2019

HUMAN SYSTEMS CONFERENCE

Leading Human Systems Innovation: Partnering to maximize warfighter effectiveness

April 16 – 17 | Aberdeen Proving Ground, MD | NDIA.org/HumanSystems19

WHO WE ARE

The National Defense Industrial Association is the trusted leader in defense and national security associations. As a 501(c)(3) corporate and individual membership association, NDIA engages thoughtful and innovative leaders to exchange ideas, information, and capabilities that lead to the development of the best policies, practices, products, and technologies to ensure the safety and security of our nation. NDIA's membership embodies the full spectrum of corporate, government, academic, and individual stakeholders who form a vigorous, responsive, and collaborative community in support of defense and national security. NDIA is proud to celebrate 100 years in support of our warfighters and national security. The technology used by today's modern warfighter was unimaginable 100 years ago. In 1919, BG Benedict Crowell's vision of a collaborative team working at the intersection of science, industry, government and defense began what was to become the National Defense Industrial Association. For the past century, NDIA and its predecessor organizations have been at the heart of the mission by dedicating their time, expertise and energy to ensuring our warfighters have the best training, equipment and support. For more information visit **NDIA.org**

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HUMAN SYSTEMS DIVISION

DIVISION LEADERSHIP

Dr. Jared Freeman
Division Chair

BG Pete Palmer, USA (Ret)
Vice Chair

Scott Kozak
Deputy Chair

Eric Jones
Industry Conference Chair

Dr. Kristin Schaefer-Lay
Government Conference Chair

WHO WE ARE

NDIA's Human System Division promotes the exchange of technical information and discussions between government, industry and academia, and the expansion of research and development in areas related to the human as a system whose performance must be integrated into any military system of systems. To this end, the division will serve as an infrastructure by providing a variety of ways for government, industry and academia to collaborate to advance human performance in air, land, sea, space and cyberspace through research, education and consultation.

SCHEDULE AT A GLANCE

TUESDAY, APRIL 16

General Session
Auditorium
8:00 am - 5:00 pm

Networking Poster and Demonstration Session
MTF Foyer
12:00 - 2:00 pm

Roundtable Discussions
Concurrent Sessions
2:00 - 3:30 pm

Networking Reception
Top of the Bay
5:30 - 7:00 pm

WEDNESDAY, APRIL 17

General Session
Auditorium
8:00 am - 5:00 pm

Networking Poster and Demonstration Session
MTF Foyer
12:30 - 2:00 pm

No-Host Reception
Steelfish Grille
5:30 pm

EVENT INFORMATION

LOCATION

Conference Sessions
Mallette Training Facility
6575 Jayhawk Road
Building 6008
Aberdeen Proving
Ground, MD 21005

Tuesday Reception
Top of the Bay
30 Plum Point Loop W
Aberdeen Proving
Ground, MD 21005

Wednesday No-Host Reception
Steelfish Grille
660 Boulton Street
Bel Air, MD 21014

EVENT WEBSITE

NDIA.org/HumanSystems19

EVENT THEME

Leading Human Systems Innovation: Partnering to maximize warfighter effectiveness

ATTIRE

Civilian: Business
Military: Uniform of the day

SURVEY AND PARTICIPANT LIST

You'll receive via email a survey and list of attendees (name and organization) after the conference. Please complete the survey, which helps make our event even more successful in the future.

EVENT CONTACT

Andrea Lane
Meeting Manager
(703) 247-2554
alane@ndia.org

Tatiana Jackson
Program Coordinator
(703) 247-9479
tjackson@ndia.org

SUBCOMMITTEE LEADS

Brad Chedister
PSWP Industry Chair

Dr. Kelly Hale
HSM Industry Chair

George Salazar
HSM Government Chair

Mark Draper
SICP Government Chair

Dr. James McCarthy
PAET Industry Chair

Dr. Peter Squire
PSWP Government Chair

Dr. Glenn Gunzelmann
PAET Government Chair

Henk Ruck
SICP Industry Chair

SPEAKER GIFTS

In lieu of speaker gifts, a donation is being made to the Fisher House Foundation.

HARASSMENT STATEMENT

NDIA is committed to providing a professional environment free from physical, psychological and verbal harassment. NDIA will not tolerate harassment of any kind, including but not limited to harassment based on ethnicity, religion, disability, physical appearance, gender, or sexual orientation. This policy applies to all participants and attendees at NDIA conferences, meetings and events. Harassment includes offensive gestures and verbal comments, deliberate intimidation, stalking, following, inappropriate photography and recording, sustained disruption of talks or other events, inappropriate physical contact, and unwelcome attention. Participants requested to cease harassing behavior are expected to comply immediately, and failure will serve as grounds for revoking access to the NDIA event.

Naval Postgraduate School

Human Systems Integration Cohorts Begin September 2019!

Deadline for Application is July 1, 2019

The Naval Postgraduate School

offers the nation's premier distance learning **Master of Human Systems Integration (HSI) degree program** and **Human Systems Integration Certificate program**.

The Human Systems Integration Program is pleased to announce **open registration** for both programs, for all federal government employees (military and civilian) and to defense contractor employees (on a space available basis).

HSI Certificate Program

Program length is one year (four consecutive academic quarters, one course per quarter). Course delivery is asynchronous (with weekly assignments). Graduates earn the NPS HSI Certificate!

Prerequisites for Certificate Program

- Baccalaureate Degree from a regionally accredited college or university
- GPA of 2.2 or better
- One lower level calculus course with a grade of C or better
- Waivers considered

Master's Degree in HSI Program

Program length is two years (eight consecutive academic quarters, two classes per quarter) with plans to have one synchronous and one asynchronous class per quarter. Graduates earn an HSI Certificate, the Master's Degree in HSI, and DAU Course Credits!

Prerequisites for the Master's Program

- Baccalaureate Degree from a regionally accredited college or university
- GPA of 2.2 or better
- One lower level calculus course with a grade of C or better
- Waivers considered

> "*All of our airmen, soldiers and seamen have demanding and critical jobs to do that depend on well-designed systems that will work the way that they do - supporting the accomplishment of their tasks rapidly and effectively.* ***It is critical that we avoid system designs that are obstacle courses of hidden hazards and latent failures.***"
>
> *~ Endsley, 2017*

Application Process for Both Programs

- To apply please visit my.nps.edu/web/dl
- Program designators:
  - HSI Certificate Program - 262
  - Master's Degree in HSI - 359

For More Information

HumanSys@nps.edu
HSI Certificate Program: nps.edu/hsicertificate
HSI Master's Degree Program: nps.edu/hsimasters

AGENDA

TUESDAY, APRIL 16

7:15 am – 5:00 pm

REGISTRATION

MTF FOYER

7:15 – 8:00 am

NETWORKING BREAKFAST

MTF FOYER

8:00 – 8:15 am

WELCOME AND INTRODUCTORY REMARKS

AUDITORIUM

Dr. Jared Freeman
Chief Scientist, Aptima
Chair, NDIA Human Systems Division

Dr. Kevin Geiss
Director, Airman Systems Directorate, 711th Human Performance Wing, Air Force Research Laboratory
Chair, Human Systems COI

8:15 – 9:00 am

KEYNOTE ADDRESS

AUDITORIUM

BG James Gallivan, USA
Chief of Staff, Army Futures Command

9:00 – 9:30 am

FEATURED SPEAKER

AUDITORIUM

Dr. James Pharmer
Principal Scientist, Naval Air Warfare Center Training Systems Division

9:30 – 10:00 am

FEATURED SPEAKER

AUDITORIUM

CAPT Ira Minor, USN (Ret)
Engineering Product Manager, Space and Naval Warfare Systems Command

10:00 – 10:30 am

NETWORKING BREAK

MTF FOYER

10:30 – 11:30 am

PANEL: HUMAN SYSTEMS COMMUNITY OF INTEREST (COI)

AUDITORIUM

Dr. Kevin Geiss
Director, Airman Systems Directorate, 711th Human Performance Wing, Air Force Research Laboratory
Chair, Human Systems COI
Moderator

Dr. Glenn Gunzelmann
Senior Research Psychologist, Air Force Research Laboratory
PAET Air Force Lead, Human Systems COI

Dr. Peter Squire
Program Manager, Human Performance Training and Education, Office of Naval Research
PSWP Navy Lead, Human Systems COI

11:30 – 11:40 am

COMMUNITY BRIEF: NDIA HUMAN SYSTEMS DIVISION

AUDITORIUM

Dr. Jared Freeman
Chief Scientist, Aptima
Chair, NDIA Human Systems Division

11:40 – 11:50 am

COMMUNITY BRIEF: HFE TAG

AUDITORIUM

John Plaga
Human Systems Integration Directorate, 711HPW.HPIF, Air Force Research Laboratory
Chair, DoD HFE TAG

11:50 am – 12:00 pm

COMMUNITY BRIEF: ARL

AUDITORIUM

Dr. Corde Lane
Director, Human Research and Engineering Directorate, U.S. Army Research Laboratory

12:00 – 1:00 pm

NETWORKING LUNCH

10 A & B

12:00 – 2:00 pm

NETWORKING POSTER AND DEMONSTRATION SESSION

MTF FOYER

2:00 – 3:30 pm

CONCURRENT ROUNDTABLE DISCUSSIONS

PAET Thrust 1: Training, Education, and Personnel Development
10A

PAET Thrust 2: Personnel Selection and Assignment
10A

SICP Thrust 1: Human-Machine Teaming
CLASSROOM 3

SICP Thrust 2: Intelligent, Adaptive Aiding
CLASSROOM 4

SICP Thrust 3: Human Information, Interpretation and Influence
CLASSROOM 5

PSWP Thrust 1: Understanding and Quantifying Warfighter Variability
10B

PSWP Thrust 2: Enhancement and Mitigation Strategies
10B

Human Systems Metrics
CLASSROOM 15

2:00 – 3:30 pm

PANEL: JOINT HSI STEERING COMMITTEE AND WORKING GROUP ACTIVITY

AUDITORIUM

Mitchell Woods
HSI Systems Safety Lead, OUSD DASD-Systems Engineering
Moderator

Dr. Jared Freeman
Chief Scientist, Aptima
Chair, NDIA Human Systems Division

Dr. Kevin Geiss
Director, Airman Systems Directorate, 711th Human Performance Wing, Air Force Research Laboratory
Chair, Human Systems COI

Andrew Monje
Acting Director, Systems Engineering, OUSD (R&E)

John Plaga
Human Systems Integration Directorate, 711HPW.HPIF, Air Force Research Laboratory
Chair, DoD HFE TAG

3:30 - 4:00 pm

NETWORKING BREAK

MTF FOYER

4:00 – 4:45 pm

ROUNDTABLE AND PANEL OUTBRIEF

AUDITORIUM

4:45 – 5:00 pm

CLOSING REMARKS

AUDITORIUM

Dr. Jared Freeman
Chief Scientist, Aptima
Chair, NDIA Human Systems Division

5:30 – 7:00 pm

RECEPTION AT TOP OF THE BAY

TRANSPORTATION ON OWN

WEDNESDAY, APRIL 17

7:15 am – 4:30 pm

REGISTRATION

MTF FOYER

7:15 – 8:00 am

NETWORKING BREAKFAST

MTF FOYER

8:00 – 8:15 am

WELCOME AND INTRODUCTORY REMARKS

AUDITORIUM

Dr. Jared Freeman
Chief Scientist, Aptima
Chair, NDIA Human Systems Division

8:15 – 9:00 am

KEYNOTE ADDRESS

AUDITORIUM

Dr. Nancy Cooke
Professor, Human Systems Engineering, Arizona State University

9:00 – 9:05 am

INTRODUCTION TO TECHNICAL SESSIONS
AUDITORIUM

Eric Jones
Principal Human Factors Engineer, Draper
Industry Conference Chair, NDIA Human Systems Division

9:05 – 10:20 am

SESSION 1: PERSONALIZED ASSESSMENT, EDUCATION & TRAINING
AUDITORIUM

COACH-ABT: Conduits for Optimizing and Accelerating Comprehensive [Unit] Health during Army Basic Training
Timothy Clark
Senior Research Engineer, Aptima

Measuring Performance and Cognitive Workload Across Proficiency Levels
Amy Dideriksen
Senior Training Research Manager, Collins Aerospace

Modeling Performance for Marksmanship Training Tools
Dr. Jennifer Murphy
Founder and CEO, Quantum Improvements Consulting

Characteristics of Engagement in Short Form Video Tutorials
Lauren Ogren
Human Systems Engineer, Naval Undersea Warfare Center Division Newport

10:20 – 10:50 am

NETWORKING BREAK
MTF FOYER

10:50 am – 12:05 pm

SESSION 2: PROTECTION, SUSTAINMENT, AND WARFIGHTER PERFORMANCE
AUDITORIUM

STANCE: Sensor Technologies for Augmenting the Naturalistic Control of Exoskeletons
Zachary Kiehl
Capability Lead & Research Engineer, Aptima

The Effect of High Deck Accelerations on Surgical Tasks
Steen Jensen
Engineering Psychologist, Naval Surface Warfare Center Panama City Division

Warrior Performance Platform (WP2™) for U.S. Navy: Leveraging Human Performance Technology to Enhance Navy's Physical Fitness, Wellness, and Nutrition Capabilities
Jake Repanshek
Director of Solutions & Technology, The Informatics Application Group

Kevin Dawidowicz
President & Co-Founder, CoachMePlus

Integrating Physical and Cognitive Performance Data through SPEAR: A DoD Initiative
Dr. Eric Sikorski
Program Manager, Combating Terrorism Technical Support Office

David Batka
Chief Opeating Officer, Titus

12:05 – 1:00 pm

NETWORKING LUNCH

10B

12:30 – 2:00 pm

NETWORKING POSTER AND DEMONSTRATION SESSION

MTF FOYER

2:00 – 3:00 pm

SESSION 3: SYSTEMS INTERFACE AND COGNITIVE PROCESSING

AUDITORIUM

Operator-Autonomy Teaming Interfaces for Multi-Unmanned Vehicle Management

Gloria Calhoun

Principal Engineering Research Psychologist, Air Force Research Laboratory

Reconnaissance Chess

William Li

Researcher, The Johns Hopkins Applied Physics Laboratory

CEDARS: Combined Exploratory Data Analysis Recommender System

Dr. Mark Livingston

Computer Scientist, Naval Research Laboratory

Human-Autonomy Teaming Essential Research Program Project 2: Transparent Multimodal Crew Interfaces

Dr. Kristin Schaefer-Lay

Engineer, U.S. Army Research Laboratory

3:00 – 3:30 pm

NETWORKING BREAK

MTF FOYER

3:30 – 4:45 pm

SESSION 4: HUMAN SYSTEMS METRICS

AUDITORIUM

When Acceptance Isn't Enough; Improving Evaluations of Novel Decision Support Tools

Jesslyn Alekseyev

Human Systems Analysis, MIT Lincoln Laboratory

Measuring Post Transition Performance Impacts

Darren Wilson, CHFEP

Senior Scientific and Technical Advisor, Science & Technology Directorate, Department of Homeland Security

Measurement Models, Metrics, and Decision Support for the HSI Personnel Domain

Dr. C.J. Hutto

Research Scientist, Georgia Tech Research Institute

Identifying Design Issues "Beyond the Checklist"

Kenneth Light

HSI Engineer, Army Research Laboratory

4:45 – 5:00 pm

CLOSING REMARKS

AUDITORIUM

Dr. Jared Freeman
Chief Scientist, Aptima
Chair, NDIA Human Systems Division

5:00 pm

CONFERENCE ADJOURNS

5:30 pm

NO-HOST SOCIAL AT STEELFISH GRILLE

TRANSPORTATION ON OWN

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Ball Aerospace pioneers discoveries that enable our customers to perform beyond expectation and protect what matters most. We create innovative space solutions, enable more accurate weather forecasts, drive insightful observations of our planet, deliver actionable data and intelligence, and ensure those who defend our freedom go forward bravely and return home safely.

Ball Aerospace located near Wright-Patterson Air Force Base, supports the missions of the Air Force Research Laboratory (AFRL), the National Space Intelligence Center (NASIC), and several Air Force Life Cycle Management Center (AFLCMC) Program Executive Officer's programs. Ball is a prime contractor providing research and development and technology transition in partnership with the Airman Systems Directorate (RH) and AFRL to discover, develop, and integrate affordable technologies to improve Warfighter performance, exploit autonomous systems and enhance Airman-machine teaming in Air, Space and Cyberspace. In collaboration with RH, Ball provides the Special Forces and Intelligence Communities with innovative, human-centered solutions to complex customer challenges and creates new warfighting capabilities. We work with RH and AFRL across multiple research programs to ensure that future Airmen – through training and technology - will work effectively and responsively with autonomous teammates in highly-contested, dynamic environments leveraging integrated, multi-domain operations.

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Collins Aerospace would like to recognize our research collaborators:

• University of Iowa OPL specializes in civilian and military flight-testing and assessment of technologies in operational contexts. This includes: development and testing of LVC, degraded visual environments, quantification of data link and sensor performance, human factors assessments, Synthetic Vision Systems, physiological-based workload measurement systems, pilot spatial orientation enhancement systems, embedded flight simulation capabilities, and more. OPL has 6 manned and 5 unmanned aircraft.

• Faubert Applied Research Centre is a non-profit research center dedicated to furthering cognitive human performance potential. The ARC works with industry thought leaders, government and academia addressing unmet needs in assessing and improving brain function and performance. One of our key technologies is NeuroTracker, an evidence-based VR training system that enhances focus, situational awareness and decision-making under pressure.

Amy Dideriksen | Advanced Technologies Lead Researcher | Collins Aerospace | Amy.Dideriksen@collins.com | (321) 308-2604

BIOGRAPHIES

DR. NANCY COOKE

Professor, Human Systems Engineering
Arizona State Univeristy

Nancy J. Cooke is a professor of Human Systems Engineering at Arizona State University and is Science Director of the Cognitive Engineering Research Institute in Mesa, AZ. She also directs ASU's Center for Human, AI, and Robot Teaming. She received her PhD in Cognitive Psychology from New Mexico State University in 1987. She has participated in several National Academies of Science, Engineering, and Medicine committees including chairing the committee on Enhancing the Effectiveness of Team Science and most recently participating in the Committee on a Decadal Survey of Social and Behavioral Sciences and Applications to National Security. Dr. Cooke was a member of the US Air Force Scientific Advisory board from 2008-2012. In 2014 Dr. Cooke received the Human Factors and Ergonomics Society's Arnold M. Small President's Distinguished Service Award. Dr. Cooke's research interests include the study of individual and team cognition and its application to the development of cognitive and knowledge engineering methodologies, human-robot teaming, cyber and intelligence analysis, remotely-piloted aircraft systems, healthcare systems, and emergency response systems. Dr. Cooke specializes in the development, application, and evaluation of methodologies to elicit and assess individual and team cognition. Her work is funded primarily by DoD.

BG JAMES GALLIVAN, USA

Chief of Staff

Army Futures Command

Brigadier General James "Jay" Gallivan was commissioned an Armor Officer through ROTC upon graduation from Florida State University in 1992.

His initial duty assignment was with the 1st Cavalry Division at Fort Hood, Texas, where he served as a tank platoon leader, scout platoon leader and tank company executive officer. He commanded Headquarters Company, 3rd Battalion, 15th Infantry and Delta Company, 1st Battalion, 64th Armor in the 3d Infantry Division (Mechanized) at Fort Stewart, Georgia. Following graduate school, he served on the Army Staff as a plans officer in the War Plans Division.

With the 3d Armored Cavalry Regiment, he served as a squadron operations officer in 3d Squadron in Iraq and as the regimental operations officer in Fort Carson, Colorado, and Iraq. He served as an interagency and civil support plans officer in USNORTHCOM's Standing Joint Force Headquarters as well as the deputy executive officer to the Commander, NORAD and USNORTHCOM.

General Gallivan commanded the 1st Battalion, 77th Armor Regiment at Fort Bliss, Texas, and in Iraq. He served as the senior reconnaissance squadron trainer and senior brigade trainer at the National Training Center in Fort Irwin, California. Prior to joining the 402nd Field Artillery Brigade and the 5th Armor Brigade, he served as the Chief of Staff with the 1st Armored Division's CENTCOM Forward-Jordan.

Following brigade command, he served as the Chief of Staff for the 1st Cavalry Division. His most recent assignment was with the National Security Council and he currently serves as the 1AD Deputy Commanding General, Operations.

General Gallivan is a graduate of the Command and General Staff College and the United States Army War College. He also received a Master in Public Administration from the John F. Kennedy School of Government.

His awards and decorations include the Legion of Merit, Bronze Star with V Device, Bronze Star, Purple Heart, Defense Meritorious Service Medal, Meritorious Service Medal, the Army Staff Identification Badge, the Combat Action Badge and the Parachutist Badge.

CAPT IRA MINOR, USN (RET)

Product Manager, ExAMS

Space and Naval Warfare Systems Command

A 1980 graduate of the U.S. Naval Academy, and 2010 graduate of the Naval Postgraduate School, Ira is a retired Navy Captain (Surface Warfare) with a Masters in Systems Engineering and a Graduate Certificate in Network Engineering, an Architecture & Systems Engineering Professional Certificate from MIT, and extensive experience working for Fortune 500 corporations in Silicon Valley. He is currently responsible for the development of the System of Systems Executable Architecture capability at SPAWAR Systems Command, and is certified in the DoD Acquisition and Cybersecurity workforces.

DR. JAMES PHARMER

Principal Scientist, Human Systems Department

Naval Air Warfare Center Training Systems Division

Dr. James "Jim" Pharmer is a Naval Aviation Systems Command Fellow and the Principal Scientist for the Human Systems Department at the Naval Air Warfare Center Training Systems Division. His research interests are in applying HSI principles to the systems engineering and acquisition processes. He holds a PhD in Applied Experimental and Human Factors Psychology from the University of Central Florida and an MS in Engineering Psychology from the Florida Institute of Technology.

POSTER AND DEMONSTRATION SESSIONS

TUESDAY, APRIL 16
12:00 – 2:00 pm

WEDNESDAY, APRIL 17
12:30 – 2:00 pm

An Integrated Model of Physical and Cognitive Effects of Non-lethal Weapons

Christian Dobbins
Dr. Poornima Madhavan
Institute for Defense Analyses

Considerations for the HSI Risk Analysis Tool

Patricia Burcham
U.S. Army Research Laboratory

Contributions of Usability Metrics to User-Centered Design

Dr. Pam Savage-Knepshield
CCDC-Data and Analysis Center
Scott Sines
PM MC, PdM FSC2

Crowdsourcing Situational Awareness through Passive Physiological and Behavioral Monitoring

Dr. Stephen Gordon
Robert Smith
DCS Corporation
Dr. Jonathan Touryan
U.S. Army Research Laboratory

Developing New Methods for Evaluating Human-Agent Team Communication

Dr. Anthony Baker
Ralph Brewer
Susan Hill
Dr. Kristin Schaefer-Lay
U.S. Army Research Laboratory

FitForce Planner: Data-Driven Support for Planning and Evaluating USMC Physical Training

Timothy Clark
Laura Cassani
Gabe Ganberg
Dr. Lisa Lucia
Angelica Smith
Aptima

Gut-on-Chip Microfluidic Systems: Applications in Host-Microbiome Interactions and Evaluation of Engineered Bacterial Platforms

Dr. Mark Nelson
Air Force Research Laboratory

Improving Human-System Performance through Technology-Enabled Employee Relationship Management

Andrew Moore
Tracy Cassidy
Software Engineering Institute
Denise Rousseau
Carnegie Mellon University

Leveraging Deep Learning and Machine Learning Algorithms to Build Adaptive and Adjustable User Interfaces to Support Human-Machine Teams

Dr. Jonathan Chow
Dr. Bennie Lewis
Lockheed Martin Space

MALUM: A U.S. Marine Corps Simulation System for Injury Avoidance

Karim Abdel-Malek
Rajan Bhatt
Jasbir Arora
Landon Evans
Kimberly Farrell
Travis Klopfenstein
University of Iowa

Meme Guard – The Case for Building Cognitive Resilience to Neurocognitive Warfare

Michael Ross
Indiana Criminal Justice Institute

Non-Invasive Real Time Implicit Communication of Human Signals (N-RICH)

Dr. Pooja Patnaik Bovard
Louis Kim
Draper Laboratory

Personnel Assessment Education and Training for Human-machine Teaming in Unmanned Underwater Vehicles (UUVs)

Dr. Jacob Norris
SPAWAR Systems Center Pacific

Portable Real-time Imaging for Cognitive Monitoring

Dr. Erik Nemeth
NeuroGen Technologies, Inc.

Dr. Bryann Gabbard
Defense Group, Inc.

Predicting Individualized Human-exoskeleton Adaptability from Baseline Sensorimotor and Cognitive Factors

Aditi Gupta
Harvey Edwards, III
Ryan McKindles
Aaron Rodriguez
Leia Stirling
Massachusetts Institute of Technology

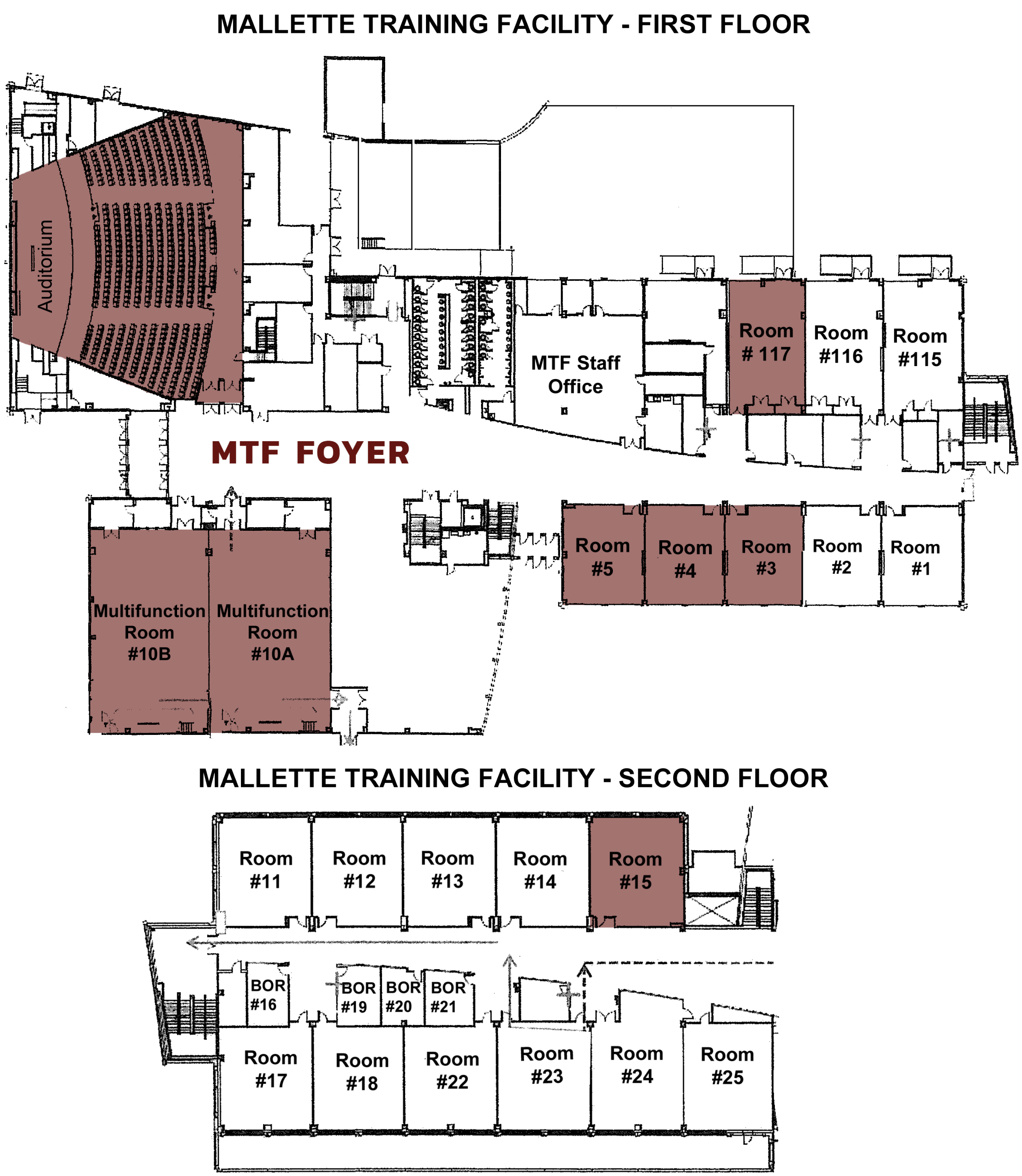
Publishing Opportunities in the Journal of DoD Research & Engineering

Dr. Ryan Makinson
Defense Technical Information Center

Touch Interaction for Console Redesign

Oliver Mestre
Jennifer O'Leary
Naval Undersea Warfare Center Division Newport

VENUE MAP




AT THE HEART OF THE MISSION
NDIA
1919
2019
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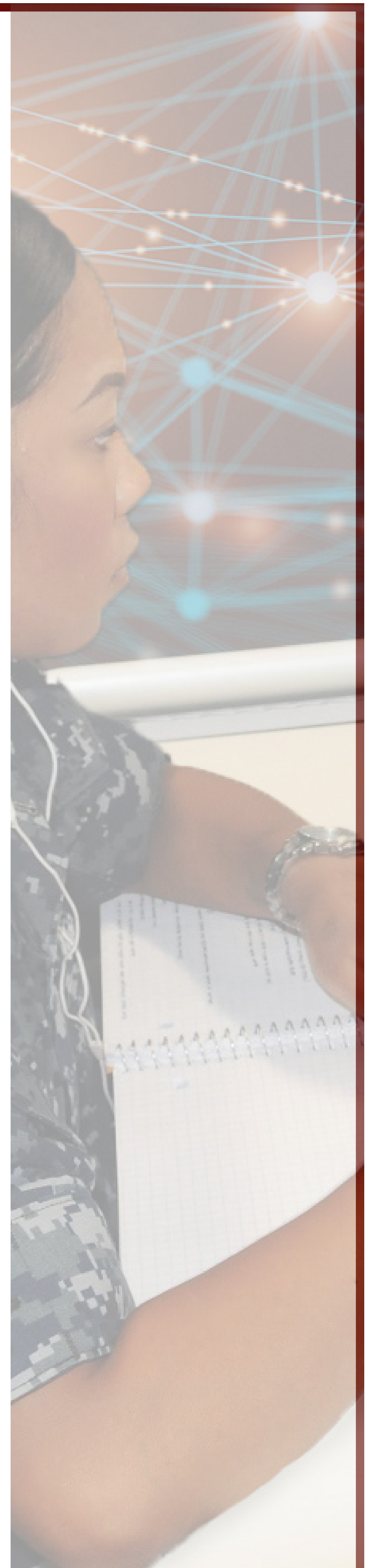
ACCELERATING SOF INNOVATION
May 20 – 23 | Tampa, FL | SOFIC.org
REGISTER TODAY!



Human Systems Community of Interest
An Overview

Dr. Kevin Geiss

AFRL 711 Human Performance Wing

Chair, Human Systems Community of Interest

Human Systems CoI: SubAreas

Personalized Assessment, Education, and Training

Right Person, Right Job, Right Skills

- Training, Education, And Personnel Development
- Personnel Selection and Assignment

Protection, Sustainment, and Warfighter Performance

Ensuring Warfighter Safety and Survivability

- Understanding and Quantifying Warfighter Variability
- Enhancement and Mitigation Strategies

System Interfaces and Cognitive Processes

Effective, Natural Human-Machine Teaming

- Human-Machine Teaming
- Intelligent, Adaptive Aiding
- Human Information Interpretation & Influence

Human Systems CoI

- **Vision:** Develop & deliver new human-centered technologies to select, train, design, quantify, protect, and operate for measurably improved mission effectiveness.

- **Mission:** Enhance mission effectiveness through:

  1) Integrated simulations for mission training, experimentation 2) Human-machine designs for mission effectiveness, 3) Assessment of operator effectiveness, 4) Operating through battlespace stresses, and 5) Mastering the political, military, economic, social, infrastructure, and information systems (PMESII) battle space.

- **Key Products:** Integrated service roadmaps; CoI taxonomy, budget & programs; seedling, and tri-service Applied Research for the Advancement of S&T Priorities (ARAP) proposals, collaboration opportunities; success stories.

- **Data Link:** Other key CoI information including roadmaps can be found on **https://defenseinnovationmarketplace.dtic.mil/communities-of-interest/human-systems/**

State of Technology: Accomplishments

- Intelligent Multi-UxV Planner with Adaptive Collaborative Control Technologies & The Technical Cooperation Program (IMPACT & TTCP) Autonomy Strategic Challenge demonstrated single operator managing 16 unmanned multi-domain assets, both live and simulated.
- Monitoring and Assessing Soldier Tactical Readiness and Effectiveness (MASTR-E) CCDC – Soldier Center in partnership with the 82nd Airborne and many HS CoI members. Leveraging cutting-edge technology and an array of technical disciplines to identify the human performance x-factors that reliably account for sustained dismounted soldier and squad lethality.
- Secure Live Virtual Constructive (LVC) Advance Training Environment (SLATE) New waveform for LVC data transmission; Enhanced range infrastructure; New standards, data specs, and interface control docs for 4^{th} & 5^{th} gen LVC. Success led to several senior OSD,USAF and USN outbriefs and a requested outbrief to senior Royal Australian Air Force leadership.
- Battlefield Assisted Trauma Distributed Observation Kit (BATDOK) Enhance patient care and survivability by leveraging an operator-centric, easy-to-use mobile interface that increases the medic's awareness throughout the care and transport of injured personnel, in both combat and humanitarian missions.

State of Technology: Investments

Gaps and Risk Areas

- Wearable technology and real-time operator state assessment
- Performance optimization via adaptive wearable robotics
- Trainable undifferentiated agents for rapid constructive force generation
- Context-aware communication for human-machine teaming performers

Service Partnering

- 4th Gen LVC Advanced Training Environment: Strategic partnership between AF and Navy on requirements and leveraging of funds for F15E Operational Flight Program (OFP) changes to reduce timeline/costs for similar OFP mods to F18 aircraft
- Directed Energy (DE) Bioeffects; ARL has placed a position within AFRL DE Bioeffects Team to pursue collaborations and leverage AF investment
- Navy and AF seedling: A Cognitive Computing Environment for Mixed-Initiative Alternative Course of Action Analysis

Future Direction

Technological

- Optimal warfighter performance and lethality: leveraging AI and big data
- Synchronized Air/Ground/Sea Medical Autonomous Platforms (SAGSMAPS) for Autonomous Care and Evacuation (ACE) to Increase Unit Lethality – with Autonomy and ASBREM CoIs
- Marine Corps experimentation with large data collection at School of Infantry – East
- Personalization of training; Proficiency-based training and assessment; Human-machine team training and assessment

Initiatives or Best Practices to Accelerate R&D Process

- Regular meetings between subarea leads and NDIA partners
- Continuation of IR&D TIMs
- Participation in NATO, The Technical Cooperation Program (TTCP), and international workshops
- HS CoI Awareness Campaign: Steering group familiarization lab visits, quarterly newsletter, bi-weekly calls, DoD - Human Factors Engineering Technical Advisory Group, National Defense Industrial Association (NDIA) Human Systems Division (HSD)

Cross-CoI, Industry, Academia Opportunities for Collaboration

- ASBREM: Military Operational Medicine Research Program Wearables meetings
- Autonomy: Machine perception, reasoning & intelligence

HS CoI Status
Key Events/Activities

- U.S.-U.K. Human Systems Workshop — Feb 2018
- Air Force Familiarization Visit — May 2018
- Navy Familiarization Visit — Aug 2018
- HS CoI Steering Group/"All-Hands" — Oct 2018
- Reliance 21 Meeting — Jan 2019
- Army Familiarization Visit — Feb 2019

- NDIA Human Systems Conference collocated with Human Factors Engineering Technical Advisory Group (HFE TAG) — Apr 2019
- HS/ASBREM CoI Internal Research & Development Technology Interchange Meeting (IR&D TIM) — Jun 2019
- HS CoI Annual Meeting — Sep 2019
- HS CoI Roadmap Review — Oct 2019
- FY19 Budget Update — Oct 2019

Takeaways

- The HS CoI is well-positioned to support recent Service strategic documents to leverage the human dimension in complex systems via use of synthetic environments.
  - Programs in Human-Machine Teaming, LVC, and Wearable Sensors address key capabilities
  - DE Bioeffects as an emerging area of interest
  - Developing and executing jointly planned proposals
- The HS CoI Steering Group will continue to strengthen awareness of Services' S&T capabilities through a series of laboratory site visits.
- The HS CoI has been leveraging collaborations with other CoIs (ASBREM, Autonomy, C4I, etc.), including ARAP proposals, Autonomous Medical Evac Workshop, and combined ASBREM/HS CoI IR&D TIMs event.

