2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION
Paper ID #52169

Delivery Drones Are Here: Are We Ready?

Dr. Salvatore Marsico, The Pennsylvania State University

Dr. Marsico is an Associate Professor of Engineering and Legal Issues in Engineering in the University College of Penn State University.

Delivery Drones Are Here: Are We Ready?

Abstract

Uncrewed Aerial Systems (UASs), commonly known as drones, are increasingly being integrated into commercial operations, particularly for product delivery. These uncrewed systems typically include the drone itself, a ground control system, a communication link, and supporting equipment to fulfill delivery requirements. Unlike traditional delivery systems, drone delivery systems are designed to provide expedited delivery services, especially last mile delivery. While drone deliveries offer many benefits to both companies and consumers, it also raises regulatory and ethical challenges- especially as these drones frequently traverse over private property.

Currently, apart from the Federal Aviation Administration's (FAA) oversight of navigable airspace, there is minimal coordination between federal, state, and local governments regarding drone operations. For drone delivery services to be adopted at scale, a comprehensive public policy framework is urgently needed—one that addresses airspace rights, safety, privacy concerns, and broader societal impacts. Public policy in this area must weigh the benefits of technological advancement against the risks, particularly regarding individual rights of privacy and property.

A guiding principle for drone related activity should be the right of people to be free from the intrusion of drones into their personal airspace. While the mission of FAA is to regulate an efficient and safe navigable airspace, it does not regulate privacy issues linked to drone delivery. The technology incorporated into a drone provides for the collection, storing, and securing of data including Global Positioning System (GPS) location, thermal information, cell phone data, and facial recognition when fitted with a camera, raises significant privacy concerns.

This article examines how policy can guide the development of laws that both enable the efficiency gains of delivery drones and safeguard individual privacy and property rights.

Introduction

The rapid advancement of Uncrewed Aircraft Systems (UAS) has enabled delivery drones becoming a critical component of modern logistics. The United States e-commerce market sales for 2025 is forecast to exceed one trillion dollars, with a forecasted growth to $1.45 trillion for 2026 [1]. E-commerce companies drone delivery market size for 2025 was approximately $2.88 billion and expected to reach $8.38 billion in 2030 [2]. The main types of drones are fixed wings, rotor, and hybrid; i.e., Vertical Takeoff and Landing -VTOL. Consumer acceptance of drone delivery looks to perceived benefits versus the risk of invasion of privacy, trespass to property, noise, and safety. Surveys highlight privacy concerns due to aerial data collection and video of property when drones are outfitted with cameras, drone crashes, noise from frequent drone

flights, and general security [3]. Drone flights produce tonal noises that are high-pitched, whining, or buzzing sounds produced by the periodic interaction of rotating propellers with the air, specifically at the Blade Passing Frequency (BPF). [4] While most current drone delivery services focus on urban centers, rural areas need these services since these areas cover 97% of the U.S. in which 19.3% of the population live [5]. A survey of 821 respondents found strong positive attitude toward drone delivery, with 87% of respondents reporting positive sentiments and 89% stating that they were likely to use a service if it were available [6]. It is important that policies developed by the Federal Aviation Administration (FAA) and state legislatures guide balancing commercial integration with privacy protections. Developing a framework to guide drone-related laws should be based on balancing logistics, FAA regulations, privacy, property and landowner rights, and security.

Engineering Education and Drones

Rapid advancements in engineering and technology requires that graduates possess robust theoretical knowledge and the ability to apply this knowledge in solving complex problems. [7] This change in thinking has led to significant reforms in engineering education, emphasizing hands-on learning, problem-solving, and interdisciplinary approaches. Bridging the gap between academic concepts and industry needs is a challenge. [8] Integrating advanced technologies through simulation-based learning (SBL) and problem-based learning (PBL) are educational approaches that focus on technical skills, system thinking, and problem solving. [9]

The intersection of engineering, drone delivery, and private property rights whereby engineers design for societal acceptance of the technology and its challenges. In engineering education, these challenges can best be looked at through the lenses of Macroethics that looks to decision making by the engineering professional applied to the "collective social responsibility of the profession and to societal decisions about technology" [10] and Human-Centered Design (HCD) [11] that "aims to make systems usable and useful by focusing on users" [12] to augment traditional engineering design approaches [13].

