Aerospace Technologies: How Drone Technologies and Society Play a Role in Shaping the Future

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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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STS Research Paper

Introduction

With an estimated growth in value from "8.15 billion USD in 2022 to 47.38 billion by 2029," the commercial drone market is continuing to emerge as one of the most sophisticated and advanced technological markets that will help shape the future ("Commercial Drone Market," 2022). The estimated growth in value can largely be attributed to the many different uses, drones play in society today. Additionally, the technology being developed for drones is continuing to evolve as they become more apparent in society today. With the many uses for drones, public opinion in the United States is divided, leading to society asking for different uses and advancements in drone technology. This apparent shift in society is important to understand in the analysis of the sociotechnical nature of drones and society. The analysis that is being conducted answers the following question that arises today: How does the sociotechnical nature of drone technology shape society, and vice versa? To answer this research question, technological momentum is being used to analyze information and draw conclusions regarding the research question. Additionally, a variety of different methods are being used while analyzing this question.

Methods

To understand the importance drone technologies and society play in shaping the future, the following question is being answered: How does the sociotechnical nature of drone technology shape society, and vice versa? In order to answer this research question, multiple sources are being identified as evidence for analysis. Various keywords are being used during

web searches including: drone, technology, commercial, military, autonomous, unmanned, UAS, UAV, aerospace, system, privacy, delivery, public opinion, job creation, drone registration, and drone usage. Discourse analysis is being utilized due to its ability to employ a variety of different source types, such as news articles, manufacturer advertising, videos, and other academic writing pieces. Research is organized in a thematic manner that breaks up the information into different sections. Specifically, the paper introduces the overarching topic, discusses the STS frameworks and research methods used, analyzes different pieces of information in hopes of answering the research question, and ultimately draws conclusions surrounding the analysis conducted.

Background Information

Today, drone technologies are becoming more prevalent. As of late 2022, "over 1.1 million recreational drones are registered with the Federal Aviation Administration (FAA)" ("Current Unmanned," 2022). Drones are beginning to become more consumer-friendly due to their decreasing cost and increasing ease of use. Due to drones becoming more consumer-friendly, both the commercial and military sectors have developed new and improved technologies that continue to expand the usage of drones. As there are many uses for drones, it is important to understand the public's opinion surrounding drone technologies.

Over time, numerous changes in legal and public opinion have occurred as society and drone technologies have further developed. Public opinion on the use of drones continues to widely vary. On the negative side of public opinion, some believe that drones used in a military setting bring significant moral issues, in addition to other beliefs that the commercial and private uses of drones present privacy concerns. On the other hand, other people think positively about

the use of drones for their abilities to help save lives and deliver goods, just a few of the many tasks they are used for. With the changing of public opinion, it is important to recognize that new policies are being developed and changed as time goes on. For a private user of drones, one will see that there are flight restrictions around airports, drone licenses being developed, and even new identification (ID) systems that the FAA are making manufacturers comply with (Spoors, 2021). This shift in the direction of more restrictive rules surrounding drones, is just one of the many examples that people, for and against drones, debate.

Between the late 1990's and early 2020's, a wide range of new drone technologies and uses were developed, leading to a number of milestones important for the drone industry's role in society. Most notably for the military, the Predator drone program was launched, bringing forth a new type of drone that could be used to conduct surveillance and missile strikes (Alkobi, 2019). This development would set a high standard for all manufacturers in the creation of future military drones. In 2010, consumers were finally able to purchase the "first ready-to-fly consumer drone" (Darack, 2017). As user interest increased in these consumer ready drones, an increased number of companies, such as DJI, would invest in producing more advanced consumer ready drones. Another significant milestone in the further integration of drones into society was the launch of the first drone delivery company, Wing (Elias, 2019). Wing operates unmanned drones that deliver a variety of small items. The successful approval of Wing's operations, would go on to lead the movement of other companies, such as Amazon, to keep pressing for faster approval in the drone delivery market. After understanding background information regarding the status of drone technologies, it is important to also understand the STS framework that is being used to further analyze the sociotechnical nature of drone technologies.

