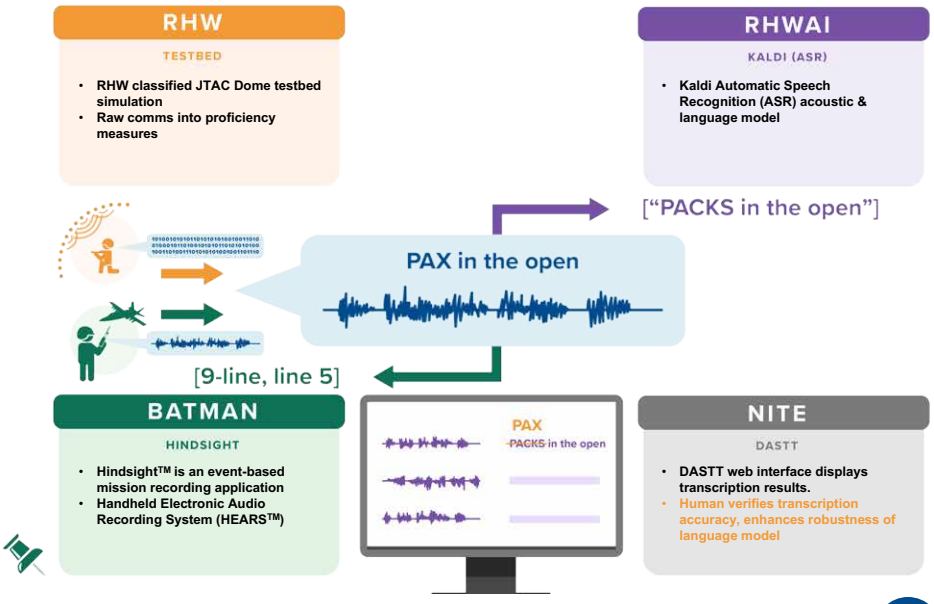
Dr. Jim Bliss, TO Lead, Leidos

Mr. Jeremy May, Software Engineer, Aptima

Mr. Donald Simones, Fighter Pilot Subject Matter Expert, RCG

Mr. Austin Eggers, Systems Engineer, Cubic

Graphic by Ms. Shania Horner



PERFORMANCE-ENABLED OPERATIONAL TRAINING ENVIRONMENT (PEOTE)

PEOTE consists of a set of technologies, architectures, and measurement approaches designed to optimize the use of Live, Virtual, and Constructive (LVC) simulation components in varied training environments, with a focus on austere environments. PEOTE incorporates opportunistic exploitation and innovation to produce an LVC environment to support training/research in multiple domains.

OPPORTUNISTIC EXPLOITATION

- Device- and approach-agnostic view of technology, practices, and information
- Takes advantage of existing operational communications and data networks to minimize additional infrastructure and maximize adoption and operational applicability
- Leverages existing mission simulation, visualization, recording, and playback components, and seeks to push the development envelope of new capabilities
- Employs existing and additional sensors and effectors to provide insight into human performance and the training environment
- Identifies capability gaps as requirements for future development

GENERALIZABLE APPLICATION

- Research and technology outcomes are focused on human-system performance assessment and enhancement
- Seeks to reduce mismatches between the virtual and live environments to maintain the suspension of disbelief for training audiences and enhance training experiences

INNOVATION

- Embraces the principles of DevOps and DevSecOps by automating the build and test cycle, continuously integrating software, hardware, and research, and continuously delivering our solutions and our research outputs
- Emphasizes the use of technologies and networks to maximize data availability with the primary purpose of using the data to discover and research human-system performance
- Pushes to automate objective and subjective data collection, extraction, transformation, loading, and analysis to free up resources for higher-level interpretation of results
- Emphasizes augmented reality (AR) and virtual reality (VR) devices and technologies to create more realistic and relevant training.
    - Partnering with the Gaming Research Integration for Learning Laboratory (GRILL) to apply emerging AR and VR technologies in live scenarios to determine the limits of these technologies, the boundary conditions that limit their effectiveness, and to frame future requirements for uses in training.

The PEOTE Line of Effort has made great strides in a short amount of time with a small, nimble team. One example of this progress is conducting a live LVC demonstration during November 2019 that was published in the Winter 2020 issue of "Fight's On!" The team demonstrated simulated weapons employment on live targets. Several weapons and effects simulators were integrated with mission modeling software to create a near-seamless connection between live and virtual weapons releases being modeled constructively, and the resultant constructive effects (destroyed targets) were translated into weapons effects (explosions) in a live space. Another more recent accomplishment was the designing, building, hosting, and operation of secure, cloud-based simulation, data collection, and analysis capabilities for the entire testbed and demonstrating the power of that capability in support of the RED FLAG-RESCUE 20-2 large force exercise. That effort enabled more robust after-action review capability and nearly completely automated exercise survey administration, collection, analysis, and reporting. Upcoming goals include more AR/VR integration, deeper measures and metrics development and implementation, further automation, and expanded sensor experimentation. PEOTE is also collaborating across divisions with 711 HPW/RH by partnering with RHB on some technical efforts and is collaborating with multiple Technical Directorates, including RY, RI, and RX. ☆

Mr. Ted Harmer, 711 HPW/RHWL

Ms. Ashley Wade, Leidos

Mr. David Malek, WSRI

Dr. Samantha Perry, Aptima

Ms. Carri Rodabaugh, Aptima

The team also reaches out to the following people when it needs specialized software, networking, and fabrication support:

Mr. Austin Eggers, Cubic

Mr. Bob Theimer, Cubic

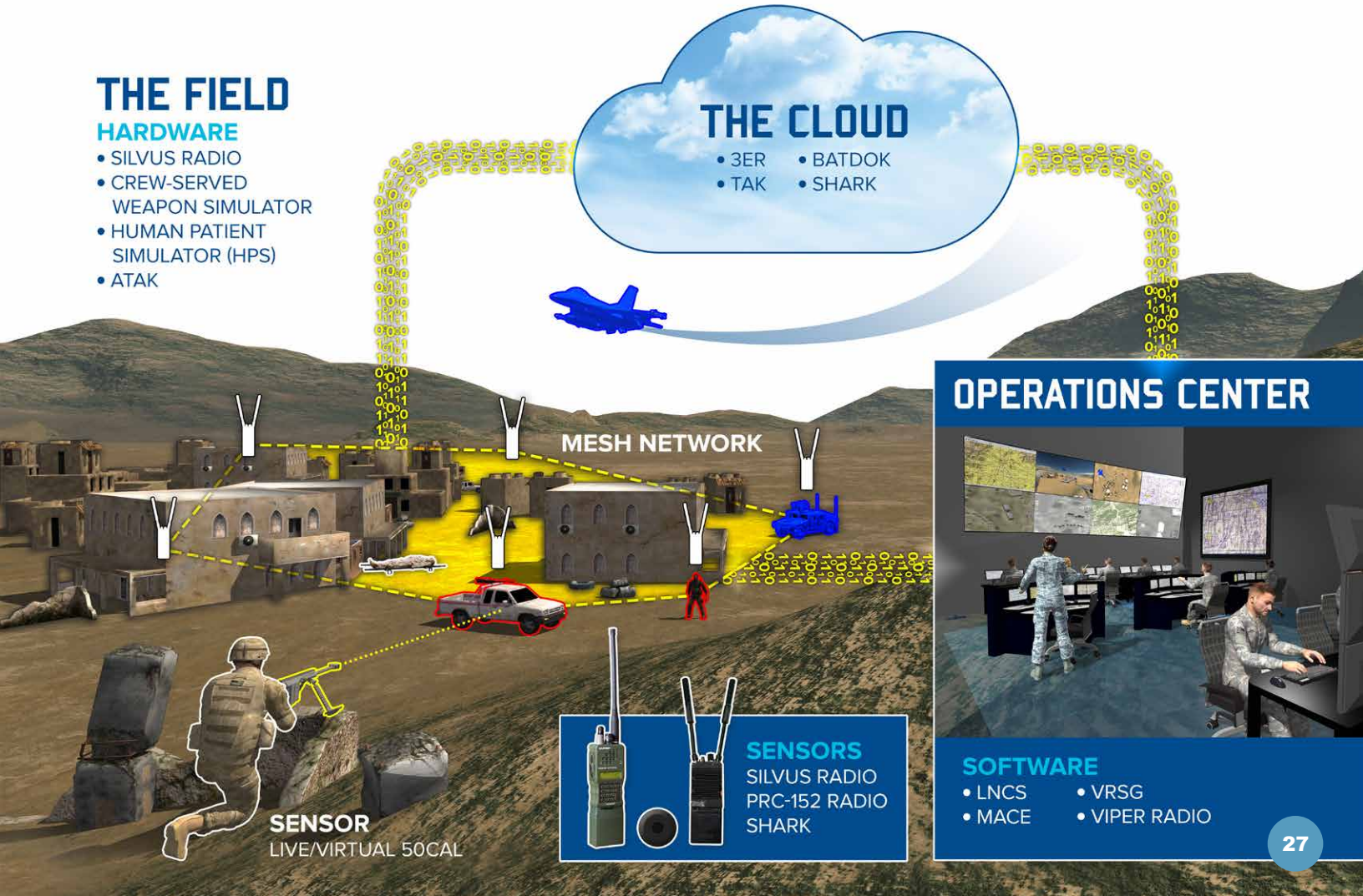
Mr. Matt Cusumano, Cubic

Mr. Brett Wiseman, Leidos

Mr. Craig Flaherty, Leidos

Mr. Chad Ploof, L3Harris

Graphic by Mr. Will Graver



PREDICTIVE ANALYTICS FOR LEARNING RESEARCH TEAM

The Predictive Analytics for Learning (PAL) line of effort has developed an innovative technique designed to personalize and optimize learning based on a patented technology known as the Predictive Performance Optimizer (PPO). This technology functions by using a mathmatical modeling approach to quantitatively track and predict knowledge. It uses individual student historical-performance data to estimate learning and forgetting and prescribes optimal future training times to help students acquire and sustain that knowledge or skill most efficiently and effectively. Our team has forged collaborative efforts with distinct communities in medicine, language learning, total-force training, aviation, and maintenance training, and we are investigating integrative approaches with machine learning methodologies to enhance predictive validity and move towards robust, scalable, intelligent tutoring systems. Our ultimate vision is to apply this technology to military readiness training across the spectrum of operations, to simultaneously enhance performance readiness and reduce training costs.

In 2021, quality improvement pilot tests and commercialization plans are in place with the American Heart Association to roll this personalized learning technology into state-of-the-art cardiopulmonary resuscitation (CPR) training systems. In addition, a full-scale, end-to-end 64-week pilot is planned to assess tailored personalization of linguist training to increase Arabic language proficiency without increasing training time. ☆

Dr. Tiffany Jastrzembski, Team Lead and Senior Cognitive Scientist, RHWS

Mr. Michael Krusmark, Research Scientist, RHW

Dr. Florian Sense, Cognitive Scientist, University of Groningen

Dr. Josh Fiechter, Cognitive Scientist, RHW

Mr. Michael Collins, Cognitive Scientist, RHW

Dr. Aihua Wood, Mathematician, Air Force Institute for Technology

Mr. Ryan Wood, Machine Learning Scientist, Oxford University

Dr. Hedderik van Rijn, Cognitive Scientist, University of Groningen

OUR TEAM HAS FORGED COLLABORATIVE EFFORTS WITH DISTINCT COMMUNITIES IN:

- **Medicine**
- **Language learning**
- **Total-force training**
- **Aviation**
- **Maintenance training**

The graphic to the right represents the primary vision of PPO: For the application of this technology to military readiness training across the spectrum of operations, to produce higher performance readiness and lower training costs.

Graphic by Mr. Will Graver

OUR ULTIMATE VISION IS TO APPLY THIS TECHNOLOGY TO MILITARY READINESS TRAINING ACROSS THE SPECTRUM OF OPERATIONS, TO SIMULTANEOUSLY ENHANCE PERFORMANCE READINESS AND REDUCE TRAINING COSTS."

— Dr. Tiffany Jastrzembski
Team Lead and Senior Cognitive Scientist, RHWS

REALISM, ASSESSMENT AND TEAM DYNAMICS FOR A READY MEDICAL FORCE

The Air Force, Army, and Navy rely on a *ready medical force* to provide Combatant Commands with a *medically ready force.* This line of effort focuses on research and development of methods and tools to address challenges to training effectiveness within the Military Health System (MHS). This FY20 new start is standing up during a time of significant change within the MHS.

The Defense Health Agency (DHA) is managing massive change as the sole agency responsible for delivering healthcare to millions of beneficiaries. Policies and other factors including limited availability of clinical experiences are driving increased reliance on medial modeling & simulation (MM&S) technologies. Streamlining of MM&S requirements is underway, but data analytic approaches lag. Instructors tackle challenges daily, and operational constraints continue to exert influences shaping the art of the possible.

Several collaborative research and development efforts are newly underway to address these challenges. First, with funding from the DHA STTR Program, we have initiated development of a training and assessment capability supporting prolonged casualty care in austere environments. This mobile capability will enable training delivery focused on recognition and treatment of decompensation in adult and pediatric patients. Solutions will balance interoperability needs for downloading/updating training content with the constraints of disconnected operational environments. Through this investment we will support training necessitated by extended patient evacuation timelines, enabling training where most needed.

Second, our collaboration with L3Harris and Leidos focuses on medical training fidelity and linking fidelity to training objectives and outcomes. This work leverages more than a decade of fidelity-research in other operational domains, applying methods and lessons learned to supported data-driven procurement of training systems within the medical context. Last, our work with Georgia Tech Research Corporation focuses on assessment, specifically to develop real-time analysis tools for team communication and coordination. Context-independent analysis solutions such as this have potential for broader applicability extending across other operational training contexts. Across these initial investment areas, outcomes and tools will inform training strategies and the acquisition of MM&S technologies. ☆

Ms. Jennifer Winner, 711HPW/RHWL

Capt. Jessica McCool, Program Manager, 711 HPW/RHWL

Dr. Teresa Millwater, 711 HPW/RHB

Dr. Leslie Blaha, Senior Research Psychologist and Carnegie Mellon University Operating Location Lead, 711 HPW/RHWL

Dr. Jamie Gorman, Georgia Tech Research Corporation

Dr. James Bliss, TO Lead, Leidos

Col (Retired) Douglas "Boots" Hodge

Ms. Montanna Wooley, Leidos

Photo by Sgt. Rick Hurtado

Photo by Ms. Maria Pinel

Photo of a US Army Major orthopedic surgeon performing hand surgery with her Honduran counterpart at the University School Hospital in Honduras, during a medical readiness training exercise that is designed to help medical personnel hone their capabilities and readiness to perform complex surgeries with limited resources in an unfamiliar environment.

Photo of US Navy corpsmen, US Air Force airmen and members of the Special Purpose Marine Air Ground Task Force – Crisis Response – Central Command participate in a combined joint casualty evacuation exercise. Conducted at an undisclosed location, this exercise served as a way to preserve medical skills in the event of a real life emergency.

INTERACTIVE TASK LEARNING

MISSION PLANNING AND DEBRIEF

Photo by Mr. Will Graver

The pointy ends of our national defense spears involve some of the most sophisticated technologies in the world. Just behind these pointy ends, however, is a collection of planning and debriefing processes mired in decades-old technologies (e.g., chalkboards, whiteboards, laminated maps) that impede the operational ability to adapt, decide and execute. To address this our team is leading research, development and evaluation efforts for next generation mission planning and debrief. The objective is to accelerate processes and improve mission outcomes.

Our approach involves combinations of new technologies that allow human-machine teams to engage in these iterative processes together. The core of our in-house development is a web-based system we call Metis, after the ancient Greek goddess of wisdom, prudence and deep thought. Metis provides a web interface for people, WebSockets and a Restful application programming interface (API) for communication with software agents or external endpoints, and a database backend for data storage and synchronization. Using this service-oriented architecture, our team has begun to develop and integrate an array of agent technologies, including the following initial capabilities:

- Air Tasking Order parser
- Reading agent that extracts constraints from mission planning guidance documents
- Mission plan generation and validation agent
- Planning product development agent that creates Coord Cards
- Automated Debrief Focus Point identification agent

Each of these agent technologies and their integration is in the prototype stage of development, but already we have begun formative evaluations. The evaluations indicate dramatic improvements in workflow and resulting decreases in process completion time. Early comparisons of machine-generated content to human-generated content show that they are comparable.

As part of our ongoing core applied research, the Mission Planning and Debrief testbed, along with the current implementation of associated agent technologies, provides a foundation on which to create the future. From a research program planning perspective, the concept is to use the testbed as a research and development platform as well as leverage its infrastructure for new investments. These investments span the continuum from fundamental research to advanced technology demonstrations as time, attention and funding allow. An example new investment involves a cross-CRA interdisciplinary collaboration exploring the use of cameras and microphones to allow the mission planning software agents to see and hear so they can become active participants in mission planning.

