Project 25: General Aviation 2030 Exploratory Analysis

Dr. Evan Harrison

Research Engineer II

Aerospace Systems Design Laboratory

School of Aerospace Engineering

Georgia Institute of Technology

The PEGASAS Team

Georgia Institute of Technology

Purdue University

Project 25
FAA Technical
Monitors

Mr. Vasudeva Kolli
Mr. Mike Paglione

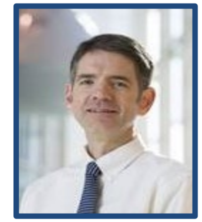
Principal Investigator (PI)
Prof. Dimitri Mavris

Co-PI
Dr. Evan Harrison

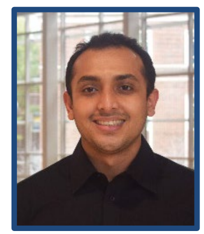
Former Co – PI and
Project Lead
Dr. Simon Briceno

Graduate Research Assistant
Jacob Stickney

Graduate Research Assistant
Mayank Bendarkar



Principal Investigator (PI)
Prof. William Crossley



Graduate Research Assistant
Arpan Chakraborty

Graduate Research Assistant
Brandon Sells

Georgia Institute of Technology

Purdue University

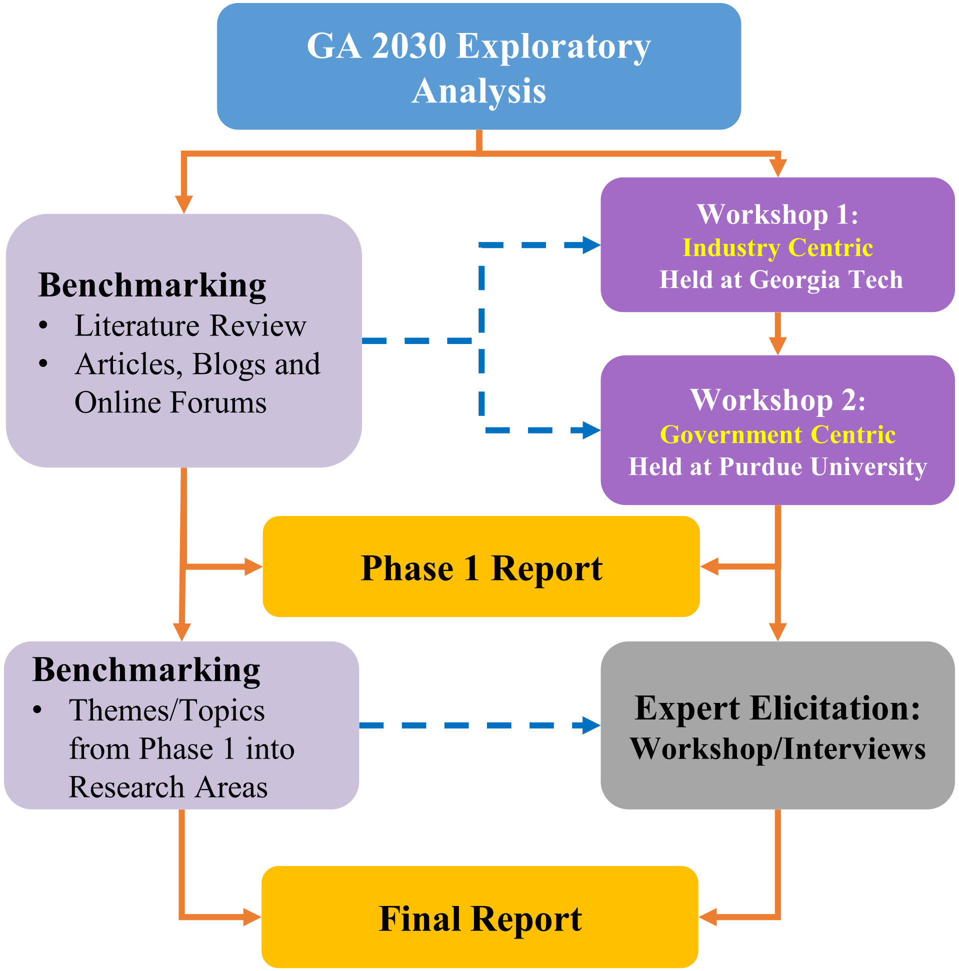
Project 25 Executive Summary

- PEGASAS team is generating a report which **describes strategic general aviation research topics** that can help the FAA and other GA stakeholders **better prepare for general aviation issues in 2030**

