National Aeronautics and Space Administration

AOSP Newsletter

Airspace Operations and Safety Program (AOSP)

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AOSP IN THE NEWS

With NASA Partnership, Orlando Begins Planning for Air Taxis, Flying Cars

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Orlando (FL) Sentinel (10/7) reports "With NASA partnership, Orlando is preparing for when flying cars are an option for those who want to soar over congested highways or between nearby cities. And they may arrive far sooner than 2062, as The Jetsons predicted."

TECHNICAL AND PROGRAMMATIC HIGHLIGHTS

NASA Kicks Off Autonomy V&V 2045 Vision NRA

POC: GUILLAUME BRAT

On Oct. 1, the NASA Autonomy Verification and Validation (V&V) 2045 Vision NASA Research Announcement (NRA) was kicked off between NASA's System-Wide Safety project and a Boeing-led contractor team. The main goal of this NRA is to develop a comprehensive landscape of the V&V needs for autonomy through 2045. Moreover, this NRA team will also develop an assurance (V&V techniques) technology roadmap to describe what services would be enabled if these technologies are realized, and identify the technologies needed to fill the gaps in the current regulatory framework for autonomy. The results of this NRA will provide guidance for future autonomy V&V technology development and will enable NASA to prioritize autonomy V&V funding over the next few years.

For this NRA, NASA selected a team led by Huafeng Yu (Boeing), including industry and academia experts. Major aviation companies were represented by Mike Durling of General Electric Global Research, Darren Cofer of Collins Aerospace, as well as Boeing and its affiliates (e.g., Aurora). Academic experts include Ella Atkins of the University of Michigan, Chuchu Fan of the Massachusetts Institute of Technology, and Ufuk Topcu of the

University of Texas at Austin. This core team will be responsible for developing the documents and will be advised by representation from government agencies, including the FAA, the Air Force Research Lab, the Naval Research Lab, and the Defense Advanced Research Projects Agency, which all have an important stake in this technology. The report's first draft will be available in Jan. 2022, while the final report will be developed by the end of Sep. 2022.

The kickoff presentations mostly focused on short introductions by the team, the project's goals and scope, the process that will be followed to develop the roadmap, and the schedule. This kickoff was well attended by NASA staff and researchers as well as representatives from other government agencies. AOSP Director Akbar Sultan and Transformative Aeronautics Concepts Program Director John Cavolowsky were in attendance and both emphasized the importance of the work in shaping the Aeronautics Research Mission Directorate's future research.

NC and UAM Conduct Follow-on Meeting with Wisk Aero

POC: KEVIN WITZBERGER

On Oct. 1, representatives from the National Campaign (NC) and the Air Traffic Management-eXploration project's Urban Air Mobility (UAM) subproject held a follow-on meeting

with Wisk Aero. The meeting's purpose was to discuss potential airspace, routes, and procedures, following initial discussions held back in Sept. Wisk Aero is a key vehicle developer and participant in the NC-1 flight tests due to their desire to lean into partnering with multiple X4 airspace partners that are currently collaborating with NASA to develop their company's Provider of Services for UAM that will be tested in the X4 simulation effort. Following the simulation activity, Wisk Aero and multiple airspace providers will conduct a flight demonstration with an electric vertical takeoff and landing vehicle to assess the functional allocation and data exchanges needed for scalable UAM operations.

ATM-X xTM ETM Team Meets with FAA and Industry

POC: JAEWOO JUNG

On Oct. 5, the Air Traffic Management-eXploration (ATM-X) project's Extensible Traffic Management (xTM) subproject Upper Class E Traffic Management (ETM) team met with representatives from the FAA and industry. In this meeting, Airbus and Sceye shared information regarding their recent flight tests, and a representative from the Aerospace Industries Association presented a proposal for the Cooperative Operations in Higher Airspace Concept. This proposal is in a draft stage and the group discussed the proposed concept. The meeting con-

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cluded with an update on NASA's ETM simulation work. The group is planning to meet once more in 2021 to further discuss and develop ETM concepts.

Proof-of-Concept of Airline Operations Center Dashboard

POC: NIKUNJ OZA, CHAD STEPHENS
 AND LANCE PRINZEL

On Oct. 5, Booz Allen Hamilton demonstrated to the System-Wide Safety project team a dashboard displaying the results of running machine learning (long short-term memory) time series methods (auto-regressive integrated moving average), and survival analysis (Kaplan-Meier estimator) on FAA System-Wide Information Management data. The dashboard displayed the risk of unstable approaches for each flight for each point along its track. By displaying this for multiple tracks, an indication of risk for regions of the airspace can also be visualized. This demonstration was a proof-of-concept that is a stepping-stone toward a dashboard demonstration that will constitute the final deliverable of Technical Challenges-1 (Integrated Terminal Area Risk). The final deliverable dashboard will take, as input, data that is currently used by the American Airlines International Operations Center and will return one or more measures

of risk, including anomalies and precursors to safety issues.

