CAIT-UTC-REG 5

Implementation and Development of UAS Practical Training for Inspection and Monitoring Activities

FINAL REPORT
August 2022

Submitted by:

Michael O'Connell
Research Engineer
Rutgers University CAIT

James Taggart
Professor of Aviation
Atlantic Cape Community College

Rutgers University Center for Advanced Infrastructure and Transportation (CAIT)
100 Brett Road, Piscataway NJ 08854

External Project Manager
Andrés Roda, Principal Engineer-Bridges, Monmouth County Dept. of Engineering

1 E Main St, Freehold, NJ 07728

In cooperation with

Rutgers, The State University of New Jersey
And
U.S. Department of Transportation
Federal Highway Administration

Disclaimer Statement

The Center for Advanced Infrastructure and Transportation (CAIT) is a Regional UTC Consortium led by Rutgers, The State University. Members of the consortium are Atlantic Cape Community College, Columbia University, Cornell University, New Jersey Institute of Technology, Polytechnic University of Puerto Rico, Princeton University, Rowan University, SUNY - Farmingdale State College, and SUNY - University at Buffalo. The Center is funded by the U.S. Department of Transportation.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CAIT-UTC-REG5		

4. Title and Subtitle	5. Report Date
Implementation and Development of UAS Practical Training for Inspection and Monitoring Activities	August 2022
	6. Performing Organization Code CAIT/Atlantic Cape
7. Author(s) Michael O'Connell https://orcid.org/0000-0001-9497-1868 James Taggart https://orcid.org/0000-0002-6594-4681	8. Performing Organization Report No. CAIT-UTC-REG 5
9. Performing Organization Name and Address Rutgers University Center for Advanced Infrastructure and Transportation 100 Brett Road, Piscataway NJ 08854 Atlantic Cape Community College 5100 E Black Horse Pike, Mays Landing, NJ 08330	10. Work Unit No. 11. Contract or Grant No. 69A3551847102
12. Sponsoring Agency Name and Address Center for Advanced Infrastructure and Transportation Rutgers, The State University of New Jersey 100 Brett Road Piscataway, NJ 08854	13. Type of Report and Period Covered Final Report 01/2019–12/2021 14. Sponsoring Agency Code

15. Supplementary Notes
U.S. Department of Transportation/OST-R
1200 New Jersey Avenue, SE
Washington, DC 20590-0001

16. Abstract
With the expanding use of unmanned aircraft systems across the transportation, infrastructure, and public safety communities, the need for qualified remote pilots to operate these aircrafts becomes increasingly important. In support of USDOT strategic goals with a focus on "Preserving the existing transportation system" this project aims to provide practical training and accreditation for prospective UAS operators in the transportation engineering field.

17. Key Words	18. Distribution Statement
Unmanned Aircraft Systems, Drones, Workforce Development, Training	

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	23	

Form DOT F 1700.7 (8-69)

Acknowledgments

The authors would like to acknowledge Rutgers University's Center for Advanced Infrastructure and Transportation for their support in these research activities. The authors would also like to thank the aeronautics department at Atlantic Cape Community College for their support.

Table of Contents

DESCRIPTION OF THE PROBLEM **6**

APPROACH **7**

National Institute of Standards and Technology (NIST) 9

AUVSI – Trusted Operator Program (TOP) 12

Outline of Trusted Operator Program (TOP) Certifications 13

METHODOLOGY **14**

FINDINGS **21**

CONCLUSIONS **22**

RECOMMENDATIONS **22**

REFERENCES **23**

List of Figures

FIGURE 1: 2019 AASHTO SURVEY RESULTS (STATE DOTS FUNDING UAS PROGRAMS) 6
FIGURE 2: SAMPLE FAA REMOTE PILOT CERTIFICATE 8
FIGURE 3: SAMPLE NIST AERIAL ROBOTICS TRAINING COURSE 9
FIGURE 4: NIST TESTING COURSE 11
FIGURE 5: ATLANTIC CAPE COMMUNITY COLLEGE UAS TRAINING COURSE 14
FIGURE 6: AERONAUTICAL SECTIONAL CHART OF CONTROLLED AIRSPACE SURROUNDING ATLANTIC CITY INTERNATIONAL (ACY) 15
FIGURE 7: STUDENTS ASSEMBLING NIST AERIAL ROBOTICS TESTING COURSE MODULES (1) 16
FIGURE 8: STUDENTS ASSEMBLING NIST AERIAL ROBOTICS TESTING COURSE MODULES (2) 16
FIGURE 9: CONFIGURATION FOR TESTING RANGE SPACING AND ALTITUDE 17
FIGURE 10: AERIAL VIEW OF ACCC TEST RANGE 18
FIGURE 11: GROUND VIEW OF ACCC TEST RANGE 18
FIGURE 12: MODIFIED OMNI BUCKET ELEMENTS WITH MEASUREMENT GAUGE AND LICENSE PLATE 19
FIGURE 13: OMNI BUCKET HAZARDOUS INSPECTION MODULE 20
FIGURE 14: VEHICLE MOUNTED OMNI BUCKET MODULE 20
FIGURE 15: STUDENT PILOT TIME TRIAL RESULTS 21

