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Design of a Proficiency-Driven Drone Pilot Training System

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Abstract: From 2015 to 2020, 4,250 drone-related injuries were recorded (Gorucu & Ampatzidis, n.d.), and the FAA has levied $341,413 in fines against drone operators between October 2022 and June 2024 (FAA, 2024). While commercial drone pilots must hold a Part 107 certification, the exam primarily assesses theoretical knowledge and lacks a standardized measure of hands-on proficiency—such as safe maneuvering, mission execution, and emergency response. Current training programs often prioritize passing the written exam over real-world readiness. This gap in practical skill development contributes to regulatory violations and safety risks. To address this, the Drone Pilot Training Management System (DPTMS) was developed as a comprehensive training solution. DPTMS integrates spaced repetition, interactive learning, and simulator-based exercises to enhance both knowledge retention and flight proficiency. Simulation results show that DPTMS can reduce operational violations by 30%, saving enterprises up to $6 million annually by preventing property damage, injuries, and other regulatory penalties.

Keywords: Unmanned Aerial Systems (UAS), Drone Pilot Training Management System (DPTMS), FAA Regulatory Standards, Aviation Safety, Hands-on Flight Training

1. Introduction

Commercial drone operations are on the rise with an expected to grow at a CAGR of 10.6% from 2025 to 2030 (Grand View Research, 2024). Despite this immense growth, pilot training remains heavily focused on passing the FAA Part 107 written exam, with little emphasis on developing real-world flight skills. Between 2015 and 2020, over 4,250 drone-related injuries were reported, and the FAA has issued over $341,000 in fines since 2022 (FAA, 2024)—underscoring the risks of inadequate training. If drones deliver just 0.5% of small cargo in Seoul by 2035, at least 38.35 crashes and 7.51 takeoff/landing accidents are expected annually (Baek & Kim, 2025), further showing the risks of underprepared operators and the importance of comprehensive training systems.

Most certification programs lack hands-on experience, leaving pilots unprepared for operational challenges and exposing enterprises to safety, legal, and financial risks. This paper presents the Drone Pilot Training Management System (DPTMS)—a solution that combines interactive learning with simulation-based exercises to enhance pilot proficiency and reduce violations.

2. Stakeholders and Objectives

The stakeholder ecosystem for drone pilot certification and operations is divided into three tiers based on each group's level of involvement, influence, and dependency.

Tier 1: Primary stakeholders are directly engaged in operations. These include drone pilots (safety, compliance, risk management), managers (fleet efficiency and workforce readiness), owners (ROI and liability), customers (service quality), and capital sources like banks (financial stability). Educational institutions and corporate training programs support enterprise employees with FAA-compliant training, excluding independent contractors.

Tier 2: Secondary stakeholders regulate and support operations. This includes drone training and testing organizations, regulators like the FAA (safety and compliance), and law enforcement (public safety and legal enforcement). Their main challenges include balancing regulation with innovation and managing incidents with limited resources.

Tier 3: Tertiary stakeholders are indirectly affected. These include victims of incidents (seeking safety and accountability), insurers (managing risk), investors (focused on profitability and growth), and government bodies (influencing the industry through policy and funding).

Key tensions across the ecosystem include regulatory compliance vs. efficiency, training cost vs. profitability, public safety vs. commercial growth, scalability vs. oversight, and investor pressure vs. sustainability.

3. AS-IS Process of Drone Pilot Proficiency

Current training programs prioritize passing the Part 107 written exam rather than practical skills like regulatory compliance and risk management, leading to frequent infractions by operating pilots. To address these deficiencies, structured, hands-on training solutions are necessary to ensure regulatory compliance, operational safety, and financial sustainability. By mitigating key tensions and fostering collaboration among stakeholders, the ecosystem can align its goals to sustain growth and enhance operational efficiency.

The Pre-Training Phase helps students prepare for Part 107 certification by assessing their readiness and choosing a training program. Eligibility requires being at least 16 years old, proficient in English, and a U.S. citizen (FAA). Students with a Part 61 license must complete an FAA-approved course, while others can either self-study and take the Part 107 exam directly or enroll in training. Training options include in-person courses ($1,495, 32 hours) with limited hands-on practice or online courses ($449, 160 hours) with no interactive learning (DARTDrones, 2024) (Drone Pilot Ground School, 2024). Both result in minimal operational proficiency, shown by an steady increase in both pass rates and actual incident rates among certified pilots (FAA UAS incident database, 2024)

The Training Phase focuses on preparing students for the Part 107 exam through structured courses, including practice tests and material reviews to reinforce knowledge. In the Post-Training Phase, students schedule and take the Part 107 exam at a PSI testing center, receiving immediate results. A passing score (≥70%) leads to a TSA background check and FAA certification, valid for 24 months (FAA Study Guide, 2024). Those who fail must wait 14 days before retesting. The Learning Phase delves into course content, including video lectures, quizzes, and practice exams. Some in-person courses provide hands-on drone training. Costs range from $129 to $1,495, depending on the format and level of instruction.

