Complex Autonomous Systems Assurance (CASA)

National Aeronautics and Space Administration

NASA's System-Wide Safety project seeks to explore, understand, and overcome technical challenges associated with assuring the safety of future aviation operations.

CASA is prototyping a process for the inclusion of untrusted (including machine-learning-enabled & autonomous) components in emerging aerospace systems.

CASA enables increasingly effective paths to safety assurance of complex and autonomous systems through the development of certification processes for airspace systems with untrusted components.

Key attributes:

- **Develop** assurance tools and methods to provide guaranteed behavior of complex and autonomous systems, such as automated contingency management in unpredictable aviation contexts
- **Demonstrate** effectiveness of assurance tools and methods for Advanced Air Mobility (AAM)

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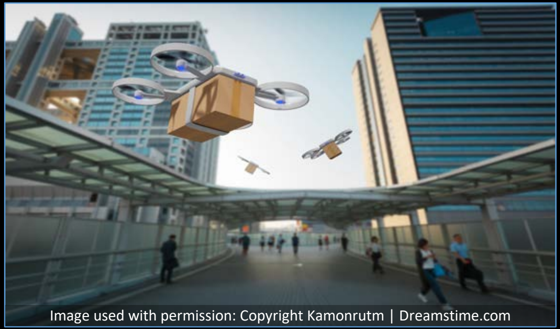

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System-Wide Safety: Complex Autonomous Systems Assurance

Prototyping a process for the inclusion of untrusted (including machine-learning-enabled and autonomous) components in emerging aerospace systems

Overview

Complex highly automated and autonomous capabilities required for Advanced Air Mobility (AAM) operations will have to meet an extremely high bar for safety and performance assurance. Methods to assure autonomous systems are in their infancy. Our researchers are investigating, developing, and evaluating these techniques for effectiveness. Future high-density operations and complex airspace systems will rely on increasingly autonomous technologies for capabilities like contingency management. Such systems may include the introduction of advanced and non-traditional technologies (e.g., learning-based and adaptive systems in the safety-critical domain).

Productivity and effectiveness necessitates ensuring the safety of autonomous systems in the airspace.

Example input images to a center-line following algorithm, rendered in X-Plane. Left/right = clear/cloudy weather. Top/bottom = 12 pm/4 pm.

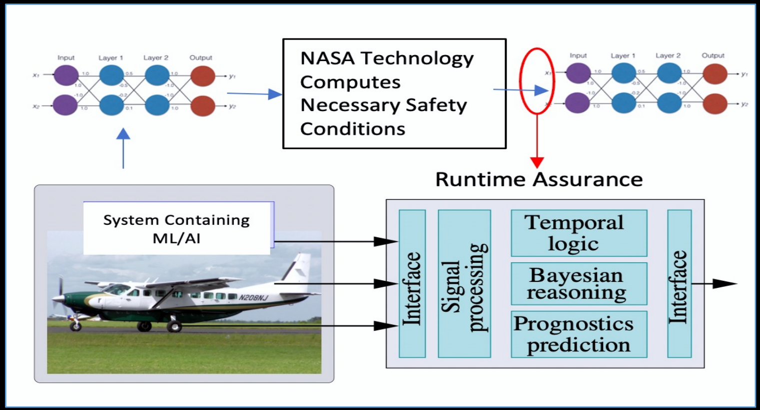
Research Conducted

We have reviewed machine-learning algorithms proposed for aviation applications to determine each algorithm's amenability to assurance. For key machine-learning enabled components, we are developing techniques to assure that algorithms, as implemented in code, are provably correct. We are also developing runtime monitoring technologies and developing recommendations for their assurance and architectures. Finally, we are working together with regulators and industry groups to understand how our current assurance processes inhibit the use of untrusted components, and how other frameworks could allow the appropriate evaluation and system-level assurance of aviation systems and operations.

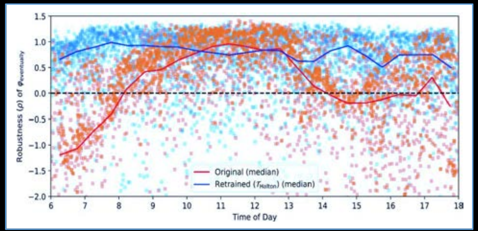
Key Collaborators

Government Agencies – Federal Aviation Administration (FAA), Defense Advanced Research Projects Agency (DARPA), Airforce Research Laboratory (AFRL), National Institute of Standards and Technology (NIST) and others.

Organizations and Industry Partners – Johns Hopkins, DLR, Boeing, GE Aviation, Inria (National Institute for Research in Computer Science and Automation), Flight Safety Foundation and others.



Run-time assurance of neural-network-based machine learning-enabled component using formal methods. The run-time monitoring keeps the overall system operating within safe bounds.



Performance of a neural-network-based algorithm as a function of time of day, before and after retraining.

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