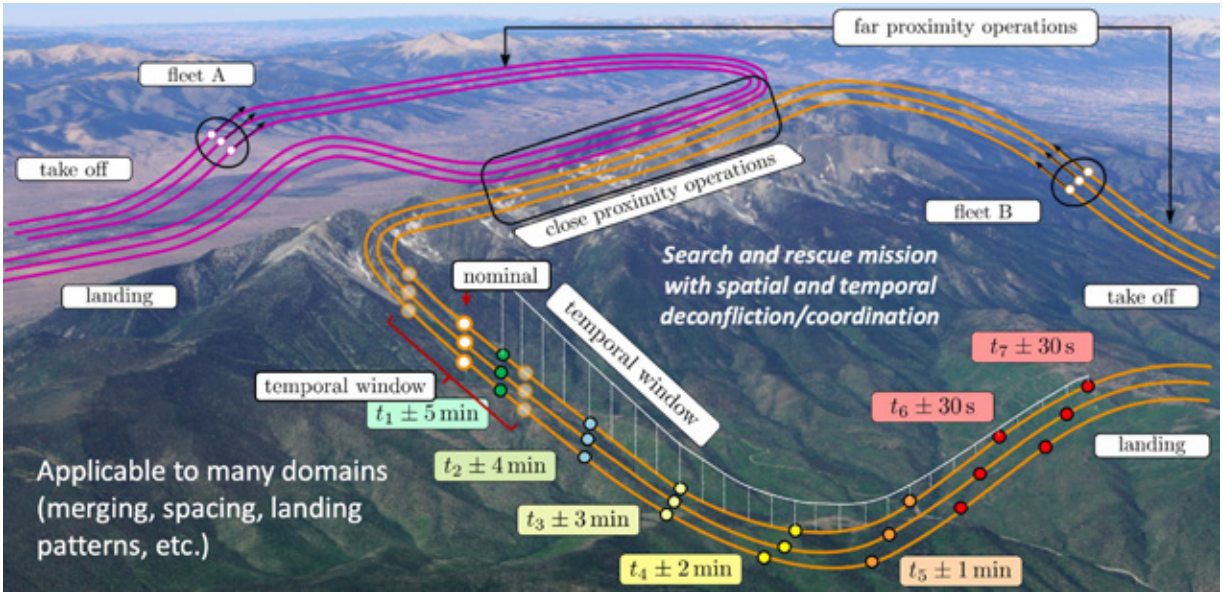
NASAfacts

ATTRACTOR: Autonomy Teaming and TRAjectories for Complex Trusted Operational Reliability

Autonomous systems (AS) are crucial to realizing the vision of new, complex transportation modes, such as advanced air mobility (AAM) and urban air mobility (UAM). A chief barrier to induction of AS into aviation is insufficient understanding of AS reliability in time-critical and safety-critical environments—an obstacle to certification. ATTRACTOR is aimed at building a basis for certification of classes of autonomous cyber-physical-human systems (CPHS) via establishing metrics and models of trustworthiness and trust in multi-agent team interactions, analyzable trajectories, explainability of computational algorithms (explainable artificial intelligence, or XAI), and persistent modeling and simulation, in the context of missions planning and operation. By "building a basis for certification," we mean acquiring an understanding of when a system is trustworthy and developing computable means to estimate trustworthiness and trust in order to eventually inform functional requirements that contribute to certification. The outcomes are applicable not just to aviation but to all domains that rely on autonomous systems.

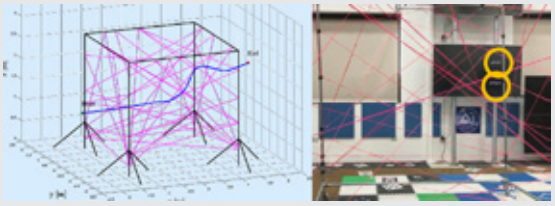
Target environments AAM, UAM, and complex, cluttered environments

The ATTRACTOR team has developed a CPHS for trajectory-based, mixed-reality multi-agent missions. To provide context for the development, search and rescue (SAR) has served as the design reference mission. ATTRACTOR comprises the following components: trajectory planning and management; navigation in challenging environments; persistent mixed-reality modeling and simulation; human–machine teaming and interaction; visual recognition and XAI; testing and evaluation; anomaly detection; metrics and models of trust and trustworthiness; technology integration; and demonstrations in simulation and flight. Most components have been integrated into the CPHS. Both the system and contributing components were found to be feasible.