- Team has generated questionnaires for seven research areas

- Completed interviews for all seven research areas

- Finalizing a report that documents “soft data” which enables the FAA to write an R&D plan for GA in 2030



Future Trends for General Aviation

Georgia Institute of Technology

Purdue University

Key Challenges and Main Topics from Phase 1

Top 4 Challenges in Future GA

Certification
- How to make the certification process more efficient for new types of aircraft and technologies

Airspace Management
- How to plan the airspace in urban and suburban areas in order to accommodate more urban VTOL concepts and UAS

Infrastructure
- How to accommodate alternative GA energy beyond 100LL - electric, MoGas, and other future sources; Maintenance stations and Vertiports for urban VTOL

Cost
- Initialization of new technologies may be expensive for GA operators, owners, users and GA supporting airports

Formulation of the Six Main Topics

Result of text mining + brainstorming processes

General Aviation
- New Energy
- Infrastructure
- Adv. Design & Manufacturing
- Automation
- Airspace Management
- Certification

Georgia Institute of Technology

PURDUE UNIVERSITY

Research Area Formulation

Lit. Review & Benchmark → Topic Definition → Gap & Impact Analysis → Question Formulation


Airports & Infrastructure


Pilot Training & Proficiency


Automation & Autonomy

Aspects of Connectivity


Future Airspace


Future Propulsion Systems


Passenger Safety & Crashworthiness

Airports & Infrastructure

Overview & Recommendations

Evolving operations

- Infrastructure to provide new energy sources (charging stations, etc.)
- Safe incorporation of **UAS operations**

Increasing utilization

- Terminal capacity
- Future high density airspace

Infrastructure Management

- Runway incursion issues (towered and non-towered airports)
- Suitable landing sites/emergency sites for intra-urban air taxi

- Potential Disruptors
  - UAS or autonomous operations
  - On-Demand Mobility (ODM)
  - Alternative energy sources
  - Information Systems
- Airport Security
  - GA airports may pose weak link in NAS security in potential high density operation scenarios
  - Increasing importance of **cybersecurity** for airport infrastructure and potential autonomous vehicles

Develop and implement a strategy for GA runway and terminal facility improvements, environmental management at GA airports, and energy management for future GA vehicles.

Identify infrastructure requirements that improve airport site security and cybersecurity for GA stakeholders.

Identify infrastructure requirements for future airport airspace management scenarios that enables future GA operational scenarios.

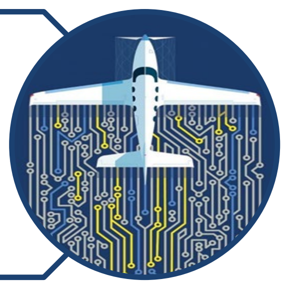
Pilot Training & Proficiency

Overview & Recommendations

Pilot shortage

Utilize improved simulator technology

Impact of automation/autonomy



- **"Life-force of GA Operations" -** *Interviewee*
- Expected Outcomes
  - Utilize **improved simulator technology**
  - Investigate **Pilot curriculum and training** improvements
  - Identify usage cases for **Automation & Autonomy (A&A) in the cockpit**
  - Address Pilot Shortage

Recommend guidelines to the FAA to develop policies that can help increase pilot base for GA in the future, given new aircraft design and technologies.

Provide guidance and recommendations to the FAA on automation and autonomy technology that can reduce pilot training time and cost.