List of Tables

TABLE 1: STUDENT TIMES FOR PRACTICAL EXAM TIME TRIALS 21

DESCRIPTION OF THE PROBLEM

The emerging use of Unmanned Aircraft Systems (UAS) as a versatile tool with a wide range of civil and commercial applications has been observed over the past decade. No longer used and developed solely by a small group of hobbyist and university researchers; Unmanned aircraft systems have grown into a multi-billion-dollar industry with applications ranging from aerial data collection and processing (photogrammetric, or otherwise) to monitoring and security applications. Transportation organizations nation-wide are adopting UAS as a tool to aid in multiple field activities. A 2019 survey executed by the American Association of State Highway and Transportation Officials (AASHTO) found that 36 of the 50 state Department of Transportations (DOTs) surveyed funded centers or programs for drone operations[1]. The survey notes that just three years prior, no states reported involvement in UAS activity on the transportation level. State DOTs are adopting these UAS technologies to assist with field missions including infrastructure inspection, traffic monitoring, emergency response, and surveying.

2019 AASHTO Survey Results (State DOTs Funding UAS Programs)

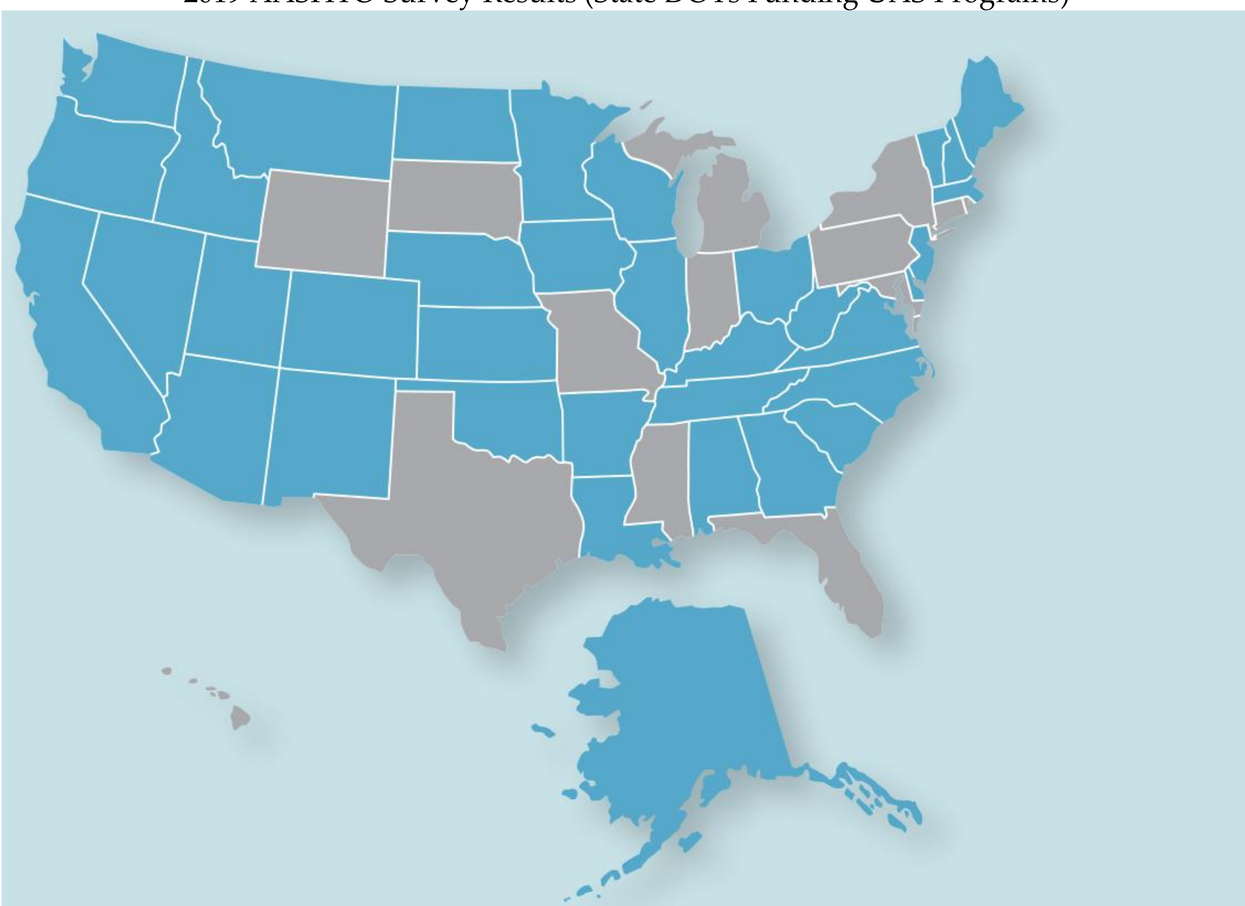

FIGURE 1: 2019 AASHTO SURVEY RESULTS (STATE DOTS FUNDING UAS PROGRAMS) [1]

