Discovery Synchronization Service (DSS) for UAM
Technical Interchange Meeting (TIM)
ATM-X Urban Air Mobility (UAM) Airspace Subproject
August 24, 2022

Agenda

- Welcome and introduction
- X4 overview
- DSS background
- X4 technical findings
- UAM conceptual needs for data sharing and access
- Discussion and polling

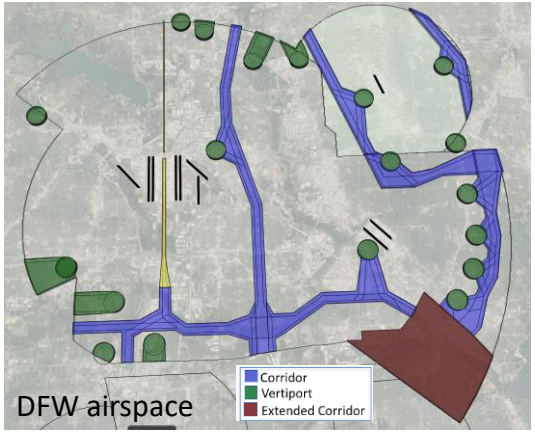
Introduction

- NASA completed the X4 Strategic Conflict Management (SCM) simulation
  - R&D effort with National Campaign (NC) Industry partners
  - Focus on Strategic Conflict Management automation software
- Applied DSS v3.17 as part of the simulated architecture
  - Sharing lessons learned with you today
- Leads us to ask: "What is the solution to facilitating data sharing and access for UAM?“
  - Not expecting answers today
  - Looking for input, dialogue, and to inform the community of upcoming R&D

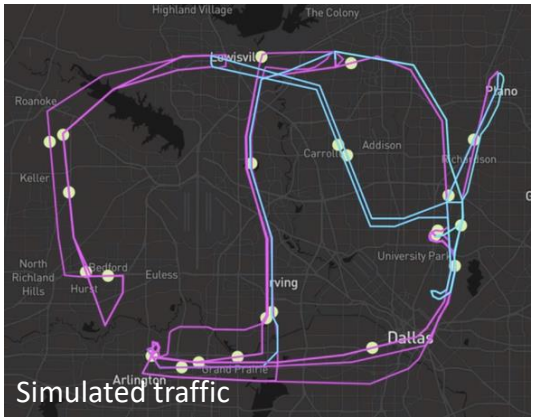
X4 OVERVIEW

X4 Overview

- Two primary objectives
  - Research and develop strategic conflict management automation
  - Prepare airspace partners for NC-1 flight test
- Target UML-2 and UML-3
- New UAM capabilities tested in a UTM-inspired architecture
  - Introduced demand-capacity balancing (DCB) and trajectory-based operational intent
  - Notional UAM architecture, specified in FAA ConOps v1.0, was the starting point
- No human participants



