ENABLING AUTONOMOUS FLIGHT & OPERATIONS IN THE NAS

Urban air mobility
NEEDS FOR URBAN AIR MOBILITY

Personal Mobility

- Safe for passengers and bystanders
- Available
- Expedient
- Affordable
- Convenient
- Reliable

Cargo Delivery
CHARACTERISTICS OF AN MVP

• “Routine Operations”
• Shared airspace with other UAM operations
• Certifiable in current regulations
• “Quiet”
• ”More evolution than revolution”
• “Recoverable”
• “Minimum equipage to interact with positively controlled airspace”
• Simple trajectories to begin- with increasing complexity
• High frequency (quick turn around)
• Has a market – eventually
• “Nearly” All Weather Ops
  • For the market to be used- it needs to have high availability
MVP – STARTING FROM HELICOPTER

- Piloted helicopter operations
- Next steps as increasing levels of autonomy – reducing training needs and therefore cost
- Differences: noise, efficiency of flight, density, simplified ops
- Likely eVTOL or Hybrid
- Resilience
Initially Airports?

Emergency landing spots
MINIMUM Viable PRODUCT – CONOPS 1
PRE-URBAN – CONCERN: LIMITED MARKET
LOWER RISK & NOISE

Traditional Air Traffic

- Low Density: 1-5 A/C per hour
- High separation distances
- Low-density environment
- Between dedicated Vertiports (formerly helicopter pads)
- Initially Airports?
- Emergency landing spots
Traditional Air Traffic

- Large flight volumes - separation
- Below Traditional Air Traffic
- Above skyline
- Between dedicated Vertiports (formerly helicopter pads)
- Initially Airports?
- Emergency landing spots
TYPES OF MISSIONS

1. Firefighting
2. Emergency Medical Transport
3. Commercial Cargo Transport
4. On Demand personal mobility
FUNCTIONS OF AN MVP

1. UAM airspace/aviation services management system
2. Increasingly autonomous vehicle and traffic operations management
3. One or more aviation service products that operators can sign up for
DISCUSSION: AIRSPACE

Controlled- additional complexity and have to deal with ATC, but common equipage, less likely to have non-avian uncooperative traffic

UTM SUA corridors – separate from all other traffic
  - VFR corridor

VFR, IFR, or UFR?
  - Starting with VFR might be a lower bar
DISCUSSION: HOW FAR CAN AUTONOMY GO WITHOUT HUMANS?

• Rule 91.3 says that Human is responsible for automation
• Human and pilot work in parallel until we get to full autonomy
• Task oriented automation- because functions are certified and not the automation.
• Societal Issues:
  • Full autonomous- may still require human communication about overall mission. This will give that warm and fuzzy.
  • Passenger control: Pax should not be expected to make decisions like “land now”, who may not be the right person.
  • Fully autonomous could be for the vehicle, and not the entire eco system. This needs to be clarified and defined. It should not have a human as a backup.
  • Who is responsible for liabilities? The legal issues? Today we blame the driver of truck or pilot or manufacturer.
General Discussion – Where is MVP?

“...as easy as driving an Uber”
“train on a simulator”

Traditional piloted Helicopter -> Pilot with reduced role/training reqs (SVO) -> Safety pilot onboard

Remote safety operator 1:1 -> Remote Supervisor m:n (RSO) -> Fully Autonomous
General Discussion – Where is MVP?

- **Traditional piloted Helicopter**
  - Pilot with reduced role/training reqs (SVO)
  - Remote safety operator 1:1
  - Remote Supervisor m:n (RSO)
  - Fully Autonomous

Start here to build trust in autonomy (the Autonomous Car Approach)
MINIMUM VIABLE PRODUCT

• Discussion – Regulatory needs
  • Does it need to be done under current regulations, or can it be done under future Part-21 regs under development?
INFRASTRUCTURE GAPS OF MEDIUM-SIZE URBAN AIR MOBILITY

- **Communications**
  - 1. Technology for assisting take off and landing
  - 1. Vertiports
  - Charging Stations
  - UTM infrastructure for UAM ATM
  - Spectrum Management infrastructure
  - Allocate appropriate spectrum (RTCA SC-228)

- **Services**
  - Airspace structure, conflict management, UAM Surveillance integration
  - Allocate appropriate spectrum (RTCA SC-228)

- **Reliability and Security**
  - Information - Common state awareness, intent
TECHNOLOGICAL GAPS OF MEDIUM-SIZE URBAN AIR MOBILITY

1. Resilient automation architecture design

1. Certified lower SWAP-C technology (e.g., radio, computers, sensors)

VFR operational technology

Collision Avoidance Sensors, DAA for UAM

Contingency Management

"Resilient CNS" without GPS - Common

Maturity, standards, interoperability with other collision avoidance functions
TECHNOLOGICAL GAPS OF MEDIUM-SIZE URBAN AIR MOBILITY

1. Autonomous Landing

Accurate, Detailed, and Robust Perception of Environment

Especially in "adverse weather"

1. IVHM

Cybersecurity
MVP Gaps

- Traditional piloted Helicopter
- Pilot with reduced role/training reqs (SVO)
- Safety pilot onboard
- Remote safety operator 1:1
- Remote Supervisor m:n (RSO)
- Fully Autonomous

Standards, tools, certification technologies, regulation, and best practices

Graceful Degradation
1. TRUST!!

1. Legal Challenges

- Interoperability e.g. Data exchange, DAA definitions
- Operating env conditions – winds, weather
- Interface
- A/C and flight standards collectively
- Gaps in certification for UAM

1. Regulatory “Clarity”

- Procedures and technology to handle non-cooperative
- Address policy and data gaps regarding integrated risk analysis: Incorporate new areas of concern (societal benefits, intermodal ...)

a. Roadmap for evolution from VFR to IFR ops.