State of HS CoI: Changes

Personnel changes:

- Dr. Corde Lane (Army) Steering Group Member
- Dr. Michelle Zbylut (Army) Steering Group Member
- Dr. Robb Wilcox (Army) Steering Group Member
- Ms. Roxanne Constable (AFRL) - Working Group Chair

Sub Area / Roadmap changes:

- Human Aspects of Military Environments (HAOME) refocused to Human Information, Interpretation, and Influence (HI3) thrust within SICP
- Addition of Robotic Maintenance Assistants to System Interfaces and Cognitive Processes (SICP)
- Noted AI threads in S&T Focus for SICP Roadmaps

Roadmap Trends for Human-Machine Teaming

- Development of wearable electronics to sense and adapt to the cognitive/physical state of the warfighter and environment enables more mission effective human agent teaming
- Applied Neuroscience related to operator and mission performance: focus on sensor development and assessment methodologies (i.e., machine learning)
- Advance cognitive modeling for realistic avatars, adaptive training, human-agent teaming, and performance monitoring and prediction
- Neuromodulation related to protection and enhanced learning outcomes
- Growth in biosciences (bioengineering and biosensors) and robotics

Events & Meetings

NDIA Human Systems Conference

- April 2019

Aerospace Medical Association Annual Meeting

- April 2019

Human Factors and Ergonomics Society Annual Meeting

- October 2019

DoD Human Factors Engineering Technical Advisory Group Meeting

- April 2019

HS CoI Internal Research and Development Event (IR&D)

- June 2019

Human Systems CoI: SubAreas

Personalized Assessment, Education, and Training

Right Person, Right Job, Right Skills

- Training, Education, And Personnel Development
- Personnel Selection and Assignment

Protection, Sustainment, and Warfighter Performance

Ensuring Warfighter Safety and Survivability

- Understanding and Quantifying Warfighter Variability
- Enhancement and Mitigation Strategies

System Interfaces and Cognitive Processes

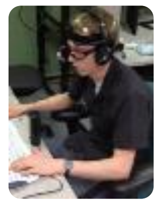
Effective, Natural Human-Machine Teaming

- Human-Machine Teaming
- Intelligent, Adaptive Aiding
- Human Information Interpretation & Influence

Service Demand Signals

Personalized Assessment, Education and Training

- Personalized, integrated assessments and training to improve performance, accelerate proficiency and increase affordability
- Enhanced warfighter performance through scenario based training & automated performance based readiness assessments
- Maintain air superiority over complex, evolving threats using adaptive training



Protection, Sustainment and Warfighter Performance

- Greater force protection to ensure survivability across all operations and environments
- Maintain health & injury recovery; reduce noise induced hearing loss
- Agile Combat Support through countering aerospace physiology and toxicology threats, reducing cognitive workload

System Interfaces and Cognitive Processing

- Achieve operational maneuverability through soldier-system integration
- Design systems to enable effective human machine interaction, including robotics & autonomous systems
- Enhanced interaction & trust w/ autonomous systems; increased SA for operators; reduced analyst workload
- Provide situational awareness; timely mission command and tactical intelligence human-agent teaming

- *Army Enduring Challenges*
- *Navy Vision/Objectives*
- *AF Core Mission/Challenges*

Personalized Assessment, Education, and Training

PAET Scope
Personalized Assessment, Education & Training (PAE&T)

Research and development in personnel assessment will produce integrated measures and adaptive testing for more precise assessment of individual potential, yielding improved personnel selection and assignment. Meanwhile, work in education and training will produce competency-based systems grounded in quantitative metrics to enable personalized, proficiency-based training to accelerate acquisition and enhance operational performance. The end result is more capable warfighters with decreased training costs.

Thrust Area 1:

Training, Education, and Personnel Development

S&T Focus Areas on Roadmap:

- Realistic, secure, and adaptive LVC environments
- Persistent **and** personalized readiness assessment and tracking
- Multi-Level modeling for readiness management
- Computational cognitive science research to support model and agent development for training and operational support

Thrust Area 2:

Personnel Selection and Assignment

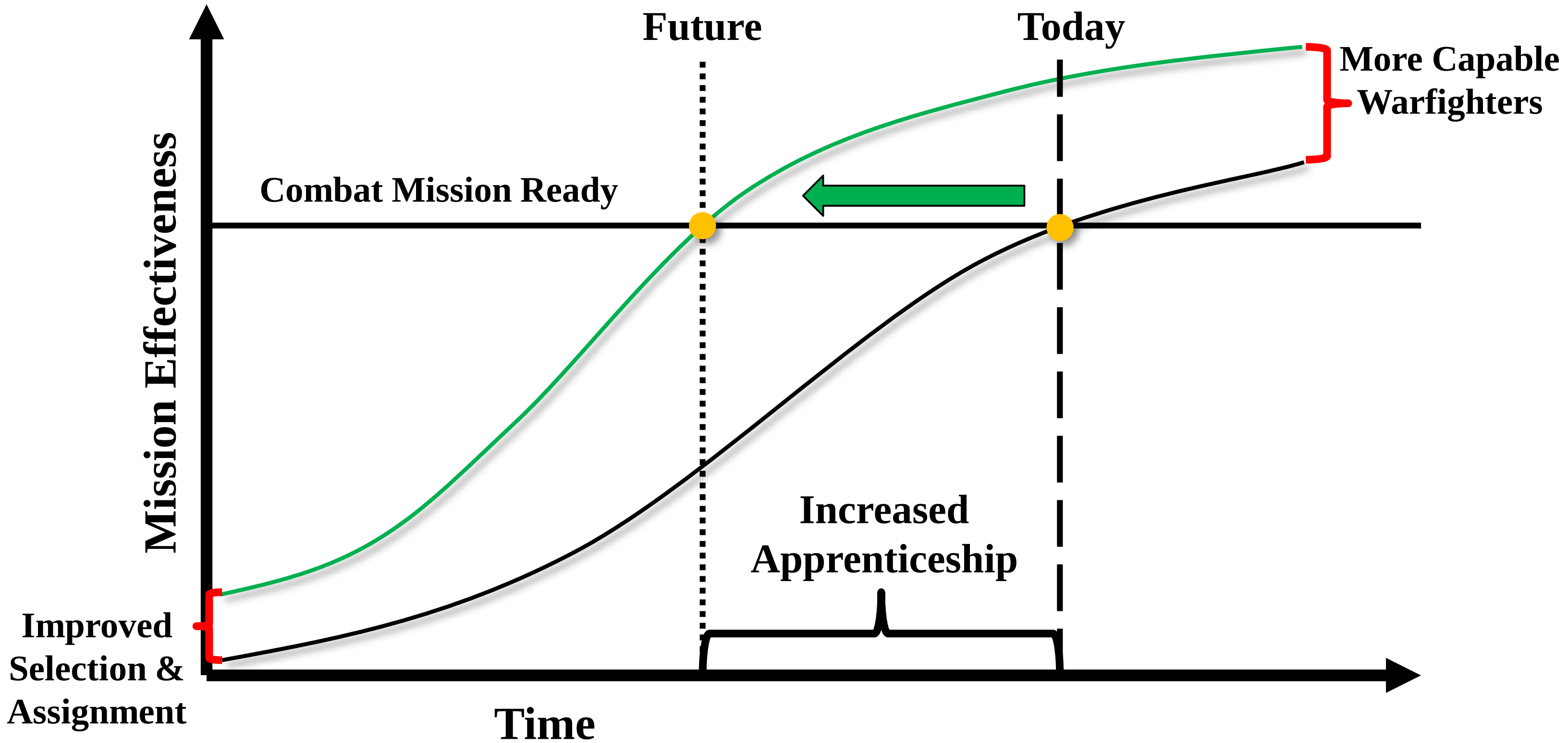
S&T Focus Areas on Roadmap:

- Predictors: Expand/refine non-cognitive measures (e.g., Tailored Adaptive Personality Assessment System)
- Outcomes: Expand/refine behavior and performance data
- Models: Expand/refine predictive analytic model for integrated cognitive plus non-cognitive measures to predict attrition, performance, and behaviors

Personalized Assessment, Education, and Training: Vision

VISION

A readiness ecosystem that ensures the right person has the knowledge, skills, and experiences needed to be mission ready for a dynamic and uncertain 21st century operating environment



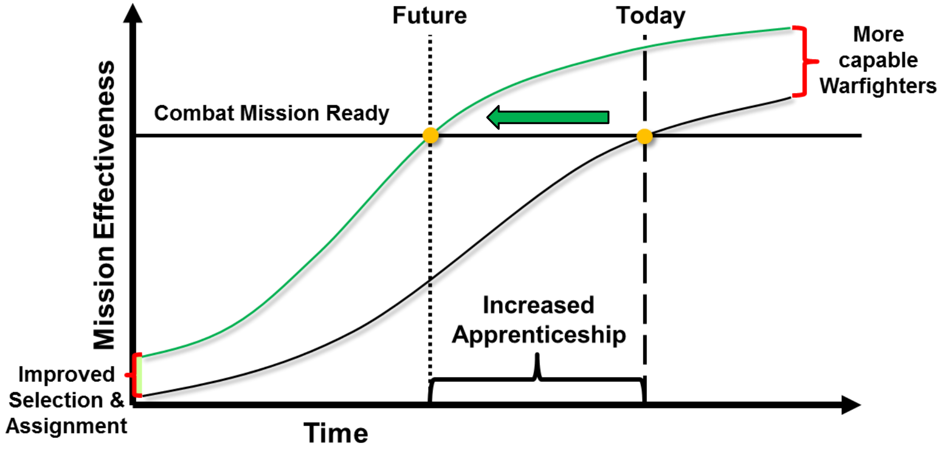
Personalized Assessment, Education, and Training: Overview

Challenges

- Unpredictable and asymmetric adversaries
- Dynamic, evolving operational environment
- Diverse personnel pool
- Budget and manpower constraints
- Need for better training at point-of-need
- Personalization to maximize mission effectiveness
  - Increased agility
  - Point of need training
  - Efficient use of training resources

Science & Technology Solutions

- Adaptive LVC synched w/operations
- Human science models (e.g. training, assess.)
- Performance measures and assessment
- Talent mgmt. functions personalized to data
- Optimization of talent mgmt. via learning science
- Proficiency-based assessment
- Cognitively-based instruction and training schedules



Thrust 1: Training, Education, and Personnel Development

Delivering the Mission

Education & Training Practices and Technologies that Support Efficient and Effective Development of Mission Readiness and Cognitive Agility

- Leverage learning sciences and technology to reduce resource costs (cost, manpower, time)
- Tailor training to individuals to enhance warfighter capabilities and agility
- Measure, track, and warehouse quantitative, proficiency-based performance measures

Delivering Capability (i.e., End States)

- Persistent, interoperable learning "ecosystem"
…with personalized measurement; readiness tracking
- Secure LVC joint/coalition training environments
…with realistic constructive teammates / adversaries
- Consistently high-quality training and education, tailored to individuals and available when needed
- Increased insight into personnel (data) informs individual learning decisions and mission planning

Key Technical Challenges

- Developing, deploying, and using proficiency-based performance measures / analyses
- Warehousing & using (big) learning data to inform life-long learning and operational decisions
- Securely integrating LVC environments
- Develop adaptive and valid cognitive agents
- Adapting learning sciences to military contexts and foster the right culture for their use

Example Program Successes

EXPERIENCE API

TXA

AITT

Thrust 2: Personnel Selection and Assignment

Delivering the Mission

- Initial Military Training attrition is ~10% ($1.7B cost/yr)
- IMT attrition could be reduced to ~ 8% (saving ~.34B/yr) if current S&T product (TAPAS) was implemented to assess personality. IMT attrition could be reduced to 6% (saving $.68B/yr) with FY22 S&T products.
- Reduce negative behaviors for enlisted by ~5%.
- Increase satisfaction, performance, and retention in critical specialties by ~15%.

Delivering Capability

Maintain our competitive edge in Human Capital (Force of Future).

- Reduce attrition and negative behaviors with more precise assessments of candidates for initial entry and job assignment.
- Improve performance and retention with an emphasis on critical specialties (e.g., cyber) through advancements in talent assessment.

Key Technical Challenges

- Predictor measures: Existing measures lack individualized precision and are not integrated.
- Outcome measures: Performance and behaviors are difficult to measure and systematically obtain over a career.
- Predictive models: Existing models are stove-piped and based on group probabilities.

Example Program Success

- Enlisted Personnel Selection – TAPAS

Takeaways

- **Metrics**
  - Quantification of individual traits, states, and performance to assess aptitude and readiness
- **Models**
  - Formal characterizations of data, behavior, and cognitive processing to support assessments, training interventions, and predictions of future capability proficiency and performance
- **Simulations**
  - Increased reliance on simulation and LVC integration to support training requirements

System Interfaces and Cognitive Processes

SICP Scope

Research and development in this area will produce human-technology interfaces that enhance warfighters' ability to focus on their primary mission. These cognitively engineered interfaces will be intuitive to use, will learn with experience, and support mixed-initiative communication.

Thrust Area 1:

Human-Machine Teaming

S&T Focus Areas on Roadmap:

- Human-Robot Interaction
- Cognitive Architectures and Integrated Intelligent Systems
- Socio-Cognitive Architectures
- Mission-Specific Natural Language Dialogue
- Unrestricted Natural Language Dialogue
- Gesture/non-verbal interaction
- Trust Calibration
- Multisensory Perception and Interfaces
- Fusion Exploitation Tool Suite
- Interfaces to C2 Information Systems
- Distributed Intelligent Interfaces for Human-Centric Info Systems
- Mission Planning and Scheduling Tools
- Closed Loop Medical Technology Research

Thrust Area 2:

Intelligent Adaptive Aiding

S&T Focus Areas on Roadmap:

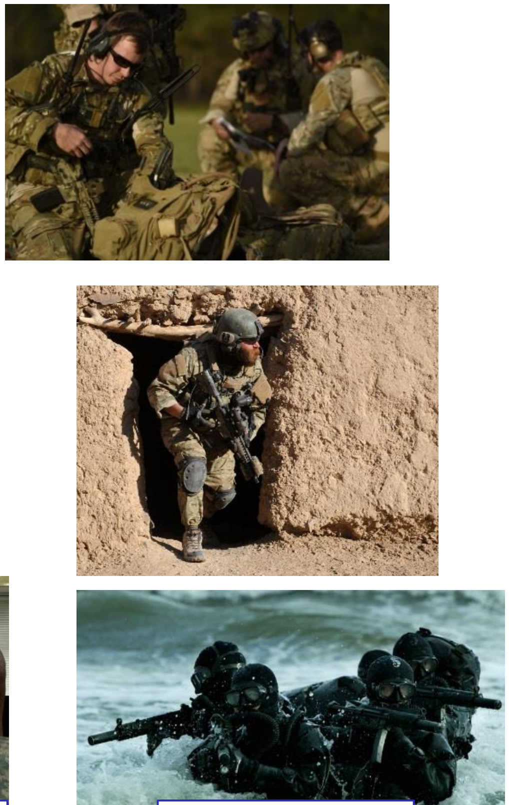
- Physiological, Behavioral, And Cognitive Sensing & Assessment
- Socially-Guided Machine Learning
- Cognition, Performance and Individual Differences
- Computational Models of Operators' Beliefs, Desires, Intentions and other Mental States
- Molecular Signatures
- Applied Neuroscience
- Human-System Co-Adaptation
- Gesture/non-verbal interaction

HUMAN SYSTEMS COI SUB-AREA:
System Interfaces & Cognitive Processes

VISION

Warfighters teamed with machines through intuitive, personalized interfaces that enhance warfighters' mission effectiveness.

Information Systems Operators



Dismounted Operators

Air Systems Operators

Medical Support Operators

Thrust 1: Human-Machine Teaming

Delivering the Mission

- Increased capability with smaller force structure across air, land, sea, space, and cyber
  - 1 MQ-9 Operator controlling 7 simulated MQ-9s
  - Reduced ISR PED Cell Operators from 5 to 3
  - Closed Loop Medical Technology Research
- USTRANSCOM Global Mission Scheduling System
  - Reduced logistics and personnel footprint ; reduced planned flying hours >2% saving $37M/year
- Trusted synthetic teammates that provide recommendations for battlespace operations
  - Reduced manpower and training requirements
- Ability to operate safely in highly contested environments
  - Reduced exposure to personnel

Delivering Capability

Seamless human-machine interfaces enabling optimized weapon system and warfighter performance in all contested domains and mission environments:

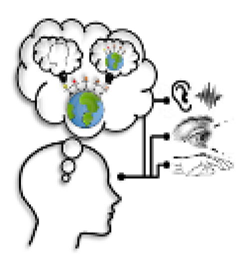
- Demonstrate highly effective, agile human-machine teaming
- Create actively coordinated teams of multiple machines
- Ensure safe and effective systems in uncertain and dynamic environments

Key Technical Challenges

- Immature intuitive, multisensory, adaptive interfaces
- Lack of robust and reliable natural language interfaces
- Absence of effective gesture control interfaces
- Fragile cognitive models and architectures for autonomous agents and synthetic teammates
- Insufficient degree of trust calibration and transparency of system autonomy
- Immature decision support tools

Program Overview

- Human-Robot Interaction
- Multisensory Perception and Data Presentation Interfaces
- Supervisory Control Technology Integration and Demonstration




Thrust 2: Intelligent, Adaptive Aiding

Delivering the Mission

- Maintain mission effectiveness despite fluctuating demands: No mission degradation in a high tempo environment
- Optimized human-machine teaming: Dynamic workload allocation to improve mission efficiency
- Provides shared situation awareness and transparency between the operator and the weapon system platform: Appropriate level of operator trust
- Optimized warfighter readiness and enhanced training: Identification of relevant biomarkers indicative of operator cognitive and physiological state

Delivering Capability

Enhance warfighter effectiveness by coupling humans and machines through the use of intelligent adaptive aids to protect from being overwhelmed by complexity and workload.

- Develop models of perception and cognition
- Assess the functional state of the operator
- Real-time measurement and assessment of warfighter performance

Key Technical Challenges

- Immature tools for individual and team functional state assessment
- Fragile cognitive models
- Operationalize minimally invasive sensor suites
- To Identify the appropriate biomarkers for determining operator performance
- Absence of effective gesture/non-verbal interfaces

Program Overview

- Applied Computational Neuroscience
- Cognitive Performance Optimization
- Monitoring, Predicting, and Optimizing Battlespace Awareness




Where We Are
Thrust 3: Human Information, Interpretation and Influence (HI3)

Delivering the Mission

- Identify adversary uses of information technology
- Characterize trends in the information channel (deception, themes, narratives, influence leaders, etc.)
- Analyze and estimate change occurring in the environment relative to USG initiatives

Delivering Capability

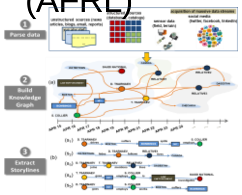
- Exploit Information Environment by extracting and enabling making meaning in multimedia
- Models and Machine Learning Algorithms to detect anomalous activity (bots)
- Extract and fuse knowledge graphs to uncover actors, roles, causal relationships.
- Socio-cultural aware decision support for COA analysis.

Key Technical Challenges

- Adversaries hide tactics and change identities if banned from platforms (hard to track)
- Deception is difficult to identify in early stages of an information campaign, need alert models
- Influence assessment is difficult, particularly for “competition” events/situations
- Blending social and computational sciences to characterize and anticipate socio-cyber behaviors
- Translation tools need global coverage & ACR for video.

Program Overview

- Bot Identification and Threat Evaluation (EUCOM)
- Analytics Using Geospatial Storytelling (ERDC)
- Big Open Source Social Science (ERDC)
- Collaborative agents in multi-agent systems (ARL)
- Blending “emic” data & game theory for deterrence analysis (AFRL)



Protection, Sustainment, and Warfighter Performance

Protection, Sustainment, and Warfighter Performance Scope

Research and development in this area will produce better understanding of the critical environmental stressors and the human factors yielding individual performance differences in operational environments in order to enhance performance and mitigate the effects of stressors. This includes designing systems that support and exploit individual differences, and developing operationally relevant metrics to monitor and assess performance.

Thrust Area 1:

Understanding and Quantifying Warfighter Variability

S&T Focus Areas on Roadmap:

- Ability to Conduct Warfighter Assessment in All Environments
- Mechanisms and Effects of Individual Differences and Critical Stressors on Warfighter Performance
- Real-Time Data Analysis and Performance Prediction

Thrust Area 2:

Enhancement, Mitigation, and Bioeffects

S&T Focus Areas on Roadmap:

- Tool(s) for conducting trade off studies between protection/load, performance, and individual differences.
- Development of Augmentation Technologies and Techniques
- Design and Development of Models and Methods for Understanding Mitigating Stressors
- Bioeffects

HUMAN SYSTEMS COI SUB-AREA:
Protection, Sustainment, and Warfighter Performance

VISION

Enable superiority of Warfighters by understanding and overcoming operational stressors, and providing protection from threats in their environment.

DARPA Warrior Web early prototype

Wearable sensor technology

<u>This will be achieved through:</u>

1. Understanding the factors that influence individual performance
2. Developing the ability to measure performance in the operational environment
3. Developing strategies to mitigate the effects of critical stressors on performance

<u>Achieving this vision will enable:</u>

1. Increased ability to perform at a higher stress level without a performance decrement or increase in injury
2. The ability to measure performance in training and operational environments
3. Warfighter protection aligned to mission specific threat, environment, and region allowing for optimal performance while maintaining protection
4. New technology capable of measuring current Warfighter state and predicting current and near term performance, resulting in 20% increase in task performance
5. Load mitigation strategies resulting in 25% decrease in metabolic cost

Thrust 1: Understanding and Quantifying Warfighter Variability

Delivering the Mission

- Data analysis and performance prediction will enable improved resilience by providing critical information on Warfighter readiness.
- Understanding the underlying mechanisms through which critical stressors influence performance will enable greater performance and protection methodologies.
- Understanding individual differences in the effect of critical stress on performance will enable greater Warfighter resilience.

Delivering Capability

- Developing technology capable of objectively measuring warfighter performance in operational environments to enable real-time monitoring of Warfighter performance.
- Understanding the underlying mechanisms through which performance is influenced will provide a pathway to optimizing Warfighter performance.
- Modeling individual responses to critical stressors will enable the leveraging of individual variability as a means of improving Warfighter performance and protection.

Key Technical Challenges

- Sensors needed that are non-invasive, don't adversely influence performance, and provide meaningful data.
- **<u>Workflow and tools to support data acquisition, storage, sharing, and analysis.</u>**
- The influence of human variability on the effects of stress on warfighter performance is difficult to predict.
- High fidelity models that predict performance and injury and/or the impact of protection strategies on performance are lacking.

Program Overview

- Determinants of hazardous biomechanics
- Ubiquitous and unobtrusive Real-World Assessment
- Impact of individual differences

Thrust 2: Enhancement, Mitigation, and Bioeffects

Delivering the Mission

- Physical augmentation to reduce metabolic cost by up to 25 %
- **<u>Modeling and Simulation tools capable of predicting physical stress on the Warfighter Performance</u>**
- Optimized load configurations and route planning leading to a 10% reduction in metabolic cost and 10% increase in operational performance.

Delivering Capability

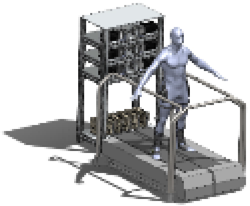
- Develop methods of lessening the effects of critical stressors on Warfighter performance
- Understand the underlying mechanisms by which physical augmentation and protection technologies affect performance. Set system requirements.
- Provide the tools (M&S, route planning, etc.) necessary to understand the relationship between new technology, mission requirements and operational effectiveness.

Key Technical Challenges

- Tools to model effects of augmentation on physical performance and injury potential are still in development.
- Route planning tools require high fidelity models of human physiological response to critical stressors.
- Individual variability influences the extent to which physical augmentation can mitigate physical loads

Program Overview

- Lower Extremity motor adaptations to actuation
- Effects of physical augmentation on walking efficiency
- Enhanced Technologies for Optimization of Warfighter Load



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Thank You

BACKUP

Human Systems Community of Interest Active Membership

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Dr. Corde Lane (Army)
Dr. Patrick Mason (Navy)

Dr. Kevin Geiss (AF)
Dr. Michelle Zbylut (Army)
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Dr. Todd Nelson (AF)
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LCDR Pete Walker (Navy)
Dr. Mark Livingston (Navy)
Dr. Shannon Salyer (OPA)
Dr. Michael Nugent (DLNSEO)
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Dr. Jeff Morrison (Navy)
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Dr. Caroline Mahoney (Army)
Dr. Ami Bolton (Navy)
Mr. Ed Davis (AF)

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Dr. David Scribner (Army)
Dr. Rebecca Goolsby (Navy)
Mr. Eric Hansen (AF)
Dr. Edward Palazzolo (Army)
Dr. Lisa Troyer (Army)
Dr. Laurie Fenstermacher (AF)
Dr. Adam Russell (DARPA)

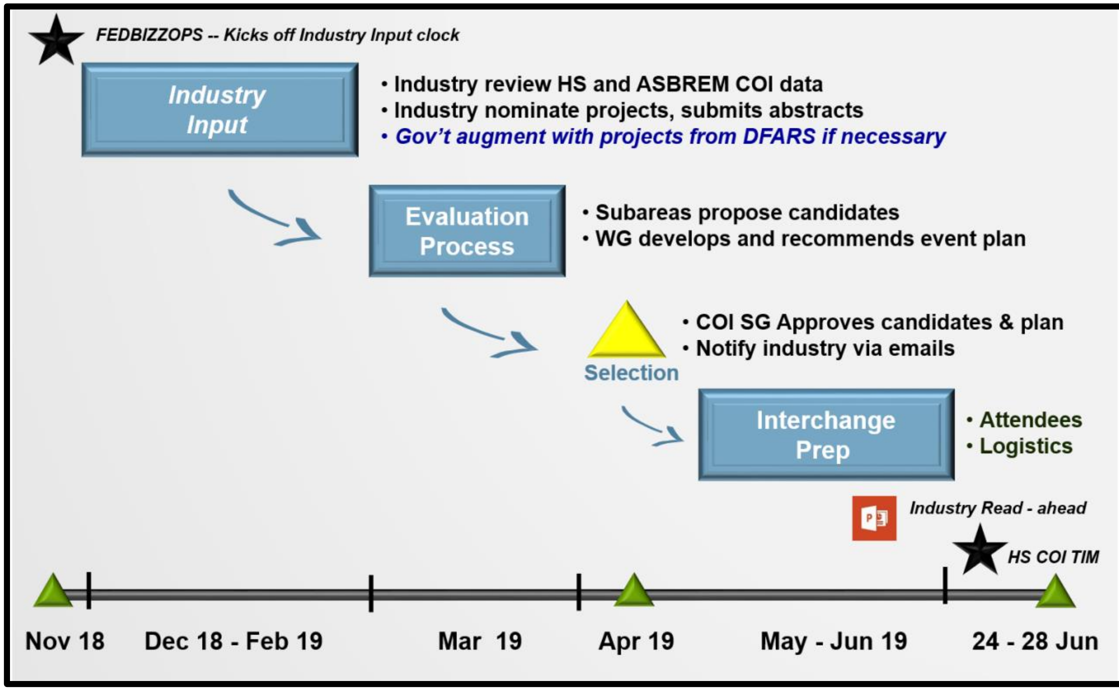
HS CoI
FY18 Completed Events/Activities

• Annual Reliance 21 Meeting	Feb 2018
• HS CoI Newsletter (Three Editions)	Feb/Jun/Oct 2018
• NDIA Human Systems Conference	Mar 2018
• NDIA S&ET Conference with CoI Poster	Apr 2018
• Human Factors Engineering (HFE) TAG	May 2018
• Air Force Familiarization Visit	May 2018
• ARAP Proposal	Jun 2018
• HSI Brown Bag	Jun 2018
• Seedling Proposal	Aug 2018
• Navy Familiarization Visit	Aug 2018
• HS CoI Steering Group/"All-Hands"	Oct 2018
• I/ITSEC Conference	Nov 2018
• FY19 Budget Update	Nov 2018

HS CoI Status
IR&D Interchange

- **New Partner: ASBREM CoI**
- **Location/time: Strategic Analysis, 24-28 Jun 2019**
- **Goals:**
  - Leverage Marketplace for insight on industry IR&D
  - Look for collaboration opportunities
- **Outcome: Continue collaboration development or not**
  - Examples: POCs given for future meetings, data exchanges, site visits, testing, CRADA/MOA discussion
- **Format: Face-to-face discussion led by Subareas**
- **Content: One hour per project; Includes Q&A and Government Caucus**

2019 HS/ASBREM CoI IR&D SCHEDULE



Acronyms

- ARAP - Applied Research for the Advancement of S&T Priorities
- BATDOK - Battlefield Assisted Trauma Distributed Observation Kit
- CCDC - U.S. Army Combat Capabilities Development Command Soldier Center
- DE – Directed Energy
- HFE TAG - Human Factors Engineering Technical Advisory Group
- HSD - Human Systems Division
- I/ITSEC – Interservice/Industry Simulation Training & Education Conference
- IMPACT - Intelligent Multi-UxV Planner with Adaptive Collaborative Control Technologies
- IR&D TIMs – Internal Research & Development Technical Interchange Meetings
- LVC – Live, Virtual, Constructive
- MASTR-E - Monitoring and Assessing Soldier Tactical Readiness and Effectiveness
- NDIA- National Defense Industrial Association
- OFP – Operational Flight Program
- PMESII - Political, military, economic, social, infrastructure, and information systems
- SLATE - Secure Live Virtual Constructive (LVC) Advance Training Environment
- TTCP – The Technical Cooperation Program

U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – ARMY RESEARCH LABORATORY

Army Modernization and CCDC-ARL

Dr. Corde lane

Director, Human Research and Engineering Directorate

16 April, 2019

APPROVED FOR PUBLIC RELEASE

CCDC ARL
The Army's Corporate Research Laboratory

DEVCOM ARMY RESEARCH LABORATORY

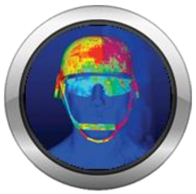
Human Sciences

Propulsion Sciences

Ballistics Sciences

Network & Information Sciences

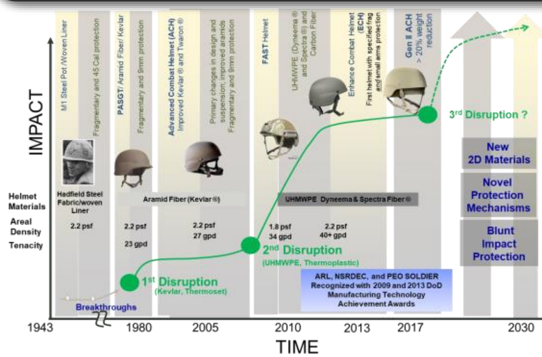
Protection Sciences



Computational Sciences

Materials & Manufacturing Sciences

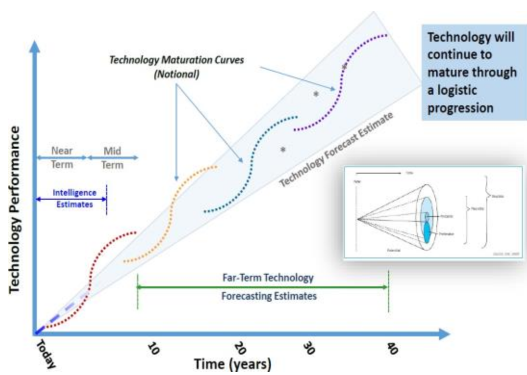
Disruptive Foundational Research



S&T Input for Concepts and Tech Forecasting

Army's Face to the World-Wide Academic Community

Close Collaboration with Futures and Concepts Center

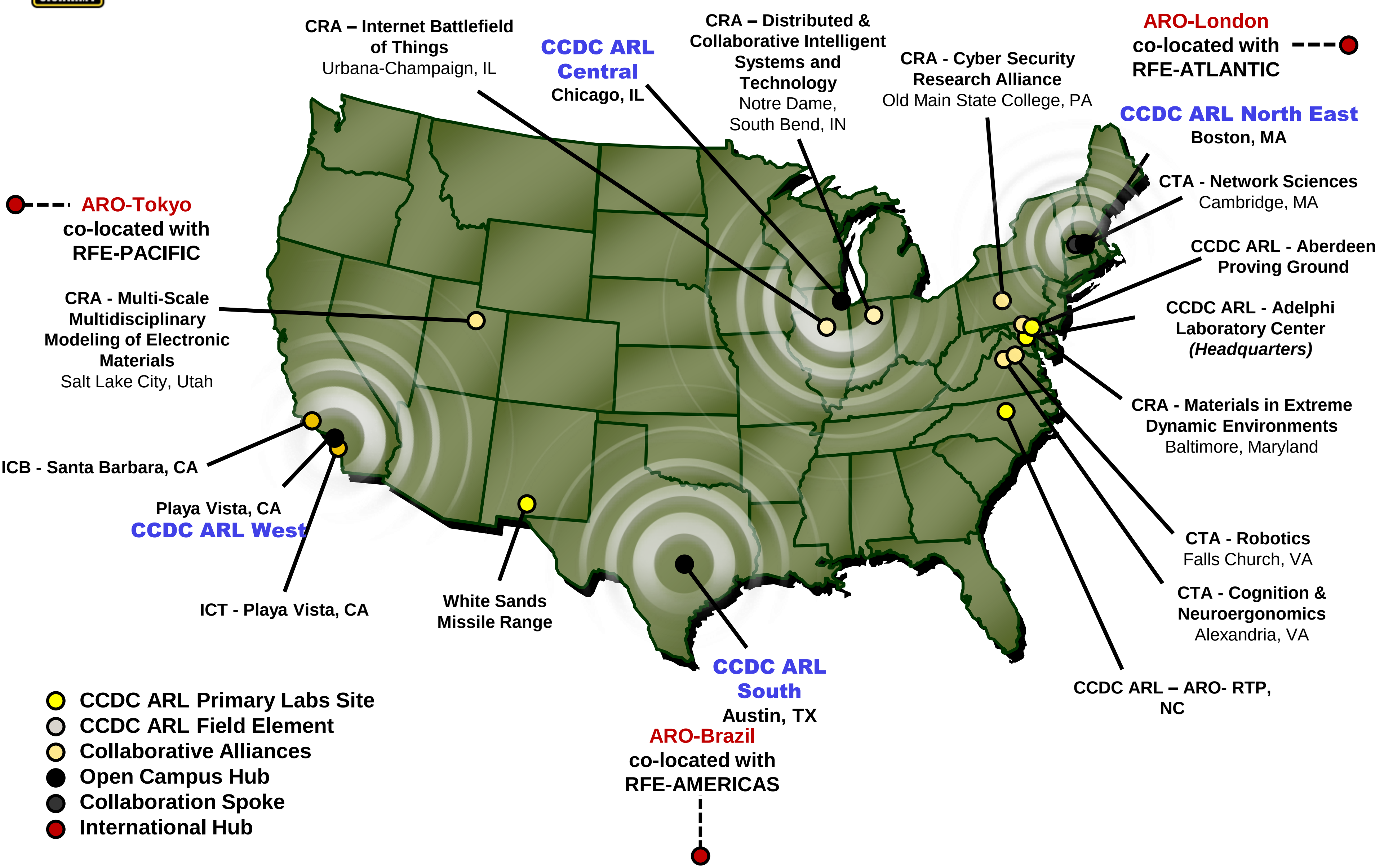


ARL Open Campus
Army Research Office

ESSENTIAL RESEARCH PROGRAMS (ERP)

Aligned to the Army's Modernization Priorities for Mid & Far Term

DEVELOPING A HUB AND SPOKE S&T GLOBAL NETWORK



Human-Autonomy Teaming: Can Autonomy be a Good Team Player?