Preliminary results are encouraging, and we are enthusiastic about the possibility of near-term technology off-ramps that can benefit training at large-force exercises. However, the end goal really is to provide technology options that benefit operations and provide flexible force readiness more broadly. Our team is collaborating with the Air Force Vanguard Skyborg program to provide a digital mission representation to a range of autonomous air vehicles. We are a part of the Mission Planning Cell Tool hosted by AFLCMC/HBM which interconnects relevant mission planning projects to rapidly provide the warfighter a digital mission planning application. Additionally, we are exploring avenues to aid mission planning from the unit level intel Airman's perspective partnering with ACC/A2 and NIWC-PAC. Our team is exploring extensions of the prototype capabilities described here. The goal is to move the technologies toward multi- and all-domain operations and a broader set of functional mission types and associated assets. ☆

Dr. Kevin Gluck, Core Research Area Lead for Personalized Learning and Readiness Sciences and Principal Cognitive Scientist, 711 HPW/RHWL

Lt. Lauren Gallego, Program Manager, RHWL

Dr. Leslie Blaha, Senior Research Psychologist and Carnegie Mellon University Operating Location Lead, 711 HPW/RHWL

Mr. Brandon Nolan, Mission Planning and Debrief Technical Lead, RHWL

Mr. Bruce Carpenter, Fighter Pilot Subject Matter Expert, RCG

Mrs. Meghan Sorensen, Software Engineer and TO12 Lead, L3Harris

Dr. Luke Nelson, Software Engineer, L3Harris

Mr. Sean Kennedy, AI Engineer, Leidos

Mr. Logan Krause, System Integrator, Ball

Mr. Jimmy Cline, Software Engineer, L3Harris

Mr. Cameron Roudebush, Software Engineer, Aptima

Mr. Patrick Dull, Software Engineer, L3Harris

Mr. Jonathan Hart, Software Engineer Intern, ORISE

THE SCIENCE OF UNDERSTANDING

Having common ground. Being on the same page. Comprehending and acting on instructions. Anticipating your teammate's needs. Shared awareness. Coordination. These are just some of the many concepts synonymous with understanding between members of a team. But because understanding is a multi-faceted and sometimes ill-defined concept, we do not yet have systematic methods to assess if we have achieved desired understanding in humans, intelligent machines, and human-autonomy teams.

The Science of Understanding research program is laying a rigorous foundation for the test and evaluation of understanding. We are defining the multidisciplinary conceptual space encompassing varieties of understanding, identifying the similarities and differences between different types of desired understanding in teams, and developing a new Theory of Mutual Understanding. We seek to define generalizable tests and metrics to measure understanding, both in laboratory and under mission-relevant teaming tasks. We are advancing statistical techniques for quantifying behaviors over time and quantifying the coordination of language, motor, and decision making behaviors between agents.

ESTABLISHING AND MAINTAINING UNDERSTANDING IN HUMAN-AUTONOMY TEAMS WILL REQUIRE ANSWERS TO TWO FOUNDATIONAL QUESTIONS:

What does it mean for humans to understand autonomous teammates?

What does it mean for intelligent machines to understand human teammates?

The ways humans and intelligent machines gather information and reason about the world and about other agents are not the same. Thus, we are pursuing the Science of Understanding with special attention to the fundamental similarities and asymmetries among humans and machines understanding each other. We adopt the perspective that cognitive models have a critical role to play in facilitating machine understanding of humans; initial results with instance-based learning models indicate that internal states of the models quantify human perceptions of autonomy reliability.

The Science of Understanding is a fundamental research collaboration between scientists in the Warfighter Interactions and Readiness Division, Naval Research Laboratory, Army Research Laboratory, Carnegie Mellon University, and the University of Minho; it is the flagship research program for AFRL's Carnegie Mellon University Operating Location. ☆

Dr. Leslie Blaha, Senior Research Psychologist and CMU Operating Location Lead, 711 HPW/RHWL and Carnegie Mellon University

Dr. Sarah Bibyk, Research Psychologist, 711 HPW/RHWM

Mr. Patrick Dull, Software Engineer, RHWL / L3Harris

Mr. Frank Feldmann, Program Manager, RHWL

Dr. Josh Fiechter, Research Psychologist, Ball Aerospace

Dr. Coty Gonzalez, Research Professor, Carnegie Mellon University

Dr. Beth Hartzler, Research Psychologist, RHWL / L3Harris

Dr. Jayde King, Human Factors Engineer, RHWL

Dr. Christian Lebiere, Research Professor, Carnegie Mellon University

Ms. Erin McCormick, Graduate Research Fellow, Carnegie Mellon University

Dr. Alfredo Pereira, Research Scientist, University of Minho

The graphic to the right represents how many perspectives/flavors of "understanding" go into the Science of Understanding. Through encompassing varieties of understanding, identifying the similarities and differences between different types of understanding, and developing a new Theory of Mutual Understanding, we are able to better quantify behaviors and coordination between agents.

WE ARE ADVANCING STATISTICAL TECHNIQUES FOR QUANTIFYING BEHAVIORS OVER TIME AND QUANTIFYING THE COORDINATION OF LANGUAGE, MOTOR, AND DECISION MAKING BEHAVIORS BETWEEN AGENTS."

— Dr. Leslie Blaha

Senior Research Psychologist and CMU Operating Location Lead,
711 HPW/RHWL and Carnegie Mellon University

SCIENCE OF UNDERSTANDING

Graphic by Ms. Shania Horner

VISION INFERENCE ACTION (VIA)

In order for the Air Force to maintain a competitive edge, it is imperative we invest in research efforts that enable rapid, effective decision-making, increase human performance, and improve human-machine teaming. Currently, the majority of our interactions with computing systems rely on traditional "input" technology, such as keystrokes and mouse clicks. To maximize the benefits of our integrated human-machine teams, it is crucial that we push the envelope and develop new technologies to create seamless, natural interactions between humans and cognitive agents.

The primary purpose of the Vision Inference Action (VIA) Line of Effort is to improve human-machine teaming and interactive task learning by enabling real-time sensing of the physical environment to inform cognitive agents' inferences about users' goals and priorities. The VIA team is currently developing a Human-Machine Teaming (HMT) Test-Bed. The HMT Test-Bed will leverage commercial products (e.g., Microsoft Surface Hubs and Azure Kinects) and open source software (i.e. Open Pose, Kaldi, Microsoft Platform for Situated Intelligence) to gather audio-visual information. This information, coupled with model-based Bayesian inference techniques and human behavior research, will facilitate location tracking, gesture recognition, facial expression interpretation, and natural language processing. The combination of these technologies will allow for our cognitive agents to grasp information about the who, where, what, and why within the current environment. All that will inform our cognitive agents in real time and enable adaptive action by a VIA Teammate.

Currently, we are exploring the use of VIA capabilities in Mission Planning (collaboration with the Mission Planning and Debrief team) and in Close Air Support by Joint Terminal Attack Controllers (collaboration with the Unobtrusive Networked Integrated Combat Operational Research Instrumentation team). We are in the initial stages of assessing user tasks and processes to highlight activities where a VIA teammate will prove most useful. Furthermore, we are experimenting with different methods within these domains for real-time human performance measurement and VIA assistance. ☆

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Captain Jessica McCool, Program Manager, 711 HPW/RHWL

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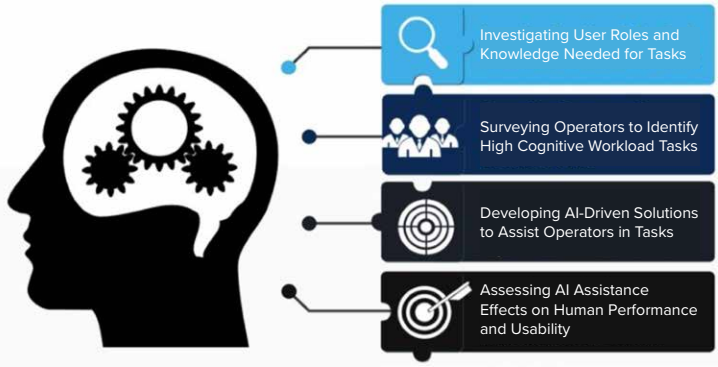
Mr. Jimmy Cline, Software Engineer, L3Harris

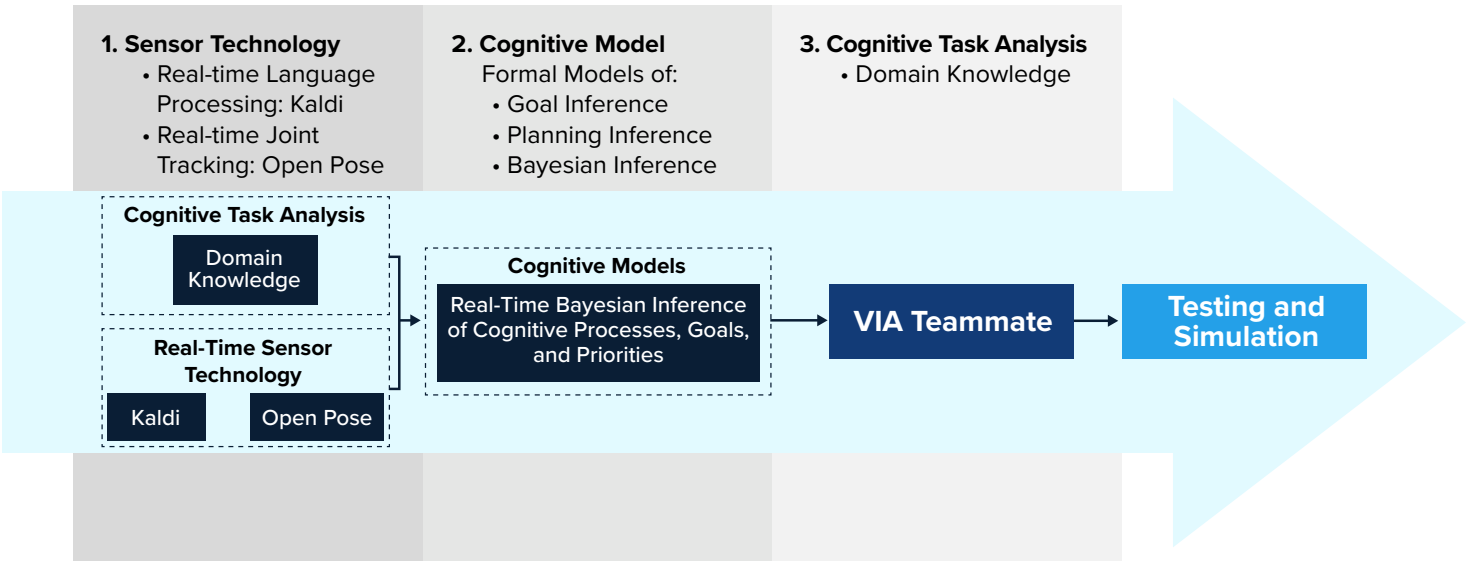
Mr. Alex Hough, Cognitive Scientist, ORISE and Wright State University

Mr. Michael Collins, Cognitive Scientist, ORISE and Wright State University

Dr. Michael Lee, Cognitive Scientist, ORISE and UC Irvine



VIA Domain Cognitive Task Analysis



VIA Research Conceptual Model

COMMANDER'S RESEARCH AND DEVELOPMENT FUNDS EFFORT

Commander's Research and Development Funds (CRDF) are enterprise-level investments in topics of high priority that are reviewed by the Research Advisory Council and approved by the AFRL Commander.

ROBUST AND SECURE MACHINE LEARNING

Recent breakthroughs in machine learning (ML), particularly deep learning technologies and applications, present great opportunities for the Air Force to develop improved warfighting capabilities. However, they also pose new security challenges and significant threats to our missions in all operational domains. There are two substantive concerns. The first is performance robustness and security vulnerabilities of deep learning models and algorithms have not been well studied and understood. Some emerging works have shown a less-thoughtfully designed and tested ML model easily can be exploited for significant performance degradation. The second concern is that it is not difficult for adversaries to deploy machine-learning-enabled systems that can deceive and/or disrupt warfighting capabilities because ML algorithms are largely developed and disseminated in public domains. Therefore, it is critical for the Air Force to invest in technologies for ML-enabled systems that maximize performance robustness, analyze and minimize security vulnerabilities, and serve as counter-measures against adversarial systems. This need is explicitly stated in the 2018 DoD Artificial Intelligence Strategy calling for increased R&D for "resilient, robust, reliable, and secure" AI/ML technologies.

To address these concerns, we formed an AFRL-wide team, including members from the Airman Systems, Information, Sensors, and Munitions Directorates, to propose a Commander's Research and Development Funds investment in Robust and Secure ML. The proposal was approved, and the R&D commenced in 2020. We adopted a teaming approach that divides responsibilities across Red Team offensive attacks, Blue Team defenses, and Green Team objective evaluation. With our history of research on conceptualizing and quantifying robustness, our Airman Systems Directorate team serves predominantly in the Green Team role.

Our objectives include (1) establishing a cross-directorate computational infrastructure, (2) conducting multi-dimensional assessments of offensive and defensive ML robustness, and (3) evaluating robustness pros and cons of human-in-the-loop active and interactive ML training and classifiers. There was considerable progress in 2020, culminating in a first annual demonstration event. We pushed the state of the art in adversarial ML evaluation by creating a new data pipeline and results visualization web tool that utilizes our novel Index of Robustness mathematical robustness measure. ☆

Dr. Leslie Blaha, Senior Research Psychologist and Carnegie Mellon University Operating Location Lead, 711 HPW/RHWL

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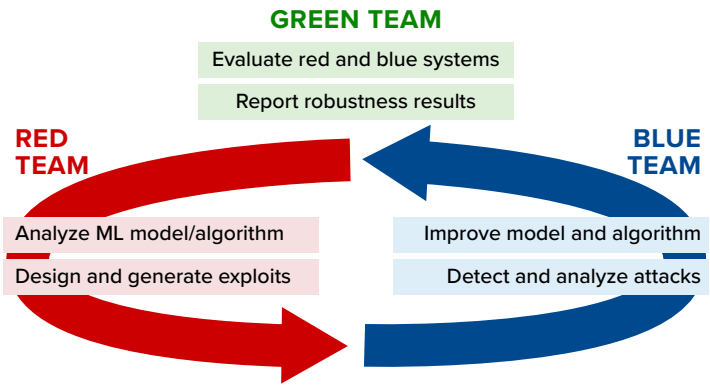
Ms. Meghan Sorensen, Software Engineer and TO12 Lead, L3Harris



Graphic by Dr. Leslie Blaha

ADAPTIVE WARFIGHTER INTERFACES

[OPERATOR INTERFACES] PROVIDE THE CRITICAL LINKAGE BETWEEN AIRMEN AND MACHINE SYSTEMS FOR ALL MISSION APPLICATIONS."

— Dr. Mark Draper
Adaptive Warfighter Interfaces Core Technical Competency Lead, 711 HPW/RHW

Dr. Mark Draper
Adaptive Warfighter Interfaces Core Technical Competency Lead and Principle Engineering Research Psychologist, 711 HPW/RHW

ADAPTIVE WARFIGHTER INTERFACES CTC

Operator interfaces are omnipresent throughout the entire Air Force; they provide the critical linkage between Airmen and machine systems for all mission applications. Airmen employ airpower by engaging with, and "interfacing" with, increasingly complex and intelligent machines and information sources, under constant threats of data uncertainty and information subterfuge. Given that future wars will increasingly be wars of cognition, victory will likely be decided by those who best synergize human and machine intelligence/capabilities to effectively operate well within their opponent's decision cycles. This is why our CTC exists.

The Adaptive Warfighter Interfaces (AWI) CTC discovers, demonstrates, and transitions the full spectrum of operator interface science and technology, communication enhancements, and human-centered decision analytics that dynamically integrate Warfighters and increasingly intelligent machines into maximally effective collaborative teams.

To be truly successful, the AWI CTC must focus away from benign, "sunny-day" normative operations and be directly responsive to the highly complex and uncertain environments expected with future warfare. These environments will likely be characterized by:

- Distributed operations with mixed, multi-echelon teams of humans and intelligent machines
- Machines continually gaining intelligence, learning, and adapting over time
- High-stress environments requiring rapid, accurate situation assessment & decision making
- Situations marked by massive data overload that occludes relevant information
- Rapidly changing information & communication environments with varying uncertainty

To successfully achieve its goals, AWI is organized into three, interrelated CRAs. The Multi-sensory Perception and Communication CRA focuses predominately on the "human side" of the system, with emphasis on characterizing and exploiting human perceptual abilities as well as enhancing communication capabilities within teams of humans and machines. The Systems Analytics CRA focuses predominately on the "machine-side" of the system, emphasizing rapid "meaning making" from large, complex datasets while enhancing analytic-enabled cognition through more effective design of machine analytics. Finally, the Collaborative Interfaces and Teaming CRA considers aspects of both human and machine in the design of human-automation collaboration methods and distributed heterogeneous teaming interface solutions.

To enhance the value proposition of this CTC, AWI focuses on advancing and aggregating individual research efforts into integrative solutions that enable high-priority Air & Space Force mission capabilities. Our research portfolio currently focuses on the following future capability visions:

- Joint All Domain C2
- Manned-unmanned teaming
- Data-driven ISR fusion
- Space applications (emerging)

So what does AWI bring to the fight? We hope to provide an entire "toolset" interaction and analytic solutions that empower Airmen and Space Professionals to accomplish their missions more rapidly and effectively, providing decision superiority to our forces in the next fight. Specific products include:

- HMT design guidelines/knowledge
- Adaptive & intuitive multi-sensory interface concepts
- Communication enhancements
- Decision aiding & enriched sense making methods
- Teaming assessment and collaboration solutions ☆

Dr. Mark Draper, Adaptive Warfighter Interfaces Core Technical Competency Lead and Principle Engineering Research Psychologist, 711 HPW/RHW

Photo by AFRL

SYSTEMS ANALYTICS

Dr. Daniel Zelik
Systems Analytics Core Research Area Lead,
711 HPW/RHWA

"The Systems Analytics Core Research Area is uniquely positioned to lead the research and design of human-centered data analytics for high uncertainty, high consequence system..."

