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Development of a Safety Hazards Risk Assessment Tool for Uncrewed Aircraft System Traffic Management During Preflight Planning

Vimmy Gujral, NASA Ames Research Center

Paul U. Lee, NASA Ames Research Center

Gregory Costedoat, San Jose' State University

Jolene M. Feldman, NASA Ames Research Center

Lilly Spirkovska NASA Ames Research Center

Charles M. Walter, ASRC Federal Data Solutions, LLC

Future Airspace Operations & Safety



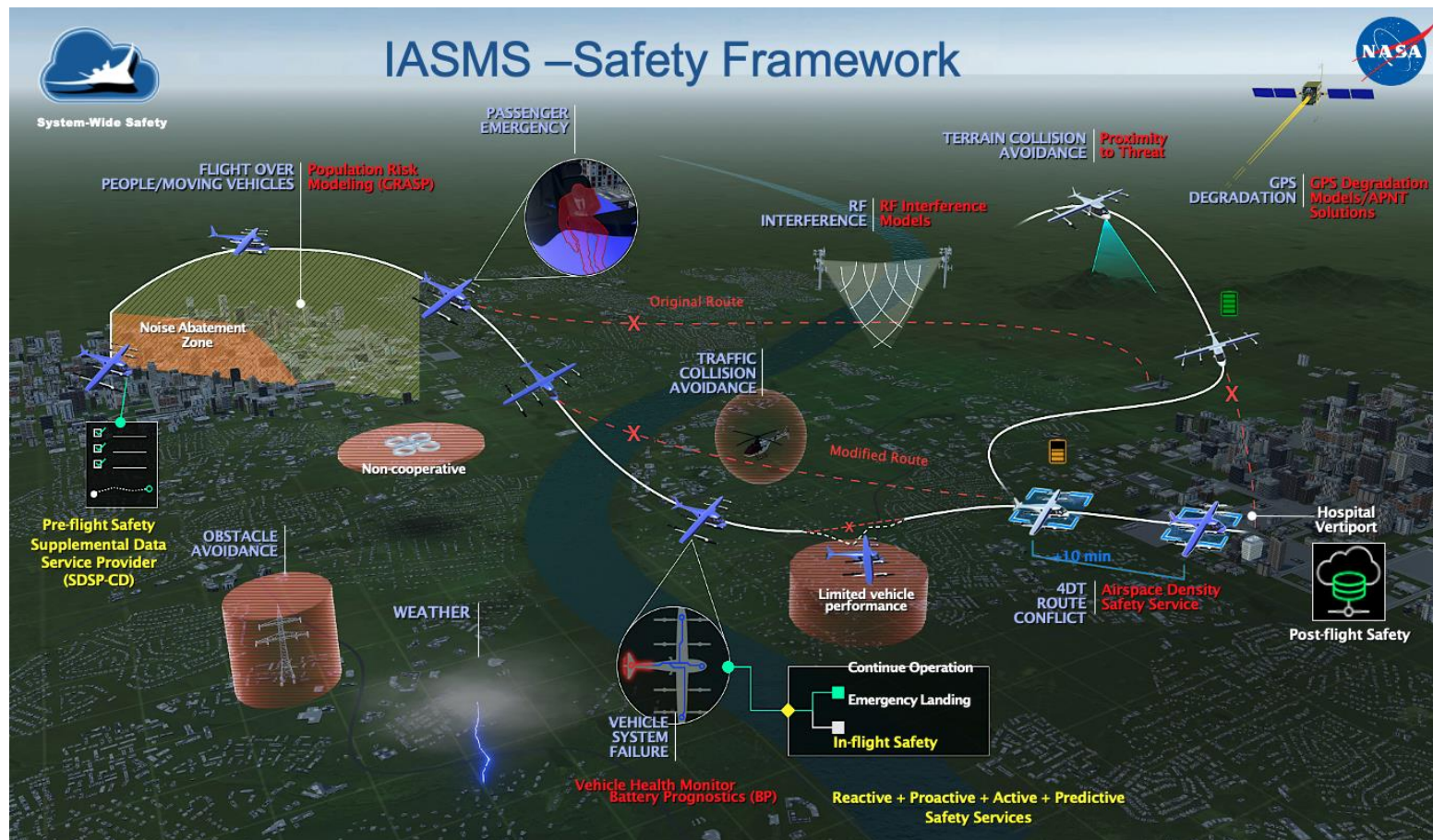
Safe and efficient scalable integration of diverse emerging operations in complex airspace

