# Analysis of the Difficulties of Integrating Commercial UAVs into the National Airspace

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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## Introduction

> *"Technological innovation therefore leads ultimately to a need for social and political innovation if its benefits are to be fully realized and its negative effects kept to a minimum". (Mesthene, 1970, p. viii)*

With significant developments in Unmanned Aerial Vehicle (UAV/ UAS) technology over the past several decades, the possibilities for widespread use of this technology in commercial applications are quickly becoming a reality. With support from lawmakers, major companies interested in this technology are determined to move forward with integrating commercial UAV systems into the national airspace. As a result of this push, the federal Department of Transportation recognizes that "the use of UAS represents a significant safety concern for the FAA, which must accommodate the expansion of commercial UAS operations as it strengthens its oversight and risk-mitigation efforts" (United States, 2018, p. 86). This process presents a significant challenge to the FAA, with widespread effects on the safety and privacy of United States citizens.

With the rapid innovation of UAV technology, it has quickly outgrown the bounds of its early regulation. Despite direction from Congress in 2012, much of the Federal Aviation Administration's (FAA) efforts have failed to adequately address the interests of companies and the concerns of the public. Instead of providing a framework for commercial UAVs to work within, companies have had to resort to other methods for working around current regulation. An exemption for UPS to begin conducting limited UAV-based deliveries is only one example of such methods (Josephs, 2019). One way of thinking about this gap between the developments of UAV technology and corresponding public policy is captured in Fig. 1 from an article in *Deloitte*

*Insights.* Technological innovation can be thought to push the boundaries of possibility, while institutions and public policy lag behind (Bersin et al., 2017).

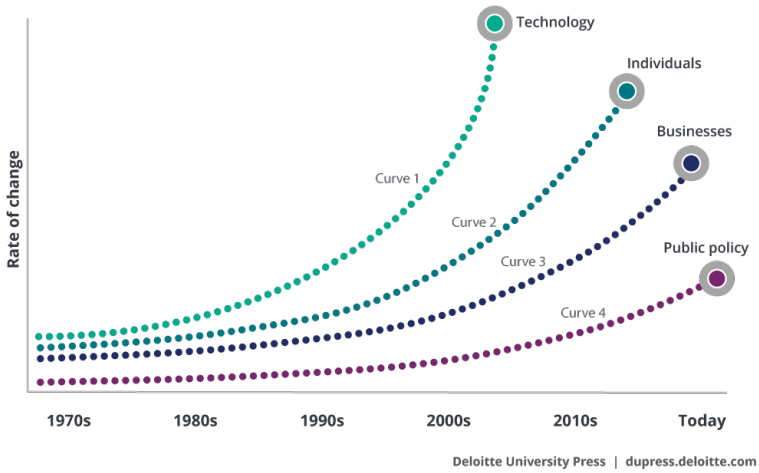


**Figure 1:** Visualization of the differences in the rate of change between technology and other societal elements. The figure shows how public policy lags significantly behind changes in technology (Bersin et al., 2017)

While this can be a useful way to think about innovation, I argue that it only captures the nascent stages of today's commercial UAV sociotechnical system. Current regulations are so poor that the "prohibitions swallow the allowances" and effectively ban most useful activities (Olsen, 2017, p.622). In order for these innovations to be useful for society, businesses and government must erect the framework to bring regulation that matches these amazing developments. Only then can companies and consumers eliminate the opportunity costs created by using older and inefficient alternative technologies. In this paper, I investigate the environment surrounding UAV regulation and the FAA's progress on the issue, with a specific focus on the future of commercial UAVs. I argue that the solution to the issue of UAV regulation lies in constructive interaction between companies, regulators, and the public, focusing on areas most in need of innovation to incorporate this novel technology.