The Importance of Technological Momentum

When creating and using drone technologies, many different aspects of technology and society interact with one another. To analyze and show the sociotechnical nature of drone technologies, technological momentum is being used. The term "technological momentum" was created by an American historian of technology, Thomas Hughes. By definition, "technological momentum infers that social development shapes and is shaped by technology" (Hughes, 1994, p. 102). Hughes goes on to say that this idea of technological momentum is time-dependent. By time-dependence, Hughes means that during a given time period under technological momentum, technologies remain at a level that allows it to influence and be influenced by society. As time extends beyond the time period under technological momentum, Hughes believes technologies will gain "momentum" and eventually become the shaper of the environment and society surrounding it as a result of the technologies becoming more complex and advanced (Hughes, 1994, p.108).

Technological momentum is used under a variety of different circumstances by scholars other than Hughes. According to one scholar, technological momentum is seen in the race for space development when looking specifically at asteroid mining (Smith, 2021). The scholar uses technological momentum to explain how the lofty goals set forth by private industry attract many engineers from different areas, leading to an accelerated development of new technologies (Smith, 2021). This interaction between new technologies and other new engineers would help shape how organizations created solutions to reaching space. The scholar found that technological momentum was easily represented in today's aerospace realm due to the high amounts of money being spent, in addition to many outside influences, in the form of government engineers, to help further developments in technology. One interesting aspect from

this scholar, is the idea that technological momentum led to a paradigm shift as new space technologies shifted out of its time-dependent period under technological momentum. This an important aspect to understand as many advanced technologies appear to follow this shift into a bigger role in society, similarly to Hughes' idea that technology will eventually shape society. A different scholar described the presence of technological momentum in the design and operation of the power grid (Flaherty, 2022). After the creation of the power grid, driven by society's needs for increased power, the power grid itself turned into a necessity today determining many of the things society can and cannot do. With this idea in mind, the scholar suggests that technological momentum, although time-dependent, can extend greatly in its length of momentum, almost to the point where there appears to be no time-dependence. This is important as there are certain technologies that continue to both influence and be influenced by society today as compared to other technologies that move out of an intertwined influence. Another scholar discussed the existence of technological momentum during the creation of the traffic collision avoidance system (TCAS) in aircraft (Ott, 2020). As the need for new safety technologies in aircraft increased after midair collisions, TCAS was developed and in turn would lead to mostly positive effects in the airline industry. The use of technological momentum in this case is important, as it shows the influence both technology and society have on each other, but also exemplifies that through technological momentum, there are still negative consequences that are unintentionally developed. These consequences lead to a heavier influence by society. Ultimately, to address the matters brought forth by other scholars regarding technological momentum, a variety of different sources and other methods are being used throughout analyzing the sociotechnical nature of drones.

Results and Discussion

Drone technologies and society play a role in defining the future through their influence on each other. This influence, by both sides, is seen in a variety of different areas. Drone technologies and society influence each other through public policy, the different uses of drone technologies, and the American public perception of drone technologies. Within the different uses of drone technologies, the interplay between drones and society is seen in the military sector, the commercial sector, the area of public service, and the area of individual ownership. After looking into these different areas, it becomes apparent that drone technologies and society influence each other in various different ways, many of which are connected, ultimately leading to a more dominant influence by drone technologies as drone technologies gain momentum over time.

Drone Technologies and Public Policy

Public policy is an important piece to fully understanding the interplay between drone technologies and society. Many different pieces of public policy are formed as the result of the influence drones and society have on each other. Drone technologies and society's influence on each other is seen within different states across the United States. From as early as 2013, "at least 44 states have enacted laws addressing drones" (*Current Unmanned Aircraft State Law Landscape,* 2022). The significant number of states introducing laws is telling, identifying just how big the drone industry is as a whole, including popular off-the-shelf drones. With such an influx in the number of people having access to cheaper and more accessible drones, regulation for the new technology is becoming more apparent for legislatures both in the United States and

overseas. The tightening in regulations displays society's influence and impact on determining how off-the-shelf drones are operated and owned. Additionally, when looking at these state laws, large amounts of drone usage are restricted in hopes of maintaining security at different facilities and improving personal privacy. On the other hand, off-the-shelf drones are still influencing how we develop future legislation. One can expect to see that future laws, especially in areas surrounding personal privacy and infrastructure security, will contain either new information regarding drones or implement changes to previous laws in hopes of increasing restrictions as drones become more advanced. This influence in legislation is clearer when looking at the situation in the eyes of technological momentum. From the mid 2010's, off-the-shelf drones have continued to rise in popularity and in the development of new features. The continued rise will persist in influencing these new policies, and society will continue to look at the positive and negative effects these new drones have and develop new policies as a result.