ATM-X DIP and TACP Data and Reasoning Fabric Teams Conduct TIM

POC: MIRNA JOHNSON

On Oct. 6, the Air Traffic Management-eXploration (ATM-X) project's Digital Information Platform (DIP) subproject and the Data and Reasoning Fabric team from the Transformative Aeronautics Concepts Program's (TACP's) Convergent Aeronautics Solutions project gathered for the first in a series of virtual Technical Interchange Meetings (TIMs) to share approaches of common capabilities identified in both projects and to identify potential areas for collaboration or integration. Each project offers a platform or framework to connect services and there are some common basic features with similar requirements. However, due to different community needs and objectives, there are also differentiation features. The first TIM covered approaches to common functionalities in terms of deployment and cloud usage. Follow-on TIMs will cover additional common functionalities, such as registry and catalog of services, as well as security for authentication and authorization.

SWS Project Meets with UAS Service Providers

POC: MICHAEL VINCENT

On Oct. 6, System-Wide Safety (SWS) project representatives Michael Vincent, associate project manager, and Ersin Ancel attended the Association for Unmanned Vehicle Systems International Hampton Roads Autonomous Systems Demonstration Day event to network with companies developing Unmanned Aircraft Systems (UAS) and UAS-related services to explore potential collaborations with the SWS project. They met with CEO Marco Sterk of Longbow Group to discuss the possibility of collaborating on their upcoming effort to get approval to fly UAS between Fort Monroe in Hampton, Virginia, and the City Environment for Range Testing of Autonomous Integrated Navigation (CERTAIN) facility at NASA's Langley Research Center in Virginia. In addition, they met with CEO Bill Fredricks of Advanced Aircraft Company to discuss the applicability of their long endurance, hybrid-powertrain UAS to monitor methane emissions from landfills. This is a current UAS operation of interest for a Small Business Innovative Research (SBIR) contractor. The SWS representatives also met with Vice

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President James Eanes of Daniel H. Wagner Associates to discuss the applicability of two of their SBIR contracts involving urban microclimate monitoring and autonomy assurance. Follow up meetings with all three contacts are currently being planned.

ATM-X DIP Team Conducts Technical Interchange Meeting with FAA
POC: MIRNA JOHNSON

As an outcome of the recent NASA/FAA Quarterly Review held in late Aug., the Air Traffic Management-eXploration (ATM-X) project's Digital Information Platform (DIP) subproject held a Technical Interchange Meeting (TIM) with the FAA from Oct. 13-14. The TIM's focus was related to the FAA's Flight and Flow Information for Collaborative Environment. The meeting provided an opportunity for NASA to hear and ask questions firsthand from the FAA on requirements, constraints, and concerns. The flight and flow data will be part of the extensible and dynamic data sharing for decision-making and negotiation. The DIP team is looking to learn more about the object data structures to inform the digital information sharing architecture for the DIP platform. The information layer is important to support microservices in an information-centric National Airspace System architecture. Standardizing information exchange will enable the platform to be more flexible and more scalable than previous systems. Follow-on activities going forward will be coordinated under the Digital Mesh Technology and Applications Research Transition team.

NASA Participation at DARPA Assured Autonomy Principal Investigator's Meeting
POC: NATASHA NEOGI

From Oct. 13-15, NASA System-Wide Safety project researcher Natasha Neogi participated in the principal investigator's meeting of the Defense Advanced Research Projects Agency's (DARPA's) Assured Autonomy project. As a subject matter expert, Neogi attended several breakout sessions related to scalability issues as well as domain specific robustness concerns. Assured Autonomy participants briefed DARPA and government subject matter experts on their progress, including efforts targeted toward the formal assurance of neural networks with rectified linear units, runtime monitoring and verification approaches for safety critical applications, and techniques for assessing the safety of Learning Enabled Cyber Physical Systems (LE-CPS) under uncertainty and disturbances. The Assured Autonomy project aims to enable continual assurance of the learning enabled system. Participants seek to create guarantees of safety and functional correctness for the system, provided provisionally at design time, and then to continually monitor, update, and evaluate the system at operation time as the system and its environment evolves. While the Assured Autonomy project research objectives prioritize challenge problems in the militarily relevant autonomous vehicle space, it is anticipated that the tools, toolchains, and algorithms created will be relevant to other LE-CPS, specifically in civil aviation and space applications. The website for the meeting is: https://www.darpa.mil/program/assured-autonomy

System-Wide Safety Project Kicks Off New Research Awards
POC: ALWYN GOODLOE AND MISTY DAVIES

This past quarter the System-Wide Safety project held two virtual kickoff meetings for new research awards. The first one occurred from Oct. 4-5 with Geometric Data Analytics, Inc. (GDA). Approximately 20 people were in