2019 NDIA Systems Conference
April 17, 2019

Nancy J. Cooke, PhD
Professor, Human Systems Engineering
Director: CHART – Center for Human, AI, and Robot Teaming
Arizona State University

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ARIZONA STATE UNIVERSITY

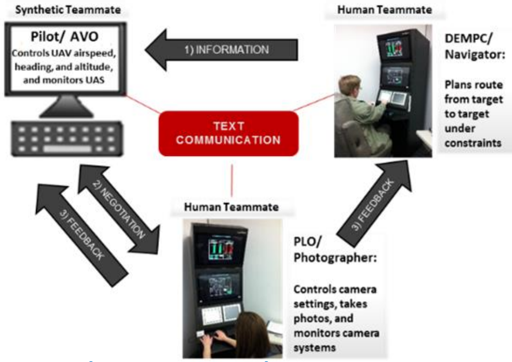
Center for Human/Artificial Intelligence/Robot Teaming (CHART)

ASU Global Security Initiative
Arizona State University

CHART assembles **multidisciplinary** teams to address **human-machine integration issues** in transportation, emergency response, manufacturing, medicine, and defense.

Launched: 2017

Primary Contact: Nancy Cooke - Ncooke@asu.edu



https://globalsecurity.asu.edu/expertise/human-artificial-intelligence-and-robot-teaming

Overview

- Taking Teaming Seriously in Human-Autonomy Teaming
- CHART Human-Autonomy Teaming Research
  - ❖ Complex Team Tasks
  - ❖ Testbeds/Synthetic Task Environments
  - ❖ Wizard of OZ
- In Depth: The Synthetic Teammate Project

Taking Teaming Seriously in Human Autonomy Teams

Team members have different roles and responsibilities – do not replicate humans and their roles. Exceptions?

Taking Teaming Seriously in Human Autonomy Teams

Effective teams understand that each team member has different roles and responsibilities and avoid role confusion, but back each other up as necessary - autonomy needs understanding of whole task. What does this mean?

Taking Teaming Seriously in Human Autonomy Teams

Effective teams ***share knowledge*** *about the team goals and the current situation and this facilitates coordination and implicit communication – human-autonomy team training?*

Taking Teaming Seriously in Human Autonomy Teams

Effective teams have team members who are interdependent and thus need to <u>interact/communicate</u> even when direct communication is impossible– some other communication model than natural language?

Taking Teaming Seriously in Human Autonomy Teams

<u>Interpersonal trust</u> is important to human teams – autonomy needs to explain and be explicable. But how much and is that enough? Should it be trusted?

CHART Human-Autonomy Teaming Research

- Complex Team Tasks
- Testbeds/Synthetic Task Environments
- Wizard of OZ
- Biometric Sensing

ASU Global Security Initiative

ARIZONA STATE UNIVERSITY

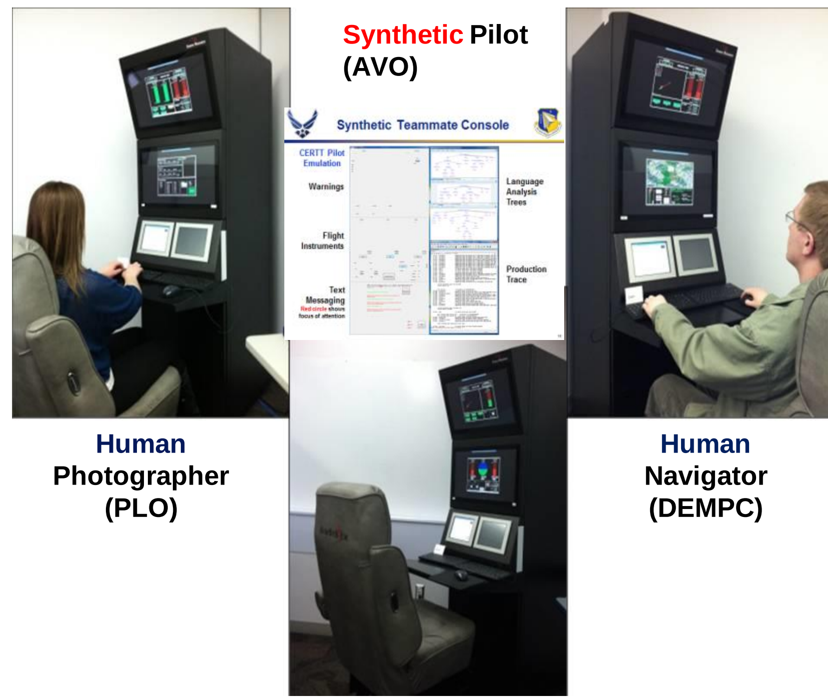
Team Cognition in Sociotechnical Systems

I study the cognitive processing of teams in the context of sociotechnical systems to improve team effectiveness

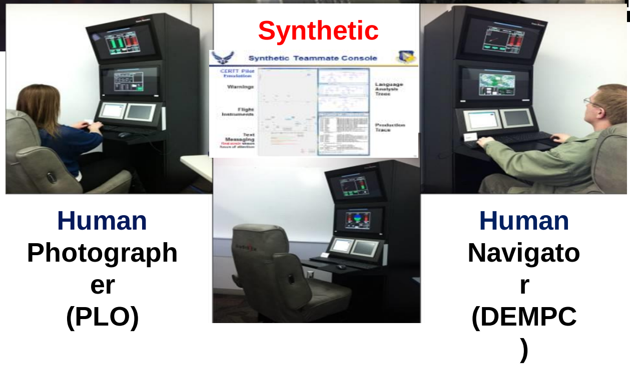
Action-Oriented Teams

Decision Making Teams

Human-Autonomy Teams

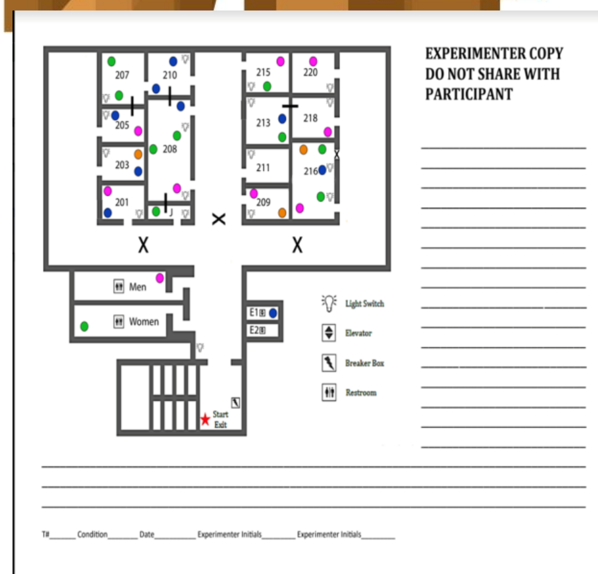


By Using Synthetic Task Environments, we bring the context into the lab



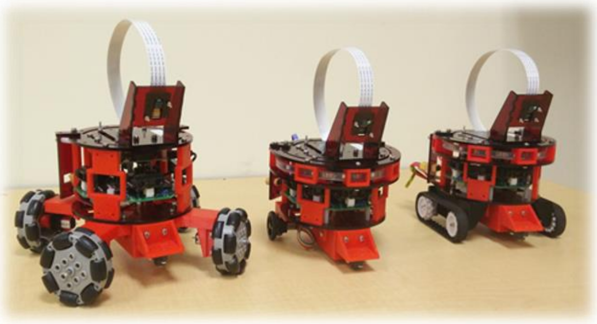
Minecraft Testbed for Human-Robot Teaming for Urban Search and Rescue

- Minecraft simulates a collapsed building
- Wizard of OZ – robot on inside searches for victims and text chats with rescuer
- Human rescuer on outside who has map
- Task is to locate victims needing immediate assistance, mark them on the map and mark structural changes
- Manipulating type of explanation – human aware or not
- Measures
    - Situation Awareness
    - Trust
    - Team Verbal Behaviors
    - Workload
    - Performance
    - Demographics



WoZ allows human-autonomy teaming concerns to drive development of autonomy

CHARTopolis: A Testbed for Studying Driver Interaction with Autonomous Vehicles



- Some vehicles will be autonomous and some remotely driven
- Human-driven cars will have to interact with the driverless cars
- Will be situated in a model urban setting

The Synthetic Teammate Project

Synthetic Teammate Kickoff Meeting
Arizona State University
December 7-8, 2017

Jerry Ball, Nancy Cooke, Mustafa Demir, Jamie Gorman, Craig Johnson, Nathan McNeese, Chris Myers, Steve Shope, Alex Wolff, Sophie He, Garrett Zabala

RPAS Research Testbed

RPAS-STE: Remotely Piloted Aircraft System (ground control station) Synthetic Task Environment

In our RPAS-STE three operators must coordinate over headsets or text chat to maneuver their RPA to take pictures of ground targets

Three team members with inter-dependent tasks

Payload Operator
controls camera settings, takes photos, and monitors camera systems

DEMPC
navigator, mission planner, plans route from target to target under constraints

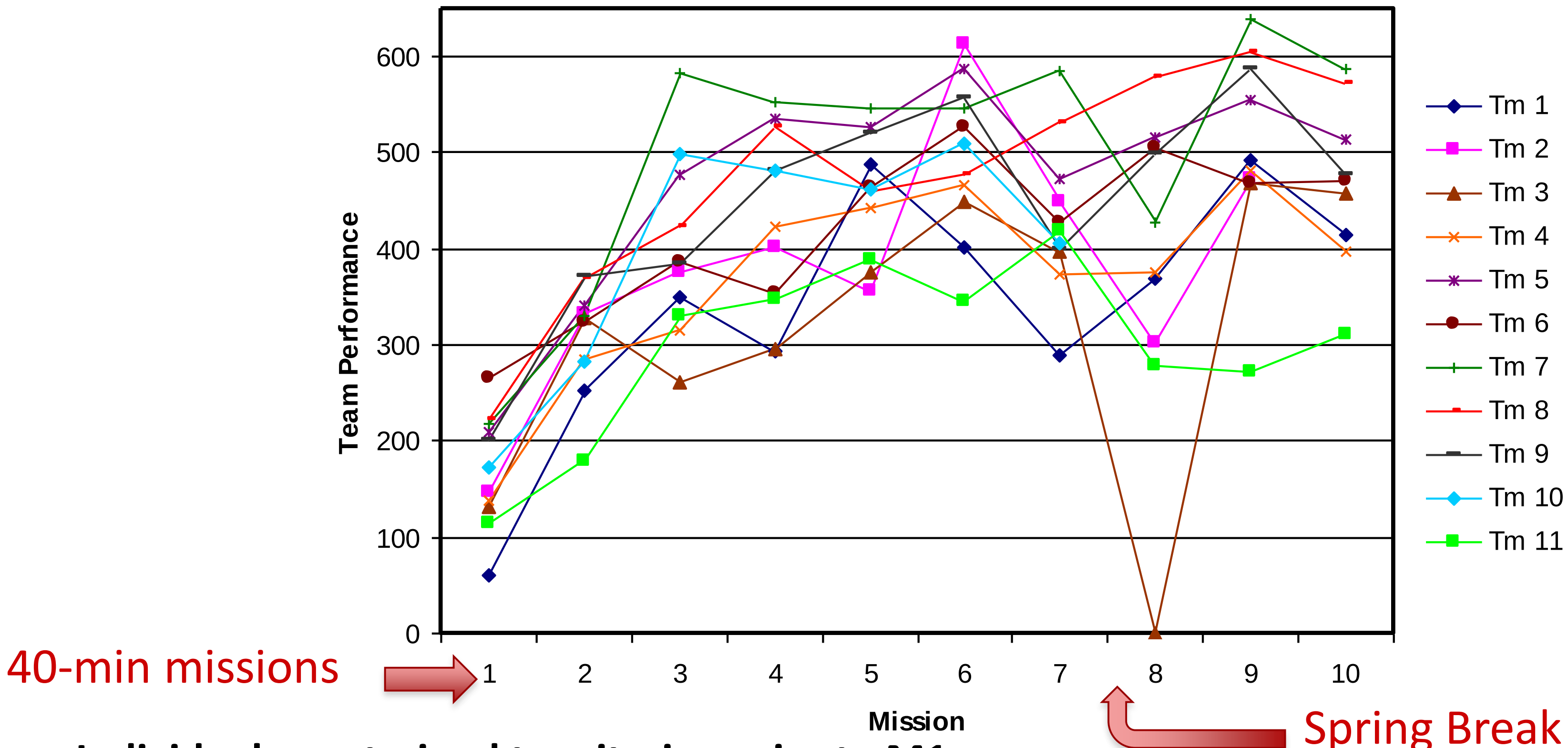
Air Vehicle Operator
controls RPA airspeed, heading, and altitude and monitors air vehicle systems

Interdependence requires interaction, communication, & coordination

Some Early Work with 3-Human Teams

Team Skill Acquisition

As teams acquire experience, performance improves, interactions improve, but not individual or collective knowledge



- **Individuals are trained to criterion prior to M1**
- **Team performance is a composite score based on how many targets they accurately process**
- **Asymptotic team performance after four 40-min missions (robust finding)**
- **Knowledge changes tend to occur in early learning (M1) and stabilize**
- **Process improves and communication becomes more standard over time**

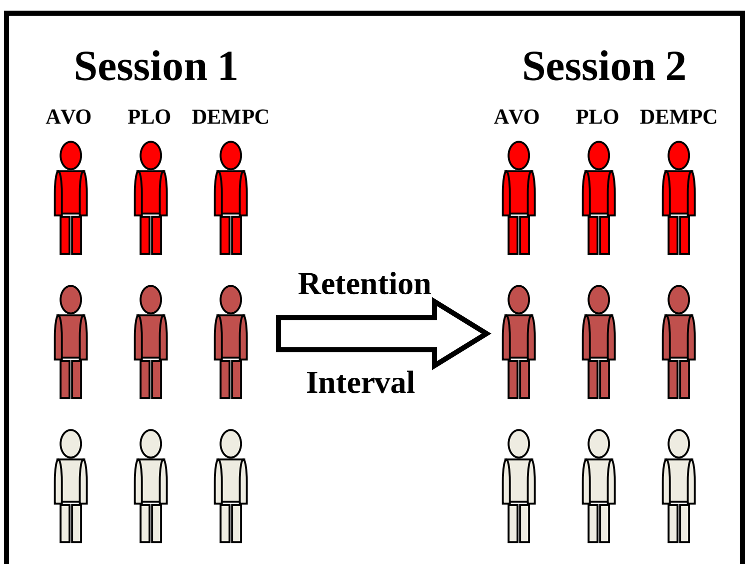
Team Retention & Composition

- 117 males(92) & females(25) divided into 39 3-person (unfamiliar) Session 2 teams
- Two between subjects conditions (retention interval and familiarity) randomly assigned with scheduling constraints
- Participants randomly assigned to one of three roles
- Session 1: 5 40-min missions
- Session 2: 3 40-min missions

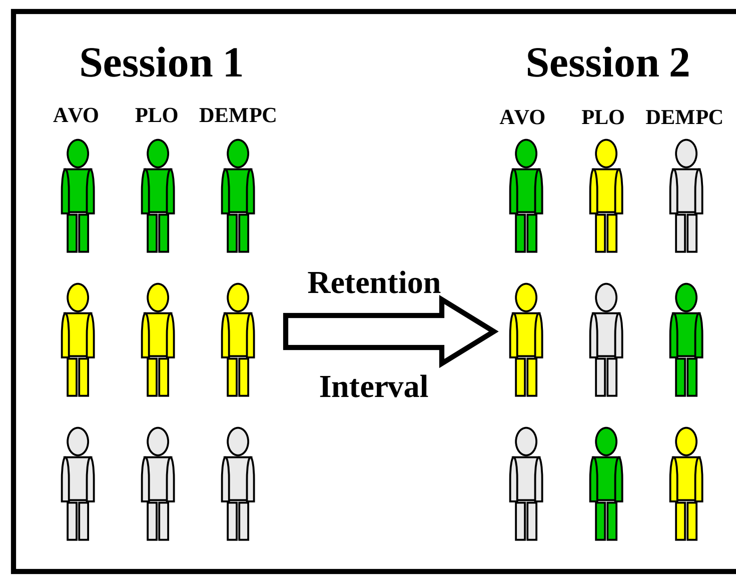
Retention Interval

Composition	3-5 weeks	10-13 weeks
Same	10 Teams	9 Teams
Mixed	10 Teams	10 Teams

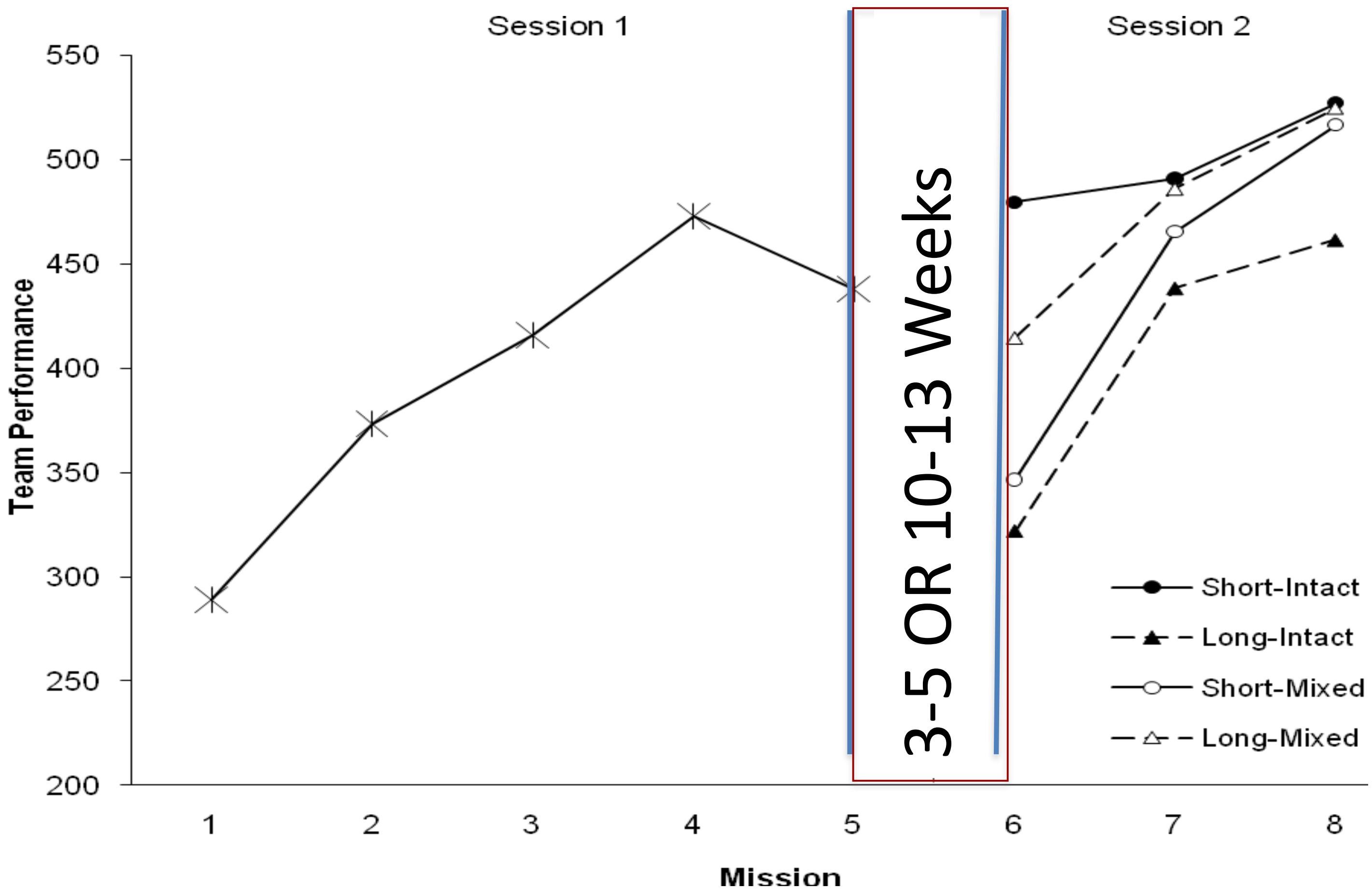
Same Condition



Mixed Condition



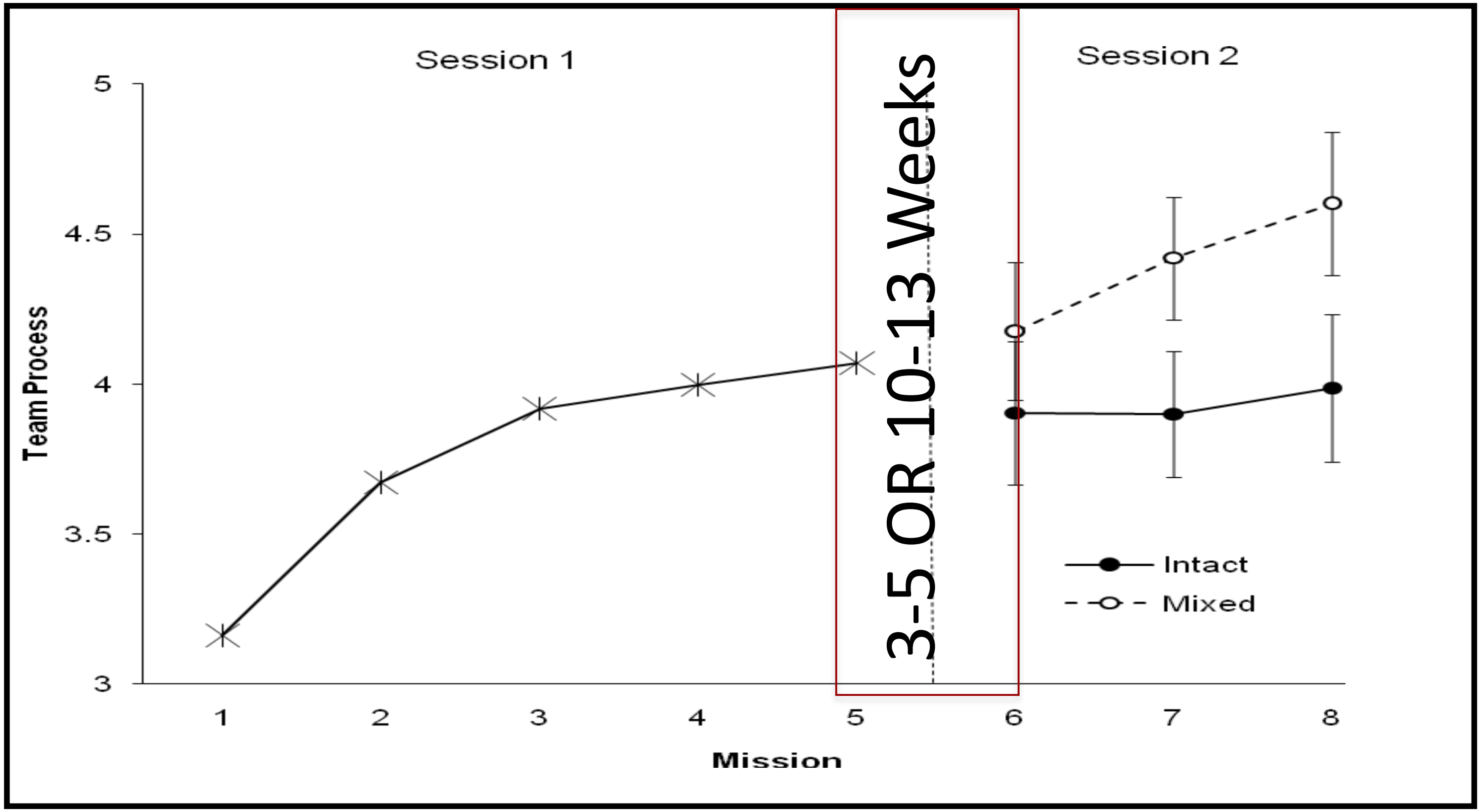
Team Retention and Composition



All but Short-Intact teams suffer <u>performance</u> loss after the break

But a different story for <u>Team Process</u>…
Team Process improves for mixed, but not intact teams after the break.

This is unexpected and supports Interactive Team Cogntiion



(There were no changes in knowledge after the break)

* Result also supported in mission planning testbed – change roles vs. seats

Interactive Team Cognition

Team interactions often in the form of explicit communications are the foundation of team cognition

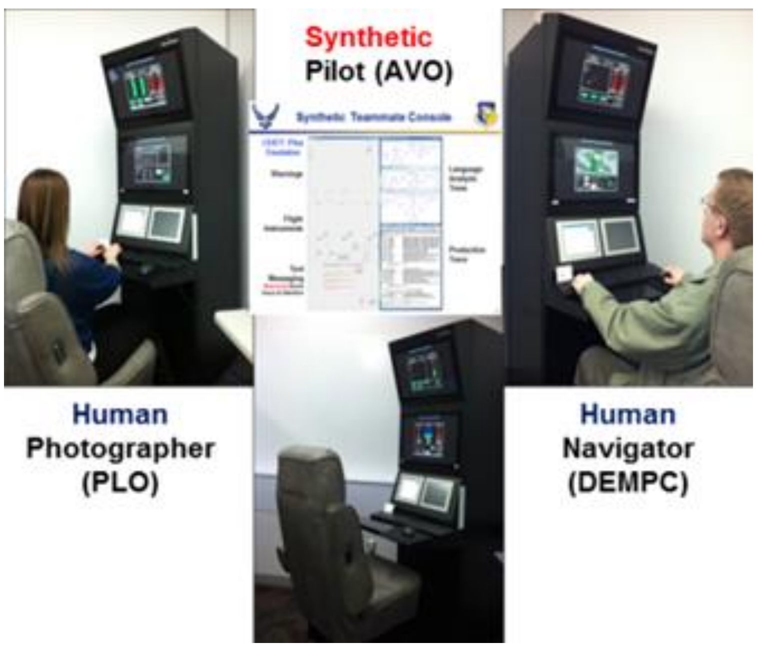
ASSUMPTIONS

1) Team cognition is an **activity; not a property** or product
2) Team cognition is inextricably **tied to context**
3) Team cognition is best measured and studied when the **team is the unit of analysis**

Cooke, N. J., Gorman, J. C., Myers, C. W., & Duran, J.L. (2013). Interactive Team Cognition, *Cognitive Science, 37, 255-285,* DOI: 10.1111/cogs.12009.

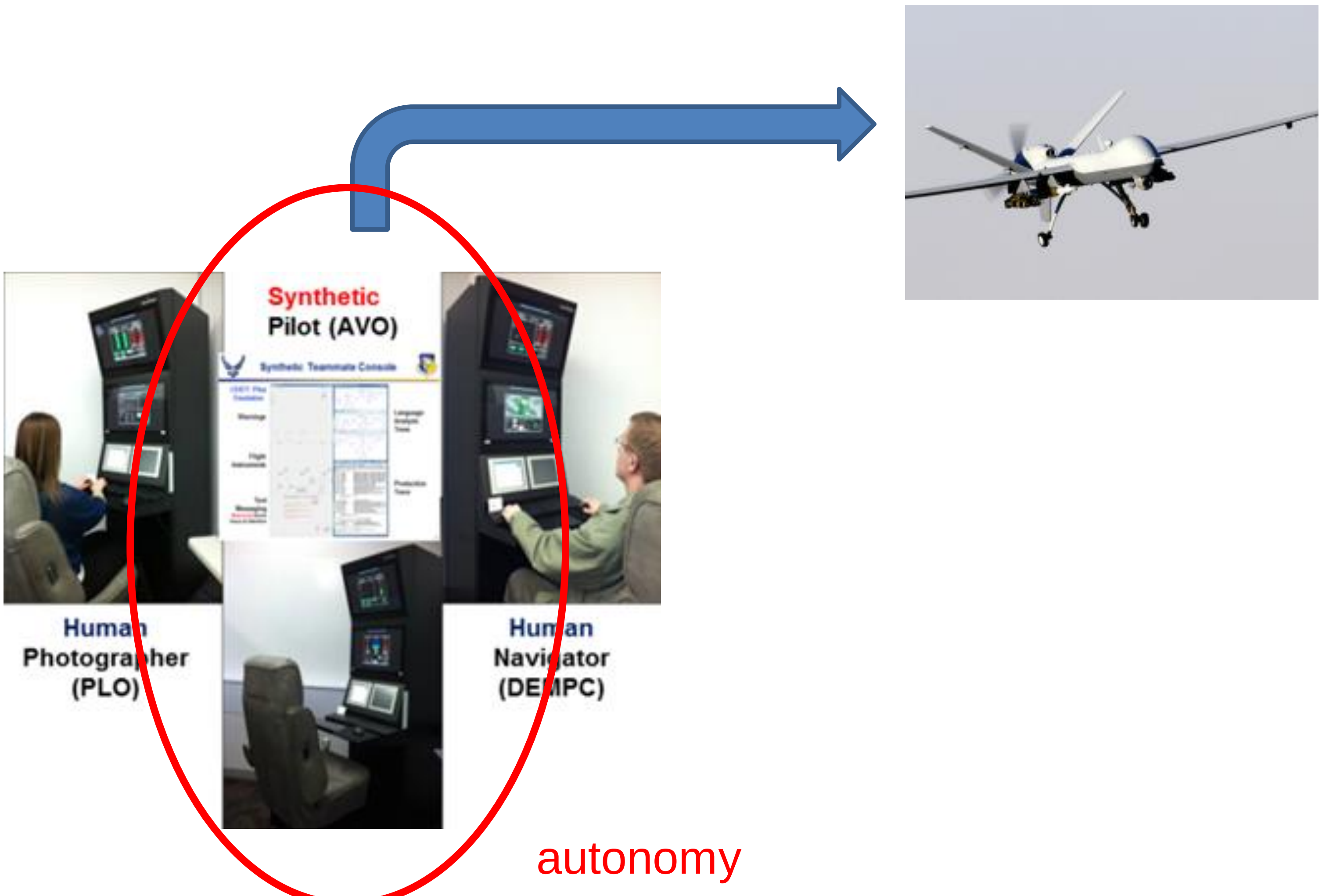
Autonomous agent as a collaborator on a heterogeneous team (role and nature of agent) that operates a Remotely Piloted Aircraft to take reconnaissance photos

Autonomous agent as a collaborator on a heterogeneous team (role and nature of agent) that operates a Remotely Piloted Aircraft to take reconnaissance photos

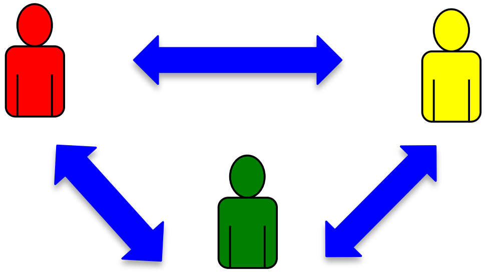


automation

Autonomous agent as a collaborator on a heterogeneous team (role and nature of agent) that operates a Remotely Piloted Aircraft to take reconnaissance photos



IMPLICATIONS OF INTERACTIVE TEAM COGNITION FOR SYNTHETIC TEAMMATE



1) Interaction goes beyond language understanding and generation
2) Coordination is central to this task – timely and adaptive passing of information among team members
3) Humans display sometimes subtle coordination behaviors that may be absent in the synthetic teammate
4) Failures of synthetic teammate will highlight the requisite coordination behaviors

The Synthetic Teammate

- Cognitively plausible agents capable of performing complex tasks & interacting with human teammates in natural language
- Effective team training any time anywhere, in DoD relevant, complex, dynamic environments
- Facilitate transition to new DoD applications

Take cognitive modeling to the level of functional systems

- The largest cognitive model built in ACT-R
  - 2459 Productions
  - 57,949 Declarative Memory chunks
- Among the largest cognitive models built in any cognitive architecture
  - 5 major components
- By computer science standards, a large program

SYNTHETIC TEAMMATE DEMO SYSTEM

CERTT Consoles:
Navigator
Photographer
Pilot

Text Messaging Subsystem

Synthetic Teammate (Pilot)

WPAFB Dayton, OH

THE SYNTHETIC TEAMMATE COMMUNICATES WITH HUMANS

Sender	Sent	Message
DEMPC	517.22	the speed restriction for f-area is from 150 to 200.
PLO	530.16	good photo. go on.
PLO	572.02	go to next waypoint.
DEMPC	633.1	the next waypoint is prk. it is entry.
AVO	736.63	What is the effective radius for oak?
AVO	747.35	What is the next point after prk?
DEMPC	768.78	no effective radius for oak.
DEMPC	803.77	the next waypoint is s-ste. it is target. the altitude restriction is from 3000 to 3100.
AVO	843.41	What is the next point after s-ste?
DEMPC	924.9	the speed restriction for s-ste is from 300 to 350.
DEMPC	982.94	the next waypoint is m-ste. it is target.
DEMPC	1123.08	the next waypoint is m-ste.

