National Aeronautics and Space Administration

AOSP Newsletter

Airspace Operations and Safety Program (AOSP)

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AOSP IN THE NEWS

NASA And Uber Plan Tests to Support Future Air Travel Over Cities

SlashGear (10/5, Roston) "Experts at NASA's Ames Research Center will work alongside a team from Uber this week to run computer simulation tests of future air travel over urban environments. The tests will be conducted in order to get data on 'certain things we already know and others we still need to invent,' according to the space agency."

NASA News: Space Agency and Uber Team-Up To Develop 'A New Future' Of Flying Cars

Daily Express (UK) (10/7, Kettley) "The NASA and Uber scheme has been dubbed Urban Air Mobility or UAM. The US space agency hopes to introduce a 'new future for city transport' through the development of flying personal vehicles. Under Urban Air Mobility, NASA's engineers will test and develop systems of low altitude flight control."

An Uber Boss Insists Its Flying Taxis Will Be Fully Functional By 2023, and Says The Company Is Talking With NASA To Find A Way To Manage Air Traffic

Aviation Week (3/25) reports "NASA has renamed its Urban Air Mobility Grand Challenge the Advanced Air Mobility National Campaign, a seemingly simple name change that signals recognition that industry's interest is in more than just downtown air transportation."

In Focusing On What Pilots Do Wrong, We May Be Missing Valuable Lessons From What They Quietly Do Right

Forbes (11/14, Kiernan) reports "the industry knows a lot about what pilots do wrong, but not nearly enough about what pilots do right. Human error accounts for 80% of aircraft accidents. Because these errors are so deadly, the aviation industry studies them carefully. ... But recent research from the NASA Engineering and Safety Center suggests that by concentrating on what people do wrong, we have been missing opportunities to learn about what people do right."

Meet NASA's Air Taxi Simulator

Aerospace America (11/26, Hofacker) reports "the Vertical Motion Simulator at NASA's Ames Research Center has a storied past, helping train astronauts and F-35 pilots alike. Now, the world's largest full-motion simulator could pave the way for urban air mobility, a future in which passenger air taxis could share the skies with package delivery drones and other cargo vehicles."

TECHNICAL AND PROGRAMMATIC HIGHLIGHTS

X-2 engineering simulation of NASA and Uber operations in a common airspace

Dashboard sumMarchy of NASA and Uber operations in X-2 engineering simulation

NASA-Uber X-2 Engineering Evaluations

POC: SAVITA VERMA

NASA, in collaboration with Uber, completed a series of engineering evaluations of the Urban Air Mobility (UAM) air traffic management (ATM) system at NASA's Ames Research Center in California from Sept. 30 to Oct. 3. These UAM simulations, known as X-2, were built on the capabilities developed for NASA's Unmanned Aircraft System Traffic Management (UTM) system and testbed, and were enhanced by the ATM-eXploration (ATM-X) project's UAM team to meet the increased density, tempo, and complexity of anticipated UAM operations. During the X-2 activity (consisting of 19 simulation runs), NASA and Uber submitted operations for different sets of flights, resulting in hundreds of simulated vehicles within a common airspace. Uber's lab was connected remotely to NASA's X-2 airspace management system, which will be further extended for NASA's UAM Grand Challenge testing. NASA algorithms for scheduling and separation were evaluated in X-2, and the early results show that the algorithms were able to maintain safe separation and establish efficient operations, with the exception of a few select situations due to uncertainties in the simulated UAM trajectories. In addition, the teams gained insights with respect to using the UTM system architecture as a basis for UAM operations. These findings are being documented for the benefit of the Grand Challenge effort and the broader UAM community. The ATM-X project is committed to delivering a lab-tested, UAM airspace system backbone for Grand Challenge activities and performing laboratory testing/simulation of scenarios with Grand Challenge partners prior to flight testing. The X-2 activity with Uber reduces risk and expedites the future integration of Grand Challenge partners for future activities.

System-Wide Safety Project Engagement at the AUVSI Safety Summit

POC: JOHN KOELLING

On Oct. 2, representatives from NASA's System-Wide Safety (SWS) project hosted a booth at the Association for Unmanned Vehicle Systems International's (AUVSI) World Safety Summit on Autonomous Technology at Levi's Stadium in Santa Clara, California. Over the course of six hours, representatives from the SWS project engaged with industry partners, other safety organizations, and students. There were more than 900 attendees at the event.

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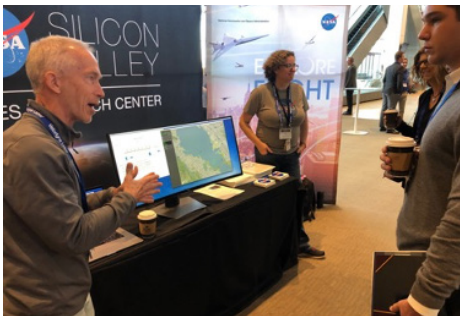

SWS project engagement at the AUVSI Safety Summit

The SWS team described the project's goals and achievements, including demonstrations showing that "In-Time System Wide Safety Assurance" (NASA Aeronautics Research Mission Directorate's Strategic Thrust 5) can help the United States improve safety in the near future and maintain or improve safety as we move toward emerging operations.

