Trust Research in AFRL

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Collaborative Interfaces and Teaming Branch

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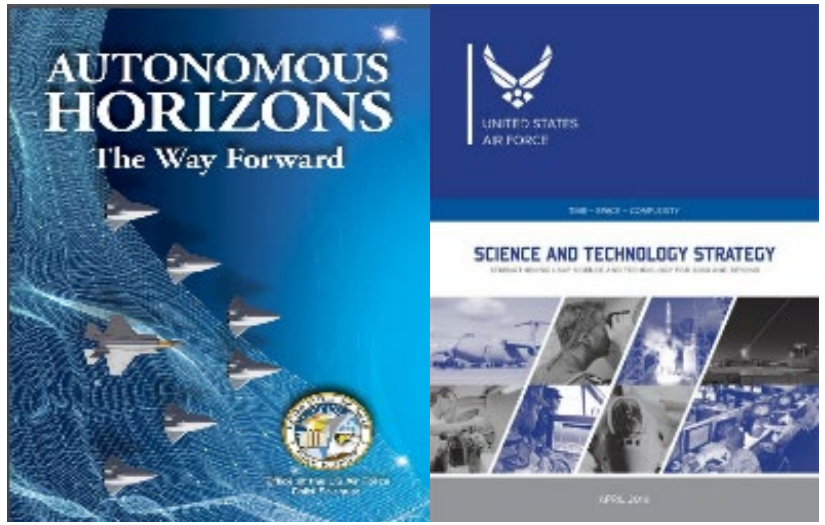
Trust Research is a Strategic Imperative

AF2030 S&T Strategy - Trusted data, Trusted AI, Trust required to support lethal combat operations

Autonomous Horizons Vol. 2 – "Autonomous systems should…Ensure trust…tenets of trust include…transparency for decision making"



Interfaces for Applied Systems
-Medusa C2 – applying Play Calling approach in novel displays
-Skyborg – Transfer of Authority of Groups/Fighter-based control

Trust/Transparency in AI – DARPA ACE; Squad-X; Alias; Trust of ML, F-35 AGCAS

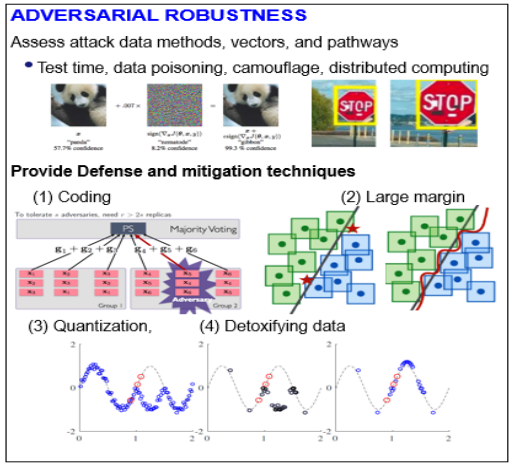
"Trust in distributed teams", "Multi-domain collaboration" – **SAB Study on Technologies for Enabling Resilient C2 (2018)**

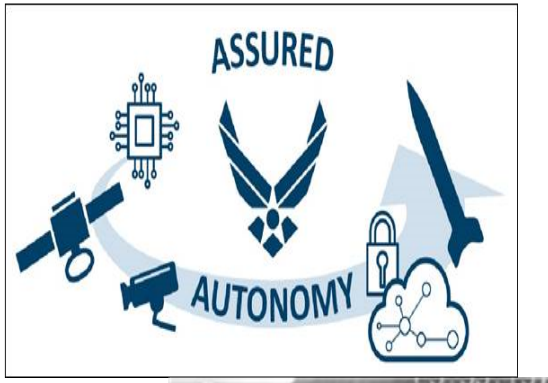
-JADC2 Operating Concept – Decision Making/Convergence of effects

