Working Paper Series
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Airspace Automation Flight Tabletop Exercise

National Campaign Wisk Activity Team
And Partners

Aircraft Partner

Wisk Aero

Airspace Partners

ANRA
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Collins Aerospace
OneSky
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C2CSP Partners

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Collins Aerospace

Abstract

Interconnections of new systems are needed for airspace automation capabilities required in Urban Air Mobility (UAM). FAA Concept of Operations (CONOPS) V1.0 shows Provider of Services for UAM (PSU) at the center of the notional architecture; however, the functional role of the PSU in data exchange and the path to get there is unclear. In partnership with Wisk Aero, Avision, ANRA, Collins Aerospace, OneSky, SkyGrid, and AURA, the NASA National Campaign held discussions and tabletop exercises to test the functional allocations and work flows between an aircraft operator, airspace providers, Command and Control Communication Service Providers (C2CSP), and FAA air traffic in a real-world scenario. The exercise included preplanning and execution of a passenger mission with nominal, contingency, and conflict management scenarios for initial UAM operations. This working paper describes initial conditions for the flight tabletop exercise, exercise summaries, lessons learned, and recommendations for future work.

Revision History

Rev	Date	Sections Affected	Description of Change	Who
0	12/20/2022	NA	Original	Brad Snelling and Nancy Baccheschi

Table of Contents

Table of Figures

Tables

1 Background

An initial set of tabletop discussions on the Minimum Viable Product (MVP) for airspace automation or Provider of Services for UAM (PSUs) was conducted May-June 2022 with Wisk, ANRA, Avision, Collins Aerospace, OneSky, and SkyGrid. The MVP for a PSU was thought of as the minimum level of capability and services required of a PSU for various maturity levels in AAM. These discussions used generalized PSU "User Stories" for discussions. The PSU User Stories focused on:

- Pre-flight Planning
- In-Flight Contingency
- In-Flight Conflict
- In-flight Non-Conformance

Many excellent topics were discussed, but there was a desire for more clarity on the operational concept in UAS Maturity Level (UML) 2B. UML-2B was defined as "later initial" operations, not the next step in AAM operations, but perhaps the next evolution beyond 2023/2024 early initial operations. The graphic in Figure 1 was used as a starting point for defining UML-2B. Continued discussions were formalized into the "Flight Tabletop Exercise". The goal of each flight tabletop exercise was to provide just enough structure and initial conditions to discuss a realistic gate-to-gate AAM flight in a simplified UML-2B environment. This working paper provides the objectives, initial conditions, results, and recommendations after completing five 3-hour flight tabletop exercises. The Command and Control Services Provider (C2CSP) aspect was also included in the exercises with participation from AURA and Collins Aerospace as a combined PSU/C2CSP.

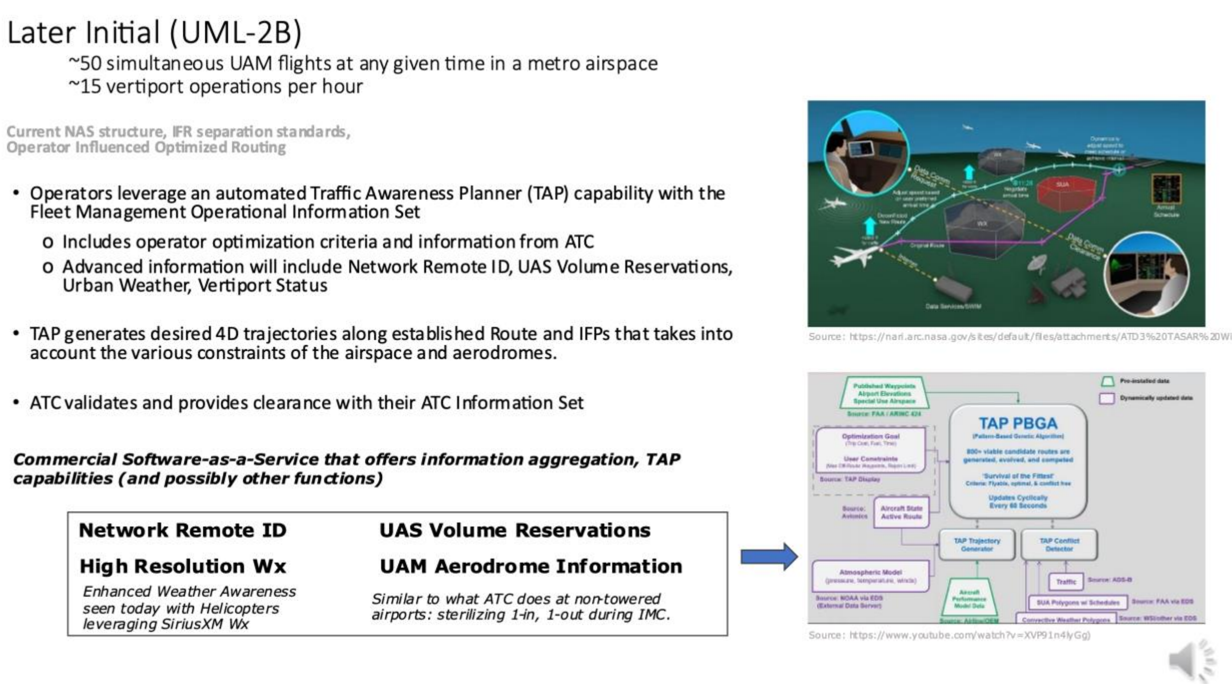

Figure 1 – Wisk UML-2B Construct

2 Objectives

A primary objective of the flight tabletop exercises was to test the functional allocations and work flows between an aircraft operator, airspace providers, C2CSPs, and FAA air traffic in a real-world scenario based on NC/Wisk "PSU User Stories" in UML-2B. While detailed components of the ATM-X airspace construct have been developed and are being tested in simulation environments, the goal of this exercise is to stretch the airspace automation concepts into a holistic operational scenario.

Characteristics of the exercise were determined as:

- Flight tabletop exercise will focus on the UML-2B stage
- Scenarios will be in the vicinity of Hollister Municipal Airport (KCVH) - Salinas Municipal Airport (KSNS)
- Scenarios will include the roles of PSUs, C2CSPs, ATC, vertiports, and aircraft operators
- Exercise will be managed with a timekeeper to ensure completion in the allotted time (2-3 hours)
- Specific people/roles will be assigned for PSU, C2CSP, ATC, Aircraft Operator, Operator Fleet Manager, and Vertiports
- All interactions, data exchanges and gaps will be logged as data
- Goal is for findings and recommendations to be captured in a final report and made available to the public domain

3 Initial Conditions

A set of initial conditions was developed to conduct the scenario based on discussion points from the previous tabletop discussions, Wisk CONOPS and experience on the activity team. These initial conditions are summarized below.

<u>Aircraft:</u> The aircraft capacity is 4 passengers in a lift+cruise configuration capable of instrument, remotely piloted operations. It has a takeoff/landing limit of 10 knots tailwind and 15 knots crosswind. This limit is artificially imposed for the exercise and not representative of the Wisk aircraft. The aircraft is assumed to be certified for RNP 0.1 approach/terminal/enroute operations. The aircraft's Detect and Avoid (DAA) solution is a fused solution for tactical conflict management, complemented by the ground control station. The aircraft is equipped with a system allowing the remote PIC to use the aircraft's VHF voice radio to receive and transmit from the aircraft.

<u>Mission Requirement:</u> The mission requirement is a passenger transport from 'Wisk Terminal' (WISK01) with 4 passengers to 'Wisk Terminal' (WISK02). Pax weight measured is 800lbs and Baggage weight measured is 80lbs. ETD is 1700Z. The notional WISK01 vertiport is collocated with Hollister Municipal Airport (KCVH), and the notional WISK02 vertiport is collocated with Salinas Municipal Airport (KSNS). These locations are shown in Figure 2. For contingencies, vertiport options were limited to WISK01 and WISK02.

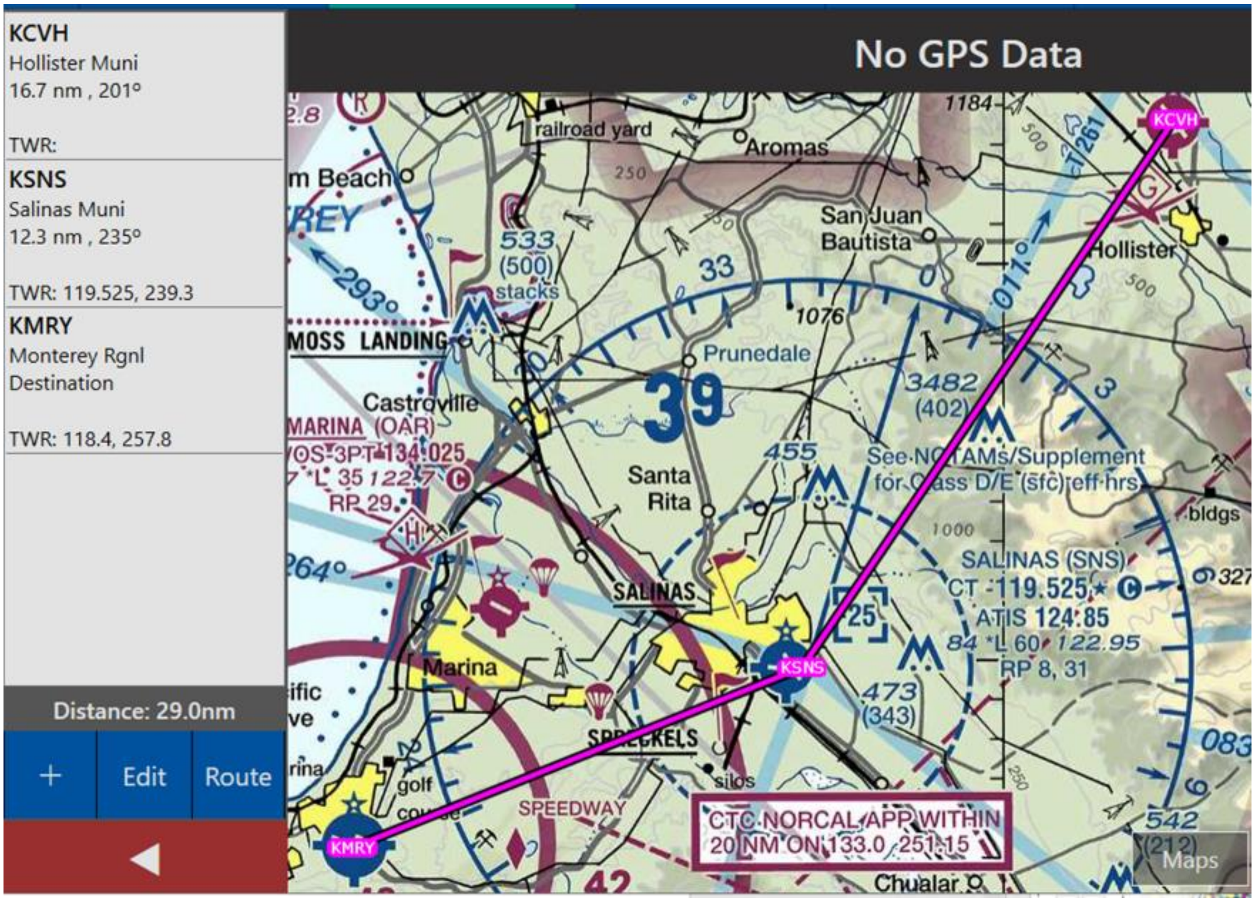

Figure 2 – WISK01 and WISK02 Vertiport Locations

<u>Instrument Flight Procedures:</u> Since there were no existing instrument procedures suitable for this route, a notional solution for takeoff to landing RNP 0.1 procedures was developed. This notional solution is scalable and called the "RF45" due to the usage of radius-to-fix (RF) legs for all course changes and 45° separation between departure/approach courses. See Appendix C: RF45 Construction for a detailed description of the rationale, construction, and features of this instrument procedure model.

