National Aeronautics and Space Administration

AOSP Newsletter

Airspace Operations and Safety Program (AOSP)

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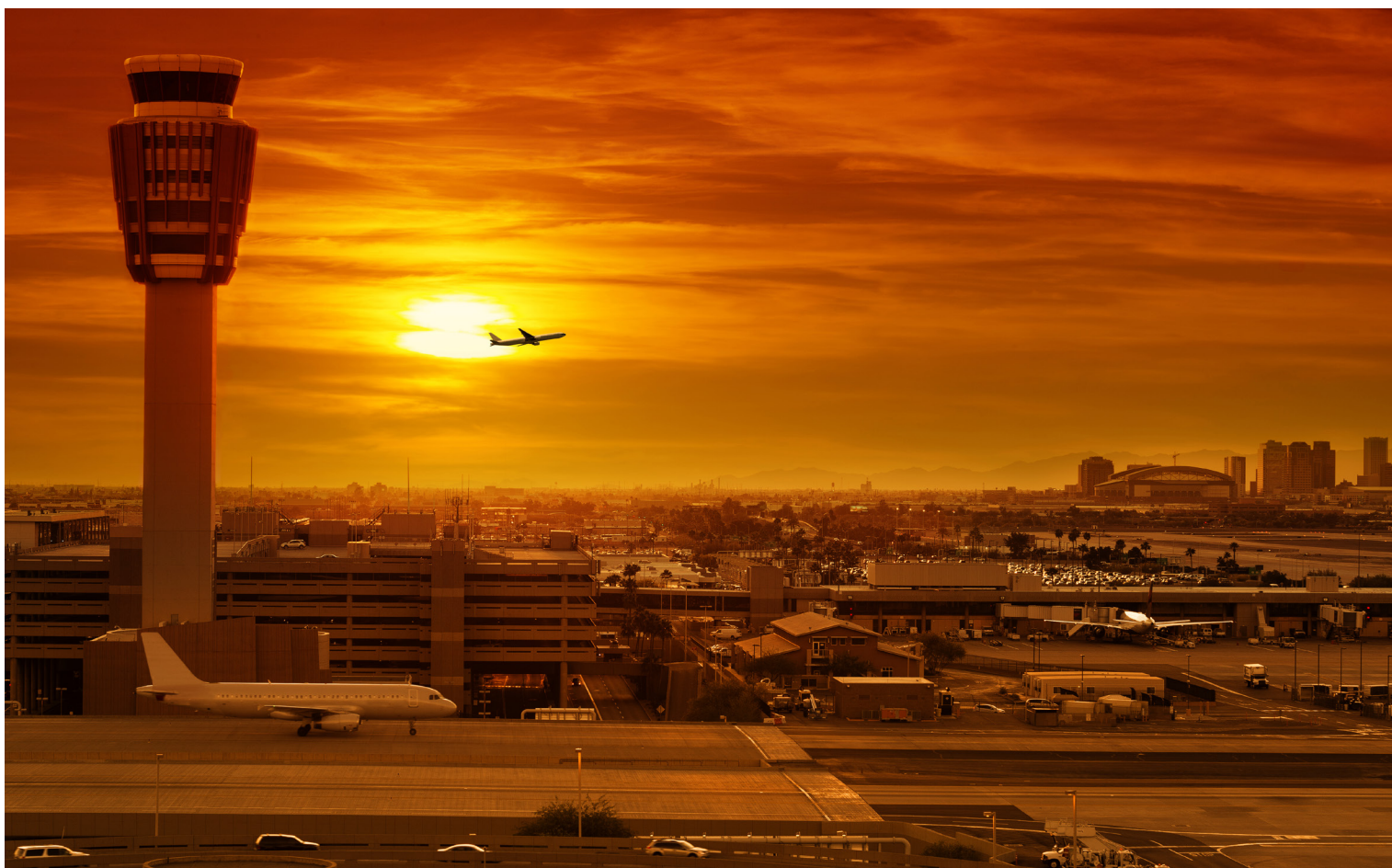
AOSP IN THE NEWS

Why Airplanes Might Soon Have Just One Pilot

CNN (1/13) reports "If you boarded a passenger plane in 1950 and peeked into the cockpit, you would have seen five people in there (almost certainly men): two pilots, a radio operator, a navigator and a flight engineer. ...In one scenario, proposed by NASA, the remaining pilot in the cockpit would be supported by a 'super dispatcher' on the ground, a trained pilot that could oversee a number of flights at once and even fully control the plane remotely if needed, for example if the cockpit pilot become incapacitated."

GE Teams To Enable Cloud-Based FMS For AAM

Aviation Week (1/24) reports "A NASA-funded team is working to connect airborne and cloud-based flight management systems to enable better real-time trajectory optimization and airspace management for advanced air mobility (AAM) and commercial aviation. Led by aviation R&D company Mosaic ATM, the team comprises flight management..."

Boeing Invests $450M In Electric Self-flying Air Taxi Project

The Hill (1/24) reports "Aerospace giant Boeing is making big investments in autonomous electric vertical take-off and landing (eVTOL) aircraft that could fly passengers and cargo around busy cities in the not-too-distant future. ... The company is working with NASA to help develop air taxis, drones and other types of aircraft to move people and goods in cities."

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TECHNICAL AND PROGRAMMATIC HIGHLIGHTS

Wendy Okolo presents on AOSP's System-Wide Safety Project during a panel session at the American Institute of Aeronautics and Astronautics SciTech Forum Conference.

AOSP Participates Prominently at AIAA SciTech 2022 Conference

POC: WENDY OKOLO, JAEWOO JUNG, KENNETH FREEMAN, NIKUNJ OZA AND MISTY DAVIES

AOSP played a prominent role at the American Institute of Aeronautics and Astronautics (AIAA) SciTech Forum Conference held in San Diego between Jan. 3–7. This year's theme was "Enabling Sustainability Through Aerospace Technology" and was a hybrid format featuring live and online presentations. Nearly 5,000 attendees registered for the 2022 conference. On Jan.

6, Wendy Okolo from NASA's System-Wide Safety (SWS) project appeared as a panelist on a Forum 360 panel, "Operational Sustainability in Increasingly Congested and Heterogeneous Airspace," which focused on the future of air transportation and the sustainability of these emerging and existing operations in the National Airspace System (NAS). Moderated by Cheryl Quinn, AOSP's deputy director, Okolo joined fellow panelists Steve Bradford, the FAA's chief scientist for NextGen; R. John Hansman, professor of aeronautics and astronautics at Massachusetts

Institute of Technology (MIT) and director of the MIT International Center for Air Transportation); and Tom Prevot, Joby Aviation's air taxi product lead to discuss the necessary changes to existing NAS operations such as the required automation capabilities, human-machine interactions, and operator and stakeholder responsibilities that will enable a safe and sustainable airspace of the future. In addition, an In-Time Aviation Safety Management System (IASMS) panel was organized by SWS project researchers and moderated by SWS's deputy project manager, Kyle Ellis.

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The IASMS panel, "Assuring Safety in Tomorrow's National Airspace System," welcomed panelists Akbar Sultan, director of AOSP; Steve Bradford of the FAA; Deborah Kirkman, director of Advanced Aviation Systems, Flight Safety Foundation; Fred Judson, director of Ohio Unmanned Aircraft Systems (UAS) Center; and Peter Shannon, founder and managing director of Radius Capital. This panel presentation offered broad perspectives on the opportunities and challenges the industry is addressing to safely transform aviation.

SWS personnel also participated in a virtual technical lecture and panel, "Autonomy and the Intangible Value of the Pilot." Panelists included Amy Pritchett, professor and department head of aerospace engineering at Pennsylvania State University; Irene Gregory, senior technologist for NASA's Advanced Control Theory and Applications; Jon Holbrook deputy of Human Factors Discipline at NASA's Engineering and Safety Center; Ella Atkins, professor and Autonomous Aerospace Systems Laboratory director at the University of Michigan; and Kathy Abbott, chief scientific and technical adviser for the FAA's Flight Deck Human Factors. The panel discussed the evolving role of the pilot with a specific focus on the benefit the pilot brings to the human-machine interaction with increased cockpit automation and autonomy.