- Within Unmanned Aircraft System Traffic Management (UTM) ecosystem
- Sustainable framework (economic, environmental and social)

To achieve this, we need to embrace innovation on all fronts:

- Advanced visualization tools
- Leverage emerging technologies
- Explore new operational methods

NASA's System Wide Safety Project

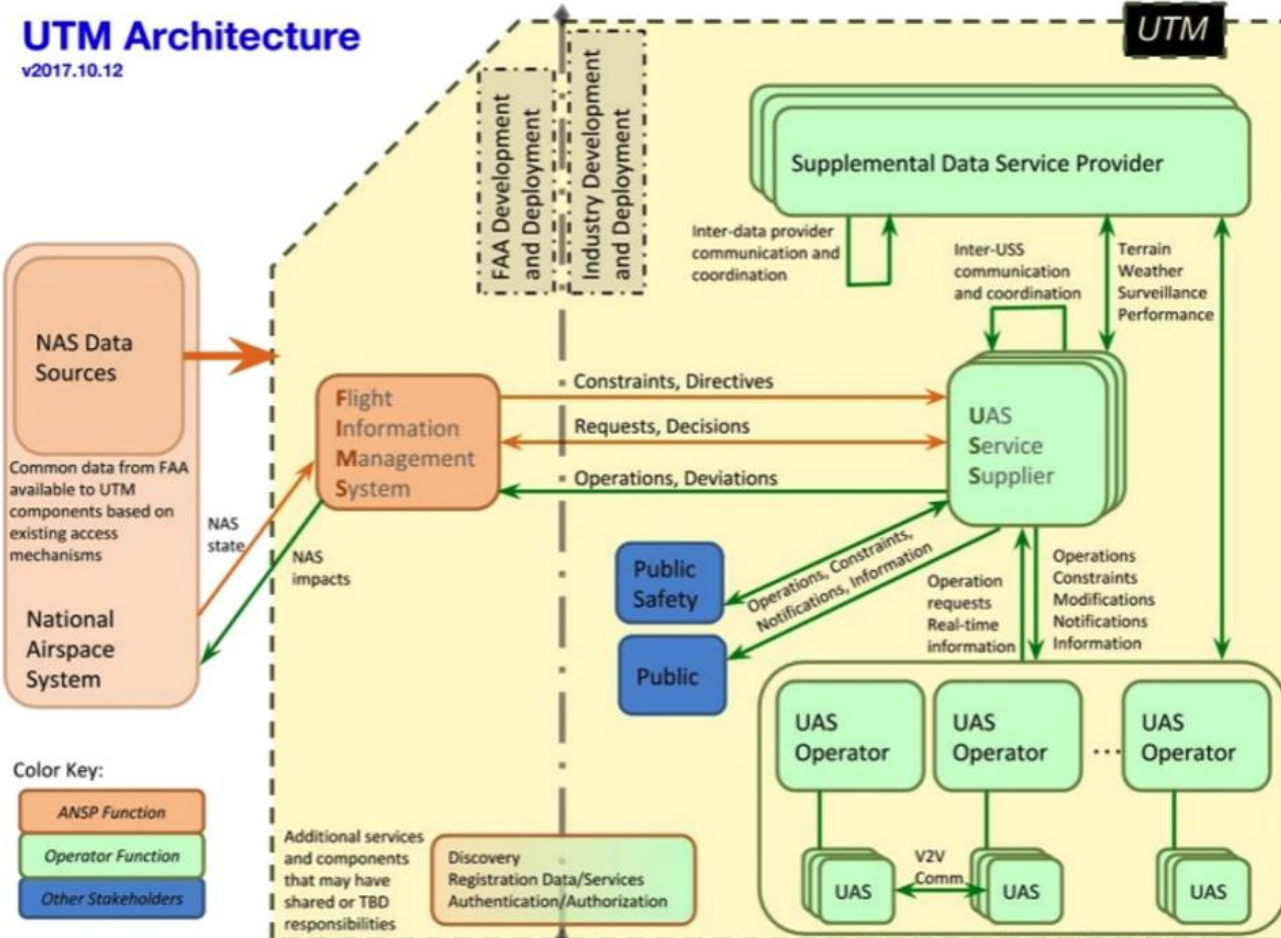


In-Time Aviation Safety Management System (IASMS)

- Safety technologies that monitor, assess and mitigate risks for diverse scalable emerging operations using flexible service-oriented architecture
- Leverages system-wide data for timely alerts and risk mitigation
- Adapts to future innovations in vehicles, airspace, services and ensures a safe future “Sky for all”
- Develop risk models and User Interface designs

This work was supported by the System Wide Safety project under the Airspace Operations and Safety Program within the NASA Aeronautics Research Mission Directorate (ARMD).