SYNTHETIC TEAMMATE VALIDATION EXPERIMENT

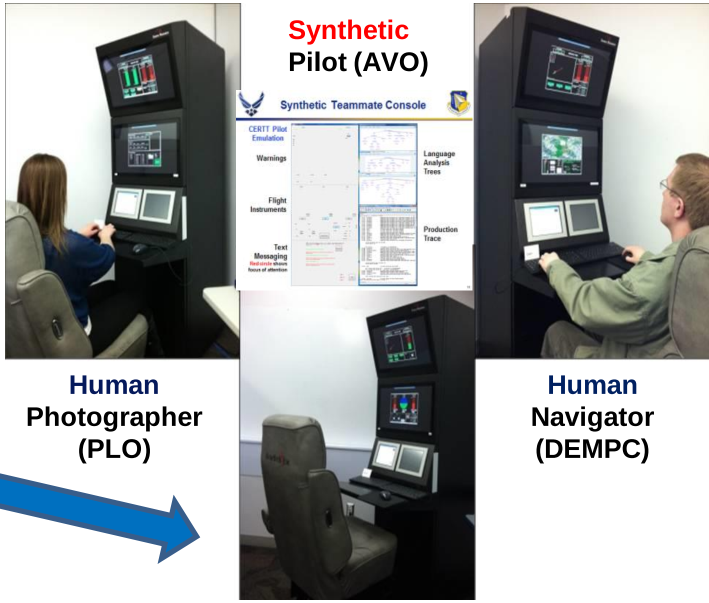
Purpose: Compare synthetic teammate teams to all-human control teams and to an all-human team with an experienced AVO (Experimenter)

Method

Participants: 30 3-agent teams,
10 team per condition

Conditions

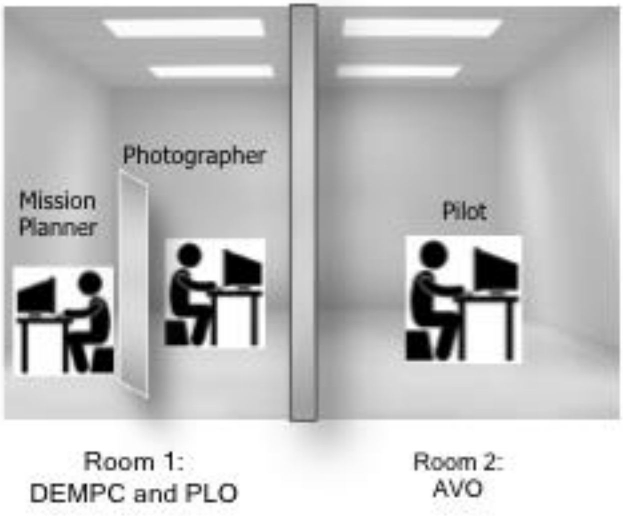
- Synthetic
  - AVO is ACT-R based cognitive model
  - Less expertise than experimenter
- Control
  - AVO is participant
- Experimenter
  - AVO is experimenter (experienced AVO)
  - Pushes and pulls information across team using a coordination script



SYNTHETIC TEAMMATE VALIDATION EXPERIMENT

Procedure

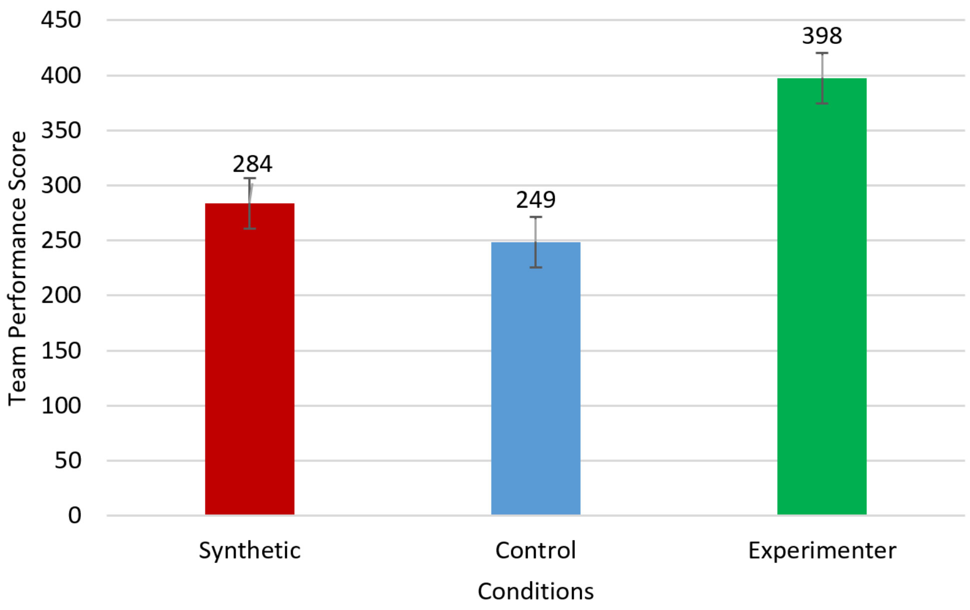
Sessions		Procedure
1	Welcoming	Consent forms.
2	Interactive Training	Interactive Training PowerPoint Slides
3	Training Mission	Hands on Training
4	Mission 1	Mission 1 is conducted
5	NASA TLX/ Knowledge Measures	Session 1: Conducting taskwork and teamwork questions, and administering the workload questions
6	Mission 2	Mission 2 is conducted
7	Mission 3	Mission 3 is conducted
8	Mission 4	Mission 4 is conducted
9	Mission 5	Mission 5 is conducted
11	NASA TLX/ Knowledge Measures	Session 2: Conducting taskwork and teamwork questions, and administering the workload questions
12	Demographics/ Debriefing	Conducting demographic questions, and giving debriefing
13	Post Checklist	



Measures

- Team performance
- Team process (process ratings, communication flow, coordination, situation awareness, verbal behavior)
- Workload, NASA TLX

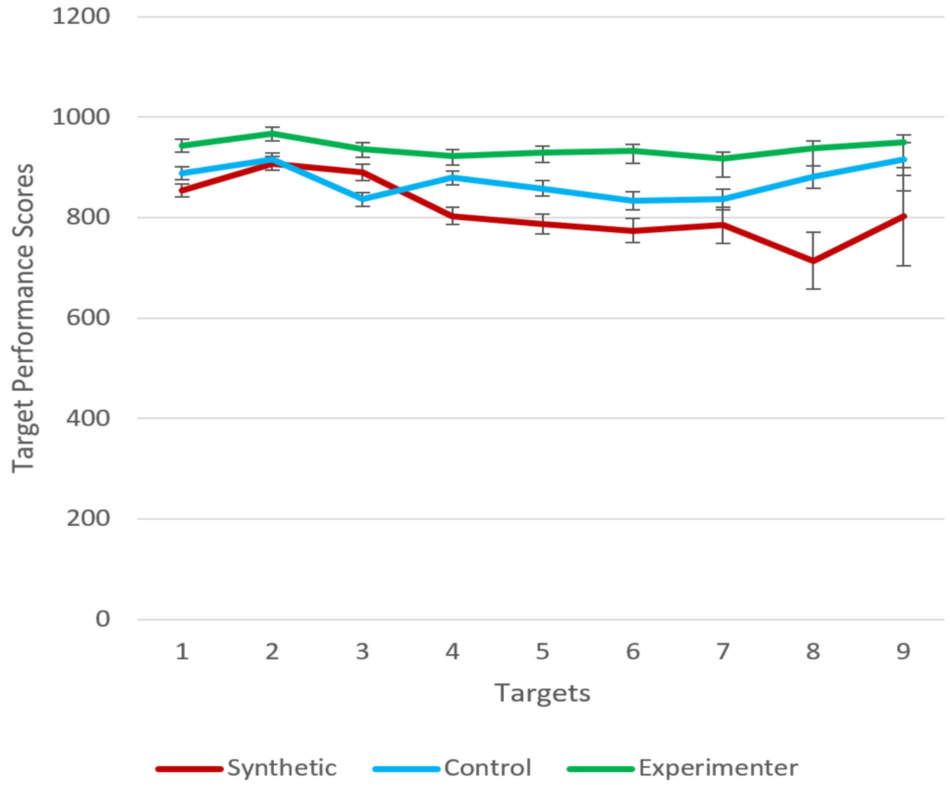
RESULTS: TEAM PERFORMANCE



Synthetic = Control < Experimenter

Experimenter teams demonstrated superior team performance compared to the control and synthetic teams which were statistically equivalent.

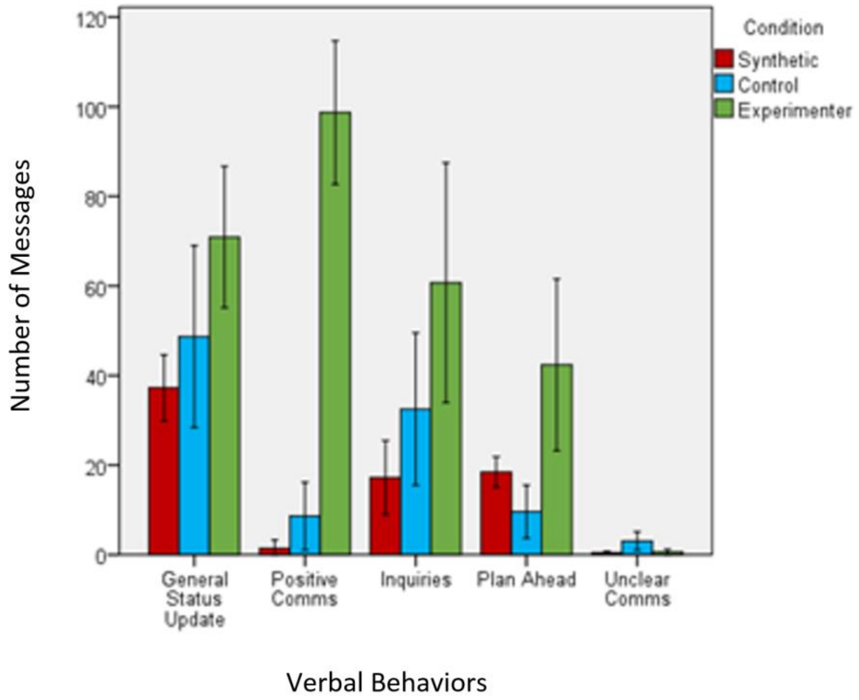
RESULTS: TARGET PROCESSING EFFICIENCY



Synthetic < Control < Experimenter

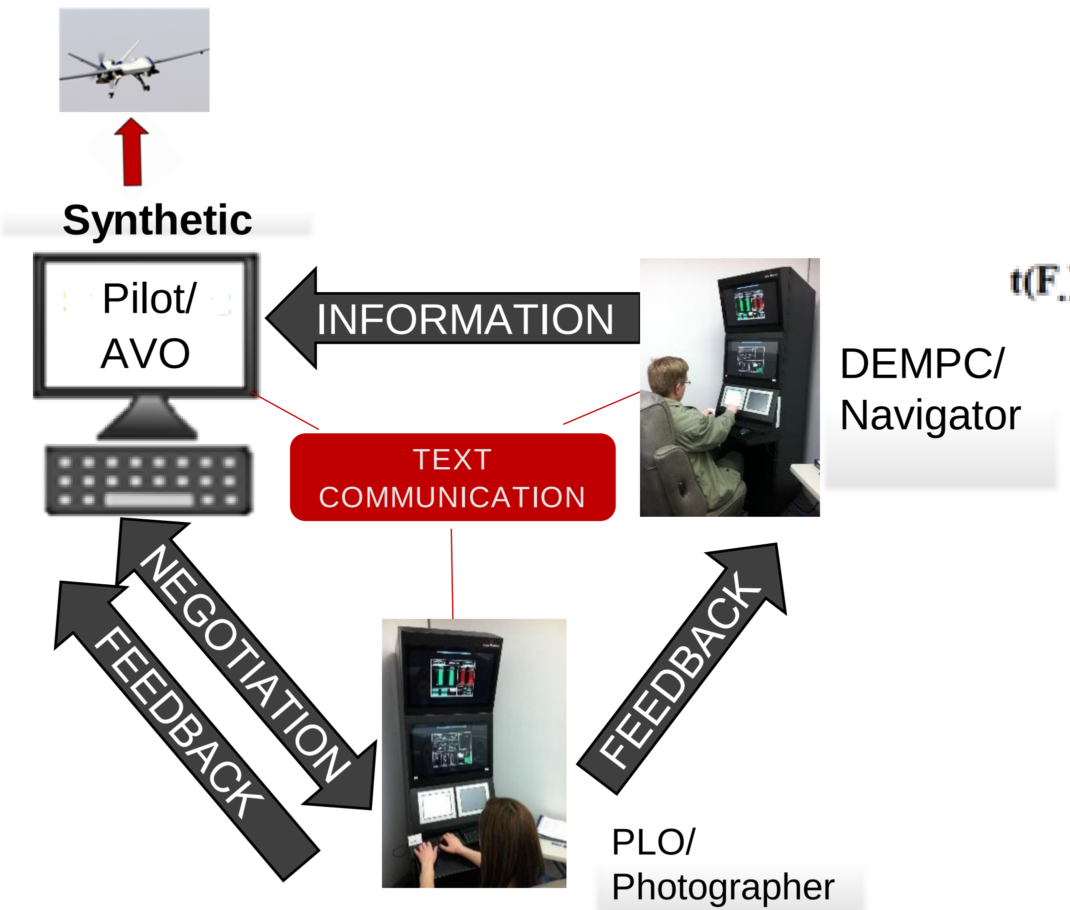
Target processing efficiency was poorer for Synthetic teams than Control teams which was poorer than the Experimenter teams; and the Synthetic teams' processing efficiency declined over time.

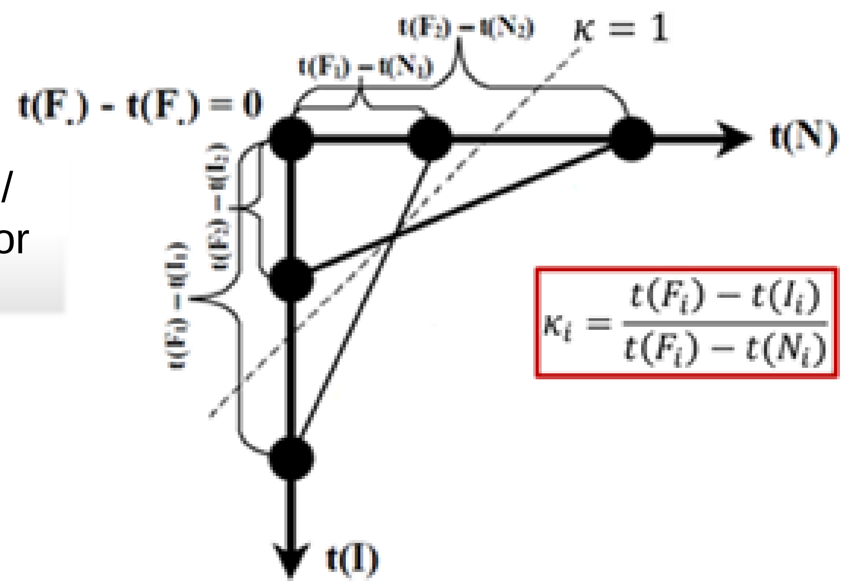
RESULTS: VERBAL BEHAVIORS OF SYNTHETIC VS. HUMAN PILOTS



The Synthetic pilot demonstrates different verbal behaviors compared to Control and Experimenter pilots (fewer status updates, positive communications, inquiries). Also Synthetic teams had fewer general status updates and more repeated requests for information. More pulling than pushing of information.

RESULTS: COORDINATION





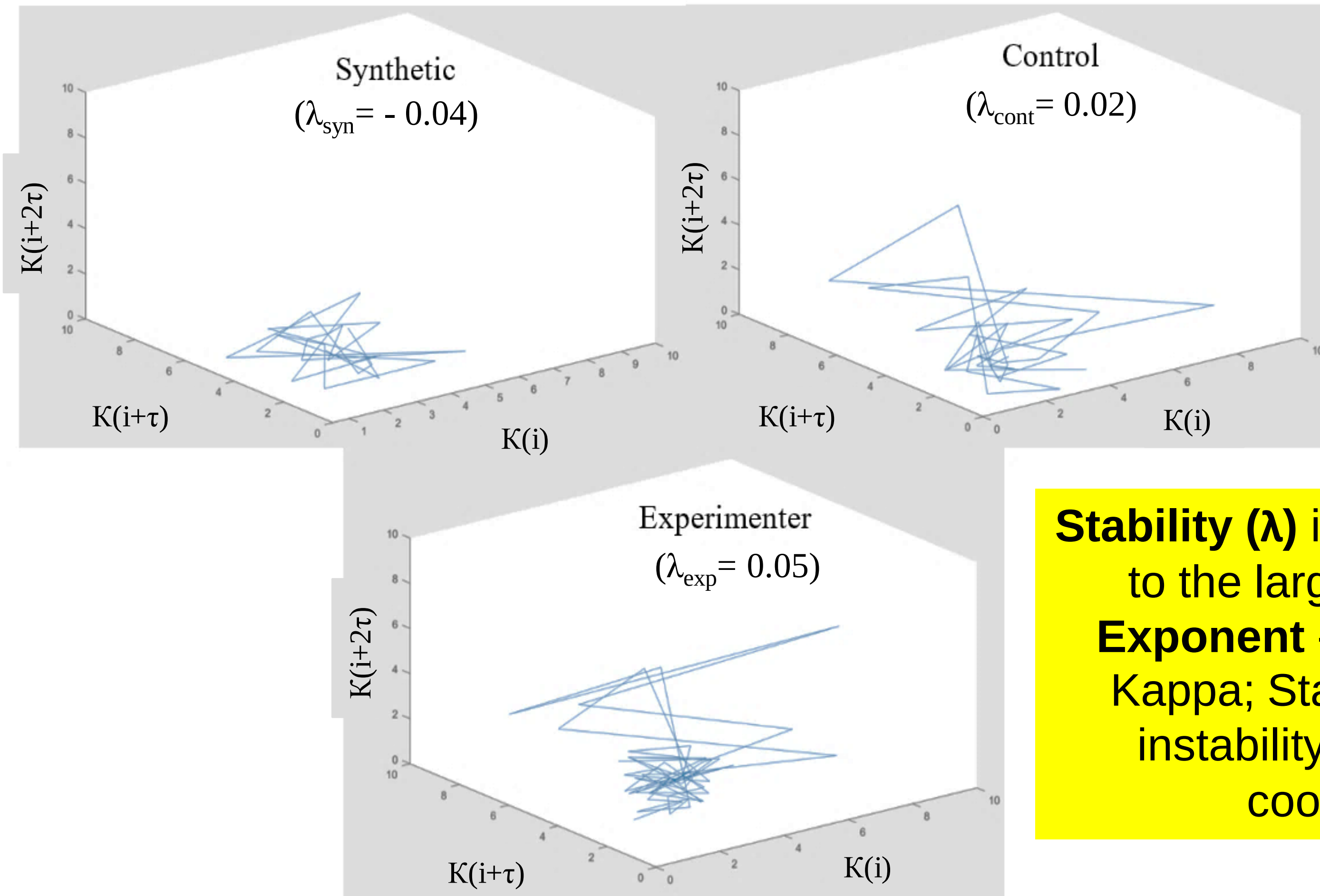
Team coordination: three key communication events at each target waypoint, Information-Negotiation-Feedback (INF), is captured by a Kappa Score (κ) (Gorman, Amazeen, & Cooke, 2010)

RESULTS: ATTRACTOR RECONSTRUCTION

- Attractor reconstruction was used to visualize team coordination dynamics
- Recover a system's dynamical structure from a one-dimensional Kappa time series and time-delayed versions of the Kappa.

From Demir dissertation 4/2017

RESULTS: SYNTHETIC TEAMS MORE STABLE THAN OTHERS

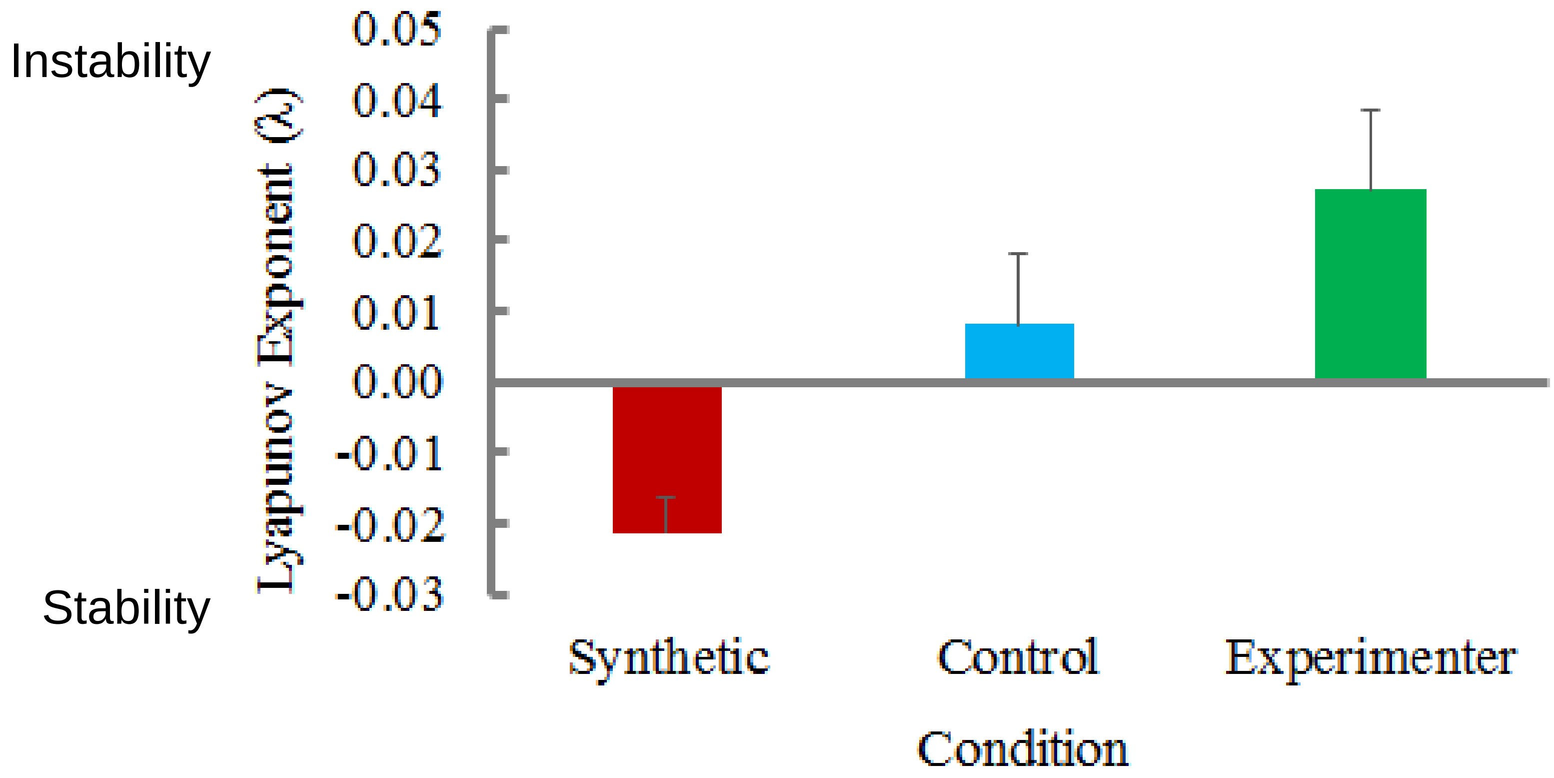


Stability (λ) is inversely related to the largest **Lyapunov Exponent** - estimated from Kappa; Stability ($\lambda<0$) and instability ($\lambda>0$) of team coordination

Sample Reconstructed attractors from three teams: a three-dimensional phase space as coordinates for the three-dimensional space [$\kappa(i)$, $\kappa(i+\tau)$, $\kappa(i+2\tau)$]

From Demir dissertation 4/2017

RESULTS: SYNTHETIC TEAMS MORE STABLE THAN OTHERS



Mean largest Lyapunov exponents = **Stability** across the conditions (vertical lines indicate SE) **synthetic < control = experimenter**
From Demir dissertation 4/2017

RESULTS: JOINT RECURRENCE QUANTIFICATION ANALYSIS (JRQA)

JRQA was used to assess joint influence of one team member on the other

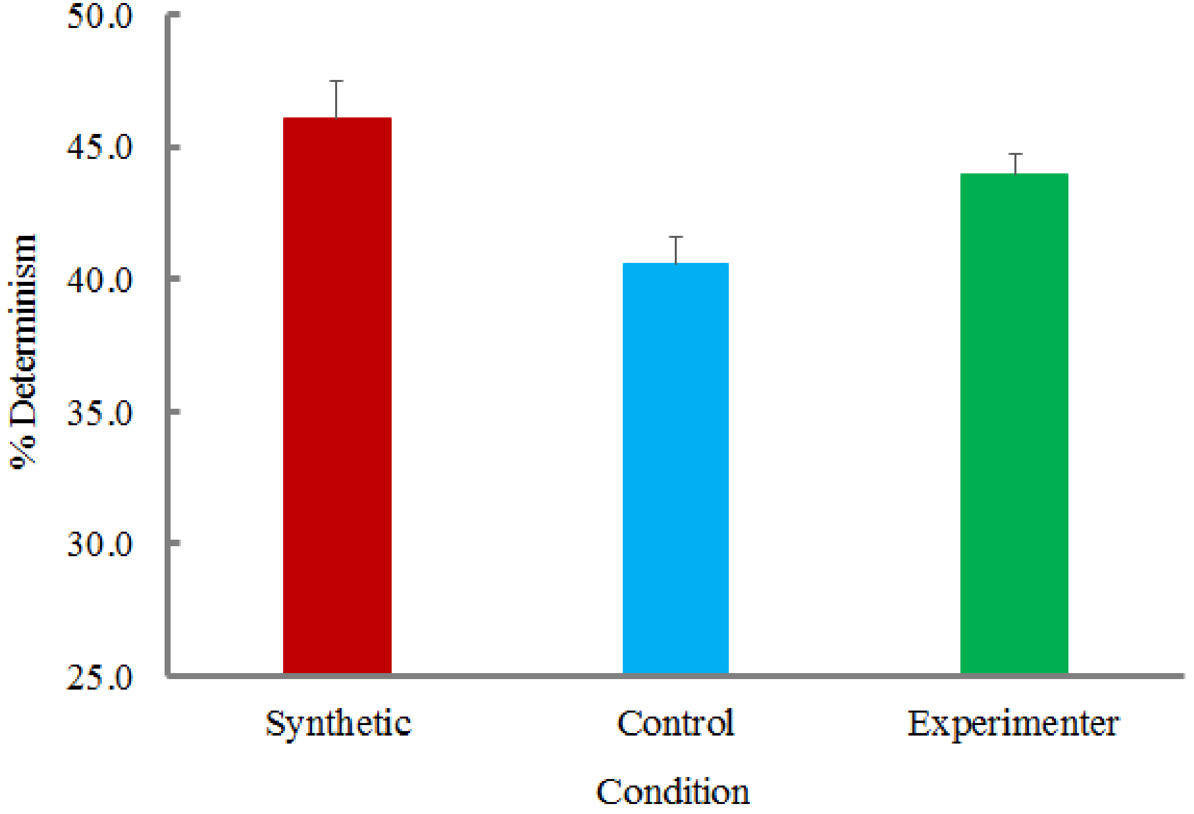
- JRQA was applied on communication flow data (i.e., sent time stamp from each UAV mission)
- % Determinism (DET): measure of system's predictability was extracted from JRQA

From Demir dissertation 4/2017

RESULTS: SYNTHETIC TEAMS MOST STABLE/PREDICTABLE AND CONTROL LEAST

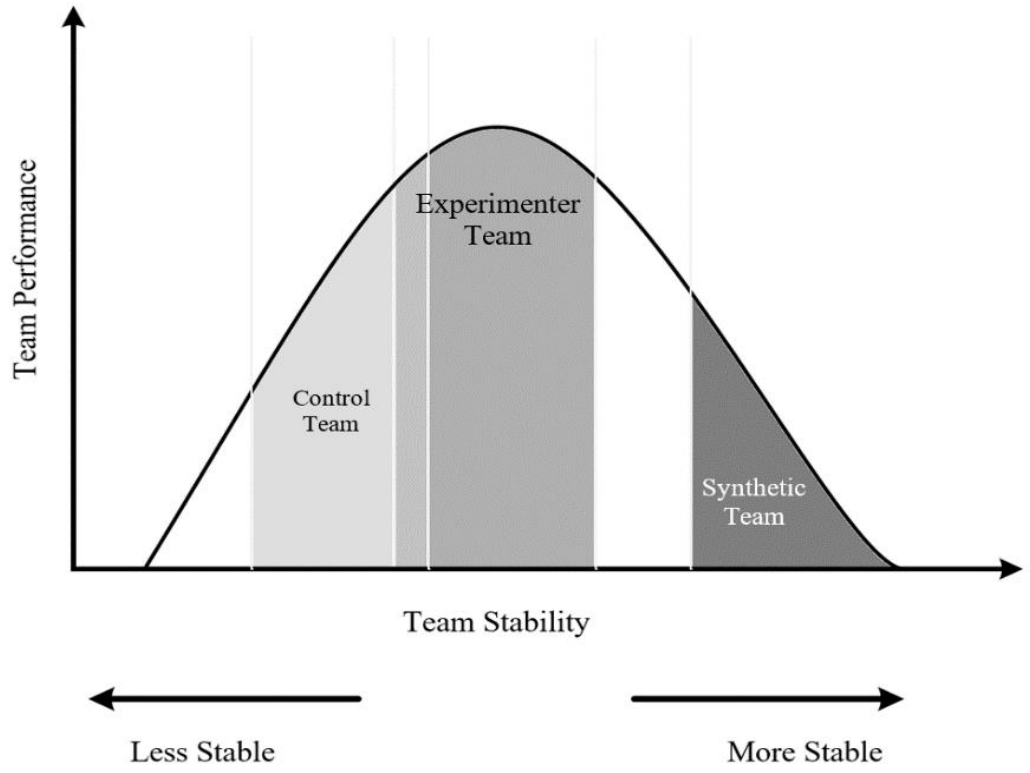
More Predictable

Less Predictable



Mean % DET = **Predictability** across the conditions
(vertical lines indicate SE) **synthetic > control < experimenter**
From Demir dissertation 4/2017

RELATION BETWEEN TEAM PERFORMANCE AND COORDINATION

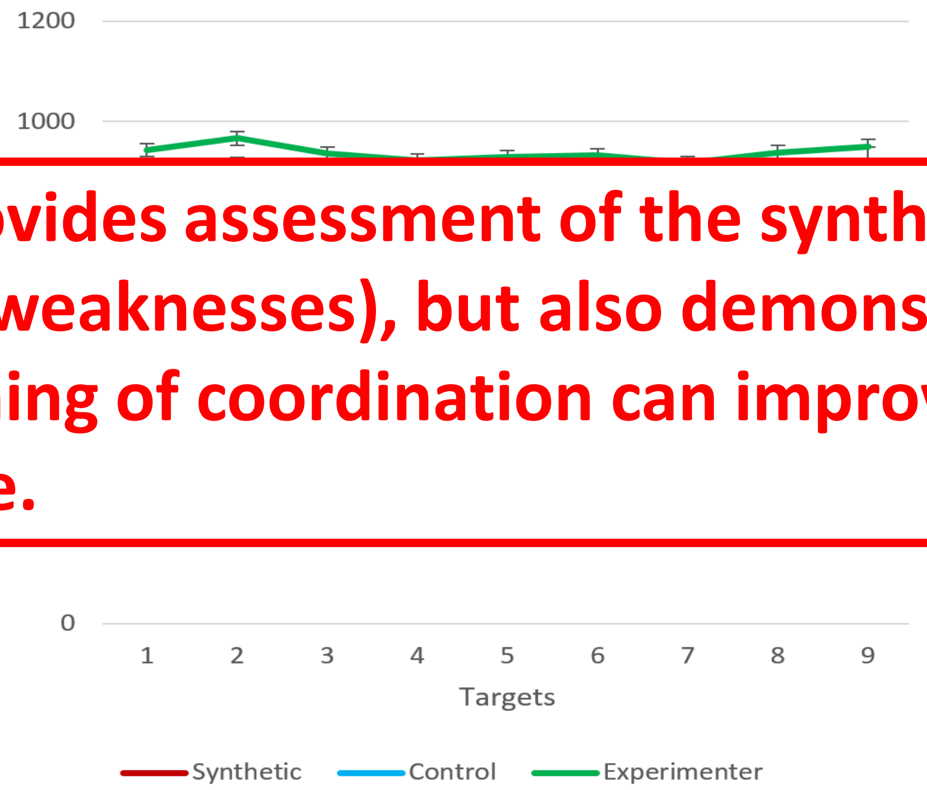


From Demir dissertation 4/2017; Coordination stability “sweet spot” discovered

SYNTHETIC TEAMMATE VALIDATION RESULTS

- The synthetic teams performed as well as control teams, but had difficulties coordinating and processing targets efficiently – failure to anticipate
- A synthetic teammate can impact team coordination and performance - entrainment
- Experimenter condition demonstrates how a teammate who excels at coordination can elevate coordination of the whole team
- Conditions were nominal. Coordination especially important in off-nominal conditions.

Results: Target Processing Efficiency



Not only provides assessment of the synthetic teammate (along with weaknesses), but also demonstrates how subtle coaching of coordination can improve team performance.

Synthetic < Control < Experimenter

Target processing efficiency was poorer for Synthetic teams than Control teams which was poorer than the Experimenter teams; and the Synthetic teams' processing efficiency declined over time.

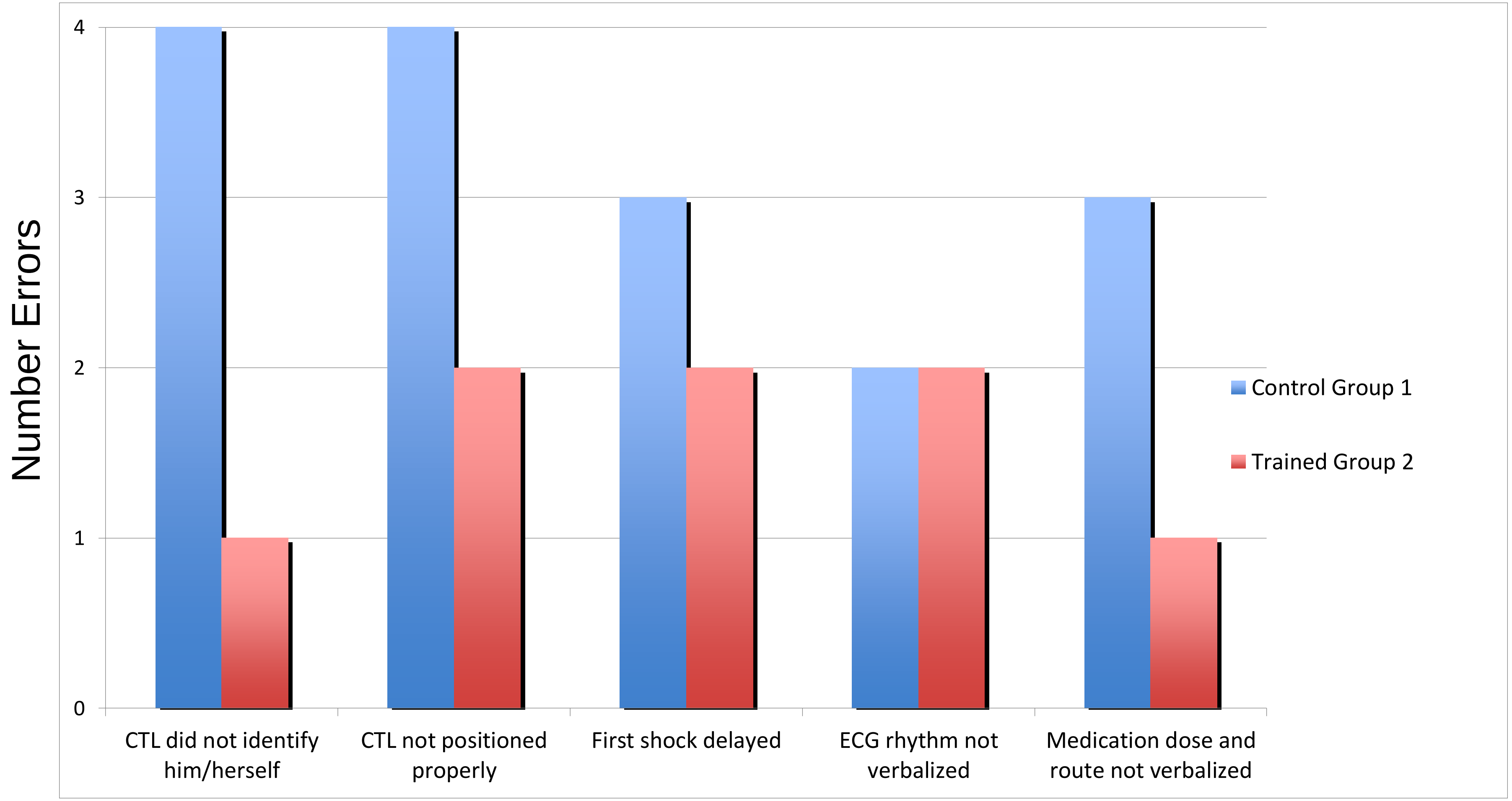
Applying Coordination Coaching to Code Blue Resuscitation

Sandra Hinski (2017) dissertation, ASU

Intensivist code leaders studied communication model for 5-10 min. prior to mock code

Arrival to code	Introduces self as code team leader
Contingency	IF: Code RN does not immediately give the CTL a brief history, code status, and confirm advanced monitoring is established THEN: CTL must directly ask the Code RN for the information
Within 30 seconds of arrival to code	Asks about ABCs IF: No one person is performing CPR or performing bag mask ventilating upon arrival of CTL THEN: CTL must direct code team member to immediately perform CPR and the RT to bag the patient
Once monitoring is established	Asks for ACLS therapies as indicated IF: Medication or shock delivery is delayed more than 10 seconds after identification of rhythm THEN: CTL must directly as pharmacist or RN do deliver the meds and/or shock
constant feedback	Asks if there are any problems, so CTL can troubleshoot or delegate task to another person, keeps team on task, should be in SBAR format
Contingency	IF: Code team does not clarifies ROSC/stabilization of ABCs OR clinical worsening THEN: CTL must clarify disposition (i.e. transfer to ICU, need for more advanced therapies, discontinuation of efforts, etc.)

Code Team Errors



Human-Autonomy Teaming
Under Degraded Conditions

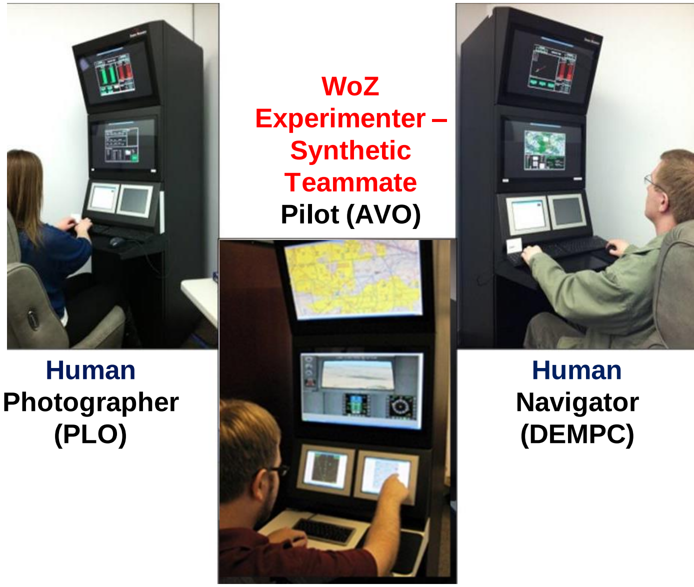
Purpose: Identify challenges of human-autonomy teaming under degraded conditions and strategies of high performing teams to address them.