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attendance from GDA, NASA's Langley Research Center in Virginia, NASA's Ames Research Center in California, the University of Virginia, Collins Aerospace, University of Minnesota, Raytheon, the National Science Foundation, Air Force Office of Scientific Research, and the Office of the Secretary of Defense. The focus of the award is to conduct a study on the potential for topological data analysis to yield actionable specifications from high-dimensional data for assuring safety-critical machine learning-enabled applications such as autonomous aircraft. The talks showed how topological tools such as persistence diagrams and distributed persistence could illuminate the shape of high-dimensional data used to train and test deep learning systems. This analysis can yield topological invariants that can serve as actionable specifications for verifying machine learning-enabled systems. Also, techniques from topology can help answer questions such as why deep neural networks produce such good results. The GDA team also presented the concept of Optimal Uncertainty Quantification, which is a method for assuring systems as reliable, safe, or unsafe in the presence of uncertainty and novel input data. In addition, several use cases were presented. The GDA presentations

were given by lead investigator Paul Bendich, as well as James Polly, Abe Smith, and Gabrielle Angeloro. Matthew Dwyer of the University of Virginia presented his research on tools for assuring machine learning-enabled systems. A lively discussion ensued as the work being carried out on this award could greatly improve the tools being built in Dwyer's group. Additionally, there was lively interaction with Collins Aerospace, Raytheon, and University of Minnesota researchers, who are interested in applying the techniques to generate tests of machine learning-enabled systems.

The second kickoff meeting occurred on Oct. 15 with Galois, Inc. The award is for a new runtime verification framework tool that specifies properties that are to be verified at runtime. The framework generates C code monitors that are integrated with the system under observation. The focus of the award is to conduct research on applying automated tools to produce a mathematical proof that the C code generated is indeed equivalent to its specification. The concept is to generate a denotation of both the Copilot specification and the C code in the mathematical language used by Satisfiability Modulo Theories (SMT) solvers and use SMT-based proof engines to prove

a bi-simulation argument. The general methodology is applicable to verifying code generated from many embedded domain specific languages.

System-Wide Safety Project Presents to AAL Safety Leaders and Executives on SMS Improvements

POC: MISTY DAVIES AND KYLE ELLIS

On Oct. 20 and 22, Kyle Ellis and Misty Davies presented Safety Management System (SMS) improvements to the American Airlines (AAL) Operations Data Analysis Group (ODAG) and Operations Standards Board (OSB), respectively. The ODAG is the monthly meeting where lead safety professionals at the airline meet to discuss outcomes and identify necessary risk controls based on continuous SMS data analyses. ODAG's findings are then briefed to airline top safety and operations executives across multiple departments at the OSB, where risk mitigation actions to be taken are reviewed. One objective of the briefings included providing awareness and an overview to new AAL leadership of the recent developments toward a predictive and prognostic safety risk dashboard, enabled by machine learning-enabled algorithms, which are being demonstrated

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on airline Flight Operations Quality Assurance and Integrated Operations Center operational data.

ATM-X Meets with Aurora Flight Sciences to Discuss Potential Collaboration Opportunities
POC: KURT SWIERINGA

On Oct. 22, the Air Traffic Management-eXploration (ATM-X) project met with Aurora Flight Sciences, a subsidiary of Boeing, to discuss potential collaboration opportunities with the Pathfinding for Airspace with Autonomous Vehicles subproject. The discussions included overviews of NASA's and Aurora's work toward enabling the integration of increasingly autonomous aircraft into airspace shared with conventional aircraft to identify potential touch points. Future discussions will be used to flush out potential collaboration responsibilities for a Space Act Agreement.

SWS Project Holds Technical Interchange Meeting with Longbow Group
POC: KYLE ELLIS

On Oct. 26, several System-Wide Safety (SWS) project researchers held a Technical Interchange Meeting with Marco Sterk and Ken Dudley of Longbow Group. Longbow Group is leading the ecosystem development of the Fort Monroe Unmanned Aircraft Systems (UAS) test site located in Hampton, Virginia, and is in discussions with several regional and national industry partners to outline several UAS operational use cases. The SWS project is in the process of identifying key collaboration opportunities for joint flight tests with Longbow Group and its ecosystem partners. An additional Space Act Agreement annex beyond the initial high density Vertiports project annex could be needed to address specific research goals for the SWS project and its Technical Challenges-2 (In-Flight Safety Predictions for Emerging Operations) and future Safety Demonstrator Series flight tests.

ATM-X PAAV Subproject Briefs the NASA/FAA AAM Executive Board's ConOps Subgroup
POC: KURT SWIERINGA

On Oct. 28, the Air Traffic Management-eXploration (ATM-X) Pathfinding for Airspace with Autonomous Vehicles (PAAV) subproject povided an overview of their planned work at the NASA/FAA Advanced Air Mobility executive board's concept of operations subgroup. The presentation included discussion of the industry's need, barriers that prevent advancement to higher levels of autonomy, and the work the PAAV subproject is doing to address those gaps.

