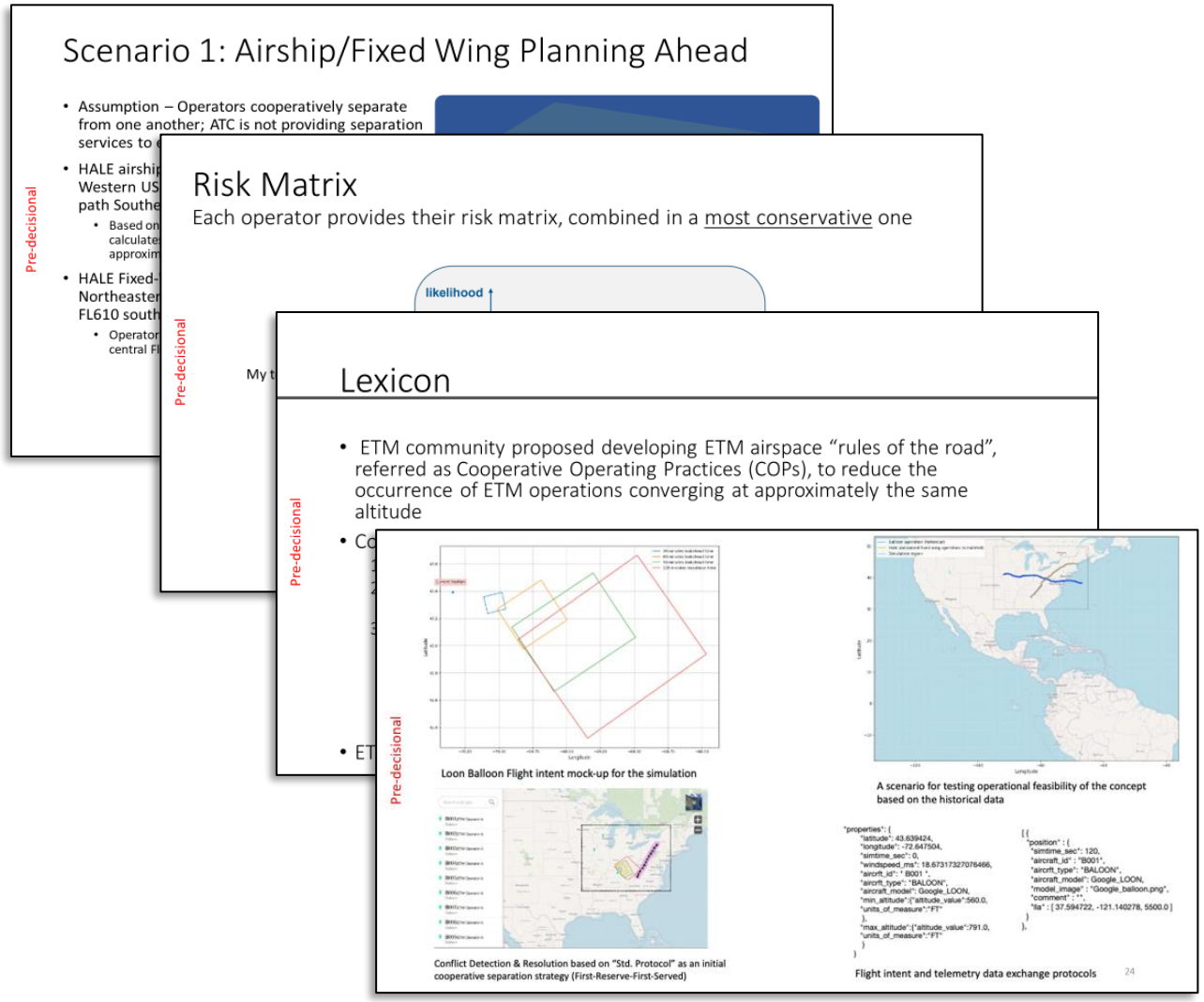
ETM: Upper Class E Traffic Management

June 10, 2021

Recap

- Meeting March 12, 2021
  - Use case discussion
  - Lexicon
    - COPs
  - Modeling and Simulation Update
- AIA Meeting: Early June
  - Feedback on Information Sharing and Services

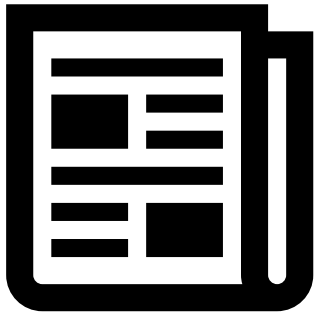
Pre-decisional



Agenda

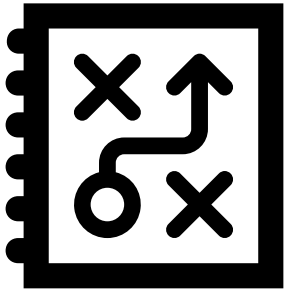
- News and Updates
- Special Presentations
- Services and Information Discussion
- Modeling and Simulation Updates
- ETM Workshop
- Wrap up

Industry Updates



News

Testing



Plans

Special Presentations

Pre-decisional

Level Set

- Developing a cooperative concept based on Industry input
- Focusing initially on:
  - “nominal” operations
  - Strategic processes
  - Development of Cooperative Operating Practices
- Apply outcomes to additional use cases for rigor
- Process informs simulation work with feedback loop to the concept

Pre-decisional

Pre-decisional

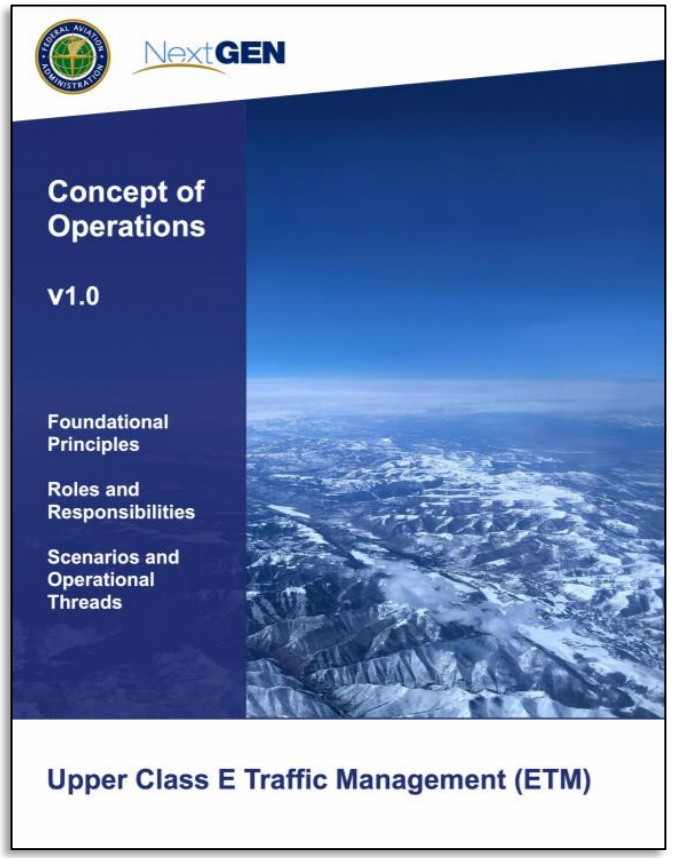
Services and Information in ETM

Services and Information Architecture

Pre-decisional

The FAA ETM ConOps v1. states the following:

- "The future of upper Class E airspace operations presents opportunities for an alternative traffic management approach. To ensure safe and efficient service provision for current, and expanded operations, the Federal Aviation Administration (FAA) is exploring an upper Class E Traffic Management (ETM) concept." (p.2)
- "An ETM construct must:
  - Scale beyond current NAS infrastructure and manpower resources to meet the needs of market forces
  - Support the management of operations where no air navigation service provider (ANSP) separation services are desired, appropriate, or available
  - Promote shared situation awareness among Operators" (p.3)



We would like to start looking at the service and data aspects of ETM that will be necessary for enabling cooperative operations. Existing examples of services are in various stages of development and implementation.

UTM Reference Requirements

Original UTM Requirements

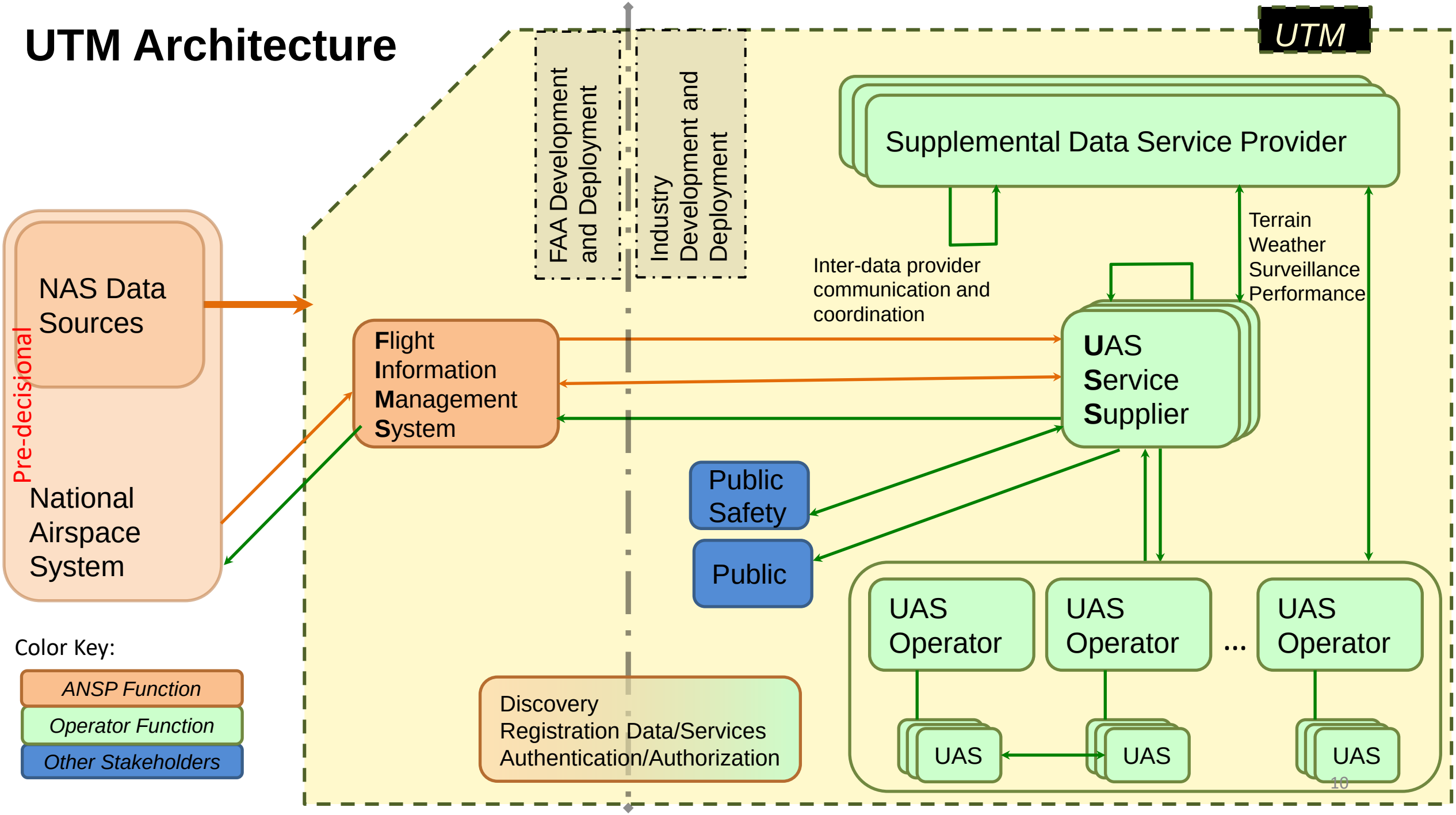
The UTM System SHALL

- aid in small UAS staying clear of each other
- aid in small UAS staying clear of traditional aviation
- support authentication and identification of small UAS
- provide common situational awareness for stakeholders related to small UAS operations
- allow for priority of Public Safety operations over other nominal operations
- allow the ANSP to issue directives, constraints, and airspace configurations related to small UAS operations
- mitigate the need for ATC to actively control small UAS in any airspace
- allow on-demand access of operational data to the ANSP and airspace regulator
- support small UAS from posing a hazard to persons or property on the ground

