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Quantifying a Scoring Limitation of a Federal UAS Flight Proficiency Exam

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To operate a drone in the U.S., the federal government requires pilots to pass a standardized Federal Aviation Administration (FAA) knowledge test. The government does not require drone pilots pass a practical exam demonstrating minimum flight proficiency. However, the government, through the National Institute of Standards and Technology (NIST), has provided a voluntary exam protocol to test flight skills. Using the NIST exam protocol, the Airborne Public Safety Association has created the only nationally recognized unmanned aircraft systems flight proficiency certification. This certification is frequently used by contractors and construction UAS courses. The literature has identified a limitation in how the exam is scored. The purpose of this study is to quantify how impactful this limitation is. The researchers conducted an experiment administering the exam to 24 licensed drone pilots. The exam was scored compensating for the scoring limitation. The study found that when the scoring limitation was accounted for, scores were inflated by approximately 5% with inexperienced pilots. Inexperienced pilots will have the highest deviation and represent the most extreme cases. Given the relatively low 5% deviation with novice pilots, the study found that this limitation is not a significant concern and can be managed by the exam proctor.

Key Words: Drone, UAS, NIST, Assessment, APSA

Introduction

Unmanned aircraft systems (UAS), commonly referred to as "drones," are a rapidly expanding technology being used in a wide range of industries. The Federal Aviation Administration (FAA) reported that as of September 2022, over 865,000 drones had been registered and more than 280,000 remote pilots certified (FAA, 2021). In the past, the regulations governing commercial drone operations were very restrictive, requiring a Section 333 exemption from the FAA. The requirements to receive this exemption made it largely impractical for most private UAS operations. However, the release of U.S. Code of Federal Regulations Title 14 Part 107—Small Unmanned Aircraft Systems (Part 107) in 2016 made access to the national airspace by drone pilots significantly easier. One of the most significant requirements of Part 107 is passing the knowledge exam. The exam consists of

60 multiple-choice questions and is administered at third-party testing centers. The knowledge exam assesses a pilot's understanding of weather, regulations, airspaces, and a wide range of important UAS concepts. However, the exam does not include a practical component. Unlike Canada, the European Union, and Australia, the U.S. federal government does not require drone pilots to demonstrate minimum competency in operating an aircraft. The lack of a government-sponsored proficiency exam creates a challenge for the industry. Unlike most other licenses, there is no government standard that organizations can rely on to verify pilots are competent to operate the equipment. Contractors must either self-evaluate or rely on third-party credentialing. When companies self-evaluate, they absorb the cost of the assessment process and all of the legal exposure of determining flight competence. Contractors may wish to credential their pilots with third-party organizations; however, there is currently only one organization with a national reputation providing this certification.

The National Institute of Standards and Technology (NIST) is a laboratory under the U.S. Department of Commerce. It has developed several suites of testing protocols for robots, including UAS. The UAS testing protocols have the express purpose of "quantitatively evaluating various system capabilities and remote pilot proficiency" (NIST, 2020). NIST provides detailed instructions on how to build, administer, and score the exam. It does not provide scoring minimums, testing services, or certifications. The Airborne Public Safety Association (APSA) was founded in 1968 and is one of the most well-known and respected aviation associations. APSA has adopted the NIST Basic Proficiency Evaluation for Remote Pilots (BPERP) exam protocol to create a flight proficiency certification. It is the only nationally recognized flight proficiency certification currently available in the United States. Contractors often use it to validate their employees have sufficient skills to operate a drone on their company's behalf. It is also an assessment tool for construction management degree programs teaching drone technology.