With the growing use of UAS as a data collection tool for the transportation engineering community, the need for commercial remote pilots who can operate these aircraft in a controlled manner while collecting project critical data becomes increasingly important. As of June 2016, the Federal Aviation Administration (FAA) requires all remote pilots who operate UAS commercially within the United States to become licensed as an Unmanned Aircraft Pilot under CFR 14 Part 107. For this licensure process, prospective pilots are required to sit for and pass a written exam prior to attaining their licenses. While this exam tests pilots on their mental flight knowledge, there is no practical abilities portion to assess prospective or existing pilots on their practical flight capabilities. Furthermore, the unique situations surrounding transportation projects such as infrastructure inspection may require pilots who have proven capabilities of operating their UAS in a challenging environment. This project aims to design and development training curricula including the development of assessment instruments for deriving both formative and summative learning outcomes. This curricula will evaluate the practical flight abilities of prospective UAS pilots.

APPROACH

Regulations surrounding the commercial use of UAS requires prospective and current UAS operators to register with the FAA as a remote pilot and to pass a written examination evaluating their knowledge of aircraft systems and airspace operations. In June 2016, the FAA released CFR 14 Part 107 establishing and expanding regulations for operating unmanned aircraft systems within controlled and uncontrolled airspace. Included in this CFR is language regarding eligibility to become a remote pilot. § 107.61 covers regulations on age, language, and physical or mental limitations, as well as requiring operators: [2]

> (d) Demonstrate aeronautical knowledge by satisfying one of the following conditions, in a manner acceptable to the Administrator:
>
> > (1) Pass an initial aeronautical knowledge test covering the areas of knowledge specified in § 107.73; or
> >
> > (2) If a person holds a pilot certificate (other than a student pilot certificate) issued under part 61 of this chapter and meets the flight review requirements specified in § 61.56, complete training covering the areas of knowledge specified in § 107.74

Pilots who operate UAS commercially under Part 107 must first demonstrate their aeronautical knowledge through passing a written exam as specified in § 107.61(d). Further information regarding initial and recurrent knowledge tests are available in § 107.73. This section establishes the materials covered in the FAA knowledge exam including [3]:

> *(1) Applicable regulations relating to small unmanned aircraft system rating privileges, limitations, and flight operation;*
> *(2) Airspace classification, operating requirements, and flight restrictions affecting small unmanned aircraft operation;*
> *(3) Aviation weather sources and effects of weather on small unmanned aircraft performance;*
> *(4) Small unmanned aircraft loading;*
> *(5) Emergency procedures;*
> *(6) Crew resource management;*
> *(7) Radio communication procedures;*
> *(8) Determining the performance of small unmanned aircraft;*
> *(9) Physiological effects of drugs and alcohol;*
> *(10) Aeronautical decision-making and judgment;*
> *(11) Airport operations; and*
> *(12) Maintenance and preflight inspection procedures.*

For federal licensure purposes, scoring at least 70% correct on the 60 question written Aeronautical Knowledge Test adequately demonstrates sufficient knowledge for one to operate a remote aircraft under 55lbs commercially. Though the exam covers operational and safety proceedures essential for flight operations, there remains no demonstration of practical flight abilities or maneuvers to assess a pilot's capability at safely and effectively piloting a drone. With this in mind, the research team identified and evaluated industry recognized third party UAS remote pilot flight review certification bodies for potential ways to provide a practical training certification element to an Unmanned Aircraft pilot training program.

FIGURE 2: SAMPLE FAA REMOTE PILOT CERTIFICATION

National Institute of Standards and Technology (NIST)

The National Institute of Standards and Technology (NIST), now under the U.S Department of Commerce, serves as one of the nation's oldest physical science laboratories with a mission to "promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life."[4] NIST provides insights, measurements, and standards for a wide array of technologies including communication, material sciences, nanotechnology, and robotics. NIST's Intelligent Systems Division is developing measurements and standards to evaluate robotic capabilities for emergency response and military organizations. This division develops and standardizes measures to test terrestrial, aquatic, and aerial robotics over a wide range of variables. Through developing these standards, NIST aims to provide ways to objectively measure and compare robotic systems and remote pilot proficiency. For aerial robotic assessment, NIST created an aerial systems assessment course in order to objectively measure various UAS capabilities across multiple units and manufacturers in a standardized course.

FIGURE 3: SAMPLE NIST AERIAL ROBOTICS TRAINING COURSE [4]

The NIST Aerial Robotics testing course contains multiple methods in which to measure the capabilities of a particular UAS. These methods include flight mechanics, a unit's ability to navigate a course within a designated time, as well as payload functionality and capabilities of the UAS's internal modules. Areas of testing include [5]:

> ***Orbit a Point (Move and Rotate)*** *- This test method evaluates the capability to move and rotate around a point. The system performs a series of basic maneuvers using an onboard camera to align with centrally located bucket targets from a defined radius and altitude.*
>
> ***Avoid Obstacles*** *- evaluates the capability to maneuver around vertical obstacles and horizontal obstacles.*
>
> ***Fly Straight and Level*** *- evaluates the capability to fly straight and level using a visual target as a guide.*
>
> ***Land Accurately*** *- evaluates the capability to land accurately from vertical and downward 45 degree descending approaches.*
>
> ***Point and Zoom Cameras*** *- evaluates the capability to point and zoom cameras at near-field and far-field visual acuity targets from a specified hover position*
>
> ***Inspect Objects*** *- evaluates the capability to move and rotate around an object of interest to identify key features.*
>
> ***Inspect Objects*** *-evaluates the capability to move around an object of interest to inspect key details from close proximity.*

