m:N WORKING GROUP

MEETING SUMMARY

November 2023

EXECUTIVE SUMMARY

From November 28th to 30th, 2023 the m:N UAS working group and its subgroups [small Unmanned Aircraft Systems (sUAS), Large UAS, High Altitude Platform Systems (HAPS), and Urban Air Mobility (UAM)] met at the NASA Langley Research Center in Hampton, VA for an in person meeting.

The subgroups meet multiple times throughout the year, virtually. Twice a year however, participants from all the subgroups come together in person to further identify and discuss challenges, and path forward ideas for incorporating UAS into the airspace.

The m:N UAS working group is run by Jay Shively (Adaptive Aerospace) and Andy Thurling (Thurling Aero Consulting) and is comprised of members from government, industry, and academia in an effort to identify and reduce barriers to m:N operations. This effort also includes identifying requirements, use cases, and metrics to support organizations and groups including the FAA, RTCA, and ASTM. Each subgroup is run by a government/industry team (see below).

sUAS Subgroup
Garrett Sadler (NASA)
Scott Scheff (HF Designworks)

Large UAS Subgroup
Conrad Rory (NASA)
Brandon Suarez (Reliable Robotics)

HAPS Subgroup
Andy Thurling (Thurling Aero Consulting)
Jeff Homola (NASA)

UAM Subgroup
Mike Politowicz (NASA)
Scott Scheff (HF Designworks), member-at-large

THE CHARGE FOR THE WEEK

What assumptions can we make about the future airspace, what are the challenges, and what might be potential mitigation strategies?

How do these assumptions change between UAS operating in airspace without separation services and those operating in ATC managed airspace?

To meet the charge, day one of the working group was full of presentations from government, academia, and industry. Topics discussed included the Part 135 process, standards for piloting multiple, simultaneous UAS BVLOS, technologies such as AI, human-automation teaming, research and airspace integration discussions from industry, as well as a share out of AFWERX's airspace integration activities.

Day two of the working group separated participants into two discussion groups: UAS operating without separation services and those operating in ATC managed airspace.

At the culmination of the three-day meeting each of the two discussion groups briefed the larger m:N UAS working group on the status of use cases, definitions, and assumptions.

NOVEMBER 28TH BRIEFINGS and DISCUSSIONS

The November 28th briefings included representatives from Industry, NASA, FAA, and academia.

A summary of the briefings and subsequent discussions are included in the following pages.

NOVEMBER 28TH BRIEFINGS

Introductions

Vanessa Aubuchon (PM, Transformational Tools & Technologies Project, NASA) and Michael Fremaux (Chief Engineer for Intelligent Flight Systems, NASA)

The m:N working group meeting was kicked off with around-the-room introductions and an overview of NASA Langley including a discussion of intelligent flight systems; a core competency at NASA Langley.

Part 135 Process

Tim Beglau, (UAS Air Carrier Operations, FAA) and Katie Constant-Coup (Technology and Standards Branch, FAA)

Tim Beglau and Katie Constant-Coup presented on AFS-700 Flight Standards which includes UAS transport of cargo and people. The presentation discussed the differences between Part 107 and 135 certification as well as outlined the five companies that are currently part 135 certified: Wing Aviation, UPS FF (Flight Forward), Amazon Prime, Zipline, and Causey Aviation. A discussion of the road to m:N ensued including who the end users might be, what their qualifications might be, what tasks will be under human control, who communicates with ATC, and ultimately who is responsible for the actions of the UAS. Possible obstacles to achieving m:N was also discussed including Detect and Avoid (DAA), handling of emergencies, handling of ATC clearances, and how these obstacles affect how many UAS one remote operator can control. Human factors considerations were also discussed including how to maintain optimal workload (and thus engagement) amongst operators.

Note that Part 107 concerns sUAS that do not permit cargo for hire. Part 107 excludes Beyond Visual Line of Sight (BVLOS); pilot or a visual observer must be used. Part 135 concerns cargo for hire.

Tim and Katie also talked about the FAA and its rule making process. Rules take on average, approximately 2-3 years to get through but sometimes take longer.

Tim and Katie also posed the following questions:

- What if there is a mandate to land all aircraft (i.e., 9/11), how will that happen? Who will be responsible?
- What if there is a VIP and the airspace needs to be closed off?
- How will aircraft be recovered if it lands somewhere not planned for?