ATM-X DIP Subproject Attends first MR-TBO TIM at the FAA Testbed in Daytona Beach
POC: MIRNA JOHNSON

From Nov. 2-4, the Air Traffic Management-eXploration (ATM-X) project's Digital Information Platform (DIP) subproject team attended the FAA's first Multi-Regional Trajectory-Based Operations (MR-TBO) Technical Interchange Meeting (TIM) at the FAA testbed in Daytona Beach, Florida. A large portion of the meeting was dedicated to reviewing the scenarios needed to begin the integration and testing phase of the FAA's 2022 MR-TBO spring demonstration. The demonstration's goal is to inform requirements in a closed-loop system to identify challenges and gaps. The scenarios reviewed covered protocols and procedures for requesting, approving, and acknowledging trial plan requests and flight trajectory updates between multiple air traffic management service providers. The operations span pre- and post-departure scenarios, with multiple

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flights as the subject in each of the scenarios. The organizations collaborating in MR-TBO are looking to understand how to update and communicate a trajectory plan that everyone is working toward. The FAA and their partners will continue to work on the concept and risk reduction activities through FY24. The ATM-X project is collaborating with the FAA to identify valuable services and scenarios to further validate MR-TBO scope and procedures. By attending the TIM, the DIP team was able to gain insight into the benefits of MR-TBO and the challenges that remain to be addressed. Feedback from the TIM is being used as input to formulate concepts and select features for a flight deck service that would be valuable to demonstrate in FY25 for DIP's Sustainable Aviation-2 demonstration.

ATM-X PAAV Attends the Multi-Vehicle Working Group Meeting
POC: ARWA AWEISS

On Nov. 3, the Air Traffic Management-eXploration (ATM-X) project's Pathfinding for Airspace with Autonomous Vehicles (PAAV) subproject attended the Multi-Vehicle (m:N) Working Group meeting. The Working Group brings together stakeholders from government, industry, and academia

to identify and reduce barriers to m:N operations, an operational configuration that envisions a ratio of multiple operators (m) controlling multiple vehicles (N) between them. The barriers addressed by the Working Group range from technical, regulatory, safety assurance, community acceptance, and others. Identified barriers are considered across a variety of multi-vehicle control contexts (e.g., Urban/Advanced Air Mobility, drone delivery, infrastructure inspection, disaster response and recovery, and high-altitude pseudo-satellite operations) and form the bases for future research to confront operational, technical, and regulatory gaps. The Working Group ultimately plans to work with regulators to identify existing regulations and determine what needs to be done to accommodate m:N operations in the future. The meeting commenced with a Working Group report followed by breakout sessions to discuss m:N high-priority issues and Detect and Avoid use cases for the Radio Technical Commission for Aeronautics.

ATM-X DIP Workshop on Architecture and Data Integration Services
POC: MIRNA JOHNSON

On Nov. 17, the Air Traffic Management-eXploration (ATM-X)

project's Digital Information Platform (DIP) subproject held their first in a series of workshops intended to provide a deeper dive into the technical concepts and core features of the DIP concept. This session focused on the platform's functional architecture and the data integration services that are being developed and will be demonstrated in DIP's first collaborative demonstration, scheduled for mid-July 2022. The objective was to inform potential collaborators of how registered services would search for, and discover, data integration and aviation services on the platform. Participants were walked through NASA's reference implementation of a data integration service that provides fused data available for service providers to consume. The virtual workshop hosted more than 150 attendees, spanning federal and state government agencies, airport authorities, and industry solution providers, enabling traditional and emerging operations. The attendees participated in live dialogues with the panel, providing insight and feedback on how their use cases, needs, and challenges can be addressed by DIP. This was a beneficial forum to engage with stakeholders to further inform them about the DIP architecture and raise interest to collaborate in the partner services demonstrations.

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GPS Prediction Application Video Production

POC: EVAN DILL AND MISTY DAVIES

The System-Wide Safety (SWS) project communications team produced a two-minute video showcasing the work of SWS researchers on a Global Positioning System (GPS) prediction application. The video features Natasha Neogi, Evan Dill, and Julian Gutierrez explaining how their research will positively impact the lives of the general public in many ways by predicting the quality of GPS anytime, anywhere. This is particularly important for the future safety of autonomous vehicles. GPS is a critical component in banking systems, our power grid, telecommunications, and even traffic lights. Determining and predicting the GPS quality of entire cities can be critical in life threatening situations and can increase safety and save on resources in everyday life. The link for the YouTube video, uploaded on Nov. 22, is: https://www.youtube.com/watch?v=HxLD302nQHg

NASA-Developed Algorithms Identify Previously Unknown Safety Issues

POC: NIKUNJ OZA

The System-Wide Safety project supports research and development of machine learning methods for vulnerability discovery, which is the process of finding safety issues that have not been codified in the exceedances (sets of rules) that represent known safety issues. These research and development efforts have led to the development of several new algorithms, including the Multiple Kernel Anomaly Detection (MKAD) algorithm. These algorithms have found several previously unknown safety issues. They have also identified anomalies that represent allowable operations that have not been codified into standard operating procedures. One example of an MKAD-identified anomaly includes unusual landing trajectories at John F. Kennedy International Airport in New York that were deemed acceptable because they represented cargo flights landing at night with no other traffic around and had a need to land closer to their cargo facilities. A second example was a drop in airspeed during takeoff that seems to happen more often in longer aircraft where throttles are rapidly increased during takeoff to reduce the probability of tail strike, but then the throttle is reduced to return to the appropriate range of airspeed. These are important discoveries for the airline industry that are made by the algorithms developed at NASA.