For reference, the existing instrument procedure to fly from KCVH to KSNS requires a climb to 6,000MSL onto the SJC R-121 prior to proceeding on-course to KSNS. This is obviously impractical for the AAM use-case of a destination that is only 16NM away. See Figure 3.

HOLLISTER, CA
HOLLISTER MUNI (CVH)
TAKEOFF MINIMUMS AND (OBSTACLE) DEPARTURE PROCEDURES
AMDT 1 05JUN08 (08157) (FAA)
TAKEOFF MINIMUMS:
Rwy 6, NA-obstacles.
Rwy 24, NA-ATC.
Rwy 13, std. w/ min. climb of 391' per NM to 3500, or 3100-3 for climb in visual conditions.
Rwy 31, std. w/ min climb of 209' per NM to 2300, or 3100-3 for climb in visual conditions.
DEPARTURE PROCEDURE:
Rwy 13, climbing right turn to heading 332° and via SJC R-121 direct SJC VOR/DME to 6000 before proceeding on course or for climb in visual conditions: cross Hollister Muni Airport at or above 3100 MSL before proceeding on course.
Rwy 31, climb heading 307° and via SJC R-121 direct SJC VOR/DME to 6000 before proceeding on course or for climb in visual conditions: cross Hollister Muni Airport at or above 3100 MSL before proceeding on course.
TAKEOFF OBSTACLE NOTES:
Rwy 13, terrain beginning 992' from DER, 348' left of centerline, up to 289' MSL.
Terrain beginning 2467' from DER, 154' right of centerline, up to 309' MSL.
Trees beginning 1277' from departure end of runway, 348' left of centerline, up to 309' MSL.
Trees beginning 2467' from DER, 153' right of centerline, up to 270' MSL.
Rwy 31, terrain beginning 76' from DER, 392' left of centerline, up to 247' MSL.
Terrain beginning 14' from DER, 179' right of centerline, up to 231' MSL.

Figure 3 – Current KCVH Instrument Departure Procedure

<u>FAA Services:</u> Few assumptions of ATC services were made in order to encourage discussion of gaps and requirements needed to support this mission. A survey of current ADS-B coverage was completed and provided to show where FAA could provide traffic separation services today. Figure 4 shows the number of FAA ADS-B receivers capable of "seeing" ADS-B equipped aircraft as a function of MSL altitude and a direct line route from WISK01 to WISK02.

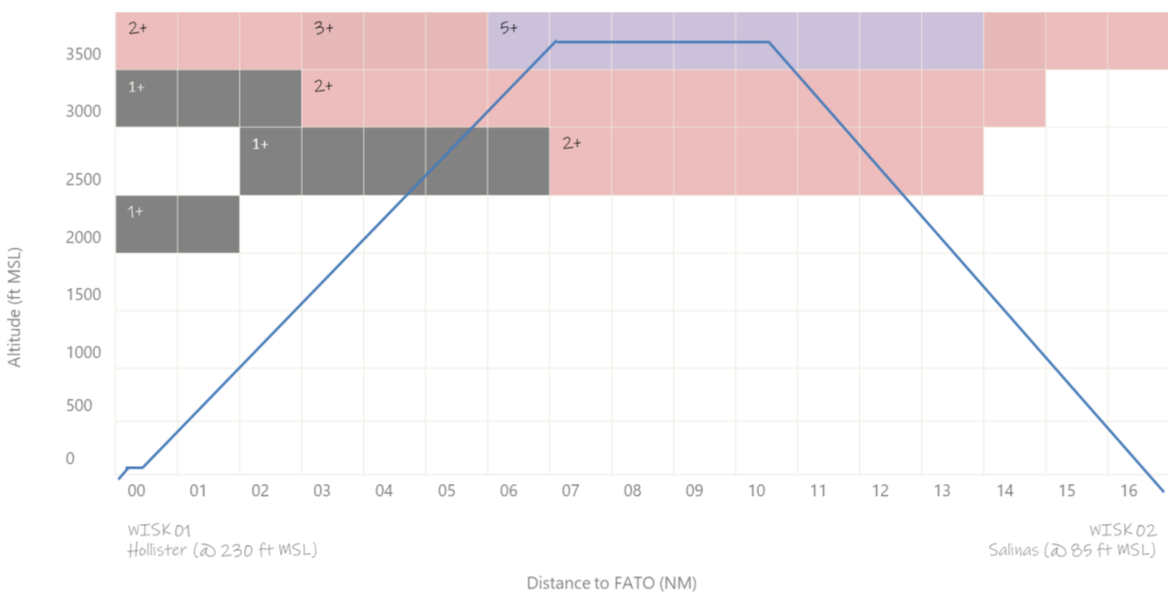

Figure 4 – ADS-B Coverage Expectation on Direct Route

Weather Conditions: Weather conditions for the exercise were presented as follows in the traditional METAR/TAF format, but PSUs were encouraged to suggest and/or provide data formats for additional or more detailed weather source data.

METARs:
WISK01 01615Z AUTO 04020G25KT 10SM CLR 19/05 A3029
WISK02 011630Z AUTO 02009KT 10SM CLR 19/02 A3030

TAFs:
WISK01 No TAF available
WISK02 011000Z 0718/0818 03010KT P6SM SKC
FM071700 02010KT P6SM SKC
FM071800 30009KT P6SM SKC

In plain terms, the weather conditions were defined as follows:
Currently at WISK01, winds are from the northeast (040 deg) at 20 knots, gusting to 25 knots. Visibility is 10 miles, sky is clear, temperature is 19 deg C, dewpoint is 5 deg C.
Currently at WISK02, winds are from the northeast (020 deg) at 9 knots. Visibility is 10 miles, sky is clear, temperature is 19 deg C, dewpoint is 2 deg C.

The 1700Z forecast for WISK02 is winds from the northeast (030 deg) at 10 knots. Visibility is over 6 miles. Sky is clear.
The 1800Z forecast for WISK02 is winds from the northwest (300 deg) at 9 knots. Visibility is over 6 miles. Sky is clear.

Role Player Interfaces: A top level diagram of the role player interfaces was provided to facilitate discussion of role player functional allocation. While it is not part of an actual system diagram, it was adapted and simplified from the ATM-X airspace construction. See Figure 5.

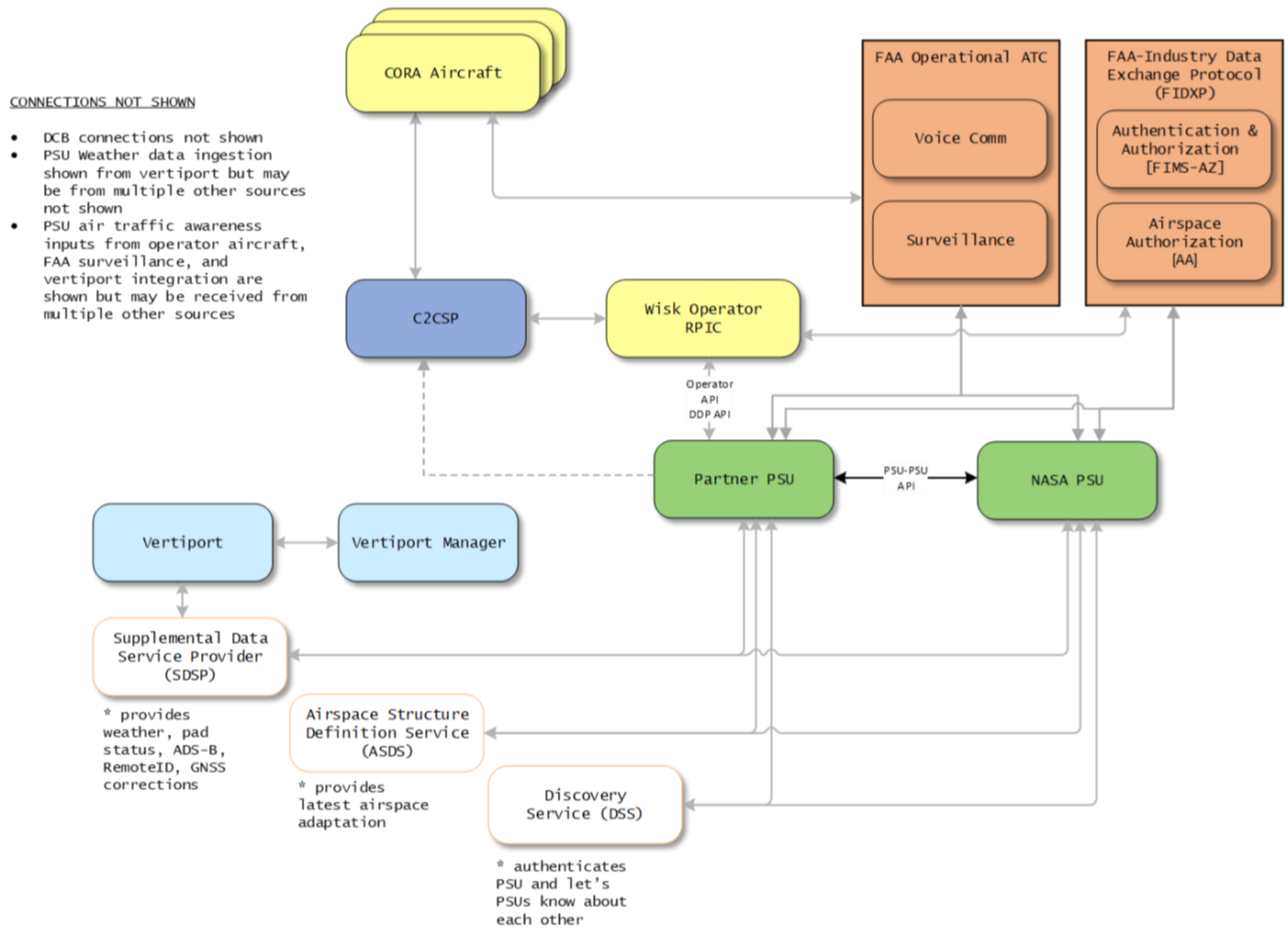

Figure 5 – Role Player Top Level Connections

The role players identified for each exercise are show in Table 1.

Table 1 - Exercise Role Players

Role	**Played By**
Scheduling Interface	Wisk
Wisk Operator Scheduler/Dispatcher	Wisk
C2CSP	AURA/Collins
MVS (RPIC)	Wisk
PSU	ANRA, Avision, Collins, OneSky. SkyGrid
NASA PSU	NASA ATI
FAA/ATC/Tower	NASA NC
Passenger Handling Services	Wisk
Ground Ops Team	Wisk
Vertiport Systems	NASA/Wisk
Aircraft/Maintenance	Wisk

The action points for the exercise are shown in Table 2.