## Part I: Challenges Faced in the Widespread Adoption of Commercial UAVs

Throughout this section, I will articulate the fundamental foundations of UAV regulation that the FAA must develop in order to facilitate a viable future for commercial UAV systems. I will first emphasize the importance of well-made regulation for the sustainability of these innovative technologies. Then, I will dive into how the elements of safety, individuals' privacy, and public acceptance pose difficulties for regulators during the implementation process. Finally, I will introduce my research and briefly connect these elements to the myriad of tasks currently in the hands of the FAA.

Within the commercial realm, government regulation plays the critical role of forming the framework in which companies operate, often in order to protect individuals. Especially within the transportation and aviation industries, this oversight is critical for the safety of the public as well as the stability of the industry. Whereas an unregulated aviation industry would be chaotic and dangerous, the U.S. history of aviation regulation has shown that, "safety regulation promotes commerce" when it is not overly restrictive (Olsen, 2017, p. 627). Throughout the middle of the 20th century, the general safety of the industry was drastically increased through key regulation and oversight from administrative agencies. Today, advances in UAV technology are leading to situations similar to those faced following the advent of manned flight. These advances have reached a point where many types of commercial systems including drone cargo are now technically feasible, but the associated regulatory framework must catch up. In order to approach this problem, we can look to the successes of the past, while considering the relevant elements of today to develop the required safety and organizational frameworks that are currently limiting widespread use of this technology.

The first and most important element for developing successful commercial drone systems is the ability to ensure the safety of such systems for the public. In order to do so, an

airworthiness evaluation of the commercial vehicles and overall systems is essential. Such evaluations would guarantee that vehicles that might interact with the public are adequately reliable and robust so as to protect people and property in the air and on the ground. One piece of this evaluation system is an analysis of the danger present to individuals on the ground in the case of an impact from a falling UAV. Thanks to recent research done by the Alliance for System Safety of UAS through Research Excellence (ASSURE) group, regulators are beginning to develop a firmer understanding of the damage that a falling UAV may cause (Arterburn, 2019). The ASSURE group conducted the most extensive set of UAV crash tests to date, giving key insights about how the design of a falling vehicle may contribute to injuries on the ground. Another important piece of the evaluation system would look into the measures taken to avoid collisions with other aerial objects such as helicopters or planes. The ability to ensure that a UAV will not cause damage to manned aerial vehicles is a mandatory prerequisite to the future of commercial UAV systems (Liu & Foina, 2016). By combining these pieces into a cohesive airworthiness evaluation program, regulators will be able to much more effectively protect the public from avoidable tragedies.

Another important element of successful commercial UAV systems will be appropriate considerations to protect individuals' privacy. As companies operate these systems, the UAVs can be expected to gather large quantities of data unrelated to their direct operations as a byproduct of flying between locations. Without appropriate regulations controlling what data may be used or sold, this information is likely to be sold off or used for data mining purposes, activities that may invade the privacy rights and expectations of citizens (Scharf, 2019). Types of privacy issues include intrusion upon individuals' privacy and the right to be left alone, as well as one's more ambiguous rights to personal data. Even today with very limited applications of

UAVs, an individual who believes that their rights have been violated may experience the many "challenges of prosecution of the specific privacy tort of intrusion upon seclusion involving nongovernmental use of drone technology" (Scharf, 2019, p. 1065). Such challenges include identifying the operator of a delinquent UAV, proving that the operator maliciously used the vehicle in violation of one's rights, and being able to quantify the damages caused by such an intrusion. These challenges can only be expected to multiply in a future society where commercial UAVs are ubiquitous. Additionally, courts of law will need further guidance on how to rule on these novel cases of privacy invasion. Only through further technological innovation, accompanying regulation, and federal guidance will many of these challenges be solved.

Beyond the clear elements of safety and privacy, public acceptance of commercial UAV systems is the third element critical to the viability of these future systems. Groups on opposing sides of the UAV argument continue to publicize and push extreme views of either the wonders that this technology may bring or the fear of its impact upon safety and privacy. The FAA must navigate through these murky waters in order to build successful regulations for the future. The FAA's historical mandates have always been "both regulating and promoting civil aviation" (Vance et. al., 2014, p. 205). In order to achieve this specific goal of promoting UAV aviation, the FAA must address the real issues that are raised by anti-UAV groups, while avoiding regulation that overly constrains commercial systems. It will not be simply sufficient to build a regulatory system that effectively protects the safety and privacy of the public, but rather a system must be built and then justified to the American public in order to achieve acceptance.