Flight restrictions and increased FAA monitoring also denote the interplay between society and drone technologies. Recently, the FAA has introduced new regulations that require anyone that owns a drone to register it with the FAA, in addition to requiring drone manufacturers to implement new remote ID features for proper identification (Spoors, 2021). Similar to the previous example that mentioned new state drone laws, the introduction of regulations by the FAA denotes the impact the momentum of drone technologies in the current day has. The newer drone technologies continue to increase user capabilities and accessibility as market demand increases. With these increased features, regulators are seeing the need for more control in hopes of maintaining order in the sky. As with any technology, rapid development is leading to society influencing new designs and technologies. Drones are also influencing how one approaches different policy and regulation issues. The drones continue to bring up the issue

as to whether drone developers should be required to make changes in hopes of bettering society, or regulators in society should be requiring manufacturers to comply with their demands in hopes of creating a safer technology. The current transition period during the late 2010's for more usage of off-the-shelf drones continues to require a back-and-forth relationship with public policy as many are still figuring out the positives and negatives to this technology. As this time period rapidly accelerates into the widespread adoption of off-the-shelf drones, one will see that these advancements in drones will continue to influence how society responds and adjusts to these new developments accordingly due to the rapid integration of technologies over smaller periods of time.

Uses of Drone Technologies

The many different uses of drone technologies can help to display the interplay between both society and the sociotechnical nature of drones. Examples of back-and-forth influence are seen in the military sector, the commercial sector, the area of public service, and the area of individual ownership, to name a few. When looking at these different areas where drones are used, one will see the specific examples of influence unique to each area, in addition to the connections to the influences seen in public policy as mentioned previously. To further analyze the sociotechnical nature of drone technologies and its relationship with society, it is important to look at each of the different areas of back-and-forth influence one by one.

Uses of Drone Technologies – Military Sector

Drones' and society's influence on each other has a significant impact in the military sector. An important example in the military sector, was the introduction of the Predator program. Starting in the late 1990's, the Predator program worked in developing the next generation of military drones (Alkobi, 2019). The introduction of this program alone was influenced by society's need for more aerial capabilities that were smaller, and have strike capabilities, in addition to other reconnaissance capabilities. The military continues to spend money in hopes of creating the most advanced combat technologies possible. This increased spending heavily influences how these drones are designed. The other increasing needs for better cameras, longer flight ranges, and other strike payloads continue to influence the direction in which manufacturers develop future drone technologies. As money continued to be funneled into the Predator program and other military programs, drone technologies significantly increased in their effectiveness, helping to shape the many ways the military approaches problems today. For example, this increased effectiveness can be seen in planning and strategy. A military might need to rethink how it approaches different situations if there are drones watching them, or they might have the ability to employ different strike capabilities in hopes of eliminating the risk of human life when trying to strike a specific target. The forms of influence mentioned help to shape a product that continues to play a significant role in a military's arsenal.

Another example useful to demonstrate the importance of interplay between drones and society in the military, is the push for the implementation of artificial intelligence (AI) systems in drone technologies. The United States has continued to invest in the use of autonomous weapons systems, such as drones, despite differing opinions that believe that humans cannot fully and effectively control autonomous weapons systems (De Vynck, 2021). As society and the military

specifically call for more automated systems, a blurred line begins to appear. This influence pushes manufacturers to implement these features, but instills a sense of risk that remains. It is important to understand that the sense of risk is developed as a result of society's ever-present wants to create an efficient product. This sense of risk then influences society to adjust how it approaches different military situations, while also developing other forms of policy, as mentioned earlier, that help to implement safeguards. This example ultimately helps to define the ever-present back-and-forth influence, as defined by technological momentum, between drone technologies and the military that help shape and define the future capabilities and strategic operation of the military as the drone sector continues to rapidly develop.