ATD-2 Phase 3 Field User's Meeting

POC: GREG JURO

On Oct. 2, the NASA Airspace Technology Demonstration (ATD) team conducted an ATD-2 Phase 3 review meeting with the six field user groups that are involved in the evaluation process at Dallas Fort Worth International Airport (DFW). This included groups from the DFW tower, Dallas Love Field tower, DFW Terminal Radar Approach Control Center, Fort Worth air route traffic control center, American Airlines, and Southwest Airlines. The primary objectives of the meeting were to determine if the field facilities desire to continue utilizing the Trajectory Options Set (TOS) feature in ATD-2 during the upcoming months and discuss potential enhancements to the system as part of the fiscal year 2020 evaluation. The field users unanimously affirmed that they would like to continue utilizing the TOS feature in the upcoming months on a target of opportunity basis. Discussion on the activation of the TOS ensued between the field facilities and a determination was made that Fort Worth Center would be the focal point for TOS activation and coordination. The ATD-2 team will continue to provide support during this time frame including additional training and onsite support as needed. Additionally, several enhancements for fiscal year 2020 were discussed, and extensive valuable feedback was obtained on the potential enhancements. The ATD-2 team will now evaluate and prioritize the potential enhancements and provide feedback to the field users in coming weeks.

UTM Hosts Senate and House Staff Members and NASA Astronaut

POC: RON JOHNSON

From Oct. 4 to 9, the Unmanned Aircraft Systems Traffic Management (UTM) project provided briefings to various groups at the Airspace Operations Laboratory at NASA's Ames Research Center in California. The hosted groups included: staff members from the U.S. Senate Sub-Committee on Commerce, on Oct. 4; staff members from the U.S. House Committee on Science, Space, and Technology, on Oct. 7; and former NASA astronaut, George D. Zamka, on Oct. 9. Each group was provided an update on the recent UTM Technical Capability Level 4 flight tests which were conducted this past summer in Reno, Nevada, and Corpus Christi, Texas.

ATD-2 Provides Briefing for Collaborative Decision-Making Automation Team

POC: BOB STAUDENMEIER

On Oct. 9, NASA's Airspace Technology Demonstration-2 (ATD-2) team provided the Collaborative Decision-Making Automation Team (CAT) with a briefing on the National Traffic Management Logs (NTML), in conjunction with the System Wide Information Management (SWIM) data it produces, in Santa Fe, New Mexico. The briefing provided updates on ATD-2 research and findings regarding the translation of the NTML logs into the SWIM feed. Examples of SWIM data that were extracted from the NTML logs were discussed along with how the ATD-2 system parsed and

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CAT team briefing, Santa Fe, New Mexico

made use of the data. Data utilized for the ATD-2 Phase 3 demo were also discussed. Lessons learned from developing the functionality were also of much interest to the group. The CAT team plans to use this information in planning their tasking regarding NTML usage procedures and best practices.

Joint NASA-FAA-Uber Meeting on High-Priority Research

POC: SAVITA VERMA

A collaborative meeting between NASA's Air Traffic Management-eXploration (ATM-X) team, the FAA and Uber was held from Oct. 16 to 17, at NASA's Ames Research Center in California. Most of the FAA personnel were from the FAA's Air Traffic Organization and NextGen offices. The focus of the meeting was to discuss Urban Air Mobility (UAM) procedures in the near and mid-term and identification of high-priority research items that would guide research in the next few years. The discussion included using the Unmanned Aircraft System Traffic Management construct to manage UAM operations and where that would be applicable. The NASA team also took the opportunity to demonstrate the recent X-2 simulation and its different uses cases. The demonstration included a live connection to Uber facilities and their flights participated in the simulation. This collaboration also included a meeting between NASA's Advanced Air Mobility Grand Challenge group and FAA and Uber visitors. The meeting ended with discussion on long-term research needs for new entrants into the National Airspace System that was led by members of the ATM-X Increasing Diverse Operations subproject team. This was a meeting to kick off a series of collaborative meetings between NASA, FAA, and Uber. Regular future meetings will be scheduled and discussion of refining the research needs for UAM operations in controlled airspace will continue.

Demonstration of X-2 to FAA and Uber visitors

System-Wide Safety Hosts ISSA ConOps Development Webinars and Workshop

POC: KYLE ELLIS

The System-Wide Safety project hosted a series of three "In-Time System-Wide Safety Assurance" (ISSA) Concept of Operations (ConOps) development webinars during September and October, led by Kyle Ellis and Paul Krois. The ConOps development team – consisting of Ellis, Krois and Laura Bass – hosted an all-day face-to-face ISSA ConOps Workshop at the National Institute of Aerospace in Hampton, Virginia, on Oct. 23. The webinars and workshop offered opportunities for NASA to engage with industry collaborators focused on advancing emerging

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Kyle Ellis, ISSA ConOps development team

operations that leverage vehicles such as Urban Air Mobility or Unmanned Aircraft Systems. The ISSA ConOps seeks to provide a framework for the aeronautics industry to reference, in developing a service-oriented architecture for In-Time Aviation Safety Management Systems (IASMS). Several industry collaborators participated in the events providing highly valuable input to the NASA ISSA ConOps. The three webinars focused on emerging operations risk identification, IASMS services, and the data and system architecture necessary to support the envisioned services. Considerations surrounding use cases, proprietary data sharing concerns, scalability, and cybersecurity were also discussed. Follow-on face-to-face workshops were held in Arlington, Virginia, and Mountain View, California, in November and December, respectively.

