# Regulatory Responses to Technological Innovation in U.S. Civil Aviation

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by

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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

Federal regulatory agencies are granted authority by Congress to issue regulations in the public interest. In *National Latino Media Coalition v. Federal Communications Commission* (1978) the court ruled that, "A valid legislative rule is binding upon all persons, and on the courts, to the same extent as a congressional statute. When Congress delegates rulemaking authority to an agency, and the agency adopts legislative rules, the agency stands in the place of Congress and makes law." In the Federal Aviation Act of 1958 Congress delegated the Federal Aviation Administration (FAA) the authority to regulate civil aviation in the interests of public safety and economic growth.

Molk and Rowell's (2016) "timeline approach" to federal regulation reveals temporal patterns of regulation, deregulation, and reregulation of industries. Molk and Rowell's timeline is adaptable to the FAA's regulatory patterns following the emergence of disruptive, industry shifting-technology.

American civil aviation is a case in point, following the introduction of jet engines and again in the 21st century with the proliferation of drone technology. Competing enterprises organize to advance common regulatory agendas. Larger organized groups, such as Airlines for America (A4A), an airline trade association, or the General Aviation Manufacturers Association (GAMA), an association of manufacturers, have the means of litigation. The public, including countless semi-organized and unorganized groups, applies pressure through public criticism and political advocacy.

U.S. civil aviation industry is a large and growing enterprise. It shuttles 2.4 million people and 58,000 tons of cargo every day and accounts for over 5% of U.S Gross Domestic Product (Airlines For America, 2019). Visitors to the U.S. who arrive through U.S. airlines

expend over $300 billion annually. In the U.S., civil aircraft manufacturing contributes a positive trade balance of $59.9 billion annually (FAA, 2016). The International Air Transport Association (IATA, 2018) predicts that American commercial airlines will expand by 481 million new annual passengers by 2037, for a total of 1.3 billion. As an emerging technology, civilian drones are proliferating as well. The FAA (2018) expects the U.S. drone industry will grow 3 times larger by 2023, and Droneii (2019) forecasts the industry will be worth $11.9 billion by 2024**.**

U.S. civil aviation is safe, but not risk free. In 2017, 347 people were killed in civil aviation accidents in the United States. In 2018, that number increased by 13% to 393 people (NTSB, 2019). The FAA's responsibilities to the industry and to the public can diverge, inducing competition for favorable regulation. Too much regulation can stifle the industry, costing growth opportunity, revenue, and jobs. Such economic costs can entail public health costs. As Sullivan, Warren, and Westbrook (2000) find, every "1% increase in the unemployment rate translates into 37,000 deaths, 4,000 state mental hospital admissions, and 3,300 state prison admissions."

**Review of Research**

Molk and Rowell (2014) propose that regulation is better understood temporally, and that the regulatory environment over time can be approximated sinusoidally between periods of regulation and deregulation (fig. 1).

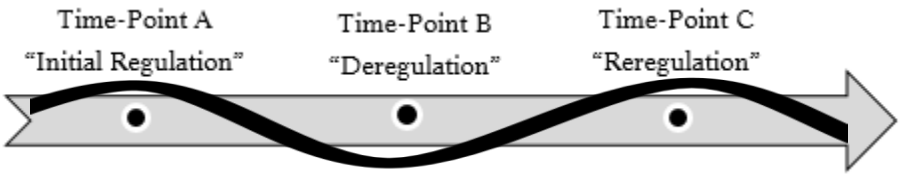


Figure 1: Molk and Rowell's Simple Regulatory Timeline (Molk and Rowell, 2014).

Present policy reflects past influences; present policy influences affect future regulatory policy. But Molk and Rowell propose an intertemporal dependence, the amplitude of the regulatory sine wave (fig. 1). Regulators do not consider intertemporal relations in regulatory policy making.

Molk and Rowell examine the regulation patterns for the environment and banking industries as examples. Hazardous waste has strict regulations for storage and it can be difficult to find an adequate location to do so. The Environmental Protection Agency's (EPA) hazardous waste disposal site decision for Yucca Mountain was made on a temporal basis of 10,000 years despite the National Academy of Science suggesting a 1,000,000-year temporal scope. The temporal scope of 10,000 years was overturned in court and the EPA was forced to look for a different site. This de-regulation and re-regulation was a costly and ineffective process. From this analysis, Molk and Rowell argue "temporal scope matters not just for estimating an action's impact on the future, but also for identifying the cause or causes of the phenomenon the regulation is designed to address."