Both of the examples mentioned, demonstrate the current state of rapid development in drone technologies within the military sector. Military drones are beginning to shift out of this time period due to drones becoming a mandatory piece of a military's arsenal, with the widespread acceptance that drone platforms are a necessity in any conflict. With this widespread acceptance, drones themselves will ultimately define and influence military strategy, development, and capabilities.

Uses of Drone Technologies – Commercial Sector

The commercial sector has continued to demonstrate the back-and-forth influence between society and drone technologies. An example of this back-and-forth influence is seen in the operations of the company, Wing. Wing has operated more than 250,000 drone deliveries to consumers after its drone operation entrance in 2012 (Straight, 2022). Many of the deliveries included food, health care items, and other e-commerce delivery services (Straight, 2022).

Society has long wanted different ways to receive various items without requiring individuals to leave one's house. Many of the people who use these services are willing to pay extra, creating a new market for companies to invest in. This constantly expanding market has continued to influence new services and companies as a result. In the example mentioned, society has heavily influenced Wing in investing in and testing new methods to deliver items. These new drone technologies include lightweight load capacities, safety technologies upon drone impact, and even other redundant systems, have all developed from society's and the commercial market's calls for a developing new technology (Straight, 2022). As Wing further develops its drone technologies and expands operations to other places around the world, its drone technologies' influence and will continue to influence how consumers obtain their items in the future. As drone delivery becomes a more prominent method of product delivery in the future after the current time period of implementing these technologies successfully, the nature of the drones will continue to shift in an environment in which its benefits help shape how much one is willing to spend to get something quicker or further out in remote areas.

The technological momentum between drones and society in the commercial sector can also be seen in benefiting the health of individuals. Zipline, a drone delivery company, specializes in delivering life-saving medical supplies to remote areas and hospitals around the world (McNabb, 2019). In this case, society has heavily influenced the development of Zipline and its new drone delivery technologies. Remote hospitals have long tried to find ways to receive medical supplies faster, as many times, delivery by vehicles can take hours or days. The drones developed by Zipline can do this job as soon as it is needed, delivering the supplies in a fraction of the time usually required. These hospitals also needed ways for the requested supplies to be delivered safely and reliably. Zipline's drones were developed to implement both a parachuting

system for the supplies needed and a backup system to make sure that the drones get to the hospitals. As society's influence played a role in defining Zipline's new drone service, the new drone technologies also played a hand in influencing the future of deliveries. For the future, it has become easier for remote areas to receive packages reliably, in addition to one receiving delicate packages safely and on time. As drones similar to this example continue to receive funding, the sociotechnical nature of drones continues to rapidly develop as both the new technologies and social systems that are connected to it continue to help set goals for each other's development and operations. After significant momentum due to new advancements under new funding periods, commercial drones will help define how society is able to obtain items around the world, at all times, while also increasing the interactions and dependence by society on drone technologies.

Uses of Drone Technologies – Public Service

The growing needs in the area of public service have displayed the influence by both society and drone technologies on each other. Society has always looked to influence companies to take on new tasks of designing technologies that can help everyone. As time goes on, companies respond to these requests and make new technologies that begin to come a part of daily life. These technologies in the public sector begin to influence and be influenced by society continuously until the technology continues to define how society lives. An example of a technology that has continued to develop with momentum in the public sector is the ever-improving commercially designed drone that is upgraded with sophisticated cameras for use by law enforcement. In Haywood County, North Carolina, law enforcement were able to acquire new DJI drones and employ them for life-saving measures in natural disasters and other

emergency scenarios (Williams, 2022). In this example, society has continued its influence in making drones more accessible and affordable for different people to use. Through society's influence, different life-saving measures are being developed and evolved. As the off-the-shelf drones, as seen in the example, continue to gain momentum in the market, influences by both society and the drones themselves occur. This influence by the drones is seen when the drone technologies begin to shape how different government agencies perform different operations. One is able to see that this influence by both society and drone technologies creates resulting regulation and policy that helps to make it easier for areas in public service to obtain and use these new technologies to give them advantages in their jobs. With both sides providing influence on each other, the momentum of drones continues to increase due to improved funding and support, as the current usage of drones for public services are not currently widespread in the current time period. As the notable qualities for drone usage in public service becomes more apparent throughout the current time period, drone technologies will continue to develop within the public sector, influencing the standards in which future areas in society will operate and conduct business.

