Sharing Operational Intent with Containment Confidence Level for Negotiating Deconfliction in Upper Class E Airspace

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Community-based Cooperative Separation Management (CSM) is expected to provide separation services in Upper Class E airspace (near and above FL600). Under CSM, operators are responsible for maintaining separation. The CSM concept is enabled by sharing Operational Intent (OI) among the operators to ensure common situation awareness. The OI is represented as four-dimensional (time and space) information that indicates where an aircraft would be contained within the space and time, with a known level of confidence. However, each vehicle's ability to stay within its region of OI may differ based on each vehicle's performance characteristics, resulting in varying OI sizes among the vehicles. Such varying OI size could adversely affect efficient and fair access to the airspace. In this paper, an OI-generation algorithm under varying OI size restriction with Containment Confidence Level (CCL) is presented. High-Altitude Long Endurance (HALE) balloon operations are used as an example application. A framework is presented by which CCL information is used in the deconfliction process. A fast-time simulation experiment is conducted to evaluate the feasibility of the proposed framework. The simulation results show a reduced number of unnecessary deconfliction actions.

I. Introduction

Upper Class E airspace represents high altitude airspace at and above FL600 (or 60,000 ft in the United Sates). A wide range of new vehicles are anticipated to access the airspace more regularly with recent advancements in technologies [1]. However, current National (NAS) infrastructure and Air Traffic Management (ATM) services provide limited traffic management provisions for civil aircraft operations above 60,000 ft.

The FAA recently published the Upper Class E Traffic Management (ETM) Concept Operations (ConOps) v1.0 [1], documenting the foundational operating principles and vision for the ETM environment. In the document, it is indicated that the ETM environment creates opportunities for an alternative traffic management approach for ensuring safe and efficient operations, which must [1]:

- "*Scale beyond the 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, and/or available"*
- *"Promote shared situation awareness among Operators"*

A community-based Cooperative Traffic Management concept is being pursued to address the needs [1]. Within the Cooperative ETM context, civil operators would be responsible for coordinating, executing, and managing their operations within a regulatory framework, analogous to the Uncrewed Aircraft System Traffic Management (UTM) concept [2].

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In such environment, Cooperative Separation is supported by ETM operator cooperatively sharing Operational Intent (OI). OI is a type of information that is exchanged between operators that can be used to identify conflicts (i.e., an intersection of OIs) and coordinate deconfliction in the event of a conflict. It is four-dimensional (4D) (time and space) information that indicates, with a known level of confidence, where an aircraft will be contained within.

Although the general description of the OI and some attributes are discussed in the ConOps [1], there are several aspects of OI sharing that need to be comprehensively addressed and agreed among the ETM community for standardization, such as restricting the OI size. This paper, particularly, presents how Containment Confidence Level (CCL), i.e., one of the attributes of OI, can be computed under varying OI size restriction and utilized in the Cooperative Traffic Management environment.

The following is the list of the work that is included in this paper:

1) A method for generating OI for the High Altitude Long Endurance (HALE) balloon
2) An algorithm that generates OI while meeting the OI size restriction
3) A method for computing the known level of confidence, i.e., referred to as Containment Confidence Level (CCL) in this paper
4) A framework that shows how the CCL information could be used to decide which resolution action to be executed
5) The outcome of a feasibility evaluation of the method proposed for using the CCL using the simulation experiment

In this paper, the HALE balloon is used as an example case. The HALE balloon has no/limited maneuverability and thus may face the greater challenge of confidently adhering to the OIs than the vehicle with better maneuverability.

II. Background

The FAA ETM ConOps v1.0 states that “cooperative separation is achieved via shared intent, shared awareness, de-confliction of operations, conformance monitoring, technologies supporting de-confliction, and the establishment of procedural rules of the road (e.g., right-of-way rules) [1]."

The OI could be further characterized with the following additional attributes in the ETM environment:

- Each OI segment indicates the intended flight operating volume. Operating volumes are 4D airspace blocks with specific entry and exit times for the ETM vehicle.
- OI may be shared in the form of a sequence of 4D volume segments, representing full intended operations with uncertainty over the next *n* hours. The volume segments may overlay on each other.
- OI could be updated using a “rolling-window” approach [2]. The ETM vehicles with limited maneuverability could adhere to the OI confidently by updating their OI regularly. Also, the “rolling-window” approach enables some operators with extended missions (weeks to months) to update OI flexibly to support their operations.

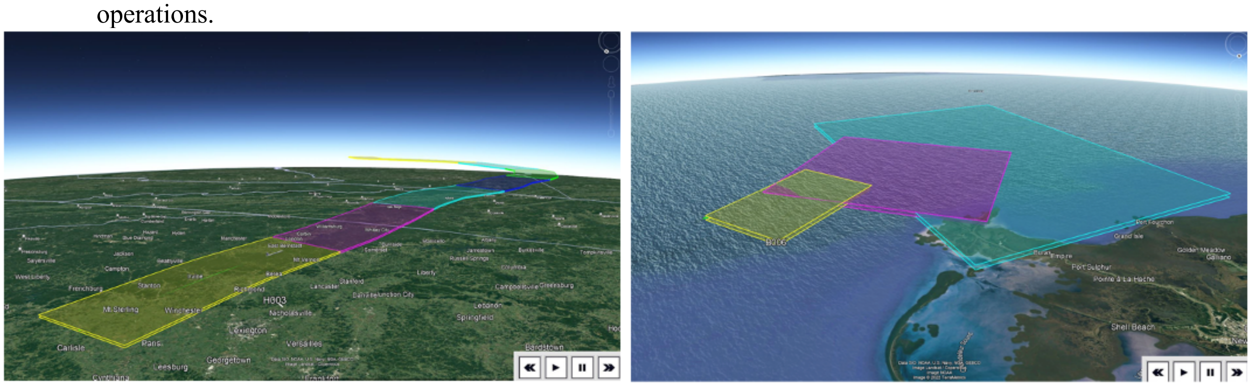

Figure 1: 4D OI examples: Each color-coded volume indicates a one-hour OI segment (e.g., yellow represents the OI segment from time 0 to 1 hour; magenta represents the OI segment for the second hour; light blue represents the OI segment for the third hour).