Also representing AOSP, the Air Traffic Management-eXploration (ATM-X) project's Extensible Traffic Management (xTM) subproject team presented several papers. The first paper, "Overview of NASA's Extensible Traffic Management (xTM) Research," with Jaewoo Jung as the first author, described the evolution of NASA UAS Traffic Management (UTM) to xTM, where the foundational UTM requirements and core properties are generalized to become an xTM requirement supporting operations of new entrants beyond small UAS. The paper also described NASA's approach for developing an xTM system for operations in high altitudes over 60,000 feet, designated as upper Class E in the United States, and the planned research to examine potential xTM-Air Traffic Control (ATC) interactions across multiple xTM systems, such as UTM, Upper Class E traffic Management (ETM), and Advanced Air Mobility/Urban Air Mobility (AAM/UAM). The second paper, "Identifying Common Use Cases across Extensible Traffic Management (xTM) for Interactions with Air Traffic Controllers," with Paul Lee as the first author, presented a set of use cases that have been identified in UTM, AAM/UAM, and ETM operations that are

The panel was moderated by AOSP's deputy director, Cheryl Quinn. Wendy Okolo participated with fellow panelists Steve Bradford, R. John Hansman, and Tom Prevot.

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related to ATC interactions. In the paper, use cases across xTM systems were categorized based on common trigger events to be used for discovering common procedures and data requirements across xTM systems that could help ease the controller's cognitive task load and allow them to manage these interactions more safely. The third paper, "Intent Modeling and Conflict Probability Calculation for Operations in Upper Class E Airspace," with Min Xue as the first author, presented a probabilistic operational intent model for vehicles operating in upper Class E airspace. This model leverages and extends past work on probabilistic conflict computation in a hybrid form. Simulation results showed that this hybrid model captures the intent conflict probability with better accuracy, especially for a larger look-ahead horizon compared to the earlier work. The paper presented an example to illustrate the use of this model in strategic planning in ETM. The xTM team plans further publications for xTM-ATC interactions and ETM in the future. A fourth paper, "Immutable Secure Data Exchange and Storage for Urban Air Mobility Environments," authored by Ken Freeman from the UAM subproject and presented by the Secure Airspace

team, discussed a cybersecurity approach for protecting data for UAM operations.

Additionally, three members of the SWS project's Data Sciences Group at NASA's Ames Research Center in California received the 2021 AIAA Intelligent Systems Best Paper Award for their paper, "Multi-Class Anomaly Detection in Flight Data Using Semi-Supervised Explainable Deep Learning Model." The paper addressed the difficult and crucial task of identifying precursors to safety incidents in aviation data. In current practice, the main approach leverages domain expertise to define expected tolerances in system behavior and flags exceedances from such safety margins. However, this approach is incapable of identifying unknown risks and vulnerabilities. Various machine learning approaches have been investigated and deployed to identify anomalies with the challenge of procuring enough labeled data to achieve reliable and accurate performance. Building on recent advancements described in machine learning literature, this paper presented an explainable, deep, and semi-supervised model for anomaly detection in aviation. The proposed model combines feature engineering and classification in feature space while leveraging all available

(labeled and unlabeled) data. The paper validated its approach with case studies of anomaly detection during the takeoff and landing phases of commercial aircrafts and use the case studies to show that the proposed model outperforms the state-of-the-art supervised anomaly-detection model. This approach reaches significantly higher accuracy and fewer false alarms with only a small amount of labeled data. This award is given annually for innovative and impactful contributions to the field and was presented at the 2022 AIAA SciTech Forum and Exposition in early January.

SWS Collaborates on Two AAM RF Spectrum Scanning Activities Executive Summary

POC: STEVE YOUNG

The System-Wide Safety (SWS) project has recently begun collaborating with the Advanced Air Mobility (AAM) 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 Range Testing for Autonomous Integrated

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Navigation test range for selected frequencies of interest. Results will be analyzed and used to help HDV 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.

ATM-X UAM Subproject is Developing Requirements with ASTM for UAM Airspace
POC: KEVIN WITZBERGER

The industry standards group that is developing industry provider of services for UAM (PSU) requirements has offered for the Air Traffic Management-eXploration (ATM-X) project's Urban Air Mobility (UAM) subproject to collaboratively participate in the writing of PSU requirements for ASTM International (formerly the American Society for Testing and Materials). The UAM subproject has accepted this opportunity and has identified staff to participate in the writing requirements. Directly authoring requirements with

ASTM will ensure that NASA's airspace expertise will translate to concrete requirements for new UAM airspace technologies that are needed as demand increases. For reference, NASA served in the more limited role as advisers rather than requirements authors in the Airspace Technology Demonstration and Unmanned Aircraft Systems Traffic Management projects. Asking NASA to collaborate on writing requirements further demonstrates the impact and relevance of the ongoing Strategic Management Conflict Simulation X4. The initial requirements development commenced in January and is expected to continue through December 2022. The draft requirements will be used by industry for field trials and testing, with the expectation that these activities will inform future iterations of the standard.

ATM-X Contractor Team Conducts Expert Interviews for ETM Market Study
POC: JAEWOO JUNG AND MIN XUE

To ensure the success of research in Upper Class E Traffic Management (ETM), the Air Traffic Management-eXploration (ATM-X) project's Extensible Traffic Management (xTM) subproject awarded a task to LMI in late 2021 for conducting

studies to gather knowledge and information on the ETM market. On Jan. 14, the team consisting of LMI, Crown, Georgia Tech, and GRA, Inc. briefed NASA on the results of their ETM market research to further understand the current and future opportunities associated with high-altitude operations and the risks and barriers for realizing those opportunities. The mid-term results updated the xTM team's knowledge of high-altitude operations previously obtained through earlier outreach activities, including tabletop exercises, industry tag-ups, and workshops. These results and updated knowledge are critical for the xTM team to develop use cases and scenarios for future ETM simulations and research.

ATM-X Presents at ENRI International Workshop
POC: KURT SWIERINGA

Between Jan. 18–19, Air Traffic Management-eXploration (ATM-X)'s deputy project manager for technology, Kurt Swieringa, presented an overview of ATM-X at an international workshop on the latest trends in air traffic management hosted virtually by the Electronic Navigation Research Institute (ENRI). The presentation provided an overview of the research ATM-X is doing to improve access to aviation

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data, develop services that improve sustainability of aviation operations, and enable the incorporation of new aviation concepts into the airspace.

SWS SBIR Partnership to Mitigate Methane Emissions at Landfills

POC: ERSIN ANCEL AND MISTY DAVIES

On Jan. 20, Human Automation Teaming Solutions, Inc. (HATS), a small company based out of Los Angeles, presented an integrated risk assessment capability and an intuitive user interface to conclude their Small Business Innovation Research (SBIR) Phase II-E/Phase III contract with NASA's System-Wide Safety (SWS) project. The prototype ground control station (GCS) software will monitor multiple unmanned aircraft and ground vehicles and the proposed use case – assisting landfill operators in conducting methane monitoring missions. During the Phase II-E/Phase III contract, SWS researcher Ersin Ancel led the development of a custom GCS software tool that can simultaneously connect to five supplemental data service provider services. Using these SWS-built services, HATS was able to demonstrate the integrated risk assessment capability and the intuitive user interface to mitigate threats. These threats include third-party casualty risk, degraded navigation and battery, radio frequency interference, and proximity to obstacles. The custom GCS software will be tested as part of the ongoing FY22 SWS Technical Challenge 2 Flight Campaign. The presentation marked the end of the SBIR Phase II-E/Phase III contract with the SWS project. The collaboration began in 2017 under the Unmanned Aircraft Systems Traffic Management project.

SWS Hosts Verification and Validation RTT Meeting with FAA

POC: AARON DUTLE AND MISTY DAVIES

On Jan. 20, Aaron Dutle of NASA's Langley Research Center in Virginia organized and hosted the first quarter meeting of the System-Wide Safety (SWS) project's Verification and Validation Research Transition Team (RTT) subgroup. The RTT is a joint effort between NASA and the FAA focused on sharing and aligning the research between the two agencies. This meeting featured a presentation by a team from Barron Associates, Architecture Technology Corporation, Electron International, and Iowa State University discussing the use of a runtime assurance architecture to incorporate untrusted software components into an electronic vertical takeoff and landing aircraft. The presentation also discussed a functional hazard assessment and the use of systems-theoretic process analysis for safety assessment of the system. The meeting had roughly 50 attendees, with participants representing NASA, the FAA, and the Department of Defense.

ATM-X Participates in the NASA-DLR Year One Annual Review

POC: TAUMI DANIELS

The NASA-German Aerospace Center (DLR) Year One Annual Review took place on Jan. 20–21. NASA's Air Traffic Management-eXploration (ATM-X) project and DLR are collaborating on a five-year joint research project that leverages air traffic management technologies and concepts developed at their respective agencies. The topics that were covered included the investigation of airspace design for new types of aircraft and exploration of the integration of the Testbed and DLR's Remote Component Environment simulation platforms. In addition, four tasks focused on Urban Air Mobility (UAM) that analyzed UAM demand, developed concepts for UAM networks, analyzed impacts of weather on UAM operations, and focused on the development of UAM flight

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performance models. The review allowed both agencies to gain further understanding of new concepts and methods to address the challenges of a future air traffic management system.