Uses of Drone Technologies – Individual Ownership

Within the area of individual ownership, the influence by both drone technologies and society is seen on each other as consumers and producers play a key role. As mentioned previously, off-the-shelf drone technologies are continuing to rapidly develop and improve as producers like DJI manufacture an increasing number of products. As these drones become increasingly available for individual consumers, more consumers are purchasing them for a variety of different reasons. As of today, "over 1.1 million recreational drones are registered with

the Federal Aviation Administration," not including other drones that are not registered (*Current Unmanned Aircraft State Law Landscape,* 2022). A great deal of the number of drones in circulation is attributed to the influence these off-the-shelf drones have on consumers and society as a whole. These drones give one the ability to fly around as a hobby, in addition to taking pictures and videos, an important part in today's society in which many post pictures and videos to multiple social media platforms. Additionally, these drones play a large role in tourism as the resulting uses of the technology in tourist hubs has forced many localities to implement regulations to restrict drone usage as safety concerns arise. As the technological features improve and manufacturers create cheaper drones that are more accessible, consumers are persuaded to make the purchase. Despite the drones' influence, society also has its hand in influencing these manufacturers. As mentioned, social media and the ability to share pictures and videos has influenced drone manufacturers to implement functions for the drone that make it easy to quickly transfer media between devices (Estacio, 2019). Additionally, consumers are calling for more compact drones that allow one to bring them around wherever they go. At the moment, consumer's influence on drone technologies will continue as suggestions and future work for manufacturers. However, as time progresses out of the current period of rapid development of the off-the-shelf drones and drones become a normal product to the everyday consumer, the drone technology itself will gain enough momentum resulting in a one-sided influence in favor of the drone technologies on society as manufacturers continue to develop new features that make their product a necessity despite consumers requests.

American Public Perception and Opinion

Public perception and opinion regarding drone technologies often changes as a result of the back-and-forth influence between drones and society in the United States. In these matters, one will often see that there are two sides to the argument. One side is for the integration of drones into society, while the other is against the integration. When looking at both sides of the argument, one is able to see the interplay between drones and society.

American Public Perception and Opinion – For Drone Technologies

When it comes to the side of society that is accepting and for the uses of drones, one will see that the drone technologies themselves mostly influence society. According to a study done by Virginia Tech, roughly 89% of people surveyed would use a drone delivery service if given the option in the area (Lloyd, 2021). The development of drone delivery systems plays a role in the persuasion of the public. As drone delivery methods are proven, greater amounts of people begin to adopt themselves into the drone delivery ecosystem, making it a part of their means to obtain goods. By being able to provide additional benefits, drone technologies are able to target another area in the consumer market resulting in new adopters of the technologies.

The general nature of the drone technology also plays a role in influencing society. A study conducted in August, 2022 found that drones were able to produce 84% lower greenhouse gasses than conventional diesel delivery trucks (Kreier, 2022). This improvement in the reduction of greenhouse gases, is one of the many advances drones have made. This benefit is seen as very important to future sustainability goals in commercial industries and other people that have strong feelings about reducing one's carbon footprint. As a result of this eco-friendly

appeal, society is able to be influenced by the drones in calling for the use of drones in commercial delivery methods in place of those that typically use gas powered vehicles, in hopes of creating an environmentally friendly world.

