The Effect of Interplay of Structures of Power on Effort Outcomes in Aerospace and their Impact on Society

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Takamitsu Suzuki

Spring 2025

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

Advisor

Dr. Joshua Earle, Department of Engineering and Society

Introduction

The Greek myth of Daedalus and his son Icarus from the 9th century BC is perhaps the oldest representation of humans' longing for flying. In the 15th century, Leonardo da Vinci came up with the concept of ornithopters whose wings flap up and down by mechanical means, primarily powered by human body movement. Breaking the unsuccessful line of thought of dynamic wings, the idea of fixed wing aircraft was first recorded by George Cayley in 1799 (Anderson, 2016). It was 1903 when the Wright brothers finally performed powered, sustained flight for the first time in history, after the tireless efforts of some great minds that came before. More recently, the subject of aerospace has seen tremendous development through World War II and the Space Race, pursuit of space as a commercial zone, and the drive for sustainable aviation. Focusing on these three recent instances, for the science and technology studies (STS) research project, the following research question is investigated throughout this paper: "how do different interplays of structures of power affect the field of aerospace and their impact on society?" In the present paper I first explore the relevant historical events and contexts, specifically for the cases of Samuel Langley, World War II, Cold War, Commercialization of Space, and Sustainable Aviation Fuel. I then analyze the cases, through the STS analysis frame of Intersecting Structures of Power. For each case, I identify the structures of power (namely government, media, public, private companies, and academia) and outline their interaction in yielding a certain outcome or impact. I then present a brief discussion on what significance this study has in today's context. Overall, I underscore in this paper the importance of understanding the interplay of structures of power in shaping aerospace advancements and their societal implications. Future work will involve deeper investigation into current events, such as commercialization of space and SAF development, to evaluate their outcomes.

STS Analysis Frames and Research Methods

In *Making Technology Masculine: Men, Women, and Modern Machines in America, 1870-1945*, Ruth Oldenziel analyzes the erasure of women and immigrants in the field of engineering through the STS analysis frame of Structures of Power. She focuses her discussion on higher education, professional organizations, and media as main structures of power and how each entity contributes toward the erasure of minority groups in engineering. She effectively untangles various cultural and social contexts in the processes where technology became framed as a symbol of modern manliness (Oldenziel, 1999). For the investigation of the proposed research question, the same STS analysis frame of Structures of Power is mainly employed, and the analysis is shaped by how each structure of power leads in yielding certain results in the field of aerospace broadly and their impact on society. I employ this analysis frame because it is beneficial in clarifying the intertwined matrices of interests of different stakeholders, and in identifying the outcomes of their interactions. Throughout the investigation, I study the influence of one structure of power over the others through qualitative assessment or comparison of quantifiable parameters such as government spending or workforce where applicable.

Samuel Langley

A little before the first successful human, powered, sustained flight by the Wright brothers in December 1903, Samuel Pierpont Langley demonstrated free (non-human) flight over 3/4 miles powered by a steam engine in 1896. Shortly after in 1898, “motivated by the Spanish-American War, the War Department, with personal backing of President McKinley himself, invited Langley to build a machine for passengers” (Anderson, 2016, 22). The invitation was sent with a fund of $50,000 (equivalent to approximately $1.8 million today). This is arguably one of the earliest instances where a government organization funded a research and development (R&D) effort in a meritocratic manner. Despite the investment, Langley was never successful in carrying out human, powered flight. In October and early December 1903, he demonstrated two attempts where his aircraft was launched from a boat on a river only to slide into the water, both times. The failure was not perceived well that the War Department cut the fund stating, "we are still far from the ultimate goal (of human flight)," and the press reported the failure with derision, which discouraged the public from human flight (Angelucci, 1973). Langley, who had not received formal education beyond high school but was merely fueled by his childhood interest in astronomy, retired from the aeronautical scene due to this ridicule.

In this case of Samuel Pierpont Langley, the government, media, and the public as three different structures of power influenced Langley's motivation and efforts; the government was in pursuit of technological advantage at the Spanish-American War that it awarded Langley with a fund. When two of his demonstrations failed after five years of the conclusion of the war, with American victory, the media reported the news with a negative overtone. This aided in forging the public's impression on Langley himself and human flight in general, which then also persuaded the Department of War to cut the funding. Its victory in the war five years before and the presence of other innovators who had been working on realizing human flight perhaps dampened the department's immediate need of the technological advantage. Here, one can see how the exchange between the three structures of power overall built a societal environment that discouraged human flight. In honor of his innovativeness, nevertheless, and the growing possibility of the United States (U.S.) war entry, what is today known as Langley Research

Center of the National Aeronautics and Space Administration (NASA) was founded in 1917 in Hampton, Virginia.