The OI volume shape and size may vary significantly based on the ETM vehicle type’s navigation performance (See figure 1). Most ETM vehicles (e.g., fixed-wing UAVs) with operating propulsion systems should be able to adhere to the predefined 4D flight path with sufficient buffer in vertical and lateral dimensions (Figure 1 left). However, vehicles with limited or no controllability (such as balloons) face challenges in flying along a predefined path. Recently, a sophisticated Artificial Intelligence (AI) based autonomous navigation system has been introduced. The method indirectly changes operating altitude to control its lateral movement by taking prevailing winds at different altitudes [3]. However, the controllability is still limited by available winds at different altitudes. Therefore, the HALE balloon operator may share their OI with a buffer that reflects the greater uncertainty associated with that type of operation, which could significantly increase over time (Figure 1 right).

The varying OI segment volume size, OI prediction horizon, and the associated CCL between ETM vehicle types may lead to inefficient and unfair airspace access, particularly if a "First-Reserved, First-Served" (FRFS) approach is adopted as the basis for the CSM in the ETM environment. One way to address the issue is by standardizing these elements. For example, the OI volume could be restricted by collaboratively determined restriction values among the community. In current-day operations, 120 nm separation distance is used for the supersonic aircraft to keep a safe distance from unknown objects in the Upper Class E airspace. The same value could be used initially, constraining the width and/or length of the OI segment for one-hour operations to be smaller than 120 nm. A recommendation of the optimal value for this constraint as well as more details about the OI attributes could be identified through a series of simulation research that NASA is planning to conduct.

III. Horizontal Operational Intent Generation for HALE Balloon

This section discusses the horizontal dimension of the OI generation for a HALE balloon, which represents the lateral extent of the HALE balloon's intended operating airspace with the specified entry and exit time. The HALE balloon has comparatively more controllability in the vertical dimension. Hence, the HALE balloon operator may maintain its desired altitude with less uncertainty and share it as part of the 4D OI. However, the HALE balloon has no propulsion system to control its lateral movement directly.

In this paper, the horizontal motion of the HALE balloon is assumed to be identical to that of the ambient wind surrounding it [4, 5]. In an Earth-bound coordinate system, the horizontal movement in latitude and longitude direction, mainly dictated by the drift due to wind, could be described as [5]:

$$\frac{dlatitude}{dtime} = -\omega(altitude)\cos[\phi(altitude)]$$

$$\frac{dlongitude}{dtime} = -\omega(altitude)\sin[\phi(altitude)]$$

In the equation above, $\omega(altitude)$ and $\phi(altitude)$ represent the speed and direction of the wind at a given altitude, respectively.

Multiple wind forecast data models could be used to predict the horizontal movement of the HALE balloon. For example, National Oceanic and Atmospheric Administration (NOAA)'s Global Forecast System (GFS) provides wind forecast data in the stratosphere for up to 16 days [6]. The GFS model produces forecasts in a grid of points. Therefore, wind forecast at any point could be interpolated from the nearest grid points.

However, there are limitations in generating an accurate prediction of the HALE balloon's horizontal movement using such a wind forecast product. The horizontal resolution of the model is typically 18 miles (28 kilometers) between the grid points [6]. Moreover, the forecast product is only available every 3 hours for sparsely dispersed altitude levels, while the HALE balloon's AI-based autonomous navigation system may frequently change operating altitudes to take advantage of prevailing winds. Hence, short-term wind prediction for the airspace region in the stratosphere could be significantly different from actual wind measures [3], resulting in less accurate prediction of its short-term horizontal movement.

Given such limitations, a simple approach is proposed for predicting the future locations of a HALE balloon. It is assumed that the actual wind information is regularly collected and available via onboard measures like radiosondes (battery-powered telemetry instrument package) for the HALE balloon. Using actual heading and wind speed collected, a possible path that the balloon could take is computed using a random-walk algorithm. At every one-minute step, the magnitude of changes in heading (°) and speed (m/s) from the previous step's latitude-longitude position is computed by drawing independent random values from a distribution derived from historical data [7]. Next, a Monte Carlo method is used to generate possible paths [2]. Those generated paths are encapsulated using a minimum bounding algorithm. Then, the computed minimum required airspace can be shared to indicate the horizontal component of the OI segment.

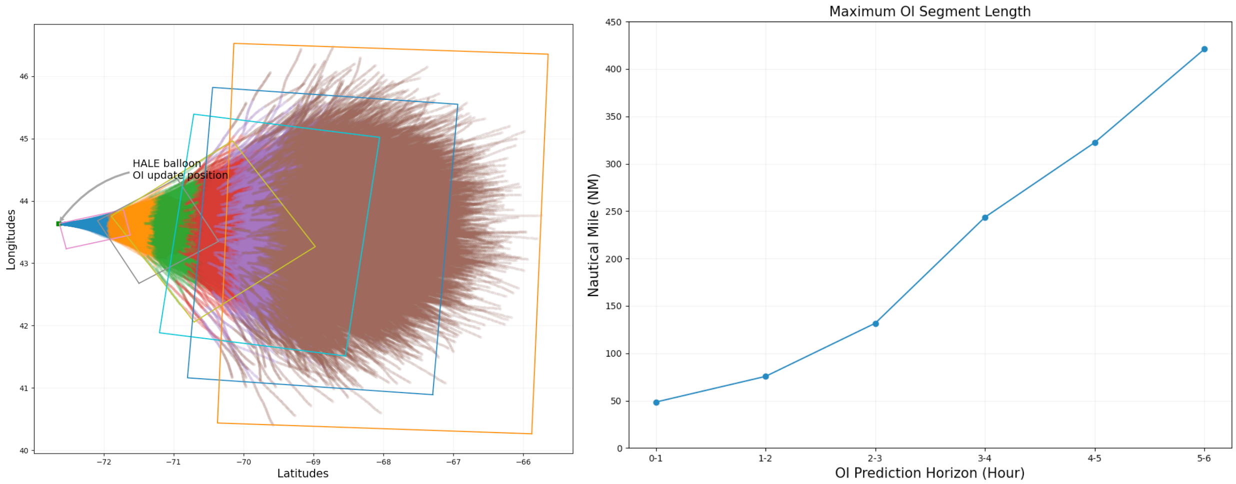

Figure 2. An example of 2-D OI polygon with four vertices bounding 10,000 possible paths calculated using the random walk approach