Table 2 – Exercise Actions

Actions	**Actions (continued)**
Pax transport request	Takeoff
Decision on flight plan intent	Depart KSNS airspace
Flight plan filed from WISK01 to WISK02 with alternates	WISK01 winds out of limits
Flight plan pending	Reroute options calculated
Flight plan acknowledged	ATC clearance approved reroute to WISK02
Pre-flight prep	Reroute selected
Charging complete	Enroute back to WISK02
Departure Clearance Communications	Inflight conflict with aircraft detected by PSU
Physical Repositioning	Altitude change to 2,500' or 3,000' requested
FATO All-Clear	While descending, DAA commands a hard right turn to avoid sUA traffic detected by RemoteID
Start Takeoff Sequence	Inflight non-conformance detected by acft/PSU
Takeoff clearance Communications	Reroute options calculated
Takeoff	ATC clearance approved for reroute
Transition	Reroute selected
Climb	Start descent
Depart KCVH airspace	Arrive WISK02 airspace
Level off (~3500' MSL)	Landing clearance received
Enroute	Land WISK02
Landing clearance received	Flight plan closed
Start descent	Safety report for inflight non-conformance due to collision avoidance maneuver
Arrive KSNS airspace	
Land KSNS	**Bonus Actions to Consider**
Flight plan closed	*C2 Link Compromised
Physical Repositioning	*Rejected Takeoff
Gate Arrival	*Missed Approach
Post flight check	*Rescinded Take-off Clearance
Decision on Flight Plan Intent (turnaround)	*Passenger/ Cabin Emergency
Flight plan filed to WISK01 with alternates	*Aircraft Emergency
Takeoff clearance received	*Separation Conflict

4 Exercise Summaries

Each tabletop was conducted amongst Wisk, NASA, and one of the airspace partners. In two of the tabletops, AURA played a role as the C2CSP as well. The exercise was set up as a passenger transport scenario between two simulated vertiports (WISK 01 at KCVH and WISK 02 at KSNS), broken up into distinct phases to assess each player's role and actions, with a couple of contingency scenarios injected at the end if there was time. Additionally, one of the rules of engagement was that this tabletop would take place in UML-2B, meaning early infrastructure and very few players in the airspace at any given time. As a result, some of the discussion that ensued was what is possible now vs what is the ideal for a later UML when more infrastructure exists (such as data vs voice capability). Wisk played the roles of operator/scheduler/dispatcher, Remote Pilot in Command (RPIC), ground ops, passenger handling, and aircraft/maintenance team. NASA played the role of one of the PSUs, specifically the NPSU (NASA PSU), as well as the moderator for the exercise. The PSU was played by each of the airspace partners, with Collins playing the additional role of C2CSP. The phases of the exercise were broken out as shown in Table 2. (*not all contingencies were exercised in each of the tabletops due to time constraints):

4.1 ANRA

4.1.1 Exercise Date/Duration: 20 Oct 2022/3 hours

4.1.2 Participants: NASA, Wisk, ANRA

4.1.3 Major Discussion Points:

There were discussions on the role of the PSU in vertiport availability. Whereas the operator (Wisk) planned to communicate with the vertiport prior to filing their flight plan intent to understand availability, ANRA believed that while just prior to take-off and while in flight (tactically) it made sense for the operator to coordinate with the vertiport, it should be part of the PSU's responsibility ahead of time as part of the overall route availability to coordinate with the vertiport based on the operator's flight intent. Much of the differences in vision can be attributed to expectations at different UMLs – the operator sees having to coordinate with the vertiport directly in UML-2b, for example, so that THEN they can determine mission timing and intent to pass along to the PSU to now provide additional information back. The operator sees the PSU mainly providing information about their planned route in early UMLs, such as conditions of the proposed routes and perhaps a recommendation of the most viable route. This would be the capability that would set PSUs apart from each other – aggregating the raw data such as weather, obstacles, and terrain into a route recommendation.

Similarly, for filing flight intent, the operator's plan is to file through the currently available options but in future UMLs, the flight plan would be filed through the PSU. Since eventually the PSU would aggregate all of the route information based on the known aircraft mission intent and all of the factors potentially affecting the route, a better term than route availability could be route viability, with a kind of alerting or status indicating whether a route is viable all the way through or if there might be issues or one might be faster (e.g., color-coded to relay viability). Additionally, route viability would be communicated by the PSU if something changes, such as the vehicle is delayed in completing ground ops and will not take off at its expected time. The PSU could help the operator determine the viability and recommendations of departing later, flying at a different speed, or some other recommendation. One unknown is what information on aircraft performance the operators will share with the PSUs. At this point, Wisk has not decided if it will share such information such as crosswind or tailwind limits, which could limit the scope of the route viabilities the PSUs pass to the operators.

Airspace clearances would currently have to be handled via a mix of voice and data since there is not a set entity that can handle relaying/accepting the information entirely digitally. In later UMLs, due to resource constraints of using voice, departure clearance, for example, is envisioned to be all digital and no voice. There was also discussion about who provides deconfliction while traveling along the route. Currently, Wisk plans to handle that onboard and never plans to hand over safety-of-flight deconfliction (i.e., an imminent collision), but eventually that may be a role in which the PSU participates to help make airspace usage and any route changes to deconflict more efficient.

Eventually the PSU's role will help to alleviate the need for every operator to talk to everyone else. The PSU will have visibility into all operators, their conformance, their limitations, etc. and can be the aggregator to relay information to other operators and/or help operators determine route viability and provide recommendations that fit into the entire air picture. Additionally, if the PSU can detect possible conflicts long before ATC or a DAA system does and can suggest reroute options, that would minimize impact to the airspace, vertiport availability, as well as the operator, and could improve airspace efficiency overall.

4.2 Avision

4.2.1 Exercise Date/Duration: 4 Oct 2022/3 hours

4.2.2 Participants: NASA, Wisk, Avision, AURA

4.2.3 Major Discussion Points:

Similar discussion took place with Avision as with ANRA, that the vertiport would be included in the route viability and therefore not treated differently from the enroute portion as far as PSU responsibilities. This tabletop included AURA, so there was more discussion about establishing the C2 link and the recognition that knowing the availability as well as the route info (including vertiport availability) were equally important. Coordination between the operator and the C2 provider would need to happen directly (i.e., not through the PSU) prior to the day of flight to ensure reservation of spectrum resources is completed in advance. In general, the C2 provider is providing assurance that the link will be available in time to support the filed flight plan/mission intent.

Certain PSU functions, such as providing potential alternative routes, are envisioned in future UMLs, but Wisk is expecting to have to carry some redundancy in those areas in earlier UMLs until that functionality is for certain available by the PSUs. For that reason, the raw data that would feed those alternative routes would still need to be provided by the PSU to the operator in earlier UMLs so the operator can execute the planning, even if it's redundant. At the very least, the operator expects the PSU to provide conflict detection and recommendations. However, that may be limited depending on how much aircraft performance data the operators share with the PSUs. Additionally, tactical deconfliction (i.e., safety of flight and/or immediate threats) would happen onboard with a DAA system vs relying on the PSU to provide safety-critical information (at least in early UMLs). PSUs would also detect non-conformance to mission intent and relay that to all other actors, including other PSUs and other operators in the area.

One challenging area that was identified as needing further discussion is how the communication happens at an airport with CTAF or UNICOM, especially when some of the operations, such as glider ops, would not have transponders and therefore the PSU has no visibility on those ops and cannot provide deconfliction or recommendations to the operator.

4.3 Collins Aerospace

4.3.1 Exercise Date/Duration: 28 Sep 2022/3 hours

4.3.2 Participants: NASA, Wisk, Collins

4.3.3 Major Discussion Points:

Operating from older requirements, the Collins PSU functional allocation included filing IFR flight plans and conveying predeparture and take-off clearances. This created much discussion as Wisk no longer desires the PSU to perform this function for the medium time frame implementation or UML-2b. Collins conveyed they file 2000 flight plans a day through their ARINCDirect service and will include flight filing services as a PSU service level option which potentially offers a more seamless transition to future maturity levels. An identified potential shortfall to de-coupling the PSU from flight filing is that there is no demand capacity balancing since operators would all be filing their flight plans without PSU involvement.

Another discussion item~~s~~ was whether the operator was going to share performance data , especially all information required to calculate the eVTOL equivalence of “bingo fuel”. As mentioned above, Wisk is unsure at this time, but Collins indicated that without aircraft performance data, route availability/viability would be limited to what C2 and surveillance coverage volumes and terrain or weather would dictate. Collins would not be able to make alternate flight plan recommendations with high probability of acceptance on specific routes without aircraft performance data.

In this tabletop exercise, Collins also spoke on behalf of the C2 role and envisioned that coordination would have to occur from the C2 player not only to the operator but also to the PSU to ensure viability of a planned mission intent based on C2 coverage and availability. Additionally, it was noted that the C2 needed to be available at the FATO, if not sooner (though masking from hangars where passengers might be boarding could present challenges).

There was a similar theme in this tabletop of who talks to the vertiport (operator or PSU or a combination) and when. Wisk sees a need to ensure, prior to filing flight plans, that a vertiport can meet their requirements and at other times they will need to confirm with the vertiport details about passenger handling services. Additionally, having a direct link to the vertiport to ensure the FATO is all clear before transitioning to it could be considered safety-of-flight, in which case Wisk would not be relying on the PSU. However, a PSU might need to act as a broker for airspace or vertiports. Future UAM planning will need to further vet this topic to determine if the PSU should relay all of this or if there should be direct communication between the operator and the vertiport at certain times.

4.4 OneSky

4.4.1 Exercise Date/Duration: 6 Oct 2022/3 hours

4.4.2 Participants: NASA, Wisk, OneSky, AURA

4.4.3 Major Discussion Points:

Many of the discussion points were similar to what has already been laid out for the previous partners.

A further discussion on PSU involvement with flight plan filing centered around having an ability to at least predict that there may be multiple flight plans filed by multiple parties that could potentially create conflicts if they are flown at the time and state they are currently filed. The PSU could have an algorithm that calculates risk potential based on what is filed. Wisk mentioned that bucketing all potential conflicts (both potential and realized) with a confidence level might be the most useful way for PSUs to alert operators to potential conflicts even if they haven't been realized yet. This could mitigate the conflict from even happening if the operator can make changes as a result.

4.5 Skygrid

4.5.1 Exercise Date/Duration: 24 Aug 2022/3 hours

4.5.2 Participants: NASA, Wisk, Skygrid

4.5.3 Major Discussion Points:

The PSU will not have direct contact with the aircraft; all comms would be between the operator and the PSU instead. One theme in this discussion (and many of the previous partners) was the eventual desire to eliminate voice and human-to-human contact. A related area of research to this would be what to do about uncontrolled airports since currently voice over CTAF is how all players in the area maintain situational awareness.

5 Lessons Learned

The following lessons learned follow from feedback received from NASA and partner participants. A significant amount of data is contained in Appendix B where many of these lessons learned were gleaned.

In UML-2B, the PSU plays less of a role than we thought. Most of the airspace partners were prepared to handle flight plan filing and associated interactions with FAA; however, the Wisk CONOPS included handling all of those interactions. In addition, this exercise did not include Demand Capacity Balancing (DCB) or much additional traffic.

So how smart does a PSU have to be? A relatively common perception is that the PSU takes on the role of FAA ATC and handles complex tasks such as DCB and inflight traffic separation responsibility. This vision for PSU functionality is required for UML-4 and beyond; however what does a PSU look like in the “crawl” or “walk” phase prior to “running” with full-up services analogous to ATC in the NAS today? In order for a PSU to perform advanced UML-4 functions, they will need to perfect the art of consuming, aggregating, and correlating disparate datasets related to weather, surveillance, C2 services, DCB, private vertiport statuses, and perhaps many more. So the first logical step for a PSU might be to start perfecting the art of acquiring these datasets, measuring data availability, understanding the data integrity, and experimenting with how to package this data to be most beneficial to aircraft operators.