Georgia Institute of Technology

Purdue University

Aspects of Connectivity

Overview & Findings

- Common Feedback
  - Information overload – need to simplify what pilots see
  - Simplified Vehicle Operations (SVO) – what information is needed and what is shown
  - Understanding what information needs to be traded to allow for automation / autonomy
  - FAA can provide structure for connectivity, industry can develop how this evolves.
  - FAA may set parameters for deployment of data transfer
- Data
  - Data ownership – what happens when data is transferred ‘through the ether’?
  - FAA can lay out service parameters to interface with web of information.
  - Data management service for aviation purposes. Have some type of restriction service to manage the amount of data exchanges. Latency service. Aviation.gov in the air and one on the ground

Aspects of Connectivity

Overview & Recommendations

Human Factors

- Avoiding Information Overload
- **Confidence** in information

Data Integrity

- Secure transfer and management of data
- Presentation of
- Possible to integrate into a single platform through **FAA certified API**

FAA Roles

- Provide structure for connectivity
- Provide standards for data transfer and quality
- Establish guidance on appropriate training

Develop capabilities for enhanced and secure data sharing among GA stakeholders and standardization of information interfaces.

Identify gaps in existing connectivity infrastructure and develop a development strategy for meeting the requirements of future enhanced connectivity scenarios.

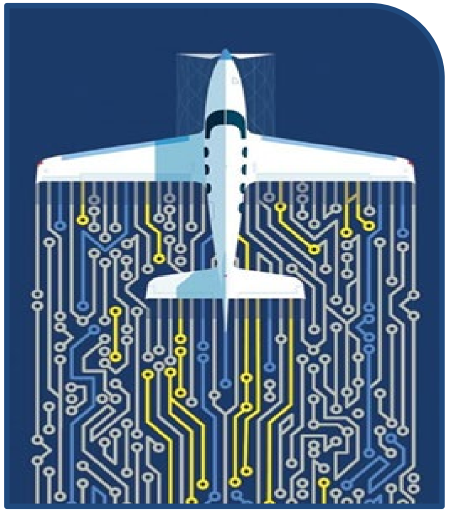
Develop a set of standards to enable a consistent protocol for the transfer of data between GA participants.

Identify and implement a strategy for ensuring the digital safety of GA participants and their data.

Automation & Autonomy

Overview

- Enabling technology/capability for GA aircraft
  - **Flight Controls**
  - **Communication**
  - **Situational Awareness**
- Additional need to investigate issues related to the application and certification of **hardware and software** for automation & autonomy
- Expected Outcomes
  - Identify **optimal level of automation** based on human factors
  - **Automation Envelope Protection** recommendations
  - New and **progressive certification** for processes and technology
  - Well defined **roadmap required**



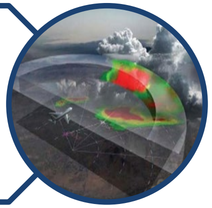
PEGASAS

Automation & Autonomy

Findings & Recommendations

Technology transfer with commercial and UAS will bring down cost

Identify optimal level of automation based on human factors



New and progressive certification

Well defined roadmap required

Expected Outcomes

- Identify **optimal level of automation** based on human factors
- **Automation Envelope Protection** recommendations
- New and **progressive certification** for processes and technology
- Well defined **roadmap required**

Develop methodologies to evaluate and ensure software and hardware reliability for automation systems on-board future GA aircraft and external systems enabling GA in future.

Recommend tools and technologies to the FAA that can help evaluate and ensure safe and reliable execution of software code quickly and effectively for given operating scenario.

Recommend tools and technologies to the FAA that can help evaluate and ensure safe and reliable operation of hardware quickly and effectively for given operating scenario.

