UAS/NAS Forum:
Technology Milestones Necessary for NAS Certification

Autonomy:
Relating UAS Automation to Certification

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An Observation

- **Manned** aircraft NAS certification primarily involves ensuring aircraft occupant safety
  - This implicitly results in a safety level for the general public
  - To require the same level of reliability for unmanned aircraft in order to achieve the same level of safety for the general public is a logically flawed approach
Example: Aircraft with Onboard Fire

• Manned aircraft:
  – Land as soon as possible (even off field) to prevent injury to aircraft occupants

• Unmanned aircraft:
  – Land or even crash as soon as possible in area that minimizes injury to people on the ground and property damage
Observations from Example

• Unmanned aircraft should get general-public safety “credit” in a certification case for:
  – In terms of vehicle size/energy/materials, proximity of flight to the general public
  – And Ability to achieve objectives (e.g., crash in the right place)

• Manned or Unmanned: benefit from the capabilities offered by both automation and human pilots
  – Preventing the fire, putting out the fire, or implementing injury/damage mitigation strategies
Risk to the General Public

• General public and aircraft occupant risk tolerances are different: Issue of choice and # of exposures
  – Cannot use $10^{-9}$ prob. of fatal injury to general public per flight hour
  – Public perception is important to the UAS community
Milestones in Autonomy

- Manual flight
- Stability augmentation and autopilots
- Integrated avionics architectures and flight management systems
- Vehicle/Health management systems
- Alerting systems
- Fault recovery
- Mission planning and re-planning
Tasks: Is it automated? Can it be automated? Should it be automated?

- Systems management
  - Fuel, engines, electric power, hydraulics, others
- Navigation
- Guidance and Flight control
- Hazard avoidance (tactical)
  - Detect, sense, and avoid other aircraft, obstacles, terrain, and weather
- Flight (re)planning (strategic)
NAS Operations May Require Automating Tasks to Achieve Required Reliability

- Human pilot not onboard
  - Detect, sense, and avoid

- Handling communication failure
  - Human pilot not available, so neither is their capabilities: Intelligence, knowledge, adaptability

- Fault tolerance and upset recovery in guidance, navigation, and flight control
  - Traditional autopilots are not to be used (e.g., disconnect) after most relevant faults or outside of limited design flight envelope
NAS Operations May Limit Which Tasks Should Be (Totally) Automated

• Tasks that are ATC functions
  – Strategic terrain and traffic avoidance
  – But do we want an “independent” check on ATC functions?

• Achieving necessary reliability levels
  – Mission re-planning, particularly in presence of unanticipated faults
  – Systems management and navigation override capabilities
Standards and Procedures May Limit How Tasks are Automated

- NAS airspace design and procedures
- Right-of-way rules
- Form of Air Traffic Control clearances
- Need for levels of automation
UAS Operations in the NAS Can be Another Motivating Factor in NAS Evolution

• Cooperative collision avoidance (e.g., ADS-B)
• Controller/Pilot datalinks, less reliance on voice
• Emerging standards and procedures: “higher level” ATC clearances
  – 4D navigation
  – Continuous Descent Approaches (CDA)
  – Self separation