In the banking industry, deregulation is often driven by demand and re-regulation is often driven by economic downturn. The lack of policy continuity is not from economic conditions changing, but lack of foresight in policy adaptability. Adaptability is essential for regulation of a volatile industry because of the incredibly broad needs overtime. This "lack of temporal context" and intertemporal awareness makes "the binary approach, switching back and forth between the status of regulated and not regulated, wasteful, inefficient, or politically suspect." Molk and Rowell's timeline is adaptable to regulatory patterns in civil aviation. This challenges how effective the FAA has been in regulating during critical periods of technological advancement.

**The Proliferation of the Jet Engine**

The proliferation of jet engine technology in civil aviation increased the accessibility of travel to the average American. The jet engine's implementation was a technological revolution for the industry. Airliners were able to transport passengers faster and further than ever before. "Subsequent nonstop flights between New York and San Francisco took only 5 hours-3 hours less than by the piston-engine DC-7." They were cheaper as well. "The one-way fare, including a $10 surcharge for jet service, was $115.50, or $231 round trip-almost 25 percent cheaper than flying by piston-engine airliners" (Smithsonian, 2007).

At a press conference in 1956, James Durfee, the Civil Aeronautics Board chairman stated he believed society was "on the threshold of a new air age" and that jet engines would "absolutely change travel habits of the American public" (Durfee, 1956 as cited in Kilpatrick, 1956). Durfee's prediction proved correct. Both the number of passengers and the amount of freight increased exponentially around the introduction of the jet engine (fig. 2).

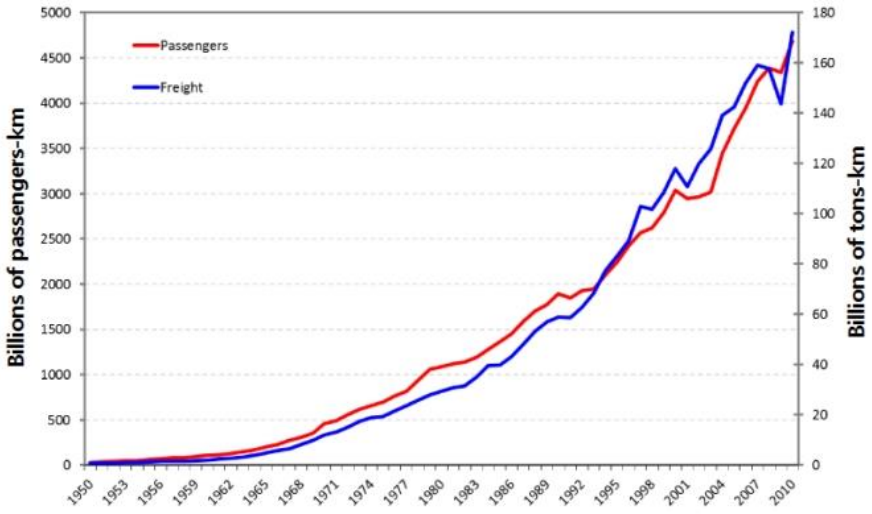


Figure 2: Analysis of Technological Innovation and Environmental Performance Improvement in Aviation Sector (Lee, Joosung & Mo, Jeonghoon, 2011).

Jet airliner companies Boeing and Douglas made this growth possible and engine company Pratt and Whitney's production drove the airline industry's expansion. International airline company Pan American was the "first major move in the airline jockeying to line up pure jet equipment" (NY Times, 1958). Many major domestic airlines like American Airlines, Delta, and United Airlines adapted to jet airliners within a year. The public would have mixed feelings toward airliners initially. In an op-ed to the NY Times (1960) Die Welt writes, "We demand safe air lanes … and airports away from crowded cities. But at the same time, we are proud that distances are shrinking… that cities are moving closer together." The exhilaration of a shrinking world outweighed the fear of accompanied dangers, and the jet airline industry prospered.

