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16. Abstract

This report describes and summarizes the research conducted during the 2020 calendar year under the Federal Aviation Administration (FAA) sponsored Joint University Program for Air Transportation Research (JUP). The JUP is a coordinated set of grants sponsored by the FAA currently with the Massachusetts Institute of Technology (MIT) and Ohio University. The program is a unique model among science, technology, engineering, and mathematics (STEM) programs. It not only provides funding to the students and hands on challenges relevant to the FAA mission, but it also provides quarterly meetings that foster open discussion among the students, the professors, and the FAA. This interaction is a key component to the research. The variety of perspectives shared at these meetings helps to foster innovative ways of addressing research problems and teaches students how to bridge the gap between theoretical research and real world problems. This report presents abstracts of the works presented at three meetings held during the 2020 calendar year.

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Contents

1 Introduction 1

1.1 Objectives 2

2 Meeting 1 3

2.1 Massachusetts Institute of Technology (MIT)- Dr. R. John Hansman 3

2.1.1 Preliminary Results from EcoD Flight Demonstration of the Delayed Deceleration Approach- Jaqueline Thomas 3

2.1.2 Flight Test Results of a Subscale Super-STOL Aircraft- Chris Courtin 4

2.1.3 Framework for Evaluation of Civil Aviation Automation Trends- Rachel Price, Clement Li, Sandro Salgueiro 4

2.1.4 Evaluation of Environmental Impact of Runway Requirements - Annick Dewald, Nicolas Miejers 4

2.2 Ohio University - Dr. Chris Bartone 5

2.2.1 Runway Surface Monitoring using and Unmanned Aerial Vehicle - Jackson Brengman 5

2.2.2 Visible Light and Infrared Spectrum Sensors for UAS-Based Mapping of Runway Surfaces- Conner Warnock 5

2.2.3 Trilateration Positioning Using Hybrid Camera-LiDAR System- Travis W. Moleski and Jay P. Wilhelm 6

2.3 Rowan University – Dr. Nidhal Bouaynaya 6

2.3.1 Current Research at Rowan University - Nidhal Carla Bouaynaya, Professor, Electrical and Computer Engineering 6

3 Meeting 2 6

3.1 Ohio University - Dr. Chris Bartone 7

3.1.1 Multi-spectral Sensors for UAS-Based Inspection of Airport Surfaces- Conner Warnock, Jackson Brengman 7

3.1.2 Airborne Collision Avoidance for sUAS based on ACAS -Maarten Kastelein 7

3.2 Massachusetts Institute of Technology (MIT) – Dr. R. John Hansman 7

3.2.1 Trajectory Inference and Prediction in Semi-structured Airport Environments Using Common Behaviors- Clement Li 7

3.2.2 Automated Assessment and Tactical Planning For Convective Weather Avoidance-Rachel Price 8

3.2.3 Future Climate Impact on Runway Requirements-Annick Dewald 8

3.2.4 Operational Noise Abatement through Control of Climb Profiles on Departure - Sandro Salgueiro 8

4 Meeting 3 9

4.1 Massachusetts Institute of Technology (MIT) - Dr. R. John Hansman 9

4.1.1 Exploring the concept of parametric safety analysis for equivalent levels of safety in the NAS-Guilherme Venturelli Cavalheiro 9

4.1.2 Automated Assessment and Tactical Planning for Convective Weather Avoidance-Rachel Price 9

4.1.3 Identifying and Learning Underlying Structure within Airspace- Clement Li 9

4.1.4 A Data Driven Approach to Understanding and Predicting Braking Action of Landing Aircraft- Marek Travnik 10

4.2 Ohio University Research Activities - Dr. Chris Bartone 10

4.2.1 Multi-spectral Sensors for Inspection of Airport Surfaces- Conner Warnock, Jackson Brengman 10

4.2.2 Detect and Avoid in a UTM/Remote ID Environment- Maarten Kastelein 11

4.2.3 Design and mission planning of Bobcat-1, the Ohio University CubeSat-Kevin Croissant, Gregory Jenkins, Ryan McKnight, Brian C. Peters, Sabrina Ugazio and Frank van Graas 11