Across Air Force missions there is a growing urgency to empower decision makers and analysts to capitalize on a range of rapidly-evolving "analytics" capabilities, including decision aids, algorithms, automation, autonomy, and artificial intelligence and machine learning systems. However, a lack of theory-driven, evidence-based approaches to integrate new analytics technologies into human-machine systems mutes the impact of capabilities developed to deliver decision advantage and full-spectrum awareness. The Systems Analytics Core Research Area is uniquely positioned to lead the research and design of human-centered data analytics for high uncertainty, high consequence system, by studying the macro-cognition of warfighters using computational analytics tools to accomplish mission objectives. Combining perspectives and principles from Cognitive Engineering / Human Factors with technologies and techniques from Data Analytics / Computer Science, our interdisciplinary research teams *develop grounded theories and methods to describe, assess, and design for effective integration of data analytics into mission systems.* Systems Analytics advances the research and development of analytics techniques and methods that promote novel understanding of mission-critical data and deliver revolutionary analytic solutions to warfighters via a unique emphasis on two "*Big Rocks*", which seek to:

1 (1) *Quantify how analytics alter thinking and reasoning.* A significant number of operational environments are highly cognitive, tightly coupled, and rely on rich and specialized expertise that is not mirrored by the current generation of AI/ML-driven analytics solutions, many of which manipulate data in ways that are both unobservable and unexplainable to users. Airmen are not passive consumers of outputs from such analytics; rather these analytics influence how human operators make sense of data—and not uniformly for the better. Our first focus is thus to assess the benefits and costs of *"Analytic-enabled Cognition."*

2 (2) *Build data representations to cope with data overload.* Operators across missions are challenged to rapidly make meaning from "Big Data". These operators must overcome the inherent complexity and uncertainty of multi-dimensional data to create actionable insights in real time. Our researchers leverage cutting-edge, commercially developed analytics but also innovate novel human-centered analytics approaches that introduce structure, meaning, and context to mission data in pursuit of the second key concept, *"Sense-making at Scale."* ☆

Dr. Daniel Zelik, Systems Analytics Core Research Area Lead, 711 HPW/RHWA

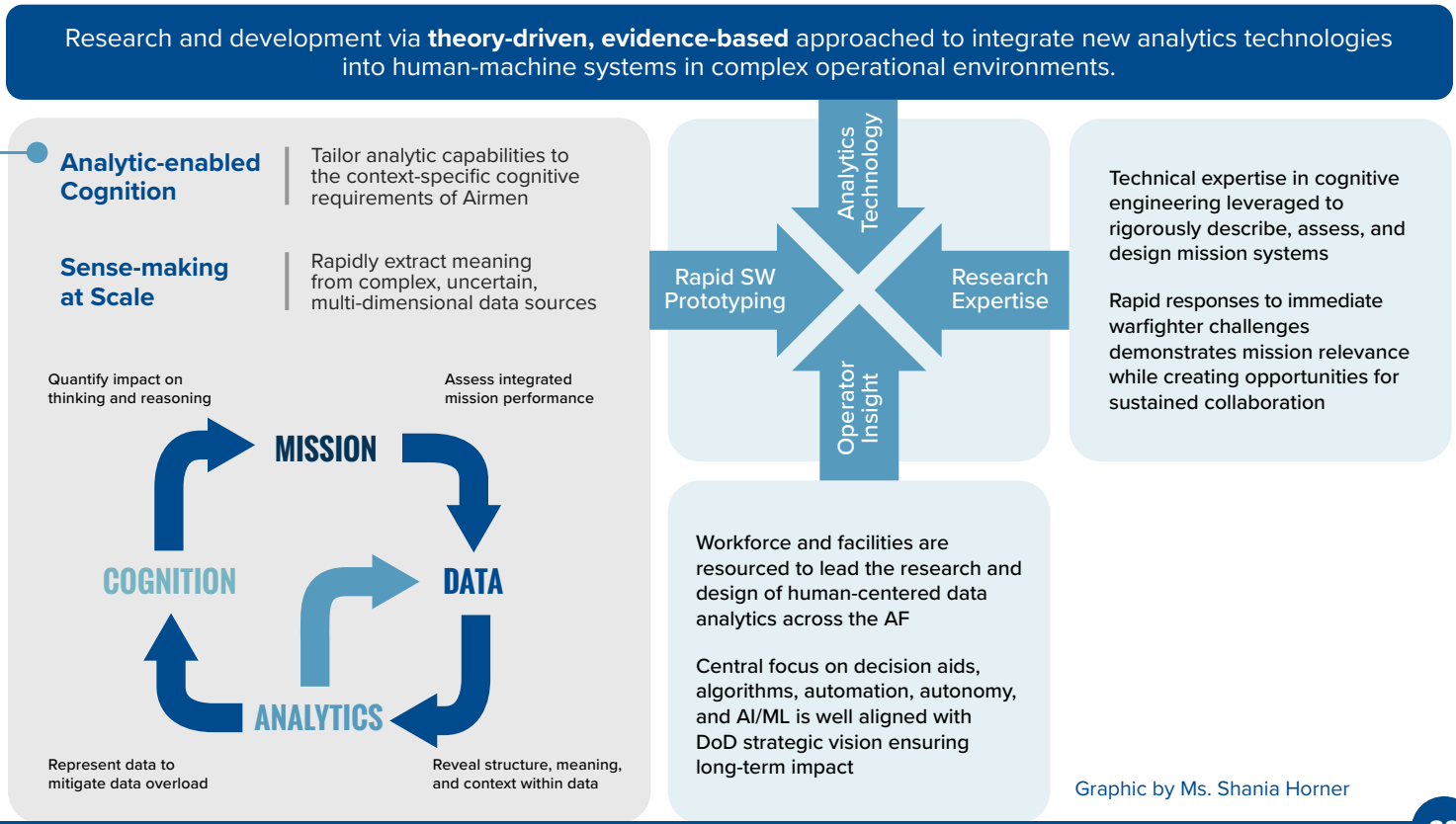
ANALYTIC-ENABLED COGNITION

HUMAN MACHINE TEAMING THEORY FOR ANALYTICS INTEGRATION

Optimizing system performance in the Air Force's data-intensive intelligence, surveillance and reconnaissance (ISR) environment requires a sophisticated understanding of the airman's sensemaking and decision making. Machine learning and artificial intelligence (AI) can be exploited to provide valuable assistance in an increasingly wide variety of ISR tasks, but this is not likely to improve overall system performance unless the assistance is well-suited to the airman's cognitive needs. The needs will vary depending upon a host of perceptual and cognitive issues; such as the current focus of attention, the overall cognitive demands, the nature of the cognitive processes engaged, and so on. So, rather than employing a static AI assistant, optimum human-machine teaming (HMT) will require real-time monitoring to identify the airman's current cognitive state to enable current and future AI agents and analytics to modify actions to seamlessly assist the airman.

The Cognitive and Physiologic Performance (CPP) program, a central component of this line of effort, will develop the real-time assessment tools for identifying the current cognitive activities of the ISR airman to optimize AI assistance. This project will use the 1N1 imagery analyst as the representative target application domain. A detailed understanding of the task environment and cognitive demands of this selected ISR position will be used to identify the cognitive processes most relevant to ISR analysts in general. In particular, the roles of intuitive and deliberative decision making processes and how they are affected by increased expertise and/or stress will be explored. Based upon these analyses, real-time performance, physiological, and neuro-ergonomic indices will be selected and tested for sensitivity to the targeted cognitive states. The studies will be initially conducted in a variety of task environments to fully test the robustness of the indices, but the research will transition to simulation validation tests in the RHWA Analyst Test Bed (ATB) facility. ☆

Dr. Daniel Zelik, Systems Analytics Core Research Area Lead, 711 HPW/RHWA



Graphic by Ms. Shania Horner

SYSTEMS ANALYTICS ASSESSMENT

The Systems Analytics Assessment line of effort seeks to assess conditions under which analytics enhance or undermine cognition via naturalistic studies of promising ISR mission technologies, including Full Motion Video (FMV), Multi-INT Fusion, and Conversational Artificial Intelligence (CAI) analytics.

The FMV Assessment team investigates whether a simulated machine recognition agent can enhance human sensemaking in simulated compound overwatch scenarios (see picture below). Initial results suggest that simulated agents that highlight people and vehicles do not significantly improve sensemaking. Whether a simulated agent highlighting EEIs will improve sensemaking will be determined next. Sensemaking measured in these scenarios is based on a unified model of sensemaking discussed in a manuscript that has been submitted and is under review. The team is also developing a software tool for decision support using Bayesian network modeling.

The Multi-INT Fusion Analytics Assessment team studies the potential to integrate multiple types of intelligence information into an informed and cohesive assessment, a critical need across the ISR community. Our team is interested in how adding a decision analytic to a multi-INT task changes the way an analyst integrates information and comes to conclusions given the available intelligence. More specifically, we are exploring the impact of decision analytic accuracy and transparency on user sensemaking, decision making, and cognitive bias in a multi-source intelligence analysis task.

The CAI Assessment team recognizes that “conversational agents” are a rapidly developing technology, with AFRL scientists beginning to look at how they can be applied to help DCGS and ISR analysts. However, there has been little research on how CAI might be used in more complex cognitive tasks in high-stakes environments. To address this gap, we are designing a study to empirically investigate how CAI use may affect human cognition, and thus the intelligence analysis process. ☆

Dr. Robert Patterson, Senior Psychologist, 711 HPW/RHWAR

Screenshot by Ms. Anna Maresca

MEANING-MAKING IN THE INFORMATION ENVIRONMENT

The Meaning-making in the Information Environment (MMIE) line of effort seeks to characterize the Information Environment to (1) anticipate/forecast adversary threat, (2) assess COAs and project adversary responses, (3) evaluate effect of actions, and (4) monitor vulnerability to adversary influence. MMIE leverages capabilities, investments, and partnerships to conduct innovative research and development, to transition tradecraft/tools, and to educate a variety of customers, operators, and students. The research portfolio focuses on several critical gaps: assessing operational effects in "competition" as well as conflict (see graphic below), developing agile methods that adapt to rapid social-cyber behavior change, characterizing mechanisms of Information Environment influence, and enabling the development of effective tactics/maneuvers and counters. In addition, MMIE seeks to foster resilience to misinformation in the operational force by identifying cognitive vulneraries that lead to susceptibility.

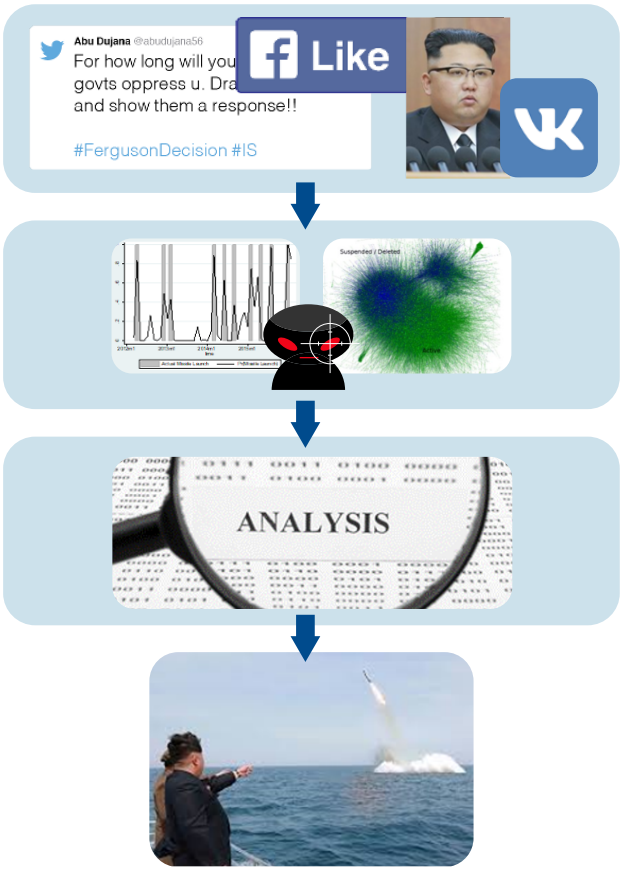
MMIE supports a range of Air Force missions: 14F analysts (Information Operations), Air Staff Q Group, Force Protection/Counterintelligence, Central Command (CENTCOM), Air Staff A1 and 480th Wing, Air Combat Command (A2T), Joint Warfare Analysis Center (JWAC), Joint Information Operations Warfare Center (JIOWC), NATO, TTCP, US Air Force Academy, Air University, Navy, Army, and Israel (Combatting Terrorism Technology Support Office). A concrete example, MMIE is in the first year of the transition effort for JWAC on Shaping and Deterrence Analysis, which focuses on developing data and analytic techniques for analysis of "red lines". Initial results demonstrated the importance of "discourse" variables (psycholinguistic indicators), in addition to traditional "event" indicators, for forecasting conflict and discerning bluffs from legitimate threats. MMIE also collaborated with JIOWIC, RI, and RY in writing Tactics Techniques and Procedures (TTP) for Joint Publication 3 for Operations in the Information Environment; the document will be available to various customers to educate operators as well as students. In response to COVID, recent research efforts focused on the detection of racism related narratives in misinformation, detection/analysis of disinformation supporting the Arkansas Attorney General Disinformation Task Force, use of information propagation models to help evaluate COVID policies (group size, social distancing) in Illinois, and analysis of disinformation narratives. ☆

Dr. Laurie Fenstermacher, Principal Electronics Engineer, HPW/RHWA

THIS LINE OF EFFORT SEEKS TO CHARACTERIZE THE INFORMATION ENVIRONMENT TO:

- Anticipate/forecast adversary threat
- Assess COAs and project adversary responses
- Evaluate effect of actions
- Monitor vulnerability to adversary influence

Graphic by Dr. Laurie Fenstermacher



JOINT ALL DOMAIN INTEGRATED ISR RESEARCH

How do we harness the unique insights of dispersed intelligence analysts and provide a simple forecast of adversary action? How do we predict the likelihood that an intelligence collection will be successful, even before we know what platforms and times will be available? How can human machine teaming, machine learning, and artificial intelligence augment or enhance human effectiveness across a joint all-domain landscape? These are just some of the questions the JADII team is addressing.

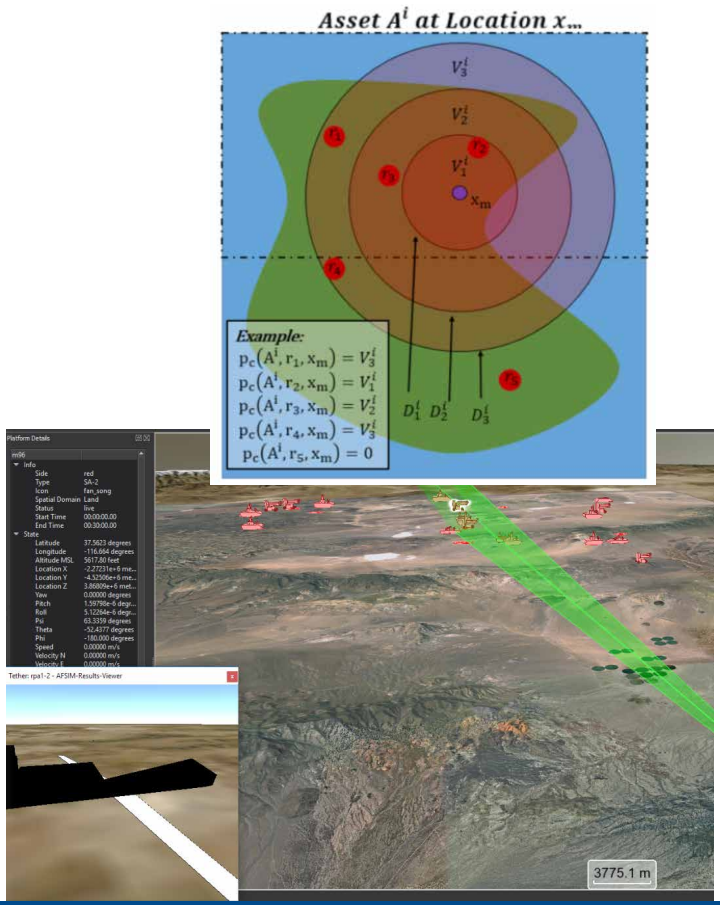
Sphinx, a predictive analysis platform, uses a crowd-sourced methodology to analyze priority intelligence requirements (PIRs) and produce decision-enabling forecast reports for the intelligence community. Sphinx distinguishes top analyst predictions and considers outlying forecasts while highlighting performance indicators. This initiative began prototyping in 3Q FY19, with TRL-7 operational use in 1Q FY20. The most recent deployment of Sphinx was a 2-week live data collection event at four geographically-separated Air Force Distributed Common Ground System (AF DCGS) sites. Research efforts are exploring bias, the impact of distributed teaming, and other factors affecting analyst performance. The Sphinx initiative is in partnership with Wright State Research Institute, 361 Interactive, the 480th ISRW, and ACC A22A.