DFW airspace



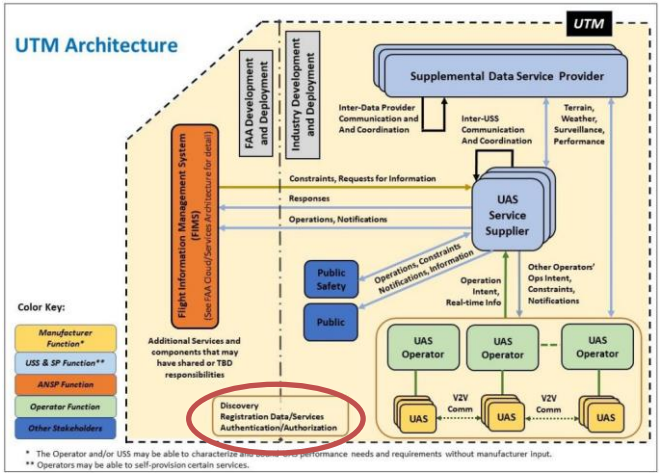
Simulated traffic

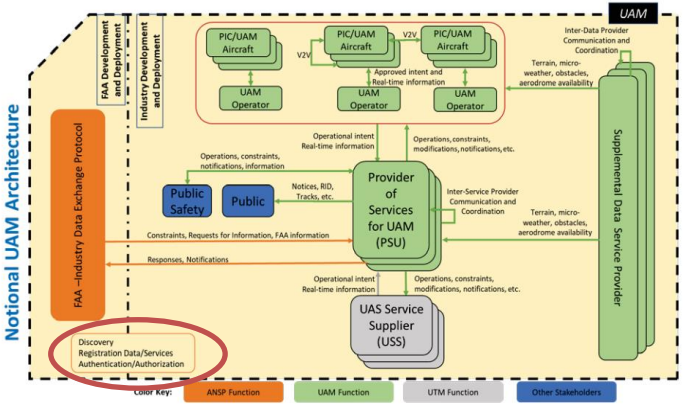
DSS BACKGROUND

Discovery in the UTM Architecture

- "Discovery" is part of the UTM-inspired architecture for UAM

- UAS Service Suppliers (USS) need to:
  - **Discover** each other in the relevant area of operation
  - Ensure **synchronization** of operational information used by each USS





Discovery and Synchronization Service (DSS)

DSS is an open-source implementation to meet certain ASTM standards for UTM

- Remote ID, USS interoperability specifications
- InterUSS (Linux Foundation project) considers interoperability for all potential implementers of DSS

UTM capabilities enabled by the DSS implementation:

1. Discovery: Allows USS to identify relevant (required) information that may be owned by another USS
2. Synchronization: Ensures information is consistent across each USS
3. Strategic Deconfliction Detection: Detects intersecting *operational volumes*

***Operational Volumes**: 4D shapes with specified ceilings and floors that encompass the sUAS operation's flight profile within an area of operation*

How DSS Works in UTM

UTM Operator needs to deconflict operations with others in the airspace

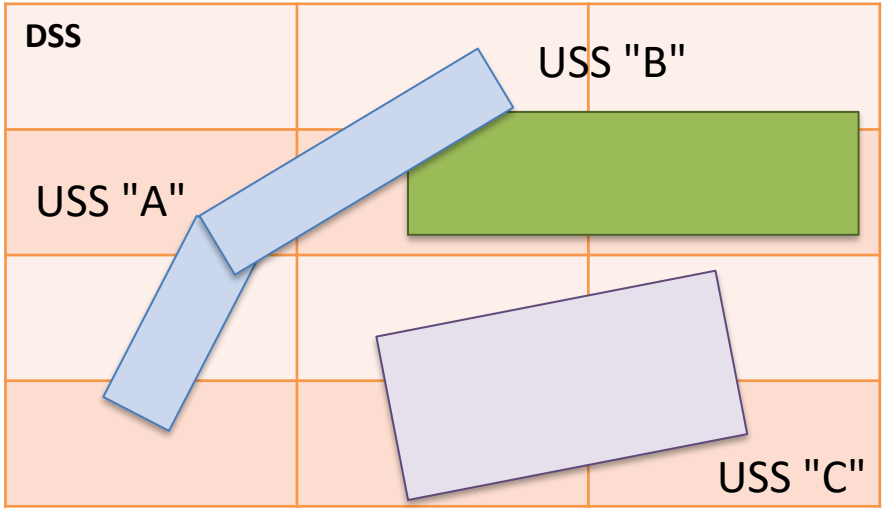
The Operator's USS only knows about its own operations, but can request information from another USS

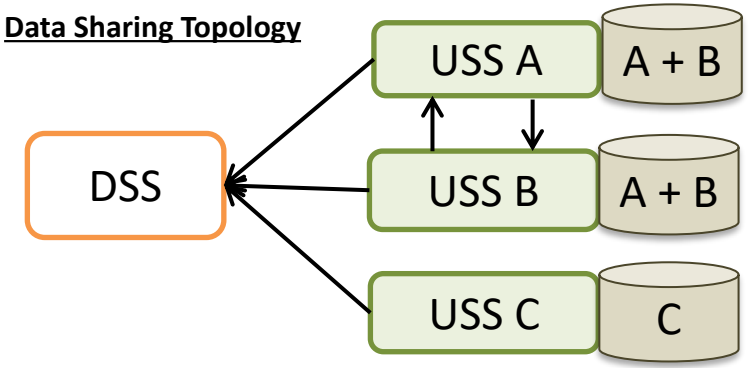
DSS informs the Operator's USS which other USS might have operations in the area

Operator's USS then requests potentially conflicting operational volumes from other USS

Operator then determines a deconflicted volume for based on information received, and updates the DSS

New operational volume is now accepted, and available for discovery

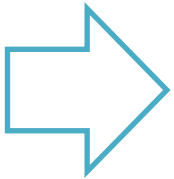




APPLICATION TO X4 SIMULATION

X4 Operational Context

- Initial operations - no significant regulatory changes to the NAS, operating under VFR and IFR
- UAM operates in an integrated ATM environment, including controlled airspace
- New infrastructure for UAM including shared resources among operators