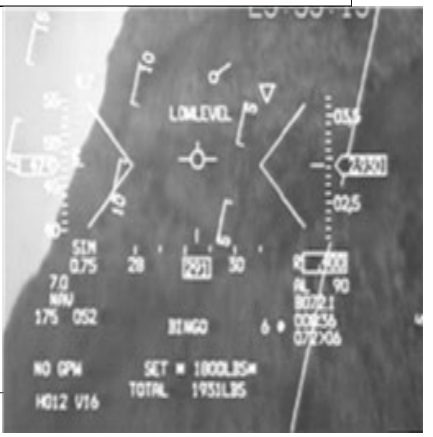
-Space Trusted Autonomy – distributed comm, mixed initiative work, trustworthiness

Trust is Relevant Across AFRL

- 711 HPW
  - Trust in autonomy, transparency, biases
- AFOSR
  - Trust and Influence Portfolio, Formal Verification Methods
- Information Directorate (*recent Trusted AI event)
  - Robust and resilient machine learning
- Aerospace Systems Directorate
  - Certification of autonomous systems/vehicle behaviors
- Space Systems Directorate
  - Space trusted autonomy
- Munitions Directorate
  - V&V to build trust in Networked Collaborative Autonomous Weapons
- Materials Directorate
  - Trust in robotics/precision manufacturing
- Sensors Directorate
  - Trusted data, data fusion





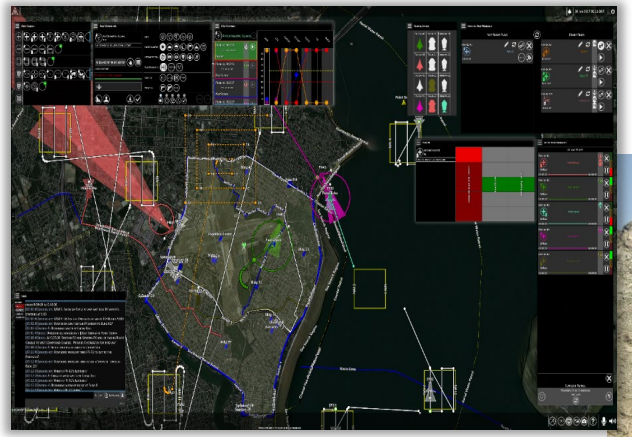


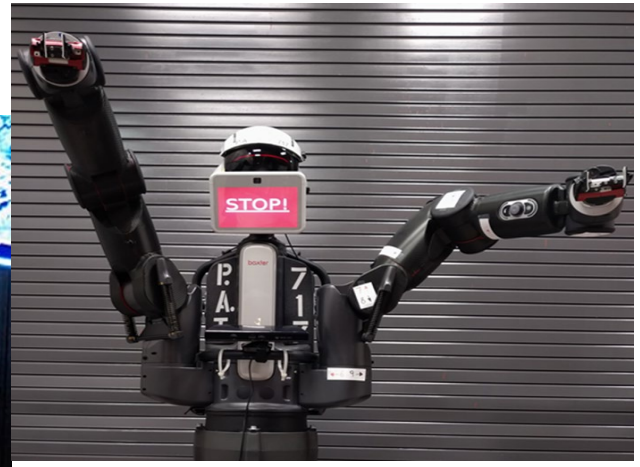
Trust Workshops/Organizing Activities (RH & AFOSR)

- Trust management in cyberspace – 2009
- Trust-based vulnerabilities 2009
  - Individual differences (PAS; suspicion)
  - Culture
- Directorate Trust Deep Dive – 2010
  - Measurement, predictors of trust, culture
- Trust measurement – 2010
- Trust in Autonomous Systems – 2012
  - 40 experts across academia-industry-gov't
  - Basic Research Initiative & multiple grants
- Trust in human-agent teams – 2015
- Support to other programs: IARPA, DARPA, OSD, NASA, FAA, IDA, ACC, etc.