Drones and drone delivery is an interdisciplinary problem requiring collaboration between engineering, law, and public policy. Engineers design systems that are technically feasible and operationally acceptable. Drone delivery systems require routing algorithms for delivery paths, a socially acceptable tonal noise level to minimize resident complaints or legal challenges. Additionally, safety being paramount requires redundant communication links that ensures a predictable response to location to minimize risk to people and property.

The challenge for engineers and engineering educators is to move beyond isolated design and functionality toward navigating regulatory hurdles. Although the FAA primarily focuses on safety and navigable airspace, commercial operators are required to perform environmental reviews that requires "best practices" to mitigate noise, such as limiting daily flights or maintaining setback distances from "sensitive receptors" such as hospitals, nursing care facilities, playgrounds. [14] Thus, engineering curricula needs to integrate public policy

constraints into the design process, which in this instance is for training students to treat drone noise thresholds as primary rather than secondary considerations. This approach provides students with an understanding of the interdisciplinary nature of engineering. It's not just about the functionality of the system but how that system functions holistically within the framework that balances technical performance with socially acceptable tonal noise.

Logistics and FAA Framework

A proposed framework for navigating competing interests for deploying drones in the logistics space would look to the executive branch providing expectations that integrating uncrewed aerial vehicles or systems into the national airspace system to account for security, and privacy. In 2015, President Obama issued a memorandum titled " Economic Competitiveness While Safeguarding Privacy, Civil Rights, and Civil Liberties in Domestic Use of Unmannned Aircraft Systems" in which the expectation was that the FAA account for privacy, security, and transparency while integrating UAVs into the National Airspace System (NAS) [15]. The rapid growth of e-commerce, especially during COVID-19, increased the demand for Last Mile Delivery (LMD) which is the last leg of the movement of goods from a logistics hub to their destination [16]. LMD drones provide logistics companies with an ability to operate at scale. However, the federal regulatory environment must be streamlined and updated for routine commercial service. As with nighttime drone operations FAA regulations requiring additional training [17], the FAA is moving in the direction of easing Beyond Visual Line of Sight for flights at or below four hundred (400) feet in uncontrolled airspace [18]. The "benefits of the proposed rule are the economic, safety, and health values" resulting from BVLOS operations [19]. In addition, a proposed FAA Part 108 considers a two-tier system which would permit fleets of up to 100 drones each having a maximum weight of 55 pounds to operate in areas designated as lower density suburban areas understood as an area with up to 7,000 people per square mile. And part two of proposed FAA part 108 would allow much heavier drone weights, up to 1320 with specialized training to operate over all population densities, including multifamily and downtown locations [20]. One aspect that may be considered is the creation of time-dependent regulations that depend on the make-up of the community: i.e., retirement community, commuter residential neighborhood, to regulate day and time of deliveries based on prioritizing privacy. Additionally, it would be prudent for municipalities and FAA to work toward minimizing contradictory the current patchwork of local regulations that are, at times, in direct conflict with regulations such as operating in the 400 to 200 feet AGL. Furthermore, it would be prudent for drone operators and government entities, local and state, to inform and coordinate with communities to be impacted describing their operations including flight paths.

Public Policy Framework

A comprehensive framework for drones would necessarily be a multi-layered approach balancing federal authority over airspace with state and local control over privacy and property. [21] More recently, a standardized regulatory framework that proposes performance-based regulations for

the operation of UAS at low altitudes beyond visual line of sight (BVLOS) with the intent to provide a predictable pathway for safe, routine, and scalable UAS operations including package delivery has been published in the Federal Register. [22]

The multi-layered approach to modern drone policy is based on the Multi-Level Governance (MLG) model where responsibilities can be local, state, and national. The FAA's jurisdiction is at the national level in which the FAA controls the national airspace (NAS), set pilot certification standards and the state/local level for concerns such as zoning and privacy.

