Unmanned Aircraft Systems Integration

Advancing Autonomous Capabilities in the Artificial Intelligence/Cyber Domain

Presented to: The Patuxent Partnership

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Overview

Intro to the FAA UAS Integration Office

Challenges to Automated Operations & Artificial Intelligence/Machine Learning

The Path Ahead
The FAA’s continuing mission is to provide the safest, most efficient aerospace system in the world.
Autonomy/Artificial Intelligence Challenges

Technology

• Can it be done?

Social Aspects

• Will we accept it?
Autonomy/Artificial Intelligence Challenges

• When discussing “autonomy” as it relates to aviation in the National Airspace System, we prefer “levels of automation”
  – “Autonomous” would be the highest (unattainable?) level of automation
  
  – “High Automation” or “Highly Automated” would be the highest attainable level of automation – some ability to safely fly a preprogrammed route and avoid airborne and ground hazards
  
  – “Low Automation” involves simple autopilot functionality requiring a high degree of pilot interaction.
Autonomy/Artificial Intelligence Challenges

• Society of Automotive Engineers (SAE) Levels of Driving Automation
  
  – Level 0: System issues warnings, but cannot sustain control
  – Level 1: “Hands On” driver and system share control such as adaptive cruise control & parking assistance
  – Level 2: “Hands Off” system takes full control but driver must be prepared to intervene
  – Level 3: “Eyes Off” driver can turn attention away from driving tasks, but must be prepared to intervene when called upon, by the system, to do so
  – Level 4: “Mind Off” driver may sleep – self driving only in geofenced areas or under special circumstances
  – Level 5: “Steering Wheel Optional” no human intervention required, such as a robotic taxi
Autonomy/Artificial Intelligence Challenges

• SAE Levels of Driving Automation Compared to Aircraft Piloting

Pilot In the Loop
- Level 0: “Warnings Only”
- Level 1: “Hands On”

Pilot On the Loop
- Level 2: “Hands Off”
- Level 3: “Eyes Off”

No Pilot
- Level 4: “Mind Off”
- Level 5: “Steering Wheel Optional”
Autonomy/Artificial Intelligence

Challenges

- **See and Avoid/Detect and Avoid**
  - 14 CFR 91.113 Right of Way Rules: When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each **person operating** an aircraft **so as to see and avoid other aircraft**.

  - Technology can be proposed as a mitigating factor to “Detect and Avoid” (DAA) in lieu of the ability to “See and Avoid”

  - Levels of DAA Automation:
    - High Automation – UA detects traffic and automatically executes avoidance maneuver to remain well clear
    - Low Automation – DAA system detects traffic and pilot manipulates the controls to maneuver the UA, to remain well clear
Detect and Avoid Technology

- Types of DAA Systems:
  - Radar
    - Ground Based
    - Airborne
  - Acoustic
  - Optical
  - Light Detection & Ranging (LIDAR)

- Remote Identification (ID)
  - Will assist with DAA
  - Enables UAS integration

- Design Considerations:
  - Cost, Size, Weight, and Power (CSWAP)
Certification of Non-Deterministic Systems

- In the aviation industry, systems are tested thoroughly prior to being certified as safe for flight
- Software is analyzed line by line and tested for every imaginable input and output to ensure reliability, predictability and repeatability
- Deterministic properties – for a given set of inputs, get the same output – every time
- How is Artificial Intelligence/Machine Learning (AI/ML) Different?
  - As the machine (hardware & software) is exposed to its environment, it “learns” from its experience in an effort to optimize performance and avoid hazardous situations
  - This learning yields a constant revision to the machines software
  - With constantly changing software, how can you ensure what was tested yesterday is still safe and reliable today?
  - The challenge is to design enough constraints into the system to not allow it to learn enough “bad’ behavior to make the system unsafe
Social Aspects

• Who is Pilot in Command (PIC)?
  – FAA definition - the “person” who has final authority and responsibility for the operation and safety of the flight…
  – Works well for manned aircraft and even remotely piloted aircraft
  – PIC accepts responsibility for the flight
  – In highly automated flight, where the aircraft is dispatching itself, flying itself, and making deviations as it sees fit, all without human interaction, who is the “person” responsible for the flight?
    • The owner? The designer? The manufacturer? The consumer?

• Are people ready to ride onboard pilotless aircraft?
  – Will they ever be (in large numbers)?
  – What would it take for you to ride?
  – Or, to put your children or grandchildren on a pilotless aircraft?
Autonomy/Artificial Intelligence
Path Ahead

Technology

• It can be done!

Social Aspects

• What are we going to do with it?
Path Ahead – Technology

• **UAS Traffic Management (UTM)**
  – Concept being developed – NASA is the lead
  – Separate but complimentary to the current FAA Air Traffic Management System
  – Primarily intended for sUAS operating below 400’
  – Cooperative interaction between operators and the FAA, through the use of UAS Service Suppliers (USS)
  – Federated System with FAA oversight and highly automated communication/coordination between USS and UAS operators, including vehicle to vehicle (V2V)
  – First step of UTM is being fielded through the Low Altitude Authorization and Notification Capability (LAANC)
  – Remote ID will be an enabler for surveillance and traffic management
Path Ahead – Technology

• Detect and Avoid (DAA)
  – Will be inherent, to some degree, within UTM
  – Fused Solutions to address Non-Cooperative Traffic
    • Combine multiple technologies (Radar/LIDAR/Acoustic/Optical) to take advantage of strengths and overcome weaknesses.
    • Much improved performance but increased CSWAP
  – Remains as one of the biggest challenges to UAS Integration into the National Airspace System (NAS) for Beyond Visual Line of Sight (BVLOS) operations
Path Ahead – Use Cases

Package Delivery
- Small Package
- Cargo

Infrastructure Inspection
- Railways
- Power Lines
- Oil Fields
- Reservoirs

Disaster Response & Recovery
- Transport of AED’s, blood, etc.
- Firefighting
- Damage Inspection
- Search and Rescue

Agricultural
- Planting
- Spraying
- Surveying

Entertainment
- Light Show Swarms
- Film Making

Human Transport
- Air Taxi
- Air Carrier
Questions?

www.faa.gov/uas