What about System Wide Information Management (SWIM)? Many discussion occurred where partners expected to obtain data (e.g. traffic, weather). According to the FAA SWIM website, “SWIM provides the infrastructure, standards, and services needed to optimize the secure exchange of relevant data for NAS systems and the aviation community.” While SWIM may provide much of the input data needed by PSU’s, what that actually looks like to a PSU and how that would benefit the operator was unclear. For example the scenario involved winds that were just below/at/above takeoff limits. Whereas, a piloted aircraft would be getting real-time updates from a tower or visual reference to windsock, could SWIM data provide near real-time weather data to piloted aircraft for all vertiports? It seems more likely that these updates and augmented surveillance updates might be better provided by services utilizing 3rd party or local data from the vertiports themselves. Reliance on SWIM data for the AAM use-case seems unclear.

Better understanding needed on FAA flight plan filing, acceptance, and ATC clearance process. It became apparent that experienced operational understanding of the current ATC filing, acceptance, and clearance process was insufficient for all players to understand the system interactions required to obtain FAA clearance for the mission with high fidelity mission intent. In fact, it appears that likely that current FAA systems are inadequate for obtaining a common operating picture of high fidelity mission intent for the AAM use-case. A better understanding of the current system is needed in order to highlight the gaps and standards needed to file high fidelity mission intent (e.g. 4D trajectory), get clearance for same, and also begin to address how demand capacity balancing will be accomplished.

Operator data sharing. Fleet operators should determine what type of performance data they are willing to share with PSUs since it will impact the level of service they can expect to receive from a PSU. For example, if a PSU does not know wind or performance limits (e.g. environmentally dependent climb performance), then the PSU cannot assist the operator with route viability and route options.

Operations at uncontrolled airports/vertiports. Wisk chose one of the more challenging departure and arrival scenarios which is to conduct VTOL or vertiport operations at existing fixed-wing airports. The departure from WISK01, collocated with KCVH sparked a lot of discussion surrounding the voice communications and visual/detect-and-avoid requirements for operations at an uncontrolled airport. The voice communications standard worked out; however the ability to remain well clear of other traffic from an autonomic point of view was not 100% clear. For example, the Wisk FOC does not have any visual contact with the takeoff area and relies on ground crew to clear for traffic.

Distinction between different data exchanges. At the start of the exercise, there was not a common understanding of the different between C2CSP and Datalink. For the purpose of this exercises, it was understood that the term “datalink” would refer to traditional methods of data communication between and Air Operations Center (AOC) and/or ATC (e.g. CPDLC). Whereas C2 was specifically reserved for the direct link required between the aircraft and the operator’s FOC where the RPIC resides.

6 Recommendations

The following recommendations follow from lessons learned and feedback received from NASA participants and partners following the exercise.

Systems engineering review. A review of each exercise should be accomplished through the lens of a requirements engineer. While this would not produce a final set of requirements in any sense, the derived requirements would be extremely beneficial to operators in the CONOPS and top level system interface planning.

Near-term follow-up workshops. NASA, Wisk, Airspace and C2CSP partners should explore further explore specific areas where agreement was not reached; for example, FAA plans for receiving high fidelity mission intent. In addition, top level discussions on the NC-2 baseline infrastructure would be beneficial for receiving feedback and planning future systems integration testing.

NC infrastructure UML target. While industry certainly needs to look at near-term operations, the focus for NC might be better suited for "UML-3". This exercise demonstrated that for low volume operations, the PSU serves a minimal role as compared to the vision of PSU providing actual traffic separation services. In order to test the system interfaces for the latter, it would be more beneficial to look beyond a scenario where the PSU basically just hands off weather and surveillance information to the operator to deal with on their own.

Mix of operators, PSUs, and vertiports. The goal of AAM is certainly not exclusive use of certain airspace but specific operators with one CONOPS and one aircraft type. Therefore, future simulations should include as many operators, PSUs, and mixed vertiports as possible. An example of mixed operators could include private piloted VFR traffic, traditional commercial 121/135 carriers, sUAS operations, and at least 2 eVTOL Part 135 carriers. An example of mixed PSUs would include bringing not just an airspace partner and NASA PSU together, but two or more airspace partners together. This could help explore the idea of PSU as a "broker" for vertiport/airspace management to ensure no party, such as a fleet operator, unfairly prioritizes their own operations over others. An example of mixed vertiports could include operations from both towered airports, untowered airports, commercial vertiports, and private vertiports. Such an approach could encourage discussion on prioritization and utilization of resources.

More complex R&D simulations: Since this was only a simple route without the need for DCB or many other real-world constraints, there is a significant chunk of expected functionality not yet under R&D. Concern was expressed that with multiple variables and PSUs interacting simultaneously, the system may go unstable depending on latencies. This concern should be tested in future simulations with higher fidelity models and multiple systems as in the previous recommendation.

FAA CONOPS 2.0. As previously recommended in the MVP notes, it is recommended that FAA release an updated CONOPS for AAM/UAM. Without common terminology and a common operating picture, it is difficult if not impossible for potential PSUs to develop the interfaces and services required to support safe and efficient AAM operations.

System criticality: It is recommended to plan future systems integration exercises or simulations to better understand the safety and/or efficiency implications of service interruptions or availability. Perhaps a primary example of this would be the implications of lost C2 link. An interesting concept presented during the exercise with Wisk was that a lost C2 link would not necessarily be considered safety critical since the aircraft is operating autonomously for the most part. But other data interruptions to study could include connectivity to PSU and the various data provided (e.g. interruption of weather data services at the arrival vertiport).

RNP 0.1 procedure, aircraft, and operator certification. With respect to current navigation capabilities, the technology supports RNP 0.1; however there needs to be focus on route definition and leg types which can support RNP 01. One specific recommendation is to start prohibiting course changes without the use of RF legs. This paper presents one takeoff to landing procedure that meets that requirement. In addition to certified procedures, FAA should plan and expect OEMs to demonstrate means of compliance for tighter RNP certifications and fleet operators to request operational approvals for same.

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Digital – Terminal Procedures Publication (d-TPP)/Airport Diagrams (faa.gov)

FAA UAM CONOPS 1.0

National Campaign Development of Airspace Operations, Infrastructure, and Data. Prepared by Advanced Air Mobility National Campaign Team, AAM-NC-069-001

UAM Airspace Research Roadmap Orientation, June 13, 2022, Ian M Levitt

Appendix A: Acronyms

This appendix contains acronyms that are used repeatedly throughout this document.

Acronym	**Term**
ATC	Air Traffic Control
C2	Command and Control
C2CSP	C2 Communications Service Provider
COP	Common Operating Picture
CTAF	Common Traffic Advisory Frequency
DAA	Detect and Avoid
DCB	Demand Capacity Balancing
FOC	Flight Operations Center
FATO	Final Approach and Takeoff
MVS	(Wisk) Multi Vehicle Supervisor
NC	National Campaign
NASA	National Aeronautics and Space Administration
PSU	Provider-of-Services for UAM
RPIC	Remote Pilot in Command
SDSP	Supplemental Data Service Provider
SWIM	System Wide Information Management
UAM	Urban Air Mobility
UNICOM	Universal Communications

Appendix B: Exercise Data

An Excel spreadsheet was used to document the role player communications for each exercise. The spreadsheet contains a tab for each exercise (per airspace partner). Each tab contains a row for the action item and columns for each role player. The cells contain the actual role and/or discussions that occurred at each step in the exercise by role player. The spreadsheet data is part of this report and should be attached. If missing, please contact National Campaign sub-project manager.

Appendix C: RF45 Construction

This appendix describes the motivation for RF45 procedure construction. The requirement from Wisk was to have a fixed route structure between vertiports. Since there are not any current departures, airways, or approaches that meet this criteria, the RF45 procedure was created to fill this void. Fixed routes could obviously be constructed directly between the vertiport centers but few, if any, aircraft would be capable of precisely tracking them. Due to a variety of factors, including air traffic, wind limits, terrain or obstacles, aircraft will not always be able to depart directly to the center point of the next vertiport. The features which the RF45 procedure was designed to address are:

- Definition of a geospatially unambiguous flight path that is repeatable by all user aircraft.
- Provides enough departure/arrival courses to account for air traffic, weather, and terrain/obstacle limitations.
- Accomplishes any course changes by RF legs. The rational for this is that no aircraft can remain on-course with Track-to-Fix (TF) to TF legs as is typically done. The aircraft will either lead the turn when the intermediate fix is a “flyby’ waypoint of flies over and must track back to course in the case of a “flyover’ waypoint.
- Reduce RF legs to the minimum radius practical to minimize total track distance.
- Use a minimum number of waypoints to reduce proliferation of aeronautical data.
- Scalable to any combination of vertiport pairs without proliferating too many new waypoints

To expand on the “wheel” concept proposed by Zahn, the following pattern was devised to handle RF legs for all course changes onto a fixed route between two vertiports and into the next vertiport. There are 5 categories of legs in this model:

Table 3 – RF45 Leg Categories/Types

Figure Label	Leg Category	ARINC424 Leg Type	Note
A	Departure/Approach Tracks	TF	
B	Inner RF Leg Alignment Leg (Radius = R1)	RF	Not required for straight-out departure or straight-in approach
C	“Wheel” RF Leg (Radius = R	RF	Not required for straight-out departure or straight-in approach
D	Outer RF Alignment Leg (Radius = R2)	RF	Not required for straight-out departure or straight-in approach
E	RF Alignment to the Fixed Route	RF	Small course change; always less than 22.5°
F	Fixed Route between 2 Vertiports	TF	

Figure 6 shows construction of the standard RF45 procedure where the outbound/inbound tracks are separated by 45°. A sample outbound or inbound route is highlighted in red with adjacent leg category labels from Table 3.