Figure 2 (left) depicts an example of OI generation for the HALE balloon. The vehicle is flying at 18.6 m/s on a heading of 93° from the north (clockwise). Ten thousand candidate paths are computed using the Monte Carlo method and bounded by convex polygons. The number of vertices was limited to be only four in this example. At each one-minute step, the independent values are drawn from the normal distributions, $N(0, 1.3)$ and $N(0, 0.2)$, to compute the heading and speed deviation, respectively. Finally, the OI is generated based on the projected paths for the next six hours, which are bounded by the polygon at the one-hour interval. Figure 2 (right) shows how the maximum length of each OI segment grew over the OI prediction time horizon.

A larger number of vertices of the OI boundary could more tightly approximate the future locations, as shown in Figure 3. The HALE balloon's paths are projected for the next six hours and segmented by every one-hour interval with the OI boundary.

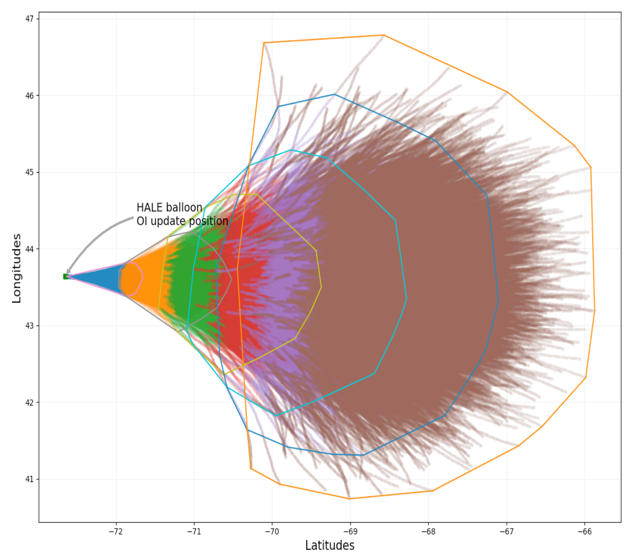

Figure 3. An example of 2-D OI polygon with eight vertices bounding 10,000 possible paths calculated using the random walk approach

Additional lateral buffer on the OI boundary in the horizontal dimension could ensure safety. Moreover, the HALE balloon operator may update OI via the "rolling-window" approach to provide the most accurate OI.

IV. Horizontal Operational Intent Generation with Size restriction

One common problem of OI prediction is that uncertainty increases over the lookahead time horizon. Such an increase in uncertainty could negatively affect the efficiency and fairness of airspace access. One way to overcome such an issue is by introducing an OI size restriction, which could be collaboratively determined by the ETM community.

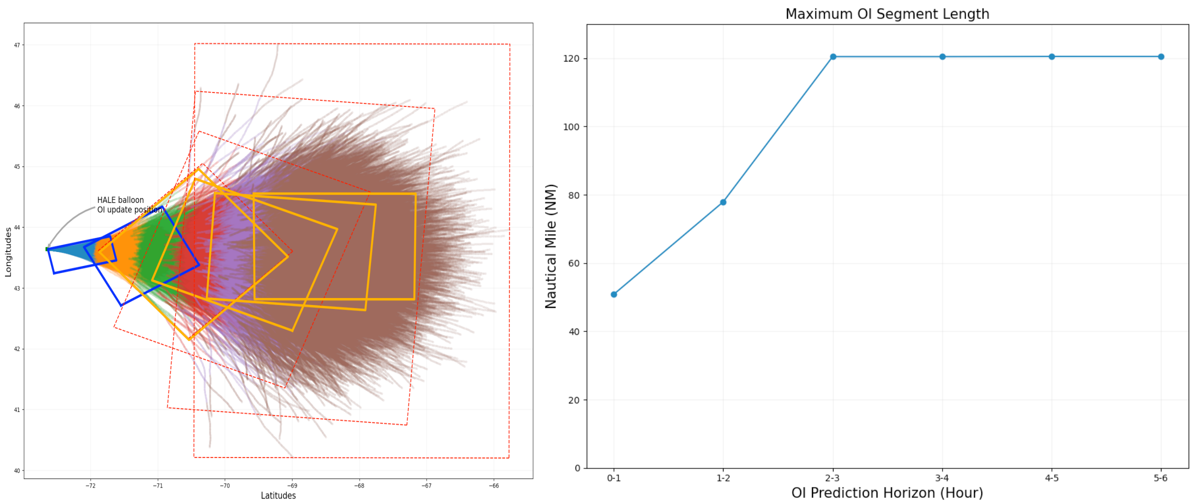

Figure 4. An example of OI generation with 120 nm size restriction

Figure 4 (left) shows the OI that meets a 120-nm size restriction. The size restriction logic first computes length of all sides of each OI segment, then checks whether the OI side with the maximum length exceeds the size restriction value. Again, the HALE balloon flies at 18.6 m/s on a heading of 93° from the north (clockwise) in this example. The algorithm first identifies the centroids for each OI segment without the size restriction. Next, the OI that meets the 120-nm size restriction is drawn, given the projected heading angle of the HALE balloon for each OI segment. This approach could capture a greater number of projected paths. In the figure, blue polygons represent the original OI polygon that meets the size restriction. The dotted red line indicates OI boundaries at different prediction horizons, where orange OI boundaries represent the OI that meets the OI size restriction. Figure 4 (right) shows the size of each OI segment that did not exceed the 120-nm size restriction.