Standards for Piloting Multiple, Simultaneous UAS BVLOS

Wendy Ljungren (Anzen Unmanned)

Wendy Ljungren briefed the group on piloting multiple simultaneous UAS beyond BVLOS. This was part of an FAA Broad Area Announcement (BAA) (BAA 697DDCK-22-C-00381 Piloting Multiple, Simultaneous UAS BVLOS) and included colleagues from ASYLON, NUAIR, and Purdue University.

The project developed and validated the minimum criteria and open-source flight control software for multiple multi-rotor UAS operating BVLOS of a remote operator. The end goal was to have final reports including m:N Operational Hazard and Safety Assessments, m:N Requirements, and an m:N Final Report that could lead to m:N industry standards. The project looked at crew management requirements, human factors and safety. From this work, m:N operations were able to be

Figure 1. UAS Control Station

successfully conducted in a busy airport environment where one remote operator was able to successfully oversee six unmanned aircraft (3 physical, 3 simulated). From a task analysis the ratio of 1 RO to 6 UAs was supported both by simulation and flight test, Figure 1. Also note that this particular operation had the operator at multiple geographically separated sites and much of the display content was driven by current FAA part 107 requirements.

Safety and Human Factors Design

The design met FAA AC 25.1302-1 for error prevention and management to the extent practicable. Note this AC is a subset of FAA HF-STD-001/002/003 guidance.

This project also gleaned additional insights including:

- Additional skills might be required that are beyond Part 61 or 107 BVLOS experience; this included video game experience (which built on fast, accurate responses to uncertain conditions as well as problem solving), and experience working within teams.
- Perhaps the remote operator role aligned more closely with Air Traffic Controllers (ATC) than manned aviators.
- Simulation built trust in automation, which was confirmed with flight test experience.

The outcome of this project highlighted an m:N recommended standards approach as well that could lead to scaled BVLOS m:N operations, Figure 2.