ATM-X PAAV Meets with Aurora/Boeing

POC: ARWA ARWEISS AND KURT SWIERINGA

On Jan. 21, Air Traffic Management-eXploration (ATM-X)'s deputy project manager for technology, Kurt Swieringa, and the ATM-X project's Pathfinding for Airspace with Autonomous Vehicles (PAAV) subproject management team consisting of Arwa Aweiss, Rich Coppenbarger, and Tod Lewis met with representatives from Aurora Flight Sciences, a Boeing-owned company, to discuss a potential flight demonstration collaboration opportunity. A draft annex of a space act agreement was reviewed and agreed on between the teams. This annex will get circulated among Aurora and ATM-X project leadership for one final review before being sent to NASA Partnership and Legal Offices and Aurora/Boeing's legal team for final review and initiation of the next step in the process.

SWS Integrated Software System Test

POC: STEVE YOUNG AND MISTY DAVIES

On Jan. 25, personnel at NASA's Langley Research Center in Virginia

successfully performed the formal software test of the System-Wide Safety (SWS) project's SWS-21 Integrated Software System Test (ISST) Build 1. The test verified the documented software requirements needed for the Core Flight System (CFS) applications to include the capability to bridge data messages from the external hardware into the CFS software bus and the ability to downlink selected software bus messages to the Research Ground Station (RGS). The RGS capabilities include the ability to upload the configuration files before each flight and the ability to notify on-board software when ground crew activity transitions between the pre-flight, in-flight, and post-flight phases. This test was necessary to obtain approval to use the system in flights planned to occur on Langley's City Environment Range Testing for Autonomous Integrated Navigation test range in the coming months. The test was conducted virtually using Microsoft Teams with a test conductor, test operator (on-site), and software assurance. This is their first adoption of the ISST for remote participation due to current COVID circumstances. The Unmanned Aircraft Systems (UAS) test aircraft was positioned on a bench in a lab at NASA Langley, where it was connected to the ground system laptop computer. The connection was physical for the pre-flight and post-flight portions of the test, and

wireless for the simulated in-flight portion. The test consisted of using the system as it would be used in the field on a test range. The system consisted of several software elements that were engaged by a ground station operator using a prescribed procedure (pre-flight, in-flight, and post-flight). The entire UAS was powered on, including the research system, avionics, and all relevant data links.

ATM-X DIP Conducts TIM with FAA on Quality of Service and SWIM IMP

POC: MIRNA JOHNSON

On Jan. 26, the Air Traffic Management-eXploration (ATM-X) project's Digital Information Platform (DIP) subproject team and the FAA held a technical interchange meeting (TIM) to discuss standardization of quality of service (QoS) information. The FAA walked through the System Wide Information Management (SWIM) Information Management Panel (IMP) service registration guidance and reviewed the definition for QoS that the FAA and International Civil Aviation Organization are working to distribute globally. DIP also shared its approach to service registration and additional metrics that stakeholders would like to see included in the set of quality information for registered services. This TIM was very valuable

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for exchanging information that can be leveraged for further DIP development, aligning on QoS concept, and identifying mutually beneficial areas to further direct our engagements.

ATM-X Partners Conduct Connectivity Testing with an Airspace Authorization Service

POC: KEVIN WITZBERGER

On Feb. 2, the Air Traffic Management-eXploration (ATM-X) project's Urban Air Mobility (UAM) subproject successfully completed another step toward developing a provider of services for UAM (PSU) while leading seven airspace partners in developing their PSUs, five of which will partner with Wisk Aero in the National Campaign-1 (NC-1) flight tests. All seven partners (ANRA, Avision, Collins, Metron/Airbus, OneSky, SkyGrid, and Unmanned Experts) and NASA successfully conducted a connectivity test to a NASA-built prototype of an FAA-Industry data exchange protocol airspace authorization service. Participants generated an operation plan that conformed to the requirements of the defined airspace and provided the operation plan to an airspace authorization service during the test. This was the fourth sprint test in a series of strategic management conflict simulation tests aimed to prepare the airspace partners and

the NASA PSU for inclusion in the NC-1 flight test. Sprint #5 exercises demand capacity balancing imbalance detection and resolution with the window opening for testing on Feb. 28, with an expected end date of April 1, 2022. 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 is tentatively scheduled to run from April through June 2022.

ATCA Annual Conversation: Sky for All and NASA's Contribution to the Future of Aviation

POC: SHAWN ENGELLAND AND MISTY DAVIES

On Feb. 9, at the virtual Air Traffic Control Association (ATCA) Annual Conference, NASA representatives Parimal Kopardekar, Misty Davies, Kurt Swieringa, and Jeanne Yu presented a focused conversation about NASA's Sky for All vision. The ATCA Annual Conference is the largest air traffic management event in the Americas and the world's only event centering on air traffic control and air traffic management technology and services needs of the FAA. Representatives of the Sky for All team centered the conversation on the vision, foundational principles and aspirations, capabilities, and use cases that will enable NASA to continue defining the path to the Sky for All vision. Davies explained

how NASA's research into airspace operations and safety will enable a more ubiquitous, sustainable, and equitable aviation future.

ATM-X PAAV Presents at the Multi-Vehicle (m:N) Working Group Meeting

POC: ARWA AWEISS

On Feb. 9, the Air Traffic Management-eXploration (ATM-X) project's Pathfinding for Airspace with Autonomous Vehicles (PAAV) subproject presented an overview of the subproject and their concept of operations research at the Multi-Vehicle Working Group (large-Unmanned Aircraft Systems) subgroup meeting. The working group was formed by NASA under the Autonomous Systems (AS) discipline of the Transformative Tools and Technologies (TTT) project within the Transformative Aeronautics Concepts Program. This working group's central goal is to bring together a broad range of interested stakeholders from government, industry, and academia. Together, they will identify 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, and community acceptance. The working group ultimately plans to work

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with regulators to identify existing regulations and determine what needs to be done to accommodate m:N operations in the future. The meeting included more than 30 attendees from industry and government. The PAAV team also presented their plans for an upcoming tabletop activity to solicit feedback on the content and approach. The tabletop is planned for Spring 2022 and is intended to identify shortfalls, solutions, and gaps related to the integration of large-Unmanned Aircraft Systems cargo operations in the National Airspace System, under future higher-autonomy or m:N paradigms, and will result in a joint deliverable between ATM-X PAAV and TTT-AS. The tabletop is a follow-on to tabletop activities conducted in 2021 with a focus on near-term assumptions such as 1:1 operations. The meeting concluded with a plan to organize a few additional meetings leading up to the tabletop activity.

Robust Software Engineering Releases AdaStress Open-Source Software
POC: ADRIAN AGOGINO AND GUILLAUME BRAT

On Feb. 14, the AdaStress software tool, developed within the System-Wide Safety project, was released under the NASA Open-Source Agreement license. AdaStress implements and extends the Adaptive Stress Testing (AST) framework,

which leverages reinforcement learning to find and analyze the likeliest failures in autonomous and safety-critical systems. By incorporating feedback into its exploration, AST can be significantly more efficient than traditional sample-based approaches to stress testing without relying on domain knowledge to expedite the search. This makes AdaStress an attractive tool for independent verification and validation, as it does not operate with a bias toward expected failure modes. AdaStress can also perform efficient stress testing on black box systems, including those that are remote and unable to be shared directly for reasons of security, privacy, or convenience. In these cases, the stress testing protocol can "anonymize" system behavior, allowing computational infrastructure to be used for stress testing without revealing the underlying failure modes of the system under test.

SWS-Boeing Agreement Annex for Autonomous Systems Research Signed
POC: LANCE PRINZEL

In mid-February, a non-reimbursable space act umbrella agreement between NASA and Boeing for Aerospace Research Technology Development, Testing and Evaluation (SAA1-33523) was signed that includes Annex 1 for

"Integration, Demonstration and Evaluation of Autonomous Systems and Tools." The annex supports System-Wide Safety (SWS) project collaborative partnership efforts with Boeing to enable the application and integration of formal-methods-based analysis, verification, testing, and monitoring tools in the design-time and operation-time assurance processes of autonomous systems. This collaboration will enable the exploration of autonomy and artificial intelligence requirements, assurance approaches, evaluation methods and means of compliance that support artificial intelligence standardization and explore paths to certification. The umbrella and annex agreements were recognized by Boeing Research and Technology executives, and it was included in the previous week in a report by Naveed Hussain, Boeing's chief technology officer, to Boeing chief engineer and executive vice president of Boeing Engineering, Test, and Technology, Greg Hyslop, reflecting the significance and visibility of the collaboration and importance of the research efforts.