Pre-decisional

ETM will be very different, but some of the core principles will remain the same

UTM Architecture

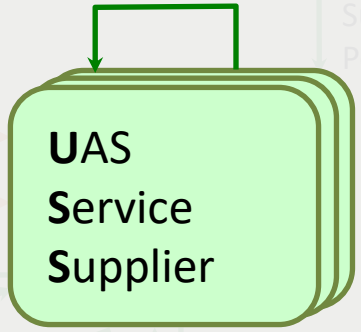


UTM Architecture

NASA Specification published
ASTM Specification forthcoming

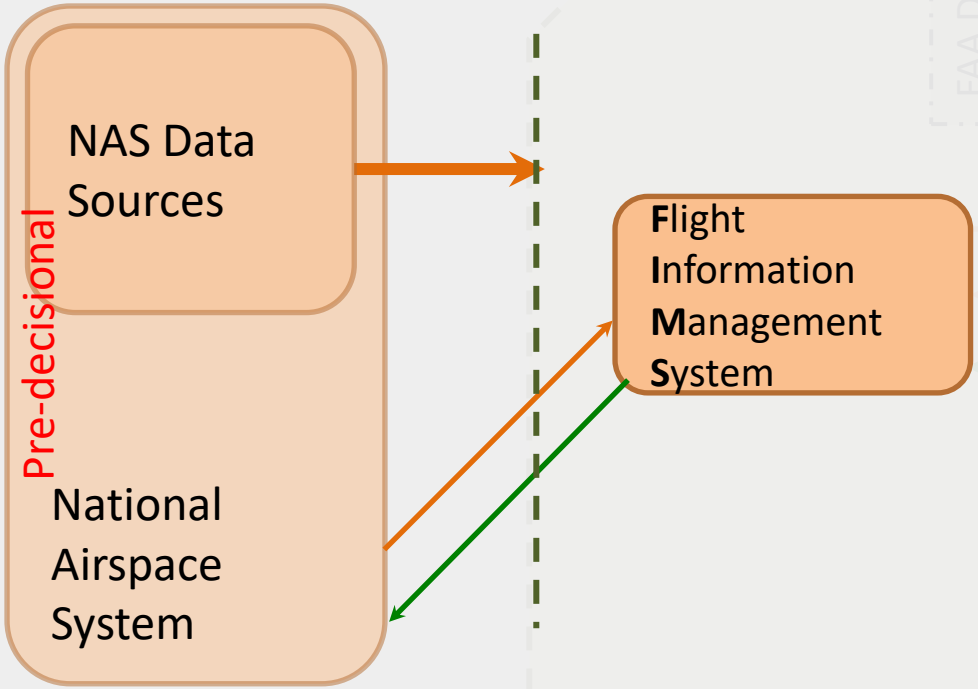
USSs share data for operations that are under their management. Data include intent, updates, requests, position reports, alerts, and other operational messages

Conceptually designed to be highly automated. In early stages, humans are in the loop for more complex tasks



Pre-decisional

UTM Architecture



Exercised in TCLs and UPPs

NASA tech transfer of initial FIMS code to FAA. FAA further developed to integrate with other systems and further concept development

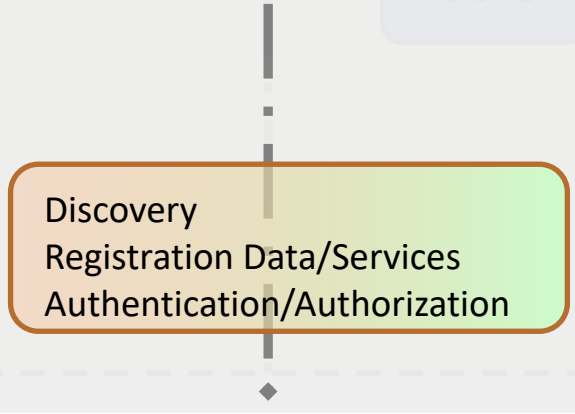
R+D here may help us to understand future requirements for other non-traditional/new entrant operations beyond small UAS

UTM Architecture

USS Discovery process highlighted by NASA as key architectural concern. Posed initial solution in TCL2 timeframe. Industry developed improved solution tested in TCL3 and 4. Input from NASA testing and industry collaboration moved discovery to an open source project driven by ASTM and industry (DSS).

Authentication and authorization paper published by NASA with close FAA discussion. Paper summarizes authorization architecture through TCL4 and somewhat beyond. As part of UPP2, industry engaged to further develop security questions and overall requirements/design.

Pre-decisional



UTM Architecture

Pre-decisional

Many SDSP types have been tested: surveillance, weather, vehicle health, static and dynamic risk assessment, conflict avoidance, communication coverage, and others

Significant opportunity for industry innovation in this aspect of UTM

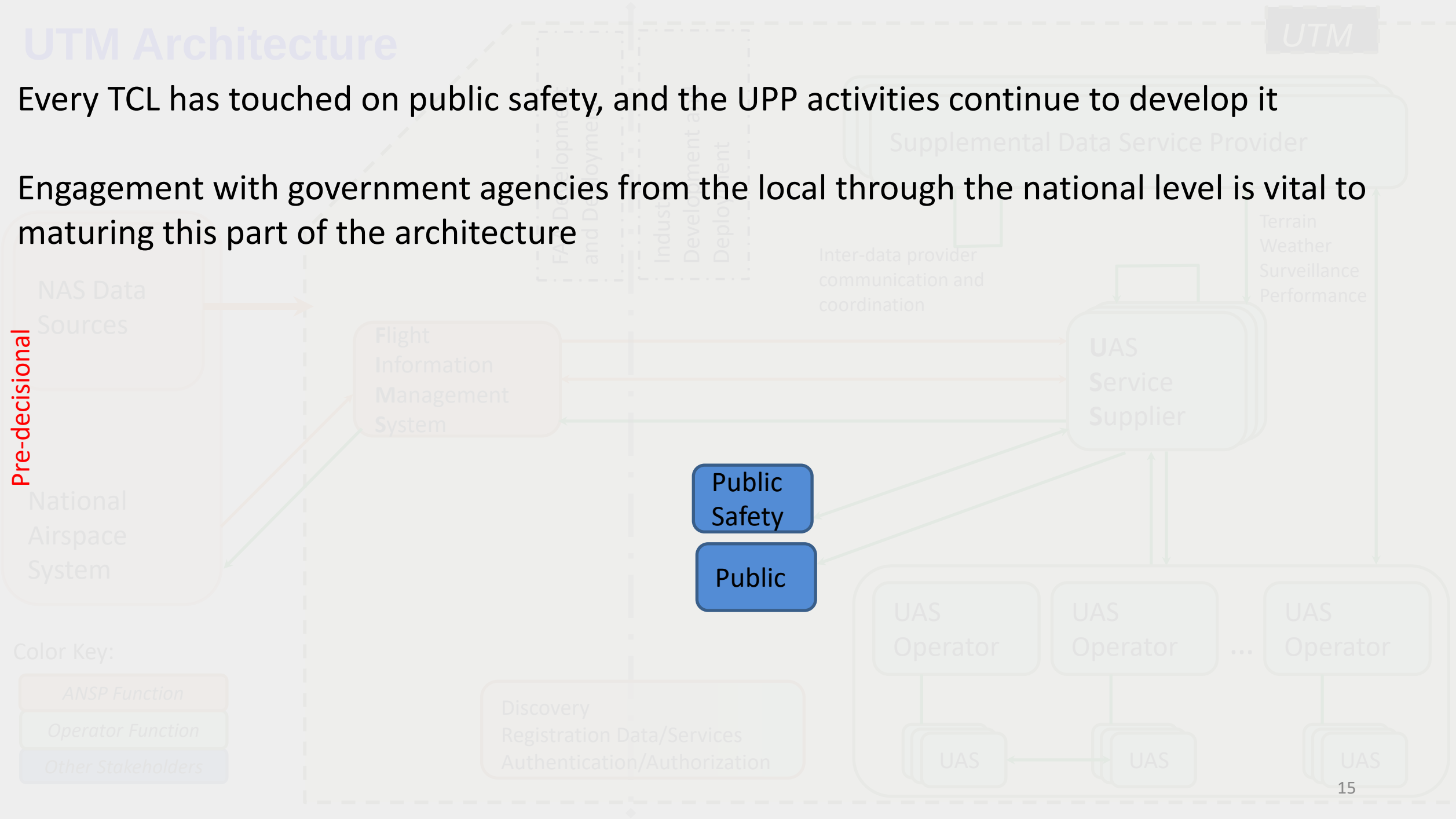
Certain SDSPs may require regulatory scrutiny and ANSP support depending on safety criticality, adoption rate, or other concerns

NASAs major contribution is the architectural context and the demonstration of proof-of-concept services

UTM Architecture

Every TCL has touched on public safety, and the UPP activities continue to develop it

Engagement with government agencies from the local through the national level is vital to maturing this part of the architecture



Data and Protocols

1. Operator plans mission
2. Operator submits plan to its supporting USS
3. USS checks plan against other entities in airspace
4. USS writes appropriate op data to DSS, discovering other USSs
5. USS notifies operator of plan submission success
6. USS sends appropriate op data to other USSs as required
7. FIMS used throughout USS-USS and USS-DSS comms for auth services

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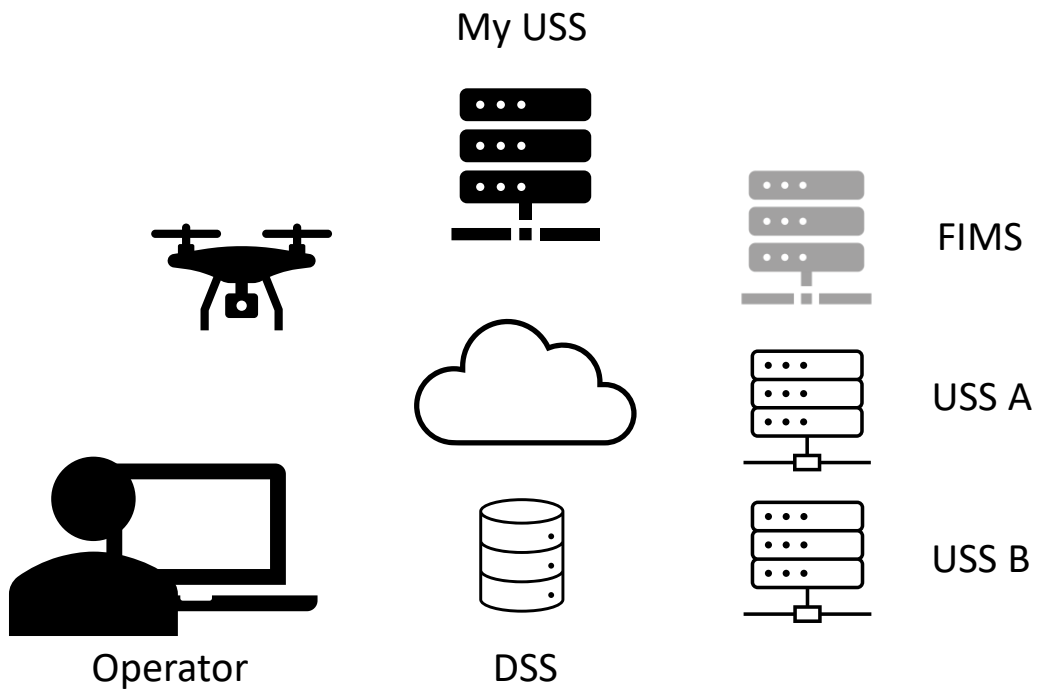