American Public Perception and Opinion – Against Drone Technologies

Those that are against the use of drone technologies are able to influence drone technologies by large amounts. One issue in particular that provides influence, is the matter of privacy concerns. After Amazon started testing its drone delivery services in Lockeford, California, some citizens voiced their major privacy concerns in the use of cameras on these drones (O'Donovan, 2022). Other individuals went as far as to threaten to shoot down these drones if they saw them over or around their house (O'Donovan, 2022). The idea of even thinking about shooting the drones presents the big issue. Members of society want the security knowing that any drones being used, are not being used to spy on people or record sensitive data about them. These growing calls for more secure and privacy friendly drones have influenced drone manufacturers in creating more secure and advanced software. Additionally, the calls for greater privacy have influenced other policy and regulation changes that help that make the use of drones for invading personal privacy, illegal.

Another view of the argument against the use of drone technologies, presents concerns regarding the availability of jobs if drones are more widely adopted for commercial purposes. Some believe that the introduction and use of drones in place of conventional jobs can significantly reduce the number of jobs in the workforce, placing many hard-working individuals out of work. These views can influence commercial users and manufacturers of drone

technologies to address these concerns and find ways to prevent the loss of jobs. The Association for Unmanned Vehicle Systems International believes that the "optimal integration of drones in the U.S. will result in the creation of about 100,000 jobs" (Sroba, 2020). Companies that use drones are hearing the voices of many that do express concern about the loss of jobs. These companies are expressing that jobs will not entirely go away, while also demonstrating that new jobs are being created. As the new drone technologies used by the companies are becoming advanced, more jobs are being created due to the need to maintain the drones being used, in addition to improving features for these drones. Society's influence was demonstrated as commercial drone users and manufacturers within the drone market were able to show that drone technologies still provide opportunities for new positions. As seen in the example, society's influence in the public perception of drone technologies is apparent and adopted. This influence in drone technologies eventually shifts as the momentum in the drone market builds up over time, especially during the current day in which society is looking for faster and more efficient methods of delivery. As the momentum builds up after shifting out of the current day and into a time in which drones are a part of everyday life, one will see that drone technologies will have greater influence on society as the drone technologies will have previously answered society's calls, shifting more people's opinions in favor of the use of drone technologies.

Limitations / Future Work

There are limitations to the research conducted, leading to suggestions for future work regarding the interplay between drones and society. A major point of limitation to the research, is that the material covered did not include the impacts of the COVID-19 pandemic. The pandemic impacted many different industries significantly, leading to a change in society's opinions. To

address this limitation, future researchers need to analyze the drone market and the advancement of drone technologies during the pandemic's time period. Researchers also need to look into the effect of the pandemic on the areas where drone usage occurs, such as medical drone delivery, food drone delivery, and package drone delivery, as society's opinions may have changed on drone usage in these areas.

Conclusion

Drone technologies and society influence each other through a variety of different areas that include public policy, the uses of drones, and public perception. It is important to understand that technologies and society are intertwined more closely than most individuals think. In the current time period, drones are advancing and improving, as they are slowly being implemented into a wide range of areas. During this time period of slower implementation, society has the ability to influence the technology itself. Drones on the other hand continue to improve productivity and effectiveness in society, as society reacts and responds to this. Influences by both society and drone technologies help to further benefit each other, increasing the momentum needed for further drone implementation into society. After further integration into society, drone technologies begin to become the shaper of the ways society carries certain tasks in the future, as society's wants and needs can be assisted by drone technologies. Ultimately, the future is and continues to be shaped by the influence drone technologies and society have on each other.

References

Alkboi, J. (2019, January 15). *The Evolution of Drones: From Military to Hobby & Commercial*. Percepto. from https://percepto.co/the-evolution-of-dronesfrom-military-to-hobby-commerical/

Commercial Drone Market Size, Share & COVID-19 Impact Analysis, By Weight (<2 Kg, 2 Kg - 25 Kg, and 25 Kg - 150 Kg), By System (Hardware (Airframe, Propulsion System, Payloads, and Others) and Software), By Technology (Fully Autonomous, Semi-autonomous, and Remote Operated), By Application (Filming & Photography, Horticulture and Agriculture, Inspection and Maintenance, Mapping and Surveying, Surveillance & Monitoring, Delivery and Logistics, and Others), and Regional Forecast, 2022-2029. Fortune Business Insights. (2022, May). https://www.fortunebusinessinsights.com/commercial-drone-market-102171