ATM-X PAAV and FAA William J. Hughes Technical Center Conduct TIM
POC: KURT SWIERINGA

On Feb. 17, representatives from NASA's Air Traffic Management-

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eXploration (ATM-X) project held a technical interchange meeting (TIM) with staff from the FAA's William J. Hughes Technical Center to discuss related work and collaboration opportunities for the integration of increasingly autonomous aircraft in airspace shared with conventional aircraft. An overview of the ATM-X Pathfinding for Airspace with Autonomous Vehicles (PAAV) subproject was presented, and touchpoints were identified.

ATM-X UAM Secure Airspace Immutable Secure Data Exchange Completes Key Step
POC: KENNETH FREEMAN

This past week, the Air Traffic Management-eXploration (ATM-X) project's Urban Air Mobility (UAM) subproject Secure Airspace effort successfully completed another step toward developing a technique to ensure secure data exchange and storage capability for UAM environments. This work leverages blockchain technology as a possible solution to secure information across the decentralized service-based UAM systems. This work completes a UAM milestone, where a blockchain-based secure data exchange model was developed and tested in simulation based on two use cases applicable to UAM environments.

SWS and ICAO Conduct TIM to Further SIMS Collaboration
POC: LANCE PRINZEL

On Feb. 18, a technical interchange meeting (TIM) was held between the System-Wide Safety (SWS) project and the International Civil Aviation Organization (ICAO) Safety Intelligence team. The meeting objectives were to continue discussions on the future of safety management systems and opportunities for NASA and ICAO to collaborate, including the In-Time Aviation Safety Management System for commercial aviation in support of NASA's Sky for All and other future aviation visions. The ICAO Safety Intelligence team provided a briefing on current developments on an Amendment 2 for ICAO's Annex 19 document for Chapter 5 that introduces changes for "safety data and safety information collection, analysis, protection, sharing and exchange" including introduction of a safety intelligence concept and governance/guidance material for eventual ICAO member state implementation. A discussion was also held on the needs for safety data access and information to support safety intelligence decision making, and various initiatives ICAO is working toward. The Safety Information Monitoring System (SIMS) was briefed to

the SWS team and discussions centered on data collection and processing, safety indicators, and SIMS applications. Actions from the meeting included: 1) continue NASA/ICAO engagement with additional technical deep-dive discussions; 2) explore partnership vehicles, such as an Interagency Agreement; 3) establish a formal collaboration so that ICAO-sensitive materials may be shared; and 4) connect with Chris Pokorski, US member of the Safety Management Panel and the FAA, and Miguel Marin, incoming ICAO deputy director of Air Navigation Bureau. ICAO meeting attendees included Elizabeth Gnehm, Ruviana Zimmerman, and Marco Merens. NASA representatives included Misty Davies, Lance Prinzel, Nikunj Oza, Chad Stephens, Paul Krois, Joe Coughlan, and Laura Bass.

ATM-X DIP Holds "DIP for Service Providers" Workshops
POC: MIRNA JOHNSON

The Air Traffic Management-eXploration (ATM-X) project's Digital Information Platform (DIP) subproject held its second and third workshops in a series of workshops this past quarter. The first of these workshops was originally held Nov. 17, 2021. The second workshop, "DIP for Service Providers," was held on Jan. 21. The workshop showed an

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increase in the number of registered participants, and attendees saw how the DIP architecture supports the onboarding process as well as how NASA services are planned to be made available via DIP. Service providers were able to ask questions about the registration process and discuss use cases for registering different types of services (e.g. single microservice versus bundle of services). The DIP workshop series intends to provide a closer look at some of the core features being developed by the DIP team. These workshops will give insight into DIP development, technology, and assumptions as well as providing a forum for engaging with the DIP team to pose questions and provide feedback on proposed designs.

The third workshop, "DIP for Flight Operators and Consumers," was held on Feb. 23. The workshop again had an increase in participation from the previous two workshops, with more than 100 registrants in attendance. The objective of the workshop was to obtain informed technical feedback to the DIP design and prepare participants for what they could expect for the demonstration. The DIP workshop series intends to continue providing a closer look at some of the core features being developed by the DIP team. These workshops give insight into DIP development, technology, and assumptions as well as providing

a forum for stakeholders engaging with the DIP team to pose questions and provide feedback on proposed designs. There will be several more workshops within this series spanning a variety of topics. For future announcements of additional workshops, visit the DIP homepage: https://nari.arc.nasa.gov/atmx-dip.

ATM-X xTM Subproject ETM Team Meets with Industry and the FAA
POC: JAEWOO JUNG

On Feb. 25, the Air Traffic Management-eXploration (ATM-X) Extensible Traffic Management (xTM) subproject Upper Class E Traffic Management (ETM) team met with representatives from industry and the FAA. At the meeting, upper Class E operators shared information regarding their recent flight tests and upcoming activities. The group conducted discussions on ETM, such as the assumptions and processes written in the proposal from the Aerospace Industries Association for cooperative operations in higher airspace. NASA's ETM team provided an early look for a potential ETM collaborative evaluation scenario, including operational volumes rendered in 3D graphics for conflict identification. The group is planning to meet again to discuss further cooperative operations and scenarios for a collaborative evaluation.

ATM-X DIP Competition for University Student Data Scientists Announced
POC: MIRNA JOHNSON

On Feb. 25, a web feature was published to announce the Air Traffic Management-eXploration (ATM-X) project's Digital Information Platform (DIP) subproject's University Challenge, "Runway Functions: Predict Reconfigurations at U.S. Airports" (https://www.nasa.gov/aeroresearch/nasa-competition-seeks-student-data-crunchers-for-runway-solutions). The University Challenge, which kicked off on Jan. 25, is the subproject's first collaboration with the NASA Tournament Lab and partnering with DrivenData. The competition is open to university students and faculty to submit their own solutions for artificial intelligence or machine learning for service(s). The goal of the first challenge is to develop automated algorithmic approaches for more accurately predicting airport reconfigurations as far in advance as possible from real-time data, including air traffic and weather. Submissions for the challenge will be due April 25 and will be competing for a prize pool of $40,000. The University Challenge was launched in late January 2022 in collaboration with the NASA Tournament Lab and partner DrivenData. To learn more, visit: https://www.nasa.gov/aeroresearch/resources/innovation-challenges#ATM-X

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ATM-X's UAM Subproject Delivers Second Software Release to AAM HDV

POC: KEVIN WITZBERGER

On March 1, the Air Traffic Management-eXploration (ATM-X) project's Urban Air Mobility (UAM) subproject delivered the second software release to the Advanced Air Mobility (AAM) project's High Density Vertiport (HDV) subproject to further enable their work on vertiport air traffic. The delivered software was developed by the UAM subproject and was comprised of the NASA provider of services for the UAM Independent Configurable Architecture for Reliable Operations of Unmanned Systems software package for Detect and Avoid for Small Unmanned Aircraft Systems, and software elements being utilized in UAM's Strategic Conflict Management. This deliverable is the second to HDV, with a third software release planned for August 2022.

SWS NASA Research Announcement Year 3 Kickoff Highlights

POC: NATASHA NEOGI

The System-Wide Safety (SWS) project held its Year 3 kickoff meeting on its NASA Research Announcement topic, "Assuring Increasing Autonomous Systems with Non-Traditional Human-Machine Roles," from March 1–2. On the first day,

the Pennsylvania State University team presented a summary of their progress regarding the Air Traffic Management-eXploration Urban Air Mobility concept of operations and task modeling in the Working Models that Compute framework, with a specific focus on a short-range cargo delivery service in a rural area where vehicle and battery health monitoring was examined. The subcontractor, Iowa State University, detailed their progress on integrating the systems theoretic process analysis methodology with traditional model-based systems engineering frameworks to enable a safety-forward systems engineering process called systems-theoretic process analysis. On the second day, the Collins Aerospace team presented their work related to modeling and verifying properties with respect to an aborted landing contingency scenario and a faulty navigation scenario. The Collins approach leverages the Architecture Analysis and Design Language (AADL) modeling framework with the Assume Guarantee Reasoning Environment (AGREE) model checker to specify high-level properties to be assured across the system. The subcontractors, Florida Institute of Technology and SoarTech, detailed and demonstrated their approach to model and train autonomous agents via reinforcement learning in the Soar cognitive architecture framework. They then verified these agents in

using the reimplementation and extension of the symbolic model checker NuXMV, with respect to properties traced down from those specified in AADL and AGREE. Natasha Neogi, NASA's technical point-of-contact for these awards, arranged for the teams to attend each other's out-brief, leading to a lively red-team oriented question-and-answer environment. This enabled a vibrant exchange of ideas across both award efforts and has led to a complementary set of research being developed to address a wide range of human-machine teaming challenges in emerging technologies and operations. These sessions were attended by external subject matter experts from the FAA and the Air Force Research Laboratory, who provided valuable feedback to the presenters.