5 Results 12

5.1 Students Graduated 12

5.1.1 Massachusetts Institute of Technology 12

5.1.2 Ohio University 12

5.2 News feature 12

5.3 Publications 13

6 Conclusions 13

Acronyms

Acronym	Definition
ACAS X	Airborne collision avoidance system X
ADS-B	Automatic Dependent Surveillance Broadcast
ASDE-X	Airport Surface Detection Equipment, Model X
ASOS	Automated Surface Observing System
AST	Aviation Safety Technologies
BVLOS	Beyond visual line of sight
FAA	Federal Aviation Administration
FICON	Field Condition
FOD	Foreign object debris
GNSS	Global Navigation Satellite System
GPS	Global positioning system
INS	Inertial navigation system
IMU	Inertial measurement unit
JUP	Joint University Program
LEO	Low earth orbit
LIDAR	Light detecting and ranging
MIT	Massachusetts Institute of Technology
NASA	National Aeronautics and Space Administration
NASR	National Airspace Resource System
NOTAM	Notice to Airmen
STOL	Short Takeoff and Landing
TCAS	Traffic alert and collision avoidance system
UAS	Unmanned aircraft systems
UTM	UAS traffic management

Executive summary

The Joint University Program (JUP) for Air Transportation Research is a coordinated set of grants sponsored by the Federal Aviation Administration (FAA). These grants are intended to encourage the development of innovative, long-term research in aviation-related technologies of interest to the FAA. An additional benefit to the program is the creation of a talented pool of well-trained graduates to advance aviation technology in government, industry, and the academic community.

An important aspect of the program are the interactive meetings. Students prepare and present briefings on the goals, progress, and plans for the research projects. The attendees, including other students, professors, and government representatives, provide discussion, insight, and constructive criticism during the meetings. The meetings allow the students to align the research with the FAA needs and priorities and allows students and professors from different universities and backgrounds to provide an interdisciplinary perspective to the research. The alignment with FAA needs and priorities facilitates the technological transfer from the academic to applied environment. This document summarizes the presentations from three meetings held in 2020. The majority of the research during this time was funded by the Airport Technology Research Branch (ANG-E26).

In an era of rapid technological change, Government research programs, defined years in advance and facing constrained research budgets, struggle not to fall behind. Programs such as the JUP allow the FAA to explore promising technological advancements with minimal risk, providing the academic agility to adapt to rapidly changing technology. In 2020, despite a necessary change in format to remote meetings over Zoom in place of face-to face meetings and challenges faced by students with the pandemic, the JUP was still able to continue to be productive, producing multiple publications. Three students also completed their degrees during this time.

1 Introduction

The Joint University Program (JUP) research grants were instituted in 1971 by the National Aeronautics and Space Administration (NASA) to advance the safety and efficiency of the National Airspace System, building on the strengths of each institution. In 1983, the Federal Aviation Administration (FAA) joined NASA in supporting the program, continuing to support the program even after NASA left the program in 2005. Over the ensuing years, the program has successfully contributed to the base of qualified researchers and to the research knowledge critical to the advancement of the National Airspace System. Graduates of the program have continued to contribute to aviation after leaving the program through roles in government, university research programs, and industry.

The aerospace industry is facing an era of change. Aircraft parts are being made by innovative composite materials and printed on 3D printers. Aircraft manufacturers are looking at electronic propulsion systems as an alternative to the current combustion engines. Industries are rapidly commercializing space transportation, and unmanned vehicles are on the brink of integration with the National Airspace System. Air transportation has long been recognized for using leading edge technology to go faster and higher while maintaining the highest levels of safety. Every decade brings new technological innovations, improving on the previous generations. Many of the innovations that have transformed the National Airspace System and contributed to the impressive aviation safety record originally stem from government grants. Industry, government agencies, and universities built on the initial investment made by government grants to develop new products, technologies, engineering methods, and scientific knowledge.