Shallow Dive into 711 HPW Trust Research

- Trust in automation
  - Transparency, reliability
- Trust of fielded systems
  - Acceptance of automation
- Trust in human-autonomy teams/Robots
  - Transparency, teaming factors
- Trust of software code
  - Predictors of re-use
- Interpersonal trust
  - Swift Trust in JADC2 teams



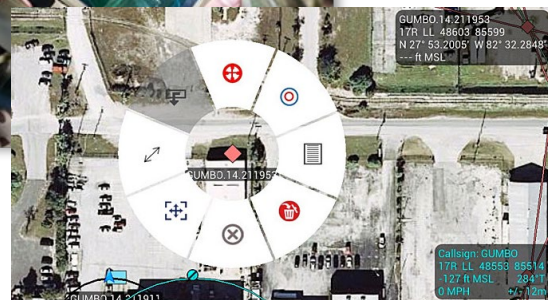


Collaborative Interfaces and Teaming CRA

Human-Autonomy Collaboration

Distributed, Heterogeneous Teaming Solutions

The Collaborative Interfaces and Teaming CRA focuses on: 1) flexible, directable, and transparent Human-Autonomy Teaming (HAT) solutions, 2) the science of human-human teaming in distributed multi-domain contexts, and 3) development of technologies to facilitate shared authority of autonomy and common ground within and between mixed human-autonomy teams.



Increased focus on teaming is an intentional strategic pivot toward JADC2

Human-Autonomy Collaboration LOE

- 6.2 FY21 Tasks
  - Models/Metrics for Human-Autonomy Teaming — Lyons et al. (2021) Frontiers in Psychology
  - Collaborative Interfaces Research
    - HMI design
    - Context-aware agents
    - Task manager

    SkyFlagONE [ABMS]; Medusa C2 [PEO Digital]; Assured Base Operations
  - Trust in Intelligent Machines
    - Swarms
    - F-35 AGCAS
    - Trust of Robots/Agents

    CMU Center of Excellence

    F-35 JPO; OSD Safety Office
  - Manned-Unmanned Teaming (Fighter-based control) — Aid for Rapid SA Acquisition
  - Transfer of Authority – distributed OPs — Battle Card Concept /AISC
  - Transparency in Machine Learning Systems (*New area in FY21)
  - Synthetic Teammates and their impact on trust in multi-team systems (*New area in FY21)

Distributed, Heterogeneous Teaming Solutions LOE

- 6.2 Tasks
  - Team performance metrics
  - Team kickstarter methods
    - How to facilitate swift trust among team members
    - Skill/role deficiencies (*New area FY21)
  - Multi-domain teaming
    - Play calling approaches for cyber
    - Multi-domain Course of Action (COA) generation and analysis
    - Integration of effects for Air, Space, and Cyber (aspirational)
  - Team resilience methods
    - How to ensure effective team process amid degradation/change (FY22 start)

Tolston et al. (2019). *BRM* (Wing Top 10 Publications 2020)
-Analysis of Black Skies Exercise Data

Capiola et al. (2020) JCEDM

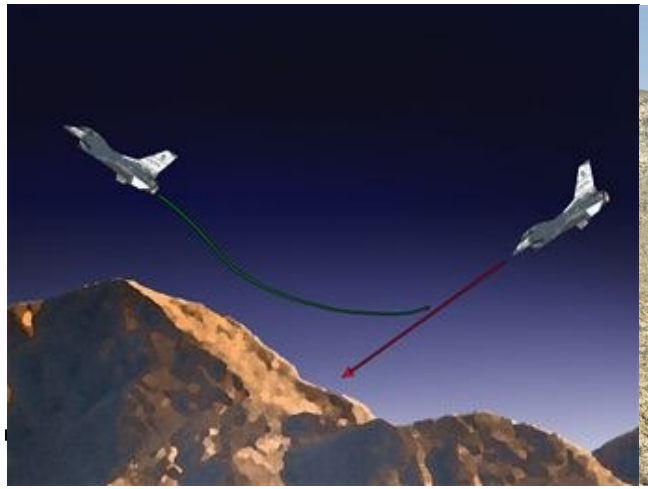
Tech Sprint 2021

805th Combat Training Squadron – Shadow Ops Center Network (ShOC-N); Nat Space Defense Center