Design reference mission: Search and rescue in wooded, mountainous area

Trustworthiness:
Assurance the CPHS performs as required

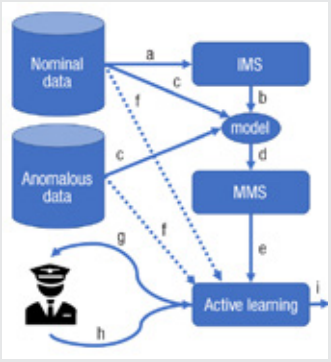


Analog of cluttered environment in simulation

Reality in flight through physical maze

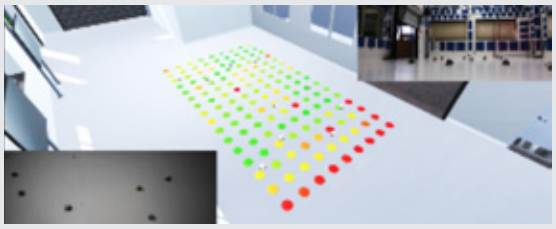
Trajectory management has been proven to generate realizable trajectories. All ATTRACTOR components contribute to trustworthiness of CPHS.

Trust:
Readiness to rely on another agent



Facilitate trust in autonomous systems by using domain expert knowledge to identify anomalies and their precursors. Explain anomalies during operations.

Certification



Mixed-reality simulation-to-flight platforms will play a crucial role in understanding of complex system behavior to inform certification requirements.

ATTRACTOR Accomplishments

The integrated CPHS built in ATTRACTOR has proven to work reliably and safely in mixed-reality (simulation and flight) demonstrations, such as single-vehicle and multiple-vehicle conflict-free trajectory management in challenging and cluttered environments. ATTRACTOR has developed a multi-center distributed mixed-reality capability (physical and virtual environments operating concurrently) in its Baseline Environment for Autonomous Modeling (BEAM), critical for generating statistically meaningful, challenging environments for testing AS. The project has also successfully applied the adaptive stress testing (AST) system to verification of trajectory management algorithms and has developed an anomaly detection system for recognizing an onset of off-nominal conditions in complex operations. ATTRACTOR has also investigated several promising approaches to improving explainability of machine learning algorithms used for object recognition during SAR.

In a collaboration with the Massachusetts Institute of Technology, ATTRACTOR has successfully demonstrated Search and Rescue Under the Canopy (SARUC) in a forested, GPS-denied environment.

Transition Opportunities

ATTRACTOR's work extends to multiple disciplines and offers numerous opportunities for transition to government and civilian organizations as well as private industry. Organizations engaged in SAR and humanitarian deliveries have already expressed interest in technology transition from ATTRACTOR. Here at NASA, ATTRACTOR's work will continue in multiple areas:

- Work on fundamental autonomy capabilities is being transitioned from NASA's aeronautics domain to the space domain; these technologies include coordinated trajectory generation, path/motion planning, swarming, semantic object classification, detect and avoid, mission/task planning, and trust/trustworthiness.
- ATTRACTOR's modeling and simulation environment, BEAM, is being tailored for NASA Transformational Tools and Technologies (TTT) activities on autonomous frameworks, concepts, and scenarios for dynamic coordination of autonomous agents.
- ATTRACTOR's work on human–autonomy teaming (HAT) has transitioned to other NASA projects: TTT/Reconnection and Micro-Scale (RAM), System-Wide Safety (SWS), and Air Traffic Management–eXploration (ATM–X).

For more information, contact:

Dr. Natalia Alexandrov, n.alexandrov@nasa.gov
Dr. B. Danette Allen, danette.allen@nasa.gov

National Aeronautics and Space Administration

Headquarters
300 E Street SW
Washington, DC 20546

www.nasa.gov

NP-2021-01-099-GRC