The continued development of the National Airspace System and the introduction of new potentially transformational technologies requires a cadre of researchers from a variety of disciplines skilled in advanced technology but with an interdisciplinary focus. Technical knowledge has limited potential for success without domain knowledge. The JUP is uniquely positioned to provide the necessary interdisciplinary education and the domain knowledge to develop research workers who can solve problems of interest to the FAA. Each university participant submits a separate proposal to the FAA. To promote interchange among the universities, reviews are held quarterly, one at each of the schools and one at the FAA William J Hughes Technical Center. At these reviews, the program participants have an opportunity to present their research activities to their peers, professors, and to FAA representatives. In addition to students funded by the JUP, students and professors who are doing related work are often invited to present and to participate in the discussions.

In addition to contributing to a skilled future workforce, the JUP provides the FAA with an agile research capability. In an era of rapid technological change, Government research programs, defined years in advance and facing constrained research budgets, struggle not to fall behind. Technology can change quickly, and it is difficult for the FAA to evaluate each new emerging technology. New technology leads to new research questions. As new technology solves aviation problems, there are often unintended or unexpected consequences, leading to new problems. New technology, for example, enables more precise patterns of airport arrivals and departures, which increases the predictability of aircraft patterns. More precise air traffic patterns leads to a higher concentration of noise over particular areas, often generating an increased number of noise complaints. Programs such as the JUP allow the FAA to explore promising technological advancements with minimal risk. The quarterly meetings of the program allow the students to align the research with the FAA needs and priorities. This alignment also facilitates the technological transfer from the academic to applied environment.

This report provides a description of the JUP. It also includes a summary of the ongoing research relevant to the JUP, including the agendas from the meetings held in 2020. The principal investigators during this time were Dr. R. John Hansman from Massachusetts Institute of Technology (MIT), and Dr. Chris Bartone from Ohio University.

1.1 Objectives

Key objectives of the JUP are to:

- Identify and explore promising areas of aviation research with the potential to further overall knowledge and understanding for emerging technologies
- Increase the number of qualified individuals with graduate degrees in Science Technology Engineering and Mathematics areas of interest to the Federal Aviation Administration

Additional objectives include:

- Foster excellence in aviation
- Maintain the competitive edge for the United States in aviation research
- Promote innovative solutions to aviation problems
- Encourage innovative, advanced research of potential benefit to the long-term growth of civil aviation.

- Contribute to the FAA mission of improving aviation safety, capacity, efficiency, and security
- Foster collaboration between the participating universities

2 Meeting 1

The first meeting of 2020 was hosted by the FAA and was held at the National Aviation Research Park on January 23rd and 24th. Representatives from the FAA and NASA were present at the meeting. As Princeton had difficulty in getting graduate students to support the work, they were not a part of the 2020 program. Instead, at the suggestion of the Aviation Research Management, other Universities were invited to participate as guests in the 2020 program. Candidate guest universities were suggested and selected by FAA employees from the Aviation Research Division. The universities were selected based on the relevance of ongoing work to the work being conducted at the William J. Hughes Technical Center, proximity to the William J. Hughes Technical Center, and the willingness and availability of the university to participate. The first guest university was Rowan University, represented by Dr. Nidhal Carla Bouaynaya, Professor, Electrical and Computer Engineering and her students. The following are abstracts from the presenters.