UTM Pathfinder Flights Concluded

POC: LOUIS GLAAB

Project Pathfinder, an activity sponsored by NASA's Unmanned Aircraft System (UAS) Traffic Management (UTM) project, completed flight testing on Oct. 26. These pathfinder endeavors provided critical test data to address several key technological barriers confronting the widespread use of small UAS within the National Airspace System. Test data included the effects of autonomous contingency management systems on a UTM system and its operators. Technologies developed at NASA's Langley Research Center in Virginia and tested in Pathfinder were Autonomous Safe Landing systems, as exemplified by Safe2Ditch, and Autonomous Sense and Avoid systems, as provided by the Independent Configurable Architecture for Reliable Operations of Unmanned Systems (ICAROUS). Safe2Ditch and ICAROUS were integrated for Pathfinder testing. The Air Traffic Operations Lab (ATOL) was configured to provide a series of test stations to acquire human factors data associated with nominal as well as off-nominal UTM-style operations. Langley's City Environment Range Testing for Autonomous Integrated Navigation (CERTAIN) UAS test range was used to conduct multivehicle flight operations and presented a series of traffic encounters for the test subjects who were assuming the

UAS outfitted with Safe2Ditch and ICAROUS technologies

Pilot station in ATOL used for the human factors data collection

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roles of UTM operators in the ATOL for Phase 2 testing. Phase 3 testing involved long range flights across Langley and were performed to broaden the test capabilities of Langley's CERTAIN test range and to prepare for Phase 4. The route from CERTAIN Range-2 to Langley's integrated engineering services building was approximately one mile long and was flown at an altitude of 375 feet above ground level. Phase 4 flights, completed on Oct. 26, included two vehicles operating simultaneously. One vehicle performed long range flights while the other flew a nominal flight path and acquired data regarding the capability of flight alarm avionics to provide vehicle-to-vehicle communication to support Autonomous Sense and Avoid systems. Overall, Pathfinder performed 262 flights over 31 flight days, requiring five months to complete all developmental and research flight testing.

ATM-X Increasing Diverse Operations Element 2 Workshop 2

POC: MATTHEW UNDERWOOD

From Oct. 28 to 30, NASA's Langley Research Center in Virginia hosted a workshop to support the Air Traffic Management-eXploration (ATM-X) project's Increasing Diverse Operations (IDO) subproject's Exploration of Air Traffic Management Services element. This workshop focused on generating use cases and architectures to support an Unmanned Aircraft System Traffic Management (UTM)-inspired airspace system for commercial subsonic aircraft operations. The ATM-X IDO subproject is focused on defining a service-based airspace system for the 2035-2045 time frame that improves efficiency and predictability for commercial subsonic transport aircraft (i.e., traditional users of controlled airspace), while also preparing the system for increased diversity associated with new entrants' use of the National Airspace System. This service-based airspace system leverages the design architecture of the UTM system and extends the philosophy and design principles of UTM to Class A airspace. The attendees discussed three use-case-specific concepts and associated technologies under development in the element, discussed operational use cases that highlight the integration of these technologies, and proposed an initial system architecture for consideration. Furthermore, discussions were held between the three elements of the IDO subproject to synchronize efforts across the various activities. The workshop was organized by Matt Underwood, the technical lead for IDO Element 2, and included approximately 20 researchers and engineers representing Langley, NASA's Ames Research Center in California, and NASA's Glenn Research Center in Cleveland, as well as members of the ATM-X project management team.

System-Wide Safety Project Meetings with Key Stakeholders at InfoShare Conference

POC: NIKUNJ OZA, JOHN KOELLING AND MISTY D. DAVIES

From Oct. 29 to 30, several members of the System-Wide Safety (SWS) project held meetings with key stakeholders during their participation at the InfoShare 2019 Conference, in Bellevue, Washington. The first meeting, on Oct. 29, was with members of the Aviation Safety Information Analysis and Sharing (ASIAS) system to discuss recent activities and upcoming plans involving ASIAS and its partner organizations. Some of the key meeting topics discussed included the ASIAS Dashboard, Directed Studies Updates, ASIAS Expansion, and Vulnerability Discovery Update. Nothing immediately actionable for SWS was discussed during this meeting, although Nikunj Oza plans to inquire about the general aviation and rotorcraft versions of ASIAS to see where SWS can potentially make its machine learning algorithms readily available. On Oct. 30, a discussion was held with American Airlines (AAL) to discuss a potential agreement with

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AAL to make their operations data available. In turn, the SWS project team will use that data to test their algorithms and, in exchange, make those machine learning algorithms available to AAL as part of their operational dashboard. There is a tentative plan to have follow-up meetings with AAL the weeks of Dec. 9 and 16 to learn more about their methods of preparing and analyzing their data currently, and to prepare a set of milestones and responsibilities that would go into a Space Act Agreement. Lastly, a meeting was held on Oct. 30, with the International Air Transport Association (IATA) to discuss the types of data to which IATA could provide access , and the ways that SWS can apply its machine learning algorithms to provide useful insights. This meeting was a follow-up to a past telecon. A follow-up telecon was held on Nov. 14, in which the SWS project was described, more details on the nature of the machine learning problems that we can work on were given, and IATA displayed their dashboard describing statistics on the underlying flights.