ATM-X Team Meets with Alaska Center for UAS Integration

POC: KURT SWIERINGA

On March 2, representatives from the Air Traffic Management-eXploration (ATM-X) project met with the Alaska Center for Unmanned Aircraft Systems Integration (ACUASI) on their efforts to work toward Unmanned Aircraft Systems (UAS) freight transportation, as part of a meeting hosted by NASA's Langley Research Center in Virginia. The ACUASI is

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attempting to establish a UAS freight transportation system in Alaska, which has several unique operational considerations and opportunities.

ATM-X UAM Management Visits NASA Langley

POC: IAN LEVITT

Between March 2–4, technical and programmatic leadership from the Air Traffic Management-eXploration (ATM-X) project's Urban Air Mobility (UAM) subproject traveled to NASA's Langley Research Center in Virginia to review UAM research. The beginning of the visit was focused on detailed refinement of a management review of the UAM Airspace Research Roadmap. The Roadmap is a key tool for consolidating NASA's UAM airspace research and development and will be released for a series of reviews with the FAA and industry over the coming months. Nipa Phojanamongkolkij led the final push to develop a tool that conveys the complex information contained in the Roadmap into a view of the subproject's progress toward mission goals. Nelson Guerreiro showed the team the latest developments of the NASA/FAA Laboratory Integrated Test Environment (NFLITE), which brings together baseline assets at the FAA's William J Hughes Technical Center and prototype capabilities at NASA Langley's Air Traffic Operations Laboratory. The NFLITE

environment provides a capability to conduct hybrid experimentation that exposes low-technology readiness level (TRL) prototypes to high-TRL production systems, allowing for early discovery of implementation issues as well as early demonstration of future capabilities to stakeholders. Maria Consiglio of NASA Langley demonstrated her team's latest development of the detect and avoid (DAA) in the Flightdeck (DANTi) tool, which is an Electronic Flight Bag implementation of the DAA algorithms that have been developed and extensively tested in conjunction with Radio Technical Commission for Aeronautics Special Committee-228. Representative of assistive DAA needed to enable early UAM operations, the DANTi implementation has attracted attention from multiple stakeholders. UAM subproject management led the entire team through an annual town hall meeting, bringing awareness of the subproject's accomplishments and goals to the three supporting centers (NASA's Ames Research Center in California, NASA's Glenn Research Center in Cleveland, and NASA Langley) and providing an opportunity for in-person harmonization and team building.

ATM-X DIP Presents to the SWIFT Meeting

POC: MIRNA JOHNSON

On March 3, the Air Traffic Management-eXploration (ATM-X)

project's Digital Information Platform (DIP) subproject conducted a presentation at the System Wide Information Management (SWIM) Industry-FAA Team (SWIFT) forum. Representatives from the DIP team gave a brief update on the DIP concept and a progress update on the Collaborative Digital Departure Re-Route service, which has been designed to utilize a collection of new machine learning-based services to provide near-real-time predictions for airport surface models. The SWIFT forum is open to the public and offers a collaborative environment for outreach activities related to FAA information services shared via the SWIM program. SWIFT bridges the gap between operations and technology, addressing questions and concerns raised regarding data sharing and information services.

NASA Langley Conducts SmartCenter/CERTAIN Micro-Weather Workshop

POC: JAY ELY

Project and technical leaders from several of NASA's Langley Research Center in Virginia organizations gathered in early March to focus on micro-weather sensing for NASA Langley's City Environment Range Testing for Autonomous Integrated Navigation (CERTAIN) Smart Center (SC). Two half-day sessions were held with 35–50 attendees participating from all levels of

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career experience. The workshop exposed a breadth and depth of efforts happening at NASA Langley and the strategic importance of investing in the CERTAIN SC ecosystem. Speakers and attendees focused on how to optimize cross-organization, cross-project, and cross-discipline collaborations and provide maximum value to ARMD and other NASA missions given NASA Langley's unique location, partnerships, and capabilities. The workshop was organized by Jay Ely of NASA Langley's Electro-magnetics and Sensors Branch in response to enthusiastic encourage-ment from George Finelli, Dan Williams, and Jennifer Kibler. During the out-brief, it was revealed how CERTAIN SC weather stations, lidars, and tower feed informa-tion to various NASA Langley data networks is essentially forming a prototype weather information ecosystem that may be integrated into the Remote Operation for Autonomous Missions Unmanned Aircraft Systems Operations Center. CERTAIN SC will be a key proving ground for visionary concepts of High Density Vertiplex, ubiquitous sensing for weather tolerant opera-tions, and micro-weather modera-tion, concepts that will become part of a new data and reasoning fabric that will enable NASA's climb toward ubiquitous Urban Air Mobility operations with system-wide automated optimization.

Update on NASA PC-12 Aircraft Purchase

POC: RAFAEL APAZA

The purchase inspection of the PC-12 aircraft took place the week of March 7 and was conducted in San Antonio. A pilot and engineer from NASA's Glenn Research Center in Cleveland traveled for the inspection. It is anticipated that the aircraft will arrive at NASA Glenn in late April. This aircraft will play a pivotal role in supporting communications, navigation, and surveillance research within AOSP.

SWS Conducts "Wildland Firefighting Operations Workshop" with Flight Safety Foundation

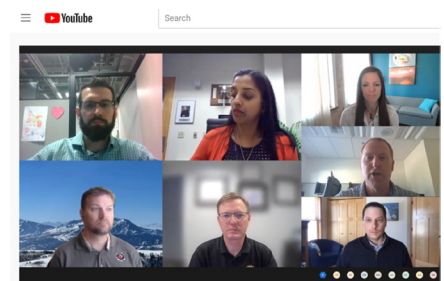POC: NATASHA NEOGI AND SUMMER BRANDT

Between March 9–11, the System-
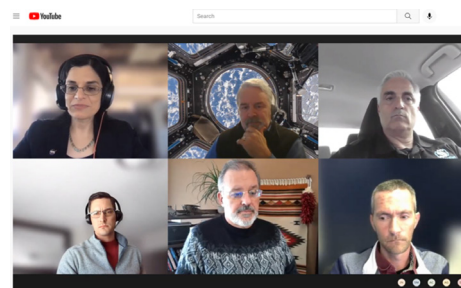
Representatives from the wildland firefighting community participate in NASA System-Wide Safety Wildland Firefighting Operations Virtual Workshop

Wide Safety (SWS) project coordinated a wildland firefighting operations workshop through the NASA Aeronautics Research Institute (NARI), engaging the

broader wildfire management ecosystem through a series of keynote talks, panels, and breakout sessions. More than 460 participants gathered to share information and identify areas of collaboration with the broader wildland firefighting community. Ideas were exchanged in operational firefighting, autonomous systems, policy and planning, and regulatory domains. ARMD's deputy associate administrator, Steven Clarke, and AOSP's deputy director, Cheryl Quinn, provided opening remarks on NASA's portfolio of interests in wildland firefighting. Seventeen breakout sessions and four panels comprised of diverse stakeholders from federal, state, local, and tribal governments, as well as industry and academia were spread across three days. SWS's Summer Brandt and Natasha Neogi organized the workshop with the aid of Abigail Glenn-Chase and Anna Cavolowsky from NARI.