- Tightly coupled w/ manned v/s unmanned. IFR is easier to implement but the IFR routes will not be great with UAM ops. Need for a third set of rules?
Real World Operational and Support Data
Collaboration demonstrations considerations:

Scenario-1:
• Using an existing helipad operation, add improved safety and efficiencies through UAM enablement and demonstrate a flight with route defined
• Keep UAM vehicle beneath 1500 feet, with human on board
• Fly from point A to point B under control of UAM solution
• Outcome would be operational requirements and procedures as well as inputs for next demonstration

Scenario-2: Higher density route that demonstrates transfer from urban to rural setting (UTM and ATM interoperability)
• Emergency situation with EMS / medical personnel or doctor-patient onboard
• Non-standard situations with vehicle and airspace management (including interaction with UTM and ATM) and non-participating aircraft

Scenario-3: Team competition in a airport with a “last-drone-standing” prize

Scenario-4: Participate in Grand Challenge

NOTE: Consider how to Demonstrate verifiable AI
MEDIUM-SIZE URBAN AIR MOBILITY

POSSIBLE COLLABORATIVE DEMONSTRATIONS

Collaboration Demonstration - Airspace Management focus (Scenario-2)

Demonstrate increasing density of routes – for example transfer from rural and/or suburban (non-vertiport, medical facility?) to urban setting (UTM and ATM interoperability).

- Emergency situation with EMS / medical personnel to scene or medical personnel to patient
- Non-standard situations with vehicle and airspace management (including interaction with UTM and ATM) and non-participating aircraft
- Integration with GA Pathways/broad area networks without encroaching (emphasis regarding avoiding conflict, creating safe well defined UAM corridor)
- Spectrum / C&C battle (protocol, spectrum grading, ...) and discussion including FCC and FAA re safe operation in the NAS (dedicated spectrum required)
- Incorporate vehicle, operators and airspace autonomy elements
- Include aspects of vertiport management (urban setting) leveraging UAM airspace structure
- Remain as vehicle agnostic as possible
Breakout Session 2 (Aug 7, 10:30-12:00)
Re Collaboration Demonstration - Airspace Management focus (Scenario-2)

1. How do we integrate UAM traffic with existing traffic (e.g. sUAS, GA airliners)
   • Airspace structure (e.g. 500-1500 feet range)
   • Conflict management
   • UAM surveillance integration (cooperative and non-cooperative)
2. Address policy and data gaps regarding integrated risk analysis
   • Incorporate new areas of concern (societal benefits, intermodal ...)
3. Spectrum management
   • Risk that Regulator will not allocate appropriate spectrum (RTCA SC-228)
   • Communications infrastructure reliability and security
4. Standards for UAM flight model and characteristics – and a dynamic Well Clear
Scenario-2 Operationalization Steps (how):
1. Get FAA buy-in extending to their ecosystem of influence (and budgets)
2. Share data with standards orgs to help develop appropriate UAM-relevant standards
3. Develop a public engagement strategy (leverage public – private partnerships)
4. Develop an industry partnership strategy (e.g. vertiport owners, vehicle mfgs)
5. Engage with current state and local organization on lessons learned
6. Work with an existing autonomous system (e.g. DoD-NASA and other collaborations)
   • Take tactical steps to improve system operation (in UAM context)
7. Cover airspace to ground operations (e.g. with management tools)
8. Explore allocation / responsibility for flights from 500’-1500’
   • Take an incremental approach
9. Gather data on UAM (e.g. passenger experience, performance, DAA...) to inform and help define Well Clear and other operational and air worthiness standards
10. Develop strategic UAM - UTM avoidance system
General Discussion – Where is MVP?

- Traditional piloted Helicopter
- Pilot with reduced role/training reqs (SVO)
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- Remote safety operator 1:1
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WHERE INDUSTRY NEEDS HELP

• Operational Rules – from FAA/NASA
  • Procedures and tools for V&V/certification of AI/Autonomy – FAA/NASA
  • Standards – coordination with standards agencies
  • Creation of government/industry working groups
• Cybersecurity
• Resilient Automation
• Contingency Management – technologies and procedures
• Human Autonomy Teaming- Standards and tools for SVO/RSO – especially training
  • Define pre-competitive technology
  • Infrastructure
    • Communication – Reduction of voice clearances
      • Additional information (e.g., intent)
    • Spectrum Management
• Mature, Scalable UTM for UAM
  • Operational data
  • Test/demonstration opportunities
Collaboration will be most productive if it includes:

1. Public acceptance (noise, privacy, safety, trust)
2. Public policy (that supports Public acceptance, works with DOT)
3. Technology providers (air framers, avionics, platform, apps, sensors, airspace management, communications (esp. re spectrum), geofence providers)
4. Security (physical port and transport, DHS)
5. Cyber security (e.g. DHS)
6. Intermodal operations (e.g. DOT)
7. Infrastructure (airport and vertiport standards, communications)
8. Standards (e.g. ASTM, SAE, RTCA, ICAO, etc.)
9. Certification (e.g. FAA)
10. Spectrum allocation (FCC)
11. Current Operations (e.g. DHS)
Enabling Autonomous Flight & Operations in the NAS

Urban air mobility

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An everyone who participated
ENABLING AUTONOMOUS FLIGHT & OPERATIONS IN THE NAS

URBAN AIR MOBILITY
MINIMUM Viable PRODuct

- Discussion – Challenge of MVP for Aerospace
  - Comes from Software Engineering where you create an initial product, then you improve with a quick product cycle.
  - Difficult to achieve with Aerospace product lifecycle timeperiod
  - MVP means something a little different