World War II

Within the few decades after Langley and the Wright brothers, the U.S. saw a growth in civil aviation sector, stimulated by the government-subsidized airmail contracts and support for aeronautics R&D (Zeitlin, 1995). Aviation was becoming an increasingly integral part of civil and government activities. In January 1939, President Franklin D. Roosevelt requested $300 million from Congress specifically for procuring aircraft for Army Air Corps. However, at the outbreak of World War II (WW2) in Europe in September 1939, the U.S. "was still making airplanes largely by hand," in the words of I. B. Holley, a historian of U.S. air force procurement (Zeitlin, 1995, 55). Aiming to massively expand the aircraft production, the President made a call for 50,000 planes within two years in 1940. Although the Army Air Corps had decided in 1938 to employ only established aircraft firms as prime contracts for the final assembly of airframes, it was aware of the disappointing experience Britain had gone through with their similar strategy in their initial phase of mass-producing aircraft. This loosened the Army Air Corps in allowing other industries such as automobile manufacturers to participate in the production scheme. As an overall result, the U.S.'s number of aircraft produced grew to the largest in the world; more than 96,000 aircraft were produced in 1944, which was about 2.4 times that of Germany, the second largest aircraft producing nation. While the number underscores the U.S.'s strength, the actual number of planes deployed was lower than the statistics. This was due to the complication in managing the manufacturing of the aircraft. In order to allow the production of uninterrupted batches of 1500 planes at a time, aircraft designs were temporarily frozen in most American aircraft factories. This was against what the Air Force wanted, continuous and urgent improvements all the time, and as such, “indispensable changes [were] introduced retrospectively in twenty special ‘modification centers’ scattered around the country” (Zeitlin, 1995, 59). This led to 25 to 50% of the total labor spent in those centers, ‘choked up,’ reducing the flow of planes to squadrons well below the number leaving the factory gates (Zeitlin, 1995).

The development surrounding aircraft during WW2 saw the involvement of government/military and aircraft/automobile companies as two main structures of power. Given the urgency of war and the potential of aircraft for reconnaissance and tactical advantage, the government led the charge in developing specialized aircraft tailored for various roles, ranging from fighters to bombers (Military Saga, 2024). Research was primarily carried out by government agencies like the National Advisory Committee for Aeronautics on aerodynamics, materials science, and propulsion systems, including the experimental results from the battle front. The advancements made in these key subjects contributed overall to combat effectiveness by being faster and more mobile and improved efficiency. While the military demanded pressing improvements on the aircraft design at all times, it was simply impractical for the manufacturers (aircraft/automobile companies) to grant that on the mass-production scale. This stance is exemplified in Henry Ford’s proposal to the Army; in June 1940, he and his associates proclaimed their ability to “produce one thousand fighter planes a day within eight months, provided that the design was frozen at the outset and changes during manufacture were tabooed” (Zeitlin, 1995, 56). As a result, aircraft production at factories was allowed to be undisturbed for as many as 1500 planes at a time, which then the military responded by setting up the modification centers across the country to implement any design changes to those aircraft that had already left the factory but were not yet delivered to the corps. The interaction between the military and aircraft manufacturers as two structures of power here can be summarized as follows: the military demands the manufacturers for mass production of aircraft whose design is constantly improved. The manufacturers are unable to respond to the demand and in return ask the military to allow temporary fixes on the design. The military approves that and instead lines up centers to retrospectively implement the design change on completed aircraft, which ends up "choking up" those centers, requiring majority of the workforce in the whole production process there and also decreasing the number of aircraft being delivered to the squadrons. This interplay, therefore, can be described as each structure of power negatively impacting in lowering each other's productivity, in terms of quantity of aircraft. However, some aspects from this scene have made lasting influence on aviation today. For example, research on aerodynamics introduced retractable landing gear and all-metal airframes, which are both standard in most commercial aircraft today. Additionally, the push by the military, the "congressional procurement policies based on price competition and the denial of intellectual property rights in new designs, together with the ideological influence of the automobile industry as a paradigm of modern manufacturing practice," set the aircraft firms up for mass production (Zeitlin, 1995, 58).