There were fewer parties involved in the jet airline industry's youth leaving each party outsized influence on the regulatory environment that governed them. In 1958 nearly every airline flying through America was a member of the Air Transport Association (ATA), a trade association of airlines. ATA, bolstered by the public desire to have faster and cheaper flights, expedited the regulation process, allowing the introduction of the jet engine to civil aviation (ATA, 1958). The civil aviation industry's regulation, following the emergence of jet airliner technology, fits the Molk and Rowell timeline.

The Federal Aviation Act of 1958 created the FAA, giving the administration the authority to regulate civil aviation in the interests of public safety and economic growth. Under public interest, the FAA would retain "control of the use of the navigable airspace of the United States and the regulations of both civil and military operations in such airspace in the interest of the safety and efficiency of both." The FAA was also authorized to "develop, modify, test, and evaluate systems, procedures, facilities, and devices, as well as define the performance characteristics thereof, to meet the needs for safe and efficient navigation and traffic control of

all civil and military aviation," in the name of public interest. This included setting airline fare and routes, limiting market competition. Any industry's involvement with the national airspace would be in association with the FAA from this act forward.

The Airline Deregulation Act of 1978 substantially deregulated U.S. civil aviation, permitting airlines to establish autonomous routes, and to price competitively. It was "an Act to amend the Federal Aviation Act of 1958, to encourage, develop, and attain an air transportation system which relies on competitive market forces to determine the quality, variety, and price of air services, and for other purposes." The Airline Deregulation Act of 1978, like the Federal Aviation Act of 1958, was only possible through combined support of the industry and the public. Fistek (1985) evaluates the Deregulation Act, finding "consumers and consumer groups supported the deregulation of the airline industry. The industry was hostile to the idea of deregulation at first, but later United Airlines and World Airlines changed their positions to support the Act."

This Act was deemed necessary by Congress because FAA regulation had limited airlines' ability to adapt and profit during the Recession of 1958. This solution was "placement of maximum reliance on competitive market forces and on actual and potential competition." In doing this, "the needed air transportation system" would be provided and "efficient and well-managed carriers to earn adequate profits and to attract capital" would be encouraged. The new regulatory environment was intended to be "responsive to the needs of the public" and would "facilitate adaption of the air transportation system to the present and future needs of the domestic and foreign commerce of the United States, the Postal Service, and the national defense." The Act's adaptability created mixed results, leading to a slow re-regulation process.

Airlines lowered fares created fare wars, causing huge revenue losses in the industry. The largest airlines were affected the most, as smaller airlines flew less frequented routes. The number of airlines between 1978 and 1985 tripled. Airlines began using hub and spoke routes to increase logistic efficiencies. Fuel waste became standard because of a combination of increased competition and route inefficiencies. Fistek (1985) felt the industry was cutthroat and safety became a secondary concern. 1985 saw the third most commercial airline deaths in history (ASN, 2020). FAA retained responsibility for safety regulations. In a 1986 investigation of FAA, a National Research Council concluded: "On balance, it is not possible for the Committee to determine the facts concerning the effectiveness and adequacy of FAA enforcement and inspection" (NRC, 1986).

Regulation has continued to increase since 1978 in response to the needs of the public, as FAA adopts safety standards to aviation innovations. In 2014 the Mercatus Center of George Mason University found that air transportation was the 6$^{th}$ most regulated industry in the United States (Ubaydli & McLaughlin, 2014). A4A, the national branch of ATA, and GAMA regard FAA safety regulations as excessive. According to A4A, many FAA regulations are "unnecessary and costly" and limit "jobs and… economic growth" (A4A, n.d.). Similarly, GAMA petitioned Congress to remove "unneeded barriers to aircraft certification" warning that inaction would "weaken our nation's aviation leadership" (GAMA, n.d.).

Molk and Rowell's timeline adapted to the FAA's regulations identifies a clear sinusoidal pattern across a broad temporal scope following the proliferation of the jet engine. The changes in regulation are driven by participants, such as ATA, A4A, GAMA, and especially the public. These regulatory decisions are made based on the current regulatory environment, lacking critical temporal and intertemporal perspectives.