2.1 Massachusetts Institute of Technology (MIT)- Dr. R. John Hansman

2.1.1 Preliminary results from EcoDemonstrator flight demonstration of the delayed deceleration approach- Jaqueline Thomas

This presentation discusses the preliminary results from the EcoDemonstrator flight demonstration of the delayed deceleration approach conducted in November 2019. In typical approach procedures, aircraft descend early in the approach and maintain level flight segments before intercepting the glide slope, resulting in the need to maintain higher thrust levels to maintain final approach speed to touchdown. In a delayed deceleration approach procedure, the aircraft maintains higher speed and thus can remain cleanly configured and at lower thrust levels for a longer duration in the approach, thus reducing configuration and engine noise. Several proof of concept flight tests of the delayed deceleration approach were flown in a Boeing 777-200 as a part of the EcoDemonstrator program in November 2019. The community noise impacts of these procedures were assessed and compared to representative standard deceleration approaches. Finally, operational implications of implementing delayed deceleration approach procedures in this program are discussed.

2.1.2 Flight test results of a subscale super-short takeoff and landing aircraft- Chris Courtin

The results from recent flight tests of a 30\% scale demonstrator of a blown-wing Super short takeoff and landing (STOL) concept aircraft are presented. The concept SuperSTOL concept is to use distributed electric propulsion to develop a fixed-wing aircraft with extremely short runway requirements, competitive with vertical takeoff and landing vehicles. The subscale demonstrator is aimed at investigating the maximum achievable in-flight lift coefficients with the blown wing, as well as the control and handling qualities with a mostly conventional aircraft configuration with unblown control surfaces. With a relatively modest amount of blowing power - a static thrust/weight of 0.45 - the flight tests show that the blown wing SuperSTOL concept can generate high lift coefficients greater than 10 in flight. It was observed that reducing the size of the propeller enabled larger Coefficient of Lift values to be achieved. In high-Coefficient of Lift flight, the roll control authority of conventional ailerons was found to be marginal, partly due to the low fight dynamic pressure and partly due to the local stall over the unblown part of the aileron. In the configuration tested, most of the elevator deflection was consumed to obtain pitch trim at low speed. A finite rotation rate to takeoff attitude was found to significantly contribute to the ground roll distance.

2.1.3 Framework for evaluation of civil aviation automation trends- Rachel Price, Clement Li, Sandro Salgueiro

Advances in algorithms and developments in automation approaches have resulted in new types of automated systems for civil aviation, creating potential opportunities and emerging issues regarding certification and operational approval. A framework for evaluating automation trends in civil aviation is being developed to assist the FAA in identifying issues and potential approaches to certification and operational approval of these systems. Development of the framework will be presented.

2.1.4 Evaluation of environmental impact of runway requirements - Annick Dewald, Nicolas Miejers

Within the coming years, temperatures and precipitation rates are likely to increase in many regions due to the effects of global warming. Future runway requirements will depend on environmental conditions including temperature and braking conditions. Therefore, it is important to understand how climate models predict temperature and how precipitation trends might change. This presentation will outline the structure being developed to evaluate the impact of relevant aircraft performance factors (temperature, density altitude, surface condition, wind direction), in relation to the relevant data being pulled from climate models. Surface condition is of particular importance, as under rainfall or snowfall conditions the grip of the aircraft wheels on the runway pavement is reduced, which limits the efficiency of wheel braking actions. In the worst case, degraded braking can lead to runway overruns. The FAA and other aviation authorities have developed methods to assess runway conditions, mainly based on flight-testing. With the large amount of flight data available today, an opportunity exists to better understand at a macroscale the phenomena behind degraded braking and predict degraded braking using data-mining techniques. This presentation introduces some exploratory work on using different data sources and data-mining techniques to identify degraded braking cases and develop predictive algorithms. Explored data-sources include Airport Surface Detection Equipment, Model X (ASDE-X) ground radar data, Pilot Braking Reports, and Notice to Air Mission (NOTAM) data (Field Condition Reporting). Future plans involving the use of Aviation Safety Technologies (AST) data and recent predictive algorithms are then discussed.

2.2 Ohio University - Dr. Chris Bartone

The general focus of the research at Ohio University this year was on airport inspection with autonomous platforms using various sensors including light detecting and ranging (Lidar), optical, infrared/thermal, with a Global Navigation Satellite System/Inertial Navigation System (GNSS/INS) unit. They also investigated the performance of optical/infrared/thermal based system for wildlife detection and reporting. The specific efforts are described in the abstracts.