V. Containment Confidence Level Computation

The CCL indicates the level of confidence that an aircraft would be contained within the OI boundary. This CCL could be represented by any value between 0 to 1, in which 1 represents complete certainty and 0 represents no confidence. The ETM operator's ability to control the vehicle to stay safely within the OI boundary is inversely related to the size of the OI. If the OI size is very large, it becomes easier to stay. However, if the size is small, it is tougher to adhere to the intent. Therefore, imposing the OI size restriction could adversely impact the CCL, but it could provide fairer access to the airspace.

In this paper, the CCL is defined as the likelihood of the vehicle staying within the OI segment. Such likelihood can be computed based on the ratio between all possible predicted paths vs. the total number of paths that exit the OI boundary. The CCL is calculated as follows:

$$Containment\ Confidence\ Level\ =\ 1\ -\ (likelihood\ that\ an\ ETM\ vehicle\ exits\ OI\ boundary)$$

Figure 5 shows an example of how CCL varies as a function of different size restriction values (60, 90, 120 and 150 nm) at one-hour intervals using the HALE balloon. CCL for the HALE balloon was calculated at initial speeds of 5, 10, 15 and 20 m/s. The CCL was computed for the six-hour OI prediction horizon. Ten thousand paths were generated to compute the OI at one-hour intervals with the size restriction.

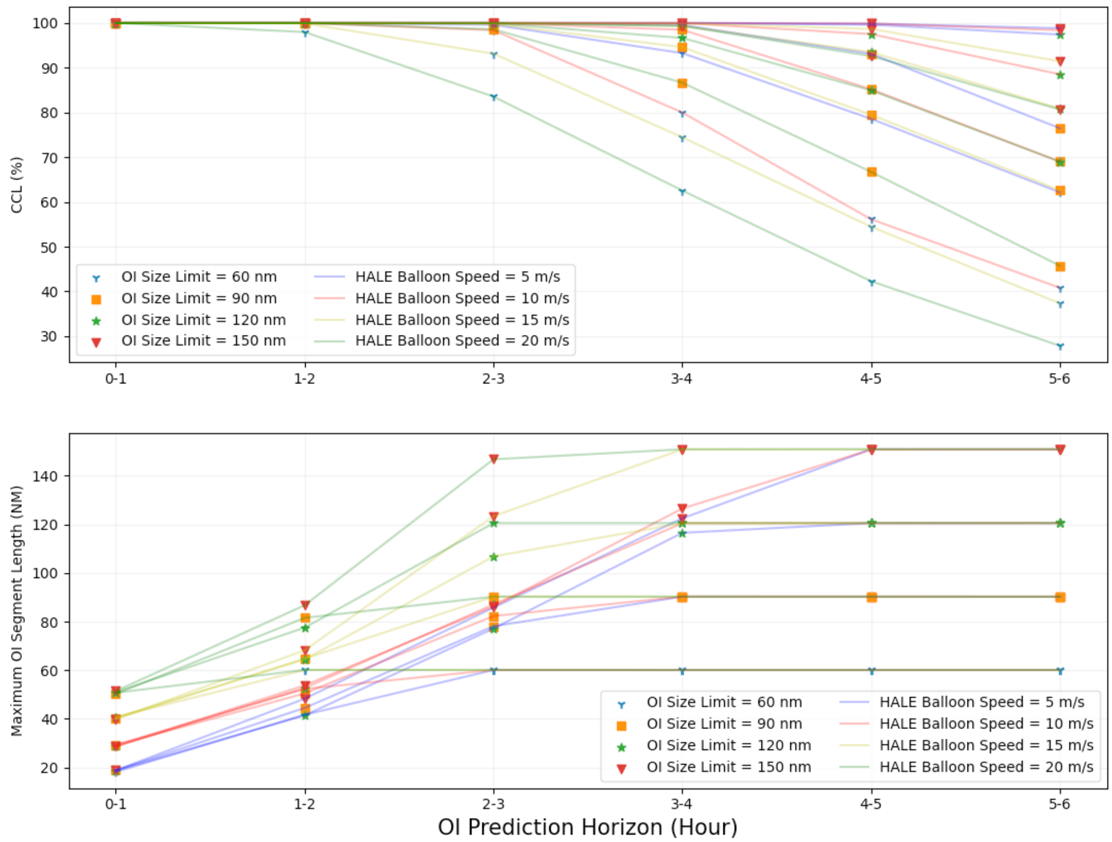

Figure 5. Impact of different OI size restrictions (60, 90, 120 and 150 nm) on the CCL under varying initial balloon speeds (5, 10, 15 and 20 m/s)

In Figure 5, it can be observed that the OI size restriction and the initial speed of the HALE balloon at the time of the OI generation both have significant impacts on the CCL. When the OI size limit is greater than 120 and 150 nm, the CCL is above 99% for all HALE balloon speed conditions up to the three-hour lookahead time (see Figure 6). A small OI size restriction could be recommended if the ambient wind speed is low. When the OI size is restricted by 60 nm, the likelihood that the vehicle leaves the OI boundary quickly increases over the lookahead time.

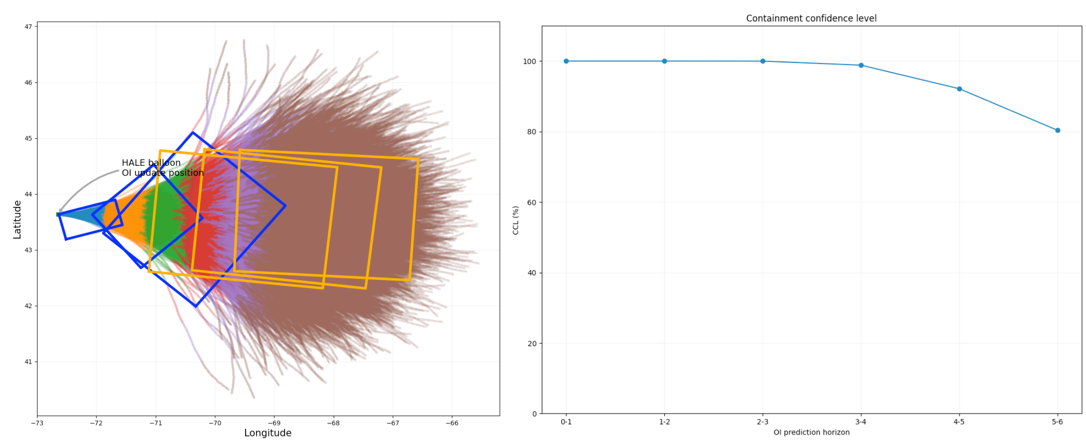

Figure 6. An example OI generation with 150-nm size restriction and CCL values at different lookahead times with an initial balloon speed of 20 m/s