The initial testing modules are designed to test and evaluate UAS technologies in a quantitative and objective manner. Courses are typically intended for vertical takeoff UAS (ie: quadcopters) and involve multiple landing and descent operations. Depending on the particular module, the UAS will be launched and perform a series of tasks along an established flight plan before returning to the launch pad. Units are assessed on accuracy of landing, flight paths, accuracy of image collection, and time. These methods are being standardized through the ASTM International Standards Committee on Homeland Security Applications Response Robots.

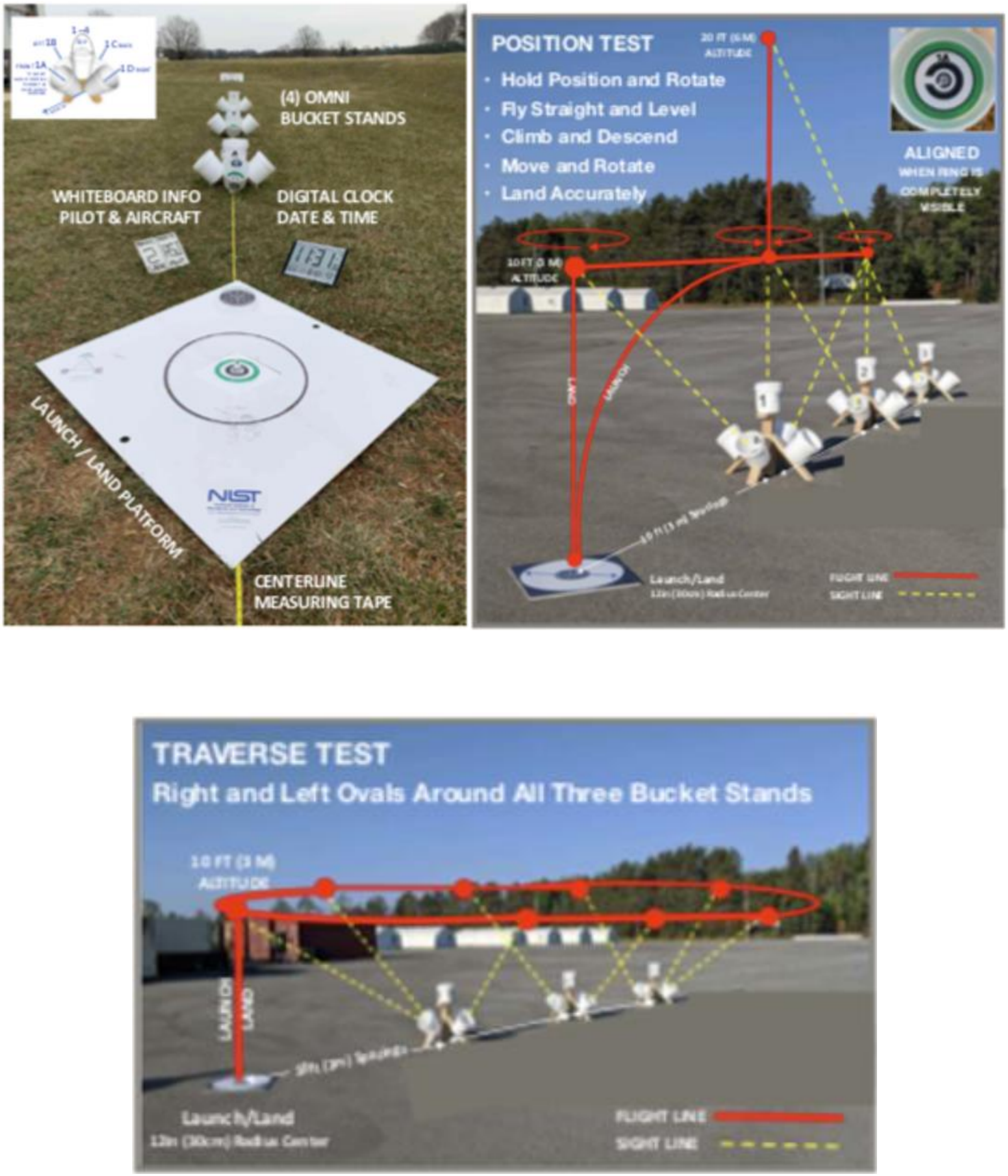

FIGURE 4: NIST TESTING COURSE [6]

AUVSI – Trusted Operator Program (TOP)

The Association for Uncrewed Vehicle Systems International (AUVSI) is a nonprofit organization with a focus on supporting the advancement of unmanned aircraft systems and robotics through professional development, outreach, and collaboration. This organization of avionic professionals collaborates with government agencies to advance the integration of UAS into the national airspace, as well as, further develop policies and procedures to regulate UAS operations. As an organization, AUVSI provides a variety of resources to aviation professionals including UAS safety outreach, educational research, flight data reports, information regarding waivers, and collaboration events and conferences.