Georgia Institute of Technology

PURDUE UNIVERSITY

Future Airspace
Overview

- General Aviation shares airspace with many other stakeholders
  - Airspace likely to become more densely populated in coming years
- The methods and tools for maintaining the airspace are evolving
  - Leveraging automation and autonomy for safer and more efficient airspace management
- **Potential Disruptors**
  - New Aircraft Concepts
  - Internet of Things
  - Wider pilot spectrum

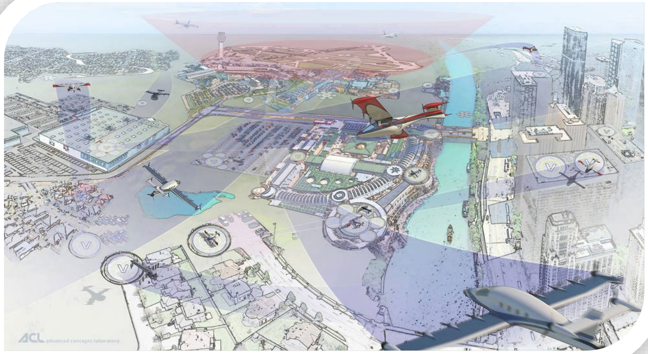


Image: https://www.nasa.gov/press-release/nasa-uber-to-explore-safety-efficiency-of-future-urban-airspace/

Image: https://www.businessinsider.com/remote-towers-change-air-traffic-control-2012-11

Develop methods and capabilities for the FAA to design and manage future GA airspace considering future GA aircraft density, technologies and operations.

- **Air Traffic Control and Management**
  - **Data communication** could streamline ATC for GA traffic
  - Influx of UAM may strain current ATC paradigm due to increased density of operations
  - New **traffic management paradigms** likely to shift the role of ATC controllers

Provide guidelines and recommendations on Services, Workforce management, and Operation classification that can help the FAA control future GA air traffic effectively and with desired safety.

- **Airspace Evolution**
  - Recommended **refinement of current structure** to account for changing operations (e.g., equipage requirements)
  - Potential augmentations include self-separation, dynamic airspace
  - Promising role of **sandbox campaigns** to test airspace classification changes

Develop methodology for the FAA to evolve the current state and shape of the airspace to accommodate the future needs of General Aviation.

- **Automation & Autonomy in Airspace Control and Management**
  - Leverage to **streamline operations** and **reduce ATC workload**
  - Key Areas of Application
    - Decision support for ATC and pilots
    - Enable new traffic management strategies (detect-and-avoid, self-separation, dynamic airspace, etc.)
    - Communication
    - In-cockpit information
  - Challenges remain relating to certification and trustworthiness

Recommend how the FAA can leverage automation and autonomy technology to reduce in-air collision, airspace excursion/incursion and improve GA pilots' communication.

Future Propulsion Systems

Overview

- GA vehicles poised to adopt several **novel propulsion architectures**
- Utilization of new architectures requires appropriate **infrastructure support**
- **Potential Disruptors**
  - Energy sources
  - Novel GA propulsion systems
  - Automation & autonomy

Image: https://www.nasa.gov/centers/armstrong/news/FactSheets/FS-109.html

Identify future GA propulsion systems in order to identify new standards for fleet integration and type certification.

Future Propulsion Systems

Findings & Recommendations

- **Powerplant Portfolio Identification**
  - Novel GA Architectures
    - Electric
    - Hybrid-Electric
    - Improved IC
  - Electric energy storage

In coordination with industry identify likely future GA powerplant architectures, detailing their operational limitations, energy source considerations, and life-cycle management strategies.

- **Certification**
  - No currently standardized path to certification of alternative-fuel/energy based propulsion
  - Electrification may enable technology swap without certification re-evaluation

Develop a set of performance-based standards for the certification of novel GA powerplant architectures.