A stochastic simulation was created to assess the impact of proficiency on pilot operations. Ten pilots flying a drone 100 times each stochastically models the likelihood for each pilot to cause property damage, injuries, and fatalities before and after taking our course. Before the implementation of DPTMS, in the 95th percentile or worst case scenario, there were 14 occurrences of property damage at a .009 chance of damage occurrence per flight. At $1500 per violation, this costs the drone enterprise $21,000 in damages. For injuries, where the cost to the enterprise is $1.5 million, the worst case scenario was 6 injuries at a 0.0028 chance of injury per flight. This cost the company a huge sum of $9,000,000. This, combined with property damages, costs the enterprise $9,021,000. In the model, the cost of a fatality caused by a company's drone operator is $6 million. No fatalities have occurred in the simulation at a low chance of 0.00001, but even one would take the total payout jump to $15,013,500, highlighting the severity of such an incident and the need for good training.

4. Problem and Need Statement

In a simulated model of 10 drone pilots flying 100 times each, pilots caused 6 injuries and 14 instances of property damage, costing their employer over $9 million. These incidents reflect critical training gaps in regulatory compliance, airspace awareness, and emergency response. Without hands-on instruction, enterprises face recurring violations, liability costs, and regulatory penalties.

Current FAA Part 107 training programs emphasize theoretical knowledge through multiple-choice exams but lack structured flight training. In-person courses offering practical instruction are costly—ranging from $449 to $1,495—creating financial barriers for many prospective pilots. As a result, operators may enter the workforce with little to no real-world flying experience, increasing safety risks. Additionally, existing programs do not adapt to varying levels of prior aeronautical knowledge. Students with advanced backgrounds may find the material redundant, while beginners may not receive adequate support. This one-size-fits-all model leads to inconsistent outcomes and reduced training effectiveness. To reduce accidents and improve pilot preparedness, training programs must integrate hands-on simulation and operational knowledge, be affordable and accessible, and use adaptive learning to match students' experience levels. Meeting these needs is essential to producing proficient pilots, reducing violations, and supporting the safe and sustainable growth of the drone industry.

5. Concept of Operations

DPTMS provides the student with different learning options for training. They will start their learning journey with theoretical knowledge, which is then reinforced with the simulator. Learning includes a list of facts, concept maps, video lectures, flashcards, chapter quizzes, and simulator exercises. This ensures active learning for all learning styles.

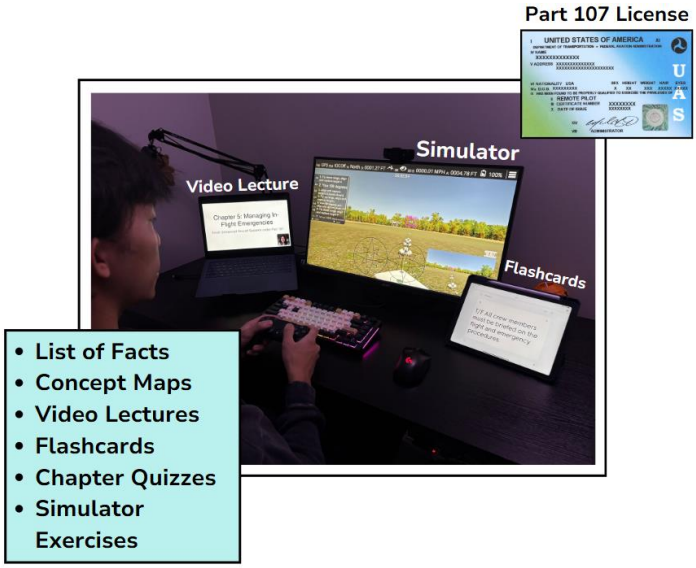

Fig 2. Drone Pilot Training System (DPTMS)

The To-Be Process retains the core structure while introducing key updates. In the Pre-Training Phase, the main addition is the DPTMS option, a $500, 138-hour training course alongside existing in-person ($1,495, 32 hours) and online ($449, 160 hours) programs, giving students more flexibility.

The Training Phase remains similar but includes the DPTMS 138-hour course, starting with a diagnostic exam to tailor learning modules. Students use a concept map, reference materials, and interactive tools like video lectures, flashcards, quizzes, and simulator scenarios to build proficiency. The phase concludes with a practice exam. The Post-Training Phase is unchanged operationally, but DPTMS enhances proficiency, modeled to reduce worst-case property damages (from $21,000 to $16,500), injuries (6 to 4), and fatalities by 30%, saving $6,016,500 overall. The Learning Phase highlights DPTMS, reinforcing its interactive and adaptive learning structure. After the diagnostic exam, students follow a structured path with graded simulator exercises before taking a final practice exam, ensuring strong preparation for the Part 107 certification.