After the implementation of Part 107, AUVSI as part of it’s professional development initiatives, began developing a certification process to augment the knowledge requirements developed through the FAA Part 107 Aeronautical Knowledge Test. The aim for this program would enable UAS operators to show “a higher level of demonstrated knowledge, flight proficiency, safety and risk management practices” [https://www.auvsi.org/topoperator] through a professional certification process. This program would later develop into the Trusted Operator Program (TOP) certification.

AUVSI’s Trusted Operator Program provides UAS professionals with a path to certification for exhibiting UAS proficiency beyond that of the base federal regulations. TOP certification expands on the knowledge required under Part 107 examination to include additional elements including [7]:

- *Safety Culture*
- *Codes of Conduct*
- *Best Practices*
- *Automation Awareness*
- *Airmanship*
- *Risk Management*
- *Human Performance*
- *Non-Technical Skills*

Outline of Trusted Operator Program (TOP) Certifications

There are currently three levels of TOP certification available to avionic professionals, with each level requiring the completion of it's predecessors. As TOP certification level advances, so does required knowledge of flight operations, safety, and practical flight capabilities. [7]

TOP CERTIFICATION LEVEL 1

• ROUTINE OPERATIONS IN ACCORDANCE WITH FAR PART 107
• OPERATIONS THAT DO NOT REQUIRE A WAIVER OF FAR PART 107
• OPERATIONS IN WHICH THE REMOTE PILOT IS COMPETENT AND PROFICIENT
• FLIGHTS USING ELECTRIC AIRCRAFT LESS THAN 5 LBS OR 2 KG
• OPERATIONS THAT DO NOT HAVE ANY OF THE CHARACTERISTICS MENTIONED IN LEVEL 2 OR 3 SUCH AS OPERATIONS CLOSE TO AIRPORTS, HELIPADS, POPULATED AREAS, PEOPLE AND LIVESTOCK

TOP CERTIFICATION LEVEL 2

ANY OF THE CHARACTERISTICS OF LEVEL 2, PLUS THE FOLLOWING:

• ANY OPERATION THAT REQUIRES A WAIVER UNDER FAR PART 107
• OPERATIONS THAT REQUIRE A VISUAL OBSERVER, OR SENSOR OPERATOR • OPERATIONS IN WHICH THE REMOTE PILOT IS COMPETENT AND PROFICIENT
• OPERATIONS WITH ELEVATED RISK FACTORS OR COMPLEXITY INCLUDING BUT NOT LIMITED TO OPERATIONS CLOSE TO AIRPORTS, HELIPADS, POPULATED AREAS, PEOPLE AND LIVESTOCK
• OPERATIONS THAT DO NOT HAVE ANY OF THE CHARACTERISTICS MENTIONED IN LEVEL 3

TOP CERTIFICATION LEVEL 3

ANY OF THE CHARACTERISTICS OF LEVEL 2, PLUS THE FOLLOWING:

• OPERATIONS IN SAFETY-CRITICAL AND COMPLEX AREAS THAT REQUIRE HIGHER LEVELS OF RISK MITIGATION
  o INDUSTRIAL AND CHEMICAL FACILITIES, INCLUDING OFFSHORE OIL RIGS, MINE SITES, POWER PLANTS
  o INFRASTRUCTURE, INCLUDING WIND TURBINES, POWER LINES, COMMUNICATIONS TOWERS, RAIL AND PIPELINES.
• OPERATIONS IN ANY HAZARDOUS OR EXTREME ENVIRONMENTS INCLUDING:
  o FROM SHIPS, MOVING VEHICLES, AIRCRAFT, CONFINED AREAS AND UNDERGROUND
  o WITHIN CLOSE PROXIMITY TO AND WITHIN SEVERE WEATHER (STORM RESEARCH)
  o REMOTE, HARSH OR HOSTILE LOCATIONS, INCLUDING WILDLIFE CONSIDERATIONS
•OPERATIONS REQUIRING THE DEVELOPMENT AND TESTING OF NEW PROCEDURES
•OPERATIONS WITH UAS OVER 55 POUNDS (25 KILOGRAMS)

TOP certification levels 2 and 3 require a practical flight assessment monitored by a certified AUVSI TOP instructor. For the flight assessment portion, AUVSI requires the assessment to align with ASTM's Standard Guide for Training for Remote Pilot in Command of Unmanned Aircraft Systems (UAS) Endorsement. For the practical flight certification portion, AUVSI refers to and utilizes the NIST Aerial Robotics Testing Course as a means to certify operator flight capabilities [7].

METHODOLOGY

This project focused on the design and development of training curricula to evaluate the practical flight abilities of prospective UAS pilots in support of USDOT strategic goals with a primary focus on "Preserving the existing transportation system". With UAS becoming adopted as a tool for a variety of transportation related use cases, including inspections and monitoring, this project aimed to provide practical training and accreditation for prospective UAS operators in the transportation engineering field. To achieve this goal, the team would update and modify an existing UAS pilot training program to incorporate both TOP accreditation and the NIST Aerial Robotics Testing Course as a means to derive formative and summative learning outcomes.