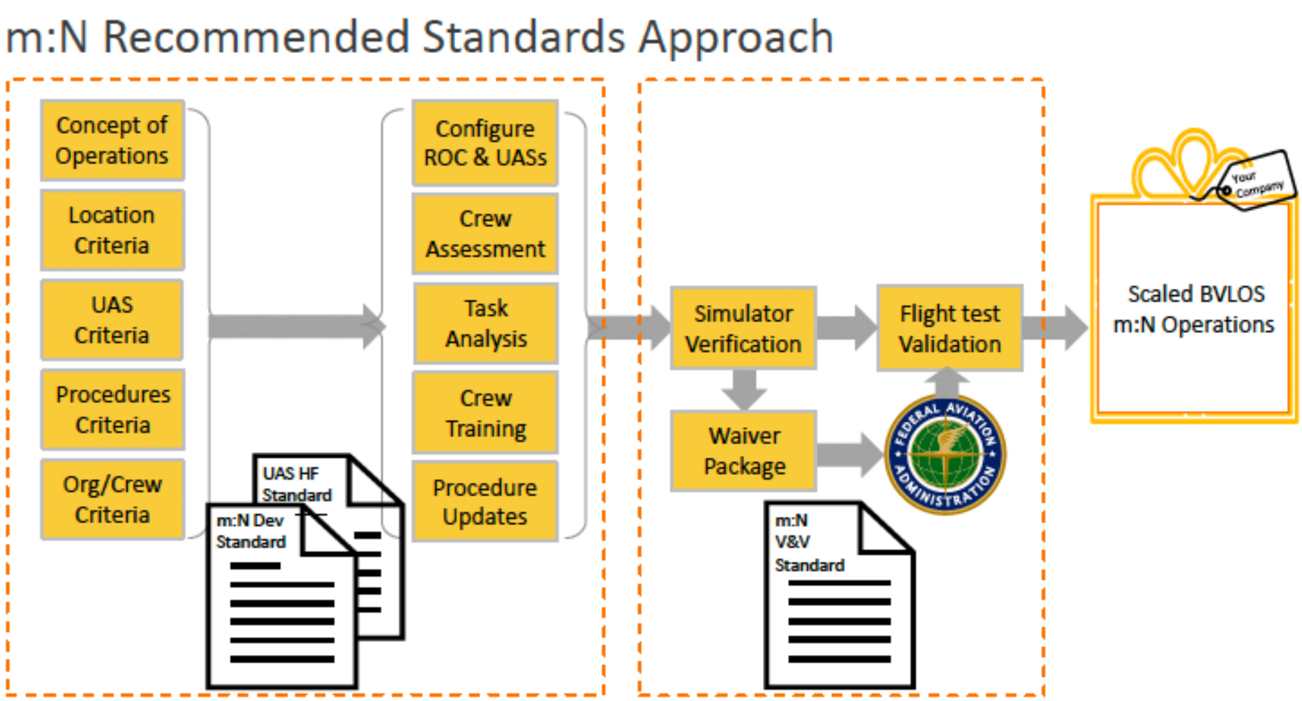

Figure 2. Project Recommendations

Info-Centric NAS (ICN) Effort

Andras Kovacs (FAA-ANG)

Andras Kovacs discussed an info-centric NAS which was defined as an airspace that seeks to address anticipated changes in aviation and aerospace while taking advantage of opportunities presenting themselves in business practices and technology. This includes accommodating new types of operations, bringing improvements to traditional air traffic services, and ensuring that as new operations emerge services and the infrastructure supporting these services must be agile and able to scale up for equitable access.

The presentation noted more diverse traffic management services in the future which would enable an increased variety and number of new vehicles, missions, and operations. This diversity including unmanned traffic services, advanced air mobility services, air traffic separation services, higher airspace services, and even transit to space. While this NAS of the future won't happen overnight, there will need to be an evolving infrastructure that could be shared amongst users, incorporate adaptive software, edge computing, and would be scalable. The sharing of airspace where possible was also recommended.

To further combat safety issues, the presentation discussed the need for continuous data exchange, machine learning, automated monitoring, prognostic risk modeling, and appropriate alerts and responses. For safety issues specific to platforms there will be a need for data comms, safety monitoring, lost link procedures, BVLOS operation, and for low flying UAS (including sUAS) a need for low noise emission.

For large UAS and AAM to be successful there was a discussion about automated systems that should be handling the majority of flight operations, role and responsibilities called out for automated systems and human managers. There was also acknowledgement that for UAS and AAM to truly be successful on a large scale there would need to be further advancements in automation, redundancy, reliability, and ATC integration.

Q&A - Ask a Controller

Andy Lacher (NASA) interviewing Mel Davis (NATCA)

A Q&A session between NASA's Andy Lacher who interviewed former Air Traffic Controller [and current National Air Traffic Controllers Association (NATCA) safety and technology officer] Mel Davis.

Automation, AI and the m:N Challenge

Missy Cummings (George Mason University)

Missy Cummings presented on the history of m:N and how automation has been scaling. Missy spoke of balancing automation and tasks as well as identifying which tasks were best for the human operator, which were best for automation, and which tasks could be shared, see Figure 3 (Cummings, How, Whitten, & Toupet, 2012).

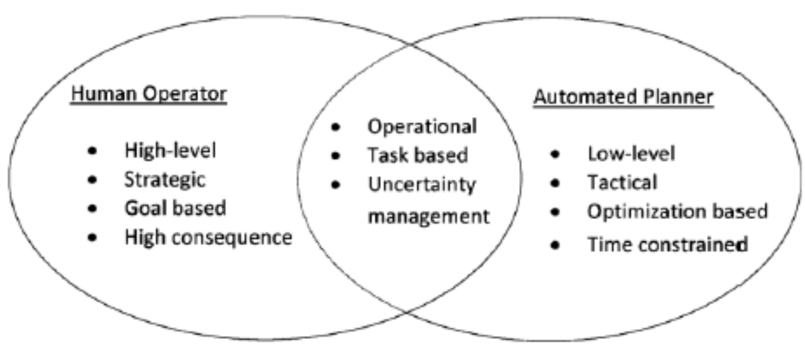

Figure 3. Human Automation Diagram

For future m:N to be successful, relationships must address the joint space, uncertainty management, autonomy performance under degraded or no comms scenarios, civilian vs. military applications, a variety of studies (not just one or the other – modeling, vs. simulation vs. pilot studies). Missy also spoke of what she termed the “hidden gotcha” which was AI maintenance; where someone (or something) must maintain the AI so that as the large language models develop over time that they still stay true to the real-world information they provide; the data must still be applicable. “How do you know when the world no longer matches the training set?” We may need tools to identify this, otherwise at some point in time it might be dangerous to use. Also, we need more real-world testing, not just simulations.