Cold War

By the end of WW2, American officials and others oversea shared a view on aviation as the critical field for the nation's superiority over other powers. Namely, the U.S. and the Union of Soviet Socialists Republics (USSR) competed over defeated Germany's booty in the form of technical facilities, equipment, and personnel in the field of aerospace, established on beliefs that:

(1) "These aviation technologies would be decisive in future warfare," and

(2) “Along with nuclear energy, they were prime symbols of a nation state’s technological and scientific prowess and, thus, of its power in international relations” (Neufeld, 2012, 49). WW2, where the government and the military power holders were the decision makers, was crucial in building this environment established upon these beliefs among the political powers. Under this environment, the launch of Sputnik, the first artificial satellite to be placed into the Earth’s orbit by the USSR in 1957, was initially perceived with very different reactions by three different structures of power within the U.S.: scientists, government officials, and the public. Scientists were elated by the news; Detlev W. Bronk, president of the U.S. National Academy of Sciences, wrote a letter to the head of the Soviet Academy of Sciences congratulating them for their “brilliant contribution to the furtherance of science.” The public, on the other hand, rather reacted with regret that “man’s greatest technological triumph since the atomic bomb” had been scored by “the controlled scientists of a despotic state” (Divine, 1993, xiv). The sense of common danger existed in the Senate; Senator Stuart Symington wrote that Sputnik was “proof of growing Communist superiority in the all-important missile field” (Divine, 1993, xv).

In this case of the Space Race during the Cold War, the launch of Sputnik by the USSR under the environment where aerospace was viewed as an indication of a nation’s prowess triggered a sense of defeat among the American public, which was reflected on the federal government’s fret, which then together pushed the scientists to overcome the USSR. In response, NASA was created the following year in 1958. In May 1961, President John F. Kennedy announced that the U.S. would land a man on the moon before the end of the decade. All told, the U.S. spent about $30 billion on the Space Race until the moon landing in 1969 (Domitrovic and Broadwater, n.d.). As will be discussed in the discussion of the commercialization of space later, NASA today plays a role in facilitating the effort to increase private accessibility to space.

Commercialization of Space

Since NASA's Apollo missions that landed humans on the Moon, the focus of space explorations shifted to space stations like Skylab and the International Space Station (ISS), fostering international collaboration. This ~50-year period saw emergence of robotic exploration, global participation from European countries as well as Russia, China, India, and Japan, and the involvement of the private sector. In May 2020, SpaceX sent humans into space as the first private company ever to do so. This in a way symbolizes the rising of space-for-space industry – where goods and services are designed to supply space-bound customers. In 2019, 95% of the estimated $366 billion in revenue earned in the space sector was from the space-for-earth economy, where goods or services produced in space are for use on earth (Weinzierl and Sarang, 2021). The space-for-space economy had been envisioned since as early as the 1970's, when research commissioned by NASA predicted the rise of a space-based economy that would supply the demands of hundreds, thousands, even millions of humans living in space. This is precisely what SpaceX and other numerous companies aim for. Redwire Space, Inc. is a manufacturing company with a motto of "in space, for space." Since they demonstrated a 3D-printing of a wrench onboard the ISS in 2014, the company has made a $74 million contract to 3D print large metal beams in space for use on NASA spacecraft. Just as SpaceX began by supplying NASA but hopes to eventually serve a much larger, private sector market, Redwire Space has also made their first step with NASA along a path toward supporting a variety of private sector manufacturing applications for which the costs of manufacturing on earth and transporting into space would be prohibitive (Weinzierl and Sarang, 2021). A NASA report from 2021 reads that one of the objectives of the NASA commercial crew program is to foster commercially supplied private human space access (Bushnell, 2021). This is well exemplified by NASA giving funds and awards to or making contracts with such private companies.