Method

Wizard of Oz Paradigm: synthetic pilot was mimicked by an experienced (remote) experimenter who failed in specific ways at specific times

Participants: 21 3-agent teams

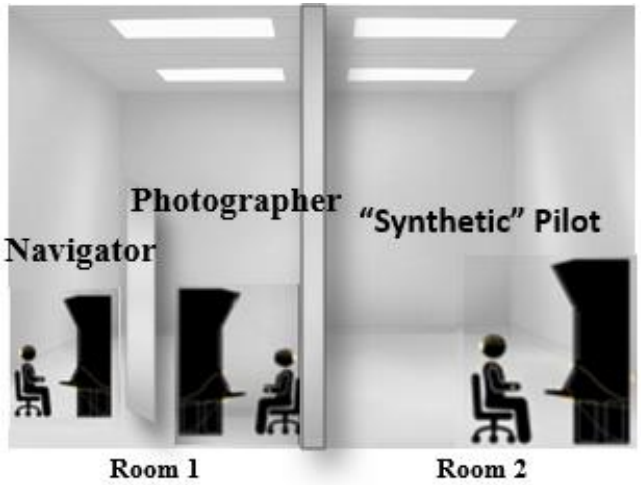
10 Missions (with multiple targets) across two sessions



Human-Autonomy Teaming Under Degraded Conditions

Procedure (Two Sessions separated by 1-2 week interval)

SESSION-I (with breaks Total: 6 hours)	SESSION-II (with breaks Total: 7 hours)
1) Consent forms (15 min)	**1)** Mission 5 (40 min),
2) PowerPoint (30 min) and hands on training (30 min)	**2)** NASA TLX I (15 min)
3) Mission1 (40 min)	**3)** Mission 6 (40 min),
4) NASA TLX I (15 min)	**4)** Mission 7 (40 min),
5) Missions 2 (40 min)	**5)** Mission 8 (40 min),
6) Mission 3 (40 min),	**6)** Mission 9 (40 min),
7) Mission 4 (40 min),	**7)** Mission 10 (40 min),
8) NASA TLX-II, Trust & Anthropomorphism (30 min)	**8)** NASA TLX-II, Trust, Anthropomorphism, Demographics, and Debriefing (30 min)
	9) Post-Check Procedure (15 min)



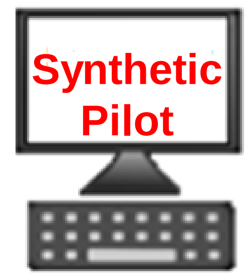
Measures

- Team performance (mission and target levels)
- Team process (process ratings, communication flow, coordination, situation awareness, verbal behavior)
- Team trust & resilience
- Workload (NASA TLX)
- Anthropomorphism
- Heart Rate (ECG), Electrical Activity of the Brain (EEG), & Facial Expression

Human-Autonomy Teaming Under Degraded Conditions

- **Automation Failures –** display fails

- **Autonomy Failures –** synthetic teammate comprehension failure



- **Malicious Attacks on Autonomy** provides appropriate feedback as it enters wrong area

Human-Autonomy Teaming Under Degraded Conditions

Experimental Sessions and Application of Failures during specific targets for each mission

		Target/ Automation	Target/ Autonomy	Target/ Malicious
Session I	Training	No Failure	No Failure	No Failure
	Mission 1	No Failure	No Failure	No Failure
	Mission 2	2nd/ Type I	4th/ Type I	No Failure
	Mission 3	4th/ Type II	2nd/ Type II	No Failure
	Mission 4	1st/ Type III	3rd/ Type III	No Failure
Session II	Mission 5	2nd/Type III	4th/ Type II	No Failure
	Mission 6	4th/ Type I	2nd/ Type I	No Failure
	Mission 7	1st/ Type II	3rd/ Type II	No Failure
	Mission 8	3rd/Type III	1st/ Type III	No Failure
	Mission 9	3rd/Type II	5th/ Type II	No Failure
	Mission 10	2nd/Type III	4th/ Type III	Last 10 min

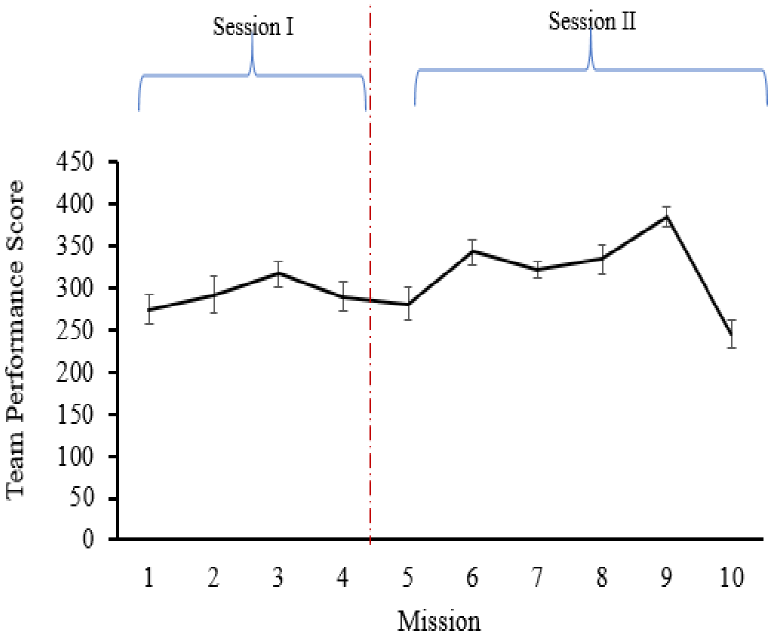
RESULTS: OVERCOMING FAILURES AND ATTACKS

Automation & Autonomy Failures, and Malicious Attacks

- Proportion of 22 teams that overcame failures was approximately equal for both types: automation (65%) and autonomy (64%), and malicious attacks (41%)
- Performance of overcoming *automation failures* increased across the missions, but decreased for *autonomy failures*

RESULTS: TEAM PERFOMANCE

Team Performance (Mission Level)



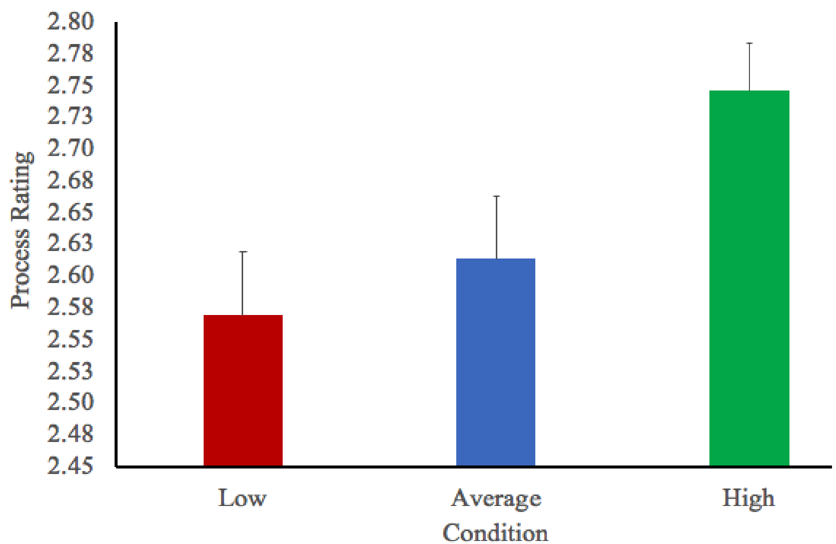
Team performance increased across the missions.

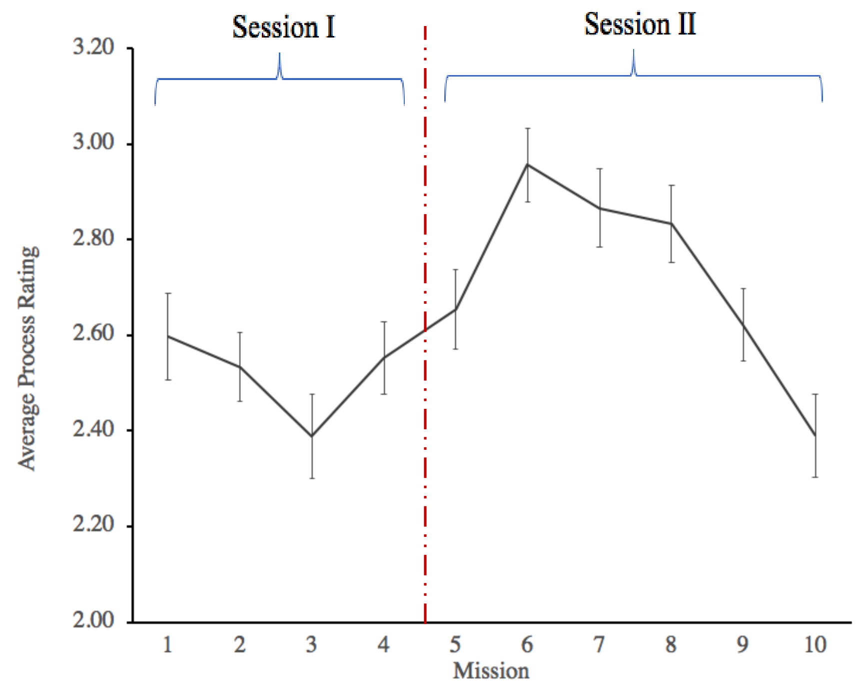
Clusters Based on Performance

- Identify high vs. low performing teams
- Team clusters via K-Means Cluster analysis
- Data
  - Mission performance score
  - Target performance score
  - Number of failures overcome
- Resulted in 3 groups of teams

Metrics\ Conditions	High-Performed	Average	Low-Performed
Number of Teams	6	8	6

RESULTS: TARGET PROCESS RATING

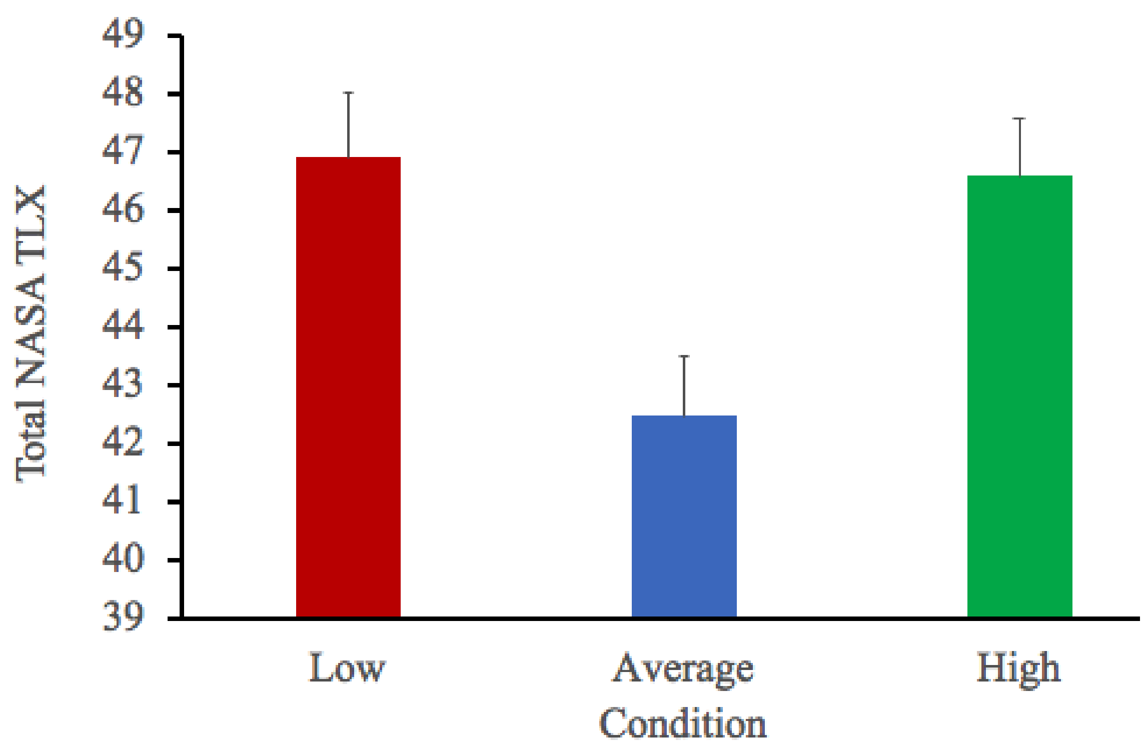




Low = Average < High Performed Teams

High-performing teams demonstrated superior team process compared to the <u>average and low teams which were statistically equivalent</u>.

RESULTS: NASA TLX WORKLOAD



High-performed = Low > Average-performed teams

The average teams had lower workload than the low- and high-performing teams; and the photographer had lower workload than the navigator.

RESULTS: TRUST

1) lower levels of trust in the autonomous agent in low performing teams than both medium and high performing teams

2) there is a loss of trust in the autonomous agent across low, medium, and high performing teams over time

3) both low and medium performing teams also indicated lower levels of trust in their human team members

Coordination Dynamics Under Degraded Conditions

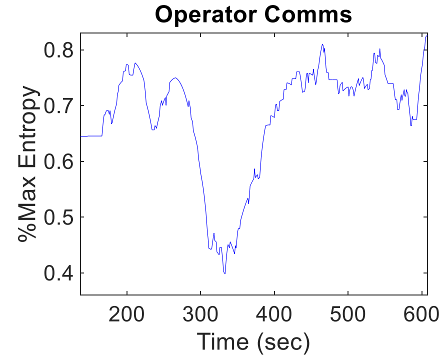
- These analyses utilize database files that contain timestamped information of vehicle, controls, and communication state throughout a mission
  - *Layered dynamics* – visualizing and tracking changes in how the system (RPAS) is organized over time
  - *Deep dive* – content analysis of mission chat transcripts to understand how the humans and autonomy dealt with automation failures and how the humans dealt with autonomy failures

Sender	Sent_Mission_Time	AVO_Recipient_Read_Time	PLO_Recipient_Read_Time	DEMPC_Recipient_Read_Time
PLO	24.04	0	0	57
AVO	97.24	0	0	133
DEMPC	136.06	138	0	0
AVO	155.07	0	0	183
PLO	181.77	0	0	212
DEMPC	215.34	218	0	0
PLO	243.65	263	0	0
AVO	245.87	0	247	0
AVO	263.46	0	269	0
AVO	275.6	0	0	277
AVO	296.83	0	0	298
PLO	313.01	317	0	315
AVO	316.65	0	333	0
AVO	330.4	0	353	0

Layered dynamics

A. Input Database

Sender	Sent_Mission_Time	AVO_Recipient_Read_Time	PLO_Recipient_Read_Time	DEMPC_Recipient_Read_Time
PLO	24.04	0	0	57
AVO	97.24	0	0	133
DEMPC	136.06	138	0	0
AVO	155.07	0	0	183
PLO	181.77	0	0	212
DEMPC	215.34	218	0	0
PLO	243.65	263	0	0
AVO	245.87	0	247	0
AVO	263.46	0	269	0
AVO	275.6	0	0	277
AVO	296.83	0	0	298
PLO	313.01	317	0	315
AVO	316.65	0	333	0
AVO	330.4	0	353	0



C. Calculate moving window entropy of symbolic time series

Chat Event	Symbol
AVO-->PLO and DEM	1
AVO-->PLO	11
AVO-->DEM	111
PLO-->AVO and DEM	4.5
PLO-->AVO	22
PLO-->DEM	222
DEM-->AVO and PLO	3
DEM-->AVO	33
DEM-->PLO	334

B. Symbol Encoding

NULL | AVO→DEM | AVO→PLO + DEM→AVO | DEM→AVO

[…0, 0, 111, 111, 111, 111, 44, 44, 44, 33, 33, 0, 0…]

Example Snippet of a Symbolic Time Series (1Hz)

- *Windowed entropy measures the number of arrangements a system occupies over a fixed amount of time.*
- *Entropy is one operational definition of system reorganization (others are %DET and %REC).*

Layered dynamics

Different layers for visualizing and tracking where failures are addressed in the system

Vehicle

<u>Fuel</u>
<u>Battery</u>
<u>Film</u>
<u>Temperature</u>
<u>Left Turn</u>
<u>Right Turn</u>
<u>Warning/Alarm</u>
<u>Altitude</u>
<u>Airspeed</u>
Climbing
Descending
Accelerating
Decelerating
Flaps Position
Gear Position
X Location
Y Location

Controls

<u>Set Shutter Speed</u>
<u>Set Focus</u>
<u>Set Camera Type</u>
<u>Set Aperture</u>
<u>Set Zoom</u>

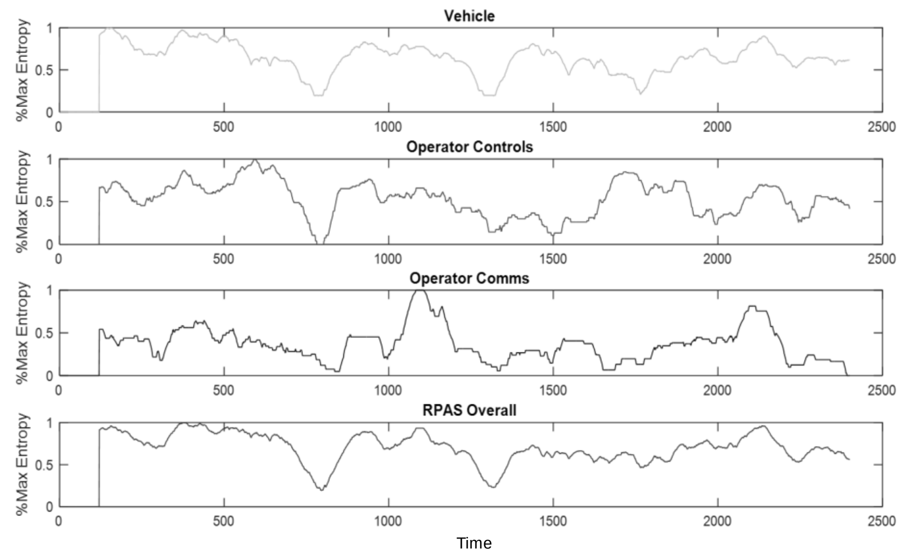
<u>Check Required Settings</u>
<u>Charge Battery</u>
<u>Reset Lens</u>
<u>Reset Temperature</u>
<u>Take Photo</u>
<u>Accept Photo</u>
<u>Change Current Route</u>
<u>Send Route Plan</u>
<u>Request Flight Plan</u>
<u>New Queued Waypoint</u>
<u>New To Waypoint</u>
<u>Set Center of Gravity</u>
<u>Set Airspeed</u>
<u>Set Altitude</u>
<u>Refuel</u>

Communications

<u>AVO-->PLO and DEM</u>
<u>AVO-->PLO</u>
<u>AVO-->DEM</u>

<u>PLO-->AVO and DEM</u>
<u>PLO-->AVO</u>
<u>PLO-->DEM</u>

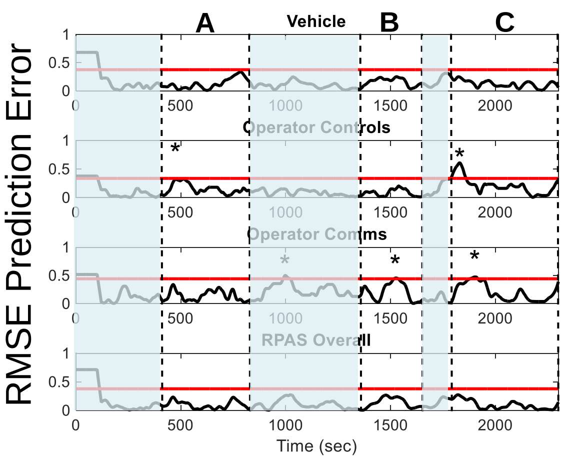
<u>DEM-->AVO and PLO</u>
<u>DEM-->AVO</u>
<u>DEM-->PLO</u>

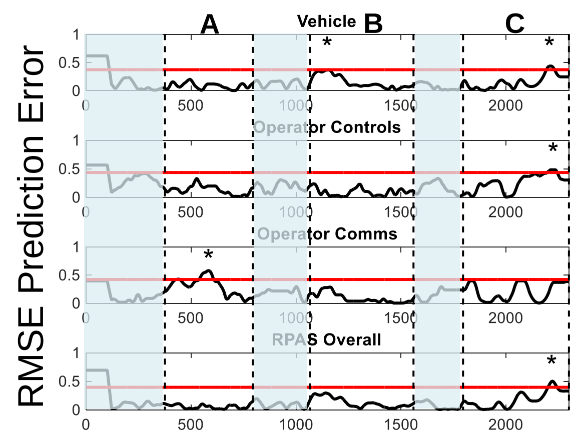


Layered Dynamics

<u>Reorganization time</u> – time from failure onset to peak significant system reorganization

A – automation failure B – autonomy failure C – malicious attack on autonomy





Effective = successfully overcoming failures

<u>Effective teams tend to:</u>

- Autonomy failures
  - Short reorganization time in the Controls/Vehicle layers ($p < .05$)
- Automation failures
  - Long reorganization time in the Communication layer ($p < .05$)

Summary: What we Have Found from the Dynamics Thus Far

For building resilient teams, intervention(s) may be developed around the core concepts of locus of resilience and loci of reorganization

Resilience to Failures

More Dynamic — More Static

Dimensions	Automation Failures	Autonomy Failures
Locus of Resilience	Interaction-based	Role-related
Behavioral Qualities	Adaptivity	Consistency/Persistence
Theoretical Underpinning	Interactive Team Cognition	I/O, Social Psychology
Measures	CAST	Trust, Anthrop., Demo's
Mechanism(s)	Communication/Interaction	Traits, Dispositions, Attitudes

Human-Autonomy Teaming Under Degraded Conditions

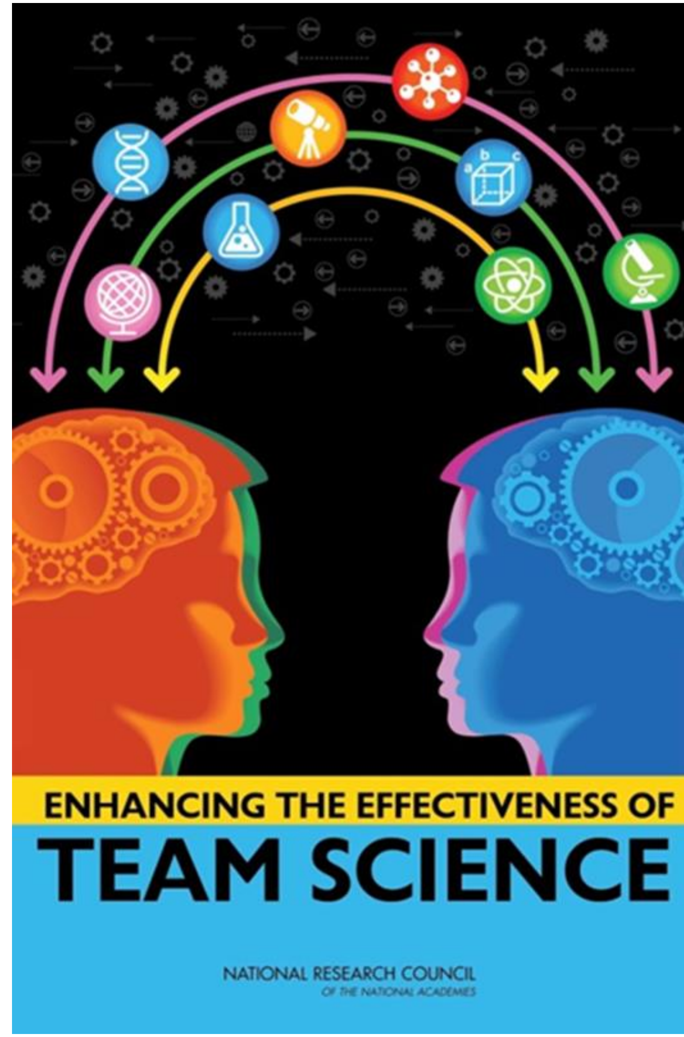
- High performing teams exhibit superior process behaviors, and also higher workload
- Trust in autonomous agent declines over time with increasing failures and is especially low for low performing teams
- Response to failures in automation requires team coordination
- Response to failures in autonomy may be more linked to attitude and trust
- Next study will test an intervention to improve response to failures

Next Steps: Taking Team Performance Measurement Out of the Lab

- Outcome can be measured in the lab because we know ground truth
- Outside of the lab, there is often no ground truth (cyber, intelligence, RPAS, USAR)

- Often team performance is measured as outcome
  - In the lab effective teams have positive outcomes
  - Outside the lab there is no obvious outcome (science teams) or outcome ≠ effectiveness (Code Blue Resuscitation, sports)

Outcome vs. Effectiveness



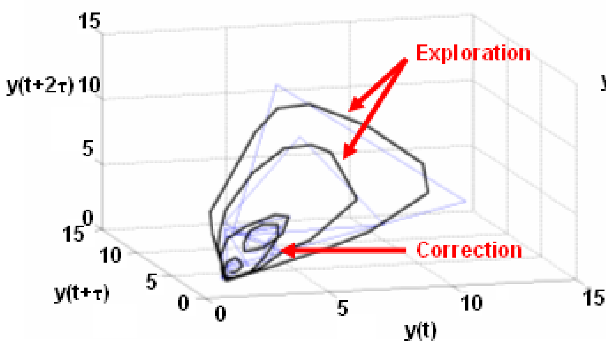
Measuring Team Effectiveness

What is team effectiveness?

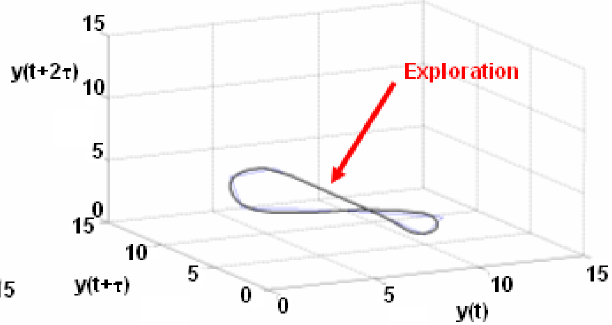
– Adaptivity: Teams respond quickly to a perturbation

– Resilience: Teams bounce back quickly from a perturbation

Measure Team effectiveness through performance dynamics



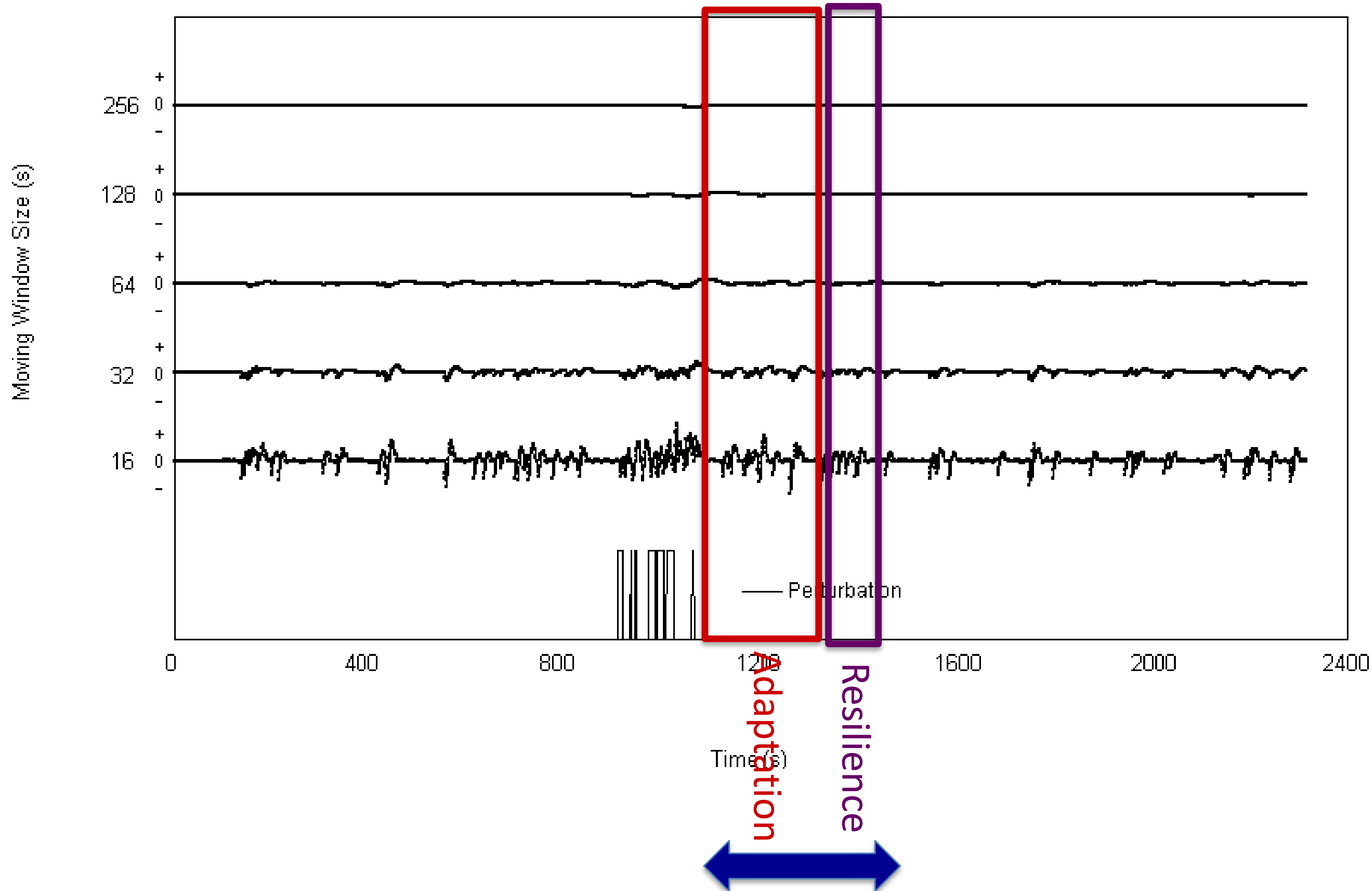
SAME



MIXED

Effective teams are adaptive and stable

Dynamics and Team Effectiveness



Collaborators

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Paul Jorgenson
Dr. Steven Shope

Testbed, empirical studies and validation

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Jamie Gorman

Dynamical system modeling; coordination measures

CLEMSON

Nathan McNeese
trust, resilience

AFRL/L3

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Ms. Mary Freiman
Ms. Erin Hanson
Dr. Chris Myers

ACT-R cognitive modeling
Develop Synthetic Teammate and Iterate

Thank You to Our Collaborators!

Thanks to My Collaborators

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CTTSO Combating Terrorism Technical Support Office

Modeling Performance for Marksmanship Training Tools

Amanda VanLamsweerde, Jennifer Murphy
Quantum Improvements Consulting

Eric Sikorski
Combatting Terrorism Technical Support Office

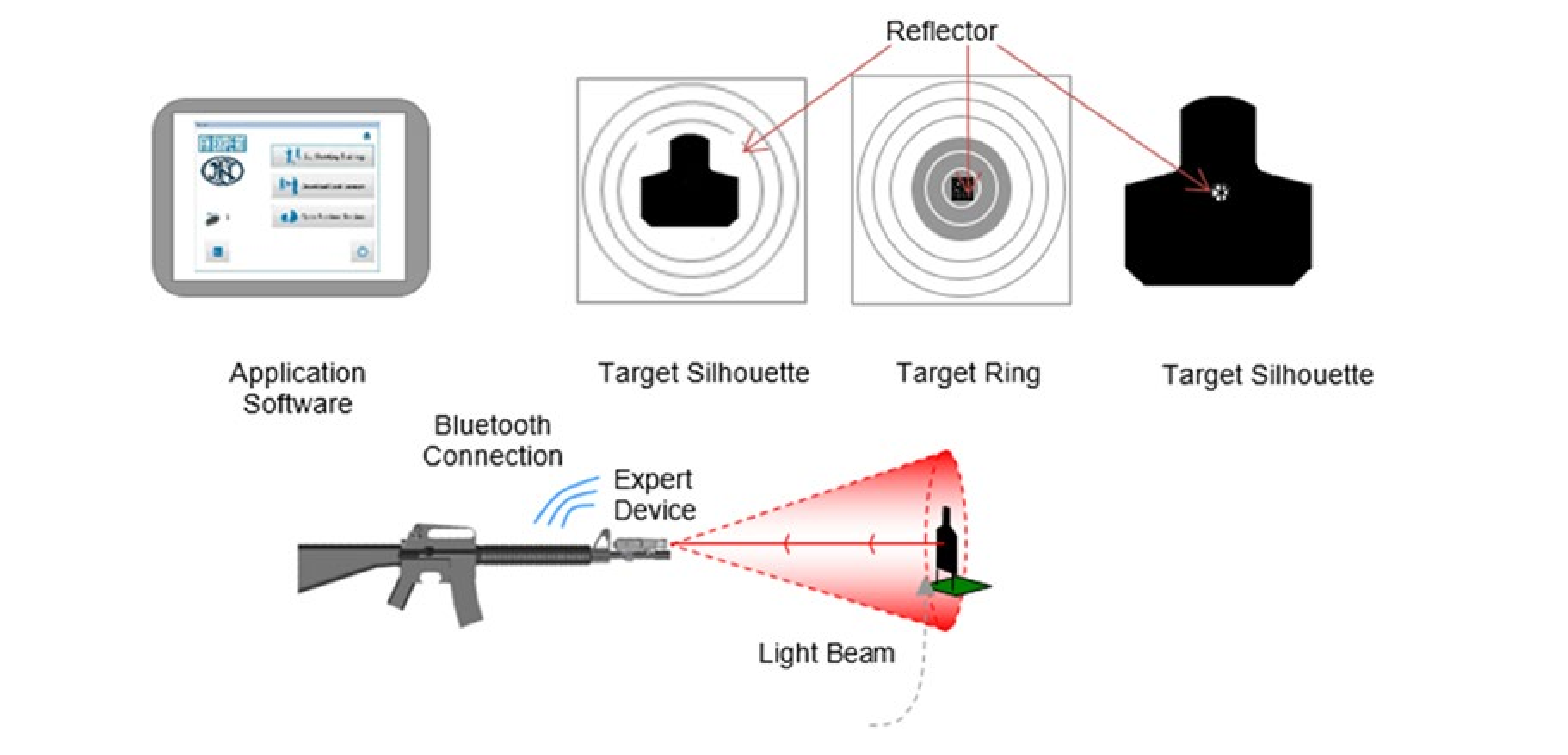
Purpose

- Marksmanship skills are critical for the U.S. Marine Corps but are expensive, time-consuming and labor-intensive to develop
- Shooters with skill deficiencies cause bottlenecks in the training process, as instructors must take additional time to remediate
- Skill deficiencies can be difficult to diagnose and multiple instructors may be required to provide remediation

Purpose

- Provide an automatic evaluation of fundamental marksmanship skills to support instructors
- Data Source: Rifle-mounted aim-trace sensor

