Upper E Traffic Management

April 24, 2020

Recap

- Meeting March 19
  - Scenarios 1 and 2
  - Research focus areas
  - TCLs
- Any major updates/milestones from Industry?
- Desire for UTM briefing



Pre-decisional


NextGEN
UTM Concept
ETM Overview and Scenarios
April 2020
FAA

The Need for UTM

- Integration of low-altitude UAS operations into NAS presents a variety of issues and novel challenges
- The predicted volume of small UAS (sUAS) operations across both controlled and uncontrolled airspace, which could be on a scale comparable, if not greater, to that of present-day manned air traffic, compounds these challenges.
  - FAA small UAS forecasts 3.9 million total, 0.7 million commercial by 2022
  - Low-altitude UAS operations present enticing incentives and business cases
- Current users want to ensure safety and continued access
- New entrants desire access and flexibility
- FAA has responsibility for developing means to safely enable new types of operations
  - Regulatory framework
  - Rules for accountability of Operators and other actors
  - Efficient and equitable access

What is UTM?

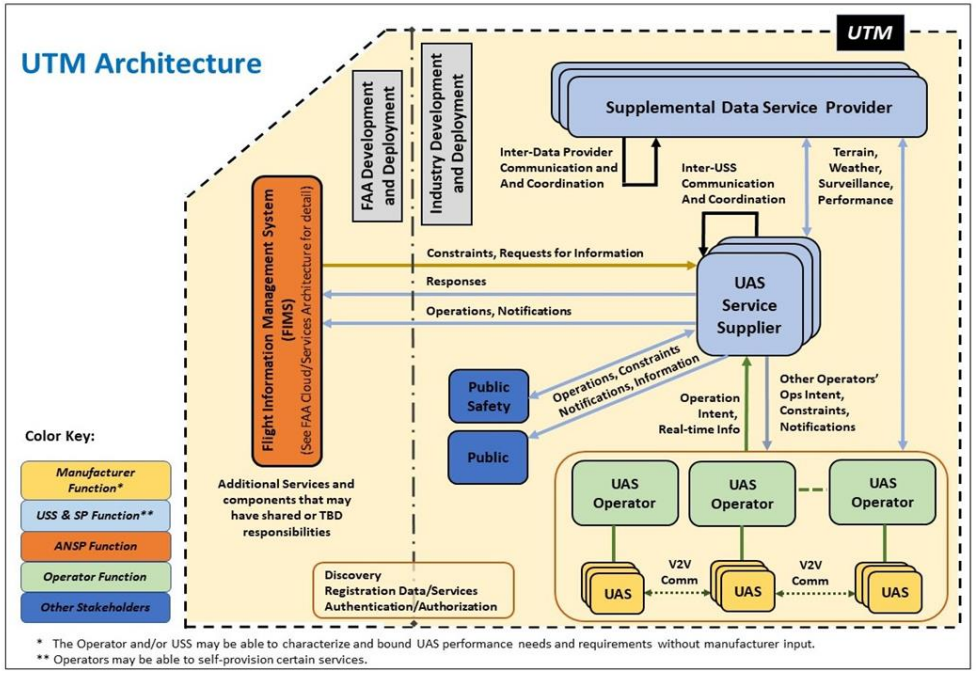
- UTM is the manner in which the FAA will support operations for UAS operating in low altitude airspace below 400 feet above ground level.
- UTM utilizes industry's ability to supply services under FAA's regulatory authority where these services do not currently exist
- It is a community-based, cooperative traffic management system,
  - Operators and entities providing operation support services are responsible for the coordination, execution, and management of operations
  - Rules of the road established by FAA
- UTM is predicated on layers of information sharing and data exchange
  - Operator to Operator, vehicle to vehicle, and Operator to the FAA - to achieve safe operations.
- Operators share their flight intent amongst each other and coordinate to de-conflict and safely separate trajectories.
- Communication between Operators, Operators and the FAA, is through a distributed information network (not between pilots and air traffic controllers via voice)

What is UTM? (cont'd)

- The FAA makes real-time airspace constraints available to UAS Operators
  - Operators are responsible for managing their own operations safely within these constraints without receiving ATC services from the FAA
- The FAA has on-demand access to UTM operational information when needed
- UAS Operators may choose to use third party UAS Service Suppliers (USSs) to support their operations, or may choose to provision their own set of services
  - USSs provide services to support the UAS community, to connect Operators and other entities to enable information flow across the USS network, and promote shared situational awareness among UTM participants
- UTM Operators are responsible for
  - Meeting the requirements established for the type of operation and associated airspace volume/route in which they are operating
  - Complying with all FAA regulations

What is UTM? (cont'd)

- UTM is an ecosystem that encompasses all infrastructure, policies, procedures, services, and personnel required to support low altitude UAS operations
- Requires the establishment of new regulatory frameworks, operating rules and performance requirements commensurate with demands of the operation
- Includes data exchange and information architecture that provides shared situational awareness among participants.