2.2.1 Runway surface monitoring using an unmanned aerial vehicle - Jackson Brengman

This presentation concentrates on an effort to assist the FAA in developing criteria required to perform mapping of an airport surface using various sensors from an unmanned aerial vehicle platform. These operations are planned to occur during periods when the airport is in a non-operational status. The purpose of the systems is to collect data to aid in the operation and maintenance of the runway surface as well as foreign object debris (FOD) detection and removal. The presentation provides details on the unmanned aircraft system (UAS) that was selected, pavement requirements set forth by the FAA and early integration of sensors.

2.2.2 Visible light and infrared spectrum sensors for UAS-based mapping of runway surfaces- Conner Warnock

This presentation concentrates low-light optical sensors to perform mapping of an airport surface using an unmanned aerial vehicle platform. The purpose of the systems is to collect data to aid in the operation and maintenance of the runway surface. The purpose of the system would be to collect data to aid operation and maintenance of the runway surface. A logistical analysis of mapping runway surfaces with UAS-based visible light/infrared spectrum sensors, and analysis of on-ground preliminary test results with both types of sensor will be presented. To be discussed: runway surface light analysis, sensor characteristics, detection requirements, and host UAS constraints.

2.2.3 Trilateration positioning using hybrid camera-LiDAR System- Travis W. Moleski and Jay P. Wilhelm

Accurate position estimation in a global or local frame is needed for a navigation solution, which results in safe and efficient vehicle guidance. Visual identification of landmarks and laser ranging was investigated to bridge a gap between accuracy and computational needs for position estimation. Visual classification of landmarks in a scene and laser ranging was hybridized using a camera and scanning LiDAR facing the same direction. The process of hybrid landmark localization was explored and performance was evaluated using computer vision from simulated environments. The hybrid method resulted in an average position error of 0.08 m in 2D, but when extended to 3D the error increased due to limited landmark separation in the third direction. The developed hybrid camera-LiDAR provided a successful position estimation for different landmark views.

2.3 Rowan University – Dr. Nidhal Bouaynaya

2.3.1 Current Research at Rowan University - Nidhal Carla Bouaynaya, Professor, Electrical and Computer Engineering

Dr. Bouaynaya shared current research done in her lab.

3 Meeting 2

Due to COVID-19, the second meeting of 2020 was postponed from April to July 29th. Instead of an in-person meeting at Ohio University, the JUP was held as a virtual meeting through Zoom. To preserve the interactive nature of the meetings, each of the presenters were asked to allow time for discussion at the end of their presentation. Due to the changes related to the pandemic, no guest university was included. Additionally, the primary NASA point of contact who had been attending the meetings retired.

3.1 Ohio University - Dr. Chris Bartone

3.1.1 Multi-spectral sensors for UAS-based inspection of airport surfaces- Conner Warnock, Jackson Brengman

This presentation begins with an overview on the plan to assist the FAA in developing criteria to perform inspection of an airport surface using various sensors from an unmanned aerial vehicle platform. The purpose of the systems is to collect data to aid in the operation and maintenance of the runway and surrounding surfaces, including FOD detection and removal. The multi-spectral approach and their integrations approach will be provided. The presentation will highlight the value added for each of the sensors for various types of features on the airport surface to be inspected. Details on the low-light optical, Lidar, and thermal/IR sensors to be used for inspection of an airport surface will be presented. Status of current sensor and platform integration efforts will be presented.