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UL4600 Version 2 Standard for Evaluation of Autonomous Products Approved
POC: MALLORY GRAYDON

Underwriter's Lab (UL) standard UL4600, "Standard for Evaluation of Autonomous Products," is a standard for autonomous road vehicles that might serve as a basis for future standards for autonomous aviation products. For more than a year, Mallory Graydon led a task group that recommended changes to its Chapter 5, which concerns the safety cases to be produced by vehicle manufacturers. On March 15, these changes, among others, were approved by the UL technical committee responsible for the standard. The updated version of the standard has been released as UL4600 version 2 at the following website: https://webstore.ansi.org/Standards/UL/UL4600Ed2020

SWS Subject Matter Expert Participates on SAE AeroTech 2022 AAM Use Cases Panel
POC: NATASHA NEOGI

On March 16, System-Wide Safety (SWS) project researcher Natasha Neogi served as a subject matter expert on the Advanced Air Mobility (AAM) Use Cases Panel at the SAE AeroTech 2022 Conference in Pasadena. This year's conference was held live. The panel was moderated by Davis Hackenberg of NASA's AAM Mission Integra-

tion Office, and included a set of industry and community experts on AAM use cases such as Eric Allison of Joby, Dan Dalton of Wisk, Brendan Groves of Skydio, and Anna Mracek Dietrich of the FAA's Civil Aerospace Medical Institute. Use cases for the public good were brought up as a key focus of discussion in the panel, and operations such as wildland firefighting, disaster response and recovery, and medical couriering were discussed. Neogi commented on regulatory challenges for various AAM use cases and provided a perspective on what NASA is doing to help address those challenges by providing guidance to the broader AAM ecosystem, standards bodies including SAE standards efforts, and the FAA. An additional focus of the panel included increasingly autonomous systems, in which Neogi emphasized a functional approach to autonomy that enables a safety focus for the overall system. The panel encompassed an optimistic message toward further maturing the technologies that would make AAM and other emerging aviation applications a reality in a safe and reliable fashion.

SWS Project Continues Engagements with SAE G34
POC: GUILLAUME BRAT, MISTY DAVIES
AND AARON DUTLE

The System-Wide Safety (SWS) project actively engaged with the

Society of Automotive Engineers (SAE) International, G-34 Artificial Intelligence in Aviation Committee this past quarter. SAE G-34 is collaborating with the European Organisation for Civil Aviation Equipment's (Eurocae's) WG-114 committee to create standards that will enable the inclusion of machine learning and artificial intelligence in safety-critical aviation systems both in the vehicles and on the ground. On Feb. 24, SWS project researcher Divya Gopinath provided a briefing on the Safe Deep Neural Network (SafeDNN) project, which focuses on verification techniques for DNNs. The SafeDNN project explores new techniques and tools to ensure that systems that use DNNs are safe, robust, and interpretable. Research directions in this project include symbolic execution for DNN analysis, label-guided clustering to automatically identify input regions that are robust, parallel, and compositional approaches to improve formal Satisfiability Modulo Theories-based verification, property inference and automated program repair for DNNs, adversarial training and detection, and probabilistic reasoning for DNNs.

On March 10, Yuning He presented a talk on system analysis using Statistical Artificial Intelligence (SYSAI), a flexible learning framework for the verification and validation (V&V) and analysis

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of cmplex and high-dimensional aerospace systems with DNN and artificial intelligence components. SYSAI provides functionality for a variety of analyses and V&V tasks, including statistical data analysis, high dimensional safety envelope and time series analysis, property checking, as well as intelligent test case generation. Yuning He demonstrated the use of SYSAI on an industry case study with Boeing, an autonomous centerline tracking system, which uses DNN to enable autonomous aircraft taxiing. The talk was attended by more than 60 people from around the planet (the United States, Europe, Australia, and Japan), including many aviation companies such as Embraer, Airbus, Boeing, and Collins Aerospace, who were also in attendance. The FAA was represented by George Romanski and Srini Mandalapu and representatives from the US Naval Research Lab were present.

Between March 16–18, members of the SWS and Advanced Air Mobility projects attended the G-34 plenary meeting virtually. During this plenary, hundreds of committee members collaborated to map out the example use cases against the proposed development and assurance process and worked through technical issues including the definition of the necessary domains and cybersecurity concerns. NASA researchers are acting as key subject matter experts across the breadth of technical activities, including systems critical to performing and managing flight.

SWS Briefs ICAO on Safety Management Systems for UAM

POC: WENDY OKOLO

On March 17, System-Wide Safety (SWS) project management office members gave a briefing to the International Civil Aviation Organization (ICAO) on the scientific assessment of safety management systems for Urban Air Mobility (UAM) operations. Within the International Forum for Aviation Research, the SWS leadership team is participating on several working groups – including safety and security – to assess gaps, open research questions, the state of the art, and recommendations for UAM operations and vehicles for ICAO. The Safety Expert Group, consisting of contributors from NASA, Canada, France, Germany, the Netherlands, Poland, Czech Republic, Italy, and South Africa, was one of the first groups to present findings to ICAO regarding considerations for safety management systems for UAM. This interaction is timely, as ICAO is planning modifications for future iterations to Annex 19, which covers the development, enhancement, and provisions for a state safety program that systematically addresses safety risks to the global air transportation system.

ATM-X DIP Launches the NASA@Work Campaign

POC: MIRNA JOHNSON

On March 21, the Air Traffic Management-eXploration (ATM-X) project's Digital Information Platform (DIP) subproject launched a federated learning campaign through NASA@Work, which is a family of techniques in which multiple separate models are trained in "silos," then combined after training into one shared model. The DIP subproject's goal in pursuing federated learning is to leverage data without the need to expose it outside of private organizations. The DIP subproject team envisions several use cases for federated learning and will gather knowledge on potential use cases and requirements. NASA@Work is an internal, agency-wide platform that provides NASA employees an unconventional and innovative way to share knowledge and advance projects. Under the charge of NASA SOLVE, a one-stop-shop for all challenges and competitions related to the agency's mission, NASA@Work fosters collaboration across the entire NASA community through interactive discussion and challenge solving. Knowledge gathered from this campaign will inform the second University Challenge that DIP plans to host through the NASA Tournament Lab in Autumn 2022. To learn more and contribute to the campaign, please visit: https://nasa-at-work.nasa.gov/c/campaigns/423/about

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SWS Leads AAM Ecosystems Working Group Sessions

POC: MISTY DAVIES AND KYLE ELLIS

The Advanced Air Mobility (AAM) Ecosystem Working Groups held a virtual workshop between March 22–23. The AAM Mission Integration Office and NASA Aeronautics Research Institute were the primary organizers of the workshop. All the projects within NASA's AAM Mission Integration Office participated, including representatives from AAM, Air Traffic Management-eXploration, and System-Wide Safety (SWS). The workshop was well attended with more than 500 estimated participants and featured a general session each day, including stage-setting presentations and industry panels, followed by several breakout sessions held in parallel to discuss major areas where maturation is needed to enable AAM. Breakout sessions were attended by approximately 50 people each and featured lively discussions among the participants. Feedback from the breakout sessions is intended to help inform research roadmaps. Several key SWS personnel led sessions, including SWS's deputy project manager, Kyle Ellis, who led a breakout session discussing integrated SWS tools and methods, and SWS's project manager, Misty Davies, who served as the crosscutting lead, was also on the organizing committee and led a breakout session on the needs and stakeholders for assured systems architectures.

AOSP Participates in NASA-United Airlines Meeting with NAC Committee Member

POC: WENDY OKOLO AND WILLIAM CHAN

On March 23, AOSP representatives attended an in-person/virtual meeting with United Airlines at NASA's Ames Research Center in California. The meeting kicked off with the director of the NASA Aeronautics Research Institute, Parimal Kopardekar, and AOSP's deputy director Cheryl Quinn, who provided an overview of NASA's aviation research. Susan Pfingstler, managing director of network operations and Air Traffic Control strategy for United Airlines, the newest member of the NASA Advisory Council (NAC) Aeronautics Committee, described United Airlines's needs, priorities, and perspectives. In addition, Gilbert Wu provided an overview of the Air Traffic Management-eXploration project's Digital Information Platform subproject, and Bryan Matthews presented an overview on the System-Wide Safety (SWS) project, which focused on SWS-developed tools and capabilities on anomaly detection and precursor identification for flight operations. As a result of the discussions, Pfingstler recommended a potential collaboration opportunity between AOSP and United Airlines.

ATM-X xTM ETM Delivers a Research Transition Product to the FAA

POC: JAEWOO JUNG

On March 24, the Air Traffic Management-eXploration (ATM-X) project's Extensible Traffic Management (xTM) subproject Upper Class E Traffic Management (ETM) team delivered an ETM research transition team engineering working group research transition product (RTP), "ETM Initial Requirements Documentation," to the FAA. This RTP marked an important step towards the NASA/FAA's stakeholder-informed effort to build an ETM system for managing operations in high altitudes. In this airspace, a variety of aircraft with large performance differences such as a balloon, solar-powered high altitude long endurance uncrewed aircraft, and high-speed fixed-wing uncrewed aircraft are expected to fly, performing wildfire response, earth observations, telecommunications, and other missions. NASA and the FAA will continue working together and engaging with stakeholders to develop the ETM system and deliver RTPs.