SWS Presents IASMS Concept at USRTC Meeting

POC: KYLE ELLIS

On Dec. 1, at the Unmanned Systems Research and Technology Center (USRTC) at Fort Monroe in Hampton, Virginia, the System-Wide Safety (SWS) project presented its In-time Aviation Safety Management System (IASMS) concept research and development efforts toward technology solutions to enable safe integration of new entrants into the National Airspace System. Attending the meeting were Steve Bradford, Diana Liang, Biruk Abraham, Nourredin Ghazavi, and T.J. Tejasen from the FAA's NextGen Office; Marco Sterk and key members of the Longbow Group; Hampton, Virginia Mayor Donnie Tuck; leaders of Hampton University; as well as Lou Glaab from NASA's Advanced Air Mobility project's High Density Vertiplex subproject. This high-level engagement represents a high-potential collaboration ecosystem for NASA to engage in key research opportunities to mature its operational services and capabilities.

SWS Project Researchers Participate in SAE Standards Meetings

POC: MISTY DAVIES

This past quarter, System-Wide Safety (SWS) project researchers engaged with the SAE G-34 Standards Committee at several meetings. From Oct. 28-29, researchers met with the full SAE G-34 committee, which is tasked to create standards that will enable

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the use of machine learning and artificial intelligence in aviation. The meeting was to discuss key concerns that need further consensus. These included the creation of criticality and complexity levels, how to address human-machine teaming within the standards, and tool qualification. There is significant overlap in issues being considered by the G-34 industry standards committee and applied research and evidence that is being generated under the SWS project umbrella. At a follow-on meeting on Dec. 2, SWS researchers again participated in the SAE G-34 committee on Artificial Intelligence in Aviation meeting. SWS researchers are actively contributing broadly across the G-34 subcommittees, serving as subject matter experts for the concerns inherent to the use of machine learning and artificial intelligence in aviation. SWS project researchers are also introducing the committee to recently developed frameworks and techniques for assuring these capabilities and providing expertise on these techniques' strengths and weaknesses.

ATM-X DIP Technical Reviews
POC: MIRNA JOHNSON

On Dec. 2, the Air Traffic Management-eXploration (ATM-X) project's Digital Information Platform (DIP)

subproject held two internal technical reviews. These included the platform Research Concept Review (RCR) and the Sustainable Aviation (SA)-1 Preliminary Experiment/Demo Review (PER). The DIP subproject is focused on designing, developing, and demonstrating a platform that supports an ecosystem of digital services to enable improved flight operator decision-making. The platform RCR's purpose is to ensure alignment with the ATM-X project's research objectives. The SA-1 demonstration will validate the platform by demonstrating the ability of traditional flight operators to access and use real-time data-driven services for Collaborative Digital Departure Rerouting (CDDR). The purpose of the SA-1 PER is to ensure the technical quality of the SA-1 demonstration, which aims to deliver a reduction in emissions and fuel associated with aviation operations. Data collection is scheduled to begin in April 2022. Requirements for the reviews were consistent with the entrance and exit criteria adapted from NPR 7123.1B, Appendix G. Reviewers have since submitted feedback and the DIP subproject team will disposition the action items and develop a timeline to resolve them by the next set of reviews. The PER of Platform in Partner Services Build Up Demo 1 is currently scheduled in March 2022 and the SA-1 CDDR

Demonstration for Final Experiment Review is scheduled in April 2022.

NASA and FAA Conduct Quarterly Review at NASA's Ames Research Center in California
POC: MIKE MADSON

The Air Traffic Management-eXploration (ATM-X) project held a quarterly meeting with the FAA at NASA's Ames Research Center in California from Dec. 6-8. Topics of discussion were selected from the ATM-X research areas of common interest. NASA and the FAA shared their plans and activities in the areas of Extensible Traffic Management, increasing the use of unmanned aircraft in the National Airspace System (NAS), collaborative demonstration of airspace technologies with commercial airlines in the DIP subproject, and shared the web portal to solicit industry feedback and describe a vision for a future NAS under the ATM-X Sky for All activity. Dec. 8 focused on Unmanned Aircraft Systems (UAS) Traffic Management (UTM). NASA and the FAA discussed approaches to advance the state of the art of UTM, including NASA/FAA UTM Research Transition Team activities. The FAA provided updates about information exchange for UAS remote identification, UAS service

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supplier standards, and Beyond Visual Line of Sight Aviation Rulemaking Committee activities, as well as objectives for a 2022 FAA-led UTM field demonstration. NASA briefed the FAA about its Federated Airspace Management development capability, also known as Freddie, and the FAA talked about their experience with using the Freddie capability for the UTM evaluation work. Both sides reaffirmed their commitment to the UTM work and agreed to continue the conversation about potential joint activities. The FAA group ended the day with a tour of the Airspace Operations Lab. There were positive actions from the discussions to conduct several follow-on Technical Interchange Meetings based on these topics prior to the next quarterly meeting, currently scheduled at the end of March 2022. This will enable deeper technical discussions among the various teams to strengthen collaboration.