With a solid foundation of the requirements that commercial UAV systems must meet, my research in the remainder of this thesis seeks to explore how further innovation in regulations might lead to the eventual integration of this technology into society. As of now, this technology

is relegated to small and inconsequential applications, and "the only viable uses of drones appear to be agricultural, environmental, and photographic" (Olsen, 2017, p. 639). Despite these currently limited applications, the commercial potential for large UAV systems such as cargo drones should not be underestimated. Many massive companies such as Amazon, Google, and others have numerous incentives to pursue this technology. The FAA and other stakeholders must make the appropriate considerations about the political and societal changes required during this sociotechnical system's formative stage. As demonstrated by Mesthene's quote from the introduction, a viable solution will only be reached through complementary innovation in social and political realms to match today's technical developments.

## Part II: Methodology for the Investigation of Modern UAV Regulations

In this section, I will establish the approach that I used to conduct my research. In order to grasp the current state of regulation surrounding commercial UAV use, one must first examine the history of aviation regulation in the United States. Over the last century, key legislation and judicial rulings have molded UAV regulations into their current form. As I develop this historical perspective, I use the work of Wiebe Bijker as a guide to compare conflicting arguments about the state of modern UAV regulation. From this understanding of the formation of aviation regulation, one can then analyze the modern regulatory environment far more effectively. Finally, I propose Arnold Pacey's theory of interactive innovation as an element that will be critical to the development of useful commercial UAV regulations. Figure 2 visualizes this process in a four-step flowchart.

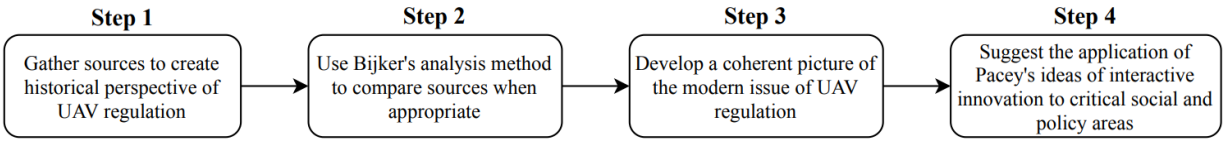


**Figure 2:** Flowchart demonstrating the research methodology applied to analyze commercial UAV regulation (Created by Author).

Wiebe Bijker builds a comparison framework during his investigation of American and Dutch coastal engineering practices, motivated by the damage and destruction caused by hurricane Katrina. The differences between the two became a point of interest when coastal structures in New Orleans failed during the hurricane, whereas Dutch structures were shown to have weathered far more severe conditions. Bijker compares two papers, one from each engineering discipline, concerning the respective country's approach and assumptions about coastal engineering. During that investigation, he examines the dichotomy between the engineering practices of the two countries and their foundations in different technological cultures. In brief, he finds that differences in three factors: national awareness of risks, involvement of individuals within affected communities, and attitudes towards disaster mitigation vs. prevention have led to contrasting systems (Bijker, 2007, p. 148-150). With two of the most recent research papers I have selected, I will apply Bijker's method to highlight differences in concerns between the authors and discover key issues that must be solved to implement commercial UAV systems.

Arnold Pacey's work in exploring what he calls interactive innovation can be applied to that case of the FAA to understand some of the organization's struggles. In his chapter called "Innovative Dialogue", Pacey builds contrasts between linear and interactive styles of innovation. Linear innovation is a style found mostly in large and rigid organizations that focus upon traditional methodologies to solve problems. These organizations are still capable of innovation, but advancements are relatively slow and often one-sided. Conversely, interactive innovation is a process of rapid growth primarily as a result of synthesis between the ideas of multiple parties. This style of innovation "depends on the imagination of the creative individual, on interaction among enthusiastic scientists or technicians, and often on interaction between

experts and users, designers and potential clients" (Pacey, 1983, p. 142). The large bureaucracy of the FAA easily lends itself to analysis using this structure, as it exemplifies a system that is focused on linear innovation.