Policies at the national level have a notice-comment period prior to enactment policy. FAA Part 108 BVLOS has recently closed the comment period (February 11, 2026) during which the FAA was seeking input regarding right of way rules for drones versus manned aircraft. Additionally, policies need to be examined for technology and certification, infrastructure requirements, and impacts on the environment and society. More importantly, stakeholder collaboration among planners, operators, regulatory agencies , and the citizenry since drone integration requires managing noise and public acceptance.

Privacy Safeguards

While the FAA manages safety, policy should guide state and local laws to address the surveillance capabilities of sensor-equipped drones. States, including Florida, provide that a reasonable expectation of privacy is presumed if a person cannot be observed from ground level and prohibit the use of drones to capture images [23]. Thus, consistent with the doctrine of "federal preemption" [24]whereby federal law supersedes state law, the FAA manages the airspace, and states must protect privacy rights. In increasing privacy protection, the FAA has set rules that all drones over 250 grams broadcast a Remote ID [25]. This allows law enforcement to identify, in real time, the location and operator when addressing a specific privacy case. To further protect privacy, the Federal Communication Commission (FCC) in December 2025 issued a ban on the importation of all new drone models or new drone equipment from "foreign countries of concern" without specific security exemptions [26]. Although not currently mandated, the FAA in cooperation with the Department of Transportation should develop a policy requiring commercial drone operators to publish a privacy impact assessment outlining monitoring guidelines [27], geofencing, data collection in private or sensitive areas without consent, and auto-redacting of personal identifying information, mandatory data encryption, or destroying unnecessary data to name a few. A potential advantage for increasing local regulatory authority is tailoring UAV no-fly zones or other restrictions specific to community needs. A localized framework of UAV no-fly zones can act in the same way as land use zoning.

Property and Landowner Rights

Frameworks should clarify the "low-altitude" airspace rights of property owners to prevent legal ambiguity relating to trespass to land rather than privileged transit. Currently there is a lack of a standardized national definition delineating federal airspace begins and private property. In

United States v. Causby, the Supreme Court of the United States in 1946 provided guidance on where private property rights of airspace end and navigable airspace begins . The ruling in Causby affirmed Congress's declaration that navigable airspace is the space above the minimum safe altitude as defined by the Air Commerce Act [28] and is public domain in which landowners retain rights to the immediate reaches of the air above their land that is essential for its use and enjoyment. Thus, the ruling balanced the public right to aviate against the needs of private property rights, recognizing landowners' rights over the "immediate reaches" but not the entire sky [28] but owns "at least as much of the space above the ground as he can occupy or use in connection with the land" [29]. However, the Causby Court did not set a number defining the minimum safe altitude. Currently, U.S. Senate Bill 1249 of 2025: Drone Integration and Zoning Act is an attempt at setting the "immediate reaches of airspace" for uncrewed aircraft at 200 feet above ground level (AGL) while allowing states to issue reasonable zoning restrictions defining no-fly zones enforced through GPS geofencing technology below 200 feet [30].

Beyond simple trespass, emerging laws focus on persistent drone flights, noise above or adjacent to private property, and surveillance which can be distracting, annoying and may impair the use and enjoyment of property that can be considered a private nuisance [31]. Here, surveillance, noise, or persistent flights is significant enough that a reasonable person would not tolerate the constant noise or presence enough so that the interference affects the quiet use and enjoyment of one's property. Thus, states and local municipalities can legislate what kinds of drone use constitute private nuisance and authorize enforcement [32], [33]. Establishing this below two hundred feet AGL zone, per U.S. Senate Bill 1249, provides landowners with a clear basis to challenge persistent overflights that interfere with their privacy and enjoyment of the land. However, as local governments use drones for law enforcement a question arises as to whether property owners have a "reasonable expectation of privacy" from aerial views. The Michigan case of Long Lake Township v. Maxon in which the Township, unable to view the property from ground level, hired a private contractor to take aerial drone videos and photographs of the Maxon property "suspected of zone violations" [34]. The Michigan Court ruled that the Township violated the Fourth Amendment [35] by intruding into an area where the Maxon's had a reasonable expectation of privacy. However, applying the Janis [36] balancing test, the videos and photographs weighed in favor of deterring future unlawful conduct compared against the societal cost of excluding the evidence, were admissible as evidence of zoning violations.