Airspace Technology Demonstration-2 FY20 Vision Workshop

POC: AL CAPPS

The Airspace Technology Demonstration-2 (ATD-2) team held a fiscal year 2020 (FY20) Vision Workshop at NASA's Ames Research Center in California, from Oct. 29 to 30. The objectives of the workshop were to layout current plans for FY20 and discuss potential future work. More than 60 ATD-2 team members participated in the workshop, which included new additions to the team.

ATD-2 team participants in the FY20 Vision Workshop at NASA Ames

Agenda items included a recap of last year's achievements, recognition of team members, transition planning for the ATD-2 system at Charlotte Douglas International Airport with the FAA and airline operators, fuser technology updates, and data-driven capabilities, use cases, and tools. Insights on plans after ATD-2 were also shared by the management. The FY20 Vision Workshop provided the ATD-2 team an overview of FY20 plans, and a general timeline of necessary activities to be completed by the end of the project. Further discussions with tech leads to add details to the plans are scheduled for Dec. 4 through 6.

ATM-X Urban Air Mobility Research Workshop 1

POC: KARL BILIMORIA, LINDSAY STEVENS AND DAVID THIPPHAVONG

From Oct. 29 to 31, the Air Traffic Management-eXploration (ATM-X) Urban Air Mobility (UAM) subproject held a UAM research workshop at NASA's Langley Research Center in Virginia. The objective of the ATM-X UAM subproject is to enable routine airspace access for UAM operations. During the workshop, the team worked together toward

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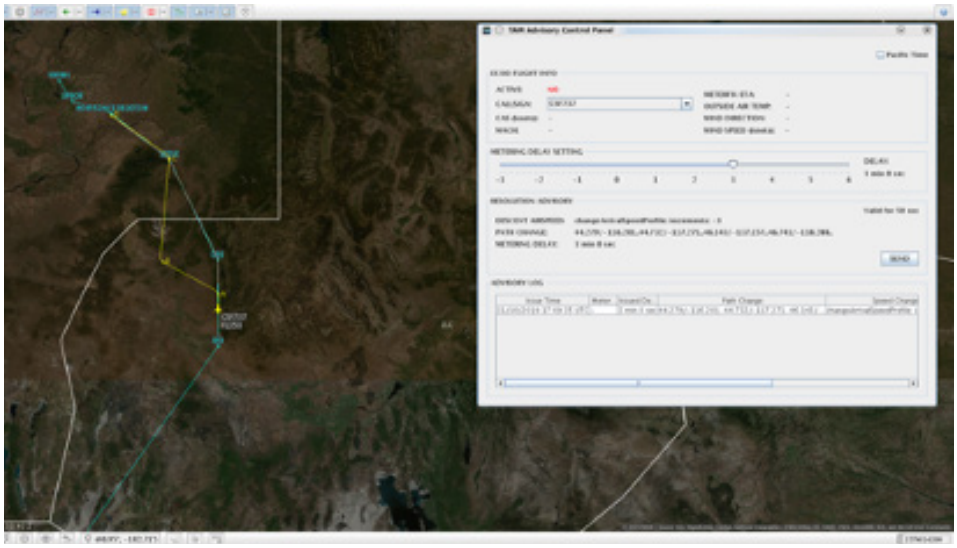
developing common airspace management concepts, simulation scenarios, and performance metrics for the fiscal year 2020 focus area: the information exchange requirements and protocols needed for UAM airspace management services to interoperate and support scalable operations. The team will explore both an Unmanned Aircraft System Traffic Management-like federated concept and a more centralized concept and characterize the differences between those two paradigms. During the course of this effort, it is expected that insights will be gained, reference research technologies will be developed, and data will be collected that will guide the UAM community in the design, development, and integration of the UAM airspace system, including in the UAM Grand Challenge. It is also expected that core technical challenges for UAM airspace management, to be tackled in Phase 2 of the ATM-X project, will be uncovered. A follow-up workshop is being planned for spring 2020.



TAM traffic viewer with chosen time delay in grey box and corresponding flight path in yellow

Completion of Tailored Arrival Manager-2 Testing with FAA Tech Center

POC: ARWA AWEISS

On Oct. 31, the ecoDemonstrator (ecoD) and Air Traffic Management-eXploration testbed team successfully completed the second of the 10 scheduled "lab shots" in preparation for the ecoD Flight Demonstration scheduled for July 2020. The objective of this test was to generate trajectory-based arrival solutions from NASA's Tailored Arrival Manager (TAM) tool and send them electronically to the Data Communication Avionics Lab (DCAL) at the FAA William J. Hughes Technical Center. Data obtained from the FAA's Boeing 737 Max simulator cab during previous TAM-1 testing were played back in the testbed software platform to create arrival scenarios to Moses Lake, Washington, which is the expected destination for ecoD flights in 2020. For each of the scenarios, conflict-free path solutions were generated by TAM, using NASA's Autoresolver algorithm, in response to manually set delay values representing time-based metering operations. Once received by the FAA, each TAM solution was converted into a Controller Pilot Data Link Communications message and loaded into a Flight Management System (FMS) test bench in the DCAL. Loading TAM solutions into the FMS revealed issues with merging path-stretch route modifications with the aircraft's nominal route. These issues were debugged and resolved during testing, resulting in successful FMS loads prior to test completion. Test findings were communicated with FAA and Boeing partners and used to establish modified TAM interface requirements for future ecoD testing and flight demonstrations.