**Part III: Modern Issues in UAV Regulation Typical of Historical Aviation Regulation**

The creation and implementation of regulations to support future commercial UAV systems is by no means a simple endeavor. However, significant work by the FAA remains to be done in order to achieve that goal. In this final section, I will first construct a brief history of significant events over the past century that have affected modern UAV regulation. From this historical foundation, I will then highlight the modern issues that stand in the way of further progress through a comparison of papers from recent years. Finally, I will suggest these arguments as a starting point from which to seek out novel solutions for novel UAV systems of the future.

Beginning in the early 20th century, the foundations of aviation regulation began to take form as necessitated by the growth of manned flight. Until this time, the "ancient doctrine of *cujus est solum ejus est usque ad coelum*, a common law maxim that individual ownership of land extended upward to the periphery of the universe", had been the widely accepted standard of real property ownership (Ravich, 2009, p. 604). Under this previous standard, any flight over private property could have been construed as an act of trespass, needlessly constraining the public aviation necessary for military and commercial purposes. As a result, Congress passed both the Air Commerce Act of 1926 (ACA) and the Civil Aeronautics Act of 1938 (CAA) to remedy this situation and give regulatory authority to an administrative agency (Mensinger, 2015, p. 411). These acts were the critical first steps towards the federalization of much of the national airspace. The vehicle that Congress used, as in many cases, was the Commerce Clause

of the Constitution. Via this clause, Congress is empowered to regulate interstate commerce as that matter falls outside of the purview of individual states (U.S. Const. Art. 8, Clause 3). Within the ACA and CAA acts, Congress divided the national airspace into navigable and non-navigable segments. Navigable airspace was defined as airspace that could reasonably be used for transportation above a minimum height, with the assertion that such space forms a pathway for air commerce. Therefore, the federal government asserted the authority to directly regulate this airspace as well as any non-navigable airspace where activities within that airspace may substantially affect the other (Ravich, 2009, p. 604). These acts effectively ended the *ad coelum* doctrine and allowed for the modern use of the national airways.

Unsurprisingly, the ACA and CAA acts failed to adequately address all aspects of the federal government's regulatory authority and instead formed the unsteady basis on which some of the modern aviation regulations stand. One prominent failure was the lack of clarity in identifying the new property rights of landowners in relation to the airspace overhead. With the landmark case of *United States v. Causby* in 1946, the Supreme Court first addressed this issue with the conclusion that landowners had a property interest in the "immediate reaches of the enveloping atmosphere" (Mensinger, 2015, p. 414). This case seemed to answer the question of division between land ownership rights and aviation regulation; however further questions about the definition of the "immediate reaches" of airspace have muddled the waters on this issue. Specifically in the case of using UAVs within such space, there still remains no clear answer. Additionally, two later cases, *Braniff Airways v. Nebraska Board* and *Aaron v. United States*, created somewhat opposing precedents about the basis and invasiveness of federal aviation regulations. In the *Braniff* case, the Court based its verdict upon an assumption that the federal government's regulatory powers are derived from Congress's commerce powers, while the

*Aaron* court assumed that navigable airspaces are inherently controlled by the federal government (Mensinger, 2015, p. 416-417). The lack of clarity about the divisions of regulatory power between the federal government and the FAA, individual states, and local governments destabilizes an already unclear situation concerning the property rights of an individual over their immediate airspace. The dynamic nature of UAVs and their ability to quickly move from one region of airspace to another of different regulatory authority brings many of these issues to the forefront of discussion.