- Focus on Strategic Conflict Management
- Design airspace structures (routes) for UAM
- Sharing trajectory-based operational intent for predictability in the ATM environment
- Coordination of strategic plans with other operators at shared resources via DCB

Demand-Capacity Balancing (DCB) for UAM

- **Demand Capacity Balancing for the NAS**: 'Strategic evaluation of system-wide traffic flows and aerodrome capacities to allow airspace users to determine when, where and how they operate, while mitigating conflicting needs for airspace and aerodrome capacity'
- For UAM, operators need to coordinate on use of shared resources (e.g., vertiports, airspace routes) as these resources have capacity limits
- For UAM operating under VFR:
  - Strategic plans should be coordinated among UAM operators to not overload the shared resources
  - Coordination does not mean perfectly time slots for each operation but such that the pilot can handle the uncertainty
- For UAM operating under IFR:
  - Strategic plans may still be responsibility of the UAM operator, but ATM may play a role

X4 Demand-Capacity Balancing (DCB) 4-Step Process

Introduced demand-capacity balancing with simplified assumptions to explore required data exchanges with DSS and among PSUs

I. Identify Capacity

- Capacity constraints defined at **vertiports** by an authoritative source, available via defined API

II. Identify Demand

- Identify relevant demand (PSU submitted operational plans) at **vertiports**

DSS

III. Identify Demand/Capacity Imbalance

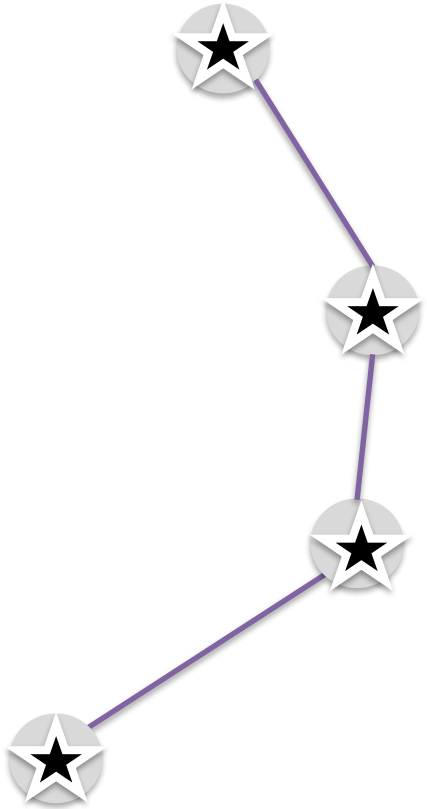
- Compare demand with capacity at **vertiports** to identify imbalance

IV. Resolve Imbalance

- Update operational plans to resolve identified imbalance

X4 Operational Plans

- Introduced trajectory-based operational intents to enable strategic conflict management
  - More precise predictions enable efficient airspace management and increase solution space for DCB
- ***X4 operational plan*** is a 4D-trajectory (4DT) specifying the sequence of waypoints to follow, and each waypoint is 3D position at a given time
  - Latitude, longitude, altitude, time
  - Vertiports are required waypoints
- PSU shares 4DT operational plans with other PSUs via defined Application Programming Interface (API)



How DSS Works with X4 DCB

UAM Operator needs to deconflict operations with others in the airspace

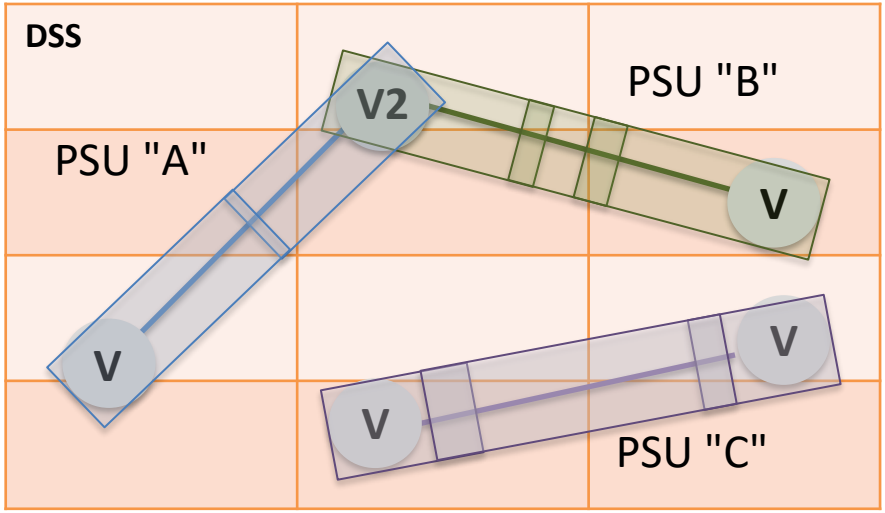
The Operator's PSU only knows about its own operations, but can request information from another PSU