Kraken, an intelligence, surveillance, and reconnaissance (ISR) feasibility engine, incorporates data on weather, terrain, restricted airspace, threats, and sensor-target pairing into a modeling and simulation framework to identify and visualize optimal capabilities to satisfy collection requirements. Kraken leverages the knowledge of experienced collection managers around the globe to improve the reliability and accuracy of algorithms used in generation of a Reconnaissance Surveillance Target Acquisition (RSTA). Research will compare the human solution to automated and human-machine solutions. Partnerships with ACC A22C and the ISR Dynamic Execution (IDEX) team in AFCENT are increasing the visibility of this dynamic research area. ☆

Dr. Jerred Holt, Research Scientist, 711 HPW/RHCMD

SOME OF THE QUESTIONS THE JADII TEAM IS ADDRESSING:

- How do we harness the unique insights of dispersed intelligence analysts and provide a simple forecast of adversary action?
- How do we predict the likelihood that an intelligence collection will be successful, even before we know what platforms and times will be available?
- How can human machine teaming, machine learning, and artificial intelligence augment or enhance human effectiveness across a joint all-domain landscape?



Graphics by Sphinx logoKraken

SENSE-MAKING AT SCALE

DYNAMIC WIDE AREA DISCOVERY AND EXPLORATION

The Dynamic Wide Area Discovery and Exploration (DWADE) line of effort is built around work domains requiring practitioners to create insights from immense datasets. DWADE is comprised of three projects, each of which seek to support practitioners confronted with data overload. The cognitive work performed by successful practitioners in each of these domains share many similarities. As a result, the larger goal is to develop generalized principles for building tools to support practitioners confronting data overload.

DWADE's first project, Hound, seeks to build support tools for intelligence analysts exploiting Wide Area Motion Imagery (WAMI). WAMI sensors provide full motion video of entire cities in a single field of view. The resulting data overload means that analysts are only able to review approximately 1.5% video collected by these sensors. Hound is a decision support tool that will find, ingest, and correlate multiple types of intelligence data to provide tipping and cueing to these analysts. This additional data will allow analysts to be more efficient in how they spend their limited manpower, and help discover activity that no one knew to look for.

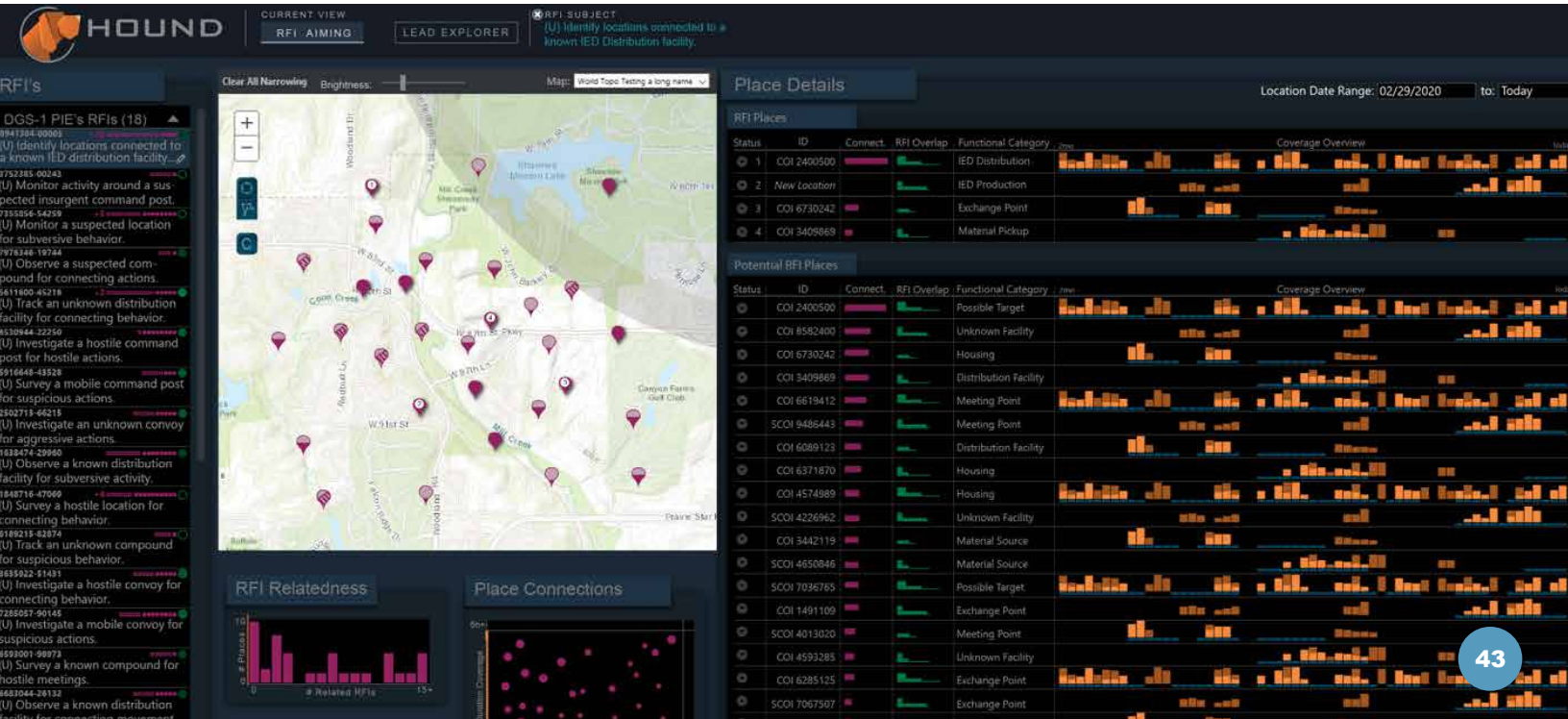
DWADE's second project, Flatline, supports COMINT analysts who monitor and translate radio communications. These analysts are responsible for monitoring both large geographic areas and wide radio bands. Flatline provides sensor metadata visualization to help analysts make more effective decisions about which frequencies to monitor. Flatline also looks to incorporate other AFRL technologies to help analysts more easily understand and translate audio content.

DWADE's third project seeks to identify the data visualization requirements to help nurses and doctors leverage Machine Learning capabilities to predict patient decompensation and intervene early. Even if algorithms can successfully predict decompensation, essentially a crash of the patient's vitals, how that information is presented to practitioners and how to allow those practitioners meaningfully interrogate that data are open questions.

These three projects all requires practitioners to develop insights while being confronted by data overload. By understanding the common cognitive work required by all three, DWADE will develop generalizable design principles that can be applied across Air Force missions. ☆

Dr. Jerred Holt, Research Scientist, 711 HPW/RHCMD

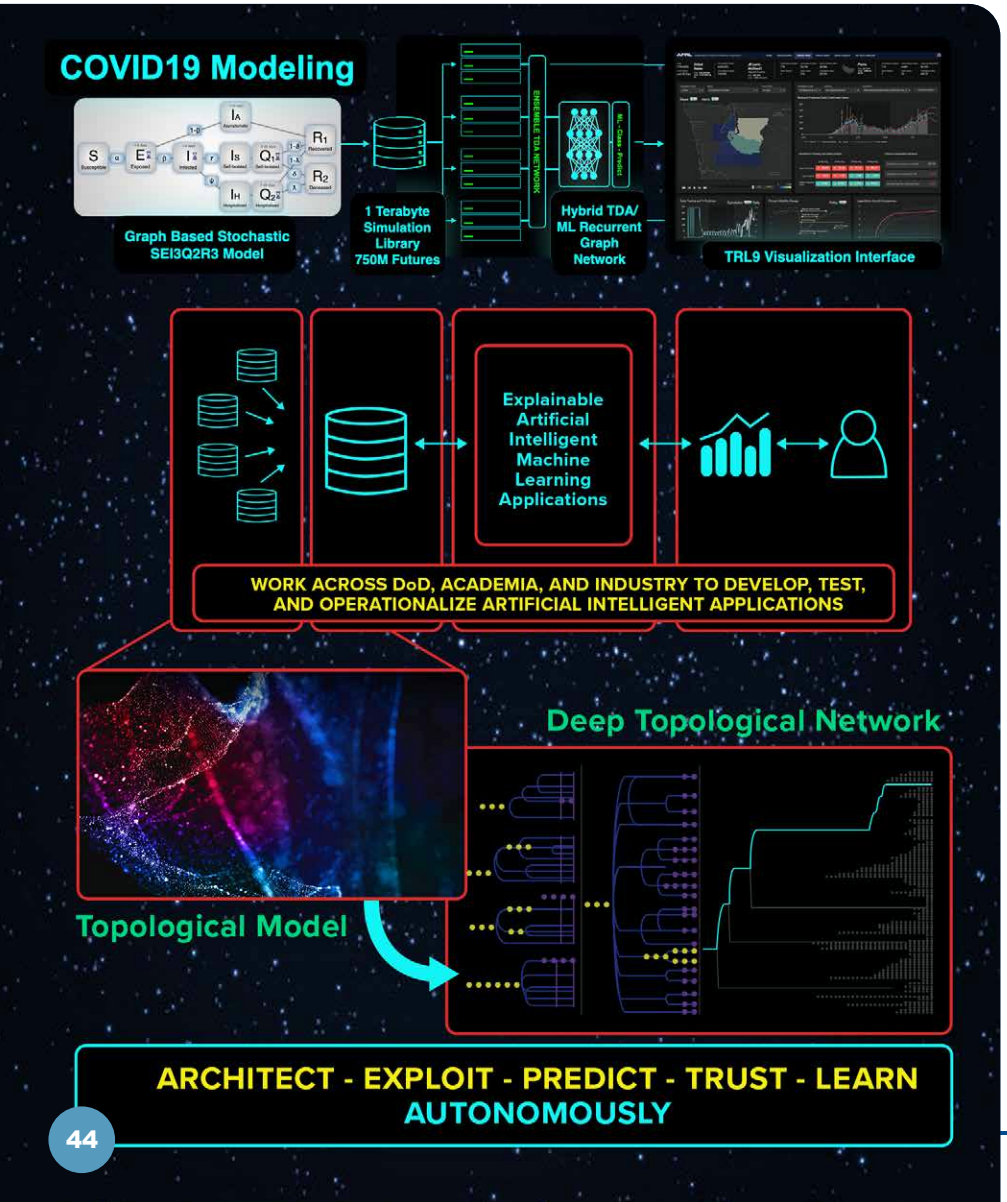
Screenshot by Dr. Jarred Holt



EXPLAINABLE ARTIFICIAL INTELLIGENCE (XAI) RESEARCH

In the past ten years we have seen the maturation of powerful compute methodologies utilizing deep network modeling approaches. Although these approaches have seen unrivaled performance across a number of domains, they can often be brittle as the world changes, have difficulty in integrating emergent information, and are difficult to trust due to black-box modeling paradigms. The XAI line of research creates novel and robust explainable artificial intelligence architectures that overcome many of these challenges. Utilizing the underpinnings of topological data analysis, XAI creates the ability to formulate fully connected ensemble modeling capabilities that learn feature representations, structures information across multiple metrics in unsupervised architectures, and provides a framework to autonomously formulate human and machine driven supervision in a compositionally parallel fashion. The architectures are constructed in much shallower frameworks than those of traditional deep learning, while preserving explainability, automated hypothesis generation, and trust in the resultant classification and prediction tasks.

The XAI architecture has been applied across a variety of domains to include computer vision (geospatial satellite, hyperspectral, LIDAR, SAR, wide-area motion, and high resolution radar), human performance optimization (EEG, exercise physiology, special forces training success prediction, brain-computer interfaces, and Air Force-wide suicide risk prediction), deep net optimization (deep net explanation, hardening against adversarial attack, RF modulation prediction, low-cost attributable aircraft design), and most recently COVID-19 modeling and forecasting.



In the most recent COVID-19 efforts, the XAI team has developed a modified stochastic graph-based SIR model. The model forecasts the number of Susceptible, Exposed, Infected, Quarantined, and Removed populations. Using this approach the team compiled a modeling simulation library of more than 3 billion models which was used to produce COVID-19 forecasts for confirmed cases, deaths, and hospitalizations at a county, state, and national level. This information, combined with other data sources were combined into a visualization interface to inform commanders and public health officials of current and projected COVID-19 impact. ☆

Maj David Smalenberger, 711 HPW/RHWA

APPLIED OPERATIONAL ANALYTICS

The Applied Operational Analytics line of effort matures and applies AFRL-developed data analytic and machine learning technologies for a range of operational missions. Generalized Network Insights from Situated Text (GNIST), for example, is an analytic to enable rapid knowledge discovery from seized email communications by casting a topic representation of emails as a network interaction task wherein users can explore the usage of topic keywords. This effort supports counter weapon proliferation by revealing cases where a foreign entity may exploit a coordinated clandestine network to solicit restricted components from individuals who are unaware of foreign involvement (see figure below).

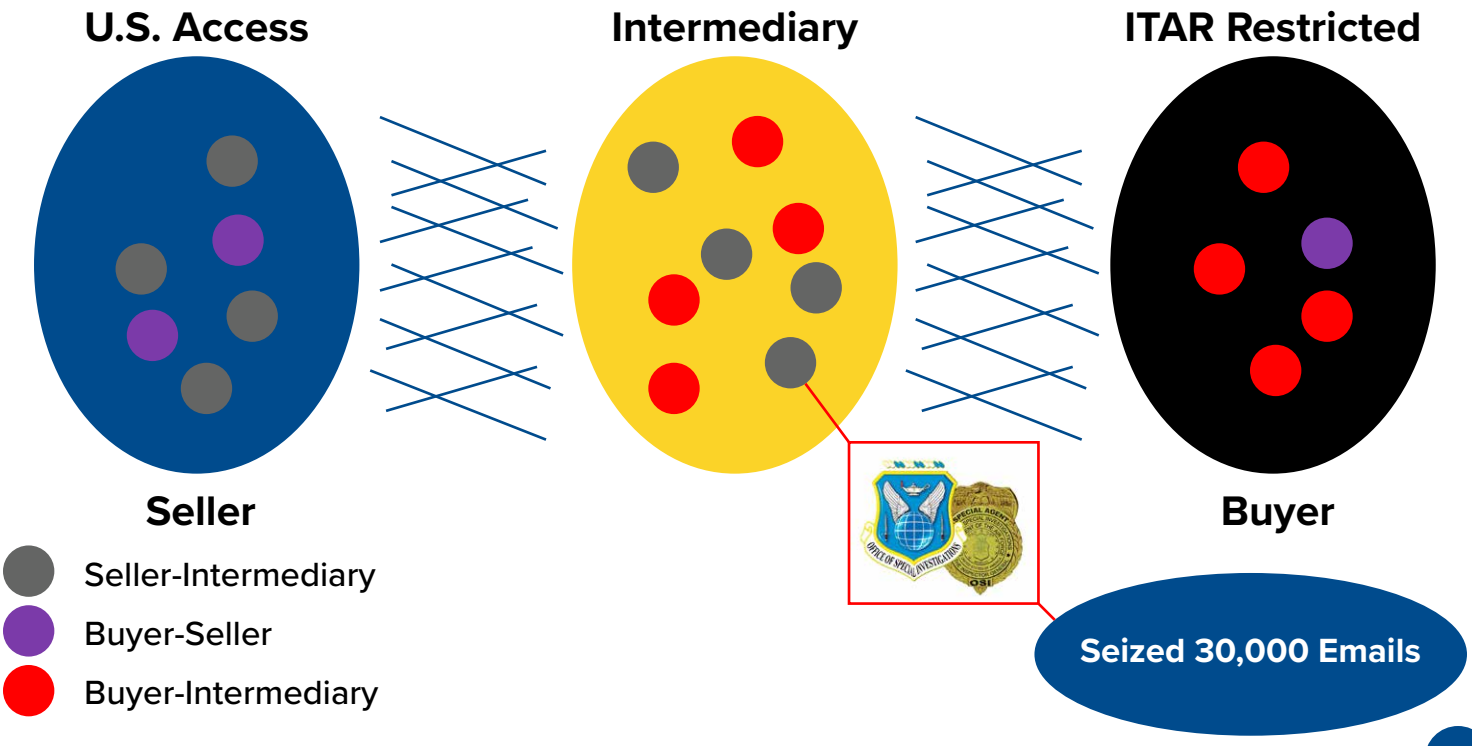
Algorithm Derived Decision Support (ADDS), another AOA project, develops analytics to enable rapid generation of finished intelligence products and to provide a human machine teaming capability in the form of product critique, feedback, and scoring. A related program focused on tactical exploitation and analysis of publicly available information (PAI) addresses emerging ML/AI opportunities by leveraging available data, open source methods to generate data representations, and standardized workflows to increase domain understanding and alleviate a time consuming manual process. An emerging thread aligns the ADDS project toward PAI to vet companies to be funded by the DoD, which faces significant OPSEC and monitoring challenges when reviewing thousands of proposal each year. This effort recently finalized a project agreement with India's Center for Artificial Intelligence and Robotics, which is planned as a collaboration between RI and RH.