References: Cummings, M. L., How, J. P., Whitten, A., & Toupet, O. (2012). The impact of human-automation collaboration in decentralized multiple unmanned vehicle control. Proceedings of the IEEE, 100, 660-671.

Tradeoff Model of Human-Automation Teaming

Chris Wickens (Colorado State University)

Chris Wickens presented on his work supporting the Army Research Laboratory (ARL), *An Influence Model of Human-Automation Team Performance*. This presentation included Human-Automation Team (HAT) performance stemming from a variety of automation types, not just robotics.

Chris also discussed the concept of automation transparency where the user is provided with information about how automation is working, why it recommends what it does, and the raw data behind such recommendations. This can be offered off-line as instructions, or on-line during use. Chris noted that while this is similar to “explainable AI” it’s not quite the same. While transparency has been shown to work (Van de Merwe et al., Bhaskera et al) there is a tradeoff with benefits to performance relative to the cost of installation and implementation. Chris also discussed the concept of Degree of Automation (DOA) where, as automation increases, situational awareness and workload could both decrease.

Research Overview of AFRL 711 Human Performance Wing

Mark Draper (AFRL)

Dr. Mark Draper presented on the related activities occurring at AFRL including discussing past AFRL human-centric m:N activities as well as current activities related to m:N (i.e., JADPACT, BOAR, Crewed/Uncrewed Teaming, AI-Enabled Distributed Teaming Monitor/Manager).

The mission of the Human Effectiveness Directorate is to lead, discover, develop and deliver bioeffects, medical and cognitive technology to enable, enhance, sustain and restore the human’s ability to dominate air, space and cyberspace. Within human effectiveness are: training and cognitive readiness, physiological readiness, brain-machine interface development, human-machine teaming, human state assessment, operational and aeromedical health, bioeffects modeling, and physiological effects research.

Mark presented on past and current activities related to m:N. He started with a timeline beginning with Vigilant Spirit (1998) which was the first application to incorporate multiple entities into their interfaces. Today Vigilant Spirit software is licensed to others and has shown up to a 1:12 control paradigm. Mark also discussed the IMPACT Human-Autonomy Teaming Testbed which is an intelligent multi-UxV planner with adaptive collaborative control technologies; including flexible play calling, decision aids, and autonomics monitoring.

Mark then went on to discuss current AFRL efforts including JADPACT, BOAR, Crewed/Uncrewed Teaming, and the AI Enabled Distributed Teaming Monitor/Manager. In the case of Base Oversight of Autonomous Response (BOAR) they teamed with Air Mobility Command (AMC) and Air Force Materiel Command (AFMC) bases to create an enterprise solution for sUAS operations on USAF installations.

Dr. Draper also discussed crewed/uncrewed teaming research where the tactical operator has control of multiple collaborative uncrewed platforms to perform various missions (combat, air refueling, etc.).

Overview of AFWERX’s Airspace Integration Activities

Diane Carrington (AFWERX) and Ciska Bloemhard (AFWERX)

AFWERX representatives Diane Carrington and Ciska Bloemhard provided an overview of the AFWERX program whose goal is to accelerate agile and affordable capability transitions by teaming leaders in innovative technology with Airman and Guardian talent.

Several AFWERX programs were discussed including AFWERX PRIME, which seeks to expand technology transition paths to accelerate emerging technology markets by leveraging government resources for rapid and affordable fielding, attracting, and optimizing external funding and talent.

There is a strong synergy between the programs AFWERX is funding and the m:N goal to improve UAS operations in the NAS. This included AFWERX's airspace innovation and prime partnerships whose mission is "To safely accelerate airspace modernization for emerging technologies by leveraging key partnerships as part of the US National Strategy."

Wing Airspace Integration

Mark Blanks (Wing)

Figure 4. Wing Operations Center

Mark Blanks talked about the automation currently available at Wing and how flight planning, path planning and routing, contingency management, aircraft health, and deconfliction between unmanned aircraft was all automated. The presentation also discussed current Wing operations centers as seen in Figure 4.

As the presentation discussed, part of Wing's success comes from flying only in areas that already have strong strategic separation. Wing UAS fly in Class G airspace away from airports and heliports and way from other crewed air traffic concentrations.

The subject of ground safety was also discussed. In the case of Wing, their sUAS are foam, lightweight (11.7lbs without a payload), and have a fragile design (to break apart during a crash) which helps to reduce ground risk. Performance parameters of Wing's UAS can be found in Figure 5.