UTM Notional Architecture

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UTM Actors

- **FAA** - the federal authority over aircraft operations in all airspace, and the regulator and oversight authority for civil aircraft operations in the NAS.
- **Operator** - person or entity responsible for the overall management of their operation. (Individual may also serve as Remote Pilot in Command)
- **Remote Pilot in Command** – person responsible for the safe conduct of each UAS flight.
- **Other Stakeholders**
  - **Public Safety** entities that ensure safety of the airspace and persons and property on the ground, security of airports and critical infrastructure, and privacy of the general public.
  - **General Public** can access data that is publicly available providing limited operational details.
- **UAS Service Supplier (USS)** - entity that assists UAS Operators with meeting UTM operational requirements that enable safe and efficient use of airspace.

UTM Actors (cont'd)

- **USS Network** - amalgamation of USSs connected to each other, exchanging information on behalf of subscribed Operators. Primary role is to share operational intent data, airspace constraint information, and other relevant details across the network to ensure shared situational awareness for UTM participants.
- **Supplemental Service Providers (SDSP)** – Supplies Operators and USSs with essential or enhanced services - including terrain and obstacle data, specialized weather data, surveillance, and constraint information
- **Flight Information Management System (FIMS)** - interface for data exchange between FAA systems and UTM participants. Enables exchange of airspace constraint data between the FAA and the USS Network.
- **NAS Data Sources** - data sources connected to the UTM ecosystem through FIMS including data such as sUAS registrations, Airspace Authorizations, operational waivers, and constraints. Allows for data flow between the UTM community and FAA operational systems, and data access for authorized users

Participation in UTM

- **VLOS UAS Operators** – Able to visually separate from other aircraft as primary means of separation. At a minimum, participate in UTM to meet applicable regulatory and policy requirements (e.g., obtaining Airspace Authorization). May increase level of participation as desired through use of additional services.
- **BVLOS UAS Operators** – Not able to visually separate from other operations and are required to utilize certain services to conduct safe operations and meet other regulatory/policy requirements. Services support shared information exchanges of flight intent and deconfliction from other UAS operations, identifying low altitude manned aircraft, etc.
- **Manned Operators** – Not required to participate in UTM but are encouraged to do so; when participating they obtain the safety benefits that are gained from shared situational awareness. Their level of participation may vary, from obtaining relevant UAS operation information for their own situational awareness to providing their own flight intent to UAS Operators.

Flight Planning

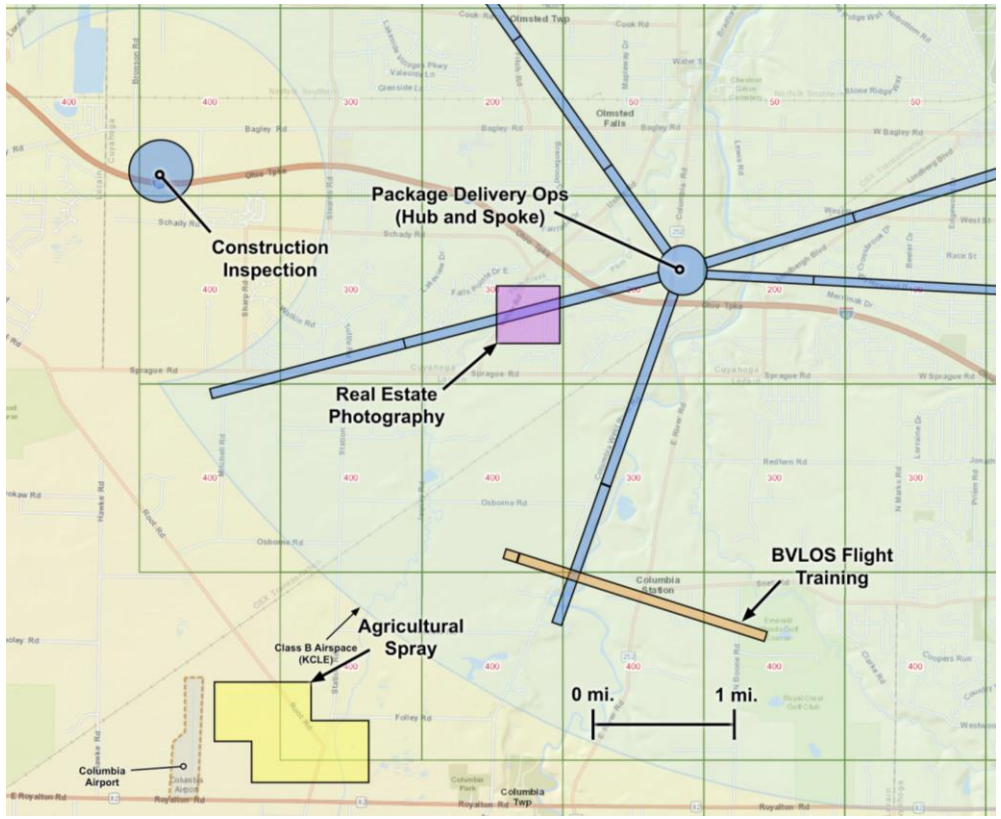
- **Pre-Flight Authorizations**
  - **Performance Authorization** – Operators substantiate their ability to meet flight performance capabilities in their intended area of operation.
  - **Airspace Authorization** – All Operators conducting UTM operations must obtain FAA authorization when operating within the bounds of controlled airspace.
- **Operation Volume** defines the flight intent of the proposed operation. Defined in 4 dimensions and is shared with other Operators for situational awareness. It is used by Operators to identify and resolve conflicts.
- **Operation State** is an indication of the current status of an operation and promotes situational awareness among participants. States include “accepted”, “activated”, “non-conforming”, “rogue”, and “closed”.
- **Constraint Information & Advisories** - UAS Operators are responsible for identifying unexpected operational conditions or flight hazards that may affect their operation. These may include: Traffic, weather, airspace restrictions, obstacles, and other low altitude flight hazards.