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Grand Challenge Team Meeting between NASA and the FAA

POC: ANNIE CHENG

From Nov. 13 to 15, a series of face-to-face meetings between NASA and the FAA were held at the FAA's Mike Monroney Aeronautical Center in Oklahoma City. The purpose of the meetings was to discuss potential collaborations on NASA's Grand Challenge planning activities for developmental testing planned during the summer of 2020. The meetings included discussions focused on defining, developing, and refining Grand Challenge scenarios. These Grand Challenge scenarios cover a range of Urban Air Mobility (UAM) operational concepts that will aim at informing requirements and system development for scalable, commercial UAM through integrated demonstrations of realistic operational scenarios within Grand Challenge activities. The Air Traffic Management-eXploration UAM subproject participated in discussions related to airspace and flight procedures concepts for UAM, to inform future FAA requirements, including flight procedures and heliport designs that might need to be reviewed to support UAM operations. It is expected the outcome of these discussions will have follow-up efforts between NASA and FAA points of contact to further refine and develop the Grand Challenge scenarios and operational assumptions.

Testbed Presentation at NASA Goddard Space Flight Center

POC: ALAN LEE AND KEE PALOPO

On Nov. 14, the testbed subproject team gave a presentation to Jacqueline Lemoigne-Stewart, the head of the New Observing Systems (NOS) area, within the Advanced Information Systems Technology program at NASA's Goddard Space Flight Center. NOS is concerned with setting up multiple sensor platforms (space-based, airborne, ground-based) and facilitating their coordination for making earth observations. Their interest in the testbed platform was to determine if it may be helpful to test their multi-platform observing systems. Credit should be given to AOSP researcher Nikunj C. Oza, leader of the data sciences group at NASA's Ames Research Center in California for facilitating the meeting.

ATD-2 Phase 3 Flight Operator Meeting

POC: GREG JURO, JEREMY COUPE AND ERIC CHEVALLEY

On Nov. 19, the Airspace Technology Demonstration-2 (ATD-2) team hosted a flight operator meeting at NASA's North Texas Facility in Dallas. The purpose of the meeting was to continue the process of developing real-time metrics for flight operators to use during the ATD-2 Phase 3 evaluation in 2020. Currently, the ATD-2 system only projects the delay savings for the specific aircraft identified as a candidate for a reroute. The real-time metrics concepts that were presented at this meeting assess the prediction accuracy of the ATD-2 system for a specific time period and project aggregate delay savings for all aircraft that are impacted by a flight operator's decision to submit a flight for a reroute. Both real-time metrics are anticipated to result in an increase of airline Trajectory Option Set submissions in the 2020 Phase 3 evaluation. Several representatives from both American Airlines and Southwest Airlines participated in the meeting. The ATD-2 team described the metrics calculations as well as potential methods to display the information to the flight operators in the operational environment. The meeting was an excellent forum for exchanging information and ideas regarding the objective of providing real-time metric information. The

NASA, American Airlines, and Southwest Airlines personnel participate in a round table discussion of real-time metrics

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flight operators concurred that the initial concepts presented by the ATD-2 team were on target to meet their needs and provided some valuable feedback for potential enhancements. The ATD-2 team will present an update at a follow-up development meeting scheduled for Dec. 10.

Autonomous Freighter Operations Tabletop Exercise with Boeing

POC: PARIMAL KOPARDEKAR, IRENE GREGORY AND MARK BALLIN

On Nov. 20, NASA and Boeing held a table-top exercise to identify research issues related to autonomous freighter operations. At the meeting, NASA and Boeing representatives went through various autonomous freighter operations scenarios and identified information flows, decisions, technology needs, procedural considerations, and gaps in understanding. Outcomes of the meeting included a preliminary list of recommendations, including a proposed simulation testbed and next steps for continued NASA-Boeing research and development collaboration.

ATM-X Technologies Showcased in New Jersey

POC: RICH COPPENBARGER, ARWA AWEISS AND NELSON GUERREIRO

In coordination with the arrival of the 2019 Boeing ecoDemonstrator (ecoD) 777 aircraft from Frankfurt, Germany, to Atlantic City, New Jersey, NASA's testbed and Tailored Arrival Manager (TAM) technologies were exhibited at the newly-founded National Aviation Research and Technology Park (NARTP) and the Atlantic City International Airport, both located near the FAA William J. Hughes Technical Center (FAATC). The NARTP exhibit, held on Nov. 21, was visited by FAA managers and FAATC employees, including FAATC Director Shelley Yak. Presentations and software demos focused on testbed as a systems integration and simulation platform for validating air traffic technologies and procedures, such as those required by TAM in support of ecoD 2020. The Urban Air Mobility (UAM) Vehicle Simulation (UVS) and UAM Mission Planner at NASA's Langley Research Center in Virginia were also demonstrated. The UAM Mission Planner is a prototype capability for pre-departure trajectory planning in the presence of known constraints, such as fleet, airspace, traffic, and weather.