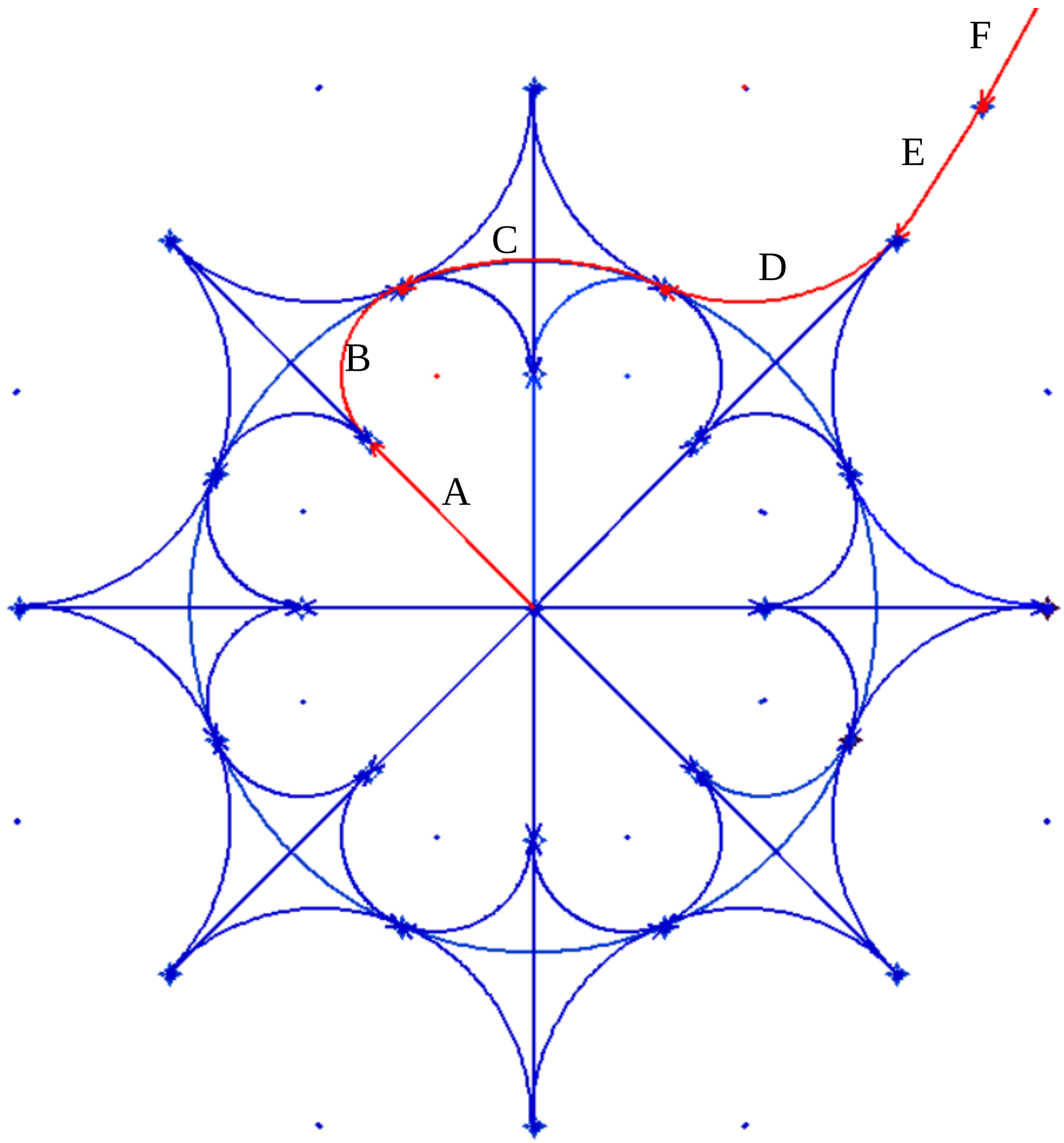


Figure 6 – RF45 Legs Categories

The selection of 45° separation between outbound/inbound tracks was based on:

- Logical factors of 360° which could represent track separations
- Final leg (A) length not less than 1NM
- Minimum RF leg radii of .5NM; chosen to support up to 100 knot outbound/inbound airspeeds
- Not too many waypoint required

Using trigonometric functions of the angle θ show in Figure 7, we are able to define the departure/approach leg (A), radius of inner RF leg (B), and radius of outer RF leg (D) as a function of the "wheel" radius (C).

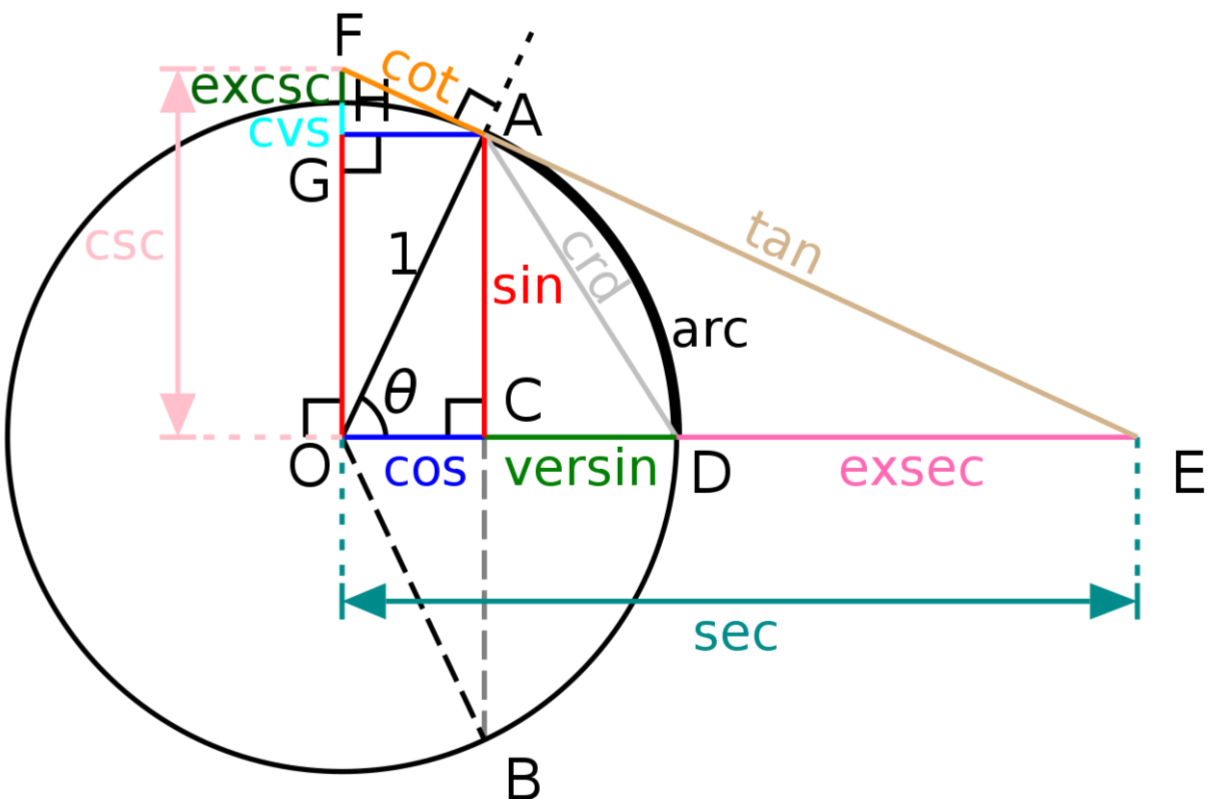


Figure 7 – Trigonometric Functions of Theta

<u>Where:</u>
S=Number degrees track separation
R=Wheel Radius
R1 = Inner RF leg radius
R2 = Outer RF leg radius

$$\theta = \left(90° - \frac{S}{2}\right)$$

$$\boldsymbol{Final\ Segment} = \mathbf{R1} * \mathbf{tan}\ \boldsymbol{\theta}$$

$$R = (R1 * \mathrm{exsec}\theta) + 2 * R1$$

$$R = R1 * (exsec\,\theta + 2)$$

$$R1 = \frac{R}{exsec\theta + 2}$$

$$\boldsymbol{R1} = \frac{\boldsymbol{R}}{\boldsymbol{sec\theta} + \mathbf{1}}$$

$$R2 = (R2 * sec\theta) - R$$

$$R2 * (1 - sec\theta) = -R$$

$$\boldsymbol{R2} = \frac{\boldsymbol{R}}{\boldsymbol{sec\theta} - \mathbf{1}}$$

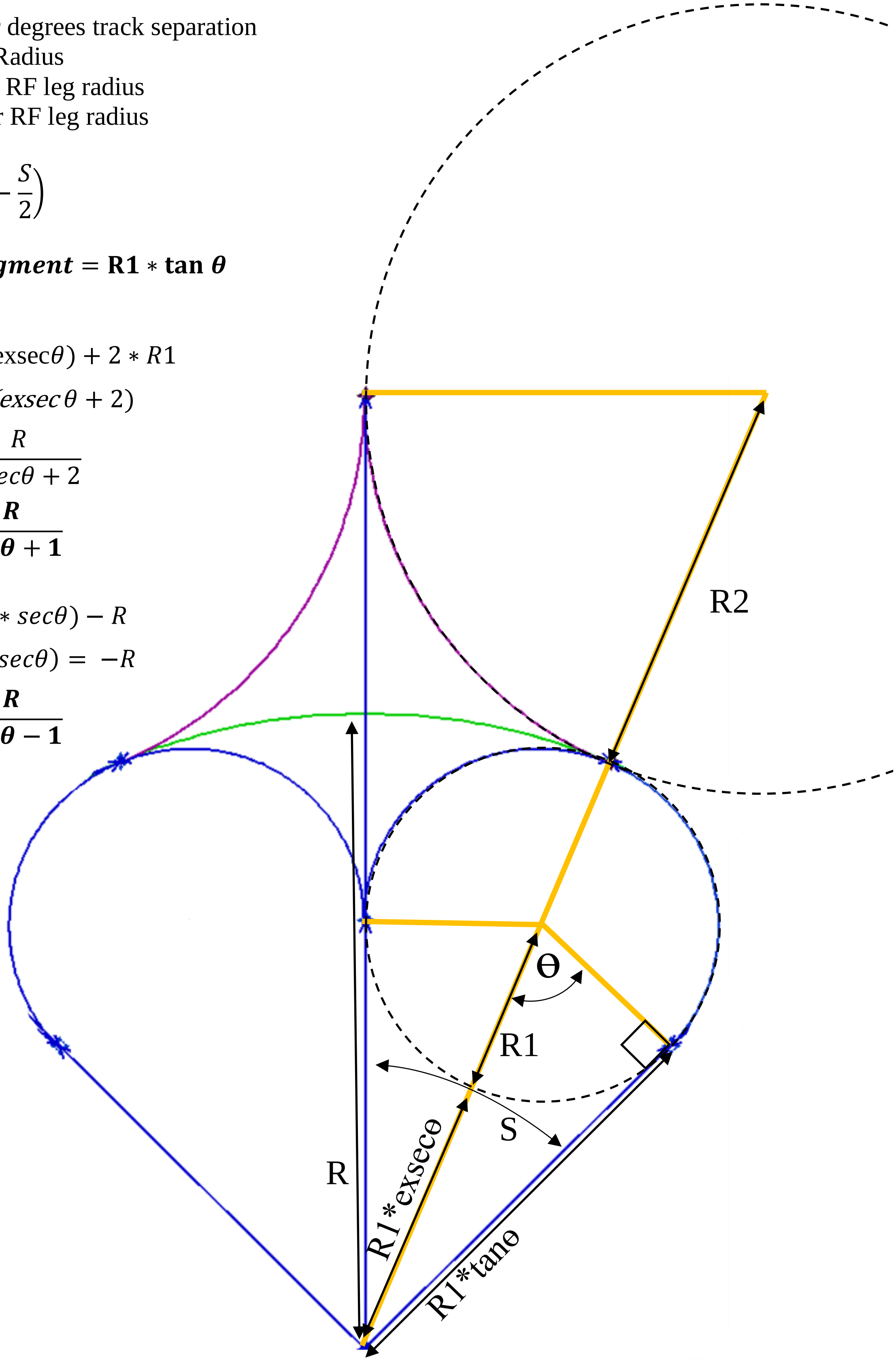


Figure 9 - RF45 Trigonometric Formulas for Final Distance and RF leg radii

Parameters for a "wheel" radius of 2NM (R = 2) are shown in Table 4 – Track Separation Parameters when R = 2. The formula for determining the final distance, R1, and R2 is show in Figure 9. The formula for the number of waypoints required for each selection of degrees serration is:

$$\# \, Waypoints \, Required = 3 * \frac{360}{S} + 1$$

Parameters for a "wheel" radius of 2NM (R = 2) are shown in Table 4.

Table 4 – Track Separation Parameters when R = 2

In/Out Track Seperation (deg)	Final Distance (NM)	R1 (NM)	R2 (NM)	# Waypoints Reqd
10	1.833	0.160	0.191	109
15	1.754	0.231	0.300	73
20	1.678	0.296	0.420	55
25	1.605	0.356	0.552	!
30	1.535	0.411	0.698	37
35	1.466	0.462	0.860	!
40	1.400	0.510	1.040	28
45	**1.336**	**0.554**	**1.240**	**25**
50	1.274	0.594	1.464	!
55	1.214	0.632	1.716	!
60	1.155	0.667	2.000	19
65	1.097	0.699	2.322	!
70	1.041	0.729	2.690	!
75	0.986	0.757	3.112	!
80	0.933	0.783	3.599	!
85	0.880	0.806	4.165	!
90	0.828	0.828	4.828	13

!	Not a factor of 360° wheel
	Final distance, R1/R2, and # wpts satisfactory
	Final distance, R1/R2, and # wpts unsat

Both Table 4 and Figure 10 show the only logical separations as 40°, 45°, and 60°. Since 45° results in easy to visualize cardinal direction courses of 0°, 90°, 180°, and 270°, it was chosen as the separation for the exercise procedure.