A small OI size restriction is recommended if the ambient wind speed is low. When the OI size is restricted by 60 nm, the likelihood that the vehicle leaves the OI is higher. Figure 7 shows an example case of generating an OI subject to a 60-nm length and width restriction, when the HALE balloon's initial speed is 20 m/s.

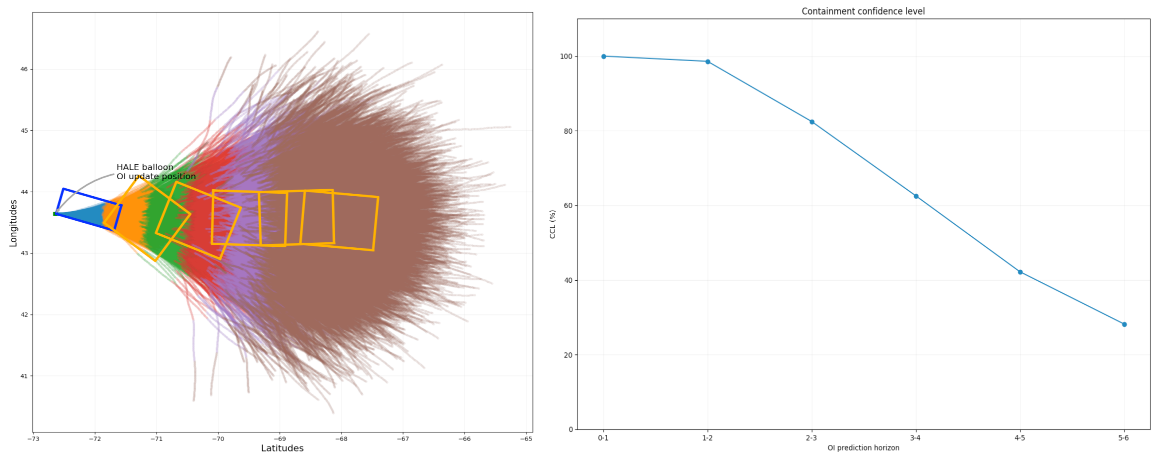

Figure 7. An example OI generation with 60 nm size restriction and the CCL values at different lookahead time with 20 m/s balloon speed

VI. Containment Confidence Level for Conflict Resolution

In an ETM environment, conflict is defined as an event where two or more OI volumes intersect in both space and time [2]. Thus, a conflict may be identified even though the intersecting OIs have low CCL values, resulting in unnecessary resolution actions to be taken.

Pre-coordination between ETM operators could avoid such unnecessary resolution actions. Consider the example illustrated in Figure 8, where two vehicles' OIs intersect. The CCL of Vehicle A's OI segment at the intersection is low. Therefore, a "wait-'n'-watch" approach could be performed. The ETM operator may choose to monitor the situation instead of revising the OI that may disrupt the operations. Figure 8 shows the schematic view of three use cases that shows how the "wait-'n'-watch" could be performed for a pair of ETM vehicles in conflict. In Figure 8, the blue polygons represent the OI of Vehicle A, and the green polygons represent the OI of Vehicle B. In the first case, an intersection of the OIs is identified, but the CCL of Vehicle A's OI segment at the intersection is less than the pre-agreed threshold value. Hence, the vehicle operators can perform a "wait-'n'-watch" approach and monitor how the operation progresses with the regular OI updates via the "rolling-window" approach that includes newly computed CCL.

In the second case, an intersection of OIs is detected when both vehicles have a high CCL value above the pre-agreed threshold. In this case, an appropriate resolution action needs to be executed to deconflict their OIs instead of performing the "wait-'n'-watch."

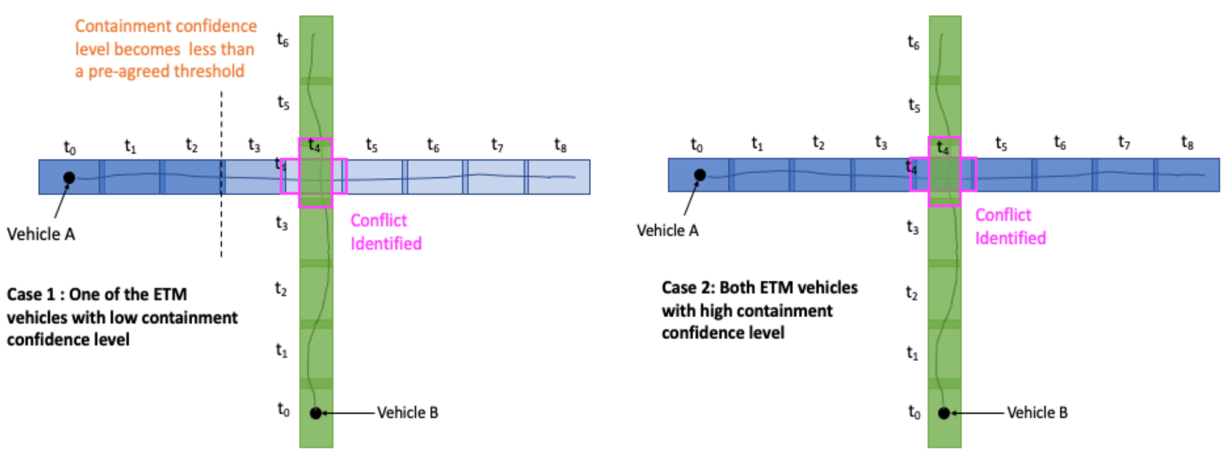

Figure 8. Illustration of inflight conflict use cases between vehicle A and vehicle B with varying containment confidence levels. Lighter shades indicate lower containment confidence levels

VII. Simulation Experiment

A scenario-based simulation approach was used to assess the feasibility of implementing the framework introduced in this paper. This section describes the experiment design, method, and results. The benefit of CCL as a part of OI is assessed. The number of conflicts detected is the key metric for the assessment.