Role of Supplemental Data Service Provider (SDSP) in Unmanned Aircraft System Traffic Management (UTM)



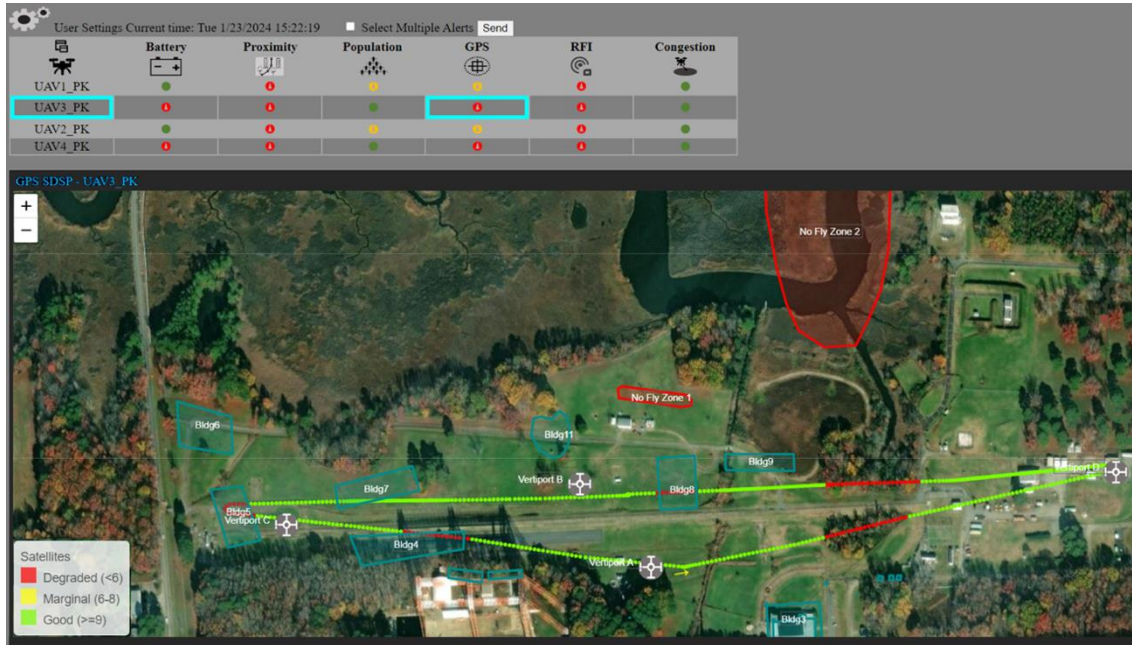
- Real time data exchange available between fleet managers/ operators and **SDSPs** or via UAS Service Supplier
- Federal Aviation Administration (FAA) can send directives and constraints to UAS fleet managers/ operators via UAS Service Supplier