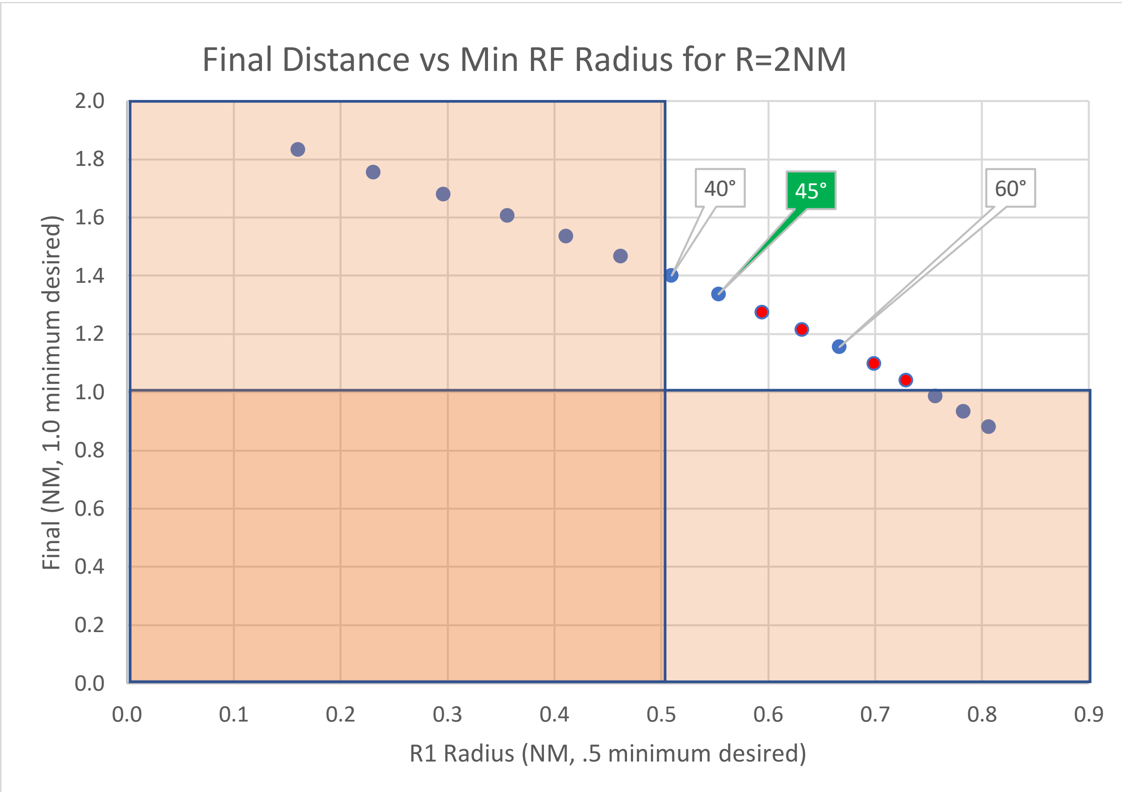


Figure 10 – Min Final Distance vs Min R1 Radius for R = 2NM

The final procedure characteristics are R = 2NM, F = 1.34NM, R1 = .55NM, and R2 = 1.24NM, with25 total waypoints required for the procedure. This procedure meets initial design criteria by:

- Utilizing RF legs for all course change and thereby enabling extremely low Flight Technical Error (FTE) to support RNP 0.1
- Minimizing the number of waypoint for a comprehensive departure and approach proedure
- Sufficient course options to allow for low crosswind and tailwind component
- Consistent and fixed enroute TF leg require 2 additional waypoints for RF leg alignment
- Supports transition to wing CONOPS for vertiport to vertiport with a minimum of 8NM distance between; smaller hops will require lower airspeeds and smaller RF leg structure
- Scalable because the same procedure could be placed at any vertiport (although some tracks may need restrictions due to air traffic, terrain, or obstacles.

The following 4 pages contain procedure plates created for the exercise and to serve as candidate ideas for publishing departures and approaches for AAM instrument procedures.