- **Automation**
  - Likely application to engine management and health monitoring
  - May also influence on simplified vehicle operations and vehicle articulation

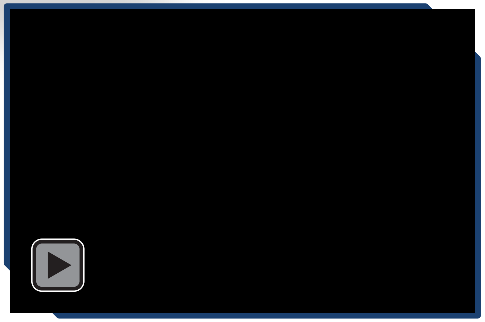
Develop a set of standards for the safe incorporation of automation into GA powerplant architectures.

Passenger Safety & Crashworthiness

Overview

- Safety and reliability of air vehicles is of chief concern to FAA
- Potential for future GA vehicles to incorporate **design features and technology** which **reduces accident rates and improves passenger safety**
- **Potential Disruptors**
  - Automation and Autonomous Control
  - Alternative Fuel/Energy
  - Wider pilot/operator spectrum
  - Additive manufacturing

https://www.youtube.com/watch?v=dDE5XgVvJxE



https://www.youtube.com/watch?v=bFOprqPmgqQ

Develop policies and methods for FAA to increase aircraft crashworthiness and passenger safety for future GA aircraft operations in all weather conditions.

Passenger Safety & Crashworthiness

Findings & Recommendations

- **Accident & Incident Definitions**
  - FAA leverage NTSB findings to improve guidance on crashworthiness
  - New crashworthiness criteria may require revision of Part 23
    - Investigate and enable emerging methods such as certification by analysis

Recommend processes for the FAA to evaluate the definition of Accidents and Incidents for future GA aircraft.

- **Passenger and Pilot Fatality**
  - Manufacturers can leverage design & technology solutions to reduce GA accidents and/or improve passenger safety
  - FAA can provide guidance on accident scenarios for use during design and certification

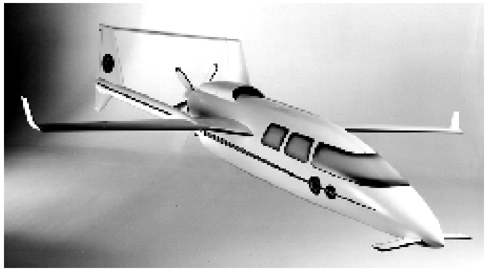
Develop methodology for the FAA, such that tools to improve crashworthiness of aircraft can be certified.

- **Automation & Autonomy**
  - Envelope Protection
  - Improved Situational Awareness
  - Importance of **human interface** with pilot

Recommend how the FAA can use Automation and Autonomy to ensure greater crashworthiness of future aircraft.

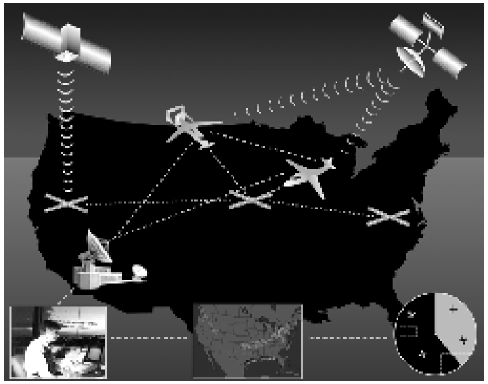
Frequently Mentioned: AGATE and SATS

- **Advanced General Aviation Transport Experiments (AGATE)**
  - FAA, NASA, General Aviation industry, universities
  - 1994 to 2001
  - Make single-pilot, light airplanes more safe, affordable and available
- **Small Aircraft Transportation System (SATS)**
  - The "challenge" for AGATE
  - Time-sensitive short-haul trips more affordable for business, medical, public safety and recreational pursuits
- **We see shared aims for general aviation 20 years later**



https://www.nasa.gov/centers/langley/images/content/69642main_Agate-fig1.gif

Safer, affordable, aircraft



https://www.nasa.gov/centers/langley/images/content/69646main_Agate-fig5.gif

Connectivity and airspace

https://www.nasa.gov/centers/langley/images/content/69647main_Agate-fig6.gif

Improved pilot training and proficiency

Report and Output

- Compile report upon completion of previous tasks
  - Identified key GA-relevant research areas
  - Outcome from interviews involving SMEs
  - Proposed research requirements for GA-related R&D activities for the 2030 timeframe