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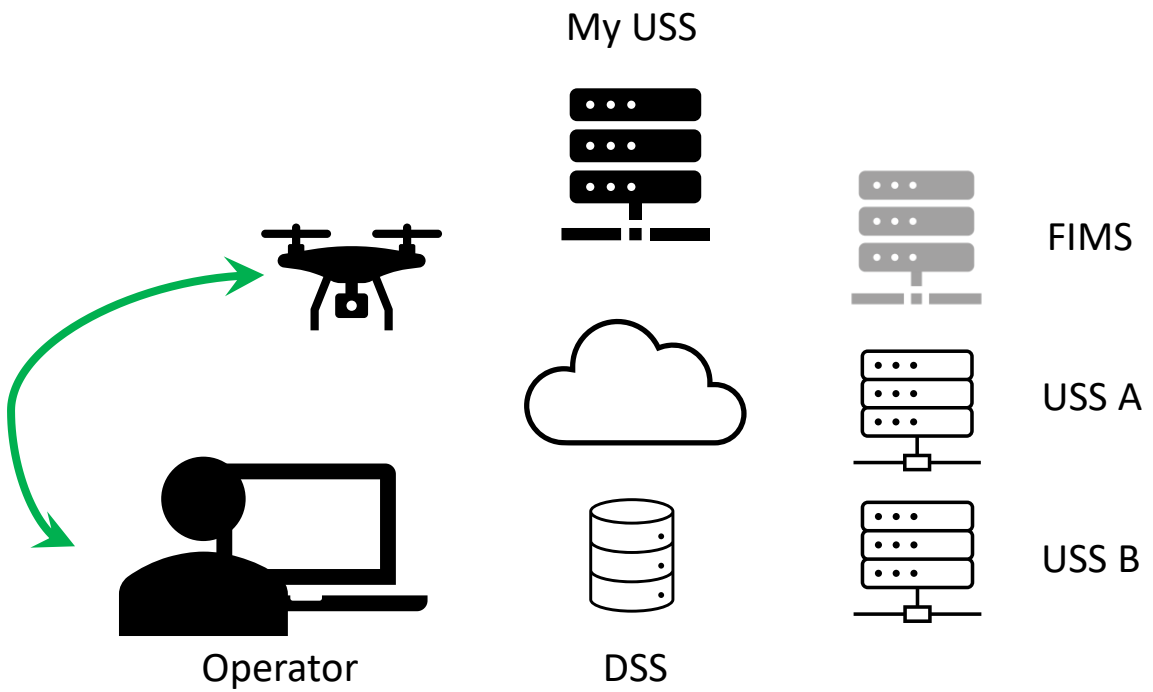

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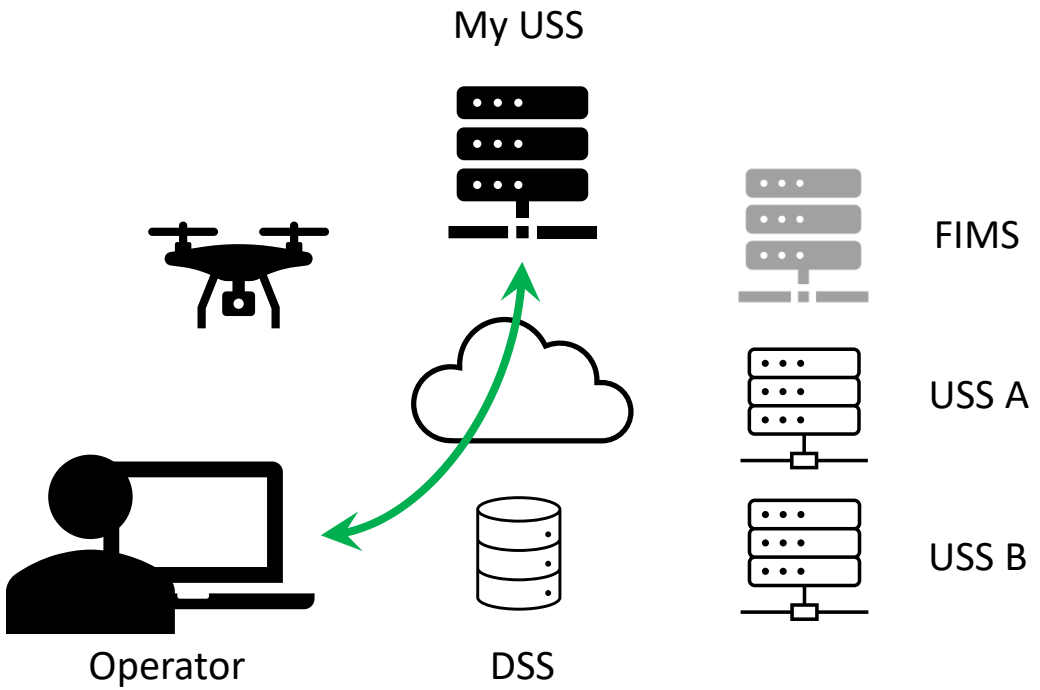

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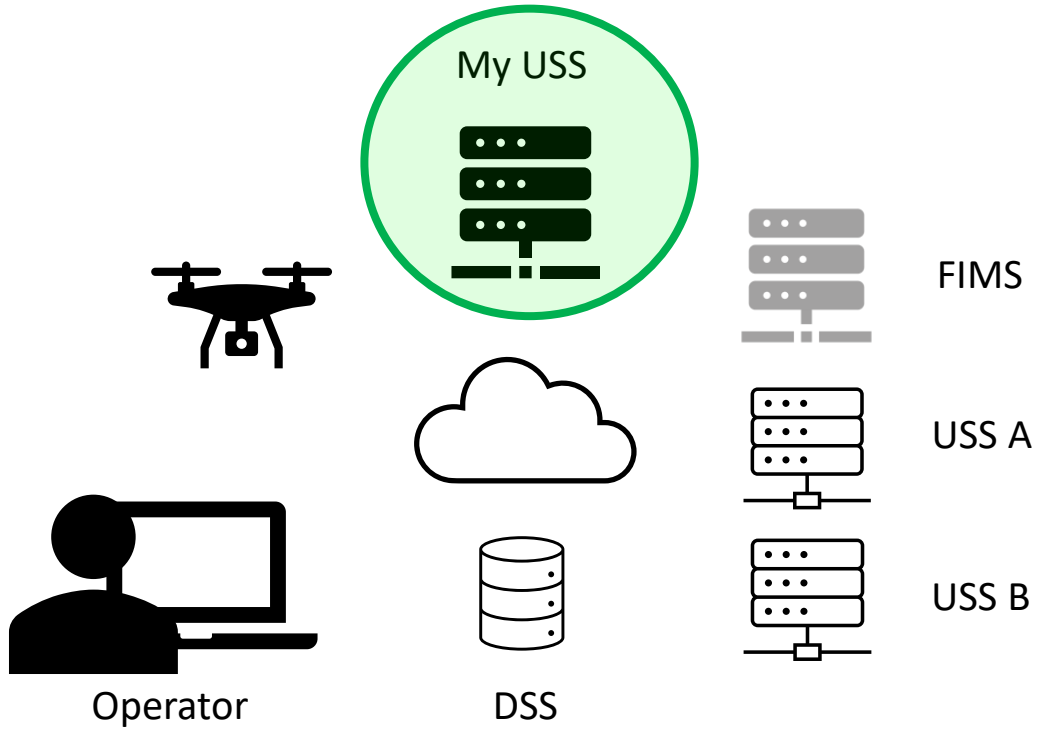

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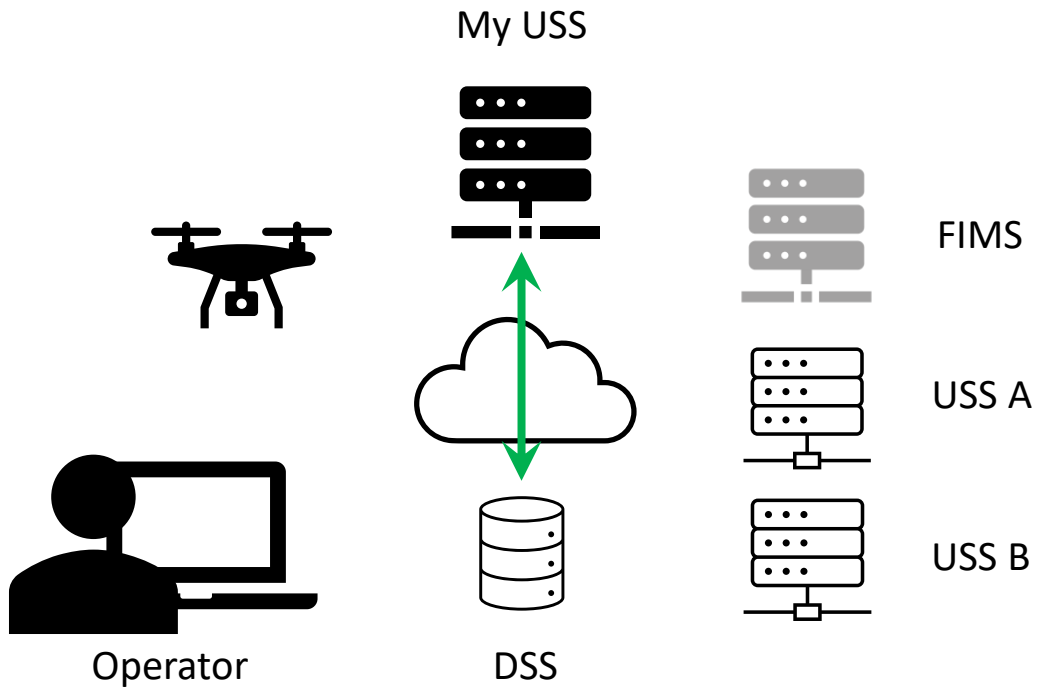