**The Proliferation of Drone Technology**

The idea of remote drones has existed over a century but the technology has only recently developed to allow application to civil aviation. Despite recent interest, the adaption and proliferation of civil drones remains in its adolescent stage. The Aerospace Industries Association (AIA, 2013), an aviation trade association, is a strong advocate of drone technology, predicting a projected market of $89 billion and the addition of 100,000 new jobs in the near future. They also emphasize 80% rate of public support for domestic drone use. Teal Group (2018) forecasts non-military unmanned aircraft systems (UAS) production to "total $88.3 billion in the next decade, soaring from $4.4 billion worldwide in 2018 to $13.1 billion in 2027." AIA (2013) also predicts "commercial use will surpass the consumer drone market in 2024, becoming the largest segment of the civil market." Their expectation is that the commercial drone market will "reach $7.3 billion in 2027." This will only be possible through an intense deregulation. The civil aviation industry's regulation, following the introduction of drone technology, has begun to fit the Molk and Rowell timeline.

AIA believes current FAA regulations restrict the potential of drone use for commercial application. Current regulations include a weight limit of 55lbs., single user flight controls manipulation, maintained visual line-of-sight (VLOS) by the pilot, and exclusive daylight operation (FAA, 2019). These regulations make operation inconvenient for businesses interested in delivery service, but not impossible. Major delivery companies Amazon, Walmart, Uber, FedEx, and UPS are opposed to regulation which limit city access (Droneii, 2019). Operation from a vehicle, remote operation, and flying over people are restricted for public safety. This eliminates drones as a means of "last mile" deliveries (FAA, 2019). Last mile delivery is the

final step in the distribution process. Goods are transported from a local hub to the final destination (Datex, n.d.).

In a regulatory battle between the FAA and drone developers and users, the Commercial Drone Alliance (CDA), a trade association, contends FAA is excessively limiting the market. The Commercial Drone Alliance argues that "saying 'no' to UAS is saying 'yes' to the alternative" (West, 2018). Some consumers agree. The FAA posted a series of YouTube drone safety videos which were received poorly by drone enthusiasts. Their views are summed up succinctly by commenter Jones Drones (2019): "'Your drone should never operate' <---True FAA Feelings." FAAs State and Local Regulation of UAS Fact Sheet (FAA, 2015) solidifies the FAA's position: "Unmanned aircraft systems are aircraft subject to regulation by the FAA to ensure safety of flight, and safety of people and property on the ground."

The FAA is currently looking into deregulating the drone industry with new proposed rules. Overlap with pre-existing regulation complicates this process. The proposed changes, called Remote Identification of Unmanned Aircraft Systems (2019), state "the FAA is integrating UAS operations into the airspace of the United States through a phased, incremental, and risk-based approach." The proposed rule changes came after a review on pre-existing regulations assessed how to progress civil drone regulation. This review was commissioned by the FAA and competed by the Center for General Aviation Research in 2009. The goal of this study was to "provide a systematic regulatory review to identify top-level gaps in existing regulations to facilitate the requirements of the FAA's decision- and rulemaking processes." The review found several unresolved conflicts in the pre-existing regulations.

> "Due to the sheer number of existing regulations that clearly apply or could apply by interpretation or amendment… the rulemakers (must) either (1) go through

> every regulation and statute and appropriately amend each one to resolve any ambiguity as to whether and how it applies to UAS design, manufacture, and operation, or (2) create an entirely new subpart of 14 CFR that specifically addresses the particular issues that arise from UAS operation."

This review makes evident the significant inefficiencies that occur in the transition between regulation and deregulation.

**The Regulation of Drones in Comparison to the Regulation of Jet Engines**

The introduction of drone technology today induces competition for favorable regulation, much like the introduction of jet technology did 60 years before. Parties which drove initial civil drone regulation and subsequent deregulation mirror the behavior of the parties which did the same for civil jet airliners. As the proliferation of jet engines posed risks to the public in the late 1950s, "the introduction of UAS into the National Airspace System (NAS) represents the incorporation of new vehicles and, potentially, new classes of aircraft, which present a certain level of risk to the current NAS stakeholders" (Center for General Aviation Research, 2009).

The revenue that came from being an initial investor in jet engines forecasts revenue expected by early commercial drone use approval. This infrastructure suggests drone regulators will experience the same divergence of interests between companies seeking profit and public safety. The first company to be approved to operate drones commercially in exception to regulations has been approved. "UPS Flight Forward, Inc., a participant in the Integration Pilot Program (IPP), became the first company to receive a Standard Part 135 air carrier certificate to operate a drone aircraft" (FAA, 2019).

