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m:N: m operators controlling N vehicles



Demand

In the next 3 years, uncrewed systems will create 70,000 jobs (US) and have an economic impact of \$13.6 billion (AUVSI, 2021)

For many domains to be profitable m:N is needed:

- Small drone delivery
- UAS cargo
- UAM
- High Altitude Long Endurance
- Autonomous automobiles

Approach

- Stand up an industry/government working group to:
 - Identify key issues
 - Work together to address common issues
 - Socialize with regulatory agencies, standards organizations
 - Advocate for m:N operations
- NASA
 - Focus on research to address high priority barriers

Break-out groups

- Large UAS
- UAM
- Small UAS
- SWARMS
- High Altitude Platform Stations (HAPS)

Progress

- Barriers by domain
- Detect and Avoid use cases
 - Large UAS
 - UAM
 - Small UAS

Technical Barriers

Type	Barriers
sUAS	1. How do you keep Staff trained on technical systems where taking over is infrequent? 2. Identify what info operator needs 3. Ensure calibrated operator trust 4. Scaling from lower number of vehicles to higher numbers 5. How do you certify autonomous systems?
Large UAS	1. SA for pilot 2. Managing multiple voice channels (w/latency) 3. Contingency management capabilities 4. How to demonstrate pilot's ability to work in m:N framework?
UAM	1. Battery management 2. On demand operators to handle exceptions 3. Crew to vehicle ratio 4. Comms 5. DAA systems (vision, sensor fusion)
HAPS	1. Identify appropriate time horizons relevant to m:N interactions 2. Identifying how SA needs to change in nominal vs contingency situations? What to display? When? To whom to display?
Swarms	1. SA of swarm state due to emergent behavior 2. Supervisory control 3. Impact of environmental and geo. Restrictions 4. Hardware failures

Operational Barriers

Type	Barriers
sUAS	1. What level of automation is needed? 2. How much workload can a single operator handle? How do you staff for spikes in workload?
Large UAS	1. In-flight changes 2. Pilot response time 3. New/increased human error under new paradigm 4. Identify correct level of pilot involvement
UAM	1. Handoff conops 2. Enough funding for infrastructure 3. Integration of ATM/UTM/etc. 4. Corridors
HAPS	1. Standard/Accepted method for demonstrating that an organization's HAPS operations are "safe" and don't degrade safety of NAS 2. Justification of how many vehicles an operator can control
Swarms	1. Define operating environment and procedures 2. Operator roles: across boundaries, when swarm splits/mergers, when failures occur 3. How many operators is enough?

Regulatory Barriers

Type	Barriers
sUAS	1. How do you show that your operations are safe enough and do not degrade the safety of the national airspace?
Large UAS	1. Identify pilot role 2. Certification with less human involvement 3. What data is needed to support regulatory changes?
UAM	1. Liability 2. Certification 3. Noise
HAPS	1. Certification of highly automated systems 2. Identifying what policies need to change
Swarms	1. Certification for non-deterministic behavior 2. Defining airspace restrictions

Public Acceptance Barriers

Type	Barriers
sUAS	1. Is the general public willing to accept sUAS flying over homes, etc.? 2. Public acceptance of automation and trust (could be a generational issue)
Large UAS	-
UAM	1. Generational differences 2. Credibility 3. Noise 4. Emissions
HAPS	1. How to weigh perceived societal value against third-party risk 2. Lack of ability to understand and quantify risk associated with upscaling HAPS operations
Swarms	1. Explanability 2. Reduce fear factor, immediate fear factor

Common Barriers

Type	Barriers	Timeline (near/mid/long term)
Technical	- Determining and maintaining adequate/appropriate SA, depends on many things: vehicle class, risk posture, LOA, scale, operator role - Is the level identified by the breakdown of roles and responsibilities?	
Operational	- Centralized (or decentralized) management system for task/work/airspace allocation If you have an operator who is managing multiple assets How many can they manage? Is it shared? If shared, how to split the responsibilities? - Should there be a distinction in operational barriers between RPAS and fully autonomous (e.g., Loon-like) operations?	
Regulatory	Certification: automation, non-determinist system, airframe	
Public Acceptance	Transparency, explainability, trust	

Next Steps

- Working group meeting NOV 29, 30 at NASA-Ames
- Develop joint roadmap to operational approval
 - What does that look like?
 - What does it include?
 - Timeline? Logical epochs?