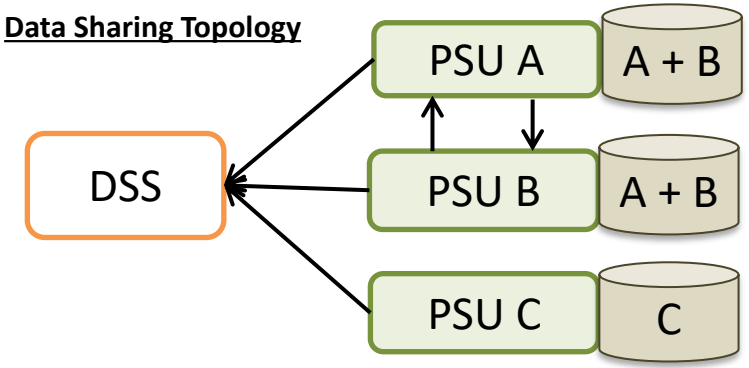
DSS informs the Operator's PSU which other PSU might have operations in the area

Operator's PSU then requests operational plans that potentially share DCB resources from other PSU

Operator then determines a new operational plan for based on information received, updates the DSS

New operational volume is now accepted, and available for discovery

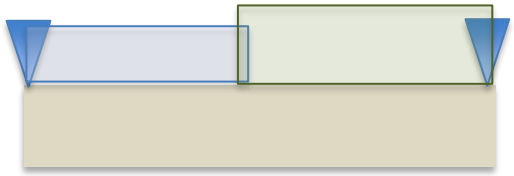




X4 TECHNICAL FINDINGS: HIGHLIGHTS

1. Discovery of relevant demand leads to intricate operational volume requirements

- For demand discovery using DSS, needs operational volume, not trajectory
- PSU creates operational volumes around the trajectory
- Leads to intricate requirements for operational volumes to sufficiently cover relevant demand (see example)
- Begs the question whether operational volumes and grid adaptation of current DSS are appropriate for UAM
  - Resources are known and defined
  - Adaptation could consist of "nodes" or "points" to present resources



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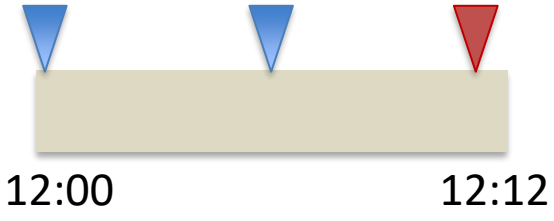
Vertiport "V2"

*For example, if capacity defined as: 2 operations per 12-minute at vertiports, these would be the **minimum** requirements:*

- *an operational volume covering each shared resource (one for arrival and one for departure vertiport)*
- *operational volume at shared resource include +/- half time bin around the ETA at the shared resource*

2. DCB requires history of past operations not retained by DSS

- DSS does not retain deleted operations.
- In X4, PSU need to work around it and store operations that are deleted from DSS
- DSS does not distinguish "completed" and "cancelled" operations
  - “completed” means the operation would be counted towards the time slot
  - “cancelled” means the time slot would be released for others



Capacity: 2 ops / 12-minute
1. 2 operations scheduled (time bin is full)
2. 1st operation completed, removed from DSS
3. Other later operation (red) could schedule within that time bin

3. DSS and PSU network need to be robust

- Single ‘PSU down’ failure impacted the entire PSU Network
  - a single PSU posted an operation to DSS but crashed before notifying to other PSUs
  - other PSUs continued to query that PSU, could not submit any operational plans due to missing information about the PSU's operational plans.
- Unreachable PSU network when DSS is down
  - when DSS was down, the PSU Network was unreachable.
- Need a robust system that is fault tolerant
  - consider system robustness requirements for future designs of DSS

UAM CONCEPTUAL NEEDS FOR DATA SHARING AND ACCESS

Looking beyond X4...