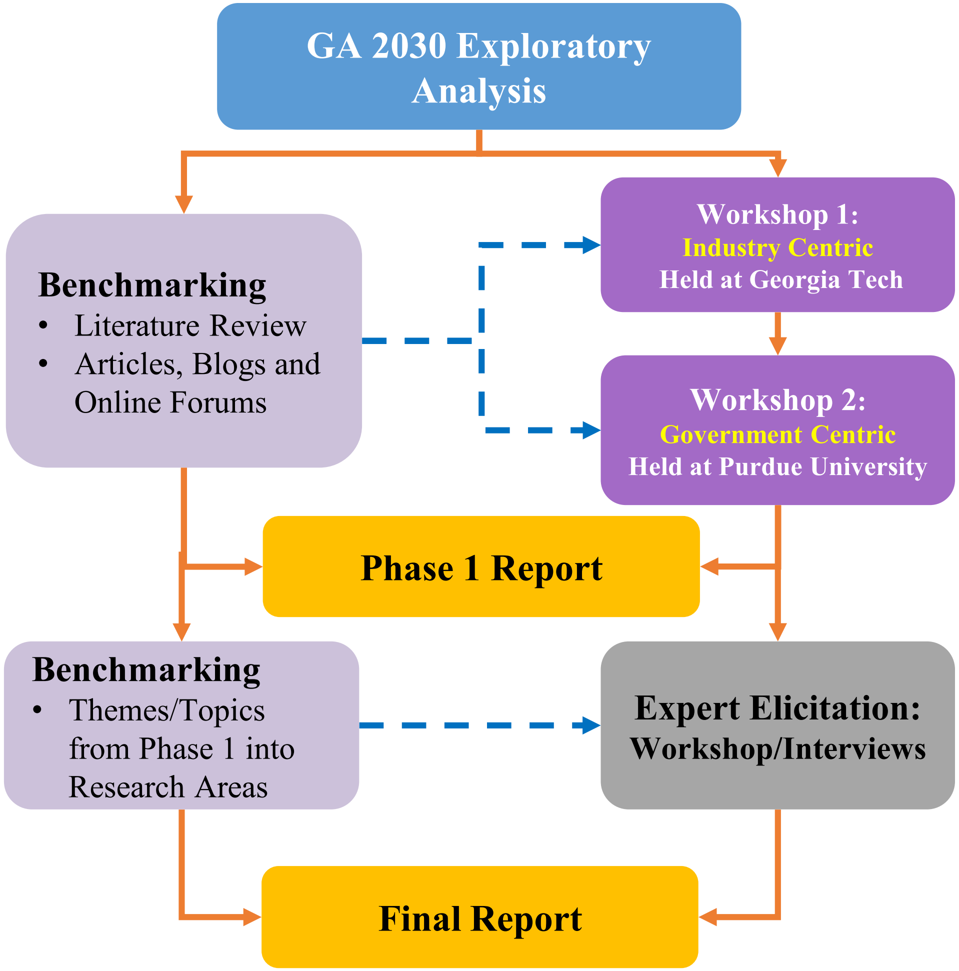
- Reporting of results in each GA research area is aligned with the FAA research and development principles, in accordance with published R&D plans

Georgia Institute of Technology

PURDUE UNIVERSITY

Summary and Future Work

- PEGASAS team is generating a report which **describes strategic general aviation research topics** that can help the FAA and other GA stakeholders **better prepare for general aviation issues in 2030**
- Team has generated questionnaires for seven research areas
- Completed interviews for all seven research areas
- **Finalizing a report that documents "soft data" which enables the FAA to write an R&D plan for GA in 2030**



Questions?

Dr. Evan Harrison – evan.harrison@asdl.gatech.edu

Prof. William Crossley - crossley@purdue.edu