Analyzing How the Growth of the Commercial Space Industry Has Affected American Public Perception in Governmental Space Missions

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The Burgeoning Space Industry

Over the past decade the act of sending just one astronaut to space costs the National Aeronautics and Space Administration (NASA) approximately $70 million dollars; SpaceX's Starship, on the other hand, will fit approximately 100 people and is estimated to cost only approximately $2 million dollars per flight (Leone, 2013 and Wall, 2019). This large disparity in prices may be indicative of a shift from governmental entities to commercial industries being the primary players in the space industry. Thus, it is evident that the growth of the commercial space industry is one that has been steadily increasing over the past few decades and deserves a closer examination as it becomes a more fundamental presence in society. As such, it is expected to have wide reaching impacts upon society. Furthermore, this will also impact governmental space endeavors, thereby causing more subsequent effects upon society.

Research Question and Methods

The exact question outlining this report, which is examined via the Wicked Problem Framework, is "due to the current and expected growth of commercial space flight within the United States, how does one expect the public perception of how the government conducts missions related to the space industry change?" The exact method of gathering data and information is primarily through the collection of pre-existing articles and documentation relating to the aforementioned question. Specifically, the collected documents relate to the space industry and cover a broad range of topics involving it, such as but not limited to, the origins of the space industry, how it has developed over the past century, and how the commercial space

industry is expected to grow and develop. Furthermore, governmental documents are also being collected, such as certain articles relating to policies that have affected, continue to affect, and/or are expected to affect, the space industry. Studies produced and/or published by the government are also subject to inspection, assuming they are related to the space industry, commercial or not, in some manner. Lastly, any information about similar developments or studies occurring within other nations around the world are also under review. While they are not directly related to or indicative of developments in the United States, they could provide some information that could be extrapolated to lend support to certain speculations or theories; however, the majority of the collected articles are to be related to the US.

Background Information

As of this date of publication, the commercial space industry in the United States is certainly still in its infancy but has terrific potential. The space industry first began in the mid-20th century with the development and launch of the first satellites, culminating in the launch of the first artificial satellite in 1957 by the then-USSR. The space industry soon experienced a boom in both developments and achievements as the US and the USSR both used it as a vehicle to establish themselves as superior and dominant to the other; hence, the aptly suitable name of the "Space Race" was attributed to this time. As is commonly known, the US in a sense "won" the Space Race when it successfully landed man on the moon in July of 1969, earning the achievement of being the first nation in the history of humanity to put a person on another celestial body. Since then, the US landed several other people on the moon, being the only nation to do so. While the governmental side of the space industry in the US has had its ups and down, the same cannot be said about the commercial space industry. The first private launch occurred in 1983 in the form of Conestoga 1, which was the name given to a rocket funded by Space

Services, Inc. of America (SSIA) (FAA, n.d.) . However, it took until 2013 for the first commercial space satellite to be put into orbit, done so by Elon Musk's company SpaceX (Klotz, 2013). As of today, SpaceX is (arguably) the forerunner for the commercial space industry in the United States, being the ones to create the first reusable rockets and having an operational rocket capable of reaching Low-Earth Orbit (LEO). Furthermore, they have a plan to launch the humans into space for a mission in 2021, which, if successful, will mark the first-time people have been sent into space by an entity other than a governmental body (Henry, 2019).

Aside from the economic potential associated with a commercial space industry (i.e. space mining), there is a more urgent motivator that has the potential to spur its growth. Since the end of the space shuttle program in 2011, the US has had to rely upon sending astronauts to the International Space Station (ISS) via the Russian spacecraft Soyuz (Kruse, n.d.). The price has generally ranged from $70 million to $80 million per seat, with a total cost of six astronauts summing to a minimum of $420 million (CBS, 2015). Thus, if a company in the US were to be the ones capable of sending the astronauts to the ISS, they could benefit both in a monetary sense as well establishing themselves as capable and reliable.

