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Examination of Urban Air Mobility Integration into the National Airspace System

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Presenter Information

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Background

Sponsored by the FAA under the FAA Center of Excellence for Unmanned Aircraft Systems (UAS), this project sought to identify the impact of UAM on the National Airspace System with respect to air traffic control, infrastructure, and operations.

Milestones:

- The research team examined published concepts of operations from the FAA, NASA, and industry with a focus on approaches UAM airspace integration, infrastructure enhancements, and new regulations, policies, and procedures.
- Based on the literature review, the team proposed an airspace concept to support UAM operations in the vicinity of Daytona Beach International Airport.
- Team constructed a simulation of the airspace concept with scenarios involving traditional crewed aircraft and UAM using the ERAU Tower Lab simulators.
- Experiments were conducted to assess the impact of UAM on workload and performance for local control (LC) and ground control (GC) ATC controllers.
- Through the development of the airspace concept and the experiments, the team provided a set of key findings and recommendations to the FAA.

Airspace Requirements

Communication, Navigation, Surveillance:

- Supports RNP 0.3 Operations.
- ADS-B In and Out.
- Mode C capability.
- Two-way voice communications.

Standard Vehicle Speeds

Flight Phase	Vertical Speed (fpm)	Horizontal speed (kt)
Approach / Departure	500	< 45 – 130 >
Cruise	N/A	130
Take-off	500	N/A
Landing	3.00	N/A
Stall	N/A	73

Approximate Separation Criteria

Separation	Vertical	Longitudinal	Lateral
UAM-Cargo/UAM	250 ft	250 ft	TBD
UAM-VFR	4000 ft	450 ft	¼ mile
UAM-IFR	1000 ft	2 miles	3 miles
UAM-AFR	500 ft	½ mile	*BOS

Corridor Width

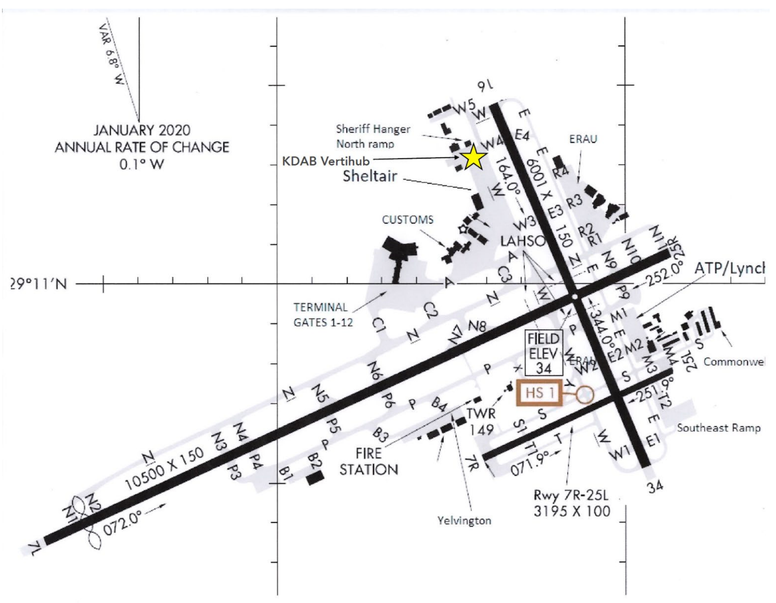
Corridor	RNP	Radius	One-way corridor	Two-way corridor
2xRNP	0.3	1,800 ft	3,600 ft	7,200 ft

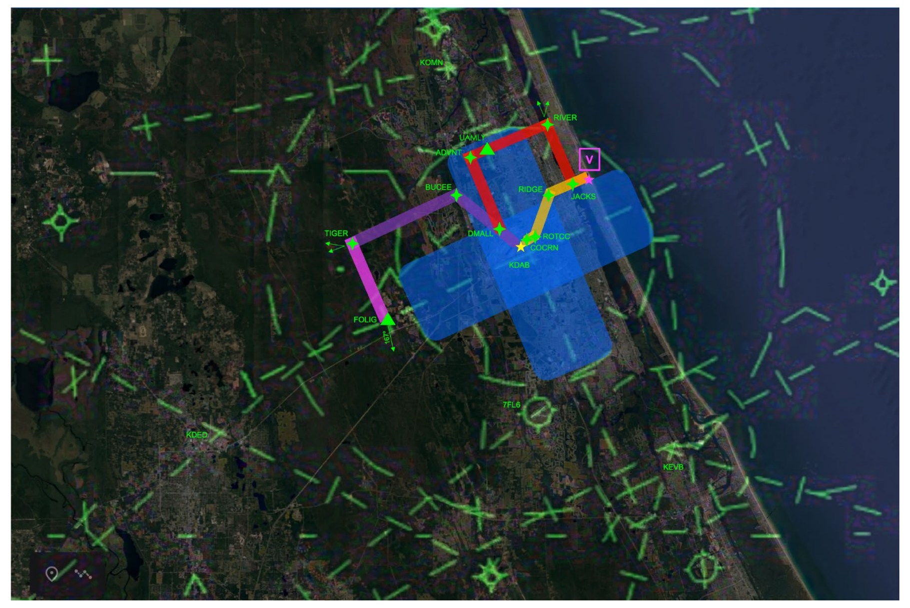
The FAA's Center of Excellence for UAS Research