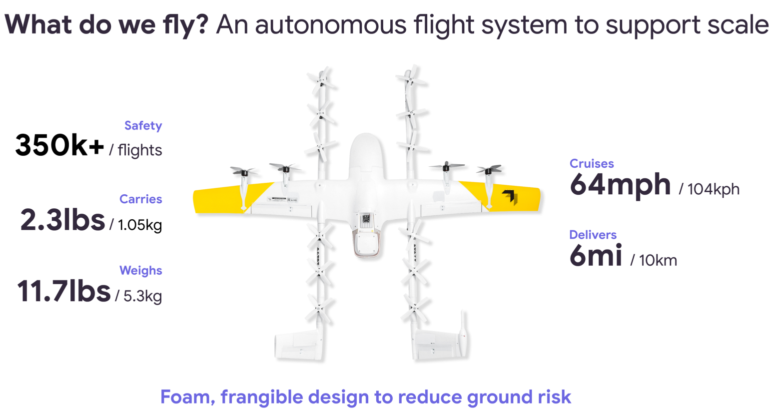

Figure 5. Wing Performance Parameters

Mark then discussed m:N and how, perhaps, m:Area was actually a better metric. Note that this discussion bled over into the following day and the breakout groups (to be discussed further in this report). Under the m:Area concept, due to the high level of automation and nature of Wing's interactions with the system, they felt area-based metrics were more reflective of operator workload and performance. With regard to automation, Wing felt their tactical system control was automated, contingency management was automated, direct communications with ATC was not required, and also that operator inputs are all area-based commands and emergency response can be handed off once aircraft are on the ground. For m:Area to work (as opposed to m:N) the pilot workload and performance would not be impacted by increasing ratios. A few assumptions would need to be in place however:

- The remote operator stays at a "strategic" level of engagement with the system and never engages tactically
- The remote operator does not need to engage or monitor an individual aircraft or subset of aircraft
- Contingency actions would be handled without pilot input

With the above assumptions in place the potential results could be that as the ratio of UAS to operator goes up, there are almost no effects on pilot workload and performance. Workload, however, would then have other drivers including size of area or complexity of airspace, depending upon specific operator tasks.

Assuring Autonomy and Other Emerging Technologies

Kim Wasson (Autonomy Cert Lead, Joby)

Kim Wasson discussed the process for aircraft and system development in terms of development assurance and system safety assessment for autonomy and other emerging technologies/considerations. Kim also discussed existing gaps in the concept phase, environment/contingencies, system boundaries, hazards and safety, acceptance and coupling, and new technology (including validation and verification).

Moving forward Kim talked about designing and developing for overall operational safety by mapping the rationale and then starting with what the product is, how it is operated, and identifying and understanding the intended environment. Kim also proposed asking the following questions in an iterative manner:

- Where in the map does a given choice live?
- Where are the gaps?
- At what system levels?
- With what bearing on which assertions?
- What rationalizes could be used to fill them?
- What's implied for development and assurance processes?

Challenges with Automation Maturity

Wes Ryan (Northrop Grumman)

Wes discussed how as automation increased, there would be additional integration challenges. There were multiple areas of concern including:

Situational Awareness

- Need to be able to see and avoid other aircraft
- Localization and navigation
- Obstacle/terrain avoidance
- Remaining well clear of things like clouds
- Aware of visual approaches

Ability to follow airspace procedures

- Visual and instrument procedures
- Traffic patterns
- Interaction with Air Traffic Control (Vectors/Clearances)

Contingencies

- Weather
- Aircraft emergencies
- Novel situations

Technology Maturity and Ability to Qualify Automation

Wes presented a notional automation capability maturity model, citing we as technologists must assess maturity, integrity, reliability, availability, etc. of data sources and technology to implement an intended function in support of a new capability, Figure 6.