Exam Scoring Limitation

The NIST BPERP test lane consists of a series of round targets at the bottom of two-gallon buckets. See Figure 1 left. Most of the targets are at a 45-degree angle with the ground. A proctor will give the pilots instruction on where to position their drone so that a particular target is visible with the on-board camera. If the drone is not directly in front of the target, the wall of the bucket will obstruct the view. Points are awarded only if the view of the target is "aligned" and not obstructed by the bucket wall. See Figure 1 right. The positioning instructions require the drone to be placed 10 feet horizontally and 10 feet vertically from the targets. If the pilot is in line with the target and precisely 10 feet (horizontally and vertically) with the target, then the camera will be at exactly 45 degrees with the ground, making the target perfectly aligned. Although this simple design has many advantages, a limitation is that this method awards points for the drone being in the correct *vector* instead of in the correct *position*. See Figure 2 for an illustration. The drone closest to the target is aligned and in the correct position. The second drone is also aligned but much further away and out of position. In the spirit of the exam, the pilot should not be awarded points. However, a strict interpretation of the scoring criteria requires points to be awarded because the target is visible even though it is significantly out of position. This limitation was first identified by Dees and Burgett (2022) and is the focus of this study.

Research Objectives

In the absence of a federal UAS practical exam, APSA has done the construction industry a significant service by providing a flight proficiency certification. Additionally, construction education programs, including the authors' home institution, use the APSA BPERP exam as part of their drone curriculum. Given the certification's value and the lack of alternatives, it is important to have confidence in how the exam is scored. This paper shows the results of an experiment where 24 Part 107 pilots were given the BPERP exam twice. The researchers recorded the attempts and compared the scores using traditional scoring practices and when a three-foot positional tolerance was imposed. The objective of the study is to evaluate if the scoring limitation identified in the literature has a meaningful impact on BPERP pass rates.

Figure 1. BPERP Targets (NIST 2021b)

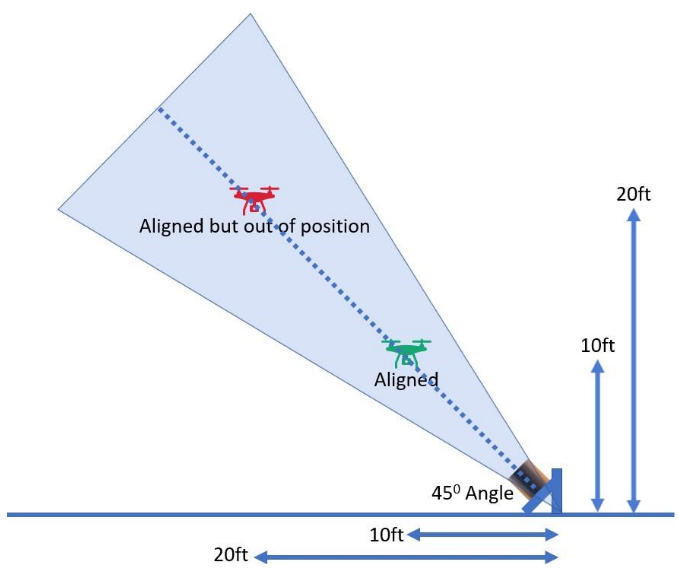

Figure 2. Scoring Limitation of BPERP

Background

Under Part 107, all pilots operating a UAS for commercial purposes must obtain a remote pilot certificate from the FAA. Earning the certificate, commonly referred to as the "drone license," requires pilots to demonstrate their drone erudition by passing a knowledge test. The test contains 60 multiple-choice questions administered over a 2-hour period. Topics assessed include Part 107 regulations, weather, aircraft loading, emergency procedures, airport operations, airspace, radio communication, and other UAS related procedures. Part 107 also requires commercial UAS pilots to take a recurrent online course provided by the FAA every 24 months. Demonstrating one's ability to operate a UAS is not required for licensure. This is considered by some to be a significant hole in the Part 107 license (Dees and Burgett, 2022). According to the Multi-Discipline Licensure Resource Project (MDLRP), a license "indicates that the professional has demonstrated the knowledge, skill and abilities to perform their services" (MDLR, 2022). Stated another way, a license validates the holder has sufficient 1) knowledge, 2) skill and 3) ability, to perform a specific task. Under the current Part 107 assessment criteria, "knowledge" is assessed but not practical "skills and abilities." Under the MDLRP definition, the Part 107 license does not comprehensively validate drone piloting competence. The APSA flight proficiency certification partially fills this gap. However, for the certification to have meaning, users must have confidence in the scoring metrics. Currently, this is not addressed in the literature and is the focus of this paper.