Cooperative Separation

- Separation is achieved via shared intent (i.g., Operation Volumes), shared awareness (e.g., Operation State), de-confliction of operations, conformance monitoring, and the establishment of procedural rules of the road (e.g., right-of-way rules).
- Operators share their flight intent and exchange real-time data with each other and coordinate to de-conflict and safely separate trajectories via information exchanges enabled through the USS Network.
- **Strategic De-Confliction** – Operations are strategically managed through interactive planning and orchestration of intent information as well as relevant environmental considerations.
- **Tactical De-Confliction** – method of separation that is necessary when strategic deconfliction alone is not adequate to support the safety flight.

Cooperative Separation Example in UTM

- An Operator is planning a flight for rail inspection in an area where UTM operations are routinely flown
- The Inspection Operator uses the services of their USS to obtain planning information, including the intent (i.e., Operation Volumes) of other operations that will be active during their desired operation time
- Several operations are identified through USS to USS data exchanges (depicted to the right)
- The Inspection Operator develops their intent in consideration of the volumes for these other operations, and deconflicts from them in 4D



Operations obtained from USSs for Planning

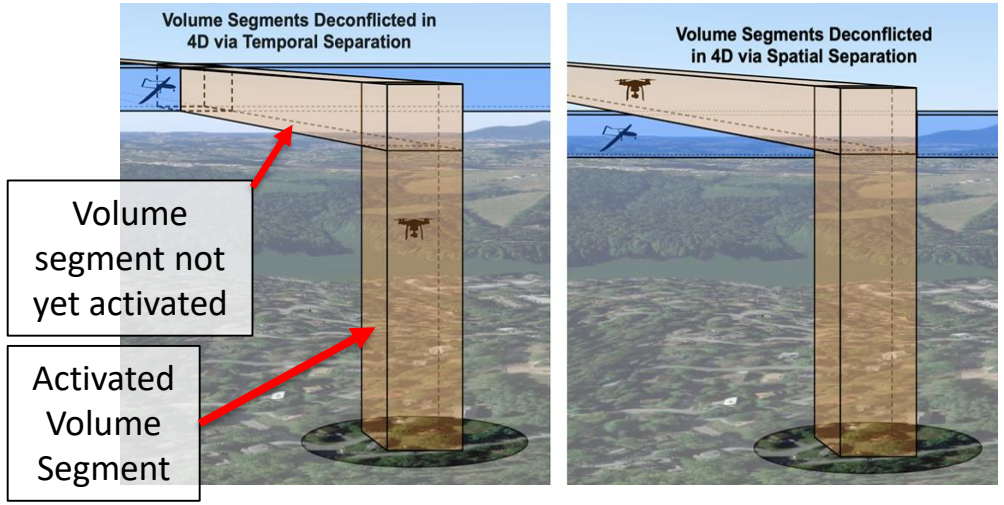
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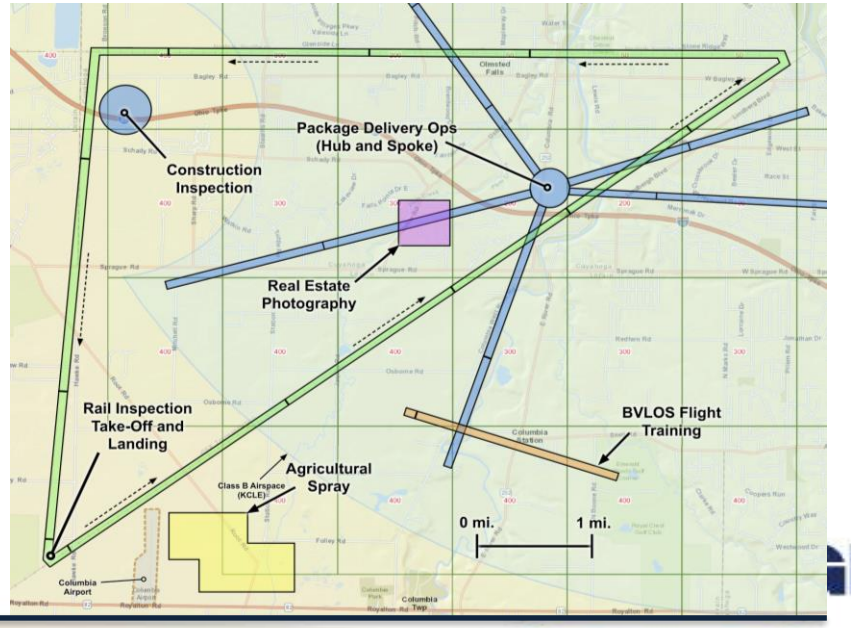
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Cooperative Separation Example in UTM