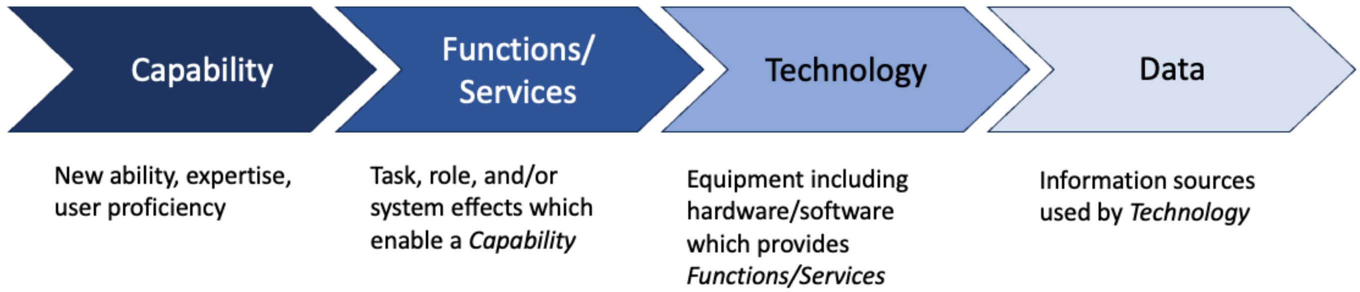

Figure 6. Automation Capability Maturity Model

Note that the above model is courtesy of NASA's AAM Ecosystem Crosscutting Working Group: Capability Maturity Model for Automation presentation (2022).

Ultimately automated processes must harmonize with human-centric processes, there must also be minimal impact on incumbent operations, m:N operations must be enabled, and operations will be working in an expected and predictable fashion. And all of the above must co-exist with not just future facing operations but incumbent operations.

Two Track Discussion for Breakout Groups

Andy Lacher (Chief Technologist for Future Airspace Operations, NASA Langley)

Andy laid the foundation for the two breakout groups (see next section) including a discussion of the four major challenge areas that emerged from the November 2022 workshop at NASA Ames which were:

- Airspace Integration
- PIC Role and Responsibility
- PIC Situational Awareness
- Operational Safety Determination

From the above challenge areas, and the working group discussions over the past year, two different types of airspace integration challenges were further identified (which became referred to as "Two Tracks") – 1) Airspace without separation services, and 2) Positive control airspace. A further breakdown of each track is below:

Track 1 – Airspace Without Separation Services

- Class G Airspace
    - While no separation services there could be traffic advisories
- Low Altitude Authorization Notification Capability (LAANC)

Track 2 – Positive Controlled Airspace

- Class E/Class D
    - Separation services (All IFR & from VFR)
    - Traffic Advisories (workload permitting)
- Class A
    - Separation Services (All IFR)
- Class B
    - Separation Services (All IFR & VFR)
- Class C
    - Separation Services (All IFR & from VFR)
    - Traffic Advisories

The charge for the two tracks:

1. What assumptions can we make about the future airspace?
2. Who is the service provider and what services do they provide?
3. What is the nature of the interaction with the air traffic management service provider?
4. What are the challenges?
5. What are potential mitigation strategies?
6. Seeing what the m:N subgroups have been doing for the past few years and now moving into 2024, should these subgroups evolve, and if so, what does that look like (i.e., what direction should the m:N group as a whole be moving into)?

Breakout Groups

Group 1: Scott Scheff (HF Designworks) and Radhika Bhopatkar (Purdue University)
Group 2: Andy Lacher (NASA Langley) and Meghan Saephan (NASA Ames)

m:N members were allowed to self-select into the two groups and participation was roughly split in half (where each group was comprised of government, industry, and academia). Each breakout group met for two hours before lunch, and then for a few hours after lunch, with share outs the following day.

Group 1 revised its dialogue after lunch, tightening the discussion by developing a CONOPS where "Company A has 100 UAS flying out of the Dallas, Texas area. Flights are under m:N operations with remote operators and their management in mixed airspace. Company B consists of the same structure, sharing airspace at times with Company A." Group 1 participants were then asked, why this is not possible today?

Breakout Group Presentations

Group 1: UAS Operating in Airspace without Separation Services - Scott Scheff and Radhika Bhopatkar

Scott Scheff shared out the findings from Group 1's discussion the previous day.

As was previously mentioned, to help stay focused the group worked around a use case of two company's operating UAS in shared airspace in a busy area (Dallas, Texas). With regard to why this is not possible today, the group felt there was a need for additional regulations, perhaps the challenge isn't so much m:N; but m:E, where E was exceptions or events; especially as more automation was incorporated and automation became more reliable. The group also felt there was a need for more metrics to help ensure safety of flight.