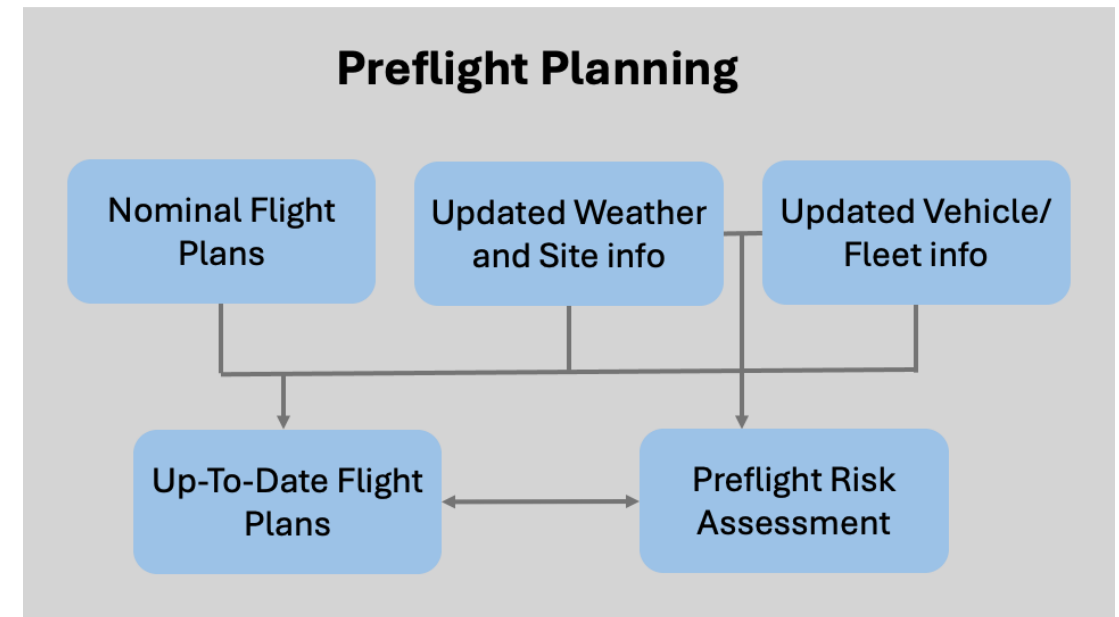


Supplemental Data Service Provider - Consolidated Dashboard (SDSP-CD)

Overview of SDSP-CD



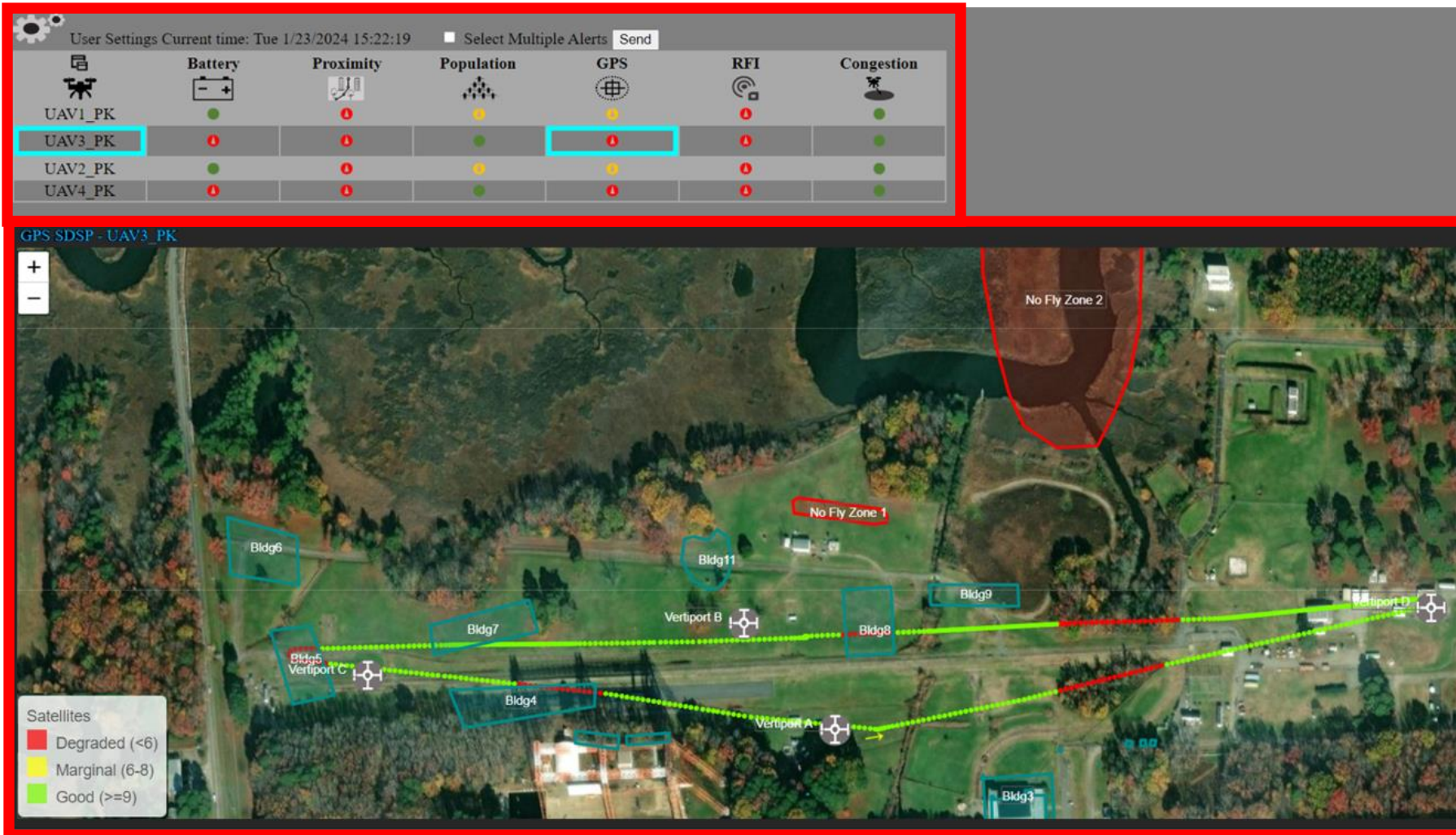
- Prototype **Preflight** Risk Assessment Tool
- Designed for **fleet manager** to ensure safe operation of a large fleet of sUAS operations