- The Inspection Operator may segment their operation into multiple operation volumes, which become active and close in sequence.
  - Segments can be adjusted temporally and spatially to deconflict from another operation
  - Promotes efficient use of the airspace and coordination between Operators
- Once planning is complete and the Inspection Operator has developed a conflict-free operation (green volumes in lower figure), they share their intent with the USS Network. Other nearby operators (and any future operators that plan for the same time) are aware of the inspection operation.
- The inspection operation is conducted under nominal circumstances (no unexpected events). Their vehicle maintains flight within active operation volumes and remains separated from other UTM operations thanks to the pre-flight planning and deconfliction activities that were performed.
  - UTM Operators monitor their vehicle for conformance to their shared intent. If vehicles remain within their respective volumes, they are considered to be conforming.

Temporal/Spatial Deconfliction Examples





Rail Inspection Operator's Strategically de-conflicted Operation (green)

ETM Overview and Scenarios

What is ETM?

- Upper Class E Traffic Management (ETM) is the manner in which the FAA will support operations for manned and unmanned vehicles operating above (and approved operations below) FL600
- ETM includes a community-based, cooperative traffic management approach
  - Predicated on information sharing and data exchange - from Operator to Operator, vehicle to vehicle, and Operator to the FAA - to achieve safe operations
  - Operators share their flight intent with each other and coordinate to de-conflict and safely separate trajectories
  - Utilizes industry's ability to supply services under FAA's regulatory authority
- ETM consists of both cooperatively managed operations and ATC-managed operations where required.

Separation in ETM

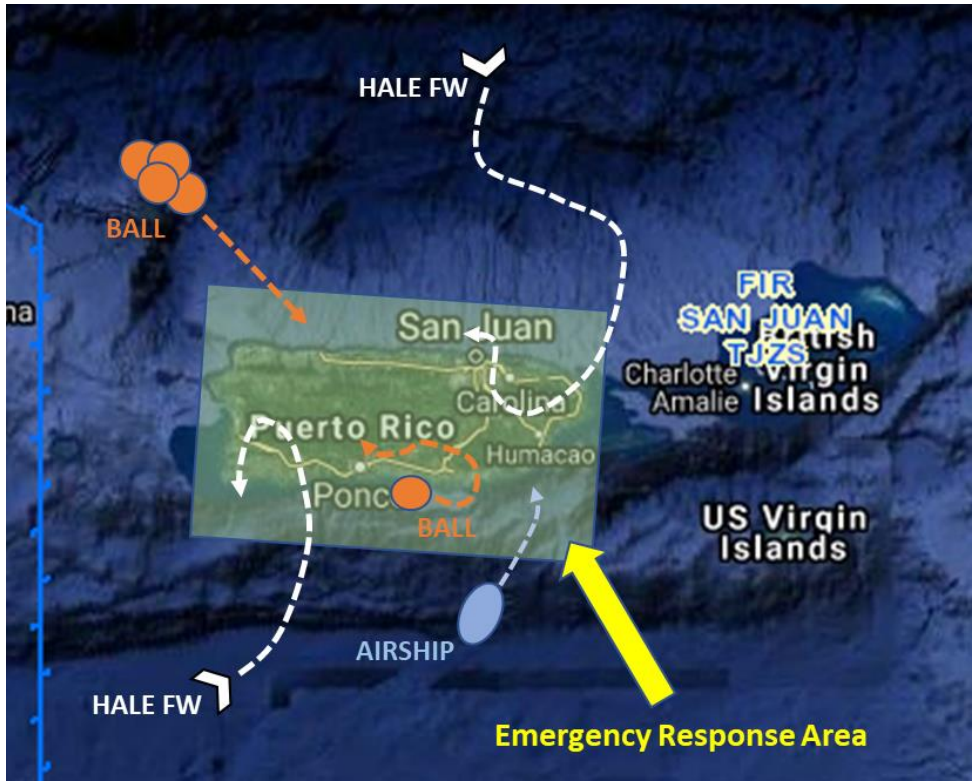
- **Cooperative Separation**
  - Cooperative separation services are separate but complementary to ATC-provided separation services.
  - Operators must comply with applicable FAA rules and regulations for the operation and the airspace in which they are operating.
  - Cooperative Operators maintain separation from one another through advanced planning and information sharing (e.g., sharing flight intent).
- **ATC-Provided Separation**
  - ATC provides operators with services that separate their trajectories and operations from others; they also manage operations around/within various airspace constraints when applicable.
  - Vehicles transiting to and from operating altitude through controlled airspace (e.g., from launch and up through Class A) are provided ATC separation services; this includes Operations that will participate in cooperative separation once in the ETM environment.
  - ATC separation services are provided above FL600 to IFR aircraft where necessary infrastructure and personnel are in place.