Conclusion

As the number of drone deliveries rises to become commonplace occurrences it is important to develop guiderails for an efficient delivery system. Developing such a system will ordinarily require that FAA regulations be in harmony with those developed by the local communities to encourage operators to self-regulate their operation to protect privacy and property. Self-regulating operating times with periods of the day to minimize the impact on the community by avoiding areas that are sensitive to personal protection, setting a minimum flight altitude of the

mission, and auto-redact personal identifiable data are a few incremental ways to begin setting a framework for an efficient delivery system.

References

[1] U. C. Bureau, "Quarterly Retail E-Commerce Sales," U.S. Department of Commerce, 2025.

[2] T. B. R. Company, "Delivery Drones Market Report 2026," The Business Research Company, 2026.

[3] E. Y. J. J. W. Yoo, "Drone delivery: Factors affecting the public's attitude and intention to adopt," *Telematics and Informatics,* vol. 35, no. 6, 2018.

[4] J.-S. V. J. P. Y. G. F. M. S. Lauzon, "Aerospace Research Central Proceedings Aeroacoustics of Drones," 8 June 2023. [Online]. Available: https://arc.aiaa.org/doi/10.2514/6.2023-4524. [Accessed 2026].

[5] K. H. M. Kaplan, "Literature Synthesis of Emerging Last-Mile Delivery Technologies and their Applications to Rural Areas: Drones, Autonomous Delivery Vehicles, and Truck-Drones," *Journal of the Transportation Research Board,* vol. 2678, no. 12, 2024.

[6] N. A. S. E. Medicine, "Perspectives on Drone Delivery: From the First Community in the U.S. to Experience Residential Package Delivery by Drone," 2021. [Online]. Available: https://trid.trb.org/View/1866558. [Accessed 2026].

[7] ABET, "Criteria for Accrediting Engineering Programs, 2025 – 2026," January 2026. [Online]. Available: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2025-2026/. [Accessed 2026].

[8] D. B. R. &. H. J. Dong, "Evaluation of the effectiveness of developing real-world software projects as a motivational device for bridging theory and practice," *Journal of Further and Higher Education,* vol. 46, no. 9, 2022.

[9] P. M. R. K. S. Beldar, "Enhancing Engineering Education through Drone Technology Skilling Program: Analyzing the Impact on Program Outcomes," *Journal of Engineering Education Transformations,* vol. 39, no. 2, 2025.

[10] J. Herkert, "Ways of thinking about and teaching ethical problem solving: Microethics and macroethics in engineering," *Science and Engineering Ethics,* vol. 11, no. 3, pp. 373-385, 2005.

[11] P. M.-Y. C. A. D. G. J. P. A. Ponsa, "Human-Centred Design in Engineering Curricula," *International Journal of Engineering Education,* vol. 28, no. 4, 2012.

[12] International Organization for Standardization, "ISO 9241-210:2019(en) Ergonomics of human-system interaction-Part 210: Human Centred design for interactive systems," 2019. [Online]. Available: https://www.iso.org/obp/ui/#iso:std:iso:9241:-210:ed-2:v1:en. [Accessed 2026].

[13] R. C. B. E. M. H. J. S. B. R. T. Kaustubh, "Ethical Human Centered Design: Practical Approaches for Aerospace Engineering Education," in *AIAA AVIATION 2022 Forum*, Chicago, 2022.