The modern era of aviation regulation began with the creation of the FAA with the Federal Aviation Act of 1958 (Mensinger, 2015, p. 416). From that point until 2012, no coherent framework existed to regulate the growing presence of UAVs. Throughout the 1990s and into the next millennia, stopgap measures were implemented to satisfy the needs of military and public UAVs. However, regulations for the operation of commercial UAVs were undefined or limited to experimental applications. Beyond research and development, recreational and hobbyist enthusiasts were the only ones with a semblance of guidance from the FAA (Ravich, 2009, p. 614-615). At the later part of this timespan, commercial applications of UAVs such as aerial photography were explicitly banned by the FAA. Not until the FAA Modernization and Reform Act of 2012 (FMRA) would the possibility of commercial drone activity regain traction. As part of FMRA, Congress mandated the FAA "to issue comprehensive regulations for the operation of UAS in the national airspace", which would include those UAVs used for commercial purposes (Mensinger, 2015, p. 406). The enactment of FMRA has been a move towards the success of commercial UAV systems, but the implementation of the act has left many stakeholders wanting. In the remainder of this thesis, I will delve into the main issues in the post-FMRA regulatory landscape and seek actionable paths forward for commercial UAV systems.

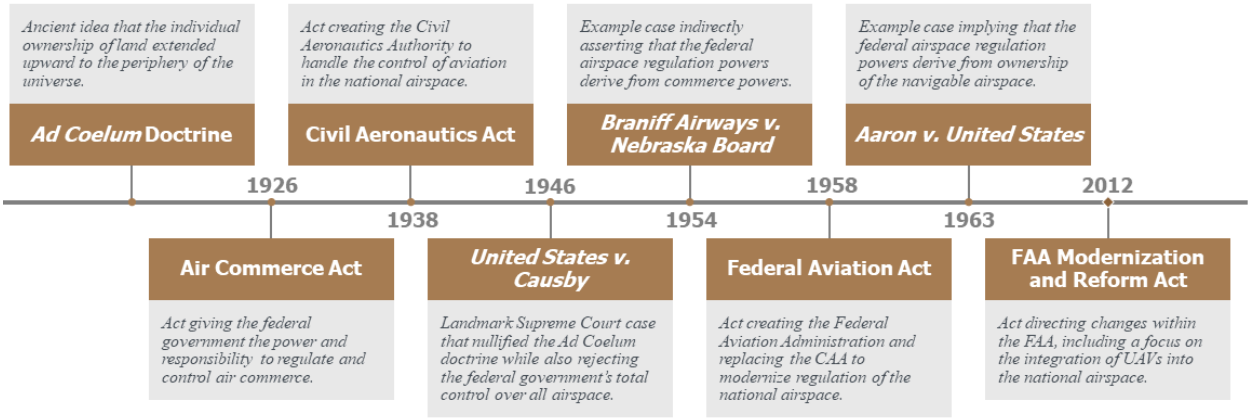


**Figure 3:** Timeline summarizing the history of acts and doctrines discussed in this thesis (Created by Author).

With a firm understanding of the history behind modern aviation regulation, one is then more equipped to approach the modern issues being faced in this field. The largest issues with the current regulatory landscape stem from the failures of the FAA to support the integration of commercial UAVs. During the decade prior to the passing of the FMRA in 2012, the commercial UAV market began to explode as a result of technological development and the relatively low cost of manufacturing many of these vehicles. Despite this growth in sales and use, the FAA's recommendations on safe operation of UAVs continued to rest upon an advisory notice for model aircraft dating back to 1981. Furthermore, the FAA set up a review process where they could issue a Certificate of Authorization for government and private civil organizations to operate UAVs in the national airspace, but it explicitly excluded commercial entities from applying (Ravich, 2009, p. 608). As the FAA's policies lagged behind the commercial UAV industry, numerous entities were being compensated for commercial activities such as aerial photography. These entities operated under the misunderstanding that following the current Model Operating Standards for recreational drones authorized them to use a recreational drone for commercial purposes (Ravich, 2009, p. 614-615). As a result, the operator of a recreational drone could easily find themselves fined by the FAA for conducting commercial drone activities, even in situations where there would have been no penalty if not for the compensation. Such a

case occurred in *Huerta v. Pirker* in 2011 where an otherwise safe and appropriate flight of a UAV was deemed to be an offense deserving of a fine because compensation had been rendered (Mensinger, 2015, p. 420-421). It is this quagmire of ancient aviation regulation that the FMRA attempted to resolve, albeit with mixed results.