National Institute of Standards and Testing (NIST)

NIST is organized under the Department of Commerce and was originally founded by Congress in 1901 with the mission of removing major challenges to U.S. industrial competitiveness (NIST, 2021). NIST continues its mission by supporting smart electric power grids, microprocessor research, nanomaterials, and robot testing (NIST, 2021a). The Intelligent Systems Division within NIST developed the various UAS testing protocol including the BPERP. Although the BPERP test is evaluated in this study, the NIST Intelligent Systems Division has created multiple tests, including the Open Lane test, Obstructed Lane test, and First Responder UAS Endurance Challenge.

Airborne Public Safety Association (APSA)

APSA is a 501(c)(3) nonprofit membership organization. It was founded in 1968 and has over 3,000 members. Its primary mission is to support aircraft in public safety through networking, education workshops, publications, conventions, and product expositions. There is no formal relationship between the NIST Intelligent Systems Division and APSA. However, some individuals have concurrent dual employment with both organizations. NIST personnel have participated in APSA workshops when developing their flight proficiency certification. NIST personnel often mention APSA on public webinars and use it as a model when describing successful uses of the exams.

Basic Proficiency Evaluation for Remote Pilots (BPERP)

The BPERP exam is used for multirotor (hovering type) small UAS. It consists of three bucket stands, each with four, 2-gallon buckets placed around the perimeter. The buckets are positioned at a 45-degree angle with the ground and 90-degrees with each other. A fifth bucket is placed on top of the bucket stand angled straight up. The bucket stands are placed 10 feet from each other, and the pilot is required to fly at an altitude of 10 feet. Round targets are placed at the bottom of the buckets. During the exam, a proctor will read off 40 instructions directing the pilot where to position the drone and which target to take a picture of. The pictures of the targets are reviewed after the exam, and a point is awarded if the green ring is unbroken. See Figure 1. The first 20 positions/points are referred to as the position phase of the test and are shown in Figure 3 on the left. The second 20 positions/points are referred to as the traverse phase and are shown in Figure 3 on the right. To earn the APSA flight proficiency certification, a pilot must earn 32 points (80%) within 10 minutes. For more information on the BPERP exam, please visit the NIST UAS Test Methods page.

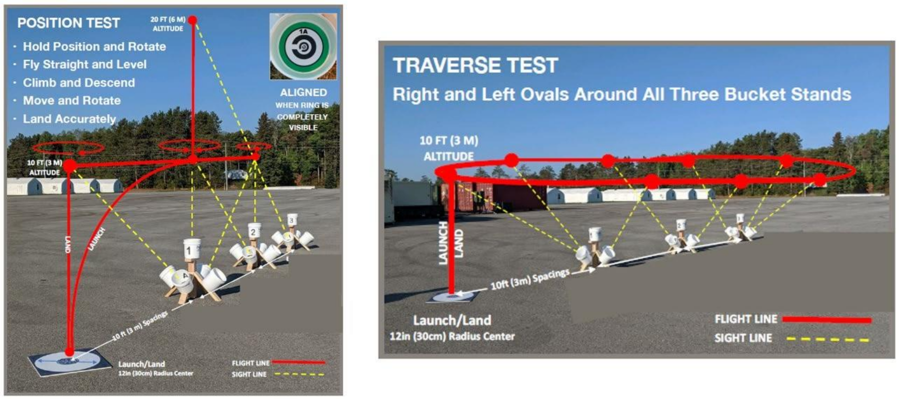

Figure 3. BPERP Positions (NIST 2020)

Gap in the Literature

The literature shows that drones are being used to support a wide range of activities (Gheisari et al., 2014; Lucieer et al. 2014; Rakha et. al., 2018). Some of the more common uses of drones in construction includes inspections (Tatum & Liu, 2017; Li & Liu, 2019), surveying (Aiyetan & Das, 2022; Adjidjonu & Burgett, 2021), and creating as-builts (Varbla et al., 2021; Hubbard, & Hubbard, 2020). The literature is nearly silent on scholarly studies addressing drone licensure and certification challenges. One notable exception is the work of Dees and Burgett (2022). Dees and Burgett make the case that the FAA Part 107 exam is important; however, it does not address flight competence comprehensively. The lack of standardized flight proficiency testing is “a significant risk for contractors using drones” (Dees and Burgett, 2022). The Dees and Burgett study experiment used similar bucket stand apparatus used in the BPERP test. Their study was the first to identify the scoring limitation of the NIST-based test. However, they stopped short of evaluating if the scoring limitation had a meaningful effect on pass rates. This is a critical gap in the literature. The APSA BPERP exam is the only nationally recognized flight proficiency certification. For it to have meaning, it is critical to have confidence in how it is scored. Evaluating if the known scoring limitation of the exam is impactful to pass rates and filling this gap in the literature is the focus of this paper.