The ongoing commercialization of space involves three structures of power: the government, private companies, and academia. A few examples of the involvement of NASA (government) in awarding funds to private companies that explore space-for-space business were discussed earlier. According to a report by Bushnell from NASA Langley Research Center, this was one of NASA's objectives for the commercial crew program. Therefore, the commercialization of space could be thought of as a joint effort between the public and private sectors. An aspect in this effort that should not be unnoticed, however, is the benefit to the public as well. While the private sector is undeniably more flexible and faster in pursuing each individual's interests (majority of which fall under the greater scheme of expanded human presence in space) compared to the centralized government whose focus inevitably is on space-for-earth activities that are in public interest (such as national security, basic science, and national pride), the space-for-space activity is bound to benefit the public as well. Memory foam, for example, was originally created by NASA in 1960 to improve the safety of spacecraft cushion and is now used in various products like pillows and mattresses. In some cases, emphasis on the benefit to public is also how the private companies acquire funding from the government; on their website, Redwire Space claims that they are "the Mission Partner of Choice for Civil, Commercial, and National Security Space" (Redwire Space, 2025). In addition to the government and the private companies, academia is another structure of power. In the great endeavor of expanding human presence in space, a lot of fundamental research is required. As a result, the academia can function as a subcontractor of the public interest from time to time. In fact, the aerospace engineering capstone project the author is part of aims to design and hot-fire a hybrid rocket motor. With the recent years' increasing demand for satellite-based missions, the need for apogee kick motors has grown for the last-mile maneuver to place the satellite in the intended orbit. Hybrid motors are advantageous in this case for their throttle-ability while being lighter than the liquid counterpart. This is an embodiment of how the academia can be subject to public interest in commercialization of space, in the environment built through the collaboration of government, private companies, and the public.

Sustainable Aviation Fuel

Beside the current mainstream of space, R&D and innovations are very much present in the aviation industry as well. For example, the U.S., China, and Russia today vie for military superiority, one of whose decisive factors is the hypersonic weapons. On the less competitive end, countries are becoming progressively more conscious of the environmental effect of aviation. According to the U.S. Environmental Protection Agency, the aviation industry is responsible for approximately 2.0 to 2.5% of the global CO2 emissions, and in the U.S., the aviation sector contributes 11% of transport greenhouse gases with aviation contributing 9% of the total emissions (U.S. EPA). With such non-negligible contributions and spurred in part by international developments, the U.S. federal government has expanded its law and policy to incentivize the use of sustainable aviation fuels (SAFs) in recent years. A SAF is a fuel derived from sustainable sources like biomass, various feedstocks, municipal solid waste, used cooking oil, etc. that meets aviation technical standards. The Federal Aviation Administration describes that SAF is critical to the long-term decarbonization of aviation and is aiming for net-zero greenhouse gas emissions from aviation by 2050. To reach this goal, the Sustainable Aviation Fuel Act bill was passed down to Congress in 2021, promoting a rapid scale up in SAF production. However, the effort faces challenges including high SAF production costs and differing tax, environmental, and transportation policy goals (Congressional Research Service, 2024). Of the various types of SAF, most research has been conducted on biofuels, which has been summarized by Marty Bradley, a professor at the University of Southern California. According to Bradley, 360 billion liters of soybean biojet fuel, if the world airline fleet were to depend 100% on it. This would require 9.0 million square kilometers of land, which is equivalent to the size of Europe. For salicornia, another type of feedstock, that would be 2 to 3 million square kilometers (Bradley, 2024). As these numbers suggest, the realistic approach for the replacement of current jet fuel with SAF is to have multiple sources, and this is indeed what we see. Air Company, a SAF developer based in New York City, was awarded $65 million by the U.S. Air Force to scale up its production and install its air-to-fuel technology on site at military bases in 2023. World Energy in California has been developing a $2 billion project since 2022 to boost its SAF production by 700% by expanding its biorefinery.

Similar to the commercialization of space, the development of SAF is carried out by the government, private companies, and academia, the same three structures of power. As was outlined earlier, the push for SAF primarily originates in the government. While the government incentivizes the private sector to implement SAF, it also facilitates more fundamental research in academia. One of the research projects conducted at the Reacting Flow Laboratory at the University of Virginia involves the study of species in post-combustion products of long-chain hydrocarbons. SAF, unlike the established jet fuel, may contain exotic hydrocarbons, whose knowledge on post-combustion/pyrolysis or unburnt species still lacks. These species could have various environmental impacts, and it is therefore important to identify them. This project at the University is funded by the National Science Foundation.