3.1.2 Airborne collision avoidance for small UAS-based on airborne collision avoidance system (ACAS) -Maarten Kastelein

The ongoing increase in the number and type of UAS operations provides a clear need for safe and efficient integration of UAS into the National Airspace System (NAS). Main obstacle in integration is the lack of certified sense and avoid (SAA) solutions. The traffic alert and collision avoidance system (TCAS) cannot meet requirements for UAS. TCAS has shown to lack adaptability to future operations, with reduced separation margins and lack of support for additional surveillance inputs. Airborne collision avoidance system X (ACAS X) is being developed to address these issues and increase surveillance, alerting, and resolution performance. This presentation discusses design, implementation, and verification of an ACAS for small UAS in low-altitude operations by application of the ACAS X framework. Simulations and flight tests results for sUAS applications will be presented.

3.2 Massachusetts Institute of Technology (MIT) – Dr. R. John Hansman

3.2.1 Trajectory inference and prediction in semi-structured airport environments using common behaviors- Clement Li

Automated situation assessment of other airborne traffic is critical for some emerging automation applications in order to avoid loss of separation and integrate with existing aircraft operations. This becomes particularly crucial in areas of relatively high traffic density, but without positive air traffic control, such as untowered airports. The current state-of-the-art for trajectory prediction can be improved through the identification of implicit or explicit structure within an airspace in the form of common flight behaviors. Common behaviors within the context of a specific airport are captured from observed historical Automatic Dependent Surveillance-Broadcast ADS-B data and used for extending trajectory prediction range and accuracy. Ongoing work and preliminary results will be discussed.

3.2.2 Automated assessment and tactical planning for convective weather avoidance- Rachel Price

Commercial aviation currently relies on human judgment to assess and avoid hazardous convective weather, both in the terminal area and en route. Existing models for convective weather penetrability focus on applications for air traffic management, and a model specifically designed for cockpit automation is envisioned. Using archived radar reflectivity observations and historical flight tracks, instances of deviation around convective weather can be identified. These instances are further analyzed to find common patterns both in the convective weather that caused the deviation and the tactics the pilot employed to avoid the weather. Heuristics for both assessment and maneuvering can be derived from the observed patterns to be used in an automated situational awareness and tactical planning process.

3.2.3 Future climate impact on runway requirements-Annick Dewald

Global warming is predicted to cause increased temperatures and more extreme precipitation events, effecting the required runway length according to current FAA sizing methods in Advisory Circular 150. This presentation will outline two future climate trends across the continental United States and present how required runway lengths with change given the climate scenarios.

3.2.4 Operational noise abatement through control of climb profiles on departure - Sandro Salgueiro

The recent advent of Performance-Based Navigation (PBN) and Area Navigation (RNAV) procedures in the United States has led to an increase in the number of aircraft-related noise complaints in some cities from households located underneath RNAV tracks. The conventional strategy to perform operational mitigation of aircraft noise over populated areas is to move the lateral trajectories of aircraft and cause them to overfly non-populated or sparsely populated areas. However, this strategy is limited to both airspace constraints and the availability of sparsely populated regions near an airport. This talk will discuss an additional alternative for the operational mitigation of aircraft noise through the control of aircraft climb profiles. By tailoring the climb profiles (i.e. climb rate and airspeed) of aircraft departing from an airport, we hypothesize that it may be possible to reduce thrust levels and therefore engine noise as aircraft overfly densely populated areas.

4 Meeting 3

The third meeting of 2020 was also held virtually through Zoom, due to the ongoing pandemic.

4.1 Massachusetts Institute of Technology (MIT) - Dr. R. John Hansman

4.1.1 Exploring the concept of parametric safety analysis for equivalent levels of safety in the National Airspace System-Guilherme Venturelli Cavalheiro

We propose a framework in which the safety analyses associated with certain regulatory standards are parametrized and made automatically repeatable. This would allow the FAA to leverage large amounts of data collected by current surveillance infrastructure (e.g. ASDE-X and ADS-B) to build better statistical models and efficiently translate measured changes in performance into potential standard adjustments while maintaining equivalent levels of safety. More generally, we also discuss how such formulation can help ensure methodological consistency and facilitate the exploration of assumption modifications, which in turn accelerates the consideration of new technologies and processes.