ETM Actors

- **Operator**– person or entity responsible for the overall management of an ETM operation; they meet regulatory responsibilities, plan operations, share intent information, and safely conduct operations. The Operator ensures PIC and/or RPIC has access to all information required to maintain safe flight.
  - **Pilot in Command (PIC)** – person aboard manned aircraft who is responsible for the safety of the aircraft while in flight.
  - **Remote Pilot in Command (RPIC)** – person responsible for the safe conduct of a UAS flight and adheres to the operational rules of the airspace in which they are flying.
- **FAA** - Federal authority over aircraft operations in all U.S. airspace, and the regulator and oversight authority for civil aircraft operations in the NAS.
- **Air Traffic Control (ATC)** – provides separation services to eligible operations in Upper Class E airspace that elect to use them as well as services to operations transiting to and from operating altitudes.
- **Third Party Service Suppliers** – entities that assist upper class E operators in meeting ETM operational requirements by providing services that support operations planning, intent sharing, vehicle deconfliction, conformance monitoring and airspace management functions.

Scenario – Cooperative Separation between HALE Vehicles
Scenario Overview

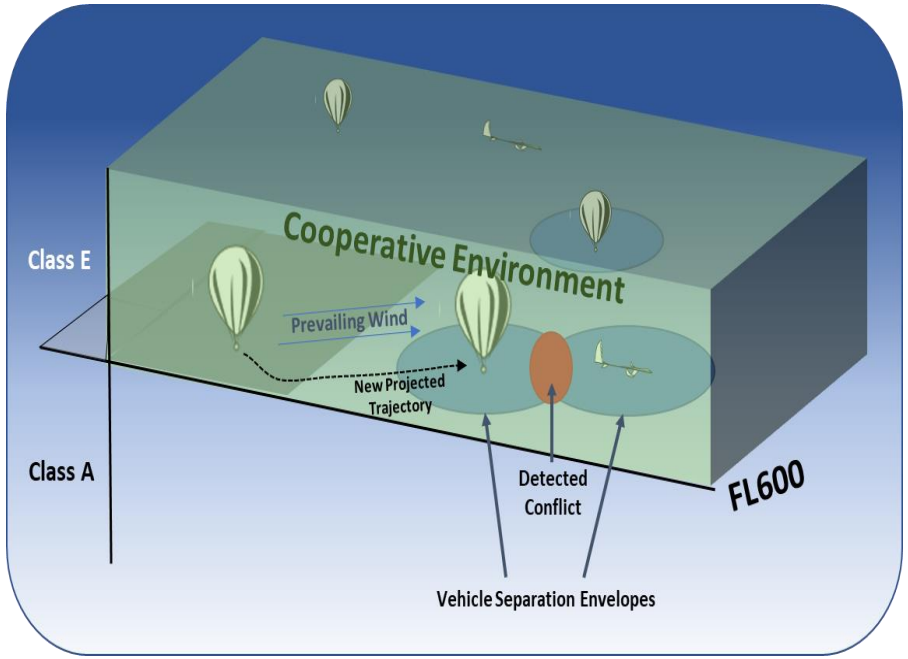
- Multiple HALE vehicles are providing communication services to an area where hurricanes have caused loss of ground-based cellular/internet communications
- HALE vehicles in this area cooperatively separate from one another. Activities to accomplish this include:
  - Sharing flight intent
    - Intent is shared whenever re-planning / updates are required
  - Identifying conflicts based on shared intent
  - Resolving detected conflicts strategically through coordination between Operators
  - Monitoring conformance to one's shared intent
  - Adhering to TBD procedural rules of the road



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Scenario – Cooperative Separation between HALE Vehicles
Scenario Narrative

1. A HALE balloon is conducting flight per its previously-shared intent, which has been deconflicted from other operations in the vicinity (another HALE balloon and a HALE fixed wing).
2. Changes to prevailing winds establishes the need for the HALE balloon Operator to determine new projected trajectory and re-plan as needed.
3. The HALE balloon Operator obtains intent information from the other two Operators
   - Their intent shows projection of their own vehicles' trajectories to some time in the future.



4. The balloon Operator compares their new projected trajectory against that of the other two operations and identifies a conflict with the HALE fixed wing operation.
5. The balloon Operator coordinates with the fixed wing Operator to resolve the conflict. The Operators agree on the actions each will take to resolve the conflict.