As it stands now, there are only 4 companies in the US that are either developing or operating spacecraft capable of sending people into LEO or further; of these 4 companies, there are only 5 spacecraft in total. SpaceX has the Dragon 2 and the Starship spacecrafts (SpaceX, 2012 and Space, 2017). Blue Origin is developing the Bionic Space Vehicle (Tate, 2012). Boeing is developing the CST-100 (Boeing, 2013). And lastly, the Sierra Nevada Corporation is working on the Dream Chaser Space System (Dunbar, 2017).

STS Framework

As stated in a previous section, the STS framework that is being employed during the analysis of this research report is the Wicked Problem Framework. The Wicked Problem Framework was first drafted in Horst Rittel and Melvlin M. Webber in 1973, and is being implemented in this specific subject due to the abstract relationship between the space industry and the public's perception of it being examined. However, it should be noted that certain critiques of it state that "the wicked/tame distinction itself is built on assumptions about science rejected by specialist scholarship" (Turnbull & Hoppe, 2017). Therefore, the usage of this framework, they argue, is ill-advised and any policy research that relies upon this framework is "ill-equipped to support [it]" (Turnbull & Hoppe, 2017). The critics claim, rather, argue for the usage of some framework that treats all public policy issues as one-in-the-same as calls for a framework that provides a universal solution rather than treat each problem as "unique." However, when one looks at the vast number of policy issues and see that they differ vastly in nature, one can obviously see how such a system would provide solutions so broad so as to be barely applicable to the individual problems.

Results and Discussion

While the main discussion regarding public opinion on both the governmental and private sectors of space industry is important, a reflection of said importance should be established first. Thus, a discussion outlining the commercial space industry and its potential for growth should be had. As stated previously, the commercial space industry is one that has yet to fully realize its potential; A potential that is expected to be worth approximately $1 trillion or more by the 2040s (Foust, 2018). Upon initial viewing, this projection may seem to be shocking or "overwhelming"

to some individuals. However, once the sections and details supporting/outlining this estimation/projection are presented, one should begin to appreciate this prediction.

The first reason supporting the potential of the commercial space industry is actually due to the state of the governmental space industry. Currently in America, there are no running or operating human-oriented space launch vehicles. And this fact is applicable to both the governmental and commercial sectors of the space industry. However, since it is NASA that currently has astronauts in the ISS some ~155km above the Earth, they are the ones who face the consequences of this issue the most. Thus, there has been a recent dependency upon other entities (whether it be other governments or private companies) to get the astronauts to-and-from the ISS, lest they not go at all. Since absence is not an option, the need for sufficient launch vehicles is nigh. As of 2011, following the end of the space shuttle program, the US has depended on Russia and their launch vehicles to transport astronauts. Over the past ~9 years since this has been going on, the costs have not been significant. In the year 2017, it cost the US approximately $490 million to transport just 6 astronauts to and from the ISS (CBS, 2015). And this was not a one-time payment either, as in the years prior to 2017 it cost NASA approximately $490 million for the 6 seats (CBS, 2015). Thus, the pressing need to have capable and operational launch vehicles that operate within the US is prevalent. The government has certainly been privy to this issue, and this is one of the reasons behind the prevalent usage of issuing out grants/money/agreements/partnerships to private companies. One such agreement is the Commercial Crew Program (CCP). The CCP, according to NASA, was "formed to facilitate the development of a U.S. commercial crew space transportation capability with the goal of achieving safe, reliable and cost-effective access to and from the International Space Station and low-Earth orbit." (Heiney, 2019). So far, 6 different companies were awarded with money, while

a total 8 participated (Heiney, 2019). Of these companies, the three most awarded were Boeing, SpaceX, and Sierra Nevada Corp, each respectively granted $4.81 billion, $3.14 billion, and $363.1 million (Heiney, 2019). Furthermore, NASA also had a partnership with Lockheed Martin regarding the design of an "X-33 space shuttle" (Shi, 2016). Unfortunately, there have not been any human-contained flights from any of these companies as of yet. However, it is already evident how profitable this relationship is. As of currently, NASA is expected to pay SpaceX $150 million and Orbital STK $260 million per flight for cargo launches to the ISS between 2020 and 2024 (Berger, 2018). Thus, we can see that NASA is, and has been for decades now, incentivizing commercial companies to develop space-industry technology and that it is profitable to enter such relationships with NASA.