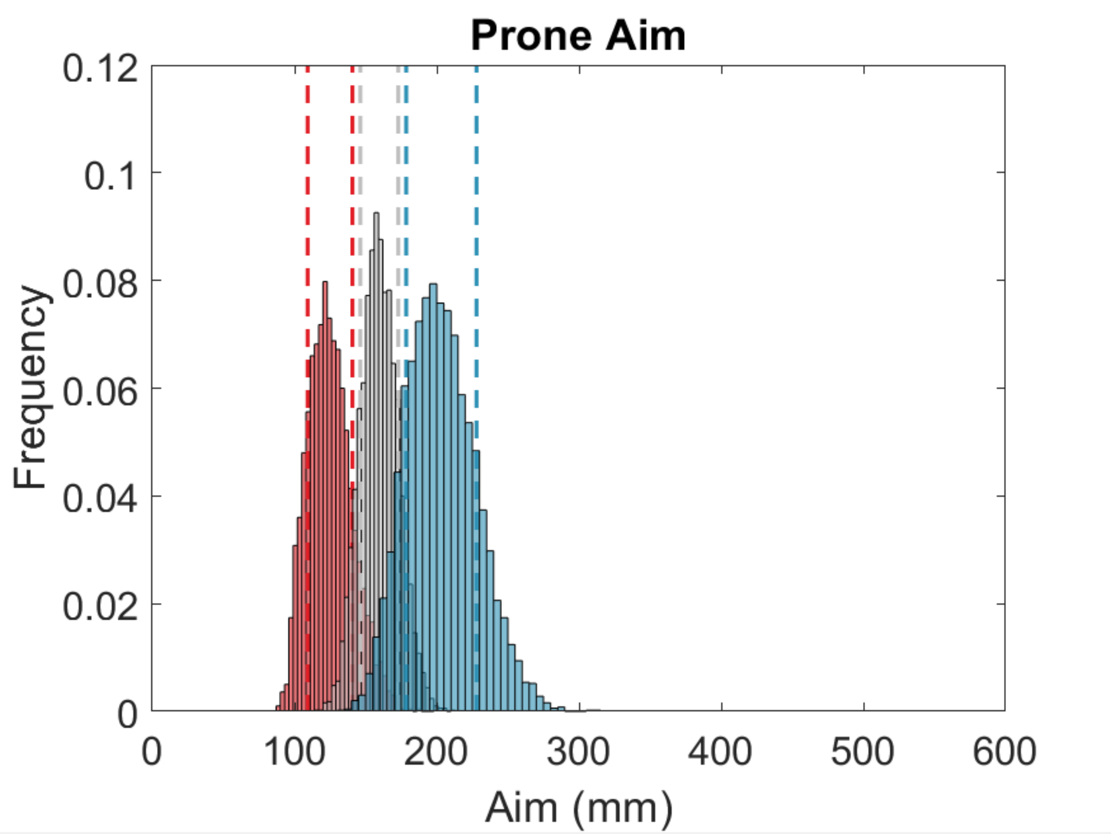
Data Collection System



Project Goals

Improved Instructor Experience

Algorithm Development and Validation



Needs Analysis

- US Marine Corps Weapons Training Battalion Instructors were interviewed about information and features that would assist in training.
- As a result of these interviews, several features were incorporated into software development:
  - Commenting function so instructors can add comments to shots
  - Video playback of shots were included
  - Timeline of shot was color-coded
  - Legends of markers were added
  - Icons were updated to be more intuitive

Software Development & Testing

- Data Collection and Data Management software designed to display the same visualization (good, moderate, poor), use the same cutoff scores, and maintain same 'look and feel'
- Systems both tested for usability throughout the development process
  - Usability conducted with Weapons Training Battalion instructors at Quantico, VA and Weapons and Field Training Battalion instructors at Camp Pendleton, CA
  - Systems updates include: new icons, new timeline colors, shot grouping visualization

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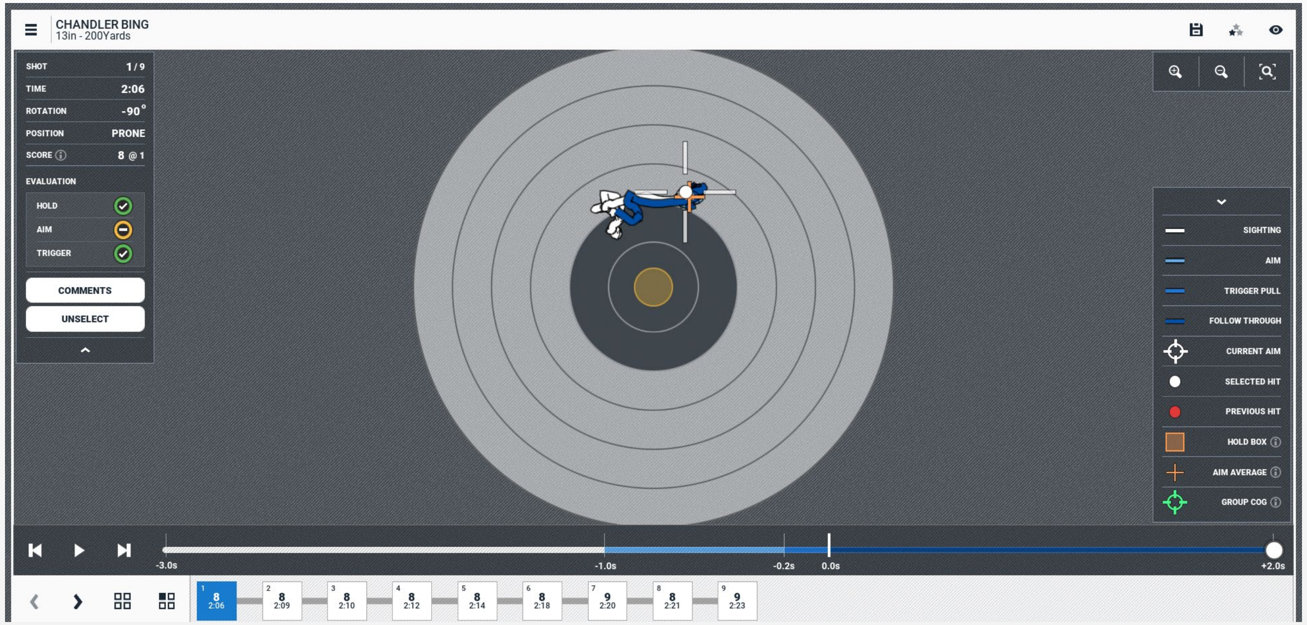
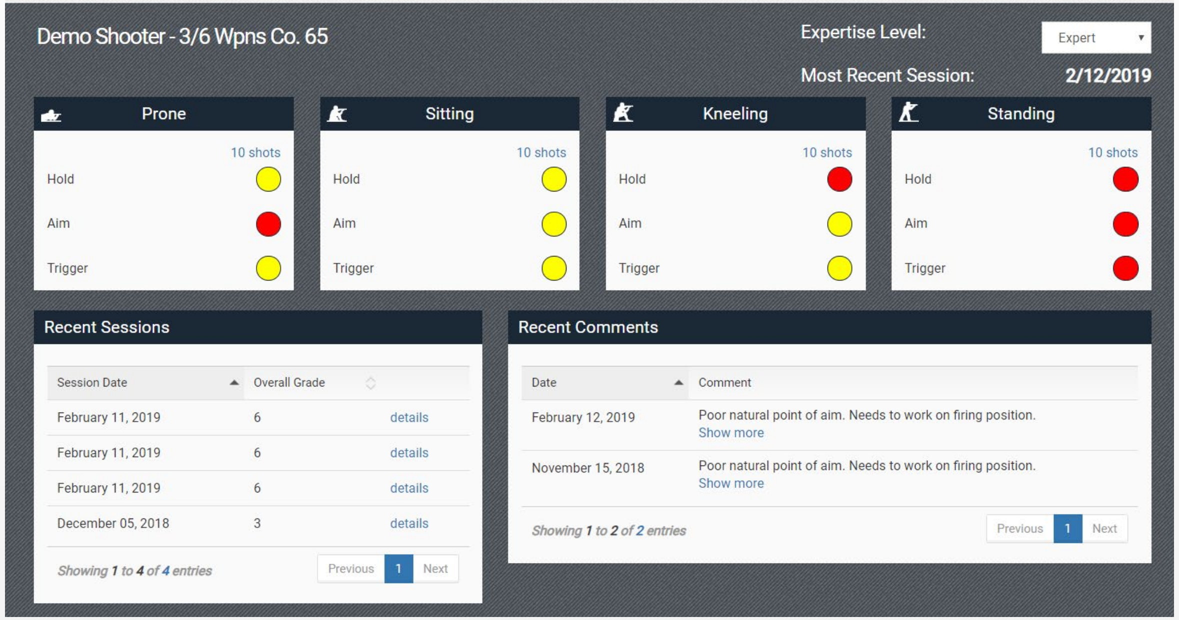
CTTSO Combating Terrorism Technical Support Office

Software Development

Data Collection Software



Data Management Software



Data Collection & Model Development

- 3 Data Collection Events
  - Quantico, VA
  - Camp Pendleton, VA
  - Quantico, VA
- Experts and novices took 10 shots in each shooting position at dry fire simulated distance 200 yards
- Performance was used to determine whether the system can discriminate between experts and novices and to create evaluation criteria

Shooter Performance Data Collection 1

- US Marine Corps Shooters at Quantico, VA
- Expert Shooters (n = 7)
- Novice Shooters (n=8)
- 10 shots in each position (prone, sitting, kneeling, standing)

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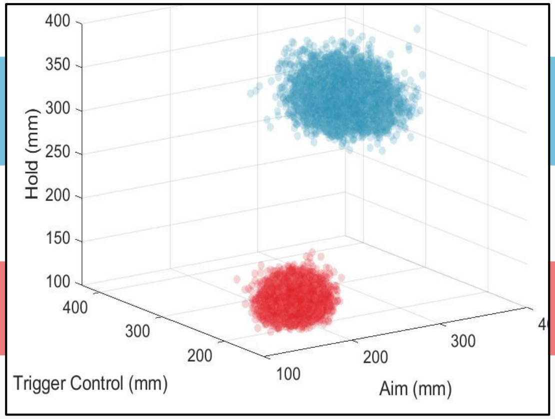
Prediction of Competency Level

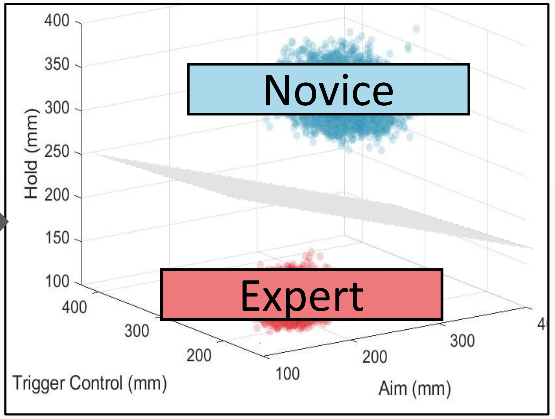
Step 1: Build Model



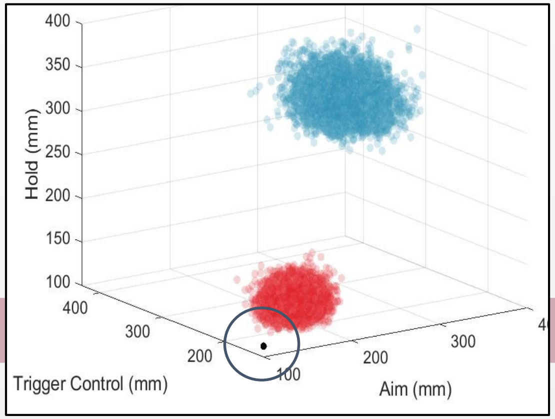
Novice Data

Expert Data

Train model (Linear Discriminant Analysis)

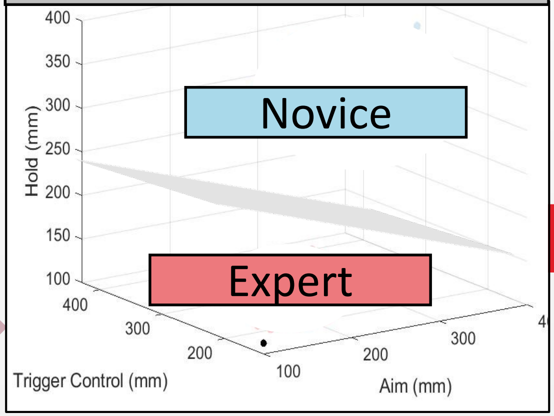


Step 2: Classify Shooter



Data

Trained model



Classify Shooter: Novice or **Expert**

Lower scores indicate better performance

Predict Competency Level

Prone Prediction Accuracy: **87%**

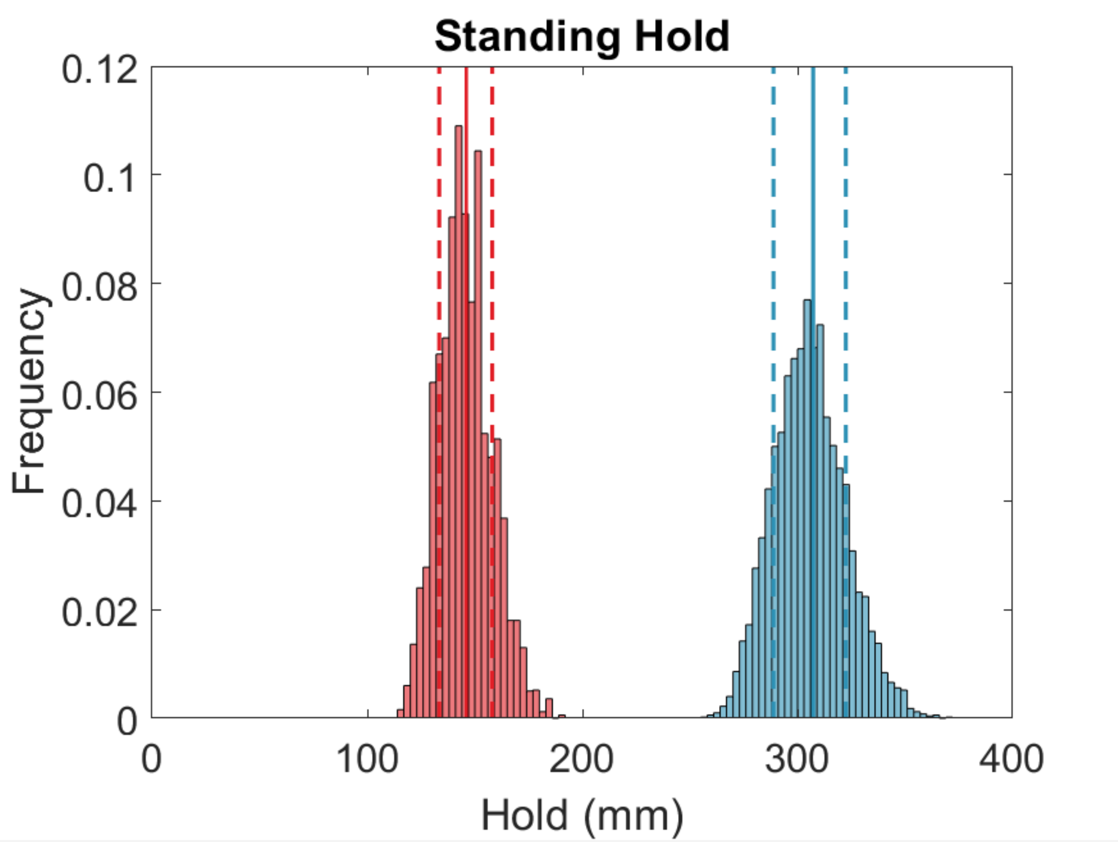
Sitting Prediction Accuracy: **80%**

Kneeling Prediction Accuracy: **87%**

Standing Prediction Accuracy: **100%**

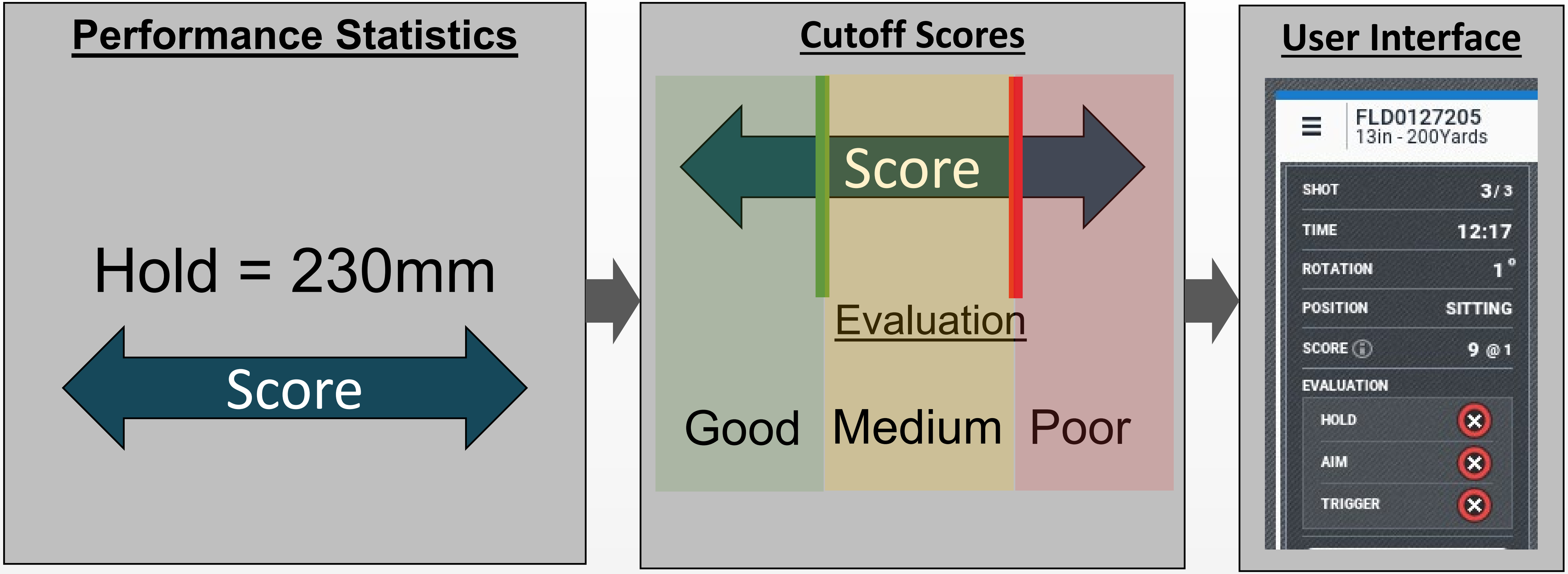
- Shooters can be accurately be classified as novices or experts, on average, 89% of the time *based on data from other shooters*.

Modeling Individual Skills



- Skills: Aim, Trigger Control, Hold
- Firing Positions: Prone, Kneeling, Sitting, Standing
- Scores were bootstrapped 5000 times to generate means and 95% confidence intervals

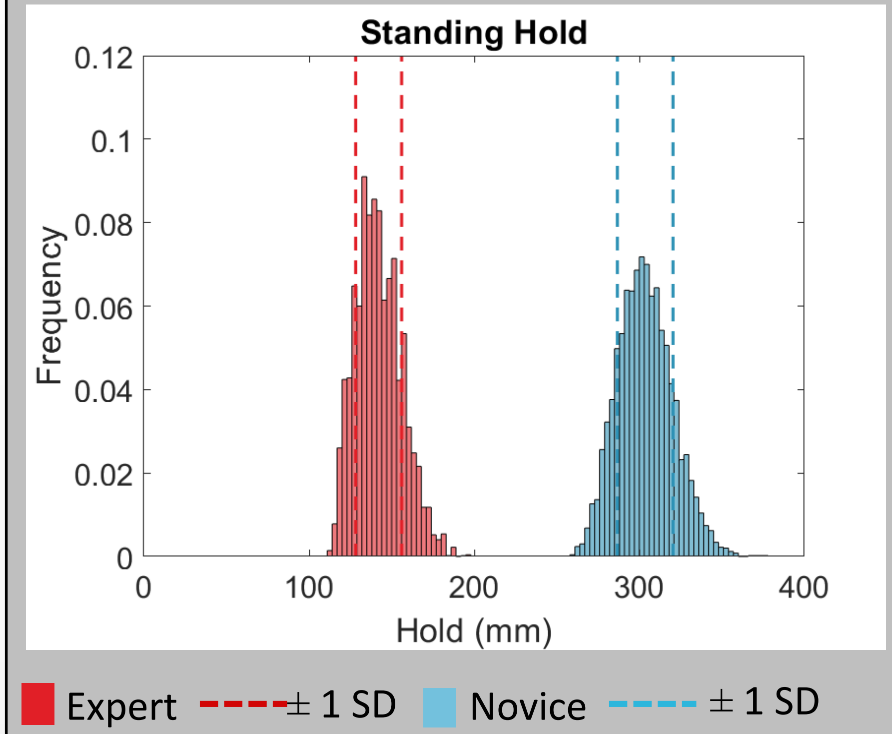
Expert ------ 95% CI Novice ---- 95 % CI



- Cutoff scores need to be created to **evaluate** performance as good, medium, or poor

System Updates

Performance Statistics



Cutoff Scores

		Hold		
Standing		Good	Neutral	Bad
		≤	≤	>
	Expert	133.42	158.00	158.00
	Marks	212.75	258.54	258.54
	Unq	289.09	322.12	322.12

User Interface

- Performance statistics (mean, 95% CI) were used to create cutoff scores.
- These cutoff scores were incorporated into software and visualized in the user interface to provide diagnostic information about shooter performance.

Shooter Performance Data Collection 2 & 3

Data Collection 2

12 Experts, 10 Novices at Camp Pendleton, CA

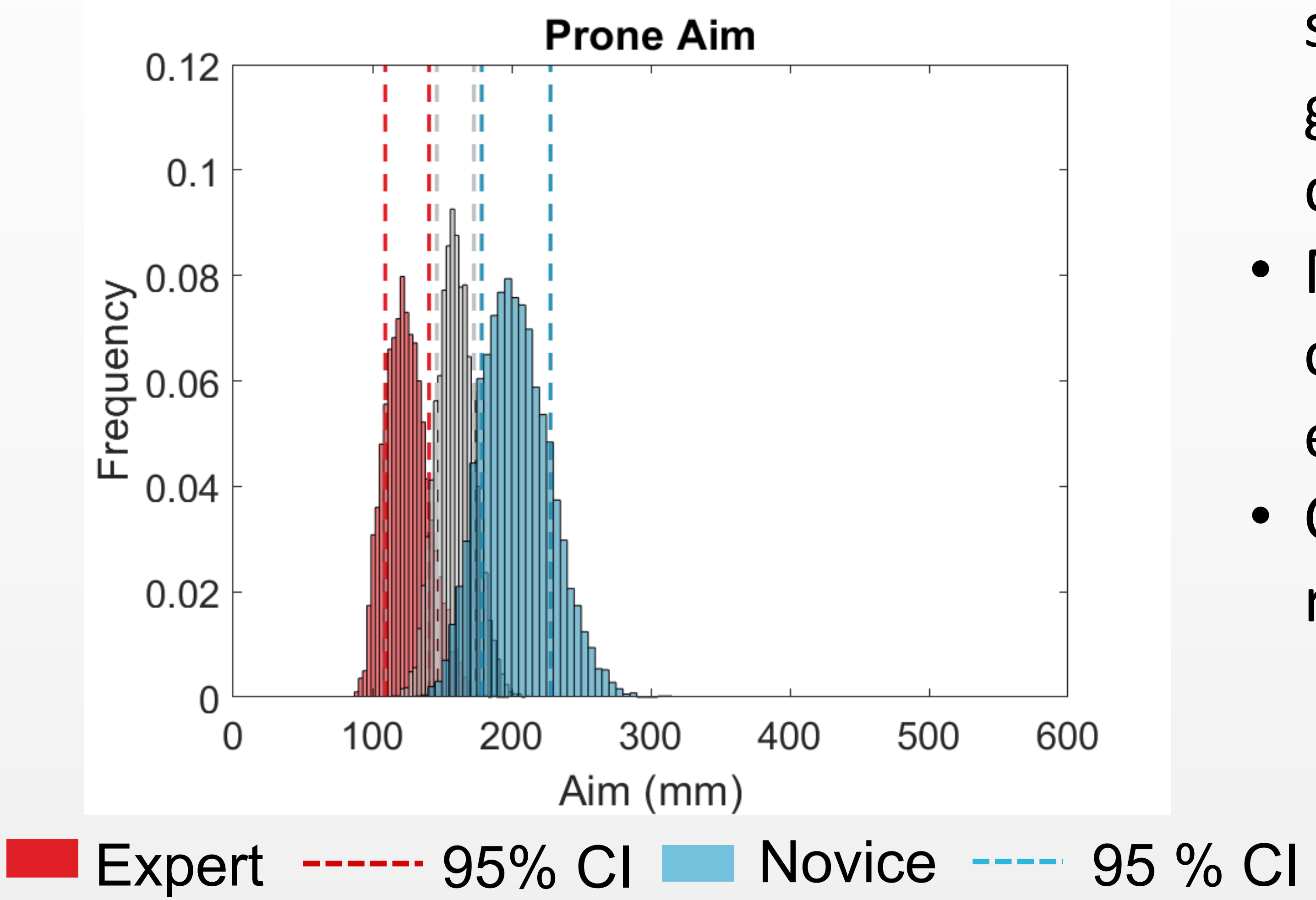
- 10 shots in each position (prone, sitting, kneeling, standing) at simulated distance 200 yards

Data Collection 3

13 Experts, 13 Novices at Quantico, VA

10 shots in each position (prone, sitting, kneeling, standing) at simulated distance 200 yards

Updates



- Data from all data collection sites were collapsed, expert and novice scores were bootstrapped to generate new performance distributions.
- Moderate distribution was created by combining novice and expert scores
- Criterion Scores were updated to reflect combined data

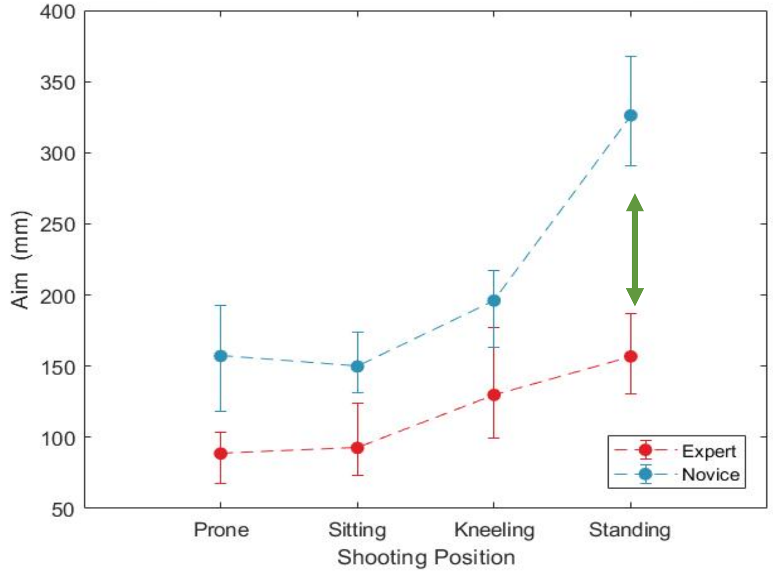
Questions?

Backup

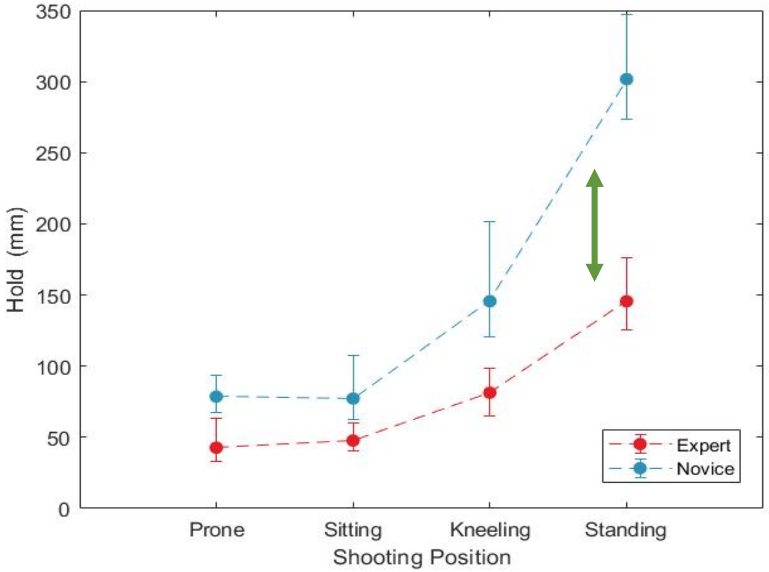
2. Individual Skills

- Experts perform better than novices across all skills
- These differences are greatest in the standing position

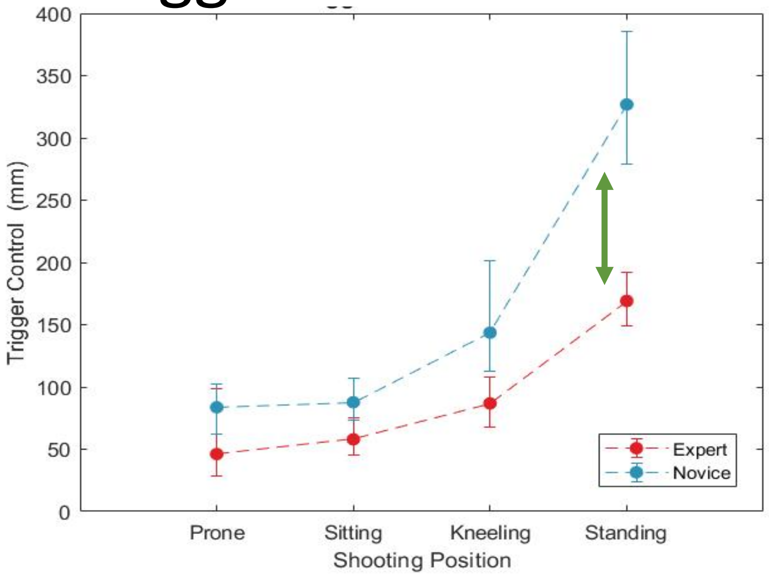
Aim Scores



Hold Scores



Trigger Control Scores



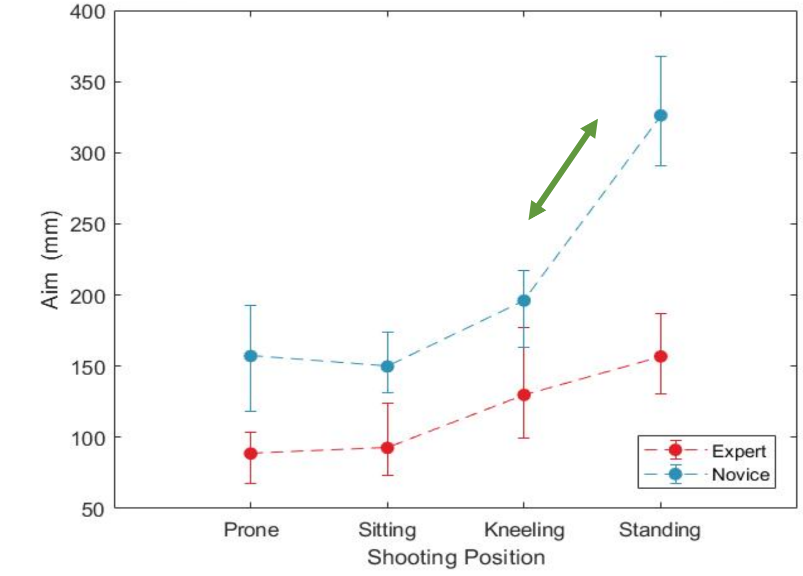
Lower scores indicate better performance

Error Bars Represent 95% Confidence Intervals

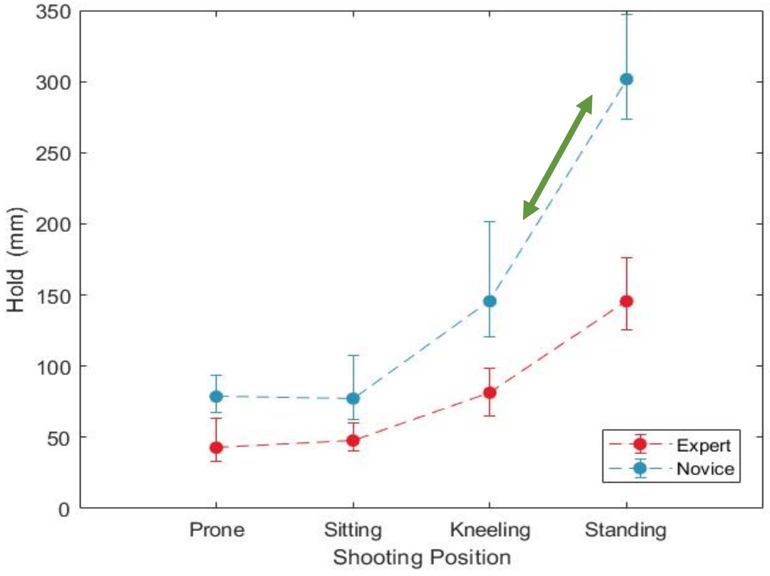
Individual Skills

- Performance is dramatically worse as shooters move into standing position

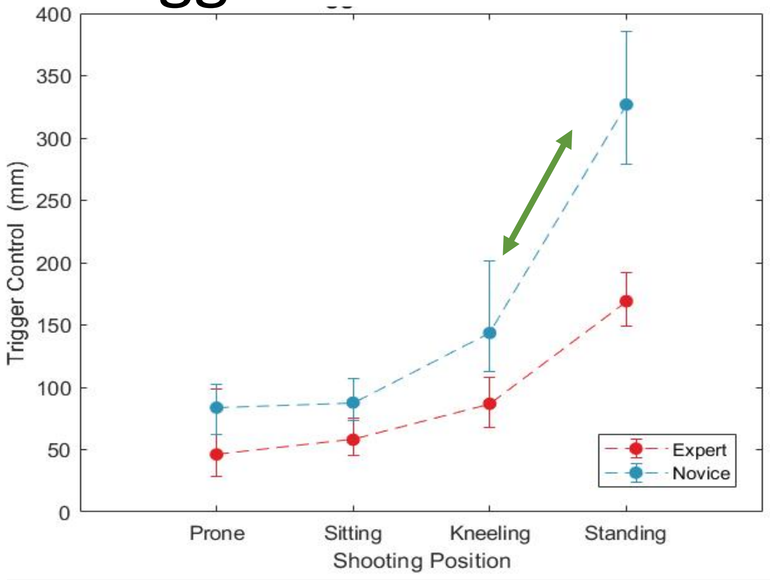
Aim Scores



Hold Scores



Trigger Control Scores



Lower scores indicate better performance

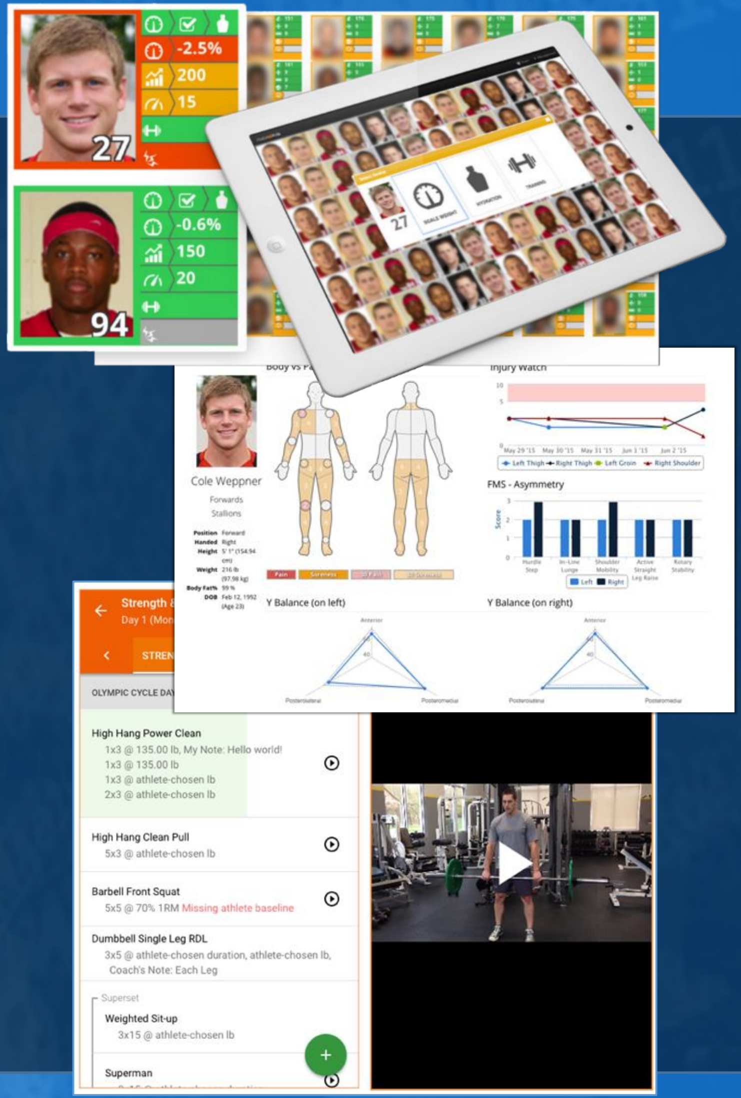
System Updates

Result	Evaluation Effect	System Updates
Skill scores differ substantially based on shooting position.	The same skill score means different things depending on the position. For example, a ‘good’ score in standing is ‘poor’ in prone.	Updated the interface so that the user can select shooting position. The cutoff scores to evaluate performance differ depending on shooting position
Skill scores differ substantially based on relative expertise.	Novices judged by an ‘expert’ standard may appear worse than they really are.	Updated the interface so user can select relative expertise (novice, moderate, difficult) of the shooter. Cutoff scores differ based on expertise level.