Finally, the Analytics for Remote Combat Exposure Assessment (ARCEA) effort seeks to improve the health, wellness, and operational effectiveness of ISR operators by accurately and unobtrusively tracking exposures and mental health risks associated with remote combat stress, a significant contributor to posttraumatic stress and other negative psychological outcomes. The ARCEA project will identify and monitor exposures to high risk by applying text classification algorithms to mission chat data, building on a proof-of-concept investigation conducted by 711HPW and 480th ISRW. The envisioned result of this effort is a remote combat exposure app to be used by a range of AF stakeholders, including resiliency teams, MOCs, ISR mission commanders, and AFRL/USAFSAM researchers. ☆

Mr. Brian Geier, Data Scientist, 711 HPW/RHWAI

PARTS, MATERIAL, TECHNOLOGY

Graphic by Mr. Brian Geier



HUMAN LANGUAGE TECHNOLOGY

Human Language Technology works on technologies for processing human language found in various media files. While there are a variety of technologies that the group works on, the major focus areas have been automatic speech recognition (ASR) and machine translation (MT). ASR automatically provides a text transcript for an audio track, while MT automatically translates text from one language to another. The group conducts research and develops larger systems that incorporate various HLTs.

One such system is the "Haystack" Multilingual Multimedia Information Extraction and Retrieval System. Haystack allows one to search through large collections of media files to find materials that are relevant to an information need. Haystack supports upload, indexing, search, retrieval, drill-down, playback, and export capabilities for video, audio, text, and images (with text overlaid) in 18 foreign languages plus English. The underlying technologies include ASR; optical character recognition (OCR); MT; language identification (both audio and text based); speaker segmentation, clustering, and recognition; topic identification; and named entity recognition. The web browser based user interface (UI) provides search and retrieval using both English and source language keywords, and it allows the user to drill down into the retrieved results. To help the user determine relevance, the UI provides snippets that contain highlighted search terms along with word clouds of highly occurring English and source language terms. When the user selects a file for further review, transcripts and translations automatically scroll in time with video and audio playback, and the user can select portions of a file and its associated transcript and translations for export.

Haystack was recently deployed at NASIC in two instances, one version is in an unclassified platform on Amazon Web Services and a second version has been approved and installed on a classified network. The HLT Group is also working with the Linguist Next Project of the Air Force's 517 Training Group at the Defense Language Institute to leverage Haystack to support curriculum development. ☆

Dr. Raymond Slyh, Principal Research Electronics Engineer, 711 HPW/RHWAI

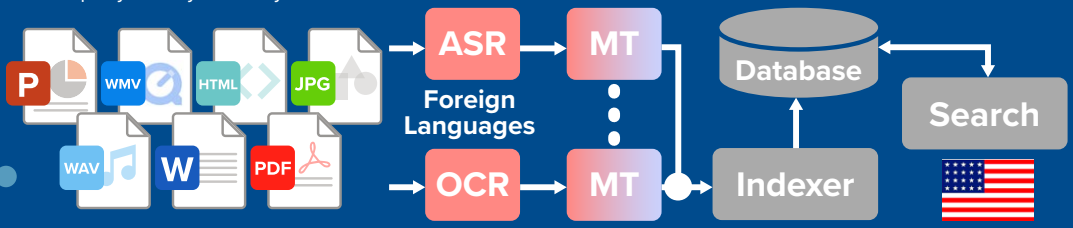
"HAYSTACK" MULTILINGUAL MULTIMEDIA INFORMATION EXTRACTION AND RETRIEVAL SYSTEM

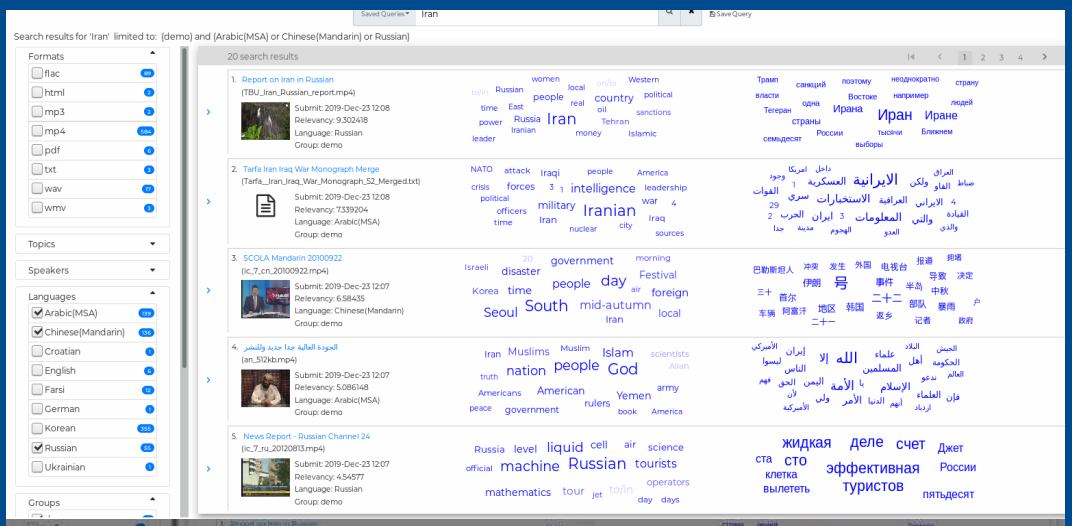
Haystack allows searches through large collections of media files to find materials that are relevant to an information need. Haystack supports upload, indexing, search, retrieval, drill-down, playback, and export capabilities for video, audio, text, and images (with text overlaid) in 18 foreign languages plus English.

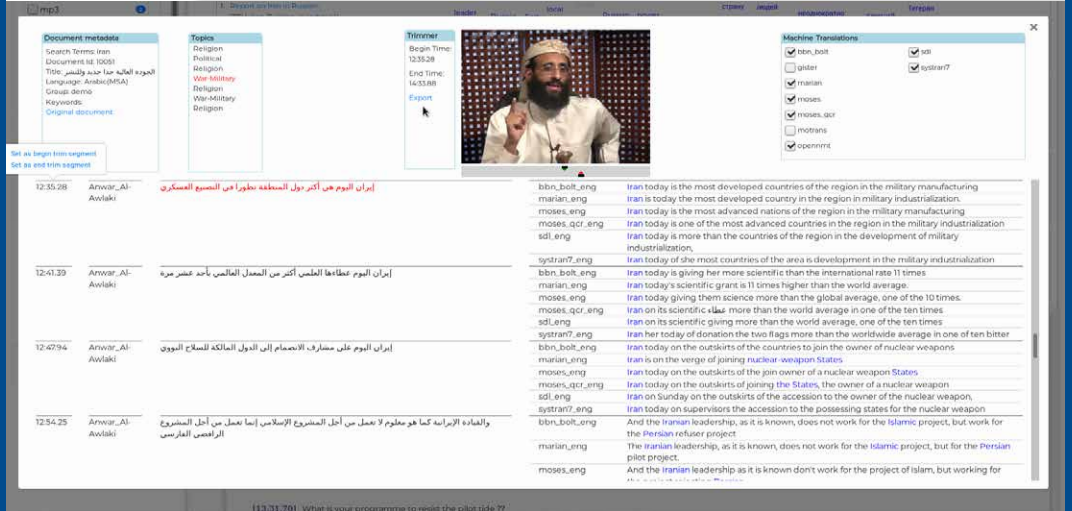
THE HLT GROUP IS ALSO WORKING WITH THE LINGUIST NEXT PROJECT OF THE AIR FORCE'S 517 TRAINING GROUP AT THE DEFENSE LANGUAGE INSTITUTE TO LEVERAGE HAYSTACK TO SUPPORT CURRICULUM DEVELOPMENT."

— Dr. Raymond Slyh
Principal Research Electronics Engineer, 711 HPW/RHWAI

Concept by Dr. Raymond Slyh







Screenshots by Mr. Eric Hansen

COLLABORATIVE INTERFACES AND TEAMING

Dr. Joe Lyons
Core Research Area Lead, 711 HPW/RHWC

The Collaborative Interfaces and Teaming Core Research Area (CRA) focuses on the development of flexible, directable, and transparent human-autonomy teaming solutions; the science of human-human teaming in distributed multi-domain contexts; and development of technologies to facilitate shared authority of autonomy and common ground within and between mixed human-autonomy teams. The Collaborative Interfaces and Teaming CRA has two Big Rocks: Human-Autonomy Collaboration and Distributed, Heterogeneous Teaming Solutions. ☆

Dr. Joe Lyons, Core Research Area Lead, 711 HPW/RHWC

"THE COLLABORATIVE INTERFACES AND TEAMING CORE RESEARCH AREA (CRA) FOCUSES ON THE DEVELOPMENT OF FLEXIBLE, DIRECTABLE, AND TRANSPARENT HUMAN-AUTONOMY TEAMING SOLUTIONS."

— Dr. Joe Lyons
Core Research Area Lead, 711 HPW/RHWC

Photo by AFRL Laboratory

HUMAN-AUTONOMY COLLABORATION

COLLABORATIVE INTERFACES RESEARCH

The importance of autonomy for realizing USAF employment of multiple manned and unmanned vehicle-teamed sensor platforms in future warfighting is well recognized. These new mixed-initiative interactive systems must enable human-machine collaboration and teaming that pairs a human's pattern recognition and judgement capability with recent machine advances in artificial intelligence and autonomy to facilitate synchronized tactical operations. AFRL has made significant advances in developing intelligent agents and ground station command and control interfaces that will enable a human-agent team to manage multiple assets. The approach utilizes a play-based delegation teaming architecture and an intelligent agent-supported Task Manager Interface to aid in workload management and shared team awareness. Instantiated in a high-fidelity system referred to as IMPACT (Intelligent Multi-UxV Planning with Adaptive Collaborative Control Technologies), this research capability to date has been used to examine the utility of a wide spectrum of control for the management of 12 (simulated) and 6 (live) heterogeneous UVs by a single human operator teamed with an intelligent agent. This effort aims to expand the station's interfaces, as well as the supporting intelligent agent technology and simulation framework to support multi-operator/multi-UV (MOMU) collaboration and provide multi-domain (including manned assets) situational awareness/command and control. Both part-task, lower-fidelity simulation/usability evaluations, as well as full-scale experimentation with the high-fidelity IMPACT system are being used to evaluate alternative approaches to candidate features/designs of interfaces and decision aids. The results of the repeated cycles of design and evaluation will feed technical efforts that address MOMU for future envisioned complex mission scenarios. ☆

Ms. Gloria Calhoun, Principal Human Factors Psychologist, 711 HPW/RHWCT

Dr. Elizabeth Frost, Research Psychologist, 711 HPW/RHWCT

Ms. Jessica Bartik, Research Psychologist, 711 HPW/RHWCT

2Lt Jacob Ehrenstrom, Human Factors Engineer, 711 HPW/RHWC

Ms. Anna Lee Van Abel, Associate Research Psychologist, 711 HPW/RHWCT

Ms. Sarah Bowman, Computer Engineer, 711 HPW/RHWCI

TRANSFER OF AUTHORITY

Transfer of Tactical Control (ToTC) is a critical issue within the Air Force given the AF2030 vision of sharing autonomous systems between Airman and the tactical challenges faced by programs such as the Skyborg Vanguard Program – which posits the need for transferring control between various teams of Airmen spanning across various operational perspectives. Within this study, we are investigating what factors have the potential to overload an operator during transfer of assets/authority – in particular for a "push" rather than a "pull" of unmanned aerial assets. Key research questions to be explored include: 1) How does an operator acquire situational awareness throughout the handoff, especially if an asset is pushed to them rather than requested by them? 2) What are the workload impacts, and how do they vary based on numbers of assets and mission phase/tasks? The team plans to use the Vigilant Spirit platform for experimentation. ☆

Dr. Chris Brill, Senior Research Psychologist, 711 HPW/RHWCT

Ms. Anna Lee Van Abel, Associate Research Psychologist, 711 HPW/RHWCT

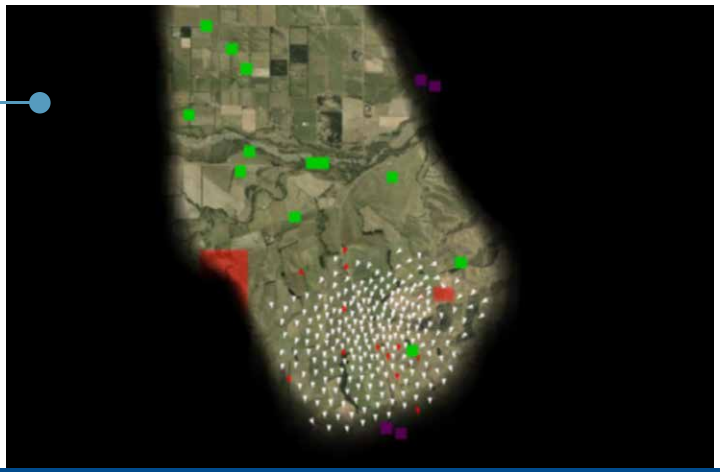
Dr. Guy French, Senior Engineering Research Psychologist, 711 HPW/RHWCI

Photo by Staff Sgt. Greg C. Biondo

TRUST IN SWARMS

This program investigates the role of trust in Human-Swarm Interaction (HSwI). Swarms comprise robotic assets operating autonomously via constraints based on robot location and environment characteristics. Their performance is often opaque, yet proper levels of trust toward swarms is critically important especially when the agents behave unexpectedly or are subject to countermeasures. As part of the Center of Excellence for Trusted Human-machine Teaming comprising AFRL researchers and academic stakeholders from Carnegie Mellon University, we have leveraged and augmented a test-bed from our academic collaborators to investigate the effects of robotic asset degradation on human perceptions of and intentions to rely on swarms. We have published preliminary research demonstrating that human trust toward swarms varied based on the proportion of asset degradations. These results show proof-of-concept for System-Wide Trust theory in HSwI, which suggests that degradations to one facet of a system pervade into human beliefs about the entire system. Research is currently underway which addresses several limitations of our initial data collection. Specifically, we are measuring human takeover of swarm foraging behavior to assess the relationship between human perceptions of and their behavioral trust toward the swarm at various proportions of swarm degradation. We are also collecting a large online sample to determine participants' ability to detect degrading assets in foraging scenarios. Future studies will further investigate the role of human biases and trust in HSwI; for example, we aim to decipher the differences in trust toward swarms in HSwI compared to trust toward the automation which tracks swarm performance. ☆

Dr. August Capiola, Research Psychologist, 711 HPW/RHWCT



An example of minimal asset degradation in a swarm. Red assets are degraded, while white are functional. Green blocks are acquired targets, while purple are not yet acquired. Red sections are no-fly zones. Visually occluded areas are undiscovered. From Capiola, A., Lyons, J. B., Hamdan, I., Nishimura, K., Sycara, K., Lewis, M., Lee., M. A., & Borders, M. (2020). The Effects of asset degradation on human trust in swarms. Proceedings of the International Conference on Human-Computer Interaction (pp. 537-549), Copenhagen.

TRUST EVALUATION OF AGCAS ON THE F-35

The Automatic Ground Collision Avoidance System (AGCAS) was fielded on the F-16 platform in 2014. Since that time it has experienced great success with 11 pilot saves to date. Due to this success, AGCAS was fielded on the F-35 platform in 2019. However, the F-35 community immediately began to experience a rash of unexpected activations of the AGCAS system following its fielding on the F-35. These unexpected behaviors could create significant system distrust within the F-35 community, thus AFRL sought to gauge pilot trust and understand the barriers to trust in AGCAS within the community. This study will investigate the development of trust and reliance behaviors among F-35 pilots and will identify trust barriers for AGCAS in the USAF F-35 pilot community. This study will identify/document interface issues, user experiences, concerns, policies, impact, and benefits of technology as they emerge. The results will support the Joint F35 Program Office, Air Force Test Center, and the Defense Safety Oversight Committee (DSOC). ☆

Dr. Chris Brill, Senior Research Psychologist, 711 HPW/RHWCT

Ms. Anna Lee Van Abel, Associate Research Psychologist, 711 HPW/RHWCT

SINCE [2014] IT HAS EXPERIENCED GREAT SUCCESS WITH 11 PILOT SAVES TO DATE.

— Dr. Chris Brill
Senior Research Psychologist, 711 HPW/RHWCT

Photo by Mr. Christopher Okula

An F-35C of VX-9 "Vampires" fires an AIM-120 during testing.

