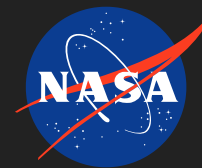


Safe Aviation Autonomy with Learning-enabled Components in the Loop: From Formal Assurances to Trusted Recovery Methods

Active Technology Project (2020 - 2024)



Project Introduction

In pursuit of autonomous aviation systems that can safely and efficiently operate within the National Airspace, this project will develop and demonstrate a framework for providing algorithmic assurances and designing fault detection, isolation, and recovery (FDIR) methods for those components of the autonomy stack that rely on data-driven methods based on machine learning. In the future, autonomous aviation systems, in the form of unmanned aircraft systems (UAS) and urban air mobility (UAM) services, are expected to result in more than 2.5 million flights per day. These systems will operate at increased levels of autonomy and will extensively leverage non-traditional software components based on machine learning techniques, in tasks as diverse as visual perception (e.g., to detect other aircraft), intent prediction (e.g., to predict future behavior of other agents), and decision-making and control. Such a proliferation of learning-enabled components (LECs) will be driven by their potential to outperform their traditional, non-learning based counterparts (e.g., for object detection and recognition) and enable entirely new capabilities (e.g., fast decision-making in non-stationary environments). However, LECs can be notoriously brittle in practice (as generalization beyond training data is still a poorly understood property) and largely lack appropriate methods for verification and validation. This tendency of theoretical statistical accuracy but demonstrated fragility in practice represents a key barrier for wider and trusted adoption of LECs. In this context, this project has three objectives:

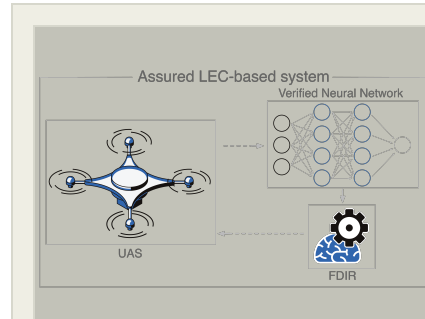
Objective 1: Assurances for Autonomous Systems with LECs: Develop and demonstrate tools and methods to provide assurances for those components within the autonomy stack that rely on machine learning techniques and other similar data-driven techniques.

Objective 2: Run-Time Fault Detection, Isolation, and Recovery for LECs: Develop and demonstrate tools and methods to detect faulty operation for LEC-based autonomous aviation systems, and devise new fault isolation/recovery methods for these systems.

Objective 3: Airspace Management with LEC-based Autonomous Systems: Develop and demonstrate tools and methods to extend the vehicle-centric assurances and FDIR capabilities devised in Objectives 1 and 2 to the airspace system level.

Anticipated Benefits

By addressing Objectives 1–3, this project will place algorithmic assurances and FDIR techniques for LEC-based aviation systems on a firm theoretical and algorithmic foundation. This will be pivotal to creating assurance cases for future aviation systems and thus to ensuring the deployment of UAS and UAM systems on a massive scale.



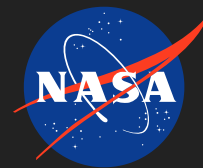
This project will develop and demonstrate a framework for providing algorithmic assurances and designing FDIR methods for those components of the autonomy stack that rely on data-driven methods based on machine learning. FDIR will...

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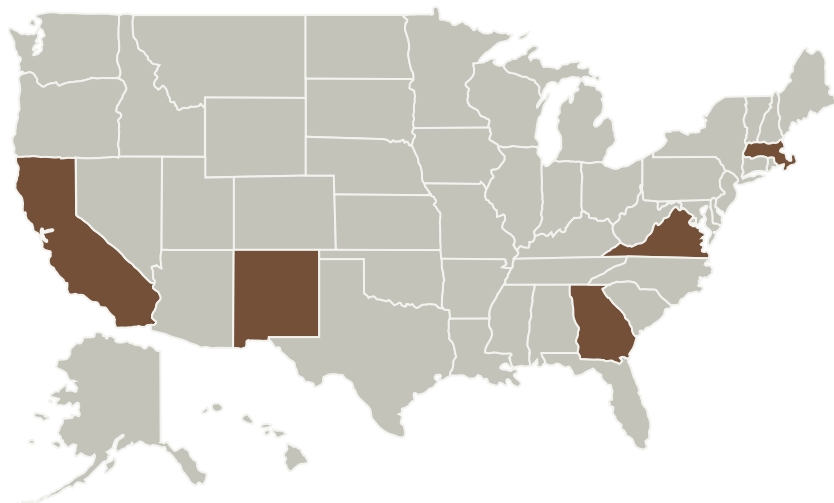
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Active Technology Project (2020 - 2024)



Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Aeronautics Research Mission Directorate (ARMD)

Lead Organization:

Stanford University

Responsible Program:

Transformative Aeronautics Concepts Program

Project Management

Program Director:

John A Cavolowsky

Project Manager:

Koushik Datta

Principal Investigator:

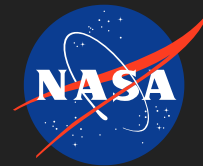
Marco Pavone

Co-Investigators:

Mykel Kochenderfer
Mac Schwager
Hamsa Balakrishnan
Chuchu Fan
Kevin Leahy
Frank Dellaert
Panagiotis Tsiotras
Meeko Oishi
Alessandro Pinto
Zhao Sun
Claire Tomlin

Safe Aviation Autonomy with Learning-enabled Components in the Loop: From Formal Assurances to Trusted Recovery Methods

Active Technology Project (2020 - 2024)



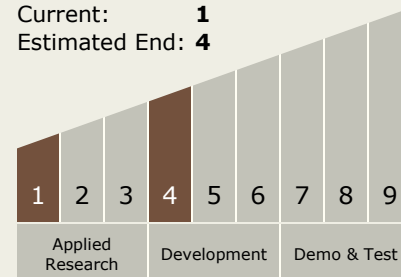
Organizations Performing Work	Role	Type	Location
Stanford University	Lead Organization	Academic	Stanford, CA
Georgia Institute of Technology	Supporting Organization	Academic	Atlanta, GA
Hampton University	Supporting Organization	Academic	
Massachusetts Institute of Technology(MIT)	Supporting Organization	Academic	Cambridge, MA
MIT Lincoln Laboratory(MIT/LL)	Supporting Organization	Academic	Lexington, MA
Raytheon	Supporting Organization	Industry	
University of California at Berkeley	Supporting Organization	Academic	Berkeley, CA
University of New Mexico	Supporting Organization	Academic	Albuquerque, NM

Primary U.S. Work Locations

California	Georgia
Massachusetts	New Mexico
Virginia	

Technology Maturity (TRL)

Start: **1**
 Current: **1**
 Estimated End: **4**



Technology Areas

Primary:

- TX16 Air Traffic Management and Range Tracking Systems
 - TX16.1 Safe All Vehicle Access

Target Destination

Foundational Knowledge

Supported Mission

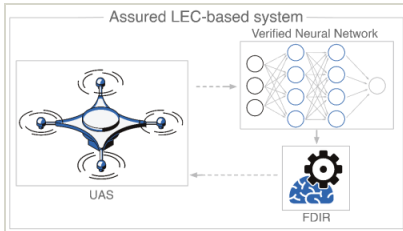
Type
Push

Safe Aviation Autonomy with Learning-enabled Components in the Loop: From Formal Assurances to Trusted Recovery Methods

Active Technology Project (2020 - 2024)



Images



Project Framework

This project will develop and demonstrate a framework for providing algorithmic assurances and designing FDIR methods for those components of the autonomy stack that rely on data-driven methods based on machine learning. FDIR will "bound" the behavior of LECs, such as a neural network, thus critically contributing to establishing assurance cases for UAS/UAM systems.

(<https://techport.nasa.gov/image/40835>)

Project Website:

<https://sites.google.com/view/nasa-safe-aviation-autonomy/home>