Group 1 also discussed the ever-evolving airspace and that in the future, airspace will need to be even more cooperative, Figure 7. The group then broke out evolution over the next 10+ years with the following assumptions:

Figure 7. Group 1 Breakout Session

- In 1 to 5 years: More low altitude Class G UAS operations
- In 5 to 10 years: More Class E UAS operations
- In 10+ years: Harmonious emergence and operation of UAS along with other classes of aircraft in the NAS

Additional assumptions included:

- Digital flight rules would be in place
- sUAS, HAPS, eVTOL platforms will be applicable to our operations without separation services either in the entire mission or at some point in their phases of flight (air cargo….probably not so much)
- Service providers will be responsible for
    - Weather/micro weather
    - Flight planning
    - Deconfliction

Key takeaways from the Group 1 discussion included:

1. Airspace
    a. Class G airspace offers a lot of freedom for operation which should be used wisely to our advantage.
    b. Operations in low altitude class G airspace is achievable soon.

2. Roles and Responsibilities
    a. Definition of the roles and responsibilities of the service provider and how they could influence m:N operations.
    b. There could be multiple service providers in a single m:N operation
    c. At times they may work together such as when there is a UVR

3. Human-Autonomy Function Allocation
    a. Assessment of Human-autonomy function allocation
    b. Need to define an evaluation method for assessing if with the selected 'm' and allocated functions to the human-autonomy team allows safe m:N operation.

    c. Over time 'm' personnel might be less like pilots and more like ATC which will affect personnel selection and training.

4. Consideration for Reshaping m:N
    a. While m:N is important, perhaps it's not the big question, maybe the big question is m:N where we define events or exceptions (off-nominal occurrences) over time for m:N operations.

5. Metrics
    a. Metrics could be used to build a safety case
        i. Service Time
        ii. Neglect Time
        iii. Increase in required resources
        iv. Number of events handled by the remote operator per unit of time
        v. Operator workload (desire for "optimized" workload)
        vi. Amount of automation (scalable automation)

Group 2: UAS Operating in ATC Managed Airspace - Andy Lacher and Meghan Saephan

Andy and Meghan shared out the findings from Group 2's discussion the previous day.

To kick off their discussion, Group 2 developed a few high-level assumptions regarding operations. This included considerations such as needing to be clear who is the separator and that there must be a time ordered/phased approach that was risk based and considering the complexity of the solution. "You can't swallow the whole elephant at once!"

Group 2 also felt that the overall goal was to have minimal interactions with ATC. To do this, the following would need to happen:

- There would need to be digitally enabled VFR-like operations including potentially in IMC. For a nearer term solution perhaps this could occur where VFR happens today and where operational complexity will allow.
- Further down the road there could be IFR operations leveraging automation to reduce the need to routine controller interactions
    - "Magic Box" process vast majority of routine controller instructions/clearances

From discussions, Group 2 also came up with several, potential opportunities including:

- Identifying under-utilized airspace with near-term opportunities (Class B, C, D airspace)
    - ATC might "not be concerned" with these areas
    - Similar to facility maps, effectively carve out to create additional Class E-like airspace operations. This could include corridors (with the potential for hand-offs if ATM needs to use the space.
    - Similarly, Class E airspace could have carve-outs to operate like Class G.
- Improving Flight Path Execution – exceeding performance of today's VFR through…
    - Conformance monitoring
    - Automated execution of a flight path more accurately matching intent than human pilotage
    - Reduces buffer
    - Precision navigation
    - Shared intent

Group 2 also came up with several observations during their discussions including:

- Humans cannot be the safety net (i.e., liability sponge)
- Need to consider both safety of the NAS and operational efficiency
- Operational limits are likely to exist
    - M:N operations may not be viable everywhere certainly not initially
- Consider m:N for only specific flight phases (not necessarily block-to-block)
    - 1:1 (or at least a smaller ratio) for complex (high tempo) phases of flight

    - Or m:N with only 1 (or a limited number) of N flights in complex phase at a time.

Group 2 felt that to meet the above opportunities however, there would still be multiple challenges to overcome. These challenges include:

- Having methods to evaluate (including metrics) effective designs
    - Pilot workload – objective measures
    - Workload/safety relationship
    - Thresholds or criteria associated with task urgency, service time, neglect time, complexity
    - Identifying what to measure and understanding why we measure it
- Transitions
    - Nominal to off-nominal (load shedding)
    - Handoffs
    - Different ratios m:N to 1:1
- Mismatch between industry perspective of technology readiness and that of the regulator
- Regulator acceptance of risk for new and novel technologies/operations through a methodical/phased introduction
- Fragmentation of industry approaches makes a cohesive strategy a challenge
    - "Can't build half a bridge" – we need OEM/Operators/Regulator/ANSP alignment, complexity of coordination, dependencies
    - If we can't solve the above it will continue to create paralysis

Discussion for a Path Forward

Group 1: UAS Operating in Airspace without Separation Services

Group 1 identified the following for potential path forward ideas noting that just as the airspace is evolving, so too is this working group.