Methodology

A sample of 24 Part 107 pilots were recruited for the study. The pilots primarily worked for government agencies throughout the state. The pilots completed a survey prior to the study that asked questions about their experience. The pilots were largely inexperienced, which was ideal for this study. Pilots with significant experience would be able to position their drone well and have scores less impacted by an imposed tolerance. Inexperienced pilots who do not have the muscle memory to position a drone well would be the ideal group for testing the boundaries of a positional tolerance. As such, inexperienced pilots were recruited because they will provide the outer most range for how impactful the scoring limitation is.

An experiment was developed where pilots completed the BPERP exam in person using traditional methods and with a computer simulator developed by the research team. Flight performance scores and times measured with the simulator have been shown to be statistically the same as with in-person testing (Dees & Burgett, 2022). The in-person test was administered on an intermural soccer field at the research team's home institution. Three NIST Open Test Lanes were set up on the field. The research team supplied DJI Mavic 2 Pro and DJI Phantom 4 Pro model drones for the experiment. The weather conditions during the experiment were warm, sunny, and with very little wind. The proctors provided positional instructions but did not correct pilots for flying beyond the specified 10-foot distance.

A critical piece of the study was to measure the actual distance between the target and the drone when an image was captured and compare that to the specified 10-foot requirement. The distance for the in-person exam was measured by recording the exam with a second drone in a hover 250 feet above the test lane. The distance was measured by overlaying a scaled grid over the video. See Figure 4. This method does not allow for the measurement of the vertical distance. However, the altitude of the drone is provided on the drone controller screen and is thus less of an unknown variable.

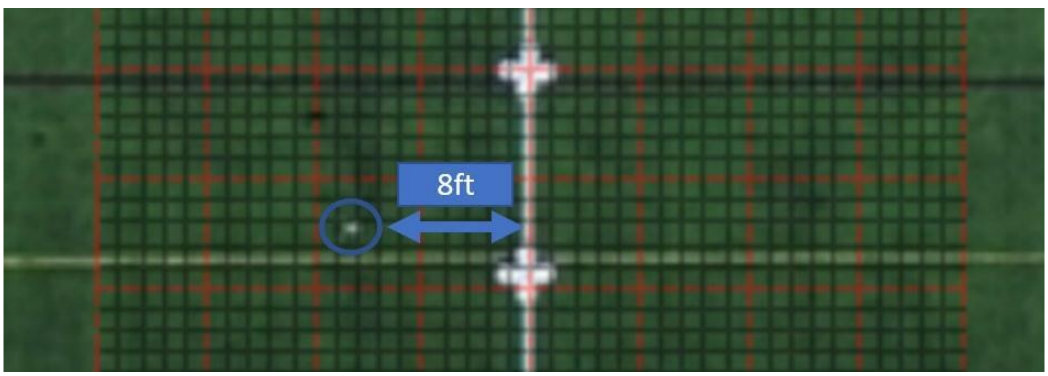

Figure 4. Measuring "S" distance with video

Immediately after the pilots completed the in-person BPERP test, they went to the research team's lab located a short drive away. Three simulator stations were set up for the participants to take the same BPERP test in the virtual environment. See Figure 5. The simulator self-proctors the exam with prerecorded audio, text instructions, and automatic scoring. The simulator also records the distance from the target when an image is virtually captured.