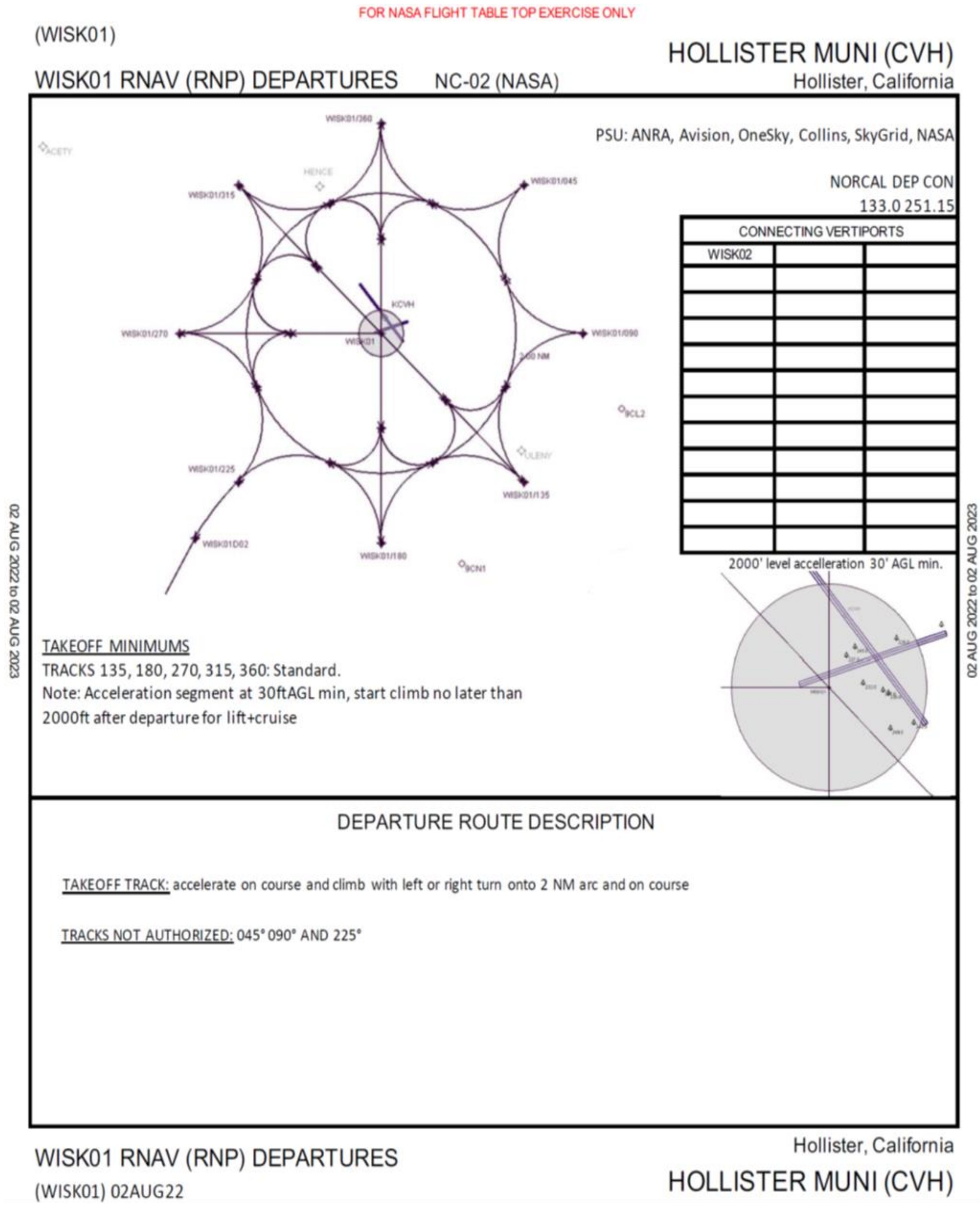


Figure 11 – WISK01 Departures

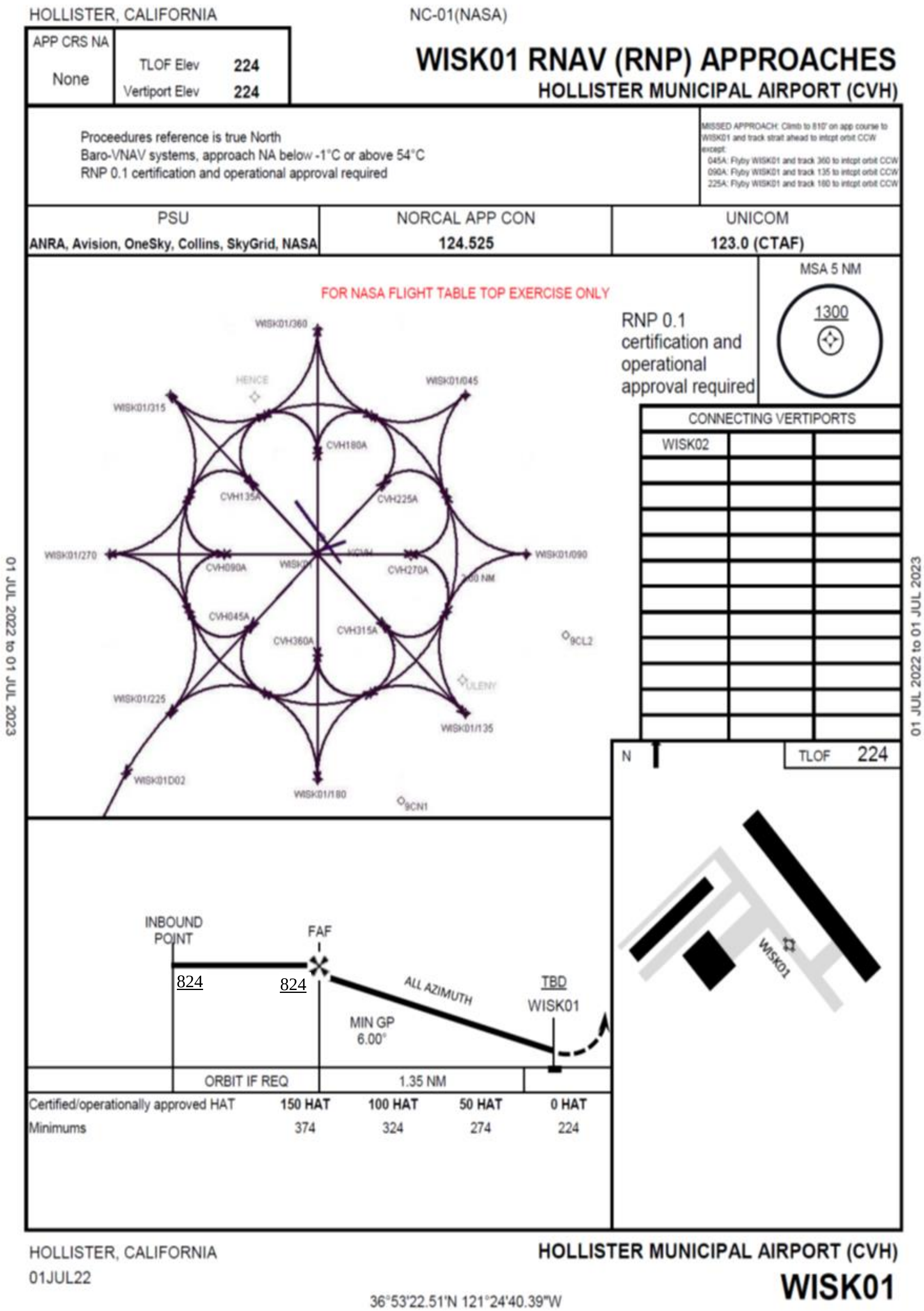
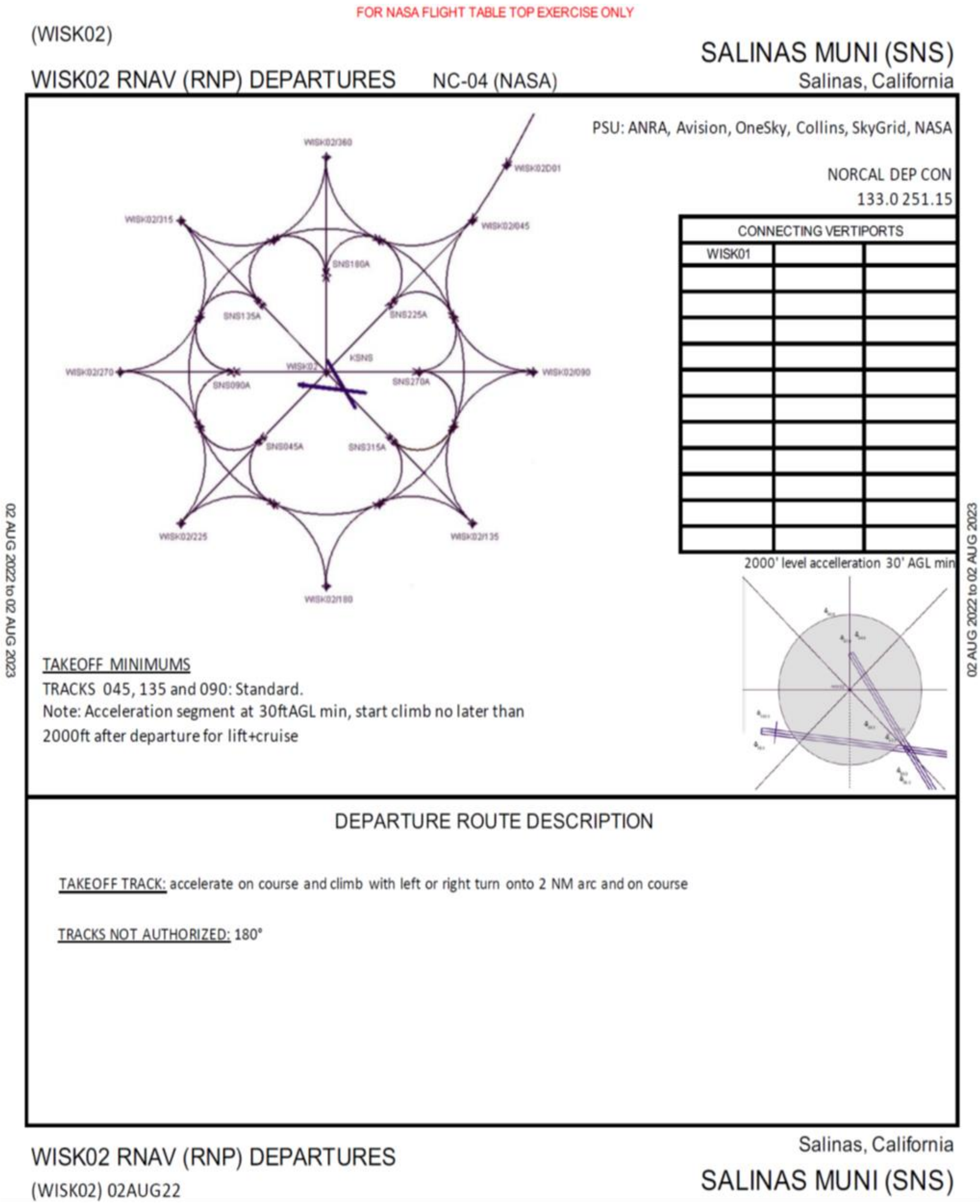


Figure 12 – WISK01 Approaches



FOR NASA FLIGHT TABLE TOP EXERCISE ONLY

(WISK02)

WISK02 RNAV (RNP) DEPARTURES NC-04 (NASA)

SALINAS MUNI (SNS)
Salinas, California

02 AUG 2022 to 02 AUG 2023

PSU: ANRA, Avision, OneSky, Collins, SkyGrid, NASA

NORCAL DEP CON
133.0 251.15

CONNECTING VERTIPORTS		
WISK01		

2000' level accelleration 30' AGL min

TAKEOFF MINIMUMS

TRACKS 045, 135 and 090: Standard.

Note: Acceleration segment at 30ftAGL min, start climb no later than 2000ft after departure for lift+cruise

DEPARTURE ROUTE DESCRIPTION

TAKEOFF TRACK: accelerate on course and climb with left or right turn onto 2 NM arc and on course

TRACKS NOT AUTHORIZED: 180°

WISK02 RNAV (RNP) DEPARTURES

(WISK02) 02AUG22

Salinas, California

SALINAS MUNI (SNS)

02 AUG 2022 to 02 AUG 2023

Figure 13 – WISK02 Departures

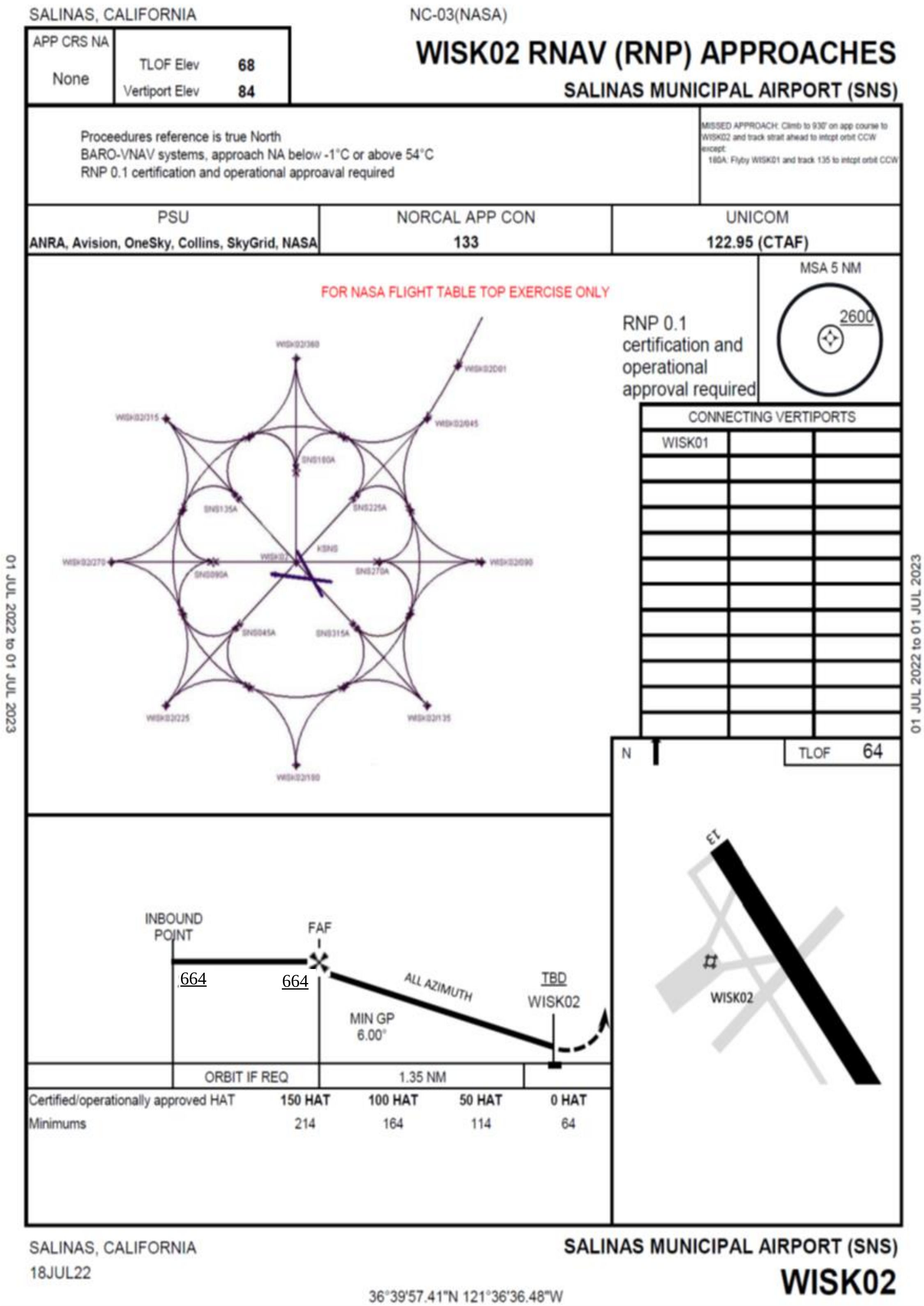


Figure 14 – WISK02 Approaches

Another feature of the RF45 procedure design is that it really doesn't need additional waypoints. The trigonometric formulas are already worked out so that the only data required are:

- Vertiport latitude, longitude, elevation
- Radius of the "wheel" if different than 2NM
- Min safe altitude
- List of any unauthorized tracks

There is actually only 1 waypoint definition required for the whole set of procedures and that is the location of the vertiport. It would be possible to add the RF45 or similar consistent procedures to FMS in such a manner that 1000s of additional waypoints are not proliferated into the aeronautical data system for each new set of vertiports. For example, many FMS today have search patterns which can program circular or search pattern routes by inputting on the center point and 1 or 2 additional parameters. It should be possible to do the same with a procedure concept such as the RF45. This satisfies that last design criteria which was "Scalable to any combination of vertiport pairs without proliferating too many new waypoints".

Finally a short format was designed to communicate mission intent during this exercise. The format provided the minimal information needed to communicate 4D trajectory. See Figure 15.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Vertiport ID						Depart and Turn Dir (L, S, R)						Depart Pt			Arrival			Turn Dir / Approach Inbound						Vertiport ID					
W	I	S	K	0	1	1	8	0	R			2	2	5	0	4	5	L	2	7	0			W	I	S	K	0	2
1	3	0	0	3	0	1	3	0	2	1	5	1	2	0	1	1	8	1	3	1	0	1	5	1	3	1	1	3	0
Departure Time						Outbound Time						GS Out (kts)			GS In (kts)			Inbound Time						Arrival Time					

Total Route Flight Plan Intent

Figure 15 – Total Route Flight Plan Intent Format

The expected flight plan intent given the mission and weather conditions should have looked similar to:

```
WISK01360L  225045S225  WISK02
130000130205150130130800130930
```

Appendix D: Exercise Safety Report

UAS INVOLVED IN EVENT (continued)

Operator	◉ Air Carrier ○ Commercial Operator ○ Military ○ Other: ______________ ○ Air Taxi ○ Government (local, state, federal, tribal) ○ Recreational / Hobbyist
Mission	○ Agriculture ◉ Passenger ○ Surveying / Mapping ○ Banner Tow ○ Photo Shoot / Video ○ Test Flight / Demonstration ○ Cargo / Freight / Delivery ○ Public Safety / Pursuit ○ Training ○ Communications ○ Recreational / Hobbyist ○ Utility / Infrastructure (Inspection) ○ Observation / Surveillance ○ Search & Rescue ○ Other: ____________________
Flight Operated As	○ VLOS (Visual Line of Sight) ◉ BVLOS (Beyond VLOS) — With Visual Observer? ○ Yes ◉ No
UAS Control Mode (at time of event)	◉ Autonomous / Fully Automated ○ Manual Control ○ Waypoint Flying ○ Transitioning Between Modes
Flight Phase (at time of event)	Arrival

Was the UAS flying in, near or over: (select all that apply)

☐ Aerial Show / Event (e.g. fireworks, airshow)
■ Aircraft / UAS
■ Airport / Aerodrome / Heliport
☐ Critical Infrastructure
☐ Crowds (e.g. sporting event, concert, festival)
☐ Emergency Services (e.g. police, fire)
☐ Indoors / Confined Spaces
☐ Moving Vehicles (e.g. highways, busy streets, bridges)
☐ Natural Disaster
☐ No Drone Zone
☐ Open Space / Field
☐ People / Populated Areas (e.g. residential)
☐ Private Property
☐ Recreational Club / Fixed Flying Site
☐ Other: ________________________

UAS / AIRCRAFT 2 INVOLVED IN EVENT

Make / Model: (or describe)	Unknown UAS — ○ UAS ◉ Manned Aircraft
UAS Weight Category	○ Micro UAS ◉ Small UAS ○ Medium UAS ○ Large UAS
UAS Configuration	◉ Multi-Rotor ○ Fixed Wing ○ Helicopter ○ Hybrid (e.g. VTOL) ○ Other: __________________
Operator	○ Air Carrier ○ Corporate ○ Personal ○ Air Taxi ○ Government (local, state, federal, tribal) ◉ Recreational / Hobbyist (UAS) ○ Commercial Operator (UAS) ○ Military ○ Other: __________________
Flight Phase (at time of event)	Cruise

If more than two aircraft or UAS was involved, please describe the additional aircraft / UAS in the "Describe Event / Situation" section.