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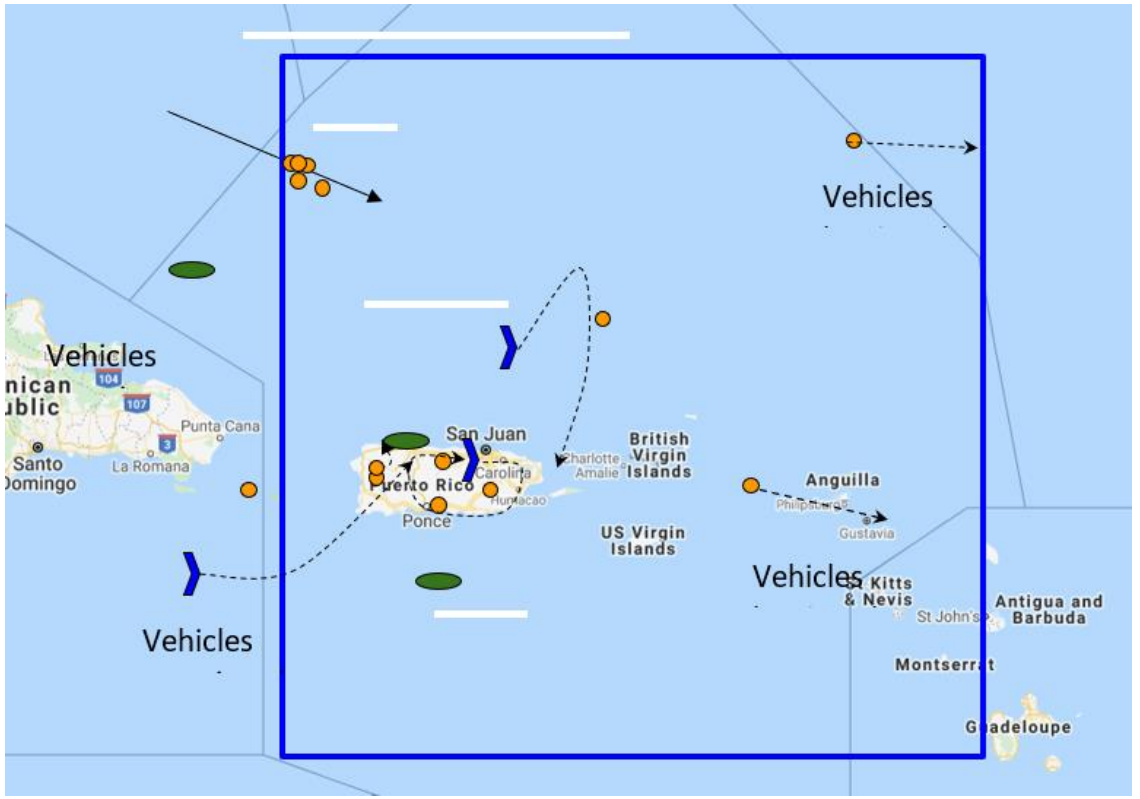
Scenario – Cooperative Separation between HALE Vehicles
Notional Questions to Foster Discussion

- How do different types of operations characterize their intent/projected trajectory?
  - How will Operators identify conflicts with this information?
    - Conflict detection example: clash analysis of volumes as is done in 3D CAD assembly design.
- In what manner are Operators exchanging data?
  - Posting to a website?
  - Automated information exchanges through APIs?
  - Email?
- If another vehicle is approaching the disaster area from some distance (for example, a couple hundred miles away), intending to operate in the same area at some point in the future (hours or days).
  - How does that new Operator determine with whom they must coordinate/exchange information? In other words, how do they know who else is out there currently operating under cooperative separation?
- What other information is shared between Operators beyond intent?
  - Example: Atmospheric data measured by Operators' vehicles could help in establishing a single source of truth that is used for conflict detection (e.g., Operators will detect the same conflict because they project their respective vehicles' trajectories using the same input data).

Next Steps?

Follow up from March 19 meeting

- Using Scenario 1 as a framework:
  - Start a little earlier in time and consider how those operations were planned and how they made their way to the area
  - What are the data that needs to be shared between operators? With ANSP? When does this data need to be shared?
  - What does operational intent look like for different operations, what are the time horizons for intent sharing for the different vehicles/operations, and what should be acted upon in the event of overlapping intent?
  - How does the cooperative military aircraft integrate with the cooperative non-military response operations? What is the process and procedure?
- Airspace structures Scenario 1 and how they are communicated to operators



Pre-decisional

Planning process

How are operations planned strategically?

- Solar Fixed-Wing HALE: Expect to provide at least 24-hour notice of planned ingress. Timing and format of ‘flight plans’ and CTMS inputs will need to be agreed and, in all likelihood, refined as we go.
- Loon program management sets-up a designated service area, assigns target service level of area and indicates priority of the area (vs. other areas)
- Loon teams plan total launch capacity to meet vehicle demand on a continuous basis.
- A fleet wide optimisation algorithm assigns each vehicle to a specific area and task. This assignment is updated every few minutes. This means that:
  - a vehicle in a service region may be automatically reassigned by the software to another service region.
  - a vehicle in a service region may be assigned to be in that same service region at a later time, which may force the vehicle to leave the region, stage itself outside, and come back at a later time.
  - Global fleet forecasting algorithms simulate trajectories of each balloon (that can then be turned into operational intents). Simulations are refreshed every minute or few minutes

Pre-decisional

Transit to Area

- Hawk30 would climb to altitude in a dedicated launch area then navigate to the service area while maintaining altitude above a certain altitude that doesn't conflict with other commercial ops.
- Getting to the area - vehicles will either:
  - Be launched from one of the launch locations around the world and navigate from their launch site to the service area. (E.g. when Puerto Rico disaster relief happened, balloons were navigated from Nevada to Puerto Rico). Note the trajectories are not direct, and depend on winds.
  - Be already airborne (for several days or months), be assigned to that region, and navigate to the desired region. Note that vehicles assigned to the region may need to leave the region for hours, days, weeks, and circle back to the region sometimes going all the way around the world, and could be replaced by another vehicle in the mean-time.

Pre-decisional

Data sharing

What data should be shared amongst operators?