Services Integrated into SDSP-CD

- Battery Reserve 
- Proximity to Threat 
- Population Density and Probability of Casualty 
- GPS Coverage 
- Radio Frequency Interference (RFI) 
- Vertiport Congestion 

Consolidated Dashboard



Dashboard: Provides a hazard summary for six services:

- Indicates their type and level of risk

Interactive Map:

- Hazard locations
- UAS flight paths
- Geographical information

Dashboard



 User Settings

Current time: Wed 8/14/2024 14:33:15

☐ Select Multiple Alerts Send

	Battery	Proximity	Population	GPS	RFI	Congestion
RECON_1						
RECON_2						
RECON_3						

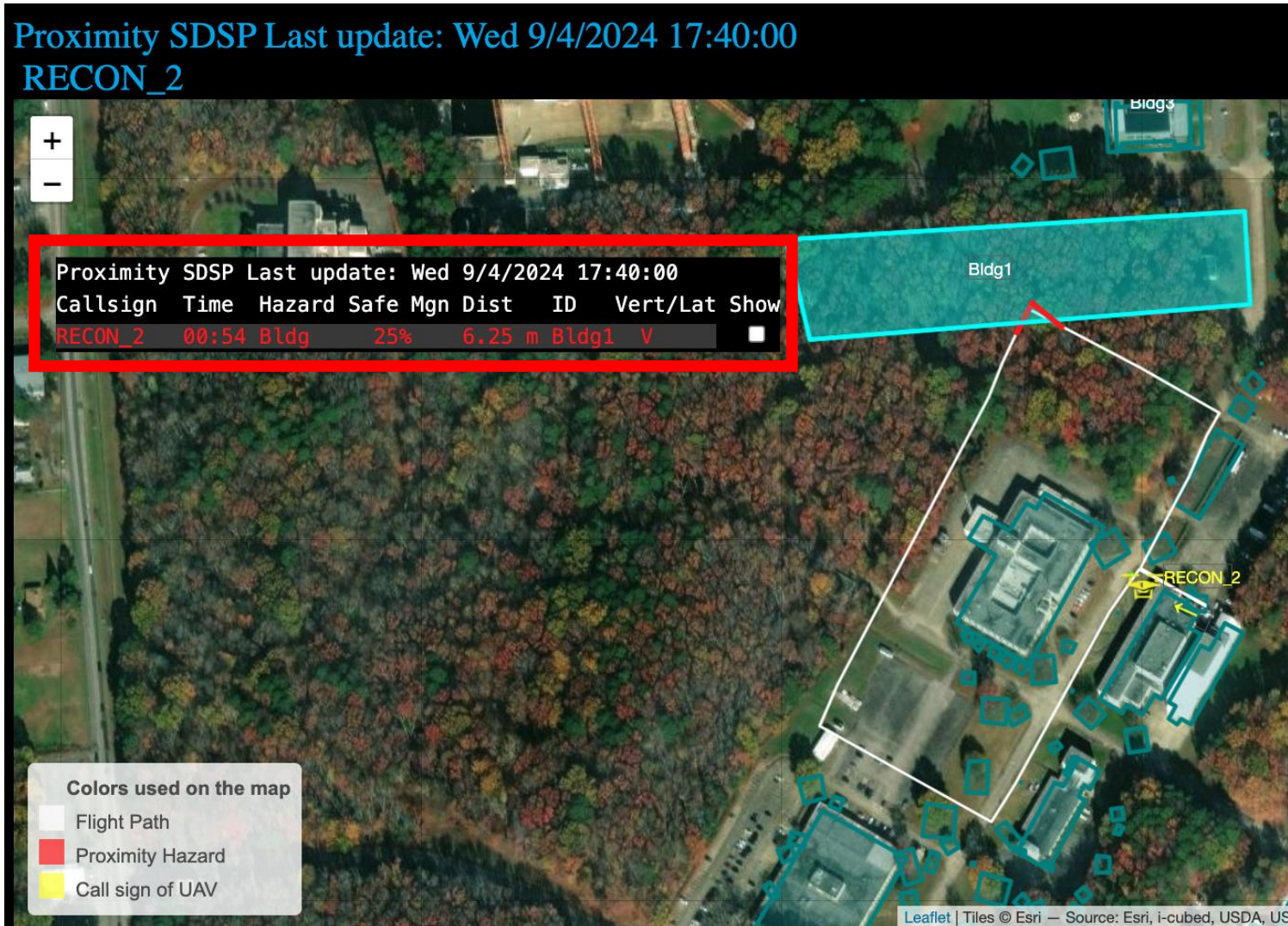
- Color-coded hazard alerts indicate the status of each service for a vehicle
- **Select Multiple Alert** feature provide combined information for the selected vehicles and services (currently working only for Battery and Proximity services)
- User Settings option to set safety thresholds from a predefined safe range for SDSP alerts