- Definition of specific research questions based on identified gaps
- Collaboration with regulatory bodies for accelerating the efforts of m:N working group
- Note a lot of good work is already being done, we don't want to recreate this work
- Similarly, we can harness the lessons learned from research in air traffic management to avoid reinventing the wheel
- m:N operations safety evaluation framework
- Identification of data requirements based on defined events/exceptions
- Potential migration from the subgroups (sUAS, Large UAS, UAM, HAPS) to a single working group tackling identified issues and providing research, whitepapers, and guidelines
- Additionally, group 1 recognized that there are other groups/organizations doing similar work and that we don't want to replicate but rather seek to support our partners and the work of other organizations (e.g., RTCA, AAM, ASTM, etc.). The group felt they could continue to make an impact moving forward with potential work products which included:
- Whitepapers
- Guidelines (including guidelines for populating elements in event metrics)
- Requirements
- Modeling and Simulation
- Seminar talks (educate, lessons learned)
- Event ontology
- Published Standards (industry consensus)

Group 2: UAS Operating in ATC Managed Airspace

Group 2 also had thoughts on ways the m:N working group could move forward, with several similarities shown between Groups 1 and 2.

- Clearly identify problem statements including fleshing out with more detailed white papers
- Devise methods to evaluate suitability of operational/technical approaches
- Including CONOPS and designs
- Develop a high-level phased implementation roadmap
- Identify & validate research challenges
- Identify opportunities for integrated limited deployment capabilities (enduring)

Next Steps

Next steps include a more detailed discussion amongst m:N leadership regarding building out a metrics whitepaper (as an outcome of this meeting). Metrics could include the m:E concept. There will be additional discussions on how to best move the m:N working group forward in 2024 and what a potential restructure of the subgroups (sUAS, large UAS, HAPS, and UAM) might look like to meet the new goals of papers to help continue supporting UAS in the NAS and related organizations including RTCA, FAA, and ASTM.

For additional information or to join the m:N working group please reach out to the individuals listed below.

m:N Working Group
Jay Shively jshively@adaptiveaero.com
Andy Thurling andy@thurling-aero.com

https://nari.arc.nasa.gov/ttt-ram/multi-vehicle

Appendix A: In Person Participants

Name	Organization
Danette Allen	NASA
Vanessa Aubuchon	NASA
Radhika Bhopatkar	Purdue
Gregory Blaize	The Boston Drone School
Mark Blanks	Wing
Timothy Bleakley	General Atomics
Ciska Bloemhard	AFWERX
Bill Buck	NASA
Diane Carrington	AFWERX
Brian Carroll	FAA
Eric Chancey	NASA
Jing Chen	Rice University
Del Christman	Autonodyne
Rese Cleaver	Droneup
Katie Constant-Coup	FAA
Melvin Davis	NATCA
Mark Draper	AFRL
Jack Dwyer	Boeing
Lou Glaab	NASA
Ken Goodrich	NASA
George Gorospe	NASA
Keith Hoffler	Adaptive Aero
Husni Idris	NASA
Devin Jack	Adaptive Aero
Walter Jones	FAA
Jin Kocsis	Purdue
Andras Kovacs	FAA
Andrew Lacher	NASA
Paul Lee	NASA
Samantha Magill	NASA
Mark Motter	NASA
Natasha Neogi	NASA
Jonathan Nguyen	NASA
Faisal Omar	NASA
Robert Owen	U.S. Army
Bryan Petty	NASA
Mike Politowicz	NASA
Wes Ryan	Northrop Grumman
Meghan Saephan	NASA
Scott Scheff	HF Designworks

Jonathan Scott	Aerovironment
Jay Shively	Adaptive Aero
Tim Skutt	Anzen Unmanned
Kevin Stafford	AFWERX
Will Stavanja	Droneup
Brandon Suarez	Reliable Robotics
Liang Sun	New Mexico State University
Scott Swanson	Parallax Research
Kurt Swieringa	NASA
Andy Thurling	Droneup/Thurling-Aero
Kim Wasson	Joby Aviation