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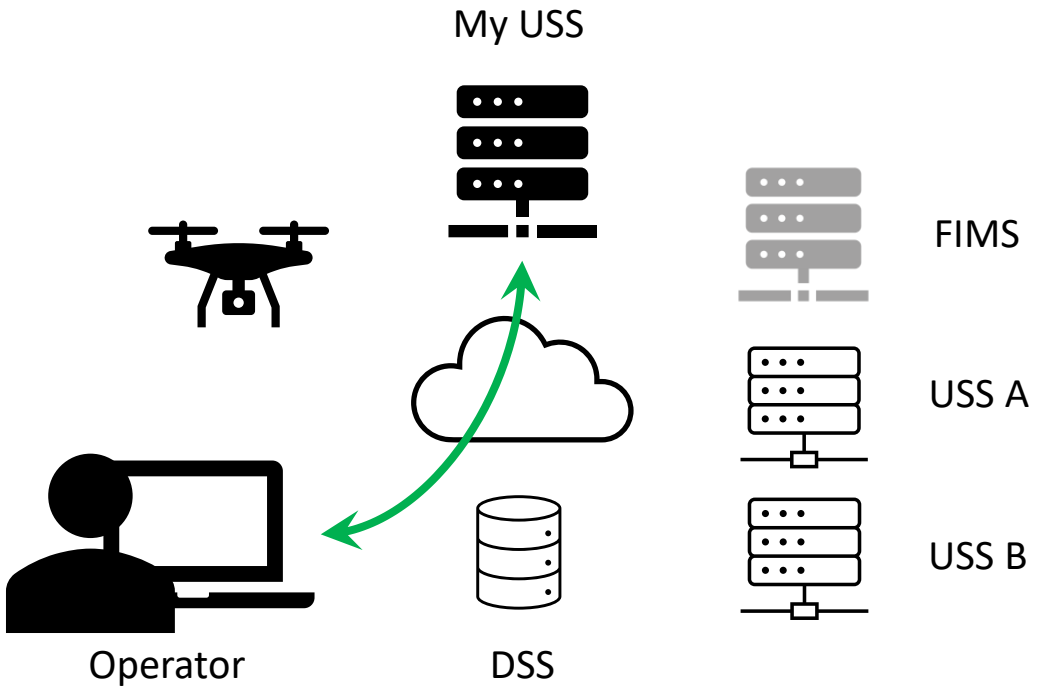

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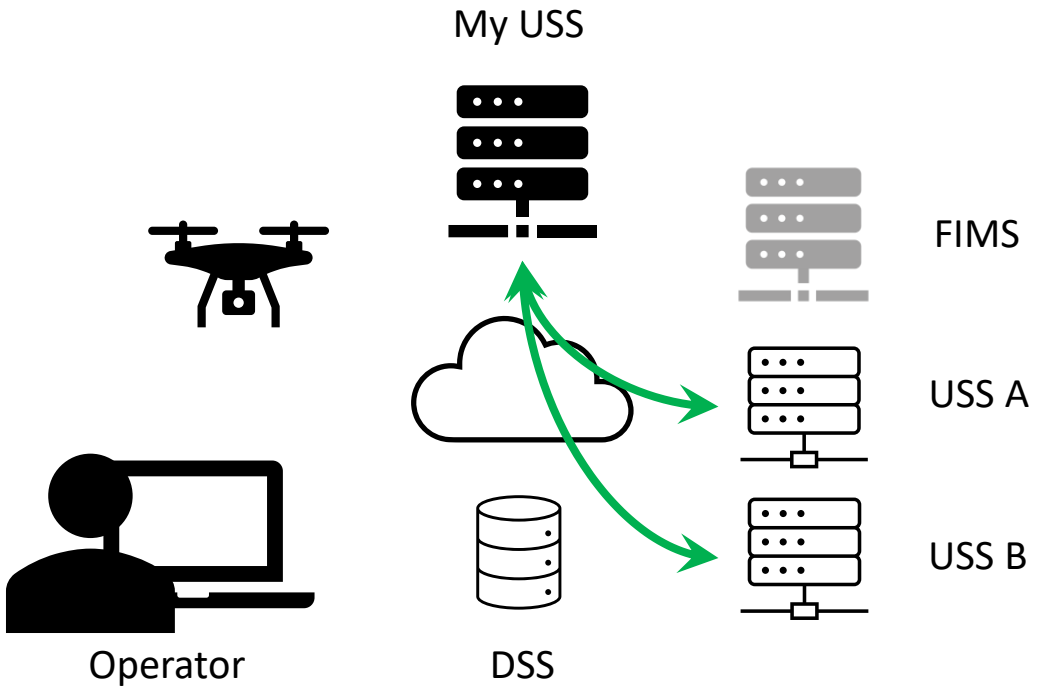

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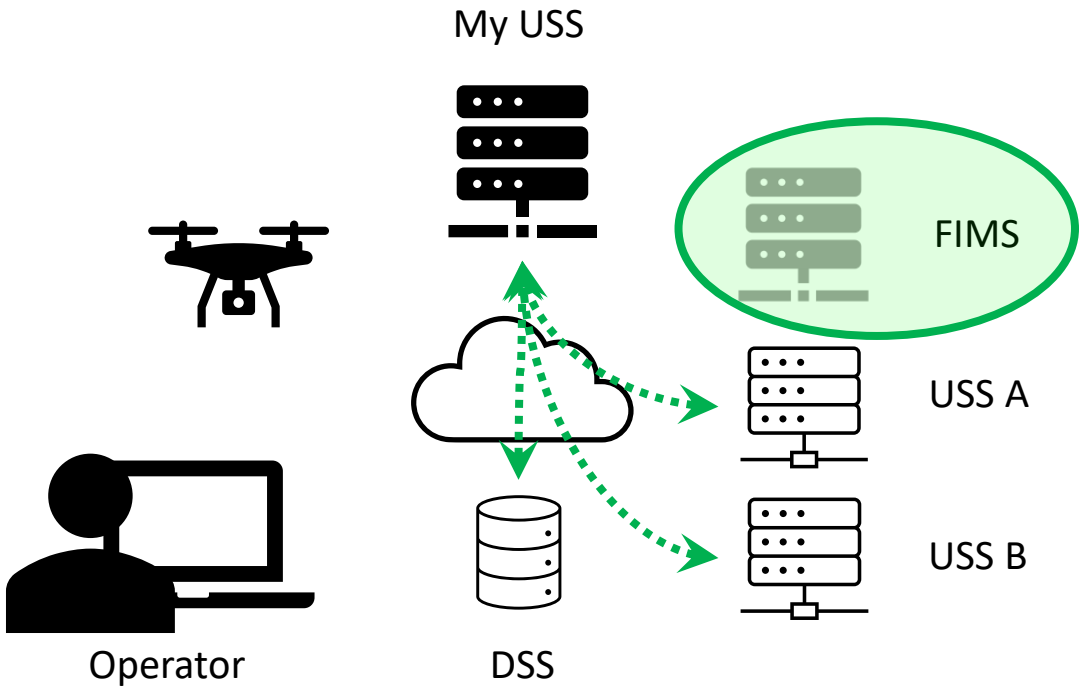

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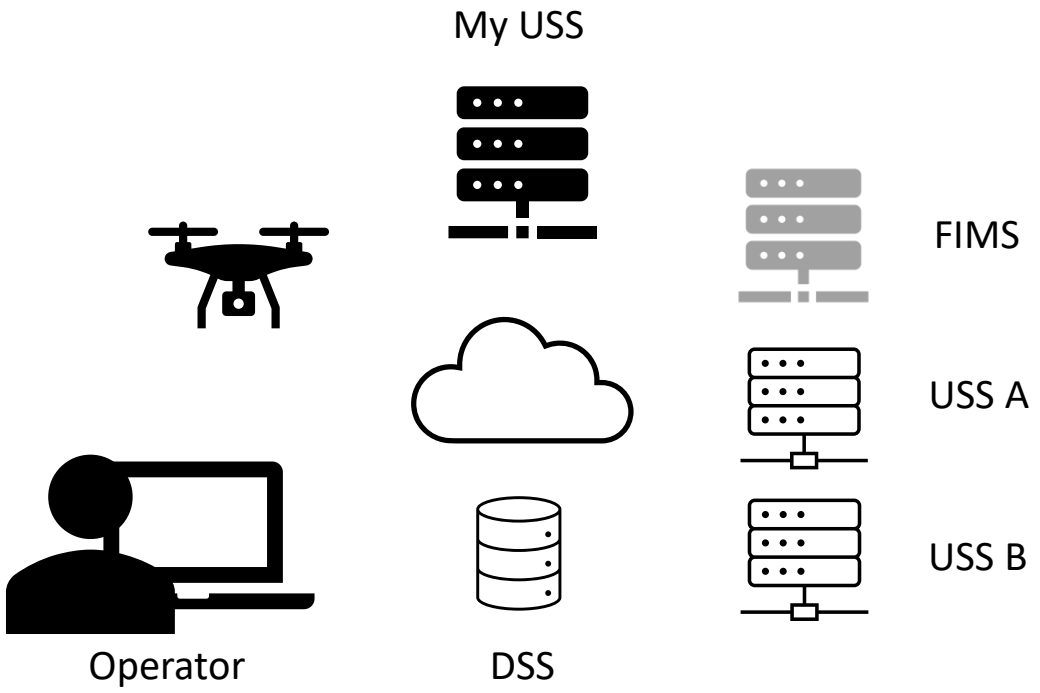
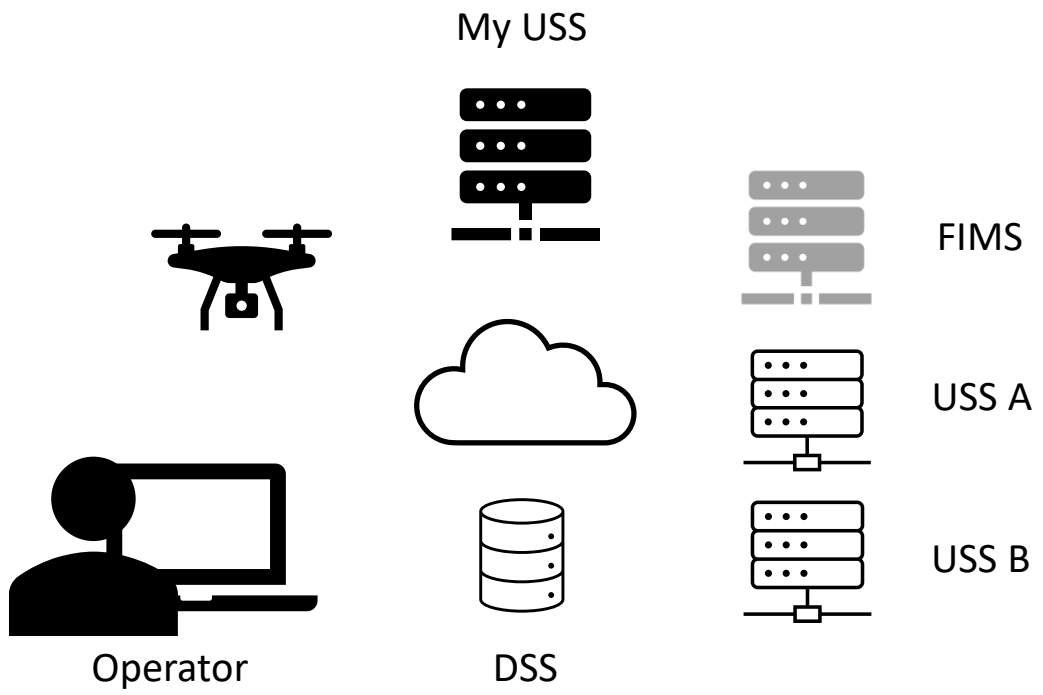


Data and Protocols

Upon commencing operation, the operator would share state data with its USS. Certain changes in the airspace or other operations are pushed to the operator from its supporting USS. Off-nominal conditions are pushed to the USS Network. DSS facilitates USS communications and synchronizing data.