AOSP researchers demonstrate the UAM Vertical Simulation capability to Boeing's Director for Technology Integration and the ecoDemonstrator, Jeanne Yu

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The UVS is a medium-fidelity flight simulator with the ability to take off and land vertically; to fly a preplanned, 4D trajectory in fully automated or manual mode; and whose flight models are based on NASA Revolutionary Vertical Lift Technology reference configurations for UAM. On Nov. 22, the technology exhibits were relocated to Atlantic City International Airport and were located near the gate where the ecoD aircraft was parked, conducting onboard tours. Attendees included government and industry personnel with interest or involvement in ecoD, including Pete Dumont, the president and CEO of the Air Traffic Control Association, as well as members of the FAA's Continuous Lower Energy, Emissions, and Noise consortium including industry partners, who showed considerable interest in TAM as a technology for enabling low energy descents in busy traffic conditions, supported by data communications and flight deck integration. The exhibit was also attended by groups of local high school students pursing science, technology, engineering, and math studies.

Grand Challenge Completes Internal Test for Development Test Flight Demonstrations

POC: SHIVANJLI SHARMA

On Dec. 4, the Grand Challenge Airspace Test Infrastructure (ATI) team conducted an internal software-in-the-loop test, as a first step in preparing for Grand Challenge Development Test flight demonstrations, scheduled for late summer 2020 at the flight test range at NASA's Armstrong Flight Research Center in California. The Grand Challenge Development Test is the first activity in a series of tests with vehicle and airspace industry partners focused on establishing the certification requirements and standards needed for the Urban Air Mobility (UAM) market to move forward. The ATI team has developed a flight test system architecture to support airspace partners and vehicle partners in a variety of configurations. The system, predominantly a cloud-based infrastructure, will be able to integrate Unmanned Aircraft System Traffic Management (UTM)-inspired UAM Service Suppliers, live flight vehicle telemetry monitoring, and data collection required to enable a successful integrated Development Test flight demonstration. The internal software-in-the-loop test included a concrete demonstration of progress across two software teams (Grand Challenge ATI and Air Traffic Management-eXploration UAM) along with a test of the first delivery of the first UAM core services build for flight test. The test demonstrated virtual traffic to emulate UAM aircraft flying in the first scenario planned for the Grand Challenge, along with key infrastructure such as the discovery service and situational displays in the Airspace Operations Lab, which will serve as the primary execution center for the ATI team during the Grand Challenge. The test also included an initial verification of an updated data collection system and validation of data persistence based on lessons learned from UTM's Technology Capability Level 4. A follow-up test is planned for Dec. 17, where additional functionality will be explored in preparation for Grand Challenge Development Test flight test activities.

UTM Hosts Australian Air Services

POC: JAEWOO JUNG AND JOSEPH RIOS

On Dec. 10, Unmanned Aircraft System Traffic Management (UTM) project personnel met with visitors from the Australian Air Services (AAS) to discuss UTM's progress at NASA's Ames Research Center in California. Representing AAS were Kristian Cruickshank, Low-Level Airspace program manager, Matthew Booth, Commercial and Strategic Partnership manager, and Paul Stoddart, Strategy Stakeholder manager. Joseph Rios, chief engineer, and Jaewoo Jung, acting deputy project manager, represented the UTM project team at the meeting. The UTM's Technical Capability Levels (TCLs) 1 through 4 were described, along with the flight

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demonstrations that took place for each TCL. The roles and responsibilities of Flight Information Management System and UAS Service Supplier were also discussed, reflecting the differences between the United States and Australia. The merits and challenges of flight demonstrations were also discussed. The meeting ended positively with a conversation on potential future collaboration.

ATM-X Completes Initial UAM Airspace System Software

POC: DAVID THIPPHAVONG AND SPENCER MONHEIM

On Dec. 23, the Air Traffic Management-eXploration (ATM-X) Urban Air Mobility (UAM) team completed development and delivery of the initial UAM airspace system software, known as X-2, with the delivery of documentation and reporting of analysis results. The X-2 system supports NASA's UAM Grand Challenge Development Test flight activities, starting during spring 2020. X-2 integrated components of NASA's Unmanned Aircraft System Traffic Management system and ATM-X's testbed platform, with enhancements to enable the density, tempo, and complexity of anticipated UAM operations. As part of the X-2 development, NASA collaborated with Uber on a series of engineering evaluations. Afterward, the X-2 team implemented additional changes to enhance system performance, increase system capacity, raise system resilience, improve configuration management, and add verification and validation capabilities based on what was learned during the X-2 engineering evaluations. The enhanced X-2 system was successfully tested recently during internal tests with the NASA Grand Challenge Airspace Test Infrastructure team, in preparation for Grand Challenge Development Test flight activities. The ATM-X UAM team will continue to develop and mature the UAM airspace system in support of Grand Challenge-1 (the follow-up to the Grand Challenge Development Test) in 2022, conducting engineering simulations on Grand Challenge scenarios in summer 2020 (X-3) and summer 2021 (X-4) with additional industry partners.