A. Method

This section describes the experiment design, scenario, and simulation apparatus.

B.1. Experiment Design

Three experimental conditions were evaluated using a realistic traffic scenario. The scenario contains eleven ETM vehicles, consisting of four HALE fixed-wing aircraft and seven HALE balloons in the Upper Class E airspace.

- Condition A - No OI size restriction: the ETM operators share their OIs with no size restriction. Both HALE fixed-wing aircraft and HALE balloon share their OIs for up to eight hours.
- Condition B – With OI size restriction: the ETM operators share OIs, but the size of the OIs is constrained by the size restriction (90, 120, and 150 nm). Hence, any OI segment horizontal dimension exceeding the size restriction is not accepted and truncated.
- Condition C – CCL with OI size restriction: the ETM operators share OIs while conforming to the OI size restriction. The CCL value associated with each OI segment is computed and shared. If one or both of the intersecting OIs' CCL values are less than a threshold value (75%, 85% or 95%), the ETM operator may perform a "wait-'n'-watch."

B.2. Scenarios

Figure 9 shows the traffic scenario used for the simulation. There are a total seven HALE balloons (B001, B002, B003, B004, B005, B006, and B007) operating and four HALE fixed-wing Uncrewed Aerial Vehicles (UAVs) (H001, H002, H003, and H004).

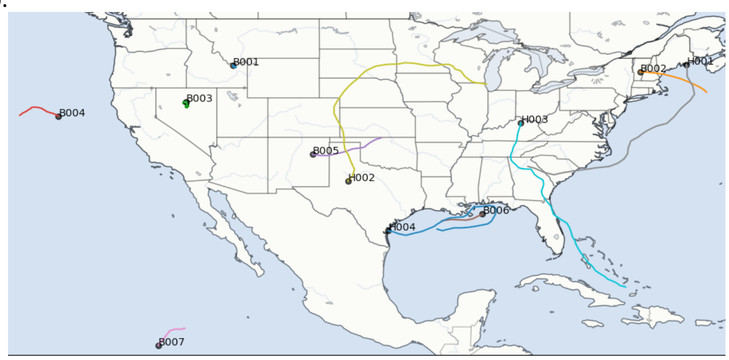

Figure 9: The simulated traffic setup

Table 1 summarizes the general assumptions for the scenario.

Table 1: General Assumptions

Element	Assumption
Airspace	• Upper Class E airspace (near and above FL600)
Air Traffic Controller (ATC)	• ATC is not providing separation services for ETM vehicles operating in Upper Class E airspace (near and above FL600)
Airspace Constraint	• No airspace constraints currently present in the Upper Class E airspace. • No convective activity
ETM operator	• All ETM vehicles operating in the ETM environment are participating in the CSM operations, cooperatively sharing OI and being responsible for keeping their vehicles separated
Operational Intent (OI)	• OIs are updated via the rolling-window approach • Number of vertices per OI segment is limited to four for computational efficiency • HALE fixed-wing UAVs have 99% confidence in their OI, given their ability to maneuver these vehicles • HALE balloon has no propulsion system. Hence, surrounding winds dictate their lateral movement
Pre-agreed resolution method	• When a conflict is detected, one of the ETM operators needs to revise OI based on pre-agreed-upon rules governing which aircraft is burdened with that responsibility • ETM operators may make a pre-arrangement that allows them to perform "wait-'n'-watch" if one or both operators' intersecting OI segment's CCL value is less than a threshold value

At the start of the simulation, all the vehicles are already operating in the ETM airspace. The traffic scenario is developed based on the inputs from the stakeholders and on the historical data [7]. The duration of the simulated traffic scenario was about 12 hours, where it only took a couple of minutes to simulate the whole traffic scenario in the fast-time simulation environment that runs in Python [2, 8]. Figure 10 summarizes the HALE balloon performance in the scenario.

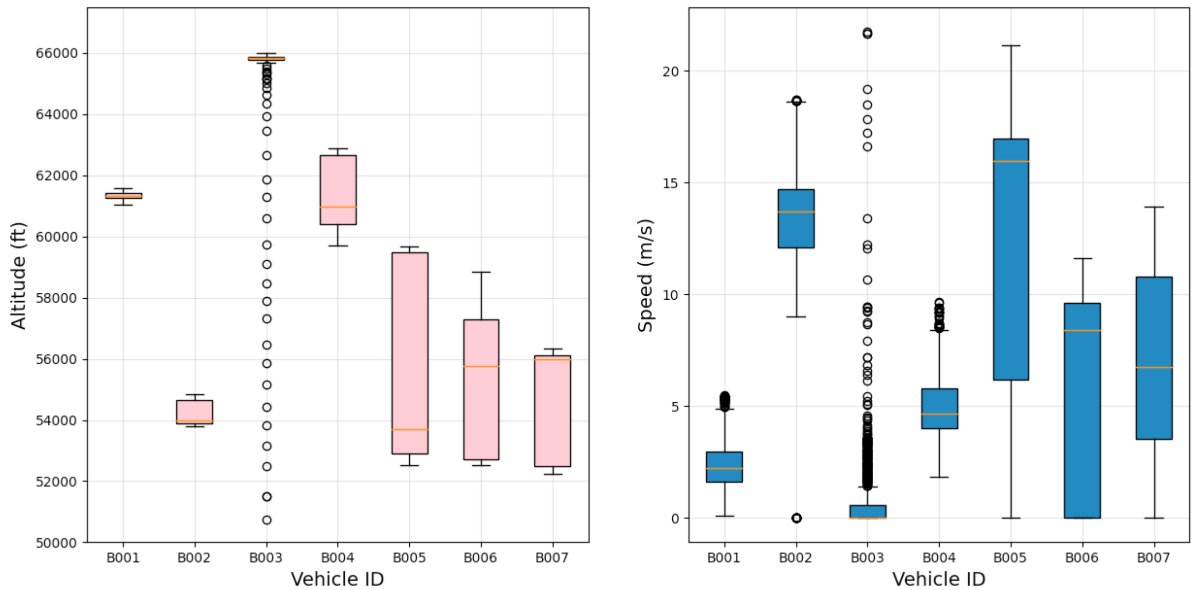

Figure 10. HALE balloon operations in the scenario (summary statistics of movement speed and operating altitudes)