ASSURE

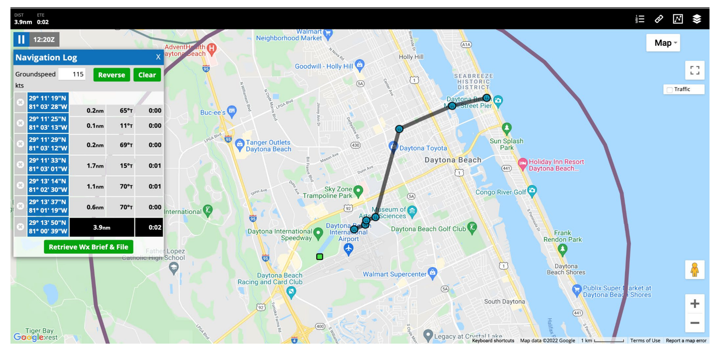
Alliance for System Safety of UAS through Research Excellence

Airspace Design

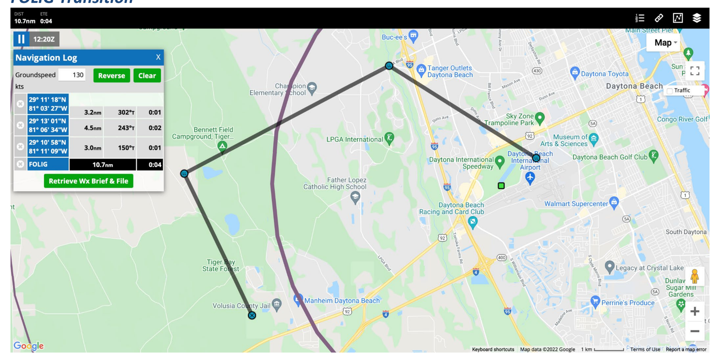




Riddle Transition



FOLIG Transition



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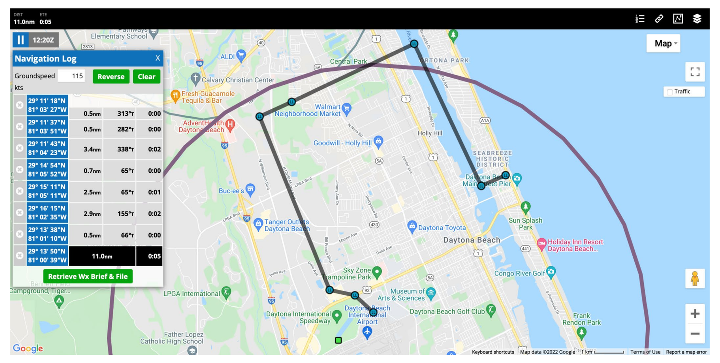

Experimental Design

Tower Lab Simulator

Two **ATC positions** were considered:

- Local Control (LC).
- Ground Control (GC).

Simulation:

- Pseudopilots to simulate ground and local airborne traffic.
- UAM traffic automated following route waypoints.
- UAM clearance only required when traversing within the airport's class C airspace.
- UAM cab coordinator serves coordinates between UAM and ATC.

Metrics:

- Workload – NASA TLX Survey
- Performance – adapted from evaluation form used in Tower Lab checking performance in traditional ATC duties as well as coordination with the UAM Cab Coordinator.

Experiments:

Run 1 and 2– Baseline – No UAM traffic

- Participants will be assigned to the Local Control (LC) and Ground Control (GC) positions
- Swap at mid-point of experiment (15 minutes each)

Runs 3 and 4 – UAM Traffic Included

- Participants are assigned LC or GC position for run 3.
- Participants swap positions for run 4.
- TLX survey given after each run
- 30 minutes per run

Impact on Controllers

NASA TLX Workload Survey Scores

Participant No.	GC No UAM	LC No UAM	GC With UAM	LC With UAM
1	24.0	44.3	40.7	52.3
2	35.3	63.7	24.3	48.7
3	5.7	8.7	3.7	12.0
4	82.7	78.7	77.7	73.7
5	75.3	62.3	65.0	71.7
6	10.7	24.7	12.7	32.3
7	51.7	63.0	59.7	71.3
8	16.7	34.3	48.3	64.7
9	57.0	64.7	57.0	77.7
10	58.3	57.7	62.3	55.3
Mean	41.7	50.2	45.1	56.0
StdDev	25.8	20.6	23.1	19.8

ATC Performance Scores

Participant No.	GC No UAM	LC No UAM	GC With UAM	LC With UAM
1	95	97	90	90
2	100	90	90	90
3	97	98	90	96
4	98	100	88	80
5	95	96	87	95
6	100	99	100	99
7	100	100	84	100
8	100	98	94	94
9	100	100	95	96
10	100	98	95	97
Mean	**98.5**	**97.6**	**91.3**	**93.7**
StdDev	2.0	2.8	4.5	5.5

Statical Analysis using Wilcoxon Signed-Rank Test showed:

- When UAM are present, the workload of the local controllers were statistically higher than ground controllers.
- For both ground and local control, the presence of UAM caused a statistically significant decrease in performance than when UAM are not present.

Key Findings

- Several UAM CONOPs exist with significant differences.
- Experiments showed an impact to workload and performance further study needed.
- Helicopter routes can be leveraged for corridor design if available.
- Wake turbulence can be mitigated through route structure.
- Sources reported market maturation by 2030 or later 2030s.
- CNS requirements should include two-way radio, transponder, IFR capabilities for pilot and aircraft.
- Specifics of UAM corridor design, pattern, and operation would vary on an airport-by-airport basis, based on a team of SMEs, aviation professionals, and airport users.
- UAM corridors and on airport vertiports need to be designed with ATCT SME personnel input to mitigate a wide range of ATC issues surrounding an aerodrome, UAM operators, pilot groups, airport personnel, and other interested parties.
- Local ATCT SOPs will need adjustments based on the UAM corridors.
- Contingency situations present unique challenges as UAM may need to depart corridor.
- Vertiport design and planning must address community buy-in, space for vertiports, location, cost, number of aircraft to accommodate, and noise considerations.
- Future work should incorporate routes and procedures from city pairs (e.g., KDAB to KMCO).

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