6. Mission Requirements

These Mission Requirements define the specific objectives that the DPTMS must achieve to ensure regulatory compliance and operational proficiency. These include enabling structured course enrollment, integrating modern learning and assessment tools, and achieving measurable reductions in regulatory violations and associated costs. The system is designed to improve knowledge retention, enhance simulation-based training, and monitor student progress effectively.

MR.1 DPTMS shall allow students to enroll in the training program and register for courses.
MR.2 DPTMS shall include a structured learning environment covering all FAA Part 107 topics.
MR.3 DPTMS shall integrate simulation-based training for hands-on learning experiences.
MR.4 DPTMS shall provide AI-driven assessment tools to evaluate student proficiency.
MR.5 DPTMS shall reduce the probability of regulatory violations and associated costs by at least 30%.
MR.6 DPTMS shall ensure a 90% or higher pass rate on internal competency assessments.
MR.7 DPTMS shall facilitate a minimum 75% first-attempt pass rate on the FAA Part 107 exam.
MR.8 DPTMS shall provide compliance tracking and progress monitoring for regulatory adherence.

7. Functional Architecture and Functional Requirements

The Functional Architecture and Functional Requirements outline the system's technical capabilities and structural design. DPTMS is built as an interactive learning platform that supports registration, structured knowledge dissemination, and simulation exercises.

The DPTMS functional requirements ensure a streamlined and efficient experience for students pursuing their Part 107 certification. The system enables quick course registration, account creation, and payment processing, with confirmations received within one minute. It provides easy access to supplementary materials, including fact lists, flashcards, and concept maps, all available within a single click.

The platform supports video lectures across multiple topics, such as regulations, airspace classifications, and weather effects on drone performance. Each video allows for pause and play toggling for user convenience. Additionally, simulator scenarios enhance hands-on training, ensuring students receive an on-screen briefing, real-time flight data, and performance scoring within seconds of starting each exercise.

To assess student proficiency, DPTMS offers technical knowledge diagnostics, chapter quizzes, practical drone flying exercises, and FAA-style practice exams with 90% resemblance to real test questions. A dedicated module provides Part 107 certification guidance, including video tutorials on FAA exam registration, TSA background checks, and the Pilot Certificate process.

Finally, FAA/EASA regulation updates are integrated, allowing developers to edit and update the curriculum instantly, ensuring students always have the most current regulatory information. This structured approach ensures efficient learning, assessment, and certification readiness.

The following is the DPTMS functional architecture:

- F.1 is the course registration. Students register for the course and pay their course fees.
- F.2 is supplementary material. This encompasses material for each chapter that is not video lectures. It includes the list of facts, flashcards, and concept map.
- F.3 is the chapter video lectures. It lists each chapter by title, ensuring each module has a lecture.
- F.4 is the simulator scenarios. It breaks down into the names of each Zephyr scenario that corresponds to a module.
- F.5 is the course assessments. It includes each point a student is assessed on their knowledge, including the diagnostic exam, chapter quizzes, practical simulator exams, and practice exams.
- F.6 is the Part 107 drone license certification guidance. Students will be walked through the process for registering for the Part 107, including the FAA exam registration, the initial 14 CFR part 61 certification if applicable, and the online TSA check.
- F.7 is the FAA/ EASA regulations updates, which exist to ensure all information is up to date in the course.

8. Implementation

Drone CertiFly's Drone Pilot Management System (DPTMS) is implemented through Google Classroom, providing a structured, user-friendly learning experience. Upon enrollment, students gain access to pre-loaded course materials, including concept maps, lists of facts, video lectures, flashcards, chapter quizzes, and simulation exercises. The process begins with a diagnostic exam to assess prior knowledge and determine if students can bypass certain modules.

After taking the diagnostic exam, a student begins the modules. Module 0 includes a course syllabus, overview of the course, instructions to enroll in the simulator, and instructor information. Modules 1-12 contain content from each chapter of the FAA's Remote Pilot Small Unmanned Aircraft Systems Study Guide.

Each module contains 5 tools for theoretical learning:

1. Concept map: This is a learning tool derived from Ausubel's theory of learning, which states that meaningful learning stems from integrating new information in a cognitive structure based on previous knowledge. It is a visual tool that has concepts and ideas linked with arrows, illustrating the relationships between them
2. List of facts: This defines each term from the module. Students will have connected unfamiliar terms to familiar ones through the concept map, making it easier to grasp their definitions at this point.
3. Video lecture: An instructor presents the module in an engaging manner with visuals and examples. reinforcing the definitions given earlier and helping apply them to the real world.
4. Flashcards: Students can learn and be quizzed on the facts in each chapter through Quizlet, a flashcard website. This increases retention through repetition and serves as the student's first assignment. They will submit their scores to their instructor after repeating the cards until they are satisfied with their performance.
5. Chapter quiz: The chapter quizzes are fill in the blank format, utilizing active recall to test student comprehension.