EMS&A – integration of Cyber into Battle Management

Trust Research Example – AGCAS Study 2015-2018

- Objective: Understanding antecedents of automation trust among pilots over time
  (Ho et al., 2017a; b; Koltai et al., 2014; Lyons et al., 2016; 2017)
- Interview & survey research
  - Sampled approx. 500 F-16 pilots, 70 F-22 pilots *by ACC request (only F-16 data reported herein)
  - Baselined trust, identified trust antecedents
- Results were used to improve the system by working with engineers
- Activation data provided to various stakeholders
  - Understanding of activations outside of test were largely unknown
- Similar Studies conducted with Rotary Wing Aircraft community & F-35



AGCAS Year 1

- Year 1: Survey (N = 142), Interview (N = 168)
- Primary Findings:
  - Trust was highly variable – moderate at best
    - Uniquely related to PAS, perceived benefits, & performance
    - Pedigree of the test community was high & that helped
    - Business case was very strong
    - Chevrons were viewed very positively – helped make the system predictable
    - Activation base rates were low approx. 10%
  - Lots of early errors causing uncertainty
    - Key was attribution & technical information
  - Lots of stories – good and bad
    - Early system save was strong trust booster
  - Pilots had little knowledge of AGCAS – lots of confusion
  - Policies/practices were varied
    - Some units flew with it off, turned off for BDC/formation flights

AGCAS Year 2

- Year 2: Survey (N = 100), Interview (N = 131)
- Trust was moderate to high
  - Performance was the key driver
  - Stories of the saves pervaded the pilot community
    - Tipping point was student save w/video
  - Knowledge increased – system began to become predictable
    - Experiences with activations increased
  - Chevrons became predictable
  - Business case unquestionable
  - However, growing concern over novel nuisance factor
  - Activate rates were around 20%
  - Pilots were instructed to use PARS in training
    - Added familiarity

AGCAS Year 3

- Year 3: Survey (N = 77), Interview (N = 103)
- Trust was very high and universal
  - Saves were very well known
    - Student save video became kind of legendary
    - Student and instructor save sealed the deal – video impact
  - Perceived benefits were universal and huge trust booster
  - System was understandable and integrated into the pilot curriculum
  - Chevrons incorporated into Strafe training & ops
  - Activation rates were approx. 34%
    - Direct experience with the system was growing
    - Plus use of PARS supported experience of maneuver
      - Also use of PARS operationally that boosted AGCAS trust
  - Nuisance issue had a fix coming
    - It was understandable, predictable, and pilots had directability
  - Instructor pilot anecdote

Recent Basic Trust Research – funded under AFOSR's Trust & Influence Portfolio

- Trust biases in HRI (PI: Dr. Gene Alarcon)
  - Studies empirically examining trustworthiness biases toward robots
    - Benevolence/integrity violations (published in Applied Ergonomics)
    - Full ABI manipulations robot vs human (IEEE HMS conference; multiple manuscripts under review)
    - Effects of Perfect Automation Schema on biases (in progress)
- Human-agent teaming/Compliance (PI: Dr. Gregory Funke)
  - Capacity to cooperate in human-agent interactions (online data collection complete – new start)
  - Robot compliance (Frontiers in Psychology 2021; HFES 2019)
- Transparency in HRI (PI: Dr. Joseph Lyons)
  - Studies examining facets of transparency in autonomous robot contexts
    - Stated Social Intent (completed, published in Human factors 2021; Applied Ergonomics 2020)
    - Decision authority (completed, under review)
    - Robot etiquette (completed, under review)
- Mental models in HRI (PI: Dr. April Rose Panganiban)
  - Studies examining how mental models develop for robotic partners
    - Examined the impact of supportive communications in Loyal Wingman Scenario (published in JCEDM 2019)
    - Individual differences in trust in autonomous partners: Implications for Transparency (IEEE Transactions on Human-Machine Systems, 2020);
    - Trust in the Danger Zone: Individual Differences in Confidence in Robot Threat Assessments (submitted to Frontiers in Psychology)

POC

Any questions?

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