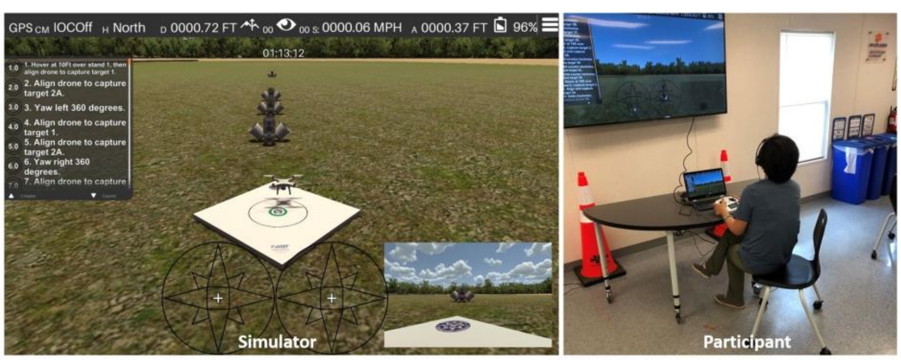

Figure 5. Simulator NIST Basic Maneuvering test

If the drone was closer than seven feet or farther than 13 feet from the target when an image was captured, that point would be disqualified even if the entire green ring was aligned. The three-foot value was developed subjectively but in consultation with industry experts. The test takers' raw scores and when a three-foot tolerance was imposed were compared.

Results

The study found that the average scores were not significantly impacted when a three-foot tolerance was imposed. The average score of the in-person and virtual BPERP was 36.4 out of 40 points. When a three-foot tolerance was imposed, the average score decreased to 34.6 points. That is a 1.8-point difference or approximately 4.5%. See Table 1.

Table 1

BPERP Scoring Comparison

Points Scored	In-Person Average	In-Person Min/Max	Simulator Average	Simulator Min/Max	Average Score
Traditional Method	38.7	33/40	35.3	19/40	36.4
3-ft Tolerance Imposed	34.3	23/40	34.8	19/40	34.6
Difference					1.8Pts/4.5%

Over three quarters of the exams taken had either zero or one point disqualified because the image was captured beyond the three-foot tolerance. Approximately 9% of the exams had two or three points disqualified. Several pilots lacked basic flight skills and had seven or eight points disqualified due to tolerance violations. See Table 2 for a breakdown of the frequency of point disqualification.

Table 2

Frequency of Point Disqualification Because of Tolerance Violation

Number of Points Disqualified	0	1	2	3	4	5	6	7	8
Percentage of Exams	58%	19%	6%	3%	3%	0%	0%	6%	6%

Conclusions

The study participants were inexperienced pilots working for state and local government agencies. Inexperienced pilots were ideal for this study because they will have a disproportionally large number of points disqualified if a positional tolerance was imposed compared to experienced pilots. This group would provide the “worst case” in quantifying the scoring limitation’s impact. The experiment demonstrated that even in the worst-case scenario with inexperienced pilots, scores were exaggerated by less than 5%. Most of the exam takers (77%) had one or no points disqualified. This study found the scoring limitation is relatively minor and for routine testing is negligible. However, when the test is used for higher-level functions such as a final exam in a drone course or for an organizational certification, it is important to manage the scoring limitation.

Discussion

The most practical way to manage positional error is with the proctor in the field. Proctors should be aware of the limitation and given instructions to either notify test takers when they exceed the given tolerance or make notes to disqualify points after the exam. It can be difficult to “eyeball” precise distances in the field. One way to assist with this is to provide parallel lines 10 feet on either side of the test lane. These lines, which can be made with paint or a length of rope, can be used as a guide for the proctor to gauge distance. A disadvantage of this is that they also provide a visual aid to the pilot. This aid is not explicitly prohibited in the NIST instructions, but it diminishes the exam’s rigor. A second option is to use a second proctor who can move around the lane to better estimate distance as the drone navigates the targets. This increases the cost and complexity of coordinating the test, however.

It is worth noting that the virtual BPERP administered on the simulator automatically imposes a three-foot tolerance without any additional measures. The exam is self-proctoring and records the results in the cloud. The only virtual BPERP currently available is on the Zephyr simulator produced by Little Arms Studios. APSA has adopted the Zephyr BPEPR as an acceptable alternative for in-person proctoring. The researchers use this simulator to credential their students taking an online UAS course. The software is available to other institutions for a fee.

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