A passing quiz score is required before advancing to the next module or moving to the hands-on simulation exercises in Zephyr Drone Simulator. The simulator provides real-world flight training scenarios that improve operational proficiency in a risk-free environment.

Fig 3. Drone Operations for Bridge Inspection

The figure shows a screenshot from a simulation exercise for Chapter 5. The student must identify structural cracks in a bridge and take aerial photos of each. Wind and weather impact drone flight, closely emulating a real life operational scenario. If the student completes the assignment to the right standard, they get a passing 'A' grade. If not, they fail and receive feedback with the opportunity to try again.

The implementation process ensures that students successfully pass the FAA Part 107 exam and develop practical drone operation skills, addressing the current lack of proficiency training in traditional programs.

9. Verification Testing Results

Testing was conducted using five subjects. Each subject was given a briefing on their task, and then no further instruction was given. Verification tests confirm that DPTMS aligns with FAA study materials, maintains platform stability, and provides accurate diagnostic assessments. The results yielded the following:

- F.R 1 - 1.2 yielded 100% verification (5/5 participants met the timing requirements).
- F.R 2 - 2.3 yielded 100% verification (5/5 participants met the number of clicks requirements).
- F.R 3 - 3.7 yielded 100% verification (5/5 participants met the number of clicks requirements).
- F.R 3.8 yielded 80% verification (only 4/5 participants met the number of clicks requirements).
- F.R 3.8 - 3.12 yielded 100% verification (5/5 participants met the number of clicks requirements).
- F.R. 4 yielded 80% verification (only 4/5 participants met the timing requirement).
- F.R. 4.4 yielded 80% verification (only 4/5 participants met the 10-second timing requirement).
- F.R. 4.8, 4.14 yielded 60% (only 3/5 participants met the 10-second timing requirement).
- The remaining F.R.s for 4 yielded 100% verification (5/5 participants met all requirements).
- F.R. 5.1 - 5.3 yielded 100% verification (5/5 participants met the number of clicks requirements).

10. Validation Testing Results

Validation results are derived from a simulation using Monte Carlo methods to model 1,000 replications of 10 pilots flying 100 flights each, with event probability derived from incident databases and FAA reports.. It stochastically models the likelihood for each pilot to cause property damage, injuries, and fatalities before and after taking our course. The simulation is replicated 1000 times. The results yield the following:

- Property damage costs per 100 flights reduced by 21.43% to $16,500, with likelihood decreasing 30% to 0.0063/ flight.
- Injury liability per 100 flights reduced by 33.33% to $6,000,000, with likelihood decreasing 30% to 0.00196/ flight.
- Fatality likelihood per 100 flights reduced by 30% to 0.0007
- FAA exam first-attempt pass rate increased to 78%.
- A projected annual cost reduction of $6,016,500 due to fewer violations.

These findings align with broader research forecasting the rise in drone-related incidents as operations scale. For

example, Baek and Kim (2025) predict that if drones are used for just 0.5% of small cargo deliveries in urban settings like Seoul, over 38 crashes and 7 takeoff/landing incidents may occur annually. Their work, which incorporates TLS, Boeing SSCJA, and ROT-based crash modeling, further underscores the importance of proactive safety systems like DPTMS that focus on pilot proficiency and operational risk reduction.

11. Conclusion / Business Plan

The implementation of the Drone Pilot Management System (DPTMS) represents a pivotal advancement in the training and certification of commercial drone pilots. As drone usage expands, studies predict dozens of annual accidents even at minimal logistical deployment rates (Baek & Kim, 2025), suggesting a growing need for proactive safety and training infrastructures like DPTMS. The system effectively bridges the gap between theoretical knowledge and operational proficiency, ensuring that pilots are not only well-versed in FAA regulations but also capable of executing real-world flight operations with a high degree of competence and safety. DPTMS delivers a holistic drone training solution by integrating adaptive learning, spaced repetition, and simulator exercises with FAA-compliant coursework, enhancing both retention and practical skills, as evidenced by a 78% first-attempt FAA Part 107 exam pass rate. Its subscription-based model—with a $500 enrollment fee and a $200 annual renewal—ensures that users gain regulatory expertise and operational proficiency while significantly reducing accident rates, property damage costs, and injury-related liabilities. Financial projections highlight a robust 300% ROI over five years with a break-even point of just 1.3 years, underscoring DPTMS's value as a scalable, cost-effective solution that sets a new benchmark in commercial drone pilot training. Future expansions include integration with AR/VR-based drone environments and automated progress tracking for FAA audit compliance.

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