Current Unmanned Aircraft State Law Landscape. (2022, October 26). NCSL. https://www.ncsl.org/transportation/current-unmanned-aircraft-state-law-landscape

Darack, E. (2017, May 19). *A Brief History of Quadrotors*. Smithsonian Magazine. https://www.smithsonianmag.com/air-space-magazine/brief-history-quadrotors-180963372/

De Vynck, G. (2021, July 7). *The U.S. says humans will always be in control of AI weapons. But the age of autonomous war is already here*. Washington Post. https://www.washingtonpost.com/technology/2021/07/07/ai-weapons-us-military/

Elias, J. (2019, October 18). *Alphabet's Wing launches first commercial drone delivery*. CNBC. https://www.cnbc.com/2019/10/18/alphabets-wing-launches-first-commercial-drone-delivery.html

Flaherty, J. (2022). *Synthesis of LaNiO2-XFX, an Oxyfluoride; The Technological Momentum of the Power Grid*. Charlottesville, VA: University of Virginia, School of Engineering and Applied Science, BS (Bachelor of Science), 2022. Retrieved from https://doi.org/10.18130/ggd8-kd68

FlytPath (Director). (2019, January 18). *Go Share function on the DJI Smart Controller*. https://www.youtube.com/watch?v=7kRN119IWr4

Hughes, T. P. *Technological Momentum*. (1994). Cambridge, Massachusetts. London, England. The MIT Press.

Kreier, F. (2022, August 5). *Drones bearing parcels deliver big carbon savings*. Nature. https://doi.org/10.1038/d41586-022-02101-3

Lloyd, J. (2021, April 22). *When the Drone Is in Your Backyard*. Issues in Science and Technology. https://issues.org/when-the-drone-is-in-your-backyard-nelsen-guthrie-vinsel/

McNabb, M. (2019, May 21). *How Zipline Became a $1.2 Billion Drone Company*. dronelife. https://dronelife.com/2019/05/21/how-zipline-became-a-1-2-billion-drone-company/

National Conference of State Legislatures. (2022, October 26). *Current Unmanned Aircraft State Law Landscape*. National Conference of State Legislatures. https://www.ncsl.org/transportation/current-unmanned-aircraft-state-law-

landscape#:~:text=Drones%20have%20become%20a%20part,with%20the%20Federal%20Aviation%20Administration.

O'Donovan, C. (2022, June 28). *Amazon drones are coming to town. Some locals want to shoot them*. Washington Post. https://www.washingtonpost.com/technology/2022/06/20/amazon-delivery-drones-california-cowboy-horses/

Ott, G. (2020). *Hydroponic Crop Cultivation (HCC) for Food Security in Small Island Developing States; The Human Factors Related to the Development and Incorporation of Traffic Alert and Collision Avoidance Systems (TCAS) in Commercial Aircraft*. Charlottesville, VA: University of Virginia, School of Engineering and Applied Science, BS (Bachelor of Science), 2020. Retrieved from https://doi.org/10.18130/v3-64wm-3x93

Smith, J. (2021). *A Space-Based Solution to Improve Roadway Safety and Efficiency in Virginia: Real-Time Winter Weather Data for Navigation; Technological Momentum in the Asteroid Mining Industry*. Charlottesville, VA: University of Virginia, School of Engineering and Applied Science, BS (Bachelor of Science), 2021. Retrieved from https://doi.org/10.18130/1vpr-jk80

Spoors, G. (2021, October 15). *Drone regulations: Everything you need to know*. Space.com. https://www.space.com/drone-regulations-everything-you-need-to-know

Sroba, K. (2020, November 8). *How will drones impact the business environment?* GHD. https://www.ghd.com/en/perspectives/how-will-drones-impact-the-business-environment.aspx

Straight, B. (2022, September 7). *The evolution of Wing drone delivery*. FreightWaves. https://www.freightwaves.com/news/the-evolution-of-wing-drone-delivery

Williams, R. (2022, July 15). *New drone technology will help Haywood County with life-saving efforts*. WYFF. https://www.wyff4.com/article/new-drone-technology-help-haywood-county-life-saving-efforts/40618718