MANNED-UNMANNED TEAMING:
INTERFACES AND METHODS

Pilots are taught to "Aviate, Navigate, and Communicate" for self-protection and mission success. These tasks are mutually dependent on Situation Awareness (SA). The USAF anticipates development of machine agents to be deployed across a wide variety of AF missions as assistants in SA maintenance, shared SA, intent, and teammate actions. Additional information streams in an already complex cockpit may increase taskload; however, physiological events causing loss of consciousness or awareness are situational contexts which necessitate the need for such technology. Gravity-induced loss of consciousness (GLOC) is a major risk for pilots (overall rate estimated at 25.9 million sorties). Risks are higher for single-crewmember fighter aircraft, compounded by conflict with near-peer adversaries. Following GLOC, cognitive impairment and disorientation lasts ~1-2 minutes, after which re-establishing ownship control and rebuilding SA must occur. SA rebuilding can be complicated by context (i.e., mission phase, airspace geometry, etc.). Additionally, single pilot control of multiple autonomous wingmen (AW) may make this extremely challenging if information is difficult to locate or extract. The current study aims to investigate utility of a "Pilot's Associate" (PA) that monitors and reports critical SA-supporting information following a simulated GLOC event. The study will utilize the ICEBox platform using a 2 (PA: absent, present) × 2 (task load: low, high) within-subjects design. Taskload will vary through temporal demand; SA is lost early (less mission complexity) or late (high battlespace complexity). We believe the results of this study will support the utility of a PA to help a pilot rebuild SA following GLOC. The results will support the Skyborg Vanguard Program. ☆

Dr. Greg Funke, Senior Research Psychologist, 711 HPW/RHWCT

Dr. April Rose Panganiban, Research Psychologist, 711 HPW/RHWCT

Dr. Michael Tolston, Research Psychologist, 711 HPW/RHWCT

Photo by LiveLeak

TRANSPARENCY IN MACHINE LEARNING

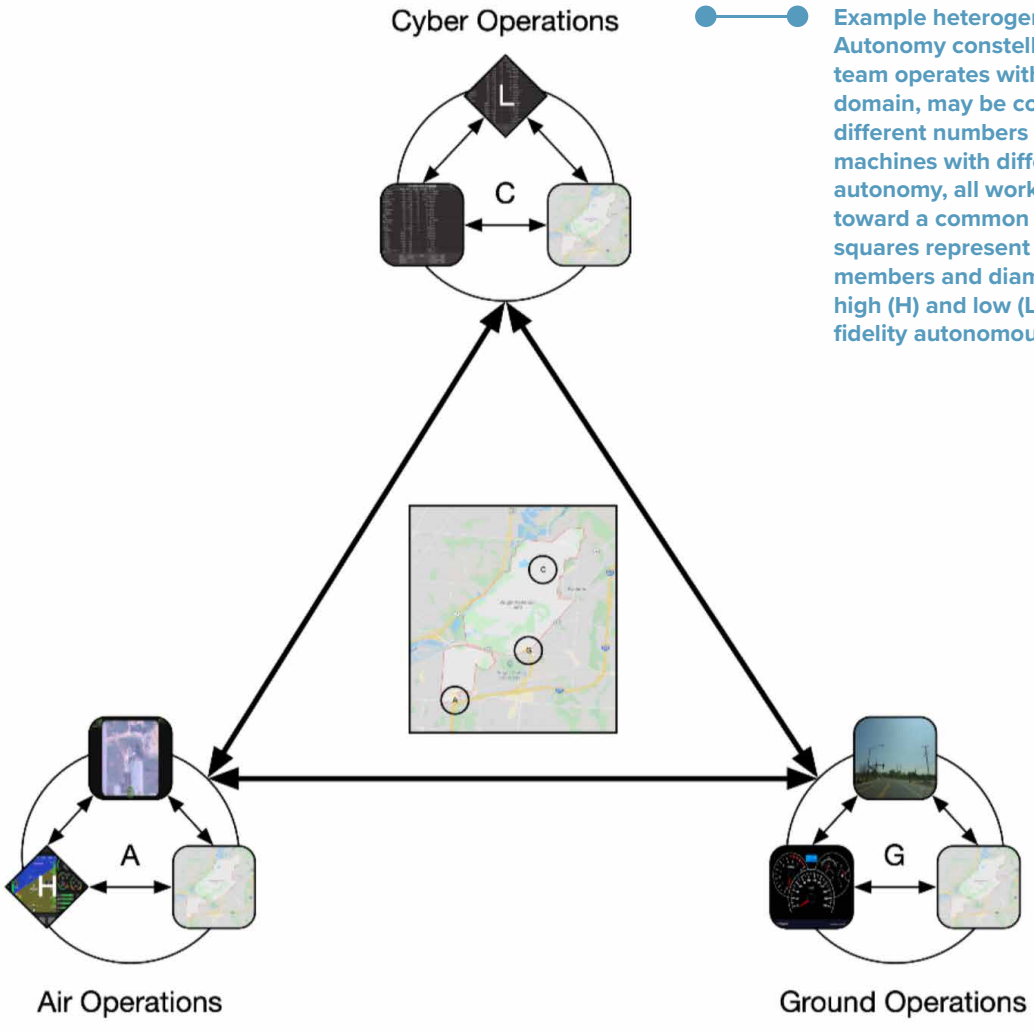
Machine Learning (ML) is influencing many different aspects of modern society. However, ML is often considered "black box" as the user does not know or understand the process the ML used to determine its assessment. Additionally, this "black box" aspect of ML leads to a lack of transparency for the user which hinders trust. The current program explores "elegant failures" (the ML stating its confidence in its assessment) as an indicator of transparency and its ability to increase trust perceptions. ☆

Mr. Gene Alarcon, 711 HPW/RHWCT

SYNTHETIC TEAMMATE RESEARCH

Human-autonomy teaming continues to grow in both capabilities and Department of Defense mission relevancy. As human-autonomy teaming expands into joint all-domain command and control (JADC2) tasks, new contexts for teaming arise, such as distributed and heterogeneous human-autonomy teams of teams, or *constellations.* Typically, research has been focused on behaviors and outcomes of a single team, with a great deal of empirical insights resulting (Cooke, et al., 2013; Gorman, et al., 2019; McNeese, et al., 2018; Myers et al., 2019). A critical component of teams is the development, maintenance, and repair of trust between team members. In this research, we seek to capture the dynamics of trust across constellations of human-autonomy teams: specifically, if, when, and how levels of trust within, and the behaviors of, one team affect trust levels and associated behaviors within other teams. We are initiating this research in collaboration with Clemson and Georgia Tech to move beyond the typical and study the diffusion of trust across human-autonomy constellations operating in a distributed manner. The research is anticipated to begin in late 2020/early 2021. ☆

Dr. Christopher Myers, Senior Cognitive Scientist, 711 HPW/RHWM



Example heterogeneous Human-Autonomy constellation. Each team operates within a different domain, may be composed of different numbers of intelligent machines with different levels of autonomy, all working together toward a common goal. Rounded squares represent human team members and diamonds represent high (H) and low (L) cognitive fidelity autonomous ones.

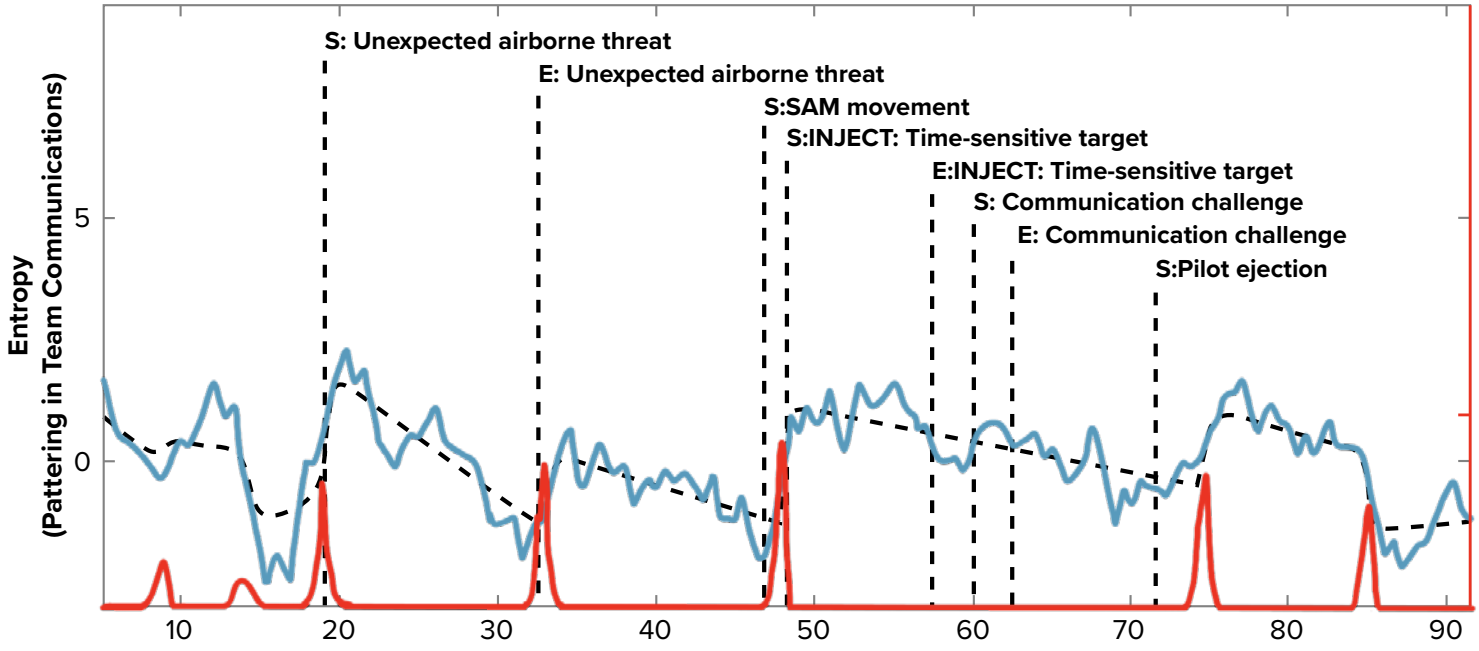
DISTRIBUTED, HETEROGENEOUS TEAMING SOLUTIONS

TEAM PERFORMANCE ASSESSMENT AND METRICS

Military teams face difficult situations, characterized by high tempo operations, distributed team environments, long shift durations, and decision making under uncertainty. Consequences of these demands include high workload, operator burnout, and reduced mission success. Monitoring teams is critical for ameliorating these negative states and improving outcomes. However, the factors that contribute to team success are poorly understood and metrics to monitor them in real-time are sparse. Despite this difficulty, there are a number of processes underlying effective teaming that can be leveraged for real-time assessment. For instance, teammates performing cooperatively show statistical similarity across behavioral and physiological responses. At AFRL, we are developing and applying cutting edge approaches to uncover the drivers and consequences of such team-level coupling. In addition to behavioral and physiological measures, team communication is a rich source of information about team functioning and decision making. We are quantifying complex patterning of team communication to assess ongoing team processes using novel statistics and methods developed in-house. Our metrics have been deployed in a high-fidelity virtual training environment to identify changes in team states in real time (see below figure). We are currently working to integrate our measures of communication, physiological and behavioral measures of teams, and environmental variables to create high precision models of team dynamics. We plan to continue to develop advanced, algorithmic approaches to automatically identify and diagnose team dynamics to improve responsiveness to mission critical events, ensure efficient and effective team decision-making and SA, and increase speed of command. ☆

Dr. Michael Tolston, Research Psychologist, 711 HPW/RHWCT

Dr. Greg Funke, Senior Research Psychologist, 711 HPW/RHWCT



Graphic by Dr. Michael Tolston

TEAM KICKSTARTER METHODS & SWIFT TRUST

Future Joint All-Domain Command and Control (JADC2) operations will require disparate and distributed team members to rapidly assemble, perform a mission, and then disassemble, frequently with little to no previous experience with their teammates. While the flexibility associated with temporary team formation may be necessary to meet the dynamic battlefield of the future, research suggests that teams with transient membership, sometimes referred to as *fluid teams*, often underperform compared to teams with stable memberships. This gap is due, in part, to teamwork factors that are necessarily influenced by team experience, such as team efficacy, transactive memory, and commitment to team goals (Bushe & Chu, 2011). However, fluid teams are common in some industries, such as aviation (flight crews) and healthcare (surgical teams), providing an opportunity for AFRL to leverage and extend previous research in these areas to optimize DoD teams.

This new line of effort will focus on mapping important factors and processes that influence teamwork in fluid and distributed teams, such as swift trust and common ground. Our goal is to create technologies that support rapid formation of fluid teams, and interventions that increase teamwork. Projects in this line are expected to address questions such as personnel selection ("How do we form the best teams?") and team performance enablers ("How do we improve fluid team performance?"). ☆

Dr. Michael Tolston, Research Psychologist, 711 HPW/RHWCT

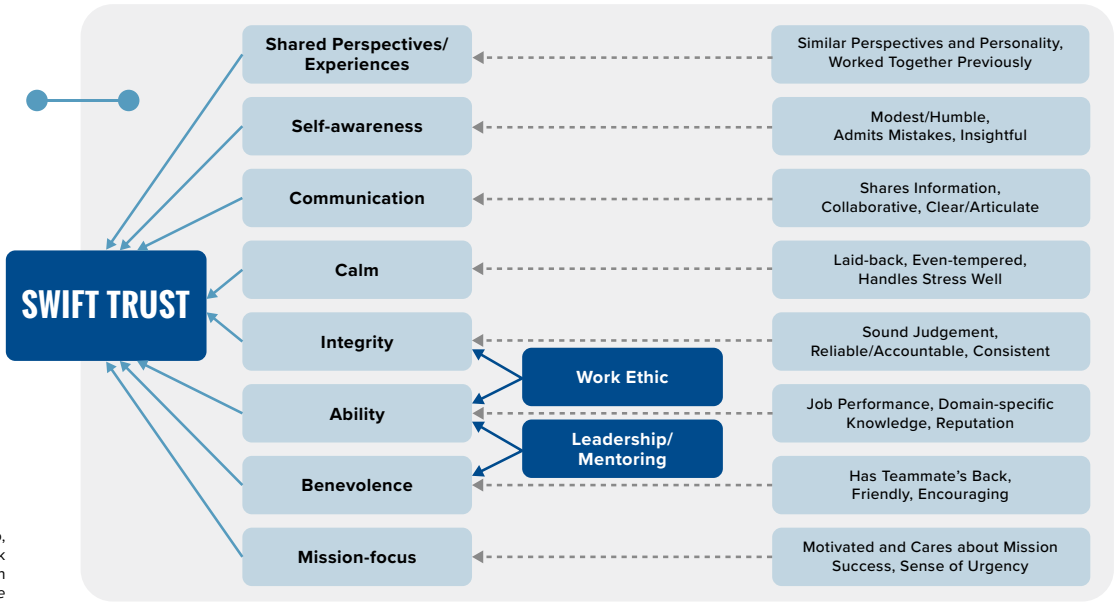
Dr. Greg Funke, Senior Research Psychologist, 711 HPW/RHWCT

SWIFT TRUST

This program investigates trust formed quickly (i.e., swift trust) in ad hoc teams. At the end of FY 20, we published a cognitive task analysis based on eleven structured interviews of subject-matter experts in Intelligence (Intel)—a heterogeneous job category comprising distributed and co-located personnel within multi-domain command and control (MDC2) environments. Eight antecedents to swift trust emerged from these interviews (i.e., ability, integrity, benevolence, communication, mission-focus, self-awareness, shared perspectives/experiences, and calm), with further analysis implying that swift trust is a relevant and emergent state in MDC2 that facilitates reliance. Now, we are designing experiments leveraging a custom test-bed informed by extant theory to identify *when* and *why* antecedents to swift trust are influential in shaping human-human reliance in experimental domains simulating aspects of joint all-domain command and control (JADC2) contexts. Our planned efforts will leverage the custom test-bed to investigate the role of variables such as differential risk, partner familiarity, communication constraints, and temporal urgency on trust between partners over time. That is, how do trust antecedents affect collaborative relationships comprising partners working together toward shared goals under unequal risk? To what extent does familiarity facilitate/hinder trust development and recovery? What mediums of communication (e.g., face-to-face, messaging, email, phone) promote trust in collaborative teams? How do time constraints affect the trust process in ad hoc teams? In time, we aim to replicate findings from the laboratory studies in applied/ecologically validated simulators within RHWC. ☆

Dr. August Capiola, Research Psychologist, 711 HPW/RHWCT

Depicted is a graphical display of antecedents to swift trust in MDC2- type contexts. Double compound lines (i.e., from Work Ethic to Integrity and Ability; from Leadership/Mentoring to Ability and Benevolence) indicate a sample characteristic that is common in two antecedents; square dots indicate theoretical overlap of traditional antecedents with MDC2- specific antecedents identified in this CTA; dashed lines connect example characteristics to their respective antecedent which they compose. MDC2 = multi- domain command and control; CTA = cognitive task analysis.



Capiola, A., Baxter, H., Pfahler, M., Calhoun, C., & Bobko, P. (2020). Swift trust in ad hoc teams: A cognitive task analysis of Intelligence operators in multi-domain command and control contexts. *Journal of Cognitive Engineering and Decision Making*, 14(3), 218-241.

TEAM PROCESS RESILIENCE

This new line of effort is focused on team resilience from a C2 perspective. One of the primary Joint All Domain Command and Control (JADC2) challenges has to do with C2 resilience – i.e., how can we maintain effective team processes in the face of disruption. This research attempts to include a consideration of agility and recovery from degraded communication environments, as well as the ability to shift team composition and location dynamically in response to enemy attack. Leveraging existing research in team skills, this study will attempt to identify which factors (process structure, distributed collaboration technologies, training or swift trust facilitators done prior to the disruption, etc.) could allow for a distributed team to maintain some level of command and control and enhance team resilience. ☆

Capt Jonathan Powers, Deputy Branch Chief, 711 HPW/RHWC

MULTI-DOMAIN TEAMING:
DISTRIBUTED COLLABORATIVE INTERFACES

This effort will develop novel visualizations for multi-domain play calling – i.e., to represent cyber effects within a human-autonomy teaming scenario for Multi-domain Command and Control (MDC2) operations. The research will focus on creation and human factor analysis of candidate visualizations and the accompanying interface features to characterize cyber effects during task execution and adaption, and will incorporate the software hooks for integration into a human-autonomy teaming testbed such as FUSION. Further, this effort will begin to examine interface features and conduct research to enable multi-domain teaming among disparate operators with different expertise, familiarity levels, and goals. ☆

Dr. Kristen Liggett, Principal Human Factors Engineer, 711 HPW/RHWCI

Dr. Gina Thomas, Research Psychologist, 711 HPW/RHWCI

Ms. Gloria Calhoun, Principal Human Factors Psychologist, 711 HPW/RHWCT

Ms. Jessica Bartik, Research Psychologist, 711 HPW/RHWCT

Dr. Elizabeth Frost, Research Psychologist, 711 HPW/RHWCT

Many of the autonomous and automated systems previously deployed have failed to appreciate the critical role that human-machine communication and coordination plays in successful human-autonomy teaming. Support for such communication and coordination has been a primary design driver in the development of the Fusion Framework. In fact, the primary motivation for the development of the Fusion Framework was the development of a simulation testbed built to support research into human-autonomy teaming.