Pilot training and assessment would take place as part of Atlantic Cape Community College's Drone Pilot and Technician program in Mayfield, New Jersey. The college provides multiple offerings for prospective UAS pilots to pursue and associates degree in UAS technologies, as well as professional level certificates in sUAS Specialists and Technicians. Two flight instructors from Atlantic Cape would become TOP Level 2 Certified in an effort to provide future TOP certification instruction to prospective UAS pilots attending these courses.

FIGURE 5: ATLANTIC CAPE COMMUNITY COLLEGE UAS TRAINING COURSE

Following accreditation, the team identified and planned the location to construct the NIST Aerial Robotics Testing Course. It was determined to develop the course on Atlantic Cape's campus to facilitate training operations. Reviews of airspace and potential environmental hazards and conditions were preformed to assess the location. As the sectional chart in Figure 6 shows, Atlantic Cape's campus falls just outside of Atlantic City International (ACY) controlled Surface to 4,100ft Class C airspace. While the campus is located beneath ACY's 1,300ft – 4,100ft Class C airspace, all flight operations performed for these testing procedures were designed to take place under 400ft; providing a large enough buffer to ensure UAS operations do not interfere with surrounding manned aircraft operations.

FIGURE 6: AERONAUTICAL SECTIONAL CHART OF CONTROLLED AIRSPACE SURROUNDING ATLANTIC CITY INTERNATIONAL (ACY) [8]

With airspace and environmental considerations in place, the team sourced and acquired material to construct the NIST Aerial Robotics Testing Course. NIST provides resources regarding course construction and materials necessary. Once materials were acquired, the prospective UAS pilots were tasked with constructing the various elements of the testing course in accordance with NIST standards and under the supervision of TOP certified instructors.

Figure 7: Students Assembling NIST Aerial Robotics Testing Course Modules (1)

Figure 8: Students Assembling NIST Aerial Robotics Testing Course Modules (2)

Nine outdoor test lane courses were constructed on Atlantic Cape's campus for pilot assessment and training. NIST provides specifications regarding element placement and spacing for various testing modules along the course. Each test lane consists of a Launch and Landing Pad, four omni bucket modules with internal decals, and flight line for the remote pilot to remain behind throughout the test. Testing lanes and module placement are scalable with UAS flight altitude directly proportional to spacing of course elements.

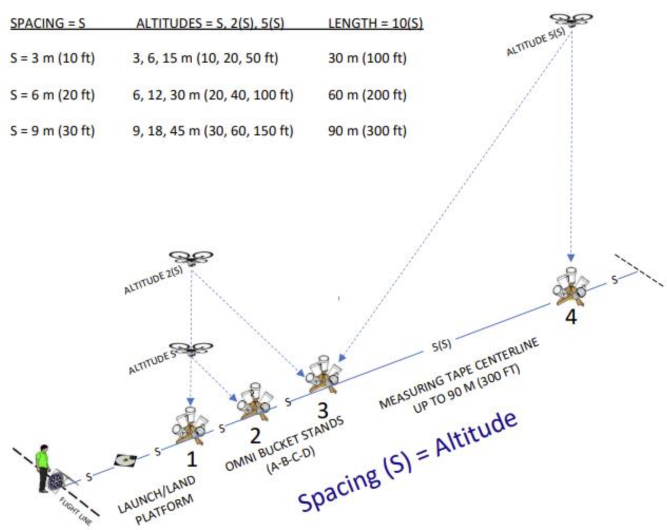

FIGURE 9: CONFIGURATION FOR TESTING RANGE SPACING AND ALTITUDE [9]

Prospective commercial UAS pilots were tasked with navigating this course within a designated period of time (10 minutes). While navigating the course, they were tasked with performing several aerial maneuvers along the flight course including: ascends, descends, hover, and fixed point orbit around an object. The four Omni bucket stations per course contained internal decals the pilots to observe and report, image, and report on their observations. To simulate infrastructure and transportation engineering activities, designated stations would be supplemented with a either a measurement gauge (air pressure and temperature) or license plate segment. Pilots were tasked with observing and recording the information relayed from these elements via UAS while completing the course. Additional course elements were developed using the NIST inspection module. The first of these modules was placed in a hazardous location with overgrown brush and sand. This module was to simulate and test pilots on their ability to inspect an object in real world conditions. An additional omni bucket module was placed on top a stationary vehicle with additional testing buckets placed at the vehicle's tires. Pilots were tasked with encircling the vehicle while collecting imagery of the module contents, simulating a motor vehicle incident. Pilots were evaluated on their time on the Open Lane test course as well as the additional inspection modules.