All of these interactions can be summarized into groups of required and optional services of a USS. Defining those services is an effort that has been handed off to the FAA and industry for UTM.



Pre-decisional

Pre-decisional

Nominal ETM Operations in Upper Class E Airspace utilizing ETM Services

Assumptions

- *Simplistic, notional* scenarios demonstrating how potential third party support services *could* support ETM cooperative operations
- Scenarios highlight how *core* third party services (similar to UTM) could be used to support ETM operations
- Cooperative scenarios only (no air traffic services addressed)

Service Structure

- ETM Service Suppliers (ESSs)
  - Entity that assists Operators in meeting ETM operational requirements
  - Supports operations planning, intent sharing, de-confliction, conformance monitoring, airspace authorization, airspace management functions, and management of off-nominal situations
  - ESSs may be self provisioned by the Operator
- ESS Network
  - Series of ESSs connected to each other that exchange information on behalf of their subscribed Operators
  - Multiple ESSs may be utilized by Operators within the same geographical area
  - Enables Operator to Operator data exchange

Pre-decisional

Notional Planning and Initial Entry into ETM Using an ESS

Operator-to-Operator Data Exchange via a Centralized Platform, De-confliction, Automated Business rules

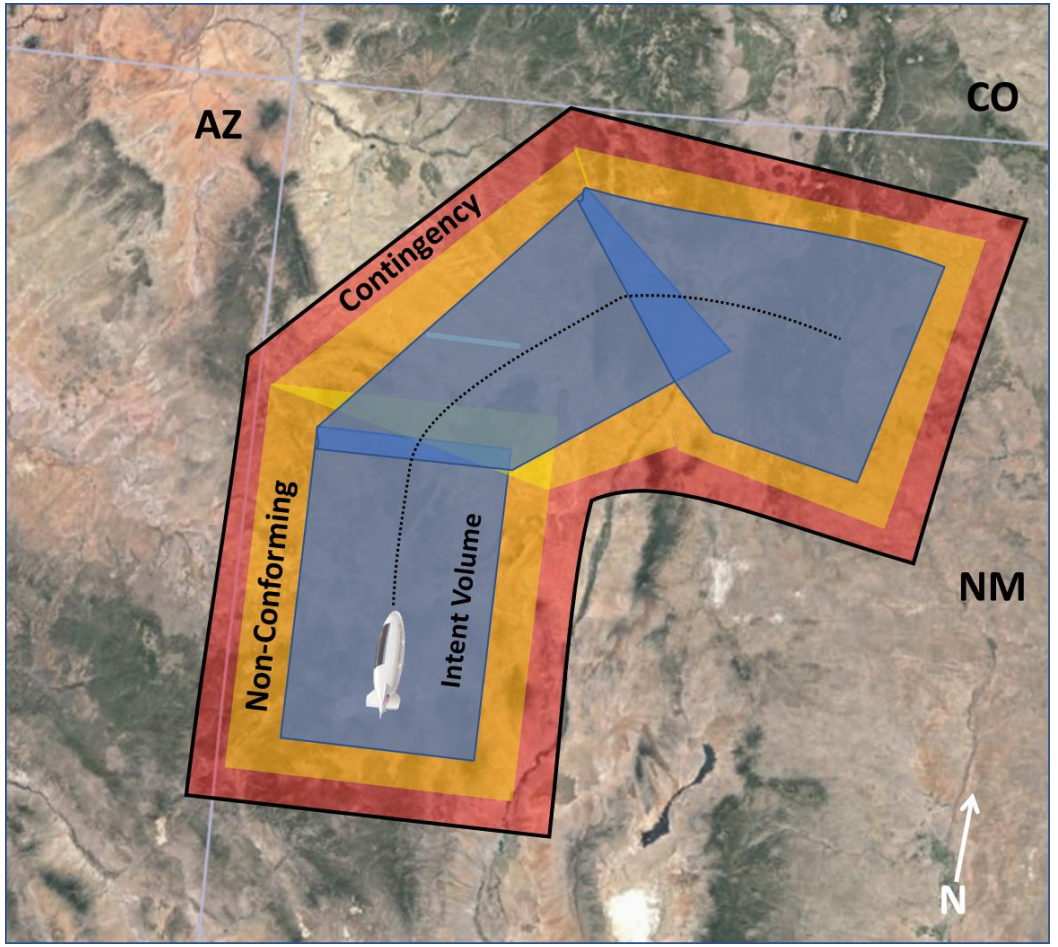
Notional Planning and Initial Entry into ETM Using ESS

- HALE airship operator is planning a surveillance operation over New Mexico
- The vehicle will fly in a 100 mile stretch of airspace between FL600 and FL640 for a period of 3 days
- While at altitude the operator will cooperatively separate from other vehicles
- The Operator subscribes to an ETM Service Supplier (ESS) to support their operation
  - ESS provides a decentralized, internet connected application programming interface that enables:
    - Operator-to-Operator data exchange
    - De-conflicts operations using automated business rules developed and agreed upon by the cooperative community (COPS)

Notional Planning and Initial Entry into ETM using an ESS

Pre-decisional

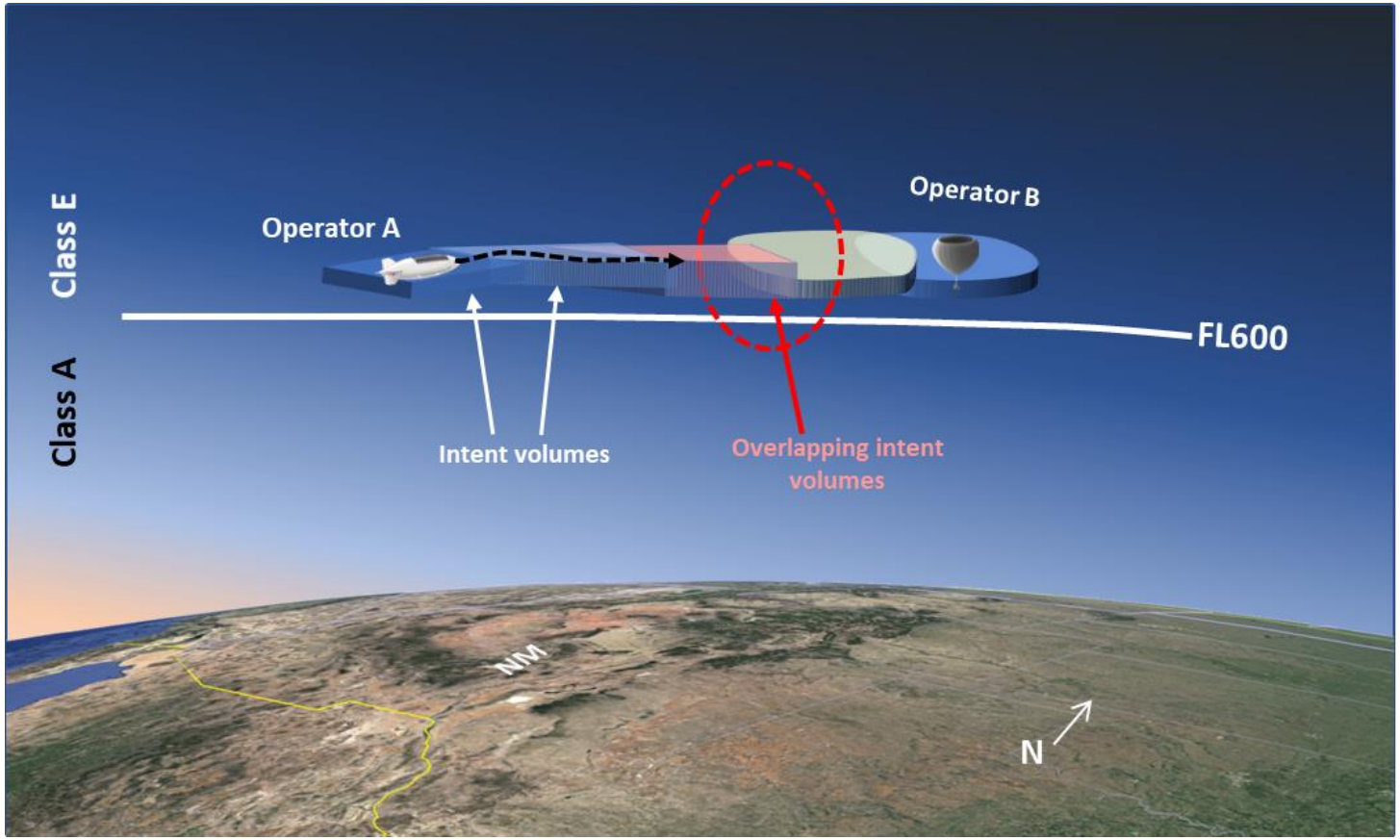
- Operator uses ESS ABC's planning tools/services to check the weather (for transit), atmospheric conditions at altitude, airspace restrictions/constraints, and what other operations are occurring in the area for the duration of the flight
- The operator logs into the ESS ABC
- The ESS loads the operator profile including:
  - The vehicle type
  - Vehicle performance characteristics
  - Pair-wise separation envelopes
  - Locational confidence
  - Equipage
  - Other relevant operational information
- The operator enters the date, time, and location of the prospective operation (e.g., lat/longs, altitudes, date, times)
- The ESS establishes an Intent Volume that accounts for the vehicle's separation envelopes, operational error, location confidence, and other relevant factors
- The Intent Volume supports safety and conformance monitoring functions, and alert/notification functions - in addition to de-confliction services



Notional Planning and Initial Entry into ETM using ESS

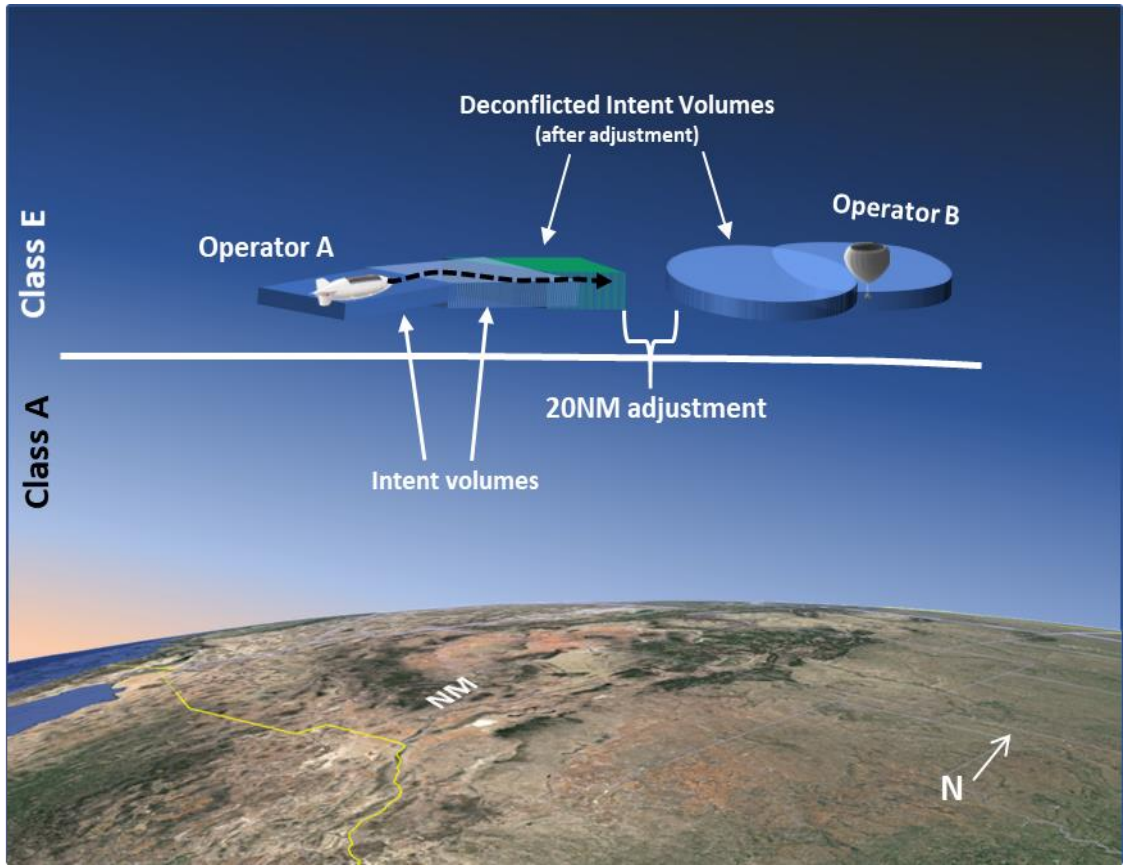
Pre-decisional

- The weather and atmospheric conditions are favorable throughout the operation and there are no posted restrictions on the airspace; however, one other operation is occurring at the East edge of the Airship's volume during times of interest:
  - A balloon operation is active from 7:00 AM to 12:00 AM on the first day of flight