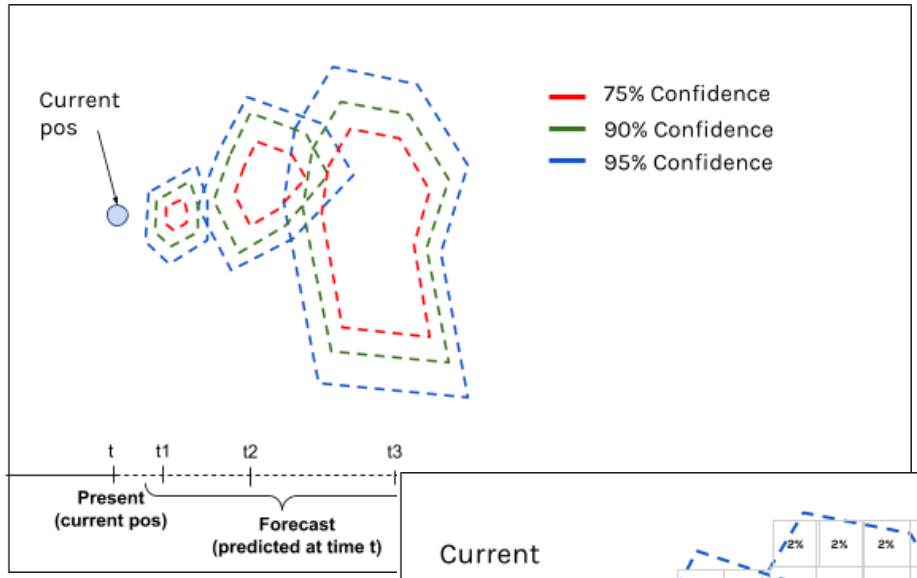
- Amongst operators, a **flight plan** should be shared similar to how one would be filed with an ANSP on an IFR plan. The reliance on ANSPs (at least while on station or transiting) should be minimal. The when is the question we're trying to answer as part of the sim.
- HALE UAS will need to file **updated flight plans periodically** when climbing through winds in excess of their airspeed since they no longer can precisely maintain course. But, they should be able to be accurate enough over the span of an hour or so using readily available wind data and models. Naturally, this precision (or lack thereof) will need to get rolled into the separation requirements.

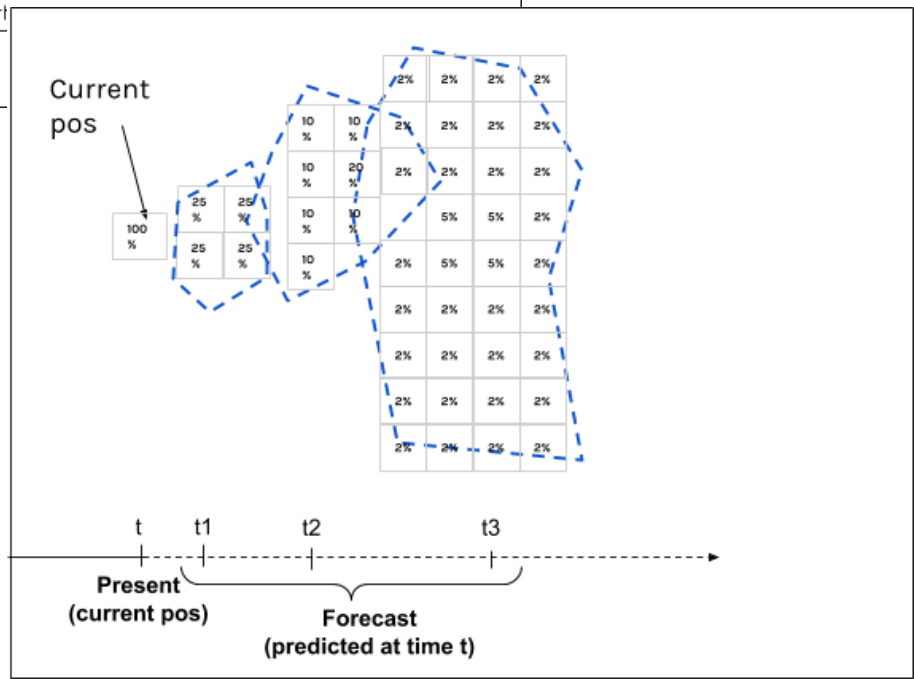
Pre-decisional

Data sharing

Pre-decisional

- Loon will **share operational intent in the form of 4-D polygons** containing probability information (e.g. probability density or probability contours) based on continuous simulations. These polygons will represent where the balloons are expected to be in the future, up to some horizon H.
- Loon will **refresh those intents every few minutes** (reducing short term uncertainty and extending information on the rolling horizon).
- Loon may share those projections with Horizon up to a few hours ahead (e.g. 24h.) However, uncertainty in the distant future is high, and operational intents at time t+24h may cover an entire FIR. We **would not expect a PSS to request conflict resolution far in the future if needed**.





Data sharing

Pre-decisional

What data should be shared with ANSP?