Figure 10: Aerial view of ACCC test range

Figure 11: Ground view of ACCC Test Range

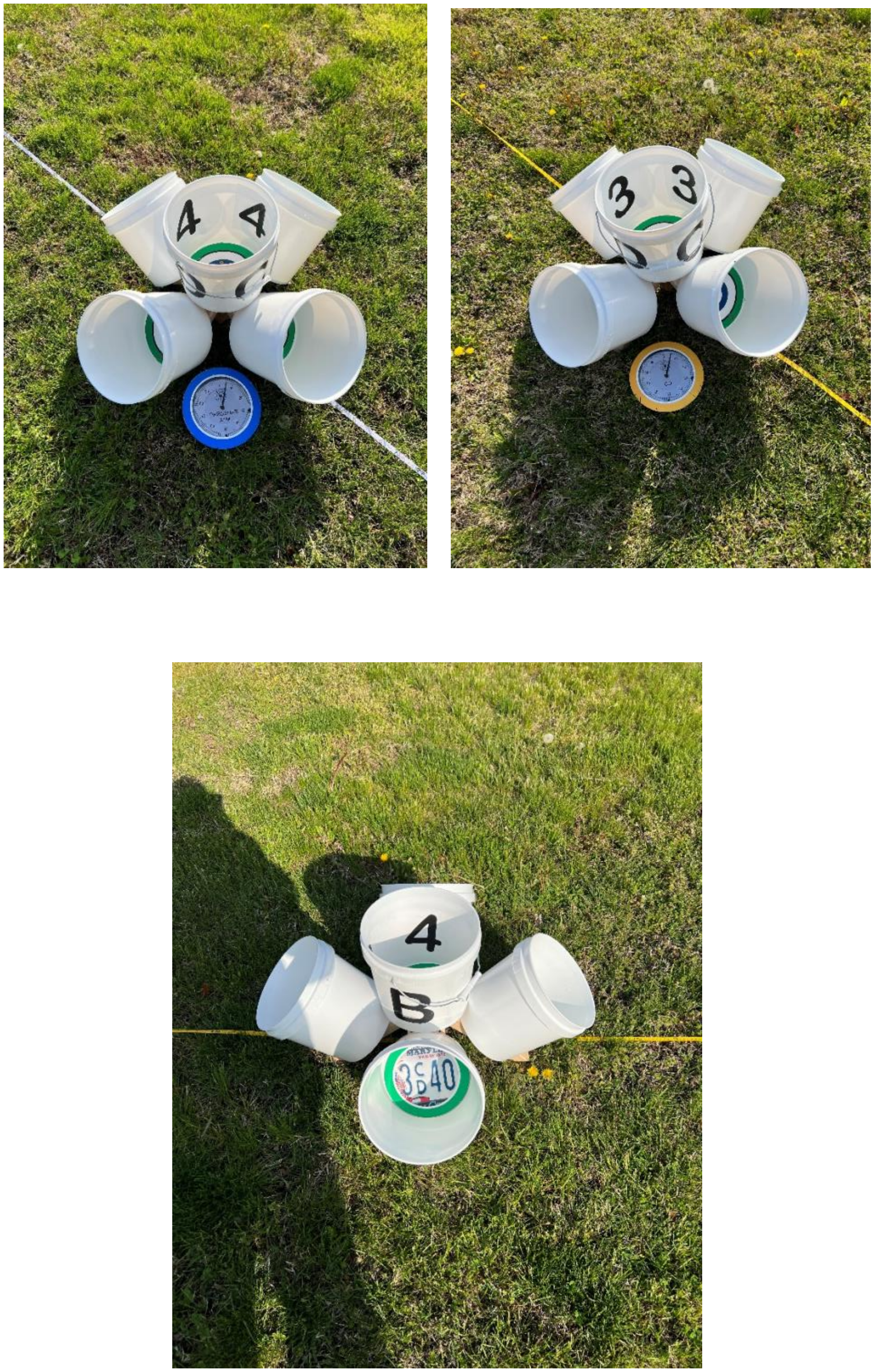

FIGURE 12: MODIFIED OMNI BUCKET ELEMENTS WITH MEASUREMENT GAUGE AND LICENSE PLATE

Figure 13: Omni bucket hazardous inspection module

Figure 14: Vehicle mounted omni bucket module

FINDINGS

Forty-six time trials were performed by the participants enrolled in the course, with completion times ranging from over 14 minutes 30 seconds to under 5 minutes and 30 seconds. Average time for course completion was 8 minutes and 20 seconds. Seven remote pilot run times were below the 10-minute threshold designated for a passing time, with a total pass rate of nearly 85%. The NIST Aerial Robotic Testing Course with omni bucket stations containing inspection modules were successful in obtaining an objective way to measure a pilot's capability in operating an aircraft beyond the requirements of federal certification for commercial UAS operation. Additionally, the hazardous location and vehicle inspection expansion provided a module to evaluate pilots on transportation engineering scenarios in a quantifiable way.