While it clarified that the FAA was responsible for the full integration of commercial UAVs into the national airspace, the FMRA and FAA's response has left other questions seriously unanswered. I have selected two papers published after the enactment of the FMRA, in which each provides its own, sometimes opposing views, about ways that UAV regulation could be further improved. On one end of the argument, many Americans feel that too much about UAV technology is new, unknown, and dangerous. Much about the current regulation fails to assuage those fears about misuse or negligence by a drone's operators. While Coffman's paper primarily focuses upon issues with novice drone operators, especially in the context of recreational drones, the public sentiments that he delves into apply equally to the realm of commercial UAVs. The fear that novice pilots, and similarly novice companies, may have too much autonomy under current regulations spurs the public to push against progress towards these future systems. The possibility of danger to, or privacy concerns around, individuals as a result of negligent or even normal operation of such systems is a strong factor behind resistance towards implementation (Coffman, 2017, p. 135-136). On the other end of the argument, regulation in its current form and quantity under the FMRA is already restricting the benefits from commercial UAV systems due to a lack of clarity. Without a distinctive framework for how a commercial system should be operated, companies interested in this space must rely on acquiring complicated and unnecessary exemptions to the current regulations. Mensinger also brings up an important point that a jurisdictional element is necessary in these regulations to

arbitrate issues on a case-by-case basis. Because of the highly dynamic nature of UAVs and the multitude of situations which may require administrative involvement, a jurisdictional element would allow regulations to be far more flexible and beneficial to all parties involved (Mensinger, 2015, p. 432-436). Regardless of their differences, both papers demonstrate fundamental issues with how the FAA has handled the implementation of UAV regulation after the passing of the FMRA.

Due to the practical restrictions on the size of this thesis and the breadth of material that could be substantially covered, my analysis was limited by several factors beyond the scope of this paper. Firstly, the majority of analysis contained here are made from papers in a range of years between 2009 to 2017 and may exclude recent developments since those dates. One important omission is the impact of the FAA Reauthorization Act of 2018 upon the process of national UAV integration. Further analysis on that topic would certainly be an exciting development with important ramifications for coming years. Secondly, the impact of the public's perception of UAV technology cannot and should not be understated. As of 2014, polls indicated that the majority of Americans do not agree that allowing widespread UAVs into the national airspace will be a change for the better (Coffman, 2017, p. 139-140).

As shown throughout the history of aviation regulation, the large bureaucracy of the FAA exemplifies an organization that is plagued by the difficulties of linear innovation, including slow progress in developing regulations and failures to address significant needs of stakeholders. These issues have potential to be solved through Pacey's process of interactive innovation if the FAA would work with companies interested in commercial UAVs to solve many of the pressing issues. Only by reaching solutions for the safety, privacy, and peace of mind of the public will this system be able to overcome the fear of the unknown experienced by many Americans. By

innovating regulations in concert with relevant companies rather than against them, the FAA will be able to achieve its mandates more quickly and more effectively than ever before.

## Conclusion

Despite the past decade of progress towards the integration of UAVs into the national airspace, the enveloping sociotechnical system will require significantly more work from the FAA and other stakeholders to grow beyond its nascent state. Companies that are interested and excited about commercial UAVs must still fight for exemptions and other ways to work around the FAA's current regulatory framework, rather than within it. While the FAA should not be blamed for the entirety of the current mess surrounding the integration process, it has failed to create an actionable framework on which companies may build out their capabilities. In order to push the national conversation about the future of UAVs forward, companies will need the backing of robust regulations from the FAA. A future that is able to capitalize upon the benefits of UAV technology will only exist through active engagement of the FAA with the American public, interested companies, and Congress.

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