Rowe, A., Spriggs, S., Boyer, J., & Hughes, T. (2018). Fusion Framework: Research Testbed for Human-Autonomy Teaming. Retrieved December 04, 2020, from https://apps.dtic.mil/sti/pdfs/AD1071132.pdf

THIS EFFORT WILL BEGIN TO EXAMINE INTERFACE FEATURES AND CONDUCT RESEARCH TO ENABLE MULTI-DOMAIN TEAMING AMONG DISPARATE OPERATORS WITH DIFFERENT EXPERTISE, FAMILIARITY LEVELS, AND GOALS."

— Dr. Kristen Liggett
Principal Human Factors Engineer, 711 HPW/RHWCI

Graphic by Ms. Shania Horner

MULTISENSORY PERCEPTION AND COMMUNICATION

Dr. Brian Simpson
Multisensory Perception and Communication
Core Research Area Lead, 711 HPW/RHWS

Effective communication of information is critical for the success of every operator, in any domain, and in every Air Force and Space Force mission. However, such missions routinely take place in settings that are perceptually, cognitively, and environmentally complex, comprising multiple sources of stimulation, intense task demands, and situation uncertainty, all of which pose unique challenges for effective portrayal of complex information. The Multisensory Perception and Communication Core Research Area is focused on identifying and exploiting the underlying sensory and cognitive mechanisms mediating perception and communication to inform the development of multimodal interfaces and advanced communication technologies. Two Big Challenges associated with this Core Research Area are 1) Exploiting Perceptual Abilities (EPA) and 2) Enhancing Operational Communications (EOC). Under EPA, research is focused on identifying the mechanisms and phenomena associated with sensory encoding, crossmodal interactions, and multisensory integration to inform the development of advanced multimodal interfaces. In addition, research is conducted to examine the inherent constraints on perceptual and cognitive processing that limit performance in situations requiring the monitoring and management of multiple sources of information. This knowledge is being exploited to enhance, or inhibit, task performance. Finally, advanced methodologies and technologies are being employed to recreate many of these phenomena virtually to support distributed operations. The objective of the second research area, EOC, is to understand and characterize the underlying processes that support effective human-human communication to inform the development of natural human-machine communication interfaces. Research in this area focuses on the identification of acoustic, linguistic, and task strategies humans employ to effectively transmit spoken information to achieve mutual understanding and avoid miscommunication. This research informs the development of synthetic agents that can monitor task environments and intelligently time the presentation of information support. Finally, advanced systems to manage complex communication situations are being developed, tested, and transitioned to the warfighter. Both EPA and EOC conduct research in unique laboratory facilities designed for rigorous stimulus control; these same stimuli are also examined in laboratories that recreate the stressors inherent in operational settings. Both performance-based behavioral data and neurophysiological data are collected to identify

THE TWO BIG CHALLENGES:

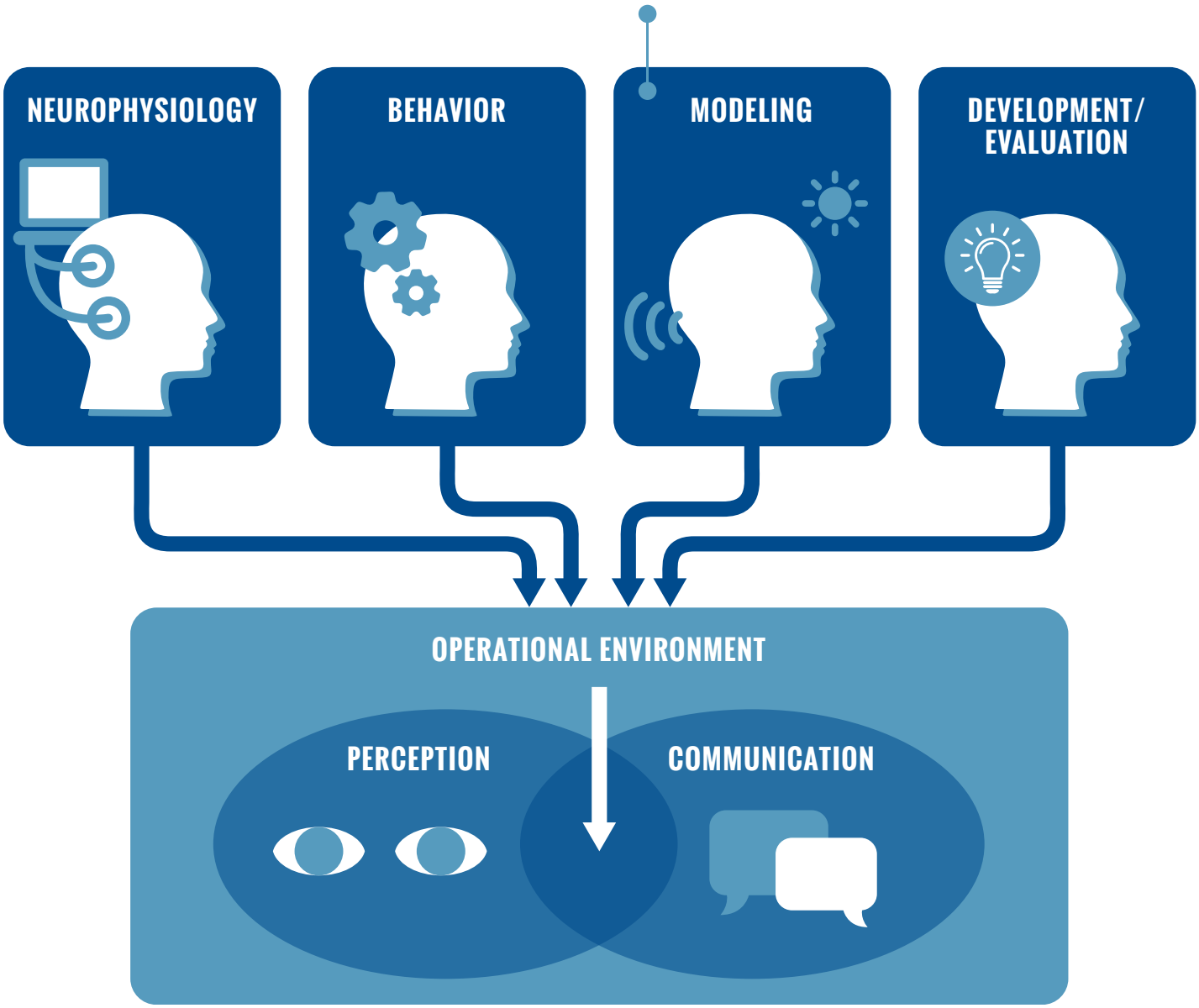
Exploiting Perceptual Abilities (EPA)

Enhancing Operational Communications (EOC)

neural correlates of perception and inform computational models that can guide multimodal display development. This approach ensure that technologies created by this CRA will support the presentation of the right information, at the right time and in the right way. ☆

Dr. Brian Simpson, Multisensory Perception and Communication Core Research Area Lead, 711 HPW/RHWS

Below represents the scientific approach of the Multisensory Perception and Communication team.



Graphic by Ms. Shania Horner

BIG CHALLENGE 1: EXPLOITING PERCEPTUAL ABILITIES (EPA)

MANAGING MULTISENSORY INFORMATION THROUGHPUT

In our everyday interactions with the world, individuals are routinely inundated with, and must effectively integrate, multiple, concurrent information streams arising from many sources. This is particularly true in military operational environments, where stimulus and task complexity are especially high and time constraints are severe. However, because operators have only a finite amount of attentional resources to filter and process this information, vulnerability to sensory overload and decision errors often increases. The Managing Multisensory Information Throughput line of effort uses neurophysiological and behavioral measures to examine the strengths and limitations of human perception and cognition and define principles that allow for the proper integration and distribution of multisensory data in operational environments. We seek to design displays that tailor to individual operators, taking into account both capabilities and proclivities of each individual, to ensure that information is processed in the most efficient way, and overall decision making and performance is optimized. To best do this we look at how sensory information processes interact, starting from basic neurological and psychophysical principles to the end goal of creating a user-centered suite that dynamically recommends the optimal multisensory information display for the person, mission goals, technology, and physical constraints of the environment. Basic research includes the assessment of *integration*: multisensory facilitation (i.e., the effect of one sense increasing the effectiveness of another) to improve performance and reduce the risk of perceptual-central tunneling, *personalization*: the use of statistical tools, such as General Recognition Theory, that enable us to strategically distribute multisensory information in a customizable display using mathematical performance-based predictions, neurobehavioral *correlation*: identifying neurophysiological markers and behavioral correlates of multisensory perception, attention, and decision processes, and *distribution*: the assessment of attentional processing capacity and performance tradeoffs to suggest when and how to off-load information from one sense to another within and between tasks to effectively mitigate perceptual and cognitive overload. Our framework will unify and personalize the sensory experience to inform display design, optimize users multitasking strategies, inform interface adaptation, and supply pertinent feedback to users so they may more effectively perform their jobs. ☆

Dr. Elizabeth Fox, Research Psychologist, 711 HPW/RHWS

Dr. Paul Havig, Senior Research Psychologist, 711 HPW/RHWS

Graphic by Mr. Will Graver

INFLUENCING PERCEPTION

Humans have a remarkable ability to parse complex visual and auditory environments, forming perceptual objects out of the scene to extract relevant information. However, this process is imperfect and often incomplete, leading to a situation in which critical information may be missed. Understanding the abilities, as well as the constraints, of human perception and cognition informs the development of advanced capabilities that will enable the US Air Force to control the human information processing space. The Influencing Perception line of effort leverages a long history of research at AFRL examining the limits of perception and communication, to better understand where the failures in perceptual analysis occur in real-word environments and, indeed, how best to control the nature of those failures. We are identifying new, optimal approaches for describing various aspects of complex, real-world scenes (presence/absence of critical objects, spatial properties of the objects in the scene, and overall scene dynamics) through advanced statistical techniques and computational models developed through an understanding of human perception. These descriptions are grounded in measurements of real-world auditory and visual environments, and leverage a vast database describing dynamic military assets. This approach enables us to generate synthetic representations of these real-world scenes for greater laboratory control to bind the development of perceptual models, which will subsequently be tested in those same real-world environments. Through measurements of both human behavior and neural activity, we are identifying markers of perceptual processes that reflect successful analysis and, importantly, where that processing fails. In so doing, we will create situations that both facilitate, and disrupt, this analysis process. ☆

Ms. Hilary Gallagher, Research Engineer, 711 HPW/RHWS

Dr. Eric Thompson, Research Engineer, 711 HPW/RHWS

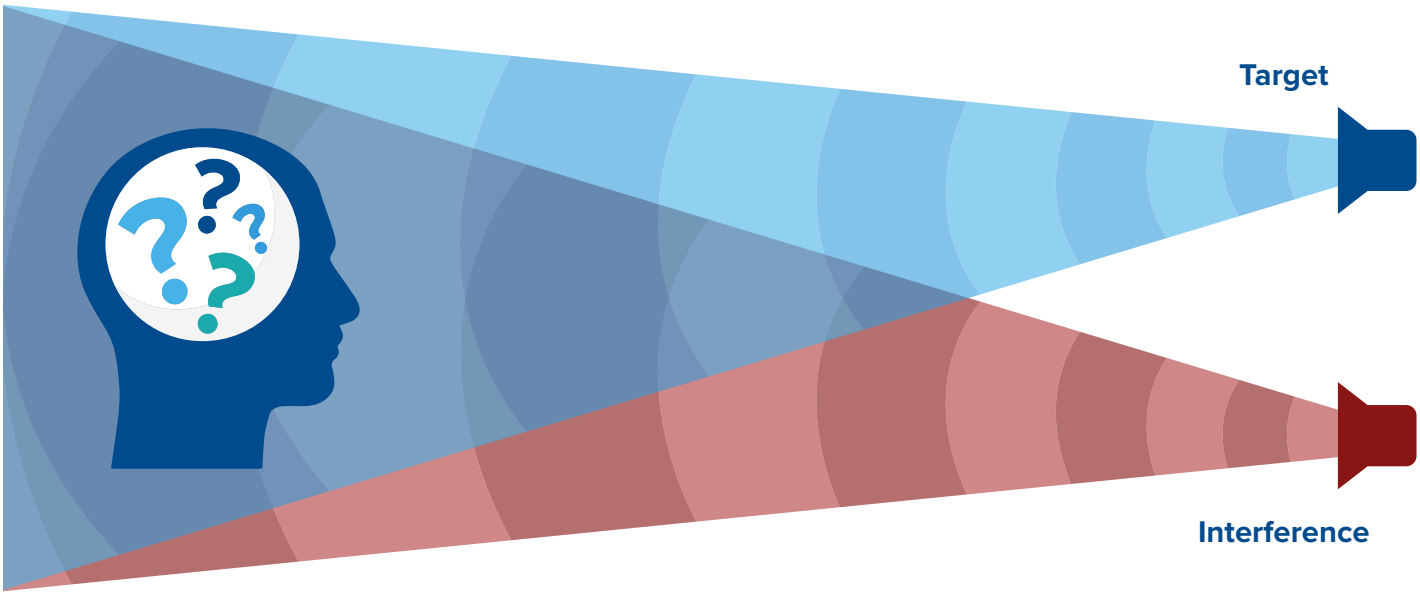
HOW?

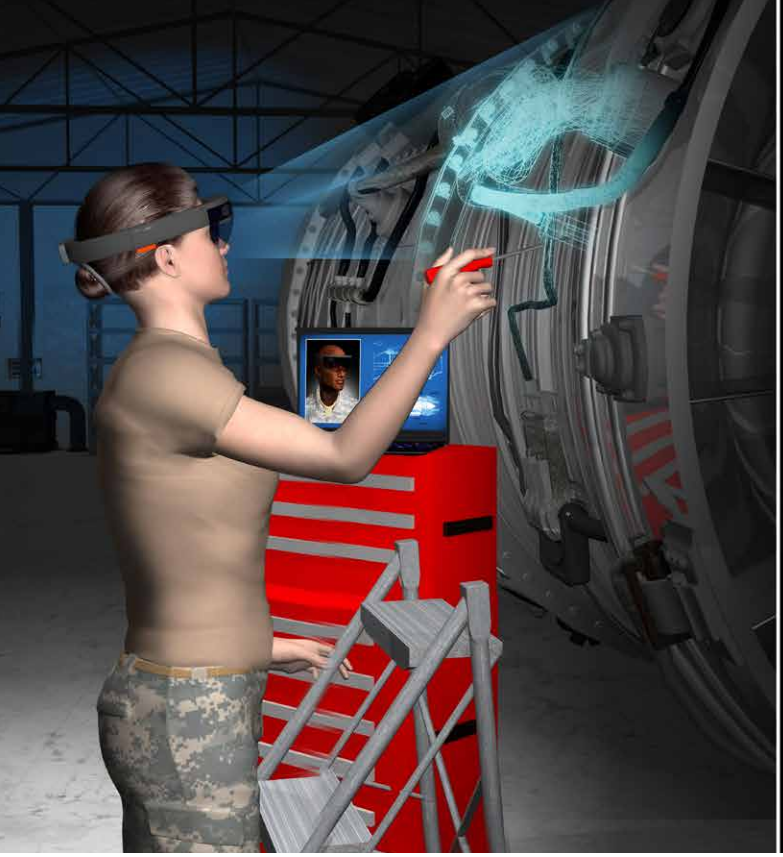
Through measurements of both human behavior and neural activity

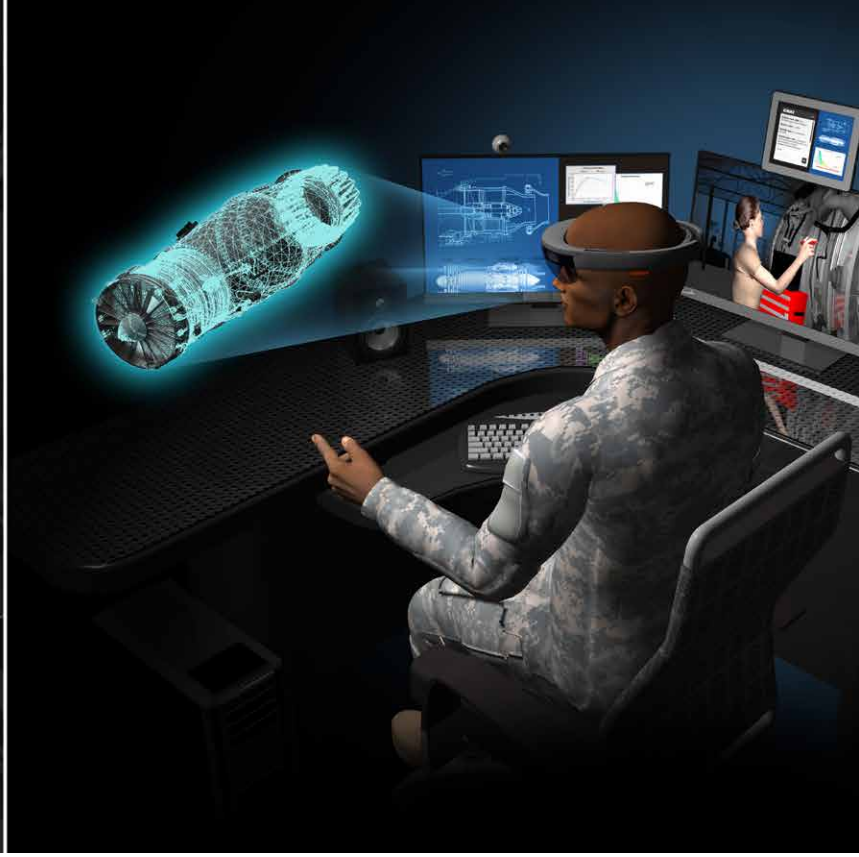
WHY?

