Enabling Autonomous Flight and Operations in the National Airspace

Workshop 2
August 6 – 7, 2019

Parimal Kopardekar, Ph.D.
Director, NASA Aeronautics Research Institute
Warm Welcome!

Embracing innovation in aviation while respecting its safety tradition
Workshop Focus

• Small unmanned aircraft systems and their operations
• Urban air mobility vehicle and their operations
Outline

• Autonomy definitions
• Not as easy as animations show
• Mixed equipage
• Minimum viable product
• Collaborations are key
• Clarity on progression will help entire ecosystem
Many Definitions of Autonomy

Autonomy: (of a vehicle) navigated and maneuvered by a computer without a need for human control or intervention under range of driving situations and conditions.
Complex Issue

• Technology readiness
• Safety
• Human-autonomy teaming
• Certification
• Acceptance
Prior Work
Mixed Equipage Challenge and Interoperability Considerations
Strategy: Minimum Viable Product

Minimum Viable Product: a limited set of functions enough to get early adopters, extends to higher complexity later, and make a difference and unique
Minimum Viable Product

• Focus could be on entire system or could be a subsystem

• Amazon: started with book e-commerce

• Aircraft: 1:1 pilot with vehicle, m:n pilot to vehicles, simplified vehicle, remotely operated, auto land, perception, vehicle health management, and fully autonomous

• Airspace: UAS Traffic Management (UTM): started with smaller airspace portion – FAA implemented data exchanges thru LAANC

• Paths for fully autonomous small UAS

• Paths for urban air mobility vehicle
Small UAS
What is Remaining to Enable Fully Autonomous sUAS?
Urban Air Mobility—Passenger or Cargo-Carrying Vehicles
UAM Maturity Levels (UML)

**INITIAL STATE**

- **UML-1**
  - Late-Stage Certification Testing and Operational Demonstrations in Limited Environments

**INTERMEDIATE STATE**

- **UML-2**
  - Low Density and Complexity Commercial Operations with Assistive Automation
- **UML-3**
  - Low Density, Medium Complexity Operations with Comprehensive Safety Assurance Automation
- **UML-4**
  - Medium Density and Complexity Operations with Collaborative and Responsible Automated Systems

**MATURE STATE**

- **UML-5**
  - High Density and Complexity Operations with Highly-Integrated Automated Networks
- **UML-6**
  - Ubiquitous UAM Operations with System-Wide Automated Optimization

* UML indicates operational system capability, not “technology readiness”
To invent an airplane is nothing. To build one is something. But to fly is everything.

• To fly autonomously is more than everything!
• To interoperate with many other aircraft in airspace is very complex!

-Otto Lilienthal
Workshop Purpose

- Get to worthy candidate MVPs – moderators will help you
- Identify where (pre-competitive) collaboration is most effective
- Identify research gaps and technology demonstrations that are most productive as entire community of interest
- Progression from here to enabling increasingly autonomous flight and operations
- We have 3 break-out sessions. You stay in the same room to ensure balance of participants
Workshop Outputs

• Minimum viable products

• Collaboration topics (pre-competitive)

• Clarity on progression will help entire ecosystem towards aircraft capabilities and operationalization
Points of Contacts

Text for urgent and critical matters during workshop:

• PK: (650) 380 3276, Parimal.H.Kopardekar@nasa.gov
• Mark Ballin: (757) 803 3602, Mark.G.Ballin@nasa.gov
• Chris Clark: (650) 224 2716, Christine.O.Clark@nasa.gov

Path Forward to Responsible Autonomy

Embracing innovation in aviation while respecting its safety tradition
Back Up
Inter-island Autonomous Cargo Delivery (2025+)

Larger vehicle – single pilot, off-board manager, or fully autonomous depending on vehicle size
Transformation in Stages—Initial Applications
Larger than Small Drones (~2020+?)
Lowest Risk – Grand Canyon or Over Water Deliveries

Left photo by Daniel Piazza, https://insider.si.edu/2016/08/grand-canyon-u-s-postal-service-still-delivers-mail-mule/