Furthermore, there exists other modes of generating capital in the commercial space industry rather than just entering partnerships and/or developing working relationships with NASA (though these are (usually) financially sound and help promote public interest in the companies involved). The main three commercial incentives to be discussed here are the potentials associated with space mining, space tourism, and satellites.

First up for discussion is space mining. Space mining can best be defined as the exploitation of raw materials from celestial objects in space, including and natural satellites, asteroids, and/or other minor planets. While the costs would undoubtedly be expensive, the potential yields may far exceed initial costs. For example, a 1997 study indicated that a (relatively) small asteroid with a mean diameter of only 1.6 km (~1 mi) could contain more than $20 trillion worth of metals (Asteroid Mining, n.d.). There are even current companies that are based entirely around asteroid mining, such as Planetary Resources, based in the state of

Washington (Wall, 2015). While there have not been any human landings as of yet, they have taken steps towards that direction, with two successful test launches as of 2020 (Wall, 2015).

Secondly, there is the potential revenue associated with space tourism. There are already certain companies that partake in such activities, such as World View Enterprises with the option of sending individuals to the edge of the atmosphere at the price of $75k per ticket (Mann, 2017). Furthermore, a company by the name of Space Adventures sent paying customers into space, allowing them to stay onboard the ISS for several days (Mann, 2017). Until recently, this adventure came to a halt in 2009 as the previous method of flight, the Russian Soyuz capsule, has been fully occupied since 2011 by Russian and American astronauts due to the end of the Space Shuttle program (Foust, 2020). However, it was recently announced that they have an agreement with SpaceX to send 4 tourists to a height on par with the ISS sometime between 2021 and 2022 (Foust, 2020). However, that is simply one (fairly limited) route that space tourism can offer. There also exists other options, such as orbiting the Earth, perhaps retracing the path that Apollo astronauts took during their various journeys to the Moon, and/or even seeing other celestial bodies in person. Obviously, these may seem a bit extreme, but as the 20th century proved with the evolution of man first flying to man stepping on the Moon in the course of ~50 years, these may very well be attainable in one's lifetime. And while it is true that few companies are presently involved in the space tourism industry, several have announced their interest in partaking in such activities. Such companies include SpaceX, Virgin Galactic, Blue Origin, and World View Enterprises (Mann, 2017).

Lastly, the satellite "industry" can also provide a substantial profit if properly planned. Satellite launches are one of the more common launches, especially when compared to launches

that hold humans. Thus, they are one of currently attainable feats/actions associated with the commercial space industry. As such, they can act as powerful incentives for companies interested in the space industry. As mentioned earlier, companies may be contacted by governmental entities (i.e. NASA) to launch select items if they are deemed suitable and appropriate, and satellites are no exception. Furthermore, like most commercial space industry related ventures, the market for commercial satellite launches is also growing. A 2018 report came out that projected that the market for commercial satellite launches is expected to reach $7 billion worldwide by 2024 (Writer, 2018). For comparison, in the US alone the market was slightly more than $2 billion in 2017 (Writer, 2018). Furthermore, this is more impressive when coupled with the fact that the first commercial satellite launch did not occur until 2013 (Klotz, 2013). In regards to a (semi)-concrete example, let us examine SpaceX's Starfleet. The full Starfleet network would contain approximately 12,00 satellites in LEO, providing internet all over the world once fully implemented (Sheetz, 2019). While an exact figure regarding how profitable this venture is expected to be, SpaceX's CEO Elon Musk stated: "We see this as a way for SpaceX to generate revenue that can be used to develop more and more advanced rockets and spaceships", thus indicating a high profit rate (Sheetz, 2019).