RECOGNITION

Participation at the 3rd World Congress on Formal Methods

POC: CÉSAR MUÑOZ

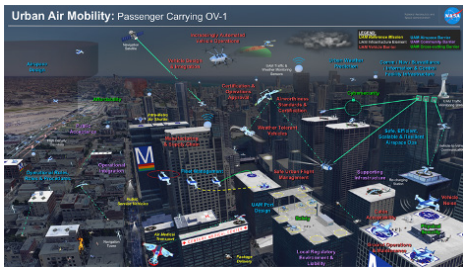
Researcher César Muñoz, from NASA's Langley Research Center in Virginia, attended the 3rd World Congress on Formal Methods (FM2019) in Porto, Portugal, from Oct. 7 to 11. FM2019 is the 23rd edition of the Formal Methods symposium. This year's symposium took the form of a world congress, which is organized every 10 years. The Formal Methods symposium is the prime conference on research and application of formal methods to software development of safety-critical systems. At the symposium, Muñoz served as the "Specification Languages" session chair. Furthermore, two papers, co-authored by Muñoz, were presented: "Provably Correct Floating-Point Implementation of a Point-in-Polygon Algorithm," by M. Moscato (NIA), L. Titolo (NIA), M. Feliu (NIA), and C. Muñoz (NASA), and "An Integrated Development Environment for the Prototype Verification System," by P. Masci (NIA) and C. Muñoz (NASA). The first paper concerns the problem of determining whether a point lies inside a given polygon. In air traffic management concepts, the point-in-polygon problem is used in geofencing systems for Unmanned Aerial Vehicles and in weather avoidance applications. Many mathematical methods can be used to solve the point-in-polygon problem. Unfortunately, a straightforward computer implementation of these methods can lead to incorrect results due to round-off errors in finite precision computations. These errors potentially result in an incorrect point-in-polygon determination even when the point is far from the edges of the polygon. The paper presents a formally verified correct implementation of a point-in-polygon method that is used in NASA's PolyCARP geofencing system. The second paper presents a modern integrated development environment for the Prototype Verification System, a system used at Langley for the verification and validation of air traffic management systems.

The website for the event is: http://formalmethods2019.inesctec.pt/

NASA Langley Researcher Invited to Speak at the Assured Autonomy Workshop 1

POC: NATASHA NEOGI

From Oct. 16 to 17, researcher Natasha Neogi from NASA's Langley Research Center in Virginia was invited to speak at the Assured Autonomy Workshop 1 in Arlington, Virginia. Neogi participated on the mobility panel, organized by the Computing



Notional UAM Scenario

Research Association/Computing Community Consortium, and gave a talk entitled, "Urban Air Mobility: Challenges and Issues," which addressed regulatory issues inherent in the acceptance of the UAM operational concept, specifically focusing on the increasingly autonomous nature of these vehicles. Neogi is collaborating on a workshop report surveying the commonalities and contrasts between the barriers to regulatory acceptance of autonomy in ground-based vehicles and airborne vehicles.

Her presentation can be viewed at the following link: https://cra.org/ccc/wp-content/uploads/sites/2/2019/10/Natasha-Neogi.pdf

System-Wide Safety Presentation and Panel at AUVSI-Hampton Roads Symposium

POC: KYLE ELLIS

On Oct. 24, Kyle Ellis, associate project manager for the System-Wide Safety (SWS) project, presented an overview of "NASA's

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Industry panel at the AUVSI- Hampton Roads Symposium

SWS Project and the industry-wide challenges surrounding safety assurance in the NAS," at the First Annual AUVSI-Hampton Roads Symposium, held at the Hampton Roads Convention Center in Hampton, Virginia. Ellis also moderated an industry-wide panel that included members from several distinct elements of the scalable emerging operations industry. Ellis discussed the vision of a transformed National Airspace System that incorporates emerging operations, the technical challenges surrounding scalability that leverages increased levels of autonomy, the need for in-time aviation safety management systems, and the opportunities that exist for those involved in the industry. Following the talk, Ellis moderated an industry-wide panel that included members from several distinct elements of the scalable industry "Gearamid": Foundational Technology, Maturation, Application Domain, Certification/ Regulation, and Policy. Chris Woolsey (Virginia Tech), Evan Dill (NASA), Cathy McGhee, (director of Innovation and Research for the Virginia Department of Transportation), Paul Krois (Crown Consulting and formerly with the FAA), and Tom Walker (Drone Up) all participated in the panel. The panel, "When will my Package Land at My Door? Safety Barriers to Emerging Operations," was well received and resulted in several new opportunities for partnership and collaboration between NASA, industry, and the Virginia state government.