Battery Service



- Predicts battery charge degradation throughout the flight
- Yellow battery icons on the route indicate nearing battery reserve limits and red battery icon when it will drop below them while the EOD (End of Discharge) point predicts a critically low reserve at landing.
- Additional details in alert box:
 - Estimated time until the battery reaches the reserve limit
 - Estimated available flight distance the vehicle can travel within that remaining battery time

Proximity Service



- Predicts proximity to static obstacles along a proposed route
- Additional details in alert box:
 - Time to hazard
 - Type of hazard
 - Safety margin
 - Shortest distance between trajectory points and obstacles
 - Obstacle ID
 - Type of threat (vertical or lateral)

Population Service



- Predicts the density of population along the route and probability of casualties in the event of an unscheduled landing
 - Highlights high population density areas
 - Marks the corresponding impact points along its flight path

GPS Service



GPS SDSP - UAV3_PK



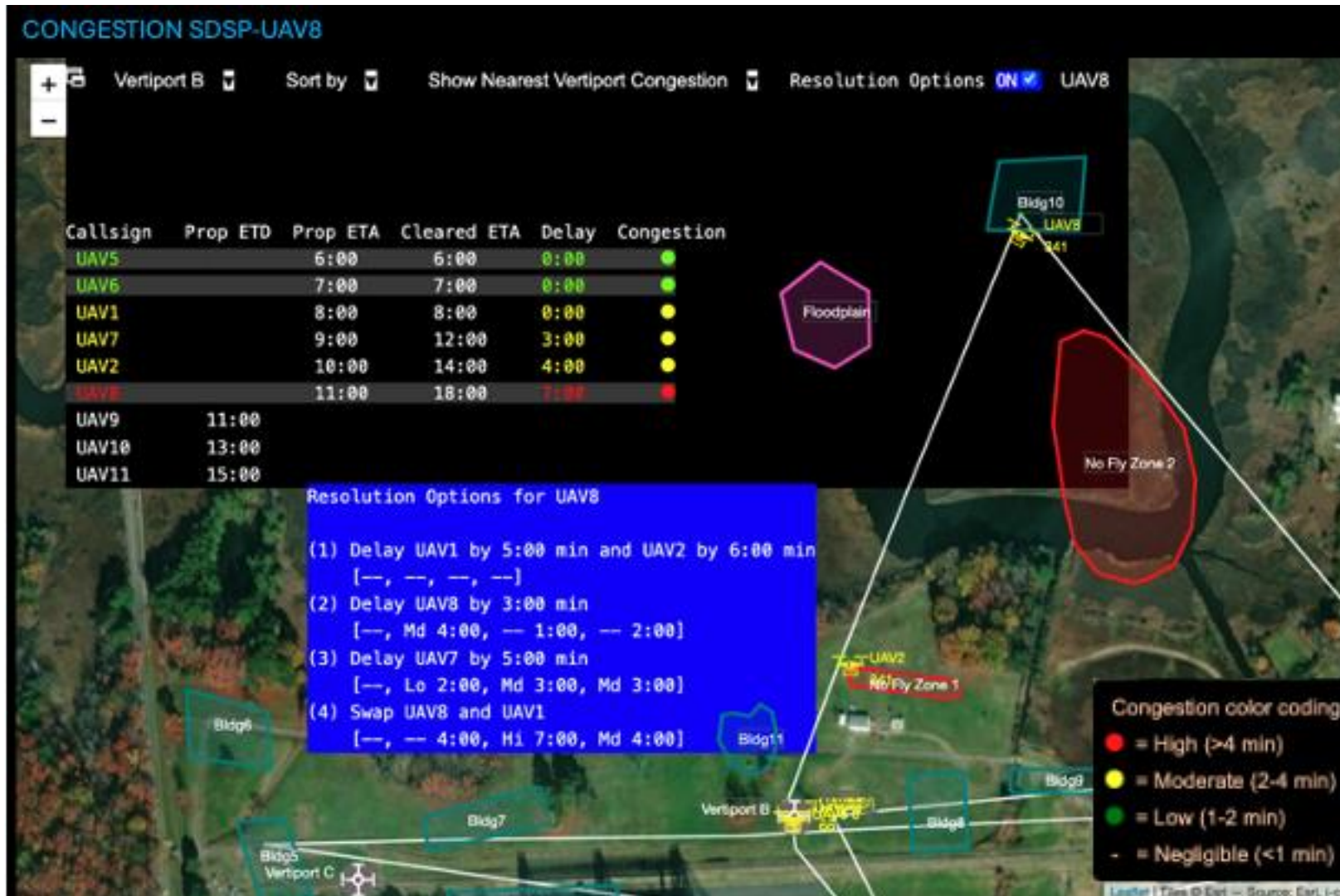
- Predicts GPS coverage for every point along the proposed flight path
- Displays the level of risk based on the number of satellites visible at each point along the flight path