Warrior Performance Platform for U.S. Navy

Leveraging Best-of-Breed Human Performance Tracking and Analytics Technology to Enhance Navy's Physical Fitness, Wellness, and Nutrition Capabilities

2019 Human Systems Conference
17 APRIL 2019



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Cutting Edge Expertise

TIAG

TIAG brings a history of transformational leadership advancing military medical science and telehealth technology

- Leads web application efforts at DoD's National Center for Telehealth &Technology (T2)
- Delivers cutting-edge health IT solutions (e.g., VA's open-source EHR)
- Developed the Army's Research Management Enterprise System, providing autonomous big data management across numerous laboratories

Delivering end-to-end individual training and readiness solutions for DoD, WP2 leverages TIAG's demonstrated military experience and technical expertise

- Quick, all-in-one-place information access empowers leaders to determine risk factors and take immediate action
- Warriors are operationally ready and less likely to sustain injuries that keep them out of the fight

COACHMEPLUS

SAMPLE OF EXISTING CUSTOMERS

INSTALLATION EXAMPLES

INDIANAPOLIS COLTS

UCLA BRUINS

BUFFALO BILLS

"Just having the opportunity to talk to players based on what we saw today -- helped them."

Brian Kelly
Head Coach
Notre Dame Football

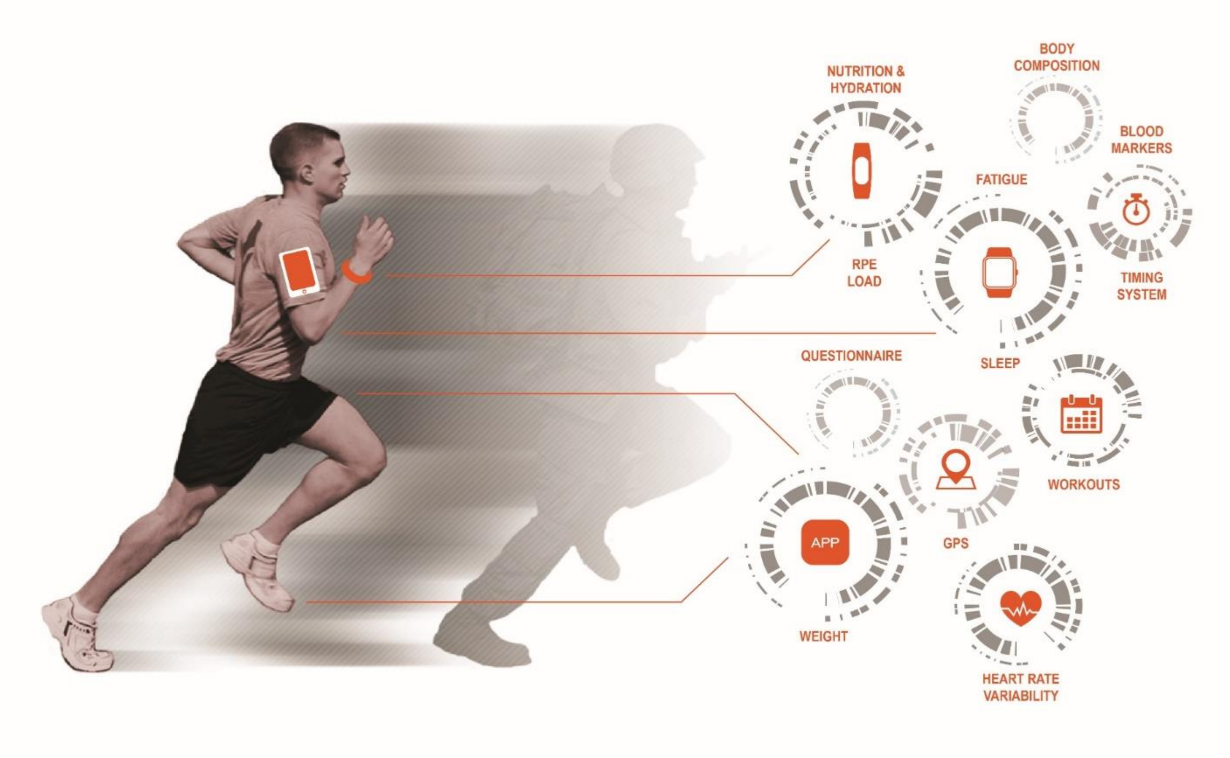
"We are doing everything we can - to help prevent the injuries that can be preventable."

Geoff Head
Sports Scientist
San Francisco Giants

"CoachMePlus is helping us ensure everyone is fully informed and prepared"

David Good
Strength Coach
Nashville Predators

Warrior Performance Platform



Human performance tracking and analytics to enhance physical fitness, wellness, and nutrition capabilities.

WP2 monitors Warriors throughout the readiness cycle, informing key command decision makers to support mission and training adjustments. Provides the ability to uncover trends, develop insights, reduce risk, and customize training programs. Leaders measure human performance based on preparation, physical fitness, strength and capabilities.

Centralized Collection of Human Performance Data

- Integrates data from virtually any available source
- Enables reporting and metrics at any level, from the individual to the enterprise
- Immediate and long-term data for "ready to perform" decisions
- Advanced analytic capabilities
- Secure, accreditation-ready platform

Advancing Proactive Human Performance Management

- Centralization of data enables proactive decision making
- Automates manually intensive data collection and analysis
- Amplifies effectiveness of human performance initiatives
- Delivers information at the right time to the right person

Speed of Information

- Rapidly discover and locate outliers
- Enable timely interventions
- Increase accountability
- Assesses key performance indicators of entire units and each individual Warrior's capability to advance mission

A Costly Problem

10%

of the total active Soldier force is **NON-DEPLOYABLE**.

90%

of Musculoskeletal Injuries (MKSI) are from **PHYSICAL TRAINING** or sports-related.

80%

of Musculoskeletal Injuries (MKSI) are considered **OVERUSE IN NATURE.**

$4B

is spent each year **DUE TO INJURIES,** non-deployable Soldiers, accidents and other health-related costs.

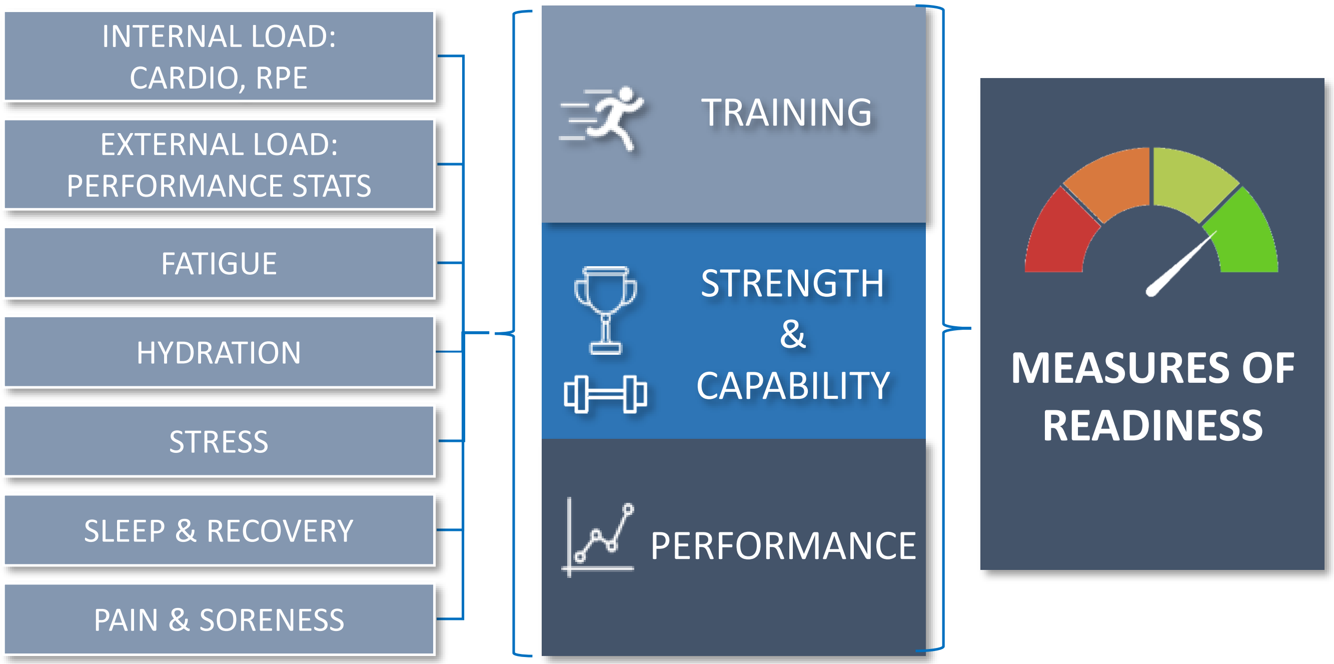
Sources: "Army Has 50,000 Active Soldiers Who Can't Deploy, Top NCO Says", Miltary.com, 11/15/15; American College of Sports Medicine, Vol 13, No 1. Jan/Feb 2014, Consortium for Health and Military Performance and American College of Sports Medicine Summit)

WP2 Benefits

BENEFITS DERIVED FROM MONITORING SOLDIERS

- **Enhance operational readiness** through improved fitness, wellness, and nutrition
- **Reduce stress-related injuries** through monitoring and timely intervention
- **Deploy training and fitness programs** targeted to specific populations
- **Employ “distance coaching”** and compliance monitoring
- **Centrally store and manage** human performance data
- **Automated reporting** at all levels, from the individual to the enterprise

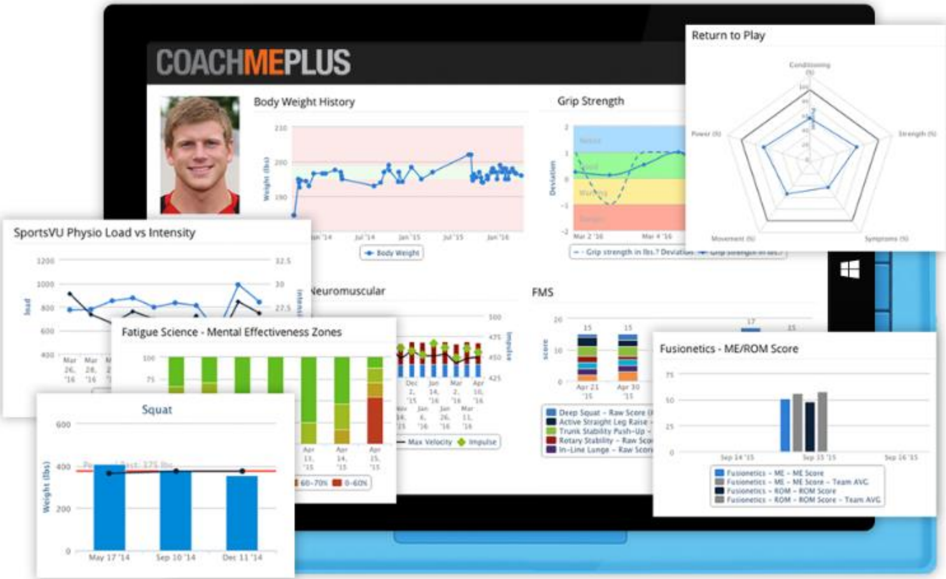
CONTRIBUTING FACTORS IN THE REDUCTION OF INJURY RISK



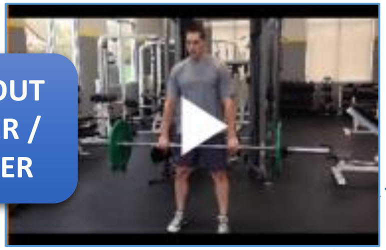
Sources: “Army Has 50,000 Active Soldiers Who Can't Deploy, Top NCO Says”, Miltary.com, 11/15/15; American College of Sports Medicine, Vol 13, No 1. Jan/Feb 2014, Consortium for Health and Military Performance and American College of Sports Medicine Summit)

Core WP2 Capabilities

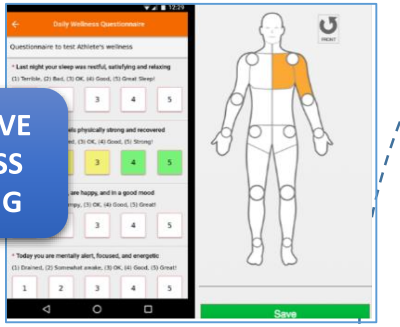
HOLISTIC HUMAN PERFORMANCE PROFILE



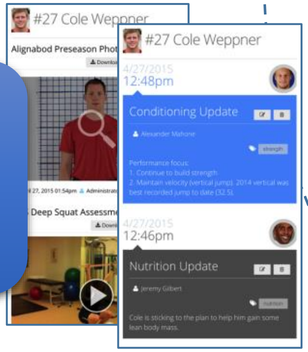
WORKOUT BUILDER / TRACKER



SUBJECTIVE WELLNESS TRACKING



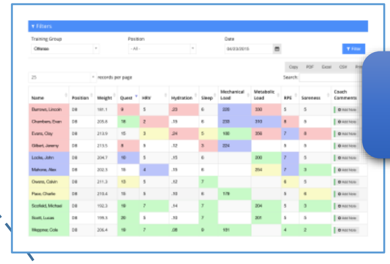
PDFS, NOTES, VIDEOS, PHOTOS, DOCS



WEARABLE DEVICE INTEGRATION

HealthKit

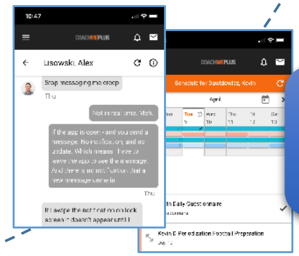
DASHBOARDS AND REPORTS



MOBILE AND TABLET ACCESS

DATA IMPORT AND EXPORT API

SCHEDULING, MESSAGING, NOTIFICATIONS



Profile/Cluster Examples

APPLIED MONITORING

Not a One-Size-Fits-All Approach – How much should be tracked in a pilot deployment?

POPULATION GROUPING

GENERAL POPULATION

GOAL: Behavior Change / Education

- Hydration
- Workouts

AT-RISK POPULATION

GOAL: Remediation / Return to Duty

- Sleep / Pain / Mood / Stress
- Fitbit / MyFitnessPal
- Workout Compliance / Body Comp
- Fatigue / Soreness

SPECIALIZED POPULATION

GOAL: Optimized Performance

- Force Plate
- Range of Motion/Movement Screen
- Cardiac Load
- Velocity Based Training

STAFFING REQUIREMENTS

Limited Staff / High Automation

- Force multiplier
- Warrior self-selection of programming and content
- Warrior engagement through app notifications and automation

Specialized Staff / High Customization

- Create efficiency with practitioners
- Explore multiple data and testing configurations
- Integrate with specialized hardware, software, military systems
- Leverage existing systems and expertise

NAVY SBIR N171-079 PHASE II HUMAN PERFORMANCE SELF-SERVICE KIOSK & APPLICATION

OBJECTIVE: Develop a platform with interactive touch screen, such as a self-service Kiosk, that displays human performance information, serving as an education tool for the user of afloat and shore based galleys.

BASE: 16 AUG 2018 – 28 FEB 2020

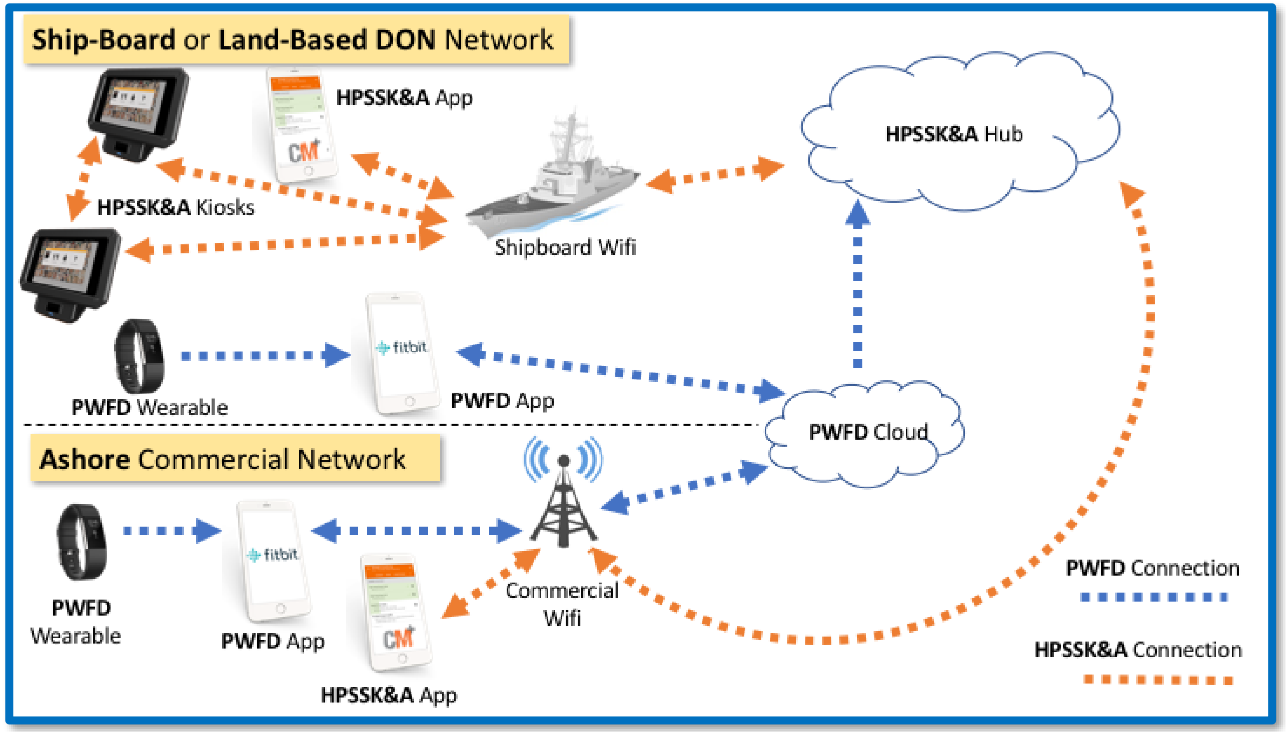
OPTION: 28 FEB 2020 - 27 NOV 2020

NAVSUP

SBIR PHII N171-079

Overview

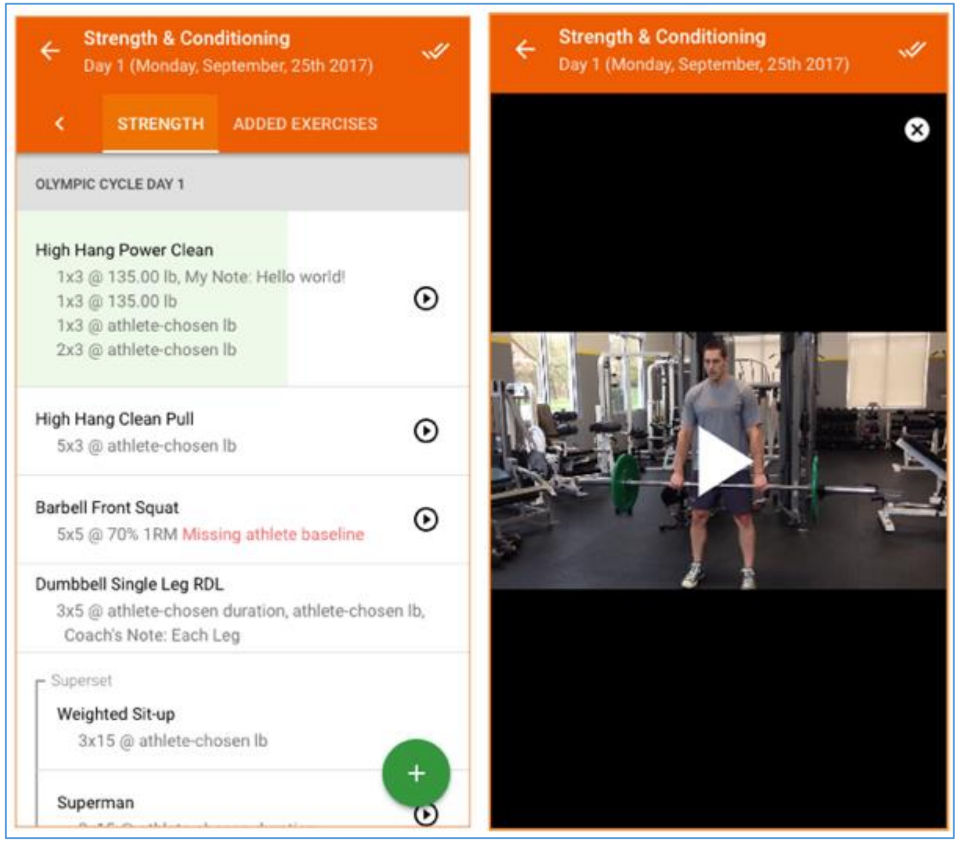
- Prototype development is underway
- Builds upon core WP2 functionality, but adds:
  - Nutrition
  - Ruggedized touchscreen kiosk
  - Support for austere environments
  - Shipboard integration
  - Data source integrations (Naval Operational Fuel and Fitness System, MyPlate and Go for Green)
  - Full cybersecurity accreditation



- Supports app-based access from personal mobile devices, as well as data integration from select wearables
- Focus on automated, "self-service" capabilities to reduce need for manual intervention at scale
- Initial operational testing scheduled for FY20

Task 3: Develop a Physical Training Module

- Programming can be configured and assigned for the individual based on Sailor's goals, environmental or physical limitations or restrictions.
- Sailors can select any exercise from the library and add activities to their day, including NOFFS programming.
- Review their completed exercises and review trends of the data over selected periods.
- Achieve the Sailor's fitness goals as well as determining the nutritional needs and proper recovery protocols to enhance readiness and performance.
- Monitoring the Sailor's physical activity will help the Sailor assess how the performance was achieved, as no two Sailors react the same to physical stress.



WP2 with Exercise with Video

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Task 3: Develop a Wellness Module

- Provide the Sailor with an intuitive interface for capturing subjective information.
- Trend the Sailor against himself or herself before we look at the data as a population
- Main subjective data points
  - ✓ Sleep
  - ✓ Mood
  - ✓ Stress
  - ✓ Soreness / Pain
  - ✓ Fatigue
- Educate the Sailor on why we are tracking the data, including showing them data trends.
- Intervention occurs and is communicated during meaningful changes in the results.

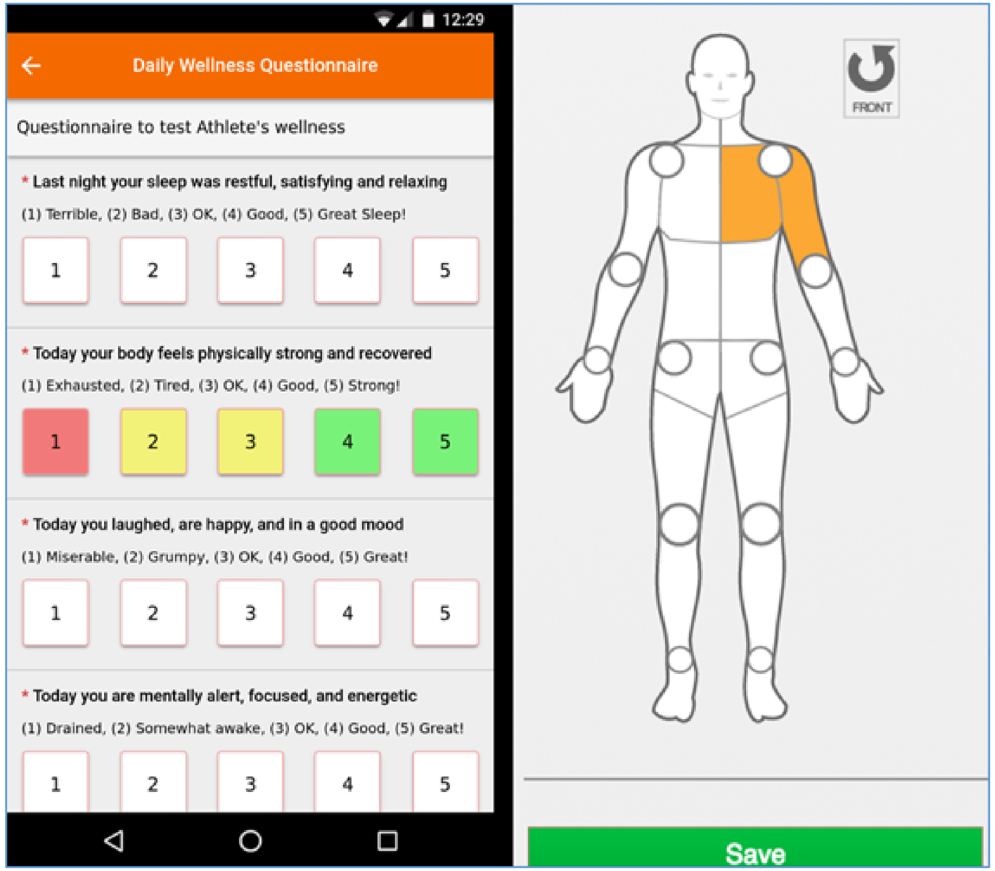


Figure 2.3: Wellness Demonstration

- Data Integration
  - Naval Operational Fuel & Fitness System (NOFFS)
  - Navy Go for Green (G4G)
  - Recipes from The Armed Forces Recipe Service (AFRS) and Joint Culinary Center of Excellence (JCCoE)
  - United States Department of Agriculture (USDA)
  - Caloric, Micronutrient, Macronutrient and other key indicators from databases
- Providing educational content through the 3D Human Anatomy and the Library will engage the Sailor and encourage compliance through compelling animations, videos, documents and interfaces which keeps the Sailor tracking in the right direction towards their fitness goals.

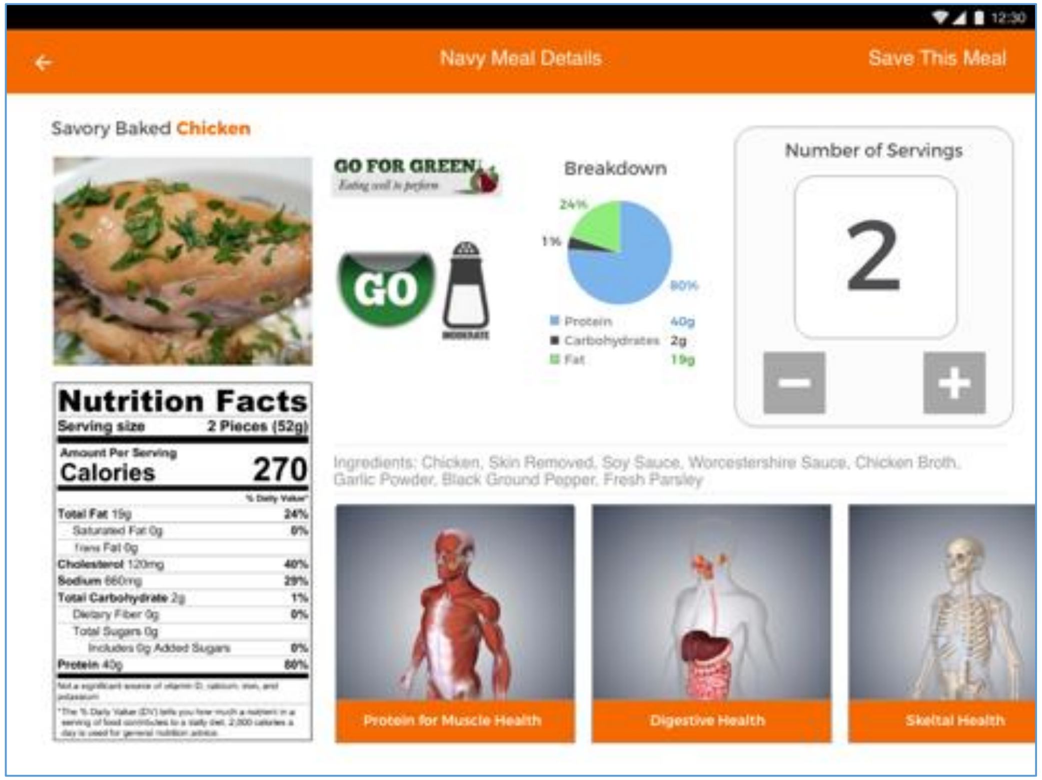
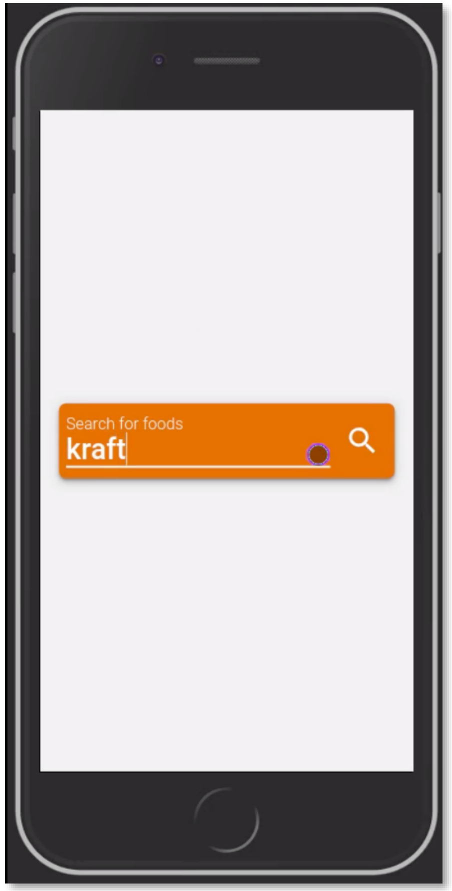


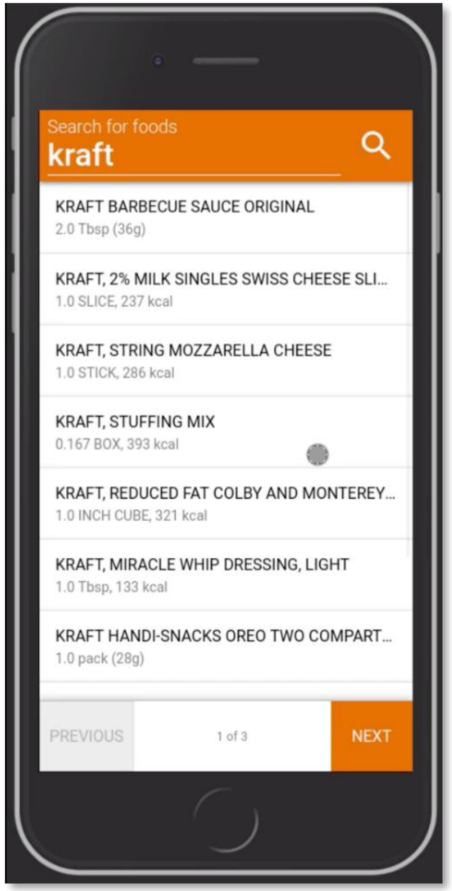
Figure 4.8: Meal Detail sample

USDA Data integrated with Search and Selection Functionality

Next steps = Go For Green, NOFFs Data

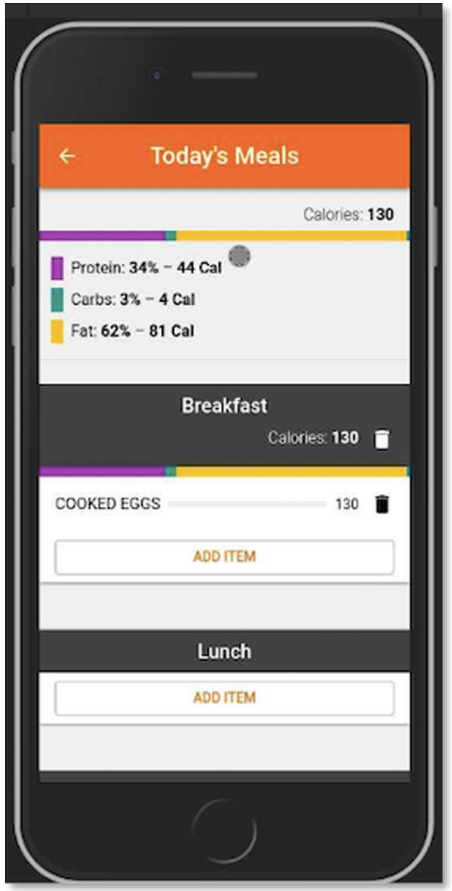


Search



Results

Select and Review



Daily Review

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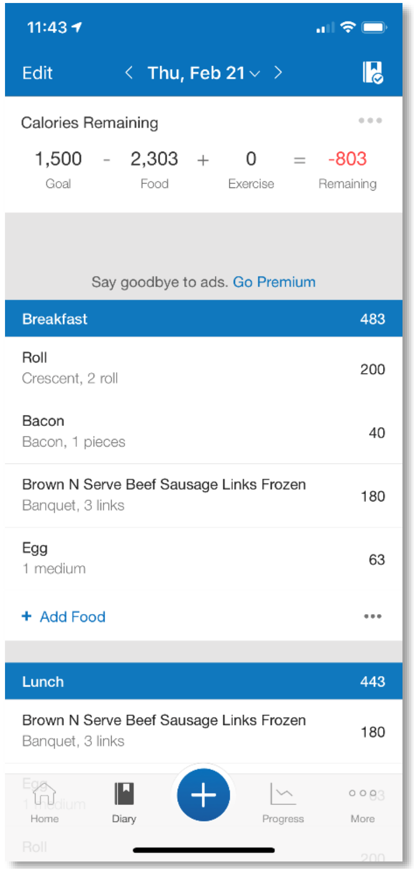
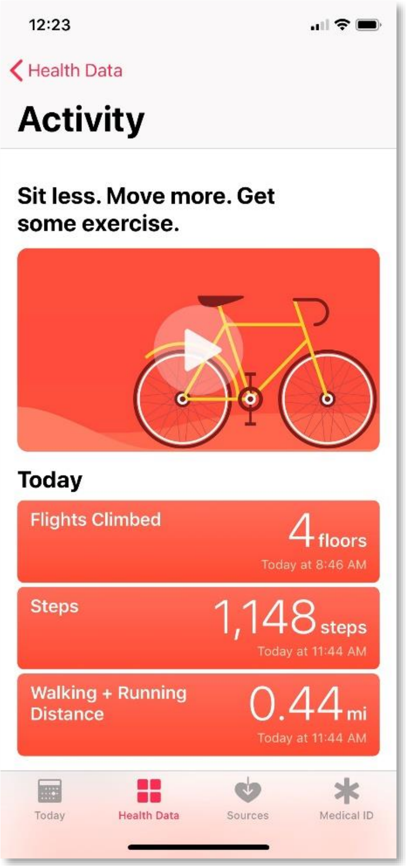
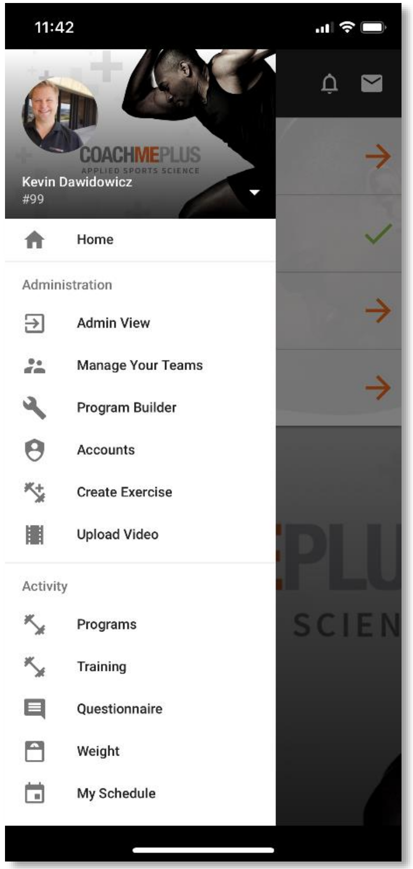
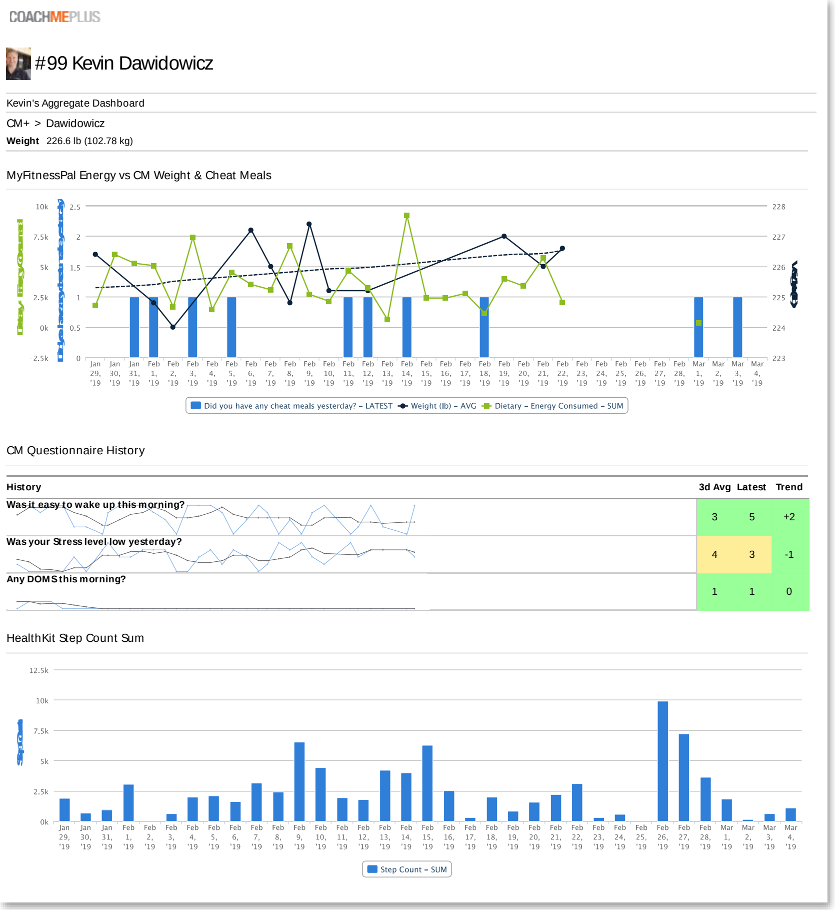
Functional Integration Demonstration (1st Iteration – 01 JAN 2019)

[Backup Slide]









myfitnesspal + HealthKit + COACHMEPLUS =

Real-time data integration into single REDI Profile for Sailor.