UAS LOCATION

Altitude: 3,000 feet ○ AGL (above ground level) ◉ MSL (mean sea level)

Closest Airport:	State:	Distance: (nautical miles)
KSNL	CA	7.00
Closest VOR / NAVAID:	**State:**	**Distance:** (nautical miles)

NEAR MISS CONFLICTS

Estimated miss distance from UAS / Aircraft:
Horizontal: 2,000.00 feet Vertical: 50.00 feet

How was the UAS / Aircraft conflict avoided?
Operator commanded evasive action ◉ Yes ○ No
Collision avoidance system maneuver ◉ Yes ○ No

CONTRIBUTING FACTORS

What factors may have contributed: (select all that apply)

☐ Airspace Authorization / Flight Planning App
☐ Command and Control (e.g. lost link, frequency interference)
☐ Environment (e.g. terrain, obstructions, lighting, fire)
■ FAA Regulation Misinterpretation / Unaware
☐ Ground Control Station / Remote Control Transmitter (e.g. hardware failure, interface / display)
■ Human Factors (e.g. fatigue, confusion, situational awareness)
☐ Software and Automation (e.g. geofencing, return to home)
☐ UA Equipment (e.g. components, sensors, payload)
☐ Weather Conditions (e.g. wind gust, lightning)
☐ Other: ________________________

DESCRIBE EVENT / SITUATION

Keeping in mind the topics shown below, discuss those which you feel are relevant and anything else you think is important. Include what you believe really caused the problem, and what can be done to prevent a recurrence, or correct the situation. (USE ADDITIONAL PAPER IF NEEDED)

While returning to KSNL, an unplanned descent to 3,000 was accomplished to avoid co-altitude traffic. After level at 3,000, automated systems detected a small UAS directly in front of the aircraft and commanded a hard left turn to avoid. Aircraft deviated 3NM off course to the south before obtaining updated ATC clearance for a new arrival at KSNL.

Page 2 of 3

CHAIN OF EVENTS
- How the problem arose
- Contributing factors
- How it was discovered
- Corrective actions

HUMAN PERFORMANCE CONSIDERATIONS
- Perceptions, judgments, decisions
- Factors affecting the quality of human performance
- Actions or inactions

NASA ARC 277U (February 2021)

Reset Form

For immediate action of UNSAFE or UNAUTHORIZED drone operations contact local authorities.

DO NOT REPORT UAS ACCIDENTS AND CRIMINAL ACTIVITIES ON THIS FORM.
ACCIDENTS AND CRIMINAL ACTIVITIES ARE NOT INCLUDED IN THE ASRS PROGRAM AND SHOULD NOT BE SUBMITTED TO NASA.
ALL IDENTITIES CONTAINED IN THIS REPORT WILL BE REMOVED TO ASSURE COMPLETE REPORTER ANONYMITY.

IDENTIFICATION STRIP: *Please fill in all blanks to ensure return of ID strip to you. NO RECORD WILL BE KEPT OF YOUR IDENTITY.* This section will be returned to you.

(SPACE BELOW RESERVED FOR ASRS DATE/TIME STAMP)

TELEPHONE NUMBERS where we may reach you for further details of this occurrence:

HOME Area ______ No. ____________ Hours ____________

OTHER Area ______ No. ____________ Hours ____________

NAME Wisk Aero

ADDRESS/PO BOX ____________

____

CITY ____________ **STATE** ____ **ZIP** ________

TYPE OF EVENT / SITUATION

NASA/Wisk Flight Tabletop Exercise

DATE OF OCCURRENCE (MM/DD/YYYY) 10/25/2022

LOCAL TIME (24 hr. clock) (HH:MM) ____________

PLEASE FILL IN APPROPRIATE SPACES AND CHECK ALL ITEMS WHICH APPLY TO THIS EVENT OR SITUATION.

REPORTER

How were you involved in the UAS operation?	○ Single Person Crew ◉ Multi-Person Crew ○ Not Involved (e.g. eyewitness)
If part of a Multi-Person crew tell us:	Crew Size: 1 (total including reporter) Role at time of event: (select all that apply) ☐ Person Manipulating Controls ☐ Remote Pilot in Command (RPIC) ☐ Visual Observer ☒ Other Crew Member: Multi Vehicle Supvsr
Reporter Location	○ Outdoor / Field Station ◉ Indoor / Ground Control Station ○ Repair Facility ○ Other: ________
Time manipulating controls of UAS (Estimated Time, round to nearest quarter hour)	Total Time to Date in all UAS Make / Models: 100.00 hrs (e.g. 14.25) Time Last 90 Days in all UAS Make / Models: 100.00 hrs (e.g. 9.50) Time to Date in UAS Make / Model involved in event: 100.00 hrs (e.g. 0.75)
Manned aircraft flight experience (if applicable)	Total Time: 0.00 hrs
FAA Certificates / Ratings held	☐ Remote Pilot / Part 107 ☐ Private - Manned ☐ Commercial - Manned ☐ ATP - Manned ☐ Flight Instructor - Manned ☐ Instrument - Manned ☐ Multiengine - Manned ☐ N/A (non-certificated recreational flyer) ☒ Other: MVS

WEATHER ELEMENTS

☒ Clear ☐ Haze/Smoke ☐ Snow ☐ Wind
☐ Fog ☐ Icing ☐ Thunderstorm ☐ Windshear
☐ Hail ☐ Rain ☐ Turbulence ☒ Other: High Winds

LIGHT / VISIBILITY

○ Dawn ○ Night ◉ Daylight ○ Dusk

Cloud Ceiling ________ feet

Visibility ________ miles

AIRSPACE

☐ Class A ☒ Class D ☐ Special Use (e.g. MOA, Restricted, Prohibited)
☐ Class B ☒ Class E ☐ Temporary Flight Restriction (TFR)
☐ Class C ☒ Class G

AIRSPACE AUTHORIZATION PROVIDER

○ Authorized Third Party (e.g. USS / UTM App, LAANC provider)
○ FAA Authorization (e.g. FAA Drone Zone, Fixed Flying Site LOA)
○ N/A (e.g. class G airspace)
◉ Other: PSU

UAS INVOLVED IN EVENT

UAS Make / Model / Series: (or write "Homebuilt")	Wisk Aero Gen6 (do not include registration or serial number)
Weight Category (at takeoff with payload)	○ Micro UAS (< 0.55 lbs) ○ Small UAS (at or above .55 lbs & < 55 lbs) ○ Medium UAS (at or above 55 lbs < 1320 lbs) ◉ Large UAS (at or above 1320 lbs)
Configuration	○ Multi-Rotor ○ Fixed Wing ○ Helicopter ◉ Hybrid (e.g. VTOL) ○ Other: ________
How many UASs were you controlling? (at time of event)	1
Rule Flying Under	○ 91 (Private / non-commercial) ○ 107 (UAS) ○ 133 (Helicopters w/ external loads) ◉ 135 (Chartered / non-scheduled flights) ○ 137 (Agricultural Operations) ○ Public Aircraft Operations ○ Limited Recreational Operations, 349 / 44809 ○ Other: ________
Airworthiness Approval Certification (if applicable)	○ Standard AC ◉ Special AC ○ Special Authorization / Section 44807
Waivers / Exemptions / Authorizations	Were you operating under any Waivers / Exemptions / Authorizations? ○ Yes ◉ No FAR Section Number / Other: ________

NASA ARC 277U (February 2021) **UAS** OMB No. 2700-0172 Exp 7/31/2022

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AVIATION SAFETY REPORTING SYSTEM

NASA has established an Aviation Safety Reporting System (ASRS) to identify issues in the aviation system which need to be addressed. The program of which this system is a part is described in detail in FAA Advisory Circular 00-46F. Your assistance in informing us about such issues is essential to the success of the program. Please fill out this form as completely as possible, enclose in an sealed envelope, affix proper postage, and and send it directly to us.

The information you provide on the identity strip will be used only if NASA determines that it is necessary to contact you for further information. THIS IDENTITY STRIP WILL BE RETURNED DIRECTLY TO YOU. The return of the identity strip assures your anonymity.

Section 91.25 of the Federal Aviation Regulations (14 CFR 91.25) prohibits reports filed with NASA from being used for FAA enforcement purposes. This report will not be made available to the FAA for civil penalty or certificate actions for violations of the Federal Air Regulations. Your identity strip, stamped by NASA, is proof that you have submitted a report to the Aviation Safety Reporting System. We can only return the strip to you if you have provided a mailing address. Equally important, we can often obtain additional useful information if our safety analysts can talk with you directly by telephone. For this reason, we have requested telephone numbers where we may reach you.

Thank you for your contribution to aviation safety.

NOTE: AIRCRAFT ACCIDENTS SHOULD NOT BE REPORTED ON THIS FORM. SUCH EVENTS SHOULD BE FILED WITH THE NATIONAL TRANSPORTATION SAFETY BOARD AS REQUIRED BY NTSB Regulation 830 (49CFR830).

Paperwork Reduction Act Statement - This information collection meets the requirements of 44 U.S.C. § 3507, as amended by section 2 of the Paperwork Reduction Act of 1995. You do not need to answer these questions unless we display a valid Office of Management and Budget control number. The OMB control number for this information collection is 2700-0172 and it expires on 7/31/2022. We estimate that it will take about 30 minutes to read the instructions, gather the facts, and answer the questions. You may send comments on our time estimate above to: P.O. Box 189 Moffett Field, CA 94035-0189.

If you want to mail this form, please fold pages, enclose in a sealed, stamped envelope, and mail to:

NASA AVIATION SAFETY REPORTING SYSTEM
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MOFFETT FIELD, CA 94035-0189

DESCRIBE EVENT / SITUATION (continued)

Page 3 of 3

CHAIN OF EVENTS	HUMAN PERFORMANCE CONSIDERATIONS
- How the problem arose - Contributing factors - How it was discovered - Corrective actions	- Perceptions, judgments, decisions - Factors affecting the quality of human performance - Actions or inactions

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