ATM-X DIP Meets with Airlines for America
POC: MIRNA JOHNSON

On Dec. 16, the Air Traffic Management-eXploration (ATM-X) project's Digital Information Platform (DIP) subproject presented a deep dive of technical content to the America for Airlines Air Traffic Management

Council. The discussion included content previously shared with external stakeholders on Nov. 17, as part of the DIP Architecture and Data Integration Services Workshop #1. The intent of the meeting was to gather direct input from flight operators on the functional architecture of DIP and the reference implementation of data integration services (DIS) to be demonstrated in DIP's first collaborative demonstration in FY22. Key questions such as the pros and cons of a unique DIS or competitive market of DIS were also discussed to help inform the architecture of DIP moving forward.

ATM-X Project X4 Partners Conduct Connectivity Tests
POC: KEVIN WITZBERGER

This past quarter, the Air Traffic Management-eXploration (ATM-X) project's Urban Air Mobility (UAM) subproject began conducting tests with its X4 simulation partners. On Oct. 1, two ATM-X project X4 airspace partners, OneSky and Unmanned Experts, conducted initial connectivity tests of their provider of services for UAM (PSUs) to a NASA prototype of an FAA-Industry Data Exchange Protocol (FIDXP) system developed for X4 simulations. The PSUs connected successfully to the FIDXP and sent requests for tokens with their encrypted signatures. After

FIDXP authenticated their signatures, authorization tokens were returned to their PSUs. With these tokens, their PSUs can then submit requests to get airspace data (e.g., corridors, waypoints, tracks, etc.) from the Airspace Structure Definition Service (ASDS). The remaining partners will schedule connectivity tests in the upcoming weeks. This was a critical first step toward achieving the X4 simulation objective of demonstrating successful information transfer between UAM airspace PSUs for strategic conflict management.

On Oct. 28, the UAM team successfully completed additional connectivity tests with all seven Strategic Conflict Management Simulation X4 airspace partners. The seven partners and NASA conducted initial connectivity tests of their PSUs to a prototype FIDXP system developed for the X4 simulation. They were all able to send and receive airspace data to and from the ASDS. This was the first sprint test in a series of X4 tests. The series of sprints within the scenarios were used to validate features that will be applied in a collaborative scenario simulation with the X4 partners that will run from March to June 2022.

Additional tests occurred on Nov. 19 and Dec. 17, in which the team again successfully completed further

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steps toward National Campaign-1 (NC-1). Six of the seven partners (ANRA, Avision, Metron/Airbus, OneSky, SkyGrid, and Unmanned Experts) and NASA successfully conducted a Nominal Flight Test Simulation. Participants were able to conduct vehicle simulation, telemetry updates, conformance monitoring, and operation close-out during the test. These were the second and third Sprint tests in a series of X4 simulation tests aimed at preparing the airspace partners and the NASA PSU for inclusion in NC-1. Sprint #4 will exercise a FIDXP Airspace Authorization scenario with the window opening for testing on Jan. 17, 2022, and an expected end date of Feb. 4, 2022. Based on the outcome of Sprint #4, an assessment will be made on whether the participants have demonstrated sufficient capabilities to continue with NC-1. The series of sprints within the scenarios are used to validate features that will be used in a collaborative scenario simulation with the partners that will run between March and June 2022.

SWS Partner Completes Large Set of Tests on Small UAS Batteries and Motors
POC: STEVE YOUNG

In Dec. 2021, the Lone Star Unmanned Aircraft System (UAS) Center of Excellence and Innova-

tion, a partner of the System-Wide Safety (SWS) project, located in Texas, completed a large set of tests for SWS on small UAS batteries and motors. Over the course of seven weeks, testing included 168 charging cycles, 146 use cycles, approximately 90 hours of battery use time, and over 310 hours of charging time on 12 separate batteries. Motor performance was recorded during the use cycles and included both indoor bench tests and outdoor flights (in a caged/netted area). The collected data is helping with SWS modeling work and our understanding on how these types of batteries and motors can fail.

SWS Collaborates on Two Advanced Air Mobility RF Spectrum Scanning Activities Executive Summary
POC: STEVE YOUNG

The System-Wide Safety (SWS) project has recently begun collaborating with the Advanced Air Mobility project's High Density Vertiplex (HDV) subproject on two radio frequency (RF) spectrum scanning activities. The first activity is collecting near-continuous scans over an extended period (Nov. 19, 2021-March 1, 2022) to baseline the RF environment across the City Environment for Range Testing of Autonomous Integrated Navigation (CERTAIN)

test range for selected frequencies of interest. Results will be analyzed and used to help the HDV subproject obtain approvals for new types of operations. The second activity will establish a real-time feed of data from SWS spectrum monitoring stations to operators and users who will be using the Remote Operations for Autonomous Missions Ground Control Center that is being setup for HDV demos at NASA's Langley Research Center in Virginia. Although just underway, both efforts are going well and should provide mutual benefits.

SWS Completes Work on Run Time Assurance for eVTOL Aircraft
POC: AARON DUTLE

In Dec. 2021, the System-Wide Safety (SWS) project completed an analysis and evaluation of run-time assurance for assuring the safety of aircraft functions and systems for a novel electric vertical takeoff and landing (eVTOL) aircraft architecture. The analysis showed that the inclusion of a run-time architecture aided in the demonstration of safety assurance for aviation systems that contain advanced control techniques, such as adaptive control, machine learning, artificial intelligence, and search-based algorithms. The results of this research will be shared during a meeting of the SWS FAA/NASA

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Research Transition Team meeting on Jan. 20, 2022.