OIs were generated for the HALE balloon using the Monte Carlo method described in this paper. A 3,000 ft vertical buffer above and below the operating altitude was added to the 2D OIs, which were generated at every 60-minute into the simulation run via the rolling-window approach.

Table 2 shows the target speeds of the HALE fixed-wing UAVs and the targeted operating altitudes used to generate OIs.

Table 2: HALE fixed wing UAV operations in the scenario (target speed and operating altitudes)

Vehicle ID	Target speed (kts)	Target altitude (ft)
H001	25	62000
H002	30	63000
H003	25	60500
H004	20	57000

OIs were generated for the HALE fixed-wing UAV based on the desired path with the intended flight speed specified in the scenario file. A 10-nm lateral buffer was added on both sides of the desired path. In addition, a 5-nm longitudinal buffer was added to the estimated entry and exit point of the OI to account for along-track error. An additional 500 ft vertical buffer was added above and below reflecting the HALE fixed-wing UAV's ability to better maintain the desired altitude.

B.3. Apparatus

A new simulation software, called ETMAutoSIM [2, 8] was developed for the study. ETMAutoSIM addresses the need to rapidly produce prototypes of the various concepts and ideas proposed by the FAA, NASA, and industry partners.

First, ETMAutoSIM processes the scenario file by interpolating the data (actual and intended latitude, longitude, altitude, heading and direction, and wind speed and heading) into uniform one-minute time steps and then writes the preprocessed file into an excel file. Second, it computes the OIs and the associated CCLs for all the vehicles in the scenario. Third, conflicts are checked at each time step. The results are logged and saved into JSON files. Finally, the files are sent to a front-end visualization tool named ETM viewer. ETM viewer reads the JSON files to visualize the situation display and ETM dashboard information.

Figure 11 shows a sequence of snapshots of B006 and H004 interaction as an example. As the simulation progresses, conflicts are identified and the intersecting OIs are highlighted. The 120-nm OI size restriction is also applied.

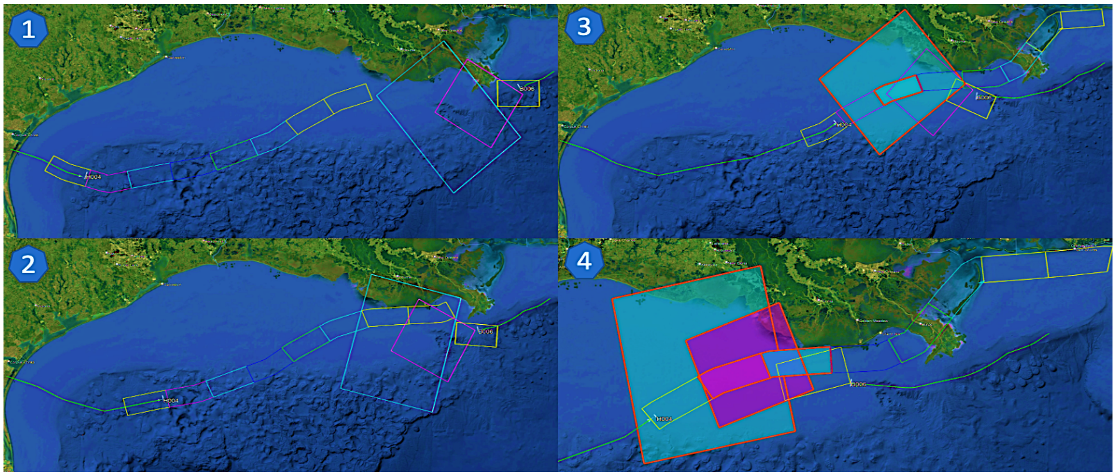

Figure 11. Snapshots of the H004 and B006 interaction over the Gulf of Mexico

B. Results and Discussion

Under Condition A (i.e., without an OI size restriction), the following vehicles were identified to have a conflict that required the ETM operators to revise OI: B001 – B003, B005 – B006, B005 – H002, B005 – H004, and B006 – H004. Two HALE balloons' (B005 and B006) OI grew substantially over long lookahead times and thus caused conflict.

Under Condition B (i.e., with OI size restrictions imposed: 90 nm, 120nm or 150nm), only one pair or aircraft (B006 – H004) was identified to be in conflict. The reason fewer conflicts were identified is that the OI segments that exceeded the size restriction were truncated; this especially reduced the HALE balloon's OI, reducing the potential for conflict.

Under Condition C, where the CCL value associated with each OI segment was also shared. The same pairs of the vehicles were identified to have conflict as for Condition A. However, the cases where "wait-'n'-watch" could be performed were identified based on the threshold values. Except for the conditions (150nm OI size restriction + 85% threshold and 150nm OI size restriction + 75% threshold), there were four cases per condition that were identified to meet the wait-'n'-watch criteria. The two conditions (150nm OI size restriction + 85% threshold and 150nm OI size restriction + 75% threshold) had only three wait-'n'-watch cases. It was due to the large OI size restriction value that allowed the vehicle flying at extremely low speed (i.e., less than 5 m/s) to have very high confidence over a large lookahead time horizon.

Table 3 shows the number of conflict pairs detected during the simulation run.