Discussion

Notwithstanding the similar structures of power involved, Langley failed while Space Race saw victory. As such, it can be conjectured that the different outcomes are attributed to the different interplays of the structures of power. The significance of the current STS research project lies in its goal to identify an ideal intersection of different structures of power for the most desired outcome to be established. However, with two (commercialization of space and sustainable aviation fuel) of the five subjects under study being current events and not at the stage to evaluate the outcomes yet, regrettably, the goal is rather unattainable. Additionally, the study conducted in this research is somewhat crude with deeper investigation possible for each of the five topics. Therefore, future work will involve closer investigation of the topics and reevaluation of the recent two events.

Noticing the success of the U.S. in Space Race, its key differentiating factor in the interaction of structures of power from the other two older events is the unified interest among the bodies. All the government, public, and the scientists shared a view that exploration of space was grand and should be (or would be ideal to be) led by the U.S. Unified under this gospel, the effort was unidirectional. This can be translated to the two more recent examples. The government, private companies, and academia are essentially pursuing the same goal (of expanding human presence in space and of more sustainable aviation). In the coming years, where a greater fraction of the population has experienced education where interests of the government and private companies are reflected, the public interest can be imagined to conform. When that is realized, all the relevant structures of power will be unified under a common goal, and a similar outcome to that of Space Race can be expected.

Conclusion

Present research explores the evolution of aerospace advancements through the lens of STS, focusing on five pivotal instances: Samuel Pierpont Langley, World War II, the Space Race, commercialization of space, and the drive for sustainable aviation. It investigates how structures of power, including government, media, public, private companies, and academia influence outcomes in the aerospace field and their impact on society.

Beginning with the historical context, current study highlights humanity's long-standing aspiration for flight, tracing its progress from ancient myths to the Wright brothers' first powered flight in 1903. The study then delves into Samuel Langley's government-funded attempts at human flight, which ultimately failed due to negative media coverage and public perception, leading to funding cuts. WW2 is then studied, where the urgency of war and the potential of aircraft led to a massive government push for aircraft production. The interplay between the military and aircraft manufacturers resulted in production challenges and delays, yet significant research advancements during this period have had a lasting impact on aviation. During the Cold War, the launch of Sputnik by the USSR triggered a competitive response from the U.S., leading to the creation of NASA and the moon landing mission. The Space Race exemplifies how political and military power dynamics drove aerospace advancements. Current research also covers the commercialization of space, highlighting the collaboration between the government, private companies like SpaceX and Redwire Space, and academia. This joint effort aims to expand human presence in space while benefiting the public through technological advancements. Finally, the development of sustainable aviation fuel (SAF), driven by government incentives, private sector innovation, and academic research is addressed. SAF is critical for reducing aviation's environmental impact, with ongoing efforts to scale up production and address challenges.

Overall, the study underscores the importance of understanding the interplay of power structures in shaping aerospace advancements and their societal implications. It is also suggested that the future of aerospace could see successes in the expansion of space exploration and sustainable aviation, based on the similar interactions between the relevant structures of power as the Space Race. Future work will involve deeper investigation into current events to evaluate their outcomes.

References

Akkari, M., Thompson, R., & Dedic, C. (2024). *Quantifying in-stream gas pressure of combustion mixtures using fs/ps CARS*. 18.

Anderson, J. (2016). Chapter 1: The First Aeronautical Engineers. In *Introduction to Flight* (Eighth Edition, pp. 1–52). McGraw-Hill Education.

Angelucci, E. (1973). *Airplanes from the Dawn of Flight to the Present Day*. McGraw-Hill.

Barbet, M., Lee, J., LaGrotta, C., Cornell, R., & Burke, M. (2024). An experimental platform for semi-autonomous kinetic model refinement combining optimal experimental design, computer-controlled experiments, and optimization leads to new understanding of N2O + O. *Elsevier Inc.*, *267*. https://doi.org/10.1016/j.combustflame.2024.113562

Bracmort, K. (2024). *Sustainable Aviation Fuel (SAF): An Overview of Current Laws and Legislation Introduced in the 118th Congress* (No. IF 12847; In Focus). Congressional Research Service.

Bradley, M. (2024, July 10). *Sustainable Aviation Emissions, Contrails, Fuels (Session 4)*.

Brushnell, D. (2021). *Futures of Deep Space Exploration, Commercialization, and Colonization: The Frontiers of the Responsibly Imaginable* (No. NASA/TM-20210009988; NASA STI Program Report Series). National Aeronautics and Space Administration.