NASA's SWS Completes Major Milestone for Increasingly Autonomous Systems

POC: MISTY DAVIES

In Dec. 2021, the System-Wide Safety (SWS) project completed a major milestone in which NASA evaluated the usefulness and efficacy of assurance approaches for increasingly autonomous systems. To make sure that the approaches were generalizable across different levels of autonomy, use cases included human-machine teaming, an automated planning application, and runtime assurance for electric vertical takeoff and landing aircraft. Several industry and academic partners, including Collins Aerospace, Penn State, Raytheon, and Pratt and Whitney, helped NASA gather evidence for the assurance approaches. Overall, the results were very promising and demonstrated there are approaches that can give a higher level of assurance and enable levels of automation and autonomy beyond what is flown today. As part of the research, NASA and its industry partners also identified remaining gaps and next steps.

RECOGNITION

SWS Participates at AIAA/IEEE DASC 2021
POC: TERRY MORRIS

From Oct. 3-7, numerous SWS project managers, leaders, and personnel participated in the 40th AIAA/IEEE Digital Avionics Systems Conference (DASC) held in San Antonio, Texas. This was the first ever hybrid DASC where presenters and attendees could participate in person or virtually. SWS personnel participated at every level of the conference, from organizing the technical program, to selecting the keynote speakers, to serving as session chairs, authors, and presenters. The impact of SWS personnel was even seen in the acknowledgements where SWS leaders were thanked for their contributions to various author papers. From the Program, Track and Session organization side of the conference, Terry Morris served as the technical program chair. Steve Young served on the Keynote and Panel Committee and was instrumental in inviting NASA's Aeronautics Research Mission Directorate Associate Administrator Bob Pearce as one of the keynote speakers. Evan Dill, Natasha Neogi, and Mahyar Malekpour did an incredible job as session chairs. Various SWS leaders and personnel contributed greatly as authors and presenters. At

least eight papers were submitted regarding SWS-funded efforts, and at least three of those papers received "Best of Session" awards.

SWS Researcher Presents Continuous Learning at SPS National Learning Session
POC: JON HOLBROOK AND MISTY DAVIES

From Oct. 20-21, Jon Holbrook was invited to virtually give the keynote address at the Solutions for Patient Safety (SPS) Fall National Learning Session. SPS represents a national network of more than 145 children's hospitals, and more than 1,200 safety leaders from across the network attended the Fall Learning Session. The objectives of the meeting were to examine best practices for promoting safety and safety culture for hospital patients and employees, and to identify new and emerging safety efforts. Holbrook was invited to present based on his work on human contributions to safety in the System-Wide Safety (SWS) project. His presentation, "Cultivating a Culture of Continuous Learning: Insights and Examples from the Aerospace Industry," described insights and examples from emerging safety efforts in the aerospace industry focused on learning not only from infrequent failures, but also from everyday events that are usually successful.

SWS Researchers Present at Aviation Safety InfoShare on Expanding Our Safety Mindset
POC: JON HOLBROOK AND CASSIE HILDITCH

From Nov. 2-4, System-Wide Safety (SWS) project researcher Jon Holbrook provided a presentation at the Aviation Safety InfoShare Conference in Pittsburgh, Pennsylvania, and described a safety mindset that expands the current understanding of what constitutes a safety-relevant event and improves the ability to learn from everyday work. The presentation offered practical suggestions, specific examples, and lessons learned based on a recent paper coordinated by the Flight Safety Foundation that included contributions from organizations across the aviation industry. Holbrook's contributions to this paper and presentation builds on his work on human contributions to safety in the SWS project. Aviation Safety InfoShare is attended by operational safety personnel from around the world for the purpose of advancing aviation safety learning through sharing safety issues and mitigation strategies. In addition, Cassie Hilditch presented findings from a survey conducted on assessing the impact of COVID-19 on pilot sleep and fatigue. This was an important opportunity to share results with the aviation industry and to garner information on developing

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fatigue challenges so that the SWS project can best support airline safety as the industry returns to full service. Hilditch's presentation was titled "How is the Pandemic Affecting Pilot Fatigue? A Survey."

SWS Associate Project Manager Presented at 2021 BAM Forum

POC: WENDY OKOLO

On Nov. 3, System-Wide Safety (SWS) project Associate Project Manager Wendy Okolo presented "UAM in the NAS: Safety Above All" at the 2021 Business of Automated Mobility (BAM) Forum: Flight Path to Urban Air Mobility (UAM)/ Advanced Air Mobility (AAM). The virtual presentation, watched by 630 forum attendees, provided an overview of SWS research and its overall mission. Okolo explained the ongoing work to develop the In-time System-wide Safety Assurance services, functions, and capabilities that form the building blocks of an envisioned In-time Aviation Safety Monitoring System. The presentation concluded with a look to potential future safety implications as the use of the National Airspace System expands with UAM and AAM. The 2021 BAM Forum was a two-day, online-only event that featured topics of interest to industry and government leaders, including unmanned

aircraft system traffic management, safety and security, and remote pilot technology and autonomy.