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Task 6: Wearable Device Integration

- Select the most effective method for delivering individual performance, activity, wellness, fatigue, sleep, and other data into the Sailor’s REDI profile.
- Integrate the live data web-enabled backend technologies with the selected wearable devices, either through API or other method.
- Manage unsynchronized PWFD data in a shipboard environment.
- Implement latest Pentagon guidance on GPS-enabled devices

Deliverable	Description
Wearable Device Integration	
Task 6 (Base)	
6.1	PWFD Selection Process for Software Prototype
6.2	PWFD Data Integration Software Development
6.3	PWFD Data Integration Synchronization Development
6.4	PWFD Demonstration of Data Integration Prototype
6.5	PWFD Develop Interfaces and Workflows
6.6	PWFD Demonstration of Interfaces and Workflows
Task 14 (Option)	
14.1	PWFD Live Environment Hardening and Prototype Iterations
14.2	PWFD Demonstration of Live Integration, Interfaces and Workflows

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Task 7: Physical Kiosk Hardware Development

- Internet capability for operating in a rugged and often less than favorable shipboard environment.
- Available memory to support 10,000 Sailors' data
- Design the kiosk to work with mobile devices, including smartphones and tablets
- We present a Demonstration of Live Environment Prototype in a secure live data environment

Deliverable	Description
Physical Kiosk Development	
Task 7 (Base)	
7.1	Physical Kiosk Concept Selection
7.2	Physical Kiosk Prototype Development
7.3	Physical Kiosk Prototype Testing / Modification
7.4	Demonstration of Initial Physical Kiosk Prototype
Task 15 (Option)	
15.1	Live Environment Hardening and Prototype Iterations
15.2	Demonstration of Live Environment Prototype

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Challenges and Ways Forward

[Backup Slide]

Challenges

- Cybersecurity Considerations
  - Cloud hosting/SaaS model
  - Personally Identifiable Information
  - Protected Health Information
  - Reciprocity between organizations
- Synchronization in Austere Environments
  - Shipboard
  - Theater
- Authentication alternatives
- Adoption/Buy-In

Future State

- Advanced Analytics / Machine Learning
  - Predictive vs. Reactive
- Mental/Behavior Health Applications
  - Post-traumatic Stress Disorder (PTSD) Event Detection
  - Traumatic Brain Injury Assessments
- External Integrations with Systems of Record
  - MHS GENSIS? DMDC?
- Cross-service compatibility

QUESTIONS

CEDARS: Combined Exploratory Data Analysis Recommender System

Mark A. Livingston[1], Stephen Russell[2],
Jonathan W. Decker[1], and Antonio Gilliam[3]

[1]Naval Research Laboratory
[2]Army Research Laboratory
[3]Strategic Analysis, Inc.

Aberdeen, MD
16-17 April 2019

2019 NDIA Human Systems Conference

Goal

- Capture a domain expert's approaches for data analysis
- Be able to intelligently recommend or automatically apply these approaches to future analyses (by the same or other analysts)

- Automate analysis of complex data sets
- Help novice analysts increase their expertise
- Assist domain experts in creative exploratory analysis
- Unify architectures for EDA with systems to automate layout and (ultimately) visual representation

Why use Recommender System (RS)?

- Data analyst's questions: what data should I explore? what analytics should I apply?
  - Transform: 'What items are relevant?' 'What services complement those items?'
- Selecting analytic operations can be cumbersome
- Analyst may overlook appropriate operations due to familiarity bias
- Enhance creativity under ambiguity and uncertainty, which is often an element of exploratory data analysis (EDA)

Why use RS for EDA?

- Confirmatory analysis is “easy to computerize” [Tukey]
- Common tasks where RS provide benefit [Herlocker et al.]
  - Find some good items
  - Annotation in context (emphasize items based on user preference)
  - Recommend a sequence
  - Recommend a bundle
  - Help with browsing
  - Improve the profile by integrating user preference into the decision making task

Previous Work

Adaptive EDA	RS in Workflows

Adaptive EDA

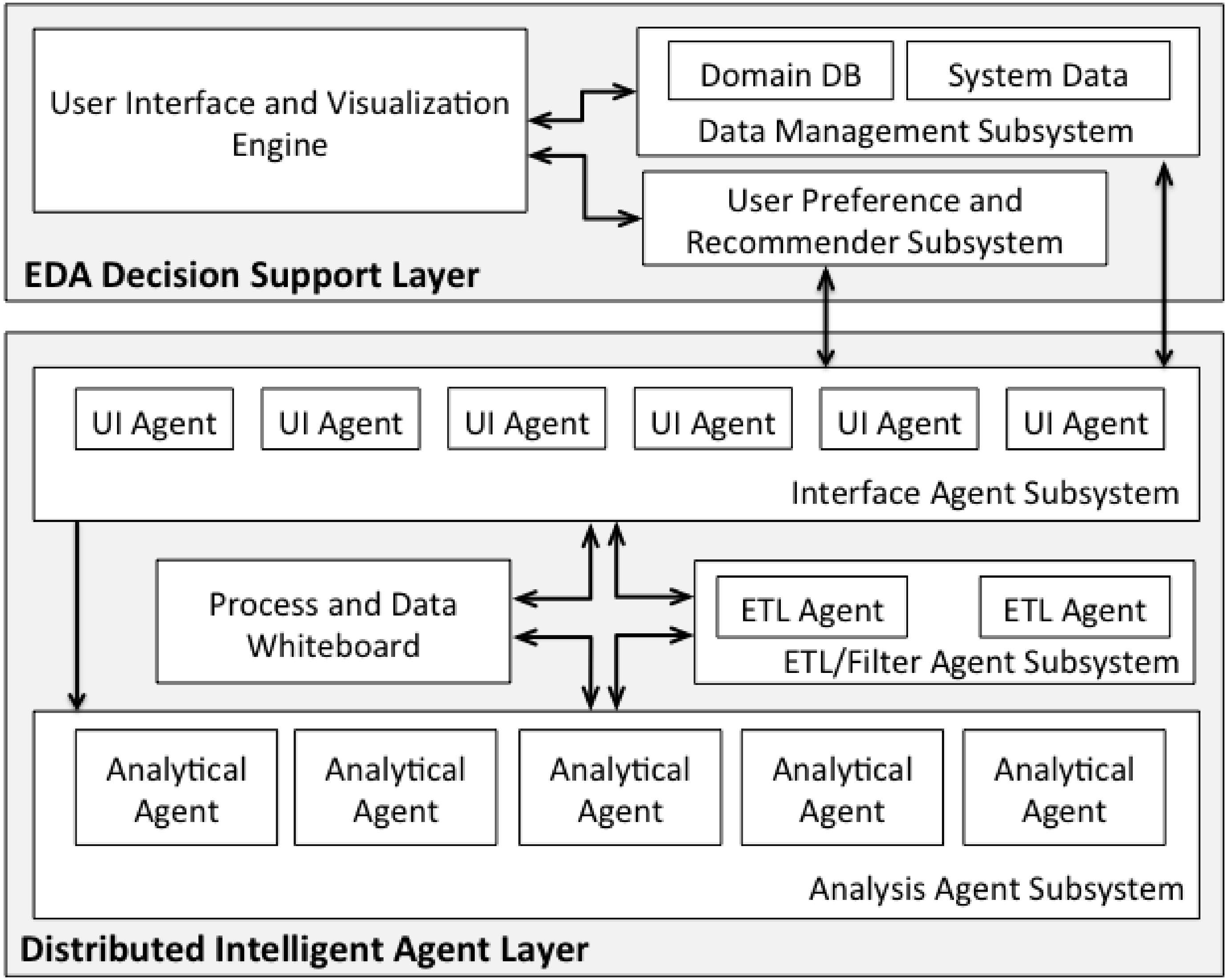
- ForceSPIRE [Endert et al.]
  - Adjusts layout by changing weights via capturing semantics of user interaction
- [Petasis et al.]
  - Use C4.5 decision tree algorithm to discover need to update rules in recognition and classification of named entities in text corpora

RS in Workflows

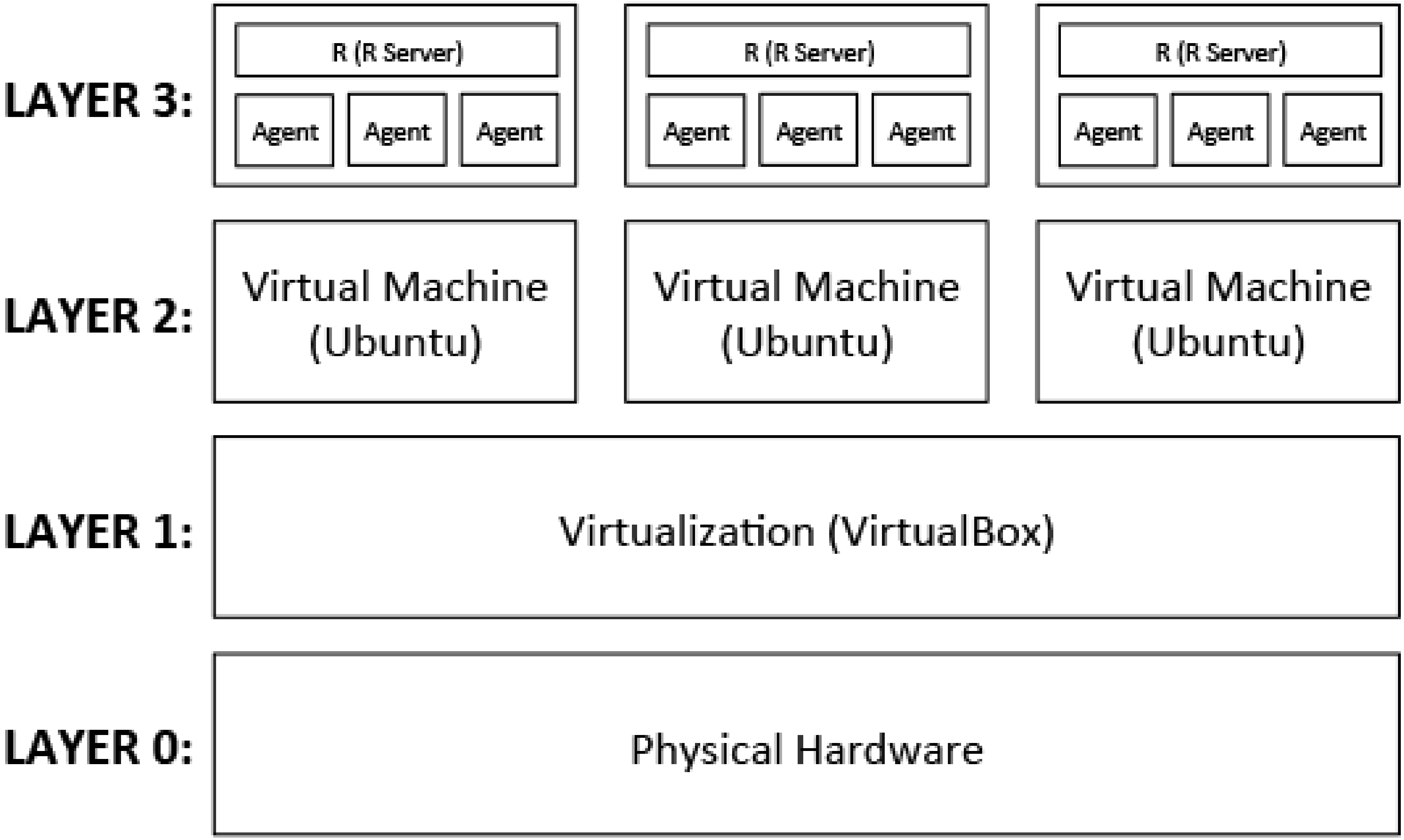
- Optimize hyperparameters
  - Improved prediction in retail applications [Chan et al.]
  - Improved recommendations by combining machine learning with rules [Bergstra&Bengio]
- Inference & logic
  - Contextually-aware RS [Adomavicius& Jannach]

CEDARS attempts to bridge gap between adaptive EDA and RS in workflows.

System Architecture



System Architecture

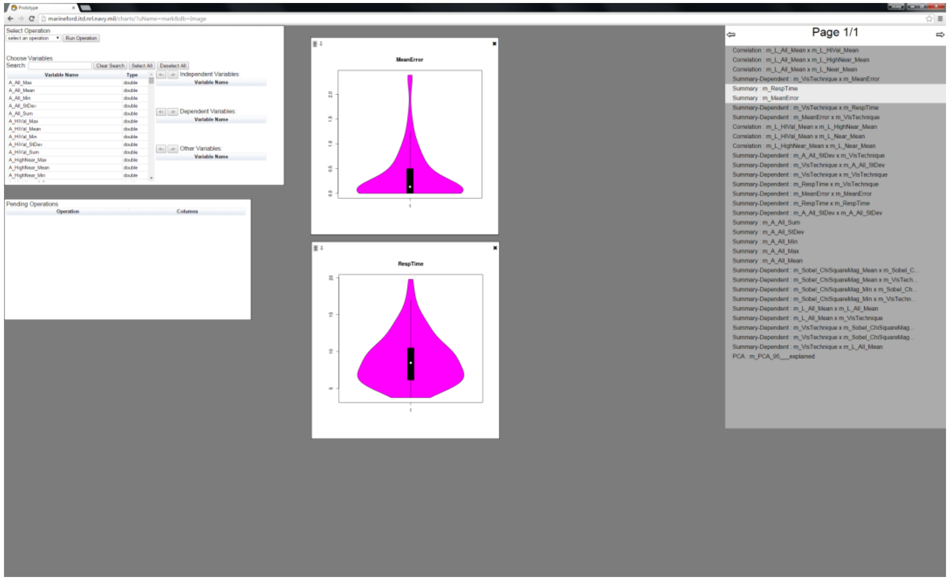


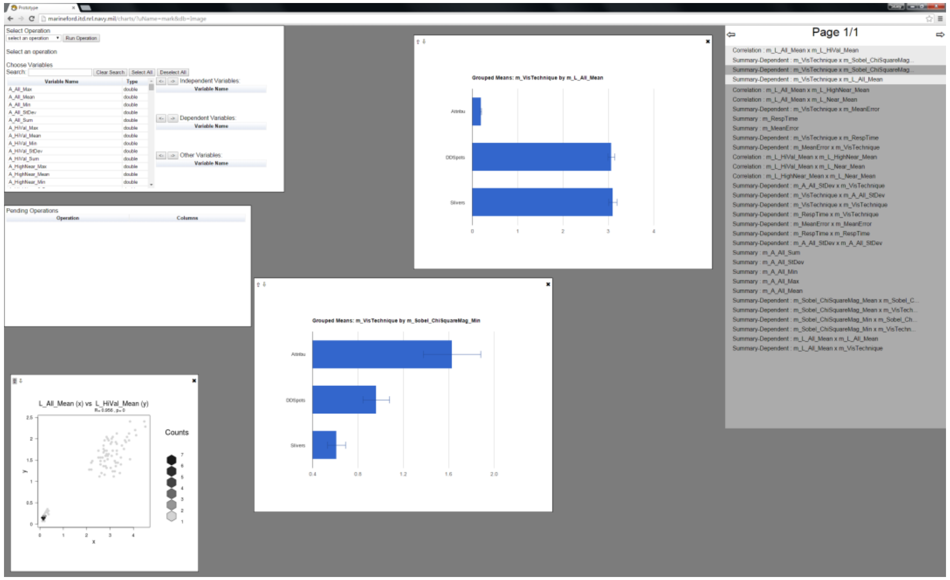
Data Organization

- Django web framework with Python scripts to ingest data
- Stores data in MongoDB
- Passes interest values (recommendation) to agents
- Agents use R for statistical computation
- EDA layer collects data from processing agents as plain text, parsed and loaded into Django
- User interface accesses local Django server with web browser

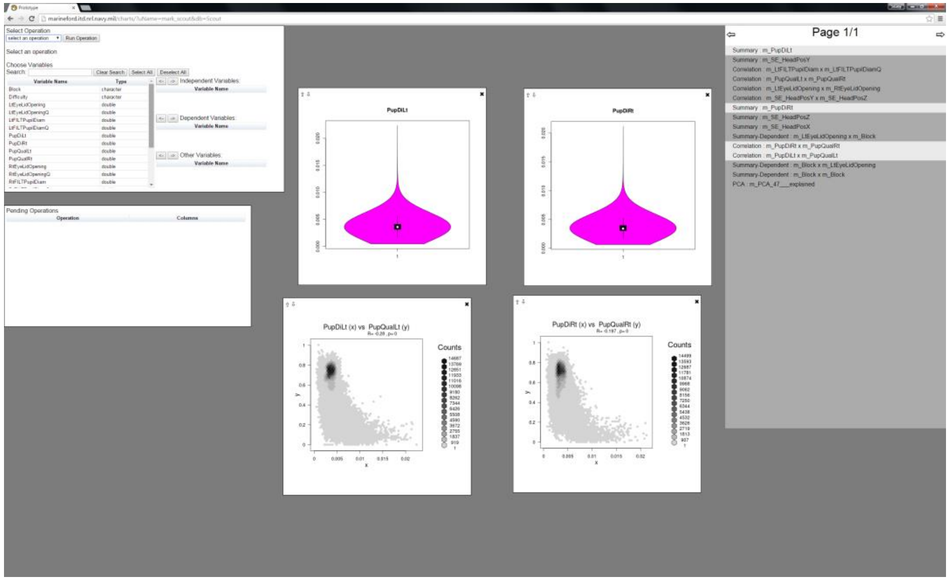
Use Case 1

- Study of image metrics on multivariate visualizations
  - Do the image metrics offer insight into user performance?
  - Approximately 600 measures
- Recommendations
  - Summary statistics
  - Requested F-tests
  - Non-requested F-tests
    - visualization technique on edge strength (Sobel) showed difference (target versus distractions)





Use Case 2



- Data from eye tracking, mostly unexplored
- Initial recommendations are for summaries of variables
  - Similarity in the distributions of two variables led to the discovery of data error
- Concern with pupil diameter measurements led to summaries, correlations, and repeated-measures ANOVAs involving those variables
  - Helped identify a need for more restrictive outlier removal threshold

Use Case 3

- Series of five human participant studies; goal was explore connections between the analysis (workflow) for data sets
- First data set: cold start, so defaults to summary statistics
  - User selects dependent variables of interest
  - CEDARS displays group means; some are of interest
  - CEDARS follows with ANOVA, then t-tests (independent variables)
- Second set: much the same with better ranking
  - User selects dependent variables, gets group means by selected variables, and user selects results of interest
  - Invokes some rules on the first data set where variables names are the same and leads to new recommendations
  - CEDARS invoked some rules using SubjectID, and user sees that one subject was error-prone and fast

Use Case 3

- Third set: Summary operations, group means, ANOVA
  - Not much of interest found
- Fourth set: Summary operations, group means, ANOVA
  - New variable is explicitly requested through summary statistics
- Fifth set: Summary operations, group means, ANOVA
  - Two new variables requested through summary statistics
  - Reclassified from numeric to factor (a standard operation in R)
  - CEDARS begins to recommend multi-factor ANOVA operations
  - CEDARS applies type change to variables with same name in fourth data set

Conclusions & Future Work

- CEDARS can replicate standard analytical practice and provide deep analysis by recommending operations on variables a domain expert had not thought to test
- CEDARS can replicate analysis applied to one data set to another with similar structure or shared names
  - Can be invoked "forward" on new data or "backward" on data in memory
- Ultimate goal of EDA: tell the story that explains the data
- CEDARS can potentially
  - Capture expertise of domain expert and data scientist
  - Use that expertise to guide novices
  - Remind experts of forgotten analytical options
  - Promote adoption of novel analysis methods
  - Unify architectures for automating layout or visual representation
- Future: more data and evaluate recommendations across data sets

Thank you!

- CEDARS: Combined Exploratory Data Analysis Recommender System technical report (forthcoming)

- Mark.Livingston@nrl.navy.mil

- https://www.nrl.navy.mil/itd/imda/research/5581/visual-analytics-and-visualization

When Acceptance Isn't Enough; Improving Evaluations of Novel Decision Support Tools

Jesslyn Alekseyev

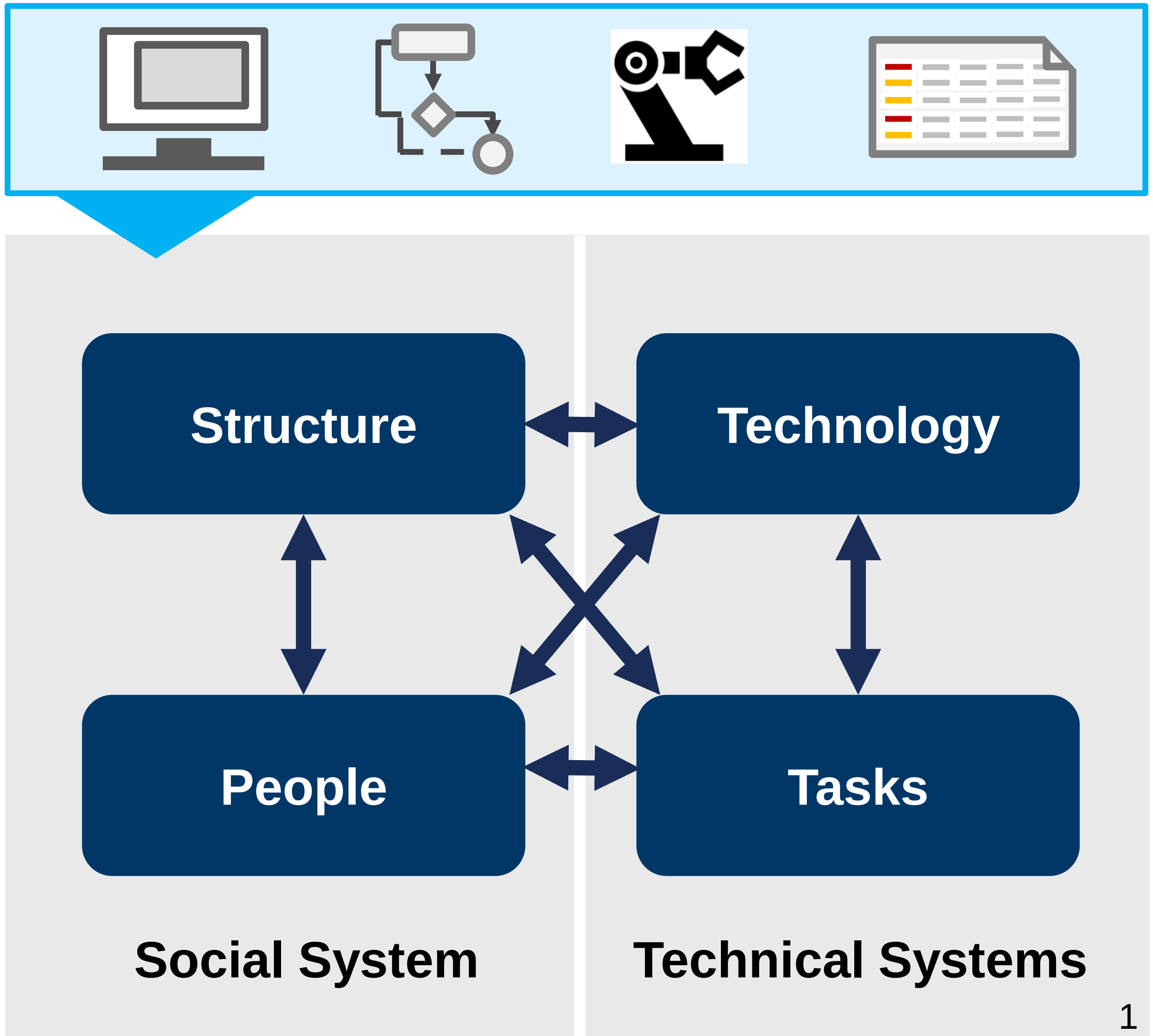
NDIA Conference
17 April 2019

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

This material is based upon work supported under Air Force Contract No. FA8702-15-D-0001. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the U.S. Air Force.

The Difficulty Introducing Novel Technology

- Need to integrate with existing
  - Processes and procedures
  - Tools and technology
  - Tasks and goals
- Many organizations rely on prospective users to evaluate new tools



[1] Adapted from: Robert P. Bostrom , J. Stephen Heinen, MIS Problems and failures a socio-technical perspective part II: the application of socio-technical theory, MIS Quarterly, v.1 n.4, p.11-28, December 1977

The User Acceptance Gap

A user can…

Potential for Operational Benefit	User Acceptance: Reject	User Acceptance: Accept
High	✗ *reject high benefit tool*	✓ *accept high benefit tool*
Low	✓ *reject low benefit tool*	✗ *accept low benefit tool*

User acceptance methods provide a means to evaluate technology

- **Challenges:**
  - **May not address potential for operational benefit or identify means to improve**
  - **May not account for additional skills or process changes required**

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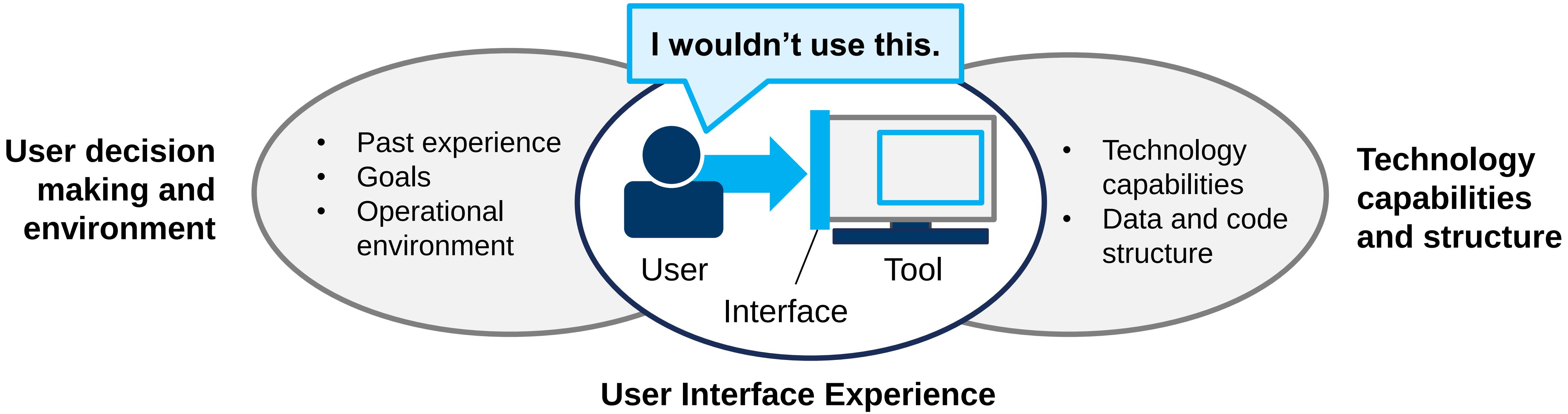
Users, Technology, and Interfaces



- **Users experience the technology through the interface**
- **Reducing project risk and targeting efforts requires proper interpretation of user feedback**

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Application Experience Framework[2]: Anticipating and Interpreting User Experience

Application Experience Layers

Application

Visual/UI
- **Presentation** — Does the look and feel match with user expectations?
- **Functional** — Are users able to interpret system behavior?

Cognitive
- **Procedural** — Are users able to complete operational tasks?
- **Model mapping** — Can users form goals and leverage the application to meet them?

[2] Working paper: J. Alekseyev (2019). "Novel Application Experience Framework to Improve Evaluations of User Interfaces"

UI = User Interface

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Application of Framework

Layer	Focus	Formative / Evaluative	Suggested Method
Presentation	Does the look and feel match with user expectations?	Formative	Review existing, new concepts
		Formative / Evaluative	Review of best practices
		Evaluative	Usability assessment
Functional	Are users able to interpret system behavior?	Formative	Review existing
		Evaluative	Cognitive walk-through
		Evaluative	Usability assessment
Procedural	Are users able to complete operational tasks?	Formative	User interviews, walk-through
		Formative	Critical decision study
		Evaluative	Cognitive assessment
Model Mapping	Can users form goals and leverage the application to meet them?	Formative	Task, goals assessment
		Formative	User interviews, walk-through
		Formative	Team interviews, walk-through
		Evaluative	Cognitive assessment

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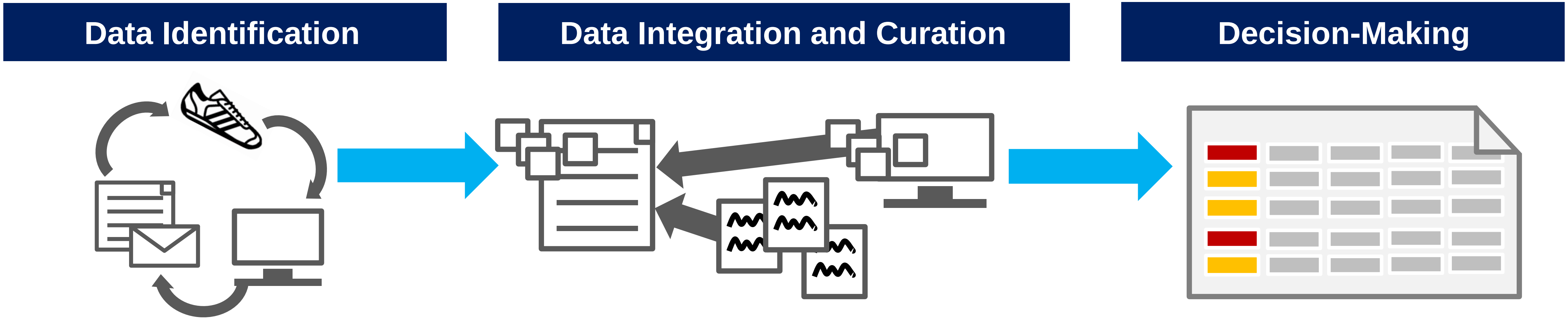
Case Study: Metrics Management for the Military Sealift Command (MSC)



Terms can have different meanings; data may be stored locally

Time-intensive to gather, clean, and compile data for each metric

Time intensive to manage, update, and maintain data

Data Management: Semi-manual process for updates or changes

Goal: Introduce technology to improve metrics management

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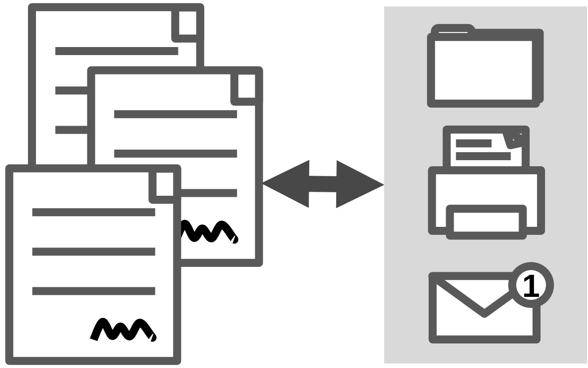
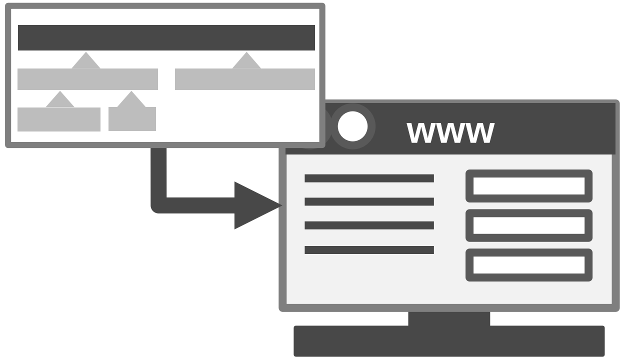
Case Study: Identifying Initial Focus

Current Capability



- Managed manually and stored locally
- User process and data understanding is tied closely to current artifacts

New Capability



- Web-based process and management, semantic data structure
- User process and data understanding will need to change

Initial Focus: Cognitive Layers

Application Experience Layers			
Visual/UI		Cognitive	
Presentation	Functional	Procedural	Model mapping

Research steps:

- Understand current process and goals
- Understand technology analog
- Map current to new

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Case Study: Mapping Steps

1. Current concept

2. Map to New Technology

Notional

Metric: Shipping Time

Definition: Ratio of
$n_{shipped}$ = # orders shipped on or by the requested date, divided by
n_{total} = total number of orders

Calculation: $n_{shipped} / n_{total}$

Data Source:
Shipping Orders Database

Managed by: Program Management, John Doe

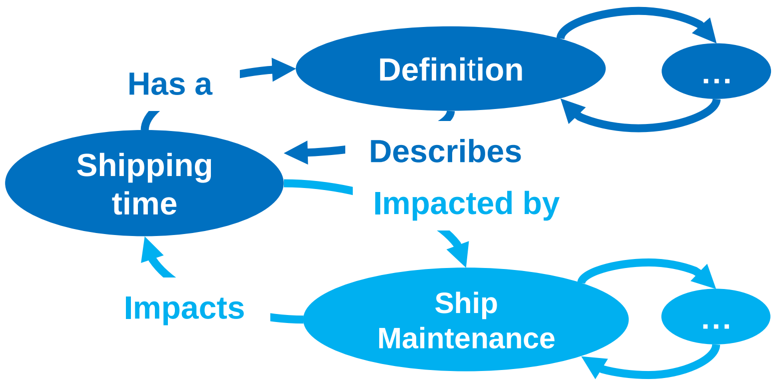
Leadership Approval: Sue Adams

Term definitions and descriptions

Process management

"Tribal" data knowledge

WWW



Example semantic data structure

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Summary and Conclusions

- Introducing novel technology into existing processes is complicated, and success can be difficult to measure
- Effective use of user acceptance measures requires robust understanding of user experience with technology interfaces
- Novel framework was developed to guide interface analysis and interpretation of user feedback, and was applied to support research and development of prototypes for MSC

MSC = Military Sealift Command

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Acknowledgements

Thank you!

Contact: Jess Alekseyev, jalekseyev@ll.mit.edu

MIT LL

- Dr. Allison Chang
- Dr. Hayley Reynolds
- Dr. Bill Moser
- Dr. George Mathew
- Mr. Brett Levasseur
- Mr. Dick Knowles

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