Table 3: # of conflicts (wait-n-watch + OI revision needed) identified per condition

Condition A or B o C	Condition Details	Conflicts	
		wait-'n'-watch	OI revision needed
Condition A	No OI size restriction	0	5
Condition B	90nm OI size restriction	0	1
Condition B	120nm OI size restriction	0	1
Condition B	150nm OI size restriction	0	1
Condition C	90nm OI size restriction + 95% threshold	4	1
Condition C	90nm OI size restriction + 85% threshold	4	1
Condition C	90nm OI size restriction + 75% threshold	4	1
Condition C	120nm OI size restriction + 95% threshold	4	1
Condition C	120nm OI size restriction + 85% threshold	4	1
Condition C	120nm OI size restriction + 75% threshold	4	1
Condition C	150nm OI size restriction + 95% threshold	4	1
Condition C	150nm OI size restriction + 85% threshold	3	2
Condition C	150nm OI size restriction + 75% threshold	3	2

Figure 12 shows the CCL value computed for each OI segment at the different OI prediction horizons at the moment of conflict detection. It only contains the CCL values of the HALE balloons (B001, B002, B003, B005, and B006) that have OI intersections with other vehicles in the scenario. Based on the vehicle speed at the moment of OI generation, the uncertainty of the future estimation varied. Thus, some HALE balloons may have more confidence in their future locations than others. On the other hand, if the surrounding wind speed that the HALE vehicle is flying with is strong, the confidence in the future location could decrease substantially, particularly when the OI size restriction value is small.

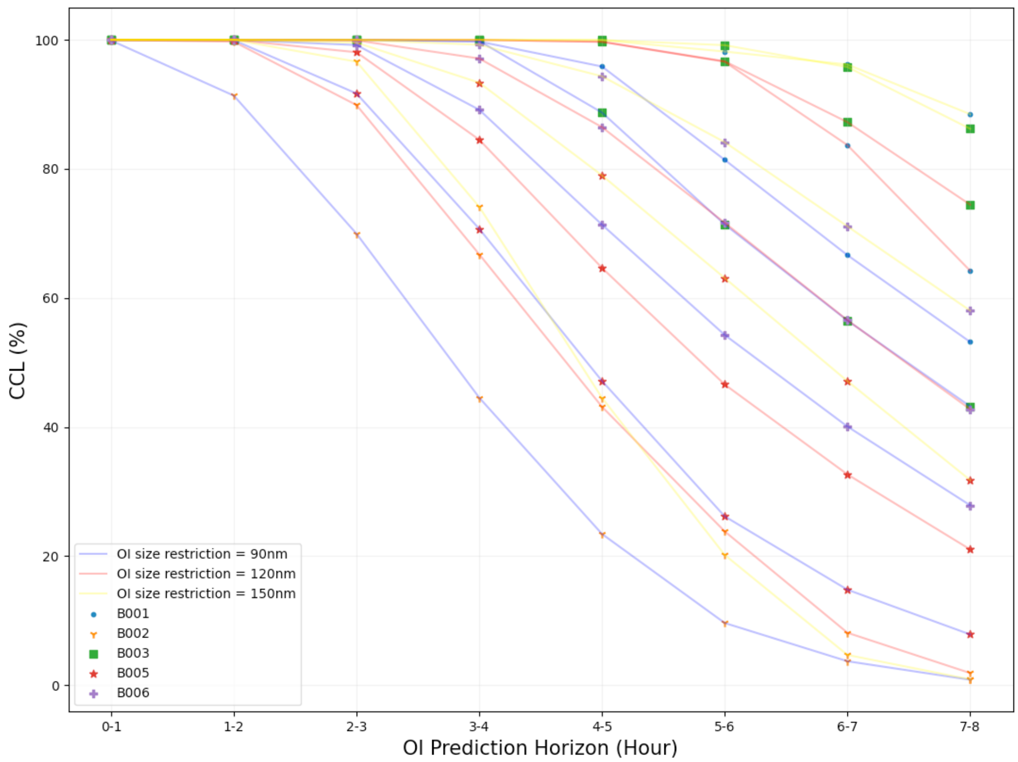

Figure 12. The CCL value computed for HALE balloons' OI segments for different time horizons at the moment of conflict detection

The study results showed two potential benefits of the proposed approach for the CSM operations:

1) It enables ETM operators to share a longer OI time horizon to provide more situation awareness.
2) It allows the ETM operator to avoid executing unnecessary OI revisions, leading to more efficient operations.

The study results of imposing OI size restrictions without CCL information (Condition B) showed that a smaller number of conflicts were detected as compared to Conditions A or C. However, the reduction in OI lookahead time horizon could limit the predictability of the ETM operators and possibly lead to a situation where there is insufficient time to resolve the conflict. Moreover, if an ETM operator does not share CCL information that is properly computed, other ETM operators may have to maintain additional separation distance to such an ETM operator's vehicle due to uncertainty in how likely the vehicle is to remain within the OI that it shared.

It is observed that the impact of OI size restriction value on the CCL relies heavily on the ambient wind conditions. Wind impact could be less influential on a fixed-wing UAV OI than on a balloon OI, because the fixed-wing UAV has more controllability than the balloon. Since this paper only looked at the HALE balloon as the example case, further investigation on how other ETM vehicles could confidently stay within varying OI sizes could be explored.

VIII. Conclusion

This paper provides one probabilistic method that the HALE balloon operator could use to predict its future locations and use such estimation to generate areas of operational intent (OI). Also, this paper presents how the OI could be generated while meeting the OI size restriction, where the OI size restriction is an idea that the ETM operators could adopt into the CSM operation as a method for standardizing the OI size for bringing more fair and efficient use of the ETM airspace. Moreover, one method for computing the CCL per OI segment is presented, which is one of the OI attributes that has been discussed in the FAA ConOps document [1] that needs to be addressed. Lastly, the framework for utilizing such CCL information was presented and evaluated using the newly developed simulation capability. The methods and the framework presented in this paper are not part of the accepted standard but are offered as a proposal for how these methods could be used during the CSM operations. Upon the acceptance of the proposed idea by the ETM community, more discussion on how the CCL computation method could be standardized.

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