SWS Participates in Prognostics and Health Management Conference

POC: CHETAN KULKARNI, CHRIS TEUBERT AND WENDY OKOLO

From Nov. 29-Dec. 2, System-Wide Safety (SWS) project researchers and management participated in the 13th Annual Conference of the Prognostics and Health Management Society. This event was fully virtual and offered speaker and panel sessions, keynote and luminary speakers, tutorials, and additional events to present the state-of-the-art and other advances in aerospace, transportation, human health and performance, and artificial intelligence. SWS project researcher Chetan Kulkarni served as the Technical Program Committee Chair and other researchers presented papers, led sessions, and gave tutorials on prognostics algorithms, recent developments, and tools. Diagnostics and Prognostics group lead Chris Teubert presented a technical tutorial, "A Guide to the NASA Python Prognostics Package," which gave a hands-on overview of the recently released Prognostics Python Packages. The tutorial familiarized participants

with a collection of research tools for developing prognostic models, simulating degradation of systems, performing prognostics, analyzing results, and developing new prognostic algorithms. Teubert also provided examples of how the tools are used at NASA for SWS and other projects and can be extended to other applications in the future.

SWS Attends Invited Talk: Innovation in Low-Altitude Navigation

POC: ANDREW MOORE AND EVAN DILL

System-Wide Safety (SWS) project researchers were invited to present NASA's innovation in low-altitude navigation, the first public presentation of the research, to a group of 75 aviators from large U.S. electric companies at the Electric Power Research Institute's Annual Unmanned Aerial Vehicle (UAV) Workshop on Nov. 30. Before this effort, Global Positioning System (GPS) navigation loss due to foliage attenuation, a common concern for this audience, had never been quantified. This work demonstrates the severity of GPS loss in forested corridors. In addition to infrastructure inspection flights, foliage-degraded navigation impacts UAV storm recovery, property survey, and search and rescue operations. UAV inspection of infrastructure, such as pipelines

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and transmission lines, frequently requires flights within "arboreal canyons" (i.e., swaths of cleared ground surrounded by trees and brush). While foliage attenuation of conventional radio signals has been well studied, this research is the first to quantify degradation of GPS signals by foliage. Attenuation of radio signals varies by foliage species and, if a flight path courses through a species that has not been characterized, a survey is required to accurately estimate the severity of GPS degradation. NASA researchers taught the aviators about the hardware and analysis needed to survey their flight corridors and were directed to review the SWS project-supported AIAA paper, "Volume Raycasting of Global Navigation Satellite System (GNSS) Signals Through Ground Structure Lidar for UAV Navigational Guidance and Safety Estimation," by Andrew Moore, Matthew Schubert, Nick Rymer, Daniel Villalobos, J. Sloan Glover, Derin Ozturk, and Evan T. Dill. The full paper, which can be accessed at https://doi.org/10.2514/6.2022-2218, describes the survey method details. A steam pipeline at a NASA facility was studied for the flight path, and 60 percent of the GPS signal was lost for 10 meters of foliage thickness between the receiver and the satellite. The signal was completely knocked out (>90 percent loss) when the thickness was 30 meters. The full study was first published at AIAA SciTech 2022.

SWS Presents IASMS Concept to the CAAS
POC: KYLE ELLIS

On Dec. 7, the Civil Aviation Authority of Singapore (CAAS) invited Kyle Ellis to present NASA's visionary concept and detailed implementation plans for the In-Time Aviation Safety Management System (IASMS). The international community views the technological developments and conceptual framework being delivered by NASA's System-Wide Safety (SWS) project as critical to enabling existing and advanced air mobility aviation sectors to safely integrate in a transformed global airspace. The presentation outlined a key roadmap of technical challenges and solutions to achieve a safely transformed airspace system that includes novel markets and modes of transportation. Partnering in the presentation was Andrew Carter of ResilienX, a key industry collaborator building out industry developed implementations of the IASMS services and capabilities at key sites such as the NUAST, Fly Ohio, and Longbow Group Unmanned Systems Research and Technology Center in Hampton, Virginia, among others. This work supports the NASA Aeronautics Research Mission Directorate's Strategic Thrust 5 research and development activities performed within AOSP.

Advanced Air Mobility Academy Series for STEM Engagement
POC: KURT SWIERINGA

On Dec. 8, NASA's Air Traffic Management-eXploration (ATM-X) project supported an educational event, hosted by the Advanced Air Mobility Academy Series for Science, Technology, Engineering, and Mathematics (STEM) Engagement. The purpose of the event is to inspire the next generation of air traffic management researchers. The event also celebrated Hour of Code, which took place during Computer Science Education Week, from Dec. 6-12, which is an annual event meant to encourage K-12 students to explore coding. The event began with a presentation that provided middle and high school students with an overview of Advanced Air Mobility and the research that ATM-X is doing to enable the future air traffic management system. The presentation was followed by a coding exercise where students created geofences around high-risk areas to enable a small unmanned aircraft to operate safely.

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