Radio Frequency Interference(RFI) Service



- Predicts the likelihood of signal disruption caused by RFI affecting communication between the ground station and vehicle
 - Displays the level of risk at each point along the proposed flight path

Vertiport Congestion Service



- Predicts how busy vertiports will be and gives insights on possible delays
- Focuses on vertiport operations rather than flight paths
- Analyzes peak traffic times to identify potential delays due to insufficient parking spots at landing areas

Vertiport Congestion Service

Flight Schedule panel

Callsign	Prop ETD	Prop ETA	Cleared ETA	Delay	Congestion
UAV5		6:00	6:00	0:00	●
UAV6		7:00	7:00	0:00	●
UAV1		8:00	8:00	0:00	●
UAV7		9:00	12:00	3:00	●
UAV2		10:00	14:00	4:00	●
UAV8		11:00	18:00	7:00	●
UAV9	11:00				
UAV10	13:00				
UAV11	15:00				

- Displays the flight schedule view for a vertiport, highlighting the predicted traffic congestion
- Includes the congestion risk for the selected vehicle and nearby vehicles scheduled to land around the same time
- Shows callsigns, proposed ETD and ETA, cleared ETA, expected delays and congestion risk level

Congestion color coding:

- = High (> 4 min)
- = Moderate (2-4 min)
- = Low (1-2 min)
- = Negligible (< 1 min)

Vertiport Congestion Service

Resolution Options for UAV8

```
(1) Delay UAV1 by 5:00 min and UAV2 by 6:00 min  
    [--, --, --, --]  
(2) Delay UAV8 by 3:00 min  
    [--, Md 4:00, -- 1:00, -- 2:00]  
(3) Delay UAV7 by 5:00 min  
    [--, Lo 2:00, Md 3:00, Md 3:00]  
(4) Swap UAV8 and UAV1  
    [--, -- 1:00, Hi 7:00, Md 4:00]
```

Resolution Option Panel:

- Suggests ways to reduce delays for flights facing moderate or high congestion
- Options are ranked by effectiveness in lowering congestion
- Options include speeding up, delaying, canceling, redirecting flights, or swapping landing sequences

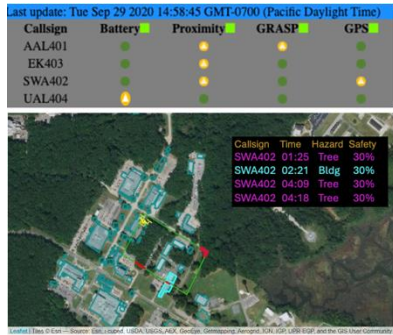
Average delay is categorized as negligible, low, moderate or high for each 3-minute period