The most significant difference between the regulatory environment for jet airliners and for civil drones is the size of the manufacturing market. While the jet airliner manufacturing market was carefully balanced between companies Boeing and Douglas, there is a dominant company in the drone manufacturing market (fig. 3).

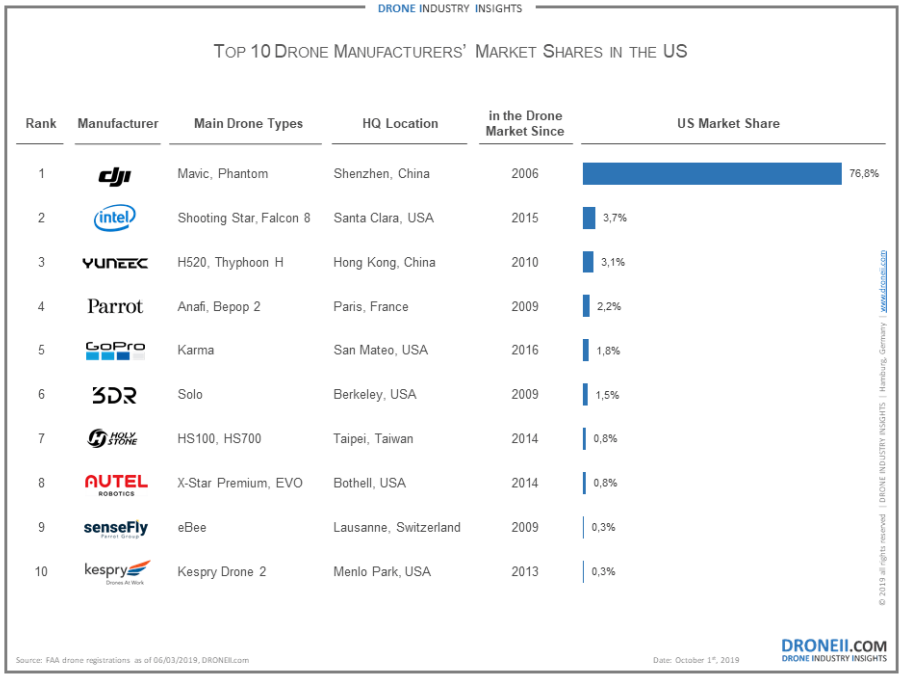


Figure 3: Drone Manufacturing Market Share by Company (Droneii, 2019).

This may affect the manufacturing regulatory environment as DJI, the primary manufacturer, has greater leverage over the drone industry than either Boeing or Douglas did over the jet airliner industry. Being a Chinese company, much of this influence is in the form of import regulation and operation of foreign drone technology. In response to tariff increases during the Trump administration, DJI increased prices and decreased availability in the U.S. (Statt & Pavic, 2019).

## Conclusion

The proliferation of the jet engine in civil aviation closely followed the regulatory patterns seen in Molk and Rowell's timeline. These patterns are beginning again with the

proliferation of drone technology. To fully align Molk and Rowell's timeline with the regulatory environments seen surrounding the jet engine and drone technology in civil aviation, it is necessary to consider the outsized influence each party involved has on the regulatory environment that governs them. This occurs when fewer parties are involved. The extreme dominance DJI has over the drone manufacturing market potentially gives the company significant influence over civil drone regulation.

Molk and Rowell assess this regulatory pattern as ineffective policy making. This assessment, in combination with lessons learned from the shifting regulatory environment seen in civil aviation surrounding jet engines, can be used to better plan the regulation of drone technology. This fundamental temporal and intertemporal analysis of disruptive, emerging technology regulation should be applied in all industries. Designing a regulatory infrastructure with deeper considerations of the past, present, and future is essential to optimizing industrial growth and public safety.

Molk and Rowell (2016) suggest a system of regulation modeling based on increasing regulation flexibility. This involves exploring options with greater outcome variance, minimizing the magnitude of regulation changes (decreasing sinusoidal amplitude), applying a constant qualitative analysis, and exploring full, up to date decision trees. The redevelopment of a regulation infrastructure is a question of temporal scope, with the benefits multiplying as the scope is increased. Implementing these ideas would be costly and time consuming initially, but could save significant time, effort, and revenue for the extended future.

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