- **Minimum Flight level** that operations will go to (deconfliction flight level). This may not be a constant through the airspace.
- **Ability for ANSP to query** operational intents details.
- Loon may also share **current and forecast maneuvering capability** (rates and achievable amounts, maybe in the form of a maneuverability envelope) such that the PSS can plan the time necessary for maneuvering, should a Loon vehicle need to perform an avoidance maneuver. The maneuvering capability WILL depend on battery levels, temperatures, sun radiation, weather storms, etc.

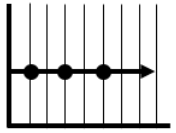
Data sharing

When does data need to be shared?

Pre-decisional

- Shared in advance of operation (expected arrival in a shared general area): broad operating intent (area and timing). “Strategic” deconfliction in accordance with “fairness” rules and then codified in “shared intent” (UTM) or a flight plan (ATM) constructs that are generally well understood. The one exception being that **traditional flight plans can’t cover the entire mission of a HAPS**. This was an issue identified by the UAS in Controlled Airspace ARC.
- Shared **when pre-determined separation criteria are met**: more detailed trajectory intent and agreed de-confliction actions. Tactical deconfliction done in accordance with the Right of Way (ROW) rules of the road, which I‘m not sure change much since they are based on maneuverability. The one exception might be a need to stratify the fixed wing ROW, i.e. HALE are less maneuverable than other fixed wing.
- Shared **after any encounter**: debrief and learning points.
- This is open to negotiation between the operating parties in a specific airspace. When there is a reasonable reason to think that a conflict is possible (i.e. two operators operating or intending to operate in the same general region). Loon would rely on services of a DSS equivalent to indicate when sharing detailed intents is necessary.

Time horizons for sharing

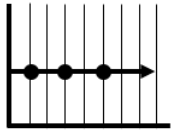


What is the right time frame to share the intent that could cause possible risk? Should it be generic or based on the individual parameters of the operation?

- Open to negotiation. For large uncertainty intents (e.g. uncertainty in space or time), intents should be refreshed as often as possible such that uncertainty is minimized and airspace usage maximized.
- Operational intents should be updated each time they change. And communicate to relevant stakeholders (e.g. the ones likely impacted by the change)
- The timeframe for alerting/resolution should absolutely depend on individual parameters of the operation. These parameters may not be static (e.g. maneuvering capability will vary as function of battery levels, temperatures, storms, etc.).
- The timeframe for alerting should be such that the probability and severity of hazard and their resulting harms are maintained below appropriate Target Safety Levels (Likely multiple TLSs to be used depending on which harm it refers to, and perhaps unique to each operating environment)

Pre-decisional

Time horizons for sharing



What is the right time frame to share the intent that could cause possible risk? Should it be generic or based on the individual parameters of the operation?

The necessity to resolve a conflict will therefore depend on when it needs to be resolved and will depend on:

- The probability that the conflict is not being resolved on time, such that a hazard happens:
- Horizon of the conflict (how far in time is the conflict)
- Probability of hazard if no action taken (are the two vehicles likely to intersect and create hazard if no action is taken ?) - This could be achieved through adding probability density to operational intents.
- Time needed to resolve (how long is needed to resolve the conflict)
- Time for deconfliction negotiation and coordination
- Telemetry transmission of new intents to the vehicles
- Time necessary to execute the maneuver to adapt intents.
- The severity of the conflict hazard (what are the consequences of the Hazard)
- Vehicles involved in conflict
- Risk to 3rd parties (incl. population density and ATM aircraft density)

Pre-decisional

Cooperative integration of military operations

- Cooperative operations will make their intents and positions available to non-cooperative operations through the PSS platform (i.e. non-cooperative military operations can query the PSS data).
- Cooperative military aircraft participates in CTMS like everyone else except that it might use something more akin to a USS-PS in the FAA UTM CONOP so as to be able to maintain the appropriate levels of security. The non-cooperative military is the more interesting problem, but they can reference a public portal of CTMS such that they are able to “see” where all other cooperative aircraft are and thus exercise due regard.
- There are so many different military operators and branches, it would be difficult for a CTMS to have a military POC that can reach out to the appropriate office. Alternatively there could be a procedure that the military follows that they would de-conflict with commercial ops as part of their flight plan or response plan.
- For the cooperative military aircraft operating reconnaissance missions for a different purpose. The RQ-4 Global Hawk or MQ-4 Triton, could fit the bill.
- Enroute flights to the simulated operating area will be under an IFR flight plan receiving air traffic services with direct two-way radio communication with the ANSP. Typical operating altitudes would be from FL510 to FL590. All regulatory equipage requirements are being met.
- On station time could vary from 1 to 20 hours.
- Flight path intent is shared with ANSP via IFR Flight plan.

Pre-decisional

Re-visit: Topic areas that are of key importance to be investigated

Investigate in the near term:

- Intent sharing:
  - the horizon of intent necessary to share in the future
  - The confidence of the intent
  - Protocols and templates for sharing
  - Required deconfliction criteria (e.g., HAPS vs supersonic to avoid wake)
- Interaction with ANSP for operation FL500-FL600

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Going forward

- Next meeting: May
- Consider alternative to in-person tabletop in the summer
- Topic items for Industry feedback

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Questions?

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