Notional Planning and Initial Entry into ETM using ESS

- The Airship Operator uses ESS ABC's planning services to de-conflict the flight according to COPs
  - The ESS runs COPs dictated automated de-confliction rulesets for pair-wise de-confliction (HALE vs Balloon)
- According to COPs, the Airship Operator is obligated to adapt intent to establish appropriate pair-wise separation
- The Airship Operator requests potential deconfliction solutions options using ESS tools - several suggestions are offered
- The Airship Operator selects the option to adjust the east corner of the Intent Volume by 20 miles for the duration of the conflict
- Operator submits operation plan and the ESS shares the plan with the ESS Network

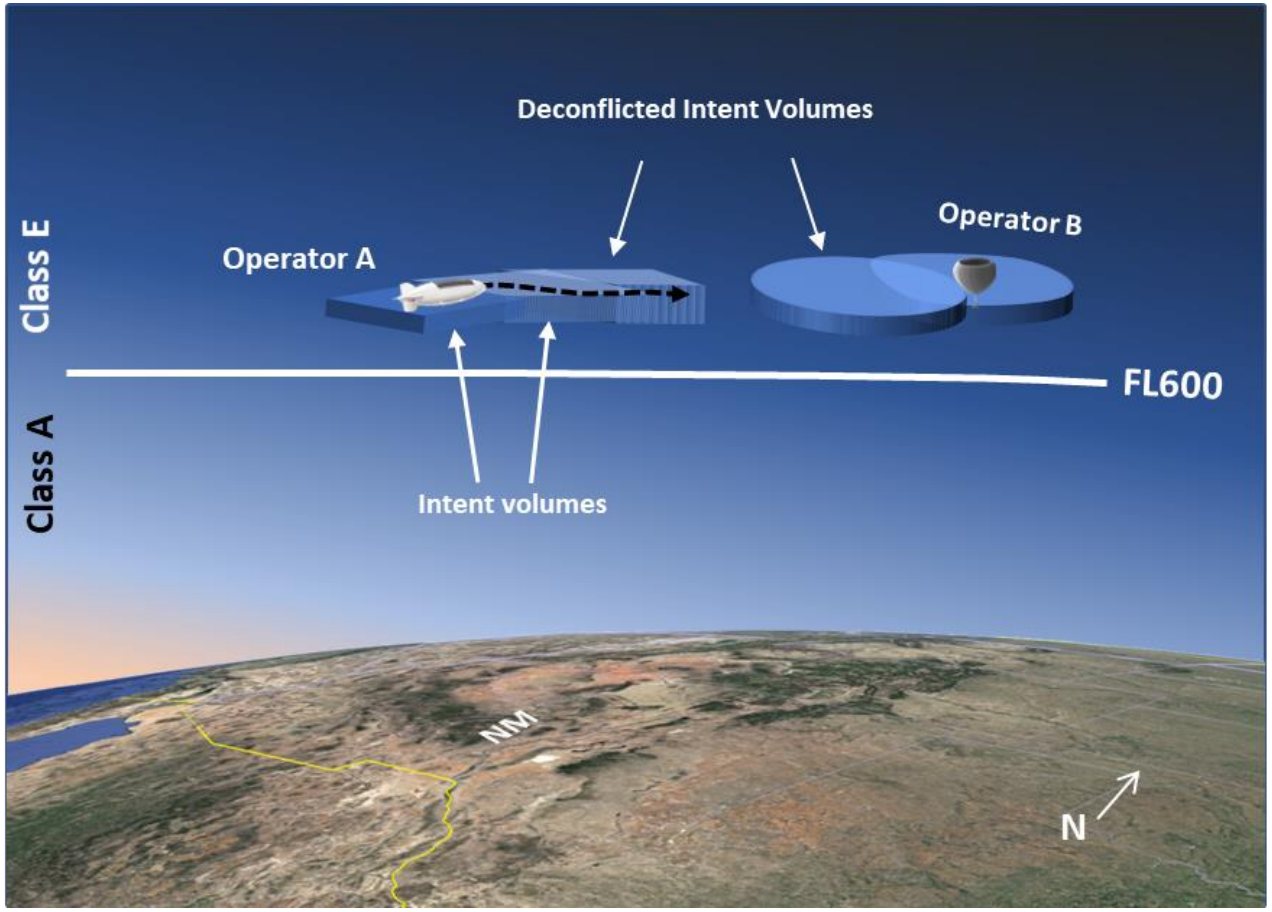


Pre-decisional

Notional Planning and Initial Entry into ETM using ESS

Pre-decisional

- ESS network makes the new Operation Plan available to other ESSs
- For situational awareness information is available on nearby operations if desired
- Both ESSs continue to check the ESS Network and other information sources for any changes impacting operations up to and throughout both operations – notifying operators of any new conflicts, weather, atmospheric conditions, or airspace changes that may impact the operation



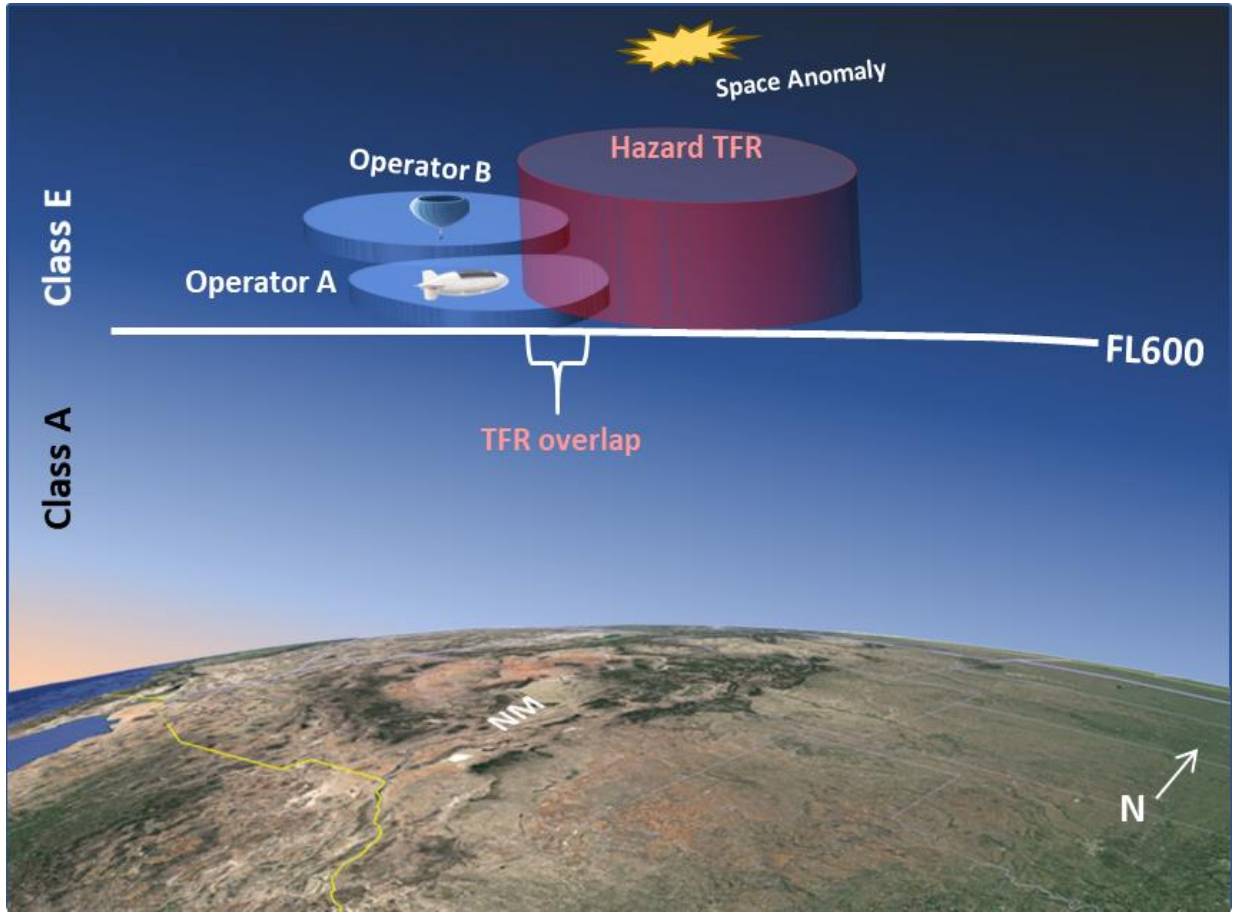
Pre-decisional

Notional In-Flight ESS Services

Notional Rolling Intent Sharing, Operator Alerts, Airspace Constraint Notifications, In-Flight De-Confliction and Operator Negotiation Support Services