To identify markers of perceptual processes that reflect successful analysis

Graphic by Ms. Shania Horner







Graphic by Mr. Will Graver

IMMERSIVE VIEWPOINT SHARING

Future Air Force operations will continue to grow in complexity, requiring coordinated activities across distributed agents, supporting missions taking place across multiple operational domains. The distributed nature of these operations suggests that all information will not be available to all Airmen at all times, and the information one may have regarding remote activities will likely be impoverished relative to the information that would be available if the Airman were on site. The goal of the Immersive Viewpoint Sharing line of effort is to develop and evaluate immersive interfaces, employing virtual, augmented, and mixed-reality technologies, to afford an operator a more intuitive understand of remotely-sensed situation information. This will be informed by leveraging state-of-the-art hardware and interface design solutions to determine interactions between display capability and perceptual constraints. A number of applications of this approach are currently being explored, including situations in which an agent (e.g., a maintainer or first responder) lacks expertise on a particular task and requires expert input to complete the task. Rather than referencing a manual or simply requesting support, the requester can share her/his "viewpoint" (visual, auditory, other) with an expert at a remote site to ensure the remote resource has all required information that would otherwise be available on-site. With firsthand access to information versus an interpretation communicated by a novice, accurate task completion efficiency can be significantly increased. In another scenario, a human operator is the occupant of a "piloted" vehicle while simultaneously in control of other vehicle systems used as forward sensor platforms for purposes of tactical situation awareness. The human operator will utilize a helmet-mounted display (HMD) approach to enable augmented, virtual, and mixed-reality multisensory appreciation of a selected remote vehicle environment from the perspective of the remote sensor. This interface approach gives the human operator the ability to "seat hop" and temporarily control and experience the actions of the remote vehicle firsthand while ownship is operated via automation. A number of research questions are being explored as a part of this effort including: What is the nature of the information that should be provided? What level of multisensory fidelity is required to support effective shared experiences? How do measures of presence and immersion vary as a function of the level of recreated information? To what degree do these constructs correlate with performance enhancements? ☆

Dr. Eric Geiselman, Senior Engineering Research Psychologist, 711 HPW/RHWS

Dr. Paul Havig, Senior Research Psychologist, 711 HPW/RHWS

PERCEPTUAL ENVIRONMENT MODELING AND SIMULATION

Our lives are filled with acoustic stimuli that continuously provide information about objects and events in our environment. Indeed, our experiences are shaped by the sounds around us, which provide context, connect us to our world, and yield information to ground our decision-making processes. Military environments, in particular, are acoustically rich and complex, and may play a major role in the success, or failure, of a mission. On the one hand, the extremes of the acoustic battlespace can impact communication effectiveness (including both speech intelligibility and the interpretation of warning signals) and may have a deleterious effect on advanced technologies such as automatic speech recognition to function effectively. Conversely, the acoustic environment may be exploited by operators, whether consciously or subconsciously, to acquire information about the status of systems with which they are interacting, where a sudden change in the acoustics may signify an emergency situation (e.g., wind over a cockpit canopy indicating an unintended change in attitude or airspeed). Thus, when simulating operational environments for training, interface development, and teleoperation, it is critical to provide a veridical representation of the acoustic environment. In effort to, among other requirements, 'train the way we fight', the Perceptual Environment Modeling and Simulation line of effort builds physical acoustic models of noise environments based on first-principle state variables as determined from real-world measurements. These models are being used to recreate acoustic environments at the location of the operator and will be integrated into simulation architectures such that these environments change in realistic ways (e.g., with changes in airspeed or attitude). In addition, communication signals will be processed such that they emulate the degradation that may occur through military communication systems. ☆

Dr. Frank Mobley, Research Physicist, 711 HPW/RHWS

Dr. Alan Wall, Research Physicist, 711 HPW/RHWS

> **IN EFFORT TO... 'TRAIN THE WAY WE FIGHT', THE PERCEPTUAL ENVIRONMENT MODELING AND SIMULATION LINE OF EFFORT BUILDS PHYSICAL ACOUSTIC MODELS OF NOISE ENVIRONMENTS BASED ON FIRST-PRINCIPLE STATE VARIABLES AS DETERMINED FROM REAL-WORLD MEASUREMENTS.**
>
> **— Dr. Frank Mobley**
> Research Physicist, 711 HPW/RHWS

Graphic by Mr. Frank Mobley

BIG CHALLENGE 2: ENHANCING OPERATIONAL COMMUNICATIONS (EOC)

COMMUNICATION RESILIENCY

Human-machine teaming aims to meld human cognitive strengths with the unique capabilities of smart machines to create intelligent, resilient teams. A key challenge within human-machine teaming is the establishment of natural human-machine interfaces that enable effective communication and coordination. In particular, interfaces based on spoken language, central to natural communication in human-human teams, hold great promise as a conduit for efficient information flow in human-machine teams. Research conducted under the Communication Resiliency line of effort focuses on developing an understanding of communication processes in human-human teams - specifically, how humans repair communication errors and establish a shared understanding (common ground) in dialogue. The results from this research inform the development of human-machine spoken dialogue systems with the capability to quickly recover from communication difficulties and reduce the deleterious effects of miscommunication on team performance in collaborative tasks. The research is grounded in theoretical models developed to describe natural communication in "everyday" conversation, but seeks to modify/extend these models to operationally-relevant military communication environments, which tend to be more extreme, and are characterized by greater perceptual, cognitive, and environmental complexity (e.g., high-tempo operations in noisy air operation centers). Such environments increase the likelihood of communication uncertainty, ambiguity, and error. In addition, idiosyncrasies associated with military communication protocols may pose additional challenges to existing models. The approach taken in this line of effort involves the development of a number of laboratory-based collaborative tasks that capture the dynamics of real operational communication environments, use of experimental paradigms to simulate conversational repairs and grounding in voice user interfaces, the development of spoken and natural language processing models capable of creating conversational alignment and recovery, and the evaluation of overall human-machine team performance within systems that employ these capabilities. The long term objective of this research effort is to provide insight into the flexible conversational strategies humans use to circumvent communication challenges to inform the development of natural communication interfaces that will inevitably encounter similar communication errors specifically within complex and time-critical human-machine interactions. ☆

Dr. Nia Peters, Research Electrical Engineer, 711 HPW/RHWS

Dr. Griffin Romigh, Research Electrical Engineer, 711 HPW/RHWS

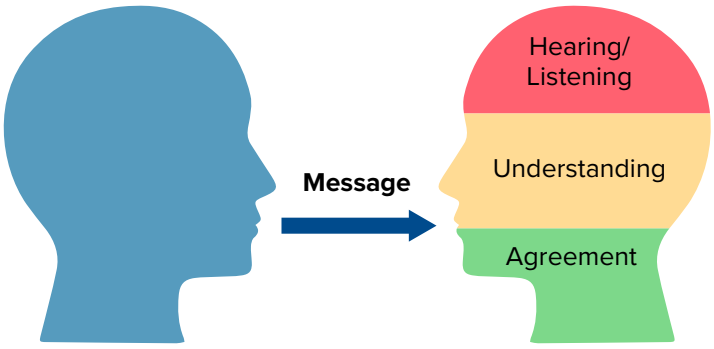
RESEARCH IS FOCUSED ON:

Developing an understanding of communication processes in human-human teams

WHY?

To inform the development of human-machine spoken dialogue systems with the capability to quickly recover from communication difficulties

To reduce the deleterious effects of miscommunication on team performance in collaborative tasks



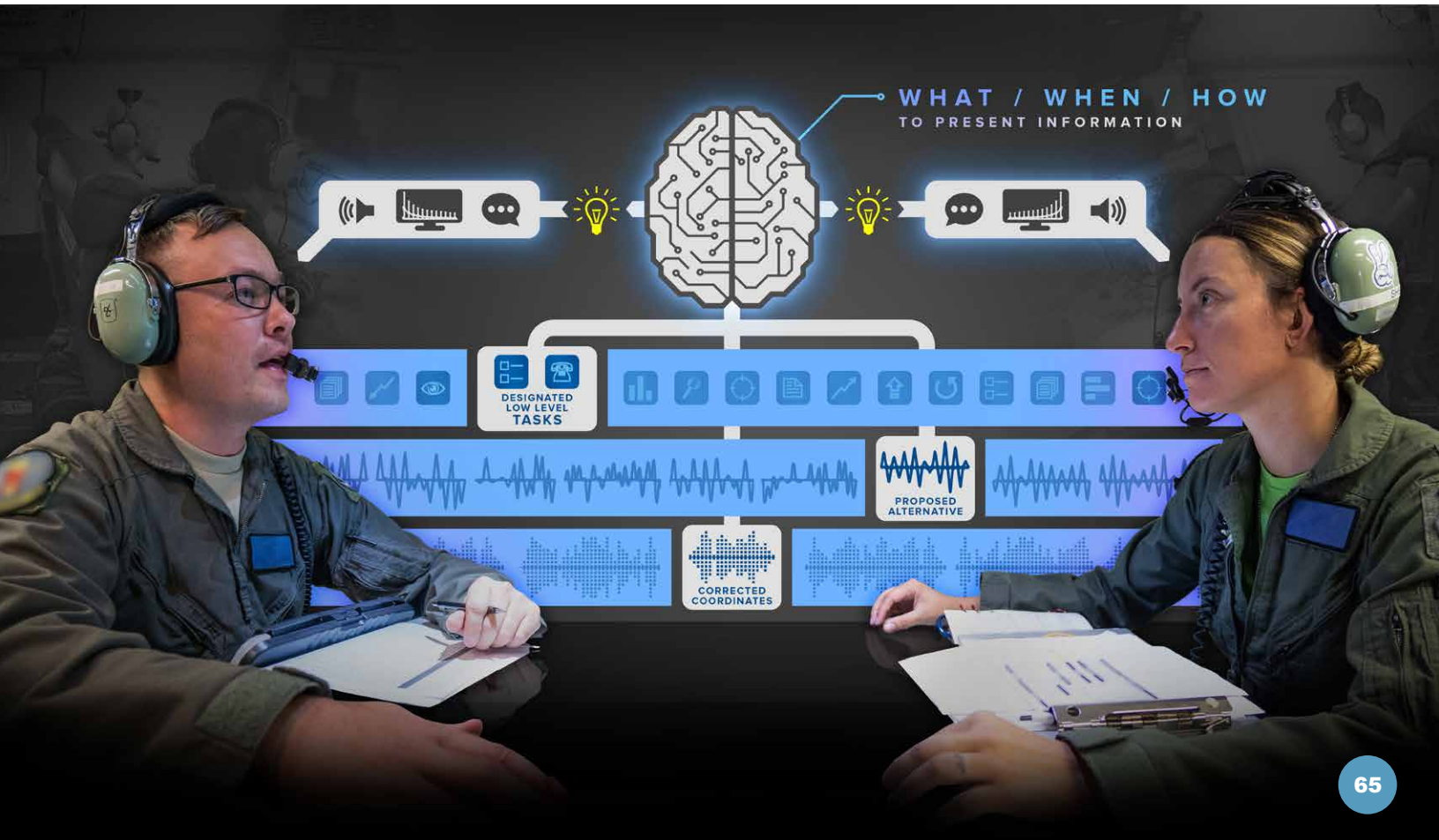
Graphic by Ms. Shania Horner

CONTEXT-AWARE COMMUNICATION INTERFACES

As the warfighting mission becomes more complex, operators are required to manage more information from disparate sources, attend to a greater number of concurrent tasks, and effectively collaborate with distributed team members across domains and mission sets. These military missions are likely to have time-critical components that rely on the expeditious presentation of up-to-date information to inform ongoing tasks. Thus, the possibility that new sources of incoming information will interrupt ongoing task flow is increased, resulting in a greater potential for human error and, consequently, reduce mission effectiveness. To this end, the goal of the Context-Aware Communication Interfaces line of effort is to develop natural human-machine communication interfaces that effectively determine "what, when, and how" an intelligent agent should disseminate information to human team members that a) adds to an operator's knowledge, and b) is least disruptive to ongoing tasks. Context-aware systems can not only automate low-level tasks, but may also make inferences from ongoing complex interactions, enabling operators to focus their efforts on critical, mission-level task objectives. Additionally, the complexity associated with real operational environments undoubtedly leads to a rich set of cues a system can leverage to determine the best time and manner to inform new sources of information and present this to teammates. Ongoing research and development involves the testing and refinement of prototype intelligent interruption systems in complex, team-based task environments that capture the interactive nature of real-world military operations. Results from this research helps to reveal specifically how ill-designed information dissemination mechanisms impact overall decision quality, task-related response times, and the processes supporting task resumption. Research devoted to context-aware communication interfaces can inform specific modifications to intelligent systems within human-machine teaming in order to mitigate such deleterious effects on human performance. ☆

Dr. Nia Peters, Research Electrical Engineer, 711 HPW/RHWS

Graphic by Mr. Will Graver



COMMUNICATION SCENE ANALYSIS AND DISRUPTION

Verbal communication is a vital piece of the success of every USAF mission, but significant challenges to effective communication exist, including interference from high levels of environmental noise, reduced fidelity from communication system distortion, and the need for operators to manage multiple simultaneous streams of information. The Communication Scene Analysis and Disruption line of effort conducts research to quantify the impact of these barriers to successful communication. Of particular interest here is the degradation in intelligibility that can occur when a speech signal of critical interest is presented in an auditory scene that comprises additional stimuli that are similar along some perceptual dimension. This perceptual masking, or informational masking (IM), seems to occur as a result of a failure in the system's ability to effectively analyze an acoustic scene to segregate target from masker. Research conducted under this line of effort focuses on identifying these specific perceptual dimensions that lead to IM, the strategies humans may use to overcome its effects, and the quantification of the impact on overall human performance, including both task performance and listening effort. Importantly, understanding the specific information listeners utilize to parse complex scenes has led to the construction and testing of specific stimuli to systematically manipulate IM, as well as the development of communication enabling technologies that can make it easier to understand speech in these complex environments. Moreover, the ability to synthesize specific speech features in these complex scenes can be used to generate seemingly intelligible, but potentially ambiguous, speech signals that similarly impact overall task performance. These synthetic stimuli can be used in training environments to improve operator performance on complex listening tasks, as well as in the development of novel communication technologies. ☆

Dr. Eric Thompson, Research Engineer, 711 HPW/RHWS

INTERACTIVE COMMUNICATION MANAGEMENT

The goal of interactive communication management research is to increase an operator's ability to access and utilize verbal information within the fight. Every mission relies on the effective communication between teammates and our operators serve in cognitively demanding roles where it will be increasingly critical to have communication interfaces that overcome, rather than contribute to, informational overload and the loss of situation awareness due to attentional tunneling. Our research aims to combine advancements in our understanding of human perception with recent developments in AI and machine learning to overcome limitations of classic communication channels. This includes limitations like the perishable nature of standard voice-based communications, the visually demanding nature of text and chat, and the cross-modal conflicts that can occur when attempting to process both simultaneously. By utilizing state-of-the-art advancements in automatic speech recognition and natural language processing, we are developing techniques to enable intuitive and flexible interaction with the communication channels themselves. This will allow operators to dynamically winnow non-critical communication traffic and receive the most relevant information at the times, and in the modalities best suited for their mission context. Current efforts include increasing the flexibility of, and enabling natural interaction with, previously developed communication management technologies, as well as developing advanced communication technology suitable for stand- alone, resource limited mobile platforms. ☆

In today's world, there are so many ways to communicate. We focus on combining advancements in our understanding, in addition to developments in AI and machine learning. This enables enhanced interaction in communication.

Dr. Griffin Romigh, Research Electrical Engineer, 711 HPW/RHWS

THE GOAL OF INTERACTIVE COMMUNICATION MANAGEMENT RESEARCH IS TO INCREASE AN OPERATOR'S ABILITY TO ACCESS AND UTILIZE VERBAL INFORMATION WITHIN THE FIGHT."

— Dr. Griffin Romigh
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