While some of these issues discovered during X4 could be fixed by slight modifications in the DSS specification, the data sharing needs for UAM will be very different from UTM

... more system actors
... more data
etc.

Need for a more a generalized solution that can support UAM requirements

UAM Cooperative Airspace Management

UAM airspace management will be cooperative:

- PIC, UAM Operator, PSU, Vertiport Operator, and ATC ('UAM system actors') make cooperative decisions in a distributed fashion

- UAM operating under VFR:
  - **PSU or UAM Operator** provides strategic conflict mgmt capabilities to improve orderly flow of UAM traffic
  - **Vertiport Operator** coordinates with **UAM Operator or PSU** on vertiport resources and arrival / departure
  - Vehicle onboard guidance may assist **PIC** in meeting their see-and-avoid responsibilities

- UAM operating under IFR:
  - **ATC** applies strategic conflict management to traditional airspace users
  - **PSU or UAM Operator** provides strategic conflict management capabilities that must be interoperable with **ATC**
  - **ATC** is the predetermined separator

Requires access to a common real-time model of the operating environment, tailored to each UAM system actor's needs

Common Operating Picture (COP)

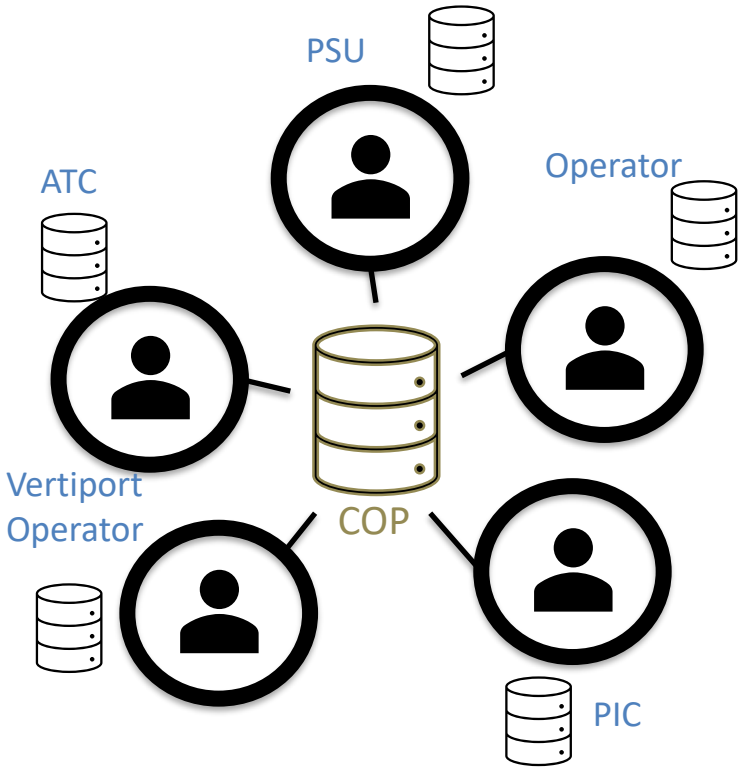
The Common Operating Picture (COP) exists when:

- relevant system actors each have access to their required data
- those data are guaranteed to be consistent, timely, and well-defined

Elements for establishing the COP:

- traffic intent and state
- NAS configuration (e.g., runway configuration, approach-in-use), dynamic hazards (e.g., special activity airspace)
- landing facility status
- shared resource capacity
- weather hazard, terrain, obstruction, wind and temperature predictions and measurements

Existing NAS infrastructure such as SWIM provide similar functionality and may be extended to meet some or all of the needs of the UAM Community.



DISCUSSION AND POLLING

CLOSING REMARKS

ATM-X UAM Subproject – Upcoming R&D

- UML-3 Cooperative Conflict Management Concept
  - Cooperative Conflict management address scalability through new ATM paradigms that distribute the responsibility for Conflict Management amongst cooperative actors
  - Relies on common situation awareness, common operating picture
  - UML-3 will be in IFR or VFR, with novel procedures enabling increased tempo

- Tactical Conflict Management (X5) Simulation
  - Strategic Conflict Management automation capabilities
  - Tactical Conflict Management automation capabilities
  - Interoperability tested through internal simulation and analysis

- UML-3 Operational Integration Assessment
  - Integrate cooperative conflict management automation from X5 into a high-TRL operational environment (FAA's WJHTC)
  - All system actors represented: Fleet Manager, UAM and non-UAM PIC, Vertiport Operator, ATC