Notional In-Flight ESS Support Services

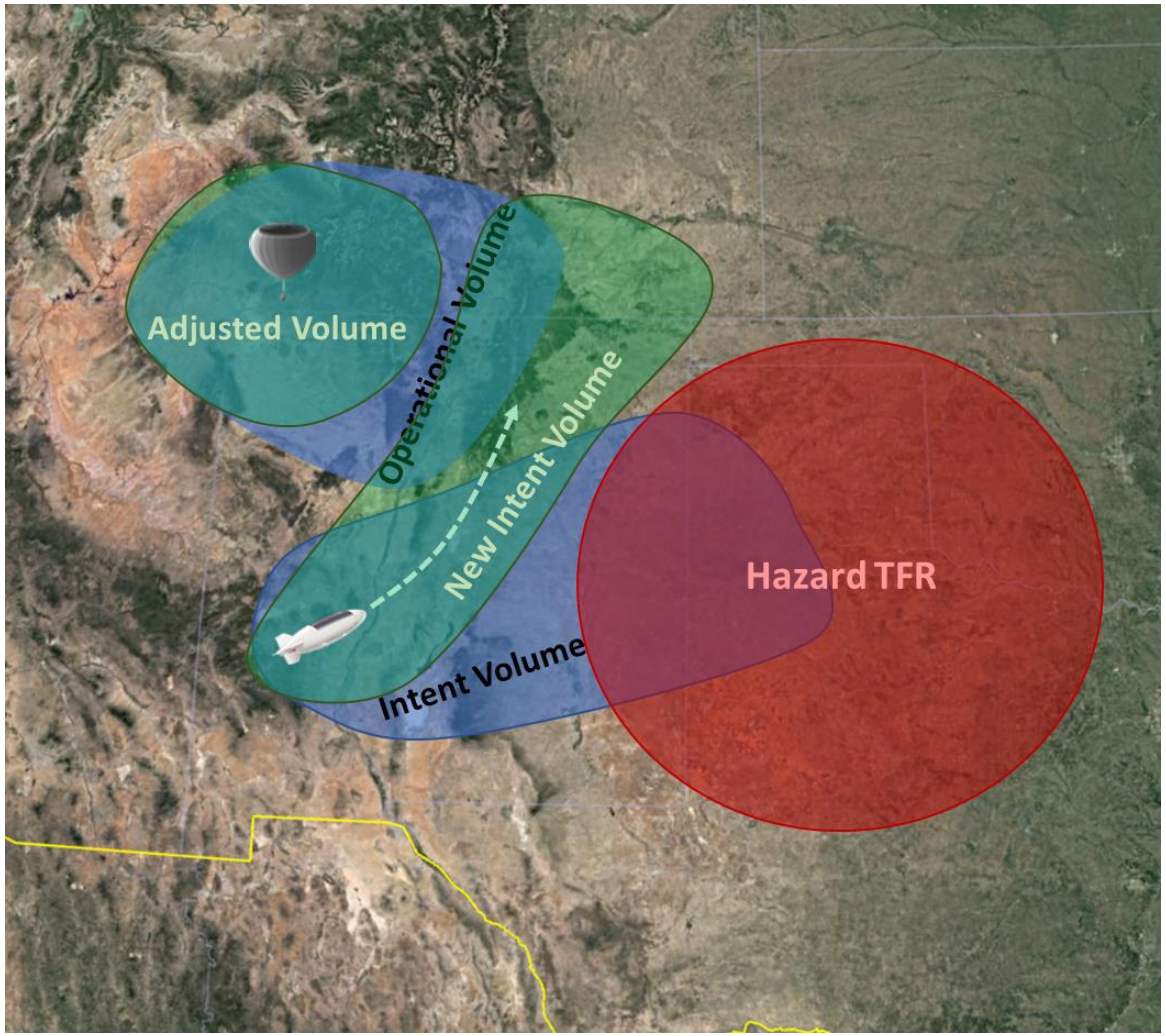
- The HALE airship operator takes off, transits to FL600, and enters the operation volume for the 3-day operation, monitoring for notifications/alerts that impact the operation and sharing any changes with the subscribing ESS, as necessary
- At 9AM on the first day of the operation, the operator receives an alert that, due to a commercial space operation anomaly, a Hazard TFR is being instantiated that impacts the HALE airship operation
- The operator evaluates the location of the TFR in reference to position using graphical ESS tools and determines that operation intent needs to be adjusted to avoid the airspace



Pre-decisional

Notional In-Flight ESS Support Services

- From a range of ESS-provided options, the operator identifies an ideal plan to expedite their exit from the airspace, however, it would create a conflict with the balloon operation that is operating in close proximity
- In this scenario the balloon operation has right of way but the HALE Airship operator negotiates with the balloon operator via their ESS to ask for leeway given extenuating circumstances.
- The ESS connects the operators, at which time the HALE airship operator requests the balloon adjust their operational volume to free up the northeastern portion of their volume for the airship's exit
- The balloon operator agrees
- Both operators submit new intent via their ESSs
- ESSs share the updated intent with the ESS network
- Both vehicles begin adjusting position



Pre-decisional

Pre-decisional

Services and Information in ETM *Feedback*

Q1: Based on the reference UTM architecture, do you see a similar architecture being applicable in ETM? What might be some differences that are unique to ETM?

- Architecturally speaking, we will need the public safety and public stakeholder portals. Those were included in UTM because the sUA is physically much closer to both of those stakeholders, thus the interest is much higher. Aircraft in ETM, on the other hand, will not be close to the ground at all and the FIMS interface with the ANSP is probably adequate.
- That said, FIMS now become much more of a "two-way street". In UTM, FIMS was mostly for publishing constraints and rarely was receiving data from USS unless they had a contingent UAS. This approach will be more a two-way transfer of data and we should be very direct with the FAA as to the future of FIMS.

Q1: Based on the reference UTM architecture, do you see a similar architecture being applicable in ETM? What might be some differences that are unique to ETM?

- Also different from UTM is the time scale at which we will need to have visibility into the plans and eventually shared intent of our ETM colleagues – and for what purpose. In UTM, the average flight length is measured in double digit minutes whereas it will not be uncommon to measure ETM sorties in double digit weeks and months. We will need to make a clear-cut distinction between strategic deconfliction decisions and strategic business decisions.
  - For example, it is advisable for a business interest to obtain some idea of how crowded the airspace is likely to be when making a decision on a new route or service area. And it is likely that an aircraft that will be a potential conflict in, for example, two months' time is already in or near that airspace. However, this by no means is a strategic deconfliction issue. Nor is this something that the ETM services must support. It is such a long time horizon that simple emails or phone calls can serve to provide the information necessary to do this long-horizon collaborative decision making.
- It will be sensible for ETMSP to provide a forum/portal through which such 'pre-coordination' could be achieved on a voluntary basis in a secure environment.

Q2: What time frame does the ETM need to support?

- Perhaps looking at the maximum amount of time it will take a solar HAPS to takeoff and reach the ETM environment, around 24 hours. This is also plenty of look ahead for pretty much any supersonic transport as well. Of course, balloon or dirigible operators may like to know further out into the future, but coupled to that desire is the increased uncertainty of their own future position. 24 hours which is more representative of the HAPS launch decision and notification loop. Launch/descent weather decisions will typically firm up over several days. Also, many Upper E residents will be solar powered and there may be diurnal energy-related factors in decision making during mission phases. At least introduce this as an M&S variable.
- However, as in UTM, the DSS will simply tell the Operator with whom they need to coordinate, and the Operators can then decide on the proper update rate and granularity with which to communicate. Since some users may not be interested in such a long time horizon, I would propose that the ETM DSS support a 12, 6, and, 3-hour uncertainty buffer around their shared intent.
- Inside of three hours, the state estimates should be good enough (NASA simulation will need to prove this) that the individual operators will be able to discover with whom they are “matched up” for continual updates throughout the rest of the deconfliction timeline.

Q2: What time frame does the ETM need to support?

- On the topic of deconfliction, UTM currently does not support the negotiation between operators in potential conflict. Given that ETM is inherently "cooperative", there is no reason why both parties to the negotiation cannot play a part in creating the required separation volume. This is clearly simpler to visualize when both parties have similar maneuver capabilities. However, there is no reason why even an unmanned, free balloon cannot play a part in the creation of appropriate separation.
- Flexible and continuous two-way negotiation is essential and the ETM system should be designed to accommodate that from the outset. Definitely agree the need to distinguish between business and safety risk decisions noting that

Q3: What would you like to know from/about other operators and operations for cooperative operations in ETM airspace? What are the key pieces of information that need to be available to operators at different mission phases

- Strategic business planning – out of scope
- Flight/Mission planning – this is the “24 hour” (or M&S determined) maximum look ahead
- Prior to ETM entry As above.
- Mission execution
- Prior to ETM exit – only relevant in the coordination with the ANSP

Information Needs: Flight/Mission Planning

Pre-decisional

Phase	Information Need	Why it's needed	When
Flight/Mission Planning If this is intended as 'pre-launch' then maybe some of the information cited by Andy Thurling would be more appropriate to the mission phase.	Shared 24/12/6/3 intent of other operators that may be in conflict with my shared intent	So I know with whom I need to negotiate	Before finalizing my shared intent
	When a conflict exists and I am coordinating with the other operator, I need to know the separation they want from my class of aircraft	So I can plan the conflict resolution timeline	Before finalizing my shared intent
	Time for the next update to the other operator's shared intent taking into account better flight path predictions and/or the passage of time (or perhaps we agree on a standard update time, say hourly between the 12 and 6 hour, half hourly between the 6 and 3, etc.)	So I can refine the conflict resolution timeline	Before finalizing shared intent
	Long-term plans of other operators	To enable efficient de-confliction planning in conjunction with weather window assessment	Ideally >24 hr before my launch

Information Needs: Prior to ETM Entry

Phase	Information Need	Why it's needed	When
Prior to ETM entry	Intent of other vehicles near my projected entry point	To plan final climb path and timing	Before launch and mid-climb (ETM – 12 and – 3 hours)

Pre-decisional

Information Needs: Mission Execution

Pre-decisional

Phase	Information Need	Why it's needed	When
Mission Execution (Nominal)	Continued updates at increasing rate and granularity from the other operators with whom I have discovered a conflict might exist	So I can refine the conflict resolution timeline	Before deciding that the risk of a collision requires both operators to achieve appropriate separation.
	When the decision is made to create separation to avoid a potential conflict, we need to "contract" for the maneuvers we are going to accomplish in order to achieve the separation.	So I know where (or in what dimension) I can create the appropriate separation	After deciding that the risk of a collision requires both operators to achieve appropriate separation.
	Continuous updates at increasing rate and granularity from the other operators with whom I am engaged in creating a separation		

Information Needs: Mission Execution

Pre-decisional

Phase	Information Need	Why it's needed	When
Mission Execution (Off-Nominal) Other vehicle	Continuous updates of position from the distressed vehicle Need to manage who receives high-rate 'push' notifications like this otherwise nominal operations which are 'very well clear' may be adversely affected	So I can avoid the distressed vehicle which probably cannot nor are they expected to, be part of a deconfliction scheme.	When the emergency is declared and then at a constant update rate (TBD)
	Continuous updates of distressed vehicle's intent (if possible) at increasing rate and granularity from the distressed vehicle Time constant and information needs will vary greatly depending upon the nature of the off-nominal (SSJ cabin pressure vs HAPS gradual loss of flight performance)	So I can avoid the distressed vehicle which probably cannot nor are they expected to, be part of a deconfliction scheme. See below, distressed vehicle might have to avoid due to its greater maneuverability	When the emergency is declared and then at a constant update rate (TBD)
	Type of distressed vehicle	So I can determine the appropriate separation to provide	When the emergency is declared
Mission Execution (Off-Nominal) Own vehicle	For HAPS, very similar to nominal in most cases – problems develop slowly		
	For fast-movers, location of proximate vehicles which may not be able to maneuver out of the way quickly		

Information Needs: Prior to ETM Exit

Phase	Information Need	Why it's needed	When
Prior to ETM exit	Clearance on the return part of my "stereo" flight plan	My clearance means I am conflict free with traffic being managed by the ANSP	Before leaving ETM airspace