TABLE 1: STUDENT TIMES FOR PRACTICAL EXAM TIME TRIALS

Time to Complete (min)	
14.7	8.22
13.3	7.8
13.3	7.7
11.7	7.5
11.6	7.4
11.1	7.3
10.3	7.2
10	7.1
9.8	7.1
9.6	7.1
9.4	7
9.2	6.8

Time to Complete (min)	
9.2	6.7
9.2	6.5
9.1	6.4
9	6.2
9	6.2
8.8	6.1
8.7	6.1
8.6	6.1
8.5	5.8
8.4	5.5
8.3	5.4

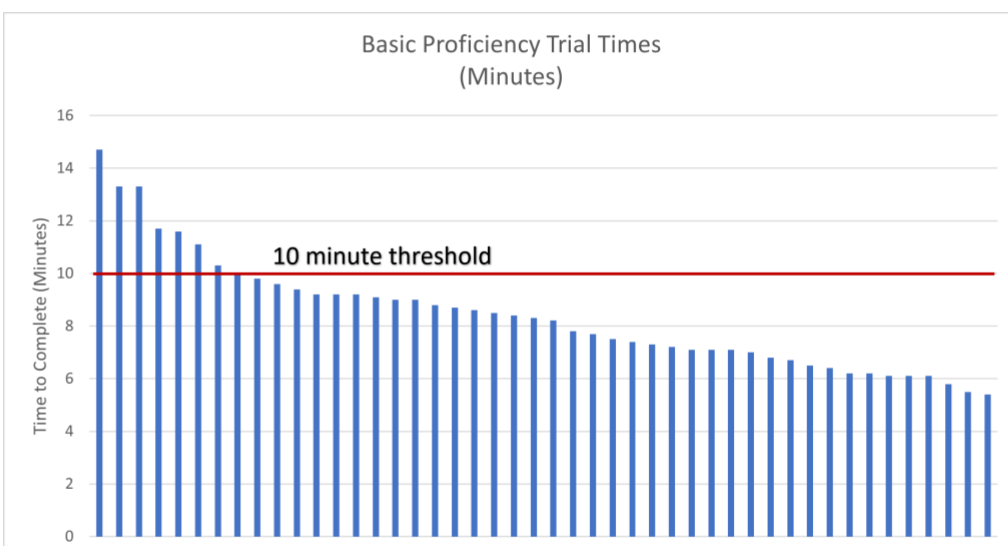

FIGURE 15: STUDENT PILOT TIME TRIAL RESULTS

CONCLUSIONS

With the expanding use of unmanned aircraft systems across the transportation, infrastructure, and public safety communities, the need for qualified remote pilots to operate these aircrafts becomes increasingly important. In support of USDOT strategic goals with a focus on "Preserving the existing transportation system" this project provided practical training and accreditation for prospective UAS operators in the transportation engineering field. FAA regulations regarding commercial UAS certification requires the passing of a written aeronautical knowledge exam prior to a certification being awarded. Further certification which entails a practical flight portion could prove useful in evaluating pilots on their capabilities beyond aeronautical knowledge. The National Institute for Standards and Technology Aerial Robotics Testing Course, initially designed to test robotic function, provides a useful method to evaluate pilots on their ability to handle a remote aircraft. These methods are currently being utilized by professional nonprofit organizations in the aviation field such as the Association for Unmanned Vehicle Systems International to certify pilots under their Trusted Operator Program (TOP). The test courses implemented at Atlantic Cape were successful in evaluating pilots on a standardized basis. The expansion of the vehicle module provided a standardized method to evaluate pilots in a transportation engineering scenario.

RECOMMENDATIONS

Additional methods and scenarios in which to evaluate and train pilots should be considered. Providing a practical element to pilot certification, whether on a federal or professional level, provides further information into a remote pilot's capabilities and can encourage development of a well-trained work force of remote pilots.

REFERENCES

[1] HTTPS://WWW.TRANSPORTATION.ORG/WP-CONTENT/UPLOADS/2019/05/MISSIONCONTROL_DRONES3.PDF

[2] https://www.ecfr.gov/current/title-14/chapter-I/subchapter-F/part-107)

[3] HTTPS://WWW.ECFR.GOV/ CURRENT /TITLE-14/CHAPTER-I/SUBCHAPTER-F/PART-107/SUBPART-C/SECTION-107.73

[4]HTTPS://WWW.NIST.GOV/EL/INTELLIGENT-SYSTEMS-DIVISION-73500/STANDARD-TEST-METHODS-RESPONSE-ROBOTS/AERIAL-SYSTEMS/AERIAL

[5] HTTPS://WWW.NIST.GOV/EL/INTELLIGENT-SYSTEMS-DIVISION-73500/STANDARD-TEST-METHODS-RESPONSE-ROBOTS/AERIAL-SYSTEMS

[6] HTTPS://WWW.NIST.GOV/SITES/DEFAULT/FILES/IMAGES/2020/07/06/TRIFOLD.PNG

[7] ASSOCIATION FOR UNMANNED VEHICLE SYSTEMS INTERNATIONAL. TRUSTED OPERATOR PROGRAM PROTOCOL CERTIFICATION MANUAL (PCM). EDITION 1.3, ASSOCIATION FOR UNMANNED VEHICLE SYSTEMS INTERNATIONAL (AUVSI), 2019.

[8] HTTPS://WWW.SKYVECTOR.COM

[9] HTTPS://WWW.NIST.GOV/SYSTEM/FILES/DOCUMENTS/2020/07/06/NIST%20SUAS%20TEST%20METHODS%20-%20INTRODUCTION%20%282020B1%29.PDF