

**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
- Handing 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