Pilot-Focused UAM Research Study Completes Phase I of Data Collection

POC: RANIA GHATAS

The Air Traffic Management-eXploration (ATM-X) project's

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Urban Air Mobility (UAM) subproject team, comprised of Rania Ghatas of NASA's Langley Research Center in Virginia and Savvy Verma, Richard Mogford, and Victoria Dulchinos of NASA's Ames Research Center in California, recently completed the first of a series of a cross-center studies called UAM Pilot/Provider of Services for UAM Information Exchange and Contingency Airspace Management Procedures. The objectives of the interviews were to elicit expert knowledge concerning current-day National Airspace System (NAS) operations and how they might be applied to near-term UAM operations including, but not limited to, communications and airspace procedures during regular and emergency operations. Phase I of data collection, Jan. 4–March 25, consisted of 12 pilots, including 9 helicopter pilots (3 air ambulance/MedEvac, 3 air tour rides, and 3 private charter) and 3 general aviation fixed-wing pilots. All pilots had at least two years' worth of experience flying in the NAS. Minimum participation requirements for helicopter pilots included having experience flying for Part 135 operators. Phase II of the study is set to start data collection runs in April 2022 and plans to recruit 3–5 aircraft dispatchers with at least two years' worth of experience working for Part 135 or Part 121 operators.

NASA-FAA Quarterly Review
POC: WILLIAM CHAN

Between March 29–30, the Air Traffic Management-eXploration (ATM-X) project hosted a two-day hybrid in-person/virtual NASA-FAA quarterly review at the NASA Aeronautics Research Institute. FAA participants included Diana Liang, Enterprise portfolio manager); Nabil Sandhu, Advanced Air Mobility Beyond Visual Line of Sight National Airspace System Evaluation (BNE) lead; Sherri Magyarits, Upper Class E Traffic Management Concept of Operations (ConOps) lead and research transition team co-lead; Nouri Ghazavi, Urban Air Mobility (UAM) ConOps lead; Matt Modderno; Michelle Cady; and TJ Tejasen. Both days consisted of ATM-X presentations on research status and schedule updates from teams representing Digital Information Platform (DIP), Extensible Traffic Management (xTM), UAM, Pathfinding for Airspace with Autonomous Vehicles (PAAV), and Sky for All. In addition to these presentations, Arwa Aweiss, Rich Coppenbarger, and Nabil Sandhu led a breakout session on BNE and PAAV. Paul Lee and Sherri Magyarits held a breakout session toward developing a framework to describe research challenges for xTM-Air Traffic Control interaction. Mirna Johnson, Jeremy Coupe, and TJ Tejasen gave

an overview and a status update on the DIP Sustainable Aviation-1a (SA-1a) Demonstration and SA-2 formulation progress. Jeanne Yu and Michelle Cady led a Sky for All breakout working session. Marcus Johnson described the NASA-Japan Aerospace Exploration Agency collaboration on Unmanned Aircraft Systems Traffic Management (UTM). FAA representatives led discussions on their UTM flight test industry day debrief and next steps. The NASA-FAA quarterly review continues to provide both agencies the opportunity to enable deeper technical discussions among the various teams to strengthen future collaborations.

ATM-X Sky for All Conducts Exploratory Virtual Workshops
POC: SHAWN ENGELLAND

The Air Traffic Management-eXploration (ATM-X) project's Sky for All activity, a community co-developed vision that will guide NASA and FAA research and development investment decisions for decades to come, recently completed a series of exploratory session interactive virtual workshops to guide the vision for the mid-21st century future aviation system. The Sky for All team led the following use case workshops: "Greener Aviation" on March 21; "Future of Freight" on March 24; "Relief from Above" on March 25; "Urban Air Travel" on

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March 31; and "Flight from New Heights," scheduled on April 11. Additional workshop sessions in April include "Digital Airspace and Communications, Navigation and Surveillance (CNS)" on April 1; "Data and Decision Support Marketplace and Micro-services for Operators" on April 4; "Intelligent and Adaptive Automation" on April 6; "Systems of Systems Architecture and Methods" on April 7; and a mini-workshop on "In-Time System-Wide Safety Assurance" with the Flight Safety Foundation on April 26. Diverse stakeholders from the aviation industry, including flight operators, service providers, manufacturers, aviation and standards organizations, government, and the public were in attendance. Each workshop is an opportunity to drive collaborative discussions that will help NASA shape the principles and aspirations, capabilities, opportunities, use cases, barriers, and research questions that will put NASA on the path toward a sustainable, safe, resilient, and adaptable shared airspace.

SWS and Flight Safety Foundation Host Workshops for IASMS Roadmap

POC: MICHAEL VINCENT, MISTY DAVIES AND KYLE ELLIS

The System-Wide Safety (SWS) project is working with the Flight Safety Foundation to lay out a high-level, long-term roadmap for the In-Time Aviation Safety Management System (IASMS) in a series of mini-workshops meant to refine material on key themes identified from stakeholder interviews. Workshops will be comprised of structured tabletop exercises to identify key dependencies (technical and policy), risks, and opportunities. NASA subject matter expert input from the small group workshops will be used to update the material being drafted in advance of external stakeholder outreach. Workshops 1 and 2 took place between March 17–18 and consisted of moderated discussions regarding safety risks of emerging aviation operations as well as potential strengths, weaknesses, opportunities, and threats to the technologies that will enable those operations. The roadmap will eventually help guide the development and deployment of emerging aviation operations, such as those being researched by NASA's Advanced Air Mobility and Air Traffic Management-eXploration (ATM-X) projects. The first day of discussions focused on data sharing and metrics, predictive analytics, and cybersecurity while the second day focused on issues surrounding autonomy, radio frequency spectrum management, and detect and avoid. Researchers and subject matter experts from ATM-X and SWS participated across both days. Workshop 3 occurred on March 29 and covered a review of an initial draft of risks and strength, weakness, opportunity, and threat analysis for "Institutional Resiliency to Significant Disruptions," "Institutional Agility to Mitigate Risks," "Robust Business Models," and "Agile Regulatory Approach." Workshop 4, scheduled for April 13, will cover "Public Education is Critical," "Harmonization of Standards," and "Equity for New Entrants and Communities." Finally, Workshop 5, scheduled for April 14, is reserved for topics not completed earlier and "Airspace and Procedures," "Weather Forecasting and Nowcasting," and "Ground Risk Assessment."

Resilience Analysis and Design Team Releases Fault Model Design Tools Python Package Version 1

POC: DANIEL HULSE

In March 2022, System-Wide Safety (SWS) project researchers released a new version of the Fault Model Design tools (fmdtools) resilience modeling, simulation, and analysis package. Researchers included Daniel Hulse and Hannah Walsh from NASA with Sequoia Andrade and Lukman Irshad representing KBR. The fmdtools package simulates system faults in the early design phase to enable a more complete, formalized, and resilience-based functional hazard assessment process. To achieve this, fmdtools provides a Python-based

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design environment where one can represent the system in a model, simulate the resilience of the model to faults, and analyze the resulting model responses to iteratively improve the resilience of the design. This 1.0 release, the first public release as a NASA tool, brings many desired new features to the toolkit, including: 1) evaluation of system resilience and performance over a number of stochastically generated parameters defined in the model or external sampling approach; 2) parallel simulation and recording of operational and resilience scenarios for increased computational performance; 3) improvements to model representation syntax that enable faster model specification and model types that simulate more efficiently; 4) improvements to graphing and plotting capabilities to better represent the system model and performance over large sets of scenarios and interaction with external packages; and 5) improvements to code function, documentation, and supported workflows. These features support the toolkit's ability to efficiently simulate early stage, high-level models over a wide range of nominal and hazardous conditions to achieve a more informed assessment of a system's vulnerability and resilience to hazards. The fmdtools 1.0 release is available on GitHub, where it will continue to be updated with new features to support desired use cases.

ATM-X DIP Makes Progress on CDDR Service Development

POC: MIRNA JOHNSON

This past quarter, the Air Traffic Management-eXploration (ATM-X) project's Digital Information Platform (DIP) subproject team continued to make progress on the development of the Collaborative Digital Departure Re-Routing (CDDR) service for the sustainable aviation demonstration of DIP. The team has completed a traffic management initiative integration service to improve the re-route recommendations from CDDR. To further inform platform feature requirements, services such as the microservices used in CDDR will share quality metrics through the platform so consumers can confidently discover and select services most appropriate for their specific use cases. The team has prototyped accuracy and quality of service metrics to evaluate which ones are valuable in this decision-making process. The software team has also developed upgrades to CDDR with a Trajectory Option Set (TOS) Mode Management capability to adapt to the varying responsibilities users have based on the site or region. In one site, a center controller may approve a re-route request, whereas another site would have a terminal controller approve a request. The TOS Mode Management allows for easy adaptation that will be

necessary as DIP eventually moves from the North Texas area in Fiscal Year 2022–2023 to a more complex airspace in Fiscal Year 2024.