4.1.2 Automated assessment and tactical planning for convective weather avoidance-Rachel Price

Commercial aviation currently relies on human judgment to assess and avoid hazardous convective weather, both in the terminal area and en route. Existing models for convective weather penetrability focus on applications for air traffic management, and a model specifically designed for cockpit automation is envisioned. Using archived radar reflectivity observations and historical flight tracks, instances of deviation around convective weather can be identified. These instances are further analyzed to find common patterns both in the convective weather that caused the deviation and the tactics the pilot employed to avoid the weather.

4.1.3 Identifying and learning underlying structure within airspace- Clement Li

The increasing availability of trajectory data for analysis and real-time operational use due to the introduction of ADS-B in the national airspace offers an opportunity to apply data mining and machine learning approaches to identifying underlying structure within the national airspace. Characterization of underlying structure will allow for improved prediction of future aircraft trajectories, which can be useful for applications such as improved collision avoidance and decision support tools for air traffic control. Development of methodologies and preliminary work applying clustering approaches to semi-structured airport environments is discussed.

4.1.4 A Data driven approach to understanding and predicting braking action of landing aircraft- Marek Travnik

The braking performance of landing aircraft is highly impacted by environmental factors. Precipitation in the form of rain or snow can accumulate on runways, decreasing the friction of aircraft wheels with the runway pavement during braking. In an extreme case, this phenomenon can result in runway overruns, as was the case with flight Southwest 1248 at the Chicago Midway airport in 2005. The influence of environmental and other factors on the braking performance of aircraft can be examined from a data driven point of view to better understand and possibly predict degraded braking. With this aim, machine-learning algorithms have previously been applied to (Field Condition Reporting) FICON data, together with Automated Surface Observing System (ASOS) weather data and runway data obtained from the National Airspace System Resource (NASR) 28-day subscription, using Pilot Braking Reports as an indicator of experienced braking action. The accuracy of the models was limited, probably due to the subjective nature of Pilot Braking Reports; every pilot experiences landing differently. This presentation shows the past work done on the issue and introduces an updated approach using AST data, indicating degraded braking using aircraft-borne measurement equipment, as a replacement for Pilot Braking Reports. Machine learning methods of different levels of complexity are proposed for the task and future additions to the models are discussed.

4.2 Ohio University Research Activities - Dr. Chris Bartone

4.2.1 Multi-spectral sensors for inspection of airport surfaces- Conner Warnock, Jackson Brengman

This presentation begins with an overview of the plan to assist the FAA in developing criteria to perform inspection of an airport surface using various sensors from an unmanned aerial vehicle platform. The purpose of the system is to collect data to aid in the operation and maintenance of the runway and surrounding surfaces, including FOD detection and removal. Several off-shelf-integrated global positioning system/inertial measurement unit (GPS/IMU) sensors will be compared that are suitable for use. The GPS/IMU attitude accuracy with varying levels of performance in terms of pitch/roll and heading was investigated. The presentation will focus on GPS/IMU selection and error analysis for sensor integration. Status of current sensor and platform integration efforts will be presented.

4.2.2 Detect and avoid in a UAS traffic management (UTM)/remote identification environment- Maarten Kastelein

The ongoing increase in the number and type of autonomous vehicle operations provides a clear need for safe and efficient integration of these autonomous vehicles into the National Airspace System (NAS). The main obstacle in integration is the lack of certified detect and avoid (DAA) solutions. New standards and regulations related to these types of operations and equipage are under development. Part of the next generation air transportation system (NextGen), is planned to include UAS traffic management (UTM) to support these types of autonomous operations. A remote identification system, Remote ID, is planned to support safe and efficient use of UTM airspace, facilitate beyond visual line of sight (BVLOS) operations and support National Security and Law Enforcement efforts. Remote ID can support collision avoidance by transmitting and broadcasting platform and operator position and identification. This presentation discusses small autonomous vehicles' DAA capabilities in a UTM/Remote ID environment and analyzes required performance from the UTM infrastructure, as well as, the need for an on-board DAA sensor for collision avoidance based on simulations and flight tests.