[14] A. A. K. P. M. a. P. B. P. Misra, "Aerial Drones with Location-Sensitive Ears," *IEEE Communications Magazine,* vol. 56, no. 7, pp. 154-160, 2018.

[15] T. W. House, "The White House, Office of the Press Secretary," February 2015. [Online]. Available: https://obamawhitehouse.archives.gov/the-press-office/2015/02/15/presidential-memorandum-promoting-economic-competitiveness-while-safegua. [Accessed 2026].

[16] A. P. E. B. M. v. H. R. H. P. Jazairy, "Drones in last-mile delivery: a systematic literature review from a logistics management perspective Open Access," *The International Journal of Logistics Management,* vol. 36 (7), no. 7, pp. 1-62, 2025.

[17] "Operation at night," 2026. [Online]. Available: https://www.ecfr.gov/current/title-14/chapter-I/subchapter-F/part-107#se14.2.107_131.

[18] "Visual lien of sight aircraft operation," 2026. [Online]. Available: https://www.ecfr.gov/current/title-14/chapter-I/subchapter-F/part-107#se14.2.107_131.

[19] "Normalizing Unmanned Aircraft Systems Beyond Visual Line of Sight Operations," [Online]. Available: https://www.federalregister.gov/documents/2025/08/07/2025-14992/normalizing-unmanned-aircraft-systems-beyond-visual-line-of-sight-operations. [Accessed 2026].

[20] "Beyond Visual Line of Sight (BVLOS)," [Online]. Available: https://www.faa.gov/newsroom/beyond-visual-line-sight-bvlos. [Accessed 2026].

[21] T. Rule, "Drones, Airspace, and the Sharing Economy," *Ohio State Law Journal,* vol. 84, no. 157, p. 34, 2023.

[22] U.S. GovernmentFederal Register, "Normalizing Unmanned Aircraft Systems Beyond Visual Line of Sight Operations," 7 August 2025. [Online]. Available: https://www.federalregister.gov/documents/2025/08/07/2025-14992/normalizing-unmanned-aircraft-systems-beyond-visual-line-of-sight-operations. [Accessed 2026].

[23] *Florida Statute § 934.50*.

[24] *Medtronic, Inc. v. Lohr,* 1996.

[25] U. S. D. o. Transportation, *Remote Identification of Drones,* United States Department of Transportation.

[26] F. C. Commission, *PUBLIC SAFETY AND HOMELAND SECURITY BUREAU ANNOUNCES ADDITION OF UNCREWED AIRCRAFT SYSTEMS (UAS) AND UAS CRITICAL COMPONENTS PRODUCED ABROAD, AND EQUIPMENT AND SERVICES LISTED IN SECTION 1709 OF THE FY2025 NDAA, TO FCC COVERED LIST,* 2025.

[27] Datumate, "Practical guide: Mitigating Risks with Infrastructure Drone Use," November 2024. [Online]. Available: https://www.datumate.com/blog/risk-mitigation-with-infrastructure-drone-use/. [Accessed 2026].

[28] *United States v. Causby,* 1946.

[29] *Hinman v. Pacific Air Transport,* 1936.

[30] *Drone Integration and Zoning Act,* Congress.gov, 2025.

[31] a. Chen, "Disputes over Drone uses in Public Airspace," sunwater institute, 2023.

[32] "State Laws and Regulations," 2024. [Online]. Available: https://www.ncdot.gov/divisions/aviation/uas/Pages/laws-regulations.aspx. [Accessed 2026].

[33] "Texas Drone Regulations," [Online]. Available: https://gov.texas.gov/film/page/drone_use. [Accessed 2026].

[34] "Long Lake Township v. Maxon," *Harvard Law Review,* vol. 138, no. 7, pp. 1941, et. seq., 2025.

[35] *U.S. Const. amend. IV.*

[36] *United States v Janis, 428 US 433,* 1976.

[37] V. Tech, "The first U.S. population to experience drone delivery gives it a seal of approval," Virgina Tech.