On March 31, the team achieved some key milestones for 2022. The team held a Demonstration Readiness Review for its Sustainable Aviation-1a CDDR tool in North Texas. This review covered readiness of procedures, software, analysis plan, and resources to execute the demonstration. Southwest Airlines and American Airlines, who are partnering for the demonstration, have confirmed readiness to support data collection beginning on April 28, 2022.

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SWS Technology Expected to Advance Career Astronaut Training and Certifications

POC: CHAD STEPHENS

On Feb. 1, research sponsored by the System-Wide Safety (SWS) project resulted in a new license (DN-1710) with AdvancingX (https://advancingx.com) for three patented NASA technologies. These patented technologies are expected to contribute to the AdvancingX focus areas of human health and risk mitigation, human factors research, and optimal team design – all of which are capabilities supporting career astronaut training and certifications. AdvancingX specializes in identifying, selecting, and training career astronaut teams for the commercial space industry for Moon and Mars missions using advanced technologies and research in human-machine teaming and space mining. The co-inventors on the licensed patents include researchers Chad Stephens, Lance Prinzel, Alan Pope, Kellie Kennedy, and Angela Harrivel of NASA's Langley Research Center in Virginia. The patents are LAR-17895-1, Patent No. US 9,623,324 B2; LAR-18996-1, Patent No. US 10,192,173 B; and LAR-19051-1, Patent No. US 10,997,526 B2.

ATM-X xTM Presents at Seminar at LeTourneau University

POC: JAEWOO JUNG

On Feb. 4, Jaewoo Jung from the Air Traffic Management-eXploration (ATM-X) project's Extensible Traffic Management (xTM) subproject presented in a virtual seminar to a group of students and faculty at LeTourneau University in Longview, Texas. Jung provided an overview of NASA's xTM research, including Upper Class E Traffic Management and the interactions between xTM-supported highly-automated operations and human-centric conventional air traffic operations. The seminar concluded with a question-and-answer session, where the students and faculty asked about technology and NASA in general.

Two ATM-X Teams Receive NASA Group Honor Awards

POC: WILLIAM CHAN

In February 2022, the ecoDemonstrator Tailored Arrivals Manager team received a 2021 NASA Group Achievement Award. The team was recognized for its work in advancing the state of the art in airspace management technologies by field testing advanced NASA technologies with the Boeing ecoDemonstrator aircraft. Tailored

Arrivals Manager relies on NASA's Autoresolver algorithm to compute fuel-efficient trajectory solutions that ensure separation while also managing time-based metering constraints. Autoresolver is designed to support dense and complex future traffic levels that will require increasingly autonomous air traffic management solutions to ensure safety and efficiency. Tailored Arrivals Manager was used in ecoDemonstrator flights where trajectory-based advisories were sent to a Boeing 737 MAX aircraft using digital data communications. The Air Traffic Management-eXploration (ATM-X) Increasingly Diverse Operations team also received a NASA Group Achievement Award. The team was recognized for demonstrating resilience, ingenuity, and dedication to complete data collection to contribute to an agency performance indicator using the Integrated Demand Management (IDM) concept. The IDM concept improves the ability to match air traffic demand to reduced capacity. The onset of the pandemic forced the team to be flexible and innovative to develop a plan for data collection that was feasible given restricted access to the center for both developers and subjects. The team conceived of an alternate plan that, with some work on the part of the developers, would allow them to use

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a skeleton crew onsite to present and collect feedback on various scenarios remotely. Despite these challenges, the team stayed focused and resilient and provided important results to the project, enabling completion of an important milestone.

Sky for All Participates in ImaginAviation
POC: SHAWN ENGELLAND

On March 3, the Air Traffic Management-eXploration (ATM-X) project's Sky for All vision team conducted a panel discussion with representatives from various NASA organizations entitled "A Sky for All: Imagining an Integrated, Dynamic Aerospace System" at imaginAviation, a three-day virtual event sponsored by NASA's Transformative Aeronautics Concepts Program. The event showcased many of NASA's aeronautical innovators, who presented updates on the programs and projects they are working on. Sky for All continued to have a presence throughout the duration of the event, including hosting a virtual "Meet and Greet Networking and Social Session" booth in the Gather.Town platform. To view the panel discussion, please visit: https://www.youtube.com/watch?v=Om5BM7x-Yd0.

Marcus Johnson Receives John J. Green Award at the ICAS Congress 2022
POC: WILLIAM CHAN AND JAEWOO JUNG

In March 2022, NASA's Marcus Johnson and Adriana Andreeva-Mori of the Japan Aerospace Exploration Agency (JAXA) were awarded the International Council of Aeronautical Sciences (ICAS) John J. Green Award for the ICAS Congress 2022. They were recognized for their efforts on the NASA and JAXA disaster response collaboration. The primary aim of the collaboration, which began in 2016, was to demonstrate the performance of Unmanned Aircraft System (UAS) Traffic Management (UTM) in disaster relief operations and support post-disaster operations in a more efficient manner using UAS. These efforts culminated in a flight test using UTM during a national disaster response drill in Japan. To continue their collaborations, NASA and JAXA recently renewed their agreement, which started in 2021, to focus on improved integration of conventional aircraft, UAS, and other Advanced Air Mobility aircraft during disaster relief operations – specifically wildfire response and post-hurricane/tsunami recovery. Additionally, Johnson is the first recipient from the United States and NASA to win this distinguished award since its inception in 2001. Johnson and Andreeva-Mori will receive their awards at the ICAS 2022 Congress in September in Stockholm, where they will also deliver a seminar on their collaboration. The ICAS Award is to honor young professionals of distinction, who, by virtue of their participation and involvement in aeronautics, have an exceptional record in fostering international cooperation between scientists.

SWS Research Receives Official "Thank You" from the FAA
POC: NIKUNJ OZA

In early March 2022, on behalf of their Oceanic Monitoring team, Andrew Mueller of the FAA's Air Traffic Safety Operations Oversight Division (AOV) sent NASA's Nikunj Oza an official message of thanks for Bryan Matthews's "tireless effort" in collaborating with the team and uncovering "…at least one possible deviation event that appears was never reported, exposing a potential safety incident that was previously undetected." Matthews's work helped AOV better understand the ability to use data analytics to investigate and understand

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other unreported deviations in the oceanic flight information regions.

ATM-X xTM Technical Lead to Speak at the AAAI 2022 Spring Symposium
POC: JAEWOO JUNG

On March 22, the Air Traffic Management-eXploration (ATM-X) project's Extensible Traffic Management (xTM) subproject technical lead Jaewoo Jung was invited to speak at the Advancement of Artificial Intelligence (AAAI) 2022 Spring Symposium at Stanford University. The symposium "Can we talk? How to Design Multi-agent Systems in the Absence of Reliable Communications" was to help identify research avenues that can move the artificial intelligence community beyond theoretical results for simple domains. Jung's talk specifically focused on communications challenges in the xTM domain.

SWS Researcher Delivers Keynote at IEEE International Conference on Assured Autonomy
POC: MISTY DAVIES AND GUILLAUME BRAT

On March 22, Guillaume Brat from the System-Wide Safety (SWS) project and Huafeng Yu, a principal investigator at Boeing, gave a joint keynote presentation at the Institute for Electrical and Electronic Engineers' (IEEE) International Conference on Assured Autonomy. The keynote was titled "Towards Safety Assurance of Artificial Intelligence (AI)-enabled Autonomous Systems," and presented recent progress toward safety assurance for AI-enabled autonomous systems, particularly machine learning-related verification and validation technologies.

SWS Presentation at Graduate Seminar Series
POC: WENDY OKOLO

On March 25, System-Wide Safety's (SWS) associate project manager Wendy Okolo presented a talk entitled "Planes, Drones, and Air Taxis: Safety Considerations in a Highly Autonomous Airspace" as part of the University of Texas at Arlington's Mechanical and Aerospace Engineering Department Graduate Seminar Series. In her talk, Okolo addressed the safety complexities of integrating Urban Air Mobility and small Unmanned Aircraft Systems into the National Airspace System and the associated considerations necessary to enable safety in operations and design. Okolo also touched on opportunities for collaboration, open access tools available, and other ways for attendees to get involved with SWS's mission. More than 50 graduate students, faculty members, and university personnel attended the hybrid virtual/in-person presentation.