4.2.3 Design and mission planning of Bobcat-1, the Ohio University CubeSat- Kevin Croissant, Gregory Jenkins, Ryan McKnight, Brian C. Peters, Sabrina Ugazio and Frank van Graas

Bobcat-1 is the first CubeSat developed in the Avionics Engineering Center at Ohio University, School of Electrical Engineering and Computer Science, and selected for launch through the NASA CubeSat Launch Initiative planned for third quarter 2020. The project has two main objectives, educational and scientific, respectively. The educational mission includes the opportunity to train students (undergraduate and graduate) in space-related applications, providing them with hands-on experience on a spacecraft mission through all the stages from the design, through the development and the control, operation and data management after deployment, as well as the data processing and analysis. The scientific objective is related to the Global Navigation Satellite System (GNSS) interoperability, focusing on the estimate of the time offset existing between different GNSS constellations. Bobcat-1 will enable an in-space experiment to evaluate the performance of the GNSS inter-constellation time offset estimate from low earth orbit (LEO). This presentation will focus on the mission, requirements, design, and development of the CubeSat and the ground station.

5 Results

Despite the constraints on the program faced by the students due to the ongoing pandemic, the program still was able achieve a number of accomplishments, graduating several students and producing a number of publications.

5.1 Students Graduated

5.1.1 Massachusetts Institute of Technology

Massachusetts Institute of Technology graduated the following student under the Joint University Program during the time period:

1. Jacqueline Thomas received the PhD for her doctoral thesis, titled "Systems Analysis of Community Noise Impacts of Advanced Flight Procedures for Conventional and Hybrid Electric Aircraft." in April 2020,

5.1.2 Ohio University

Ohio University graduated the following students under the Joint University Program during the time period:

1. Andy Appleget received his MSEE for his thesis "A Consolidated GNSS Multipath Analysis Considering Modern GNSS Signals, Antenna, Installation, and Boundary Conditions," MSEE, Summer 2020.
2. Undergrad student Averie Vongsy, who participated in Lidar Sensor integration, graduated with his BSEE, Spring 2020, and now works for the U.S. Air Force, Air Force Research Laboratory, Eglin, AFB, CA.
3. Undergrad student Jackson Bergman, who worked on *Multi-spectral Sensors for Inspection of Airport Surfaces*, graduated with his BSEE, Spring 2020, and is now working on his Master's Degree at Ohio University.

5.2 News feature

Jacqueline Thomas was featured in the MIT news for her work on the ECO D demonstrator program. An excerpt is displayed in Figure 1.

Jacqueline Thomas PhD '20 recounts her final academic year at MIT, from once-in-a-lifetime fieldwork to a virtual thesis defense.

"I knew the science was sound, I knew the math was sound, but even when everything is going as planned and you are actually seeing it happening with your own eyes, it's still surreal," says Jacqueline Thomas PhD '20 on watching a Boeing 777 commercial airplane land using an approach she designed as an MIT grad student.

Photo courtesy of Jacqueline Thomas

From delayed deceleration to Zooming

Excerpt from https://news.mit.edu/2020/delayed-deceleration-zooming-jacqueline-thomas-mit-0614

Figure 1. Jacqueline Thomas MIT news excerpt

6 Conclusions

This report summarizes the research sponsored by the FAA under the Joint University Program in 2020. The Joint University Program underwent a number of changes during 2020. Instead of three universities, this year there was only the participation of two universities, with one guest university. The outbreak of the COVID-19 pandemic not only put constraints on the ability to hold in person meetings, but also constrained the ability of the students to conduct the research, with limited access to on site facilities. Nonetheless, the program was able to successfully facilitate multiple publications and the graduation of several students.

7 Publications

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