Pre-decisional

Pre-decisional

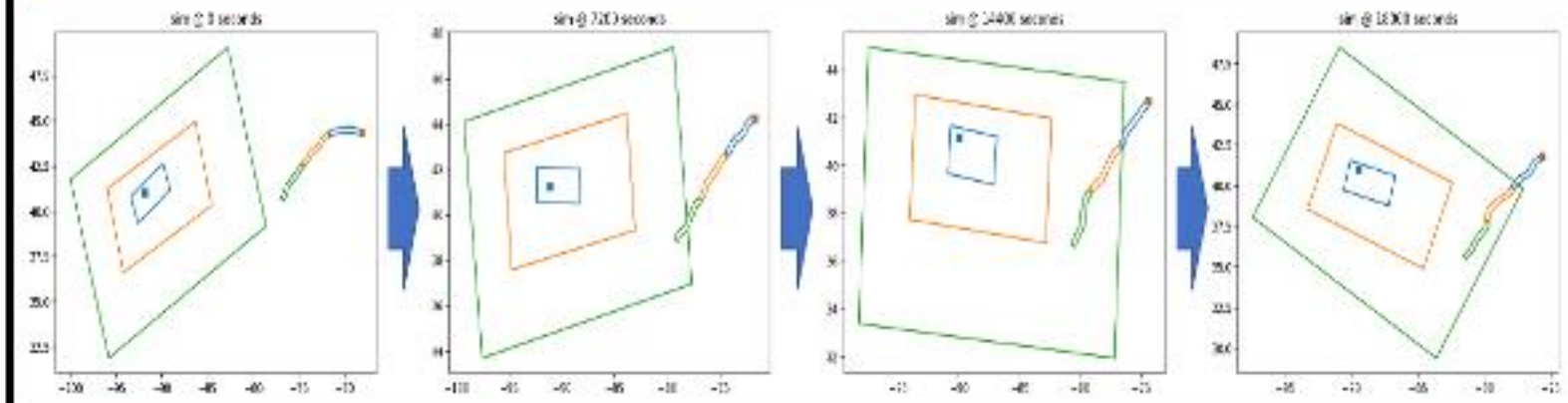
Modeling and Simulation Updates

Modeling and Simulation

- NASA
  - Papers Papers Papers
  - Fast-time simulation
  - Development of initial cooperative strategy
- FAA

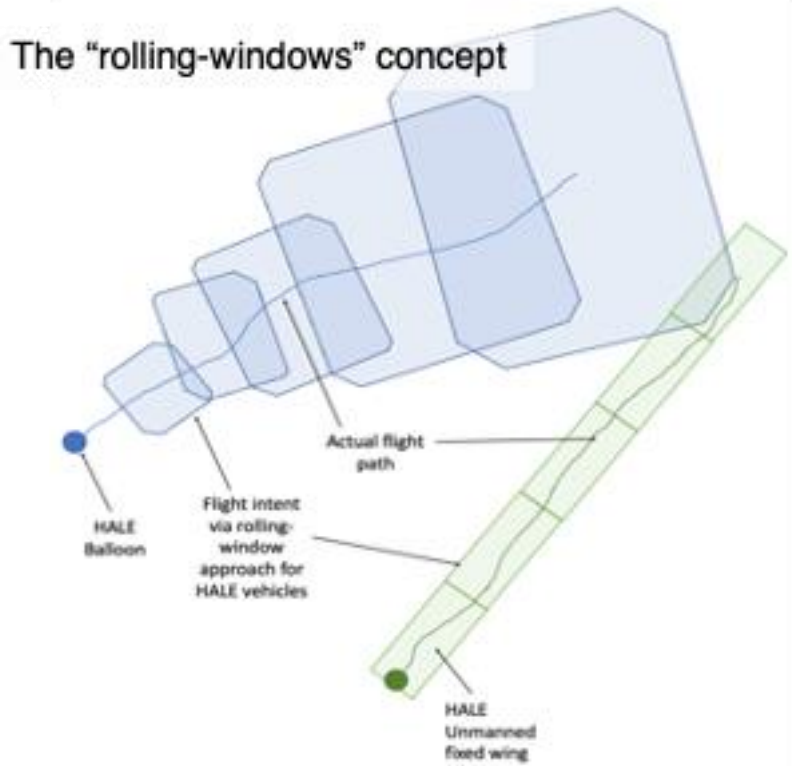
1

4



Pre-decision

2



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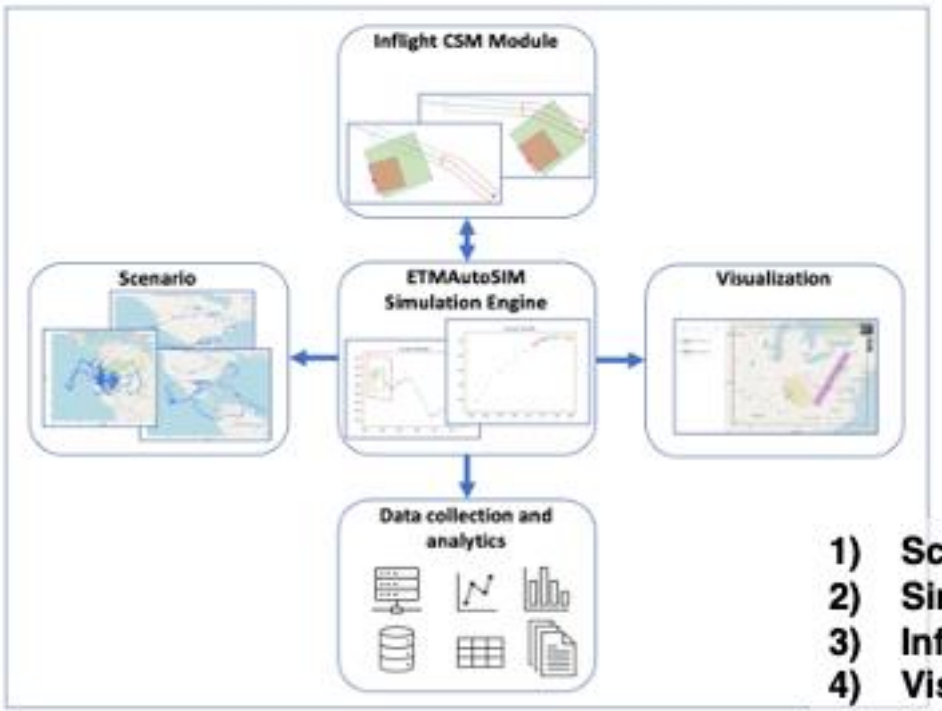
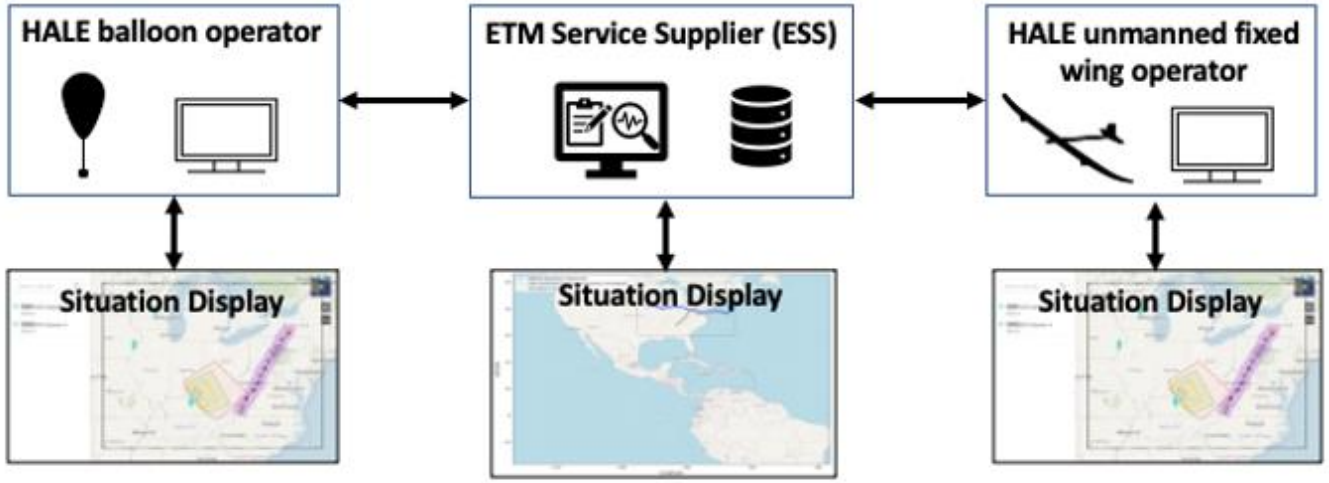


1) Scenario
2) Simulation engine
3) Inflight CSM
4) Visualization
5) Data collection and analytics

1



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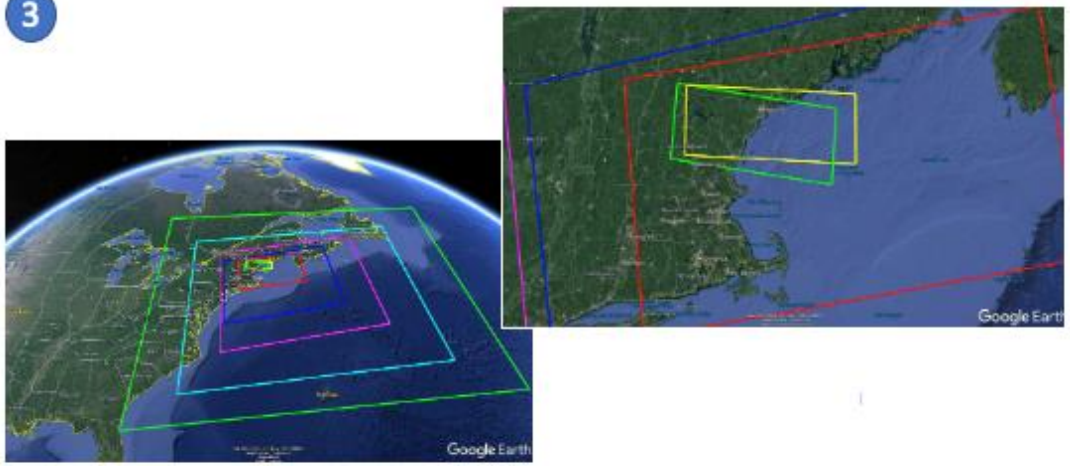

2

Pre-decisional

Aircraft	Emergencies	Requests	Special Operations	Weather	Separation	Conformance
Aircraft ID (unique ID generation capability)	Type of emergency	Pilot-In-Control (PIC)/ Remote - Pilot-In -Control (RPIC) requests	Type of special operation (e.g., military operations, temporary flight restriction)	Affected airspace area	Amount of separation between aircraft/objects (proximity monitoring tool)	Amount of deviation from flight intent (lateral and vertical, alert when vehicle fly below FL600)
Current Route (position, heading, aircraft turn rate, altitude, climb/descent rate, ground speed)	Fuel on board	Reason for request	Begin and end time of operation	Affected altitudes	Deviation between separation and prescribed limits	Time until aircraft reaches assigned altitude, speed, heading with visual support
Flight intents (continuously update and alert when update is not received)	Malfunction		Projected duration of mission	Wind speed and direction (current and predicted)	Number of aircraft on the airspace	
Aircraft capabilities (maximum turn rate, climb/descent rate, cruising speed, maximum and minimum speed)	Number of human beings on board		Area and altitude of operations	Temperatures	Conflict alerts based on 4-D intersection of flight intent shared	
Equipment on board						
Aircraft type						
Aircraft status (Cruise, landing, launching)						
(IFR vs Cooperative operations participants)						
Communication (contact, frequency)						
Indication of responsible ESS and ETM operator						
Aircraft priority (special conditions, equipment malfunctions, emergencies)						
Altimeter setting						

List of information to be displayed and shared to support the Cooperative Operations

Announcement

Pre-decisional

Pre-decisional

Wrap up

Pre-decisional

Questions?

jeffrey.r.homola@nasa.gov
jaewoo.jung@nasa.gov