- A dashed line means congestion is fully resolved within a 3-minute period
- No dashes mean congestion is not fully resolved and delay may extend into next time period

Resolution options were created manually for the study to explore automated solutions

ITERATIVE DESIGN, DEVELOPMENT, AND EVALUATION OF SDSP-CD

2021



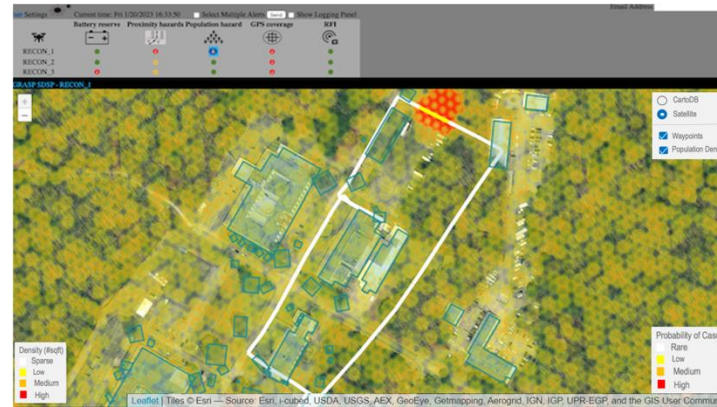
Introduction of Two-Panel Design included a first panel presenting four services with a status indicator next to each service and second panel displaying a map with detailed alert information

2022



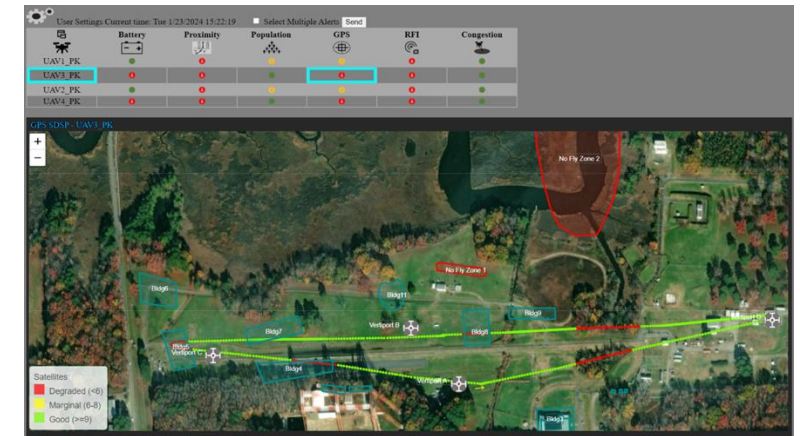
Introduction of consolidated dashboard with user-selectable parameters, adjusted color scale, simplified legends, streamlined navigation and added "Select Multiple Alert" feature

2023



Integrated RFI service with new proximity and battery alert features: added shortest distance to obstacle and hazard ID columns to the proximity alert box, introduced a distance-to-reserve column in the battery alert box and added a yellow marker on route that indicated approaching the battery reserve threshold

2024



Integration of Congestion service, improved Select Multiple Alert feature, added banded rows, added a new column in proximity alert box to indicate type of threat (vertical/ lateral) and some more feedback incorporated from previous evaluation

Ongoing Research

User feedback and performance metrics from each version were used to refine and enhance the next iteration ¹⁸

SDSP-CD Usability Study 2024

Objective: SDSP-CD User Interface Evaluation

- Evaluation of updated interface with a new vertiport congestion service
- Comparison of updated interface with previous version to verify the UI improvement

Method:

- Updated interface for preflight planning
- Participants in fleet manager role
 - Sixteen Part 107 certified participants

Result:

- Strong general agreement on UI improvement
- Broad consensus in effectiveness for reducing potential safety hazards
- Satisfactory design for most services
- Suggestions for future improvements



Costedoat, G., Lee, P.U., Feldman, J.M., Gujral, V., Spirkovska, L., and Walter, C.M.,

["Usability of an Updated Version of the Supplemental Data Service Provider-Consolidated Dashboard for Supporting Uncrewed Aircraft System Traffic Management."](#)

AIAA 2024-3738. AIAA AVIATION FORUM AND ASCEND 2024 . July 2024.

Next Steps



- Incorporate updates into SDSP-CD
- Improve UI for Congestion Service
- Incorporate additional services like wind/weather into SDSP-CD
- Integrate SDSP-CD into flight and mission planning tools

Thank you!

Questions?

vimmy.gujral@nasa.gov