Invited Speaker: 9th International Conference on Model and Data Engineering

POC: CÉSAR MUÑOZ

César Muñoz, a researcher from NASA's Langley Research Center in Virginia, delivered an invited talk at the 9th International Conference on Model & Data Engineering (MEDI 2019) held in Toulouse, France, on Oct. 30. The conference aimed at providing a forum for the dissemination of research and promoting the interaction and collaboration between communities on modeling (formal methods, software engineering) and data theory (Big Data, NoSql databases, data integration, and interoperability). Muñoz's presentation on "Formal Methods in the Development of Highly Assured Software for Unmanned Aircraft Systems" provided an overview of formal methods technology developed at Langley for the design, validation, and verification of highly assured autonomous Unmanned Aircraft Systems. Muñoz's talk emphasized the use of formal notations since the early stages of the software development process. These notations enable verification and validation techniques where safety-critical systems can be checked against functional and operational requirements in a rigorous way. Muñoz's travel was sponsored by the Ecole Nationale Superieure d'Electrotechnique, d'Electronique, d'Informatique, d'Hydraulique, et des Telecommunications in Toulouse, France.

U.S. Patent Office Issues Research Patent

POC: KAPIL SHETH

On Nov. 12, the U.S. Patent and Trademarks Office issued Patent 10,475,346, "Miles-in-Trail Passback

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Restrictions for Use in Air Traffic Management," to authors Kapil Sheth and Sebastian Gutierrez-Nolasco (previously employed by UC Santa Cruz, currently by Crown Consulting, Inc.). The patent application was initially filed on Oct. 8, 2015. Air traffic managers in the National Airspace System regularly prescribe Miles-in-Trail restrictions, a common traffic management initiative, to efficiently handle air traffic. Imposed Miles-in-Trail is the value of spacing required between aircraft flying along a certain path and it is used when downstream traffic congestion is anticipated. Miles-in-Trails may be implemented independently or in conjunction with other initiatives (e.g., a severe weather avoidance plan route or a playbook route, ground delay programs, etc.). This patent was issued for computation of Miles-in-Trail values passed back to upstream centers for real-time implementation in dynamically changing actual traffic scenarios. The paper describing this technology is available at www.aviationsystems.arc.nasa.gov.

NASA ARMD Hosted "Night of Flight" on Capitol Hill

POC: LAUREN CLAUDATOS, AL CAPPS AND NELSON GUERREIRO

NASA's Aeronautics Research Mission Directorate (ARMD) hosted a "Night of Flight" event for Capitol Hill on Nov. 20, where folks were invited to grab a bite to eat, drink, and learn about more than a dozen NASA aeronautics projects in an interactive showcase. This event, which took place at the Rayburn House Office Building on Capitol Hill, allowed congressional personnel and their staff to get hands-on experience with some of the latest technologies being developed within ARMD's projects. Eight members of Congress and approximately 375 congressional staffers attended the event. Several AOSP projects participated in the event. As part of the event, the Unmanned Aircraft System (UAS) Traffic Management project was showcased in a highlight reel of flight test and concept videos alongside an interactive Fly a Drone! activity, where people could learn about the different kinds of small UAS, the many applications for use, and experience first-hand the challenges (and fun!) of remotely piloting one. The feedback was overwhelmingly positive as people learned more about the increasingly complex operations NASA demonstrated in successful collaboration with industry and how those lessons learned can help inform future policy and research. Additionally, the Airspace Technology Demonstration-2 (ATD-2) team also participated in the event by highlighting the strong partnerships between NASA, the FAA, and industry, which has resulted in an Integrated Arrival, Departure, and Surface concept demonstration with new system capabilities for

Scott Pressley, American Airlines southeastern air traffic manager, Mike Hoprich, CLT National Air Traffic Controllers Association ATD-2 point of contact, Bob Staudenmeier, Cavan Solutions, NASA Support

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complex National Airspace System challenges. An additional area of outreach was communicating ATD-2's significant fuel savings benefits, reduced passenger time on the airport surface, reduced engine run time, and environmental benefits, such as reduced greenhouse gas emissions. Staff were very interested in the efforts by NASA and its partners, as well as savings seen to date and potential for additional savings as the program moves into additional airports nationwide through the FAA's Terminal Flight Data Manager program. Also, several researchers demonstrated the Air Traffic Management-eXploration (ATM-X) project's Urban Air Mobility (UAM) Vehicle Simulation (UVS) and UAM Mission Planner capabilities. The UAM Mission Planner is a prototype capability for predeparture trajectory planning in the presence of known constraints, such as fleet, airspace, traffic, and weather. The UVS is a medium-fidelity flight simulator with the ability to take off and land vertically; fly a preplanned, 4D trajectory in fully automated or manual mode; and whose flight models are based on NASA's Revolutionary Vertical Lift Technology reference configurations for UAM. Attendees of the "Night of Flight" event were able to observe the planning of a set of operations in the Atlantic City, New Jersey region in an airspace with a defined set of routes (provided to NASA by the FAA), observe the UVS executing a given flight trajectory, and even try their hand at manually flying the UVS along a preplanned trajectory. Congressman Bobby Scott of Virginia as well as ARMD's Bob Pearce, acting associate administrator, Jay Dryer, deputy associate administrator for programs, and Jon Montgomery, deputy associate administrator for policy, were among those who participated in in-depth discussions with AOSP representatives about the functionality demonstrated by the UVS and UAM Mission Planner.

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