Carrigan, C., & Bardini, M. (2021). Majorism: Neoliberalism in Student Culture. *Anthropology & Education Quarterly*, *0*(0), 1–21. https://doi.org/10.1111/aeq.12361

Divine, R. (1993). *The Sputnik Challenge, Eisenhower's Response to the Soviet Satellite*. Oxford University Press, Inc.

Domitrovic, B., & Broadwater, J. (n.d.). *Was Federal Spending on the Space Race Justified?* [Debate]. Retrieved November 9, 2024, from https://billofrightsinstitute.org/activities/was-federal-spending-on-the-space-race-justified?form=MG0AV3

Elkowitz, L., Wanchek, A., Rockwell, R., Goyne, C., & Dedic, C. (2024). Dual-mode scramjet control using optical emission sensors. *Optica Publishing Group*, *63*(5), 1355–1363.

Hill, P., & Peterson, C. (n.d.). Preface. In *Mechanics and Thermodynamics of Propulsion* (Second Edition, pp. iii–vi). Addison-Wesley Publishing Company.

Innovations in Aircraft Development During WWII: A Historical Overview. (2024, March 25). *Military Saga*. https://militarysaga.com/aircraft-development-in-wwii/

Inventory of U.S. Greenhouse Gas Emissions and Sinks. (2025). [Dataset]. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

Kamimoto, T., & Kobayashi, H. (1991). Combustion Processes in Diesel Engines. *Progress in Energy and Combustion Science*, *17*, 163–189.

Korkut, E., & Fowler, L. (2021). Regulatory and Policy Analysis of Production, Development and Use of Sustainable Aviation Fuels in the United States. *Policy and Practice Reviews*, *9*. https://doi.org/10.3389/fenrg.2021.750514

Lewis, S., & Harris, W. (2001). *Sustainment Measures for Fighter Jet Engines*.

Leyva, I. (2017). The relentless pursuit of hypersonic flight. *Physics Today*, *70*(11), 30–36.

Neufeld, M. (2012). The Nazi aerospace exodus: Towards a global, transnational history. *History and Technology*, *28*(1), 49–67. https://doi.org/10.1090/07341512.2012.662338

Oldenziel, R. (1999). Introduction. In *Making Technology Masculine—Men, Women and Modern Machines in America, 1870-1945* (pp. 9–18). Amsterdam University Press.

Oldenziel, R. (1999). 2. From Elite Profession to Mass Occupation. In *Making Technology Masculine—Men, Women and Modern Machines in America, 1870-1945* (pp. 51–90). Amsterdam University Press.

Perez, J., Riccardi, M., Cohen, D., Gerwin, B., Lloyd, J., Michel, J., Rodriguez, A. T., Stelling, J., Young, L., Zhao, S., DeSpain, K., Ess, N., Guilak, J., Keogh, J., Koester, C., Landin, E., Neathery, R., Ramsey, C., Romanova, A., … Yang, E. (2022). *Titan 2 hybrid rocket engine documentation* [Technical report]. Rice University.

Redwire. (2025). *About Redwire*. https://redwirespace.com/about/

Rolls-Royce plc, T. T. P. D. (1996). 1: Basic mechanics. In *The Jet Engine* (Fifth Edition, pp. 1–10). Rolls-Royce plc.

Ruttan, V. (2006). 3 Military and Commercial Aircraft. In *Is War Necessary for Economic Growth? Military Procurement and Technology Development* (pp. 33–68).

Sutton, G., & Biblarz, O. (2017). 1. Classification. In *Rocket Propulsion Elements* (Ninth Edition, pp. 1–25). John Wiley & Sons, Inc.

Svetlichnyj, O., & Levchenko, D. (2019). Commercialization of Space Activities: Correlation of Private and Public Interest in the ePursuit of Outer Space Exploration. *Advanced Space Law*, *4*, 80–91.

Weinzierl, M., & Sarang, M. (2021, February 12). The Commercial Space Age Is Here. *Harvard Business Review*. https://hbr.org/2021/02/the-commercial-space-age-is-here

Zeitlin, J. (1995). Flexibility and Mass Production at War: Aircraft Manufacture in Britain, the United States, and Germany, 1939-1945. *Technology and Culture*, *36*(1), 46–79.