There is a common consensus among the general public that NASA's support peaked in the late 1960s/early 1970s following with the successful Apollo 11 launch and that it has been steadily decreasing ever since then. And while this may have some merit, this view is overly simplifying the complex relationship between the general public and its view on NASA. So, prior to engaging in a discussion detailing how it is expected the public to respond to the rise of the commercial space industry, it is first imperative to examine how the public has responded to NASA over the past half-century or so.

First, let us begin by examining another commonly accepted belief: During the Space Race between the US and the USSR, NASA public support was at an all-time high. However, this could not be further from the truth. According to one report, "[consistently] throughout the 1960s a majority of Americans did not believe *Apollo* was worth the cost, with the one exception to this a poll taken at the time of the *Apollo* 11 lunar landing in July 1969" (Launius, 2003). In fact, it was reported that between 45 and 60 of Americans were critical of the government in that they believed too much money was being spent on space (Launius, 2003). Thus, the data shows that the belief that Americans approved of the Apollo missions in the 1960s was not only wrong, it was actually in direct opposition with how most of the public felt. Other findings even indicate that "the public was never enthusiastic about human lunar exploration, and especially about the costs associated with it" (Launius, 2003).

Furthermore, the notion that NASA support has been declining ever since the Apollo missions is also incorrectly held by the majority of people. A certain poll shows that while the number of people who favored a government funded human trip to the Moon deceased throughout most of the 1960s, albeit with occasional spikes upwards, the opposite can be said for the subsequent years (Launius, 2003). When compared to those in favor in 1967 to those in favor in 1995, it is evident that both more people were in favor in the latter years as well as less people opposed it (Launius, 2003). This discrepancy is even more apparent when looking at the public opinion on the Space Shuttle. A study conducted between 1981 and 1996 found that the "public [had] consistently agreed that the Space Shuttle [was] a good investment"; that same could not be said about what the public felt about Apollo (Launius, 2003). Ultimately, the notion that NASA's opinion has decreased over time is unfounded. In fact, not only has public support increased since the 1960s, more than half of Americans view it in a favorable light. Over "70%

say they have a favorable impression", and this trend has been consistent from "1978 to 1999" (Launius, 2003). In fact, this number has even increased since then, as a study conducted in 2019 found that 81% of people held favorable opinions of NASA, third only to the National Park Service (86%) and the U.S. Postal Service (90%) (Pew Research Center, 2019). Furthermore, 65% of the public think that it is essential for NASA to continue involvement in space exploration, while a further 72% believe it to be essential that the US continue to be a "world leader in space exploration" (Pew Research Center, 2019).

Thus, it can be conclusively said that not only did NASA public support not peak in the 1960s, it has in fact increased since then, with a majority of Americans holding the administration in high regard. However, it is important to note that there are also critics of it. As established earlier, it is not uncommon for NASA to enter partnerships with commercial companies in order to compensate for their (limited) budget. Thus, they have entered multi-million deals with companies such as SpaceX and Boeing, some of which can be to the ire of the public. For example, following an "anomaly" reported with the testing of the Crew Dragon capsule designed to take astronauts to the ISS, some were insulted due to the lack of transparency from either NASA and SpaceX (Orlando Sentinel Editorial Board, 2019). As stated in one article, "[the] secretive aspects of Elon Musk's ventures is fine when he's spending his own money… [however], it's not fine when the public is bankrolling his efforts, as it is with SpaceX's crewed spaceflight program" (Orlando Sentinel Editorial Board, 2019). This notion is not just limited to SpaceX, as there have been similar reservations in regards to certain mishaps on Boeing's side as well. Regardless of the companies, certain critics have stated that any "problems that lead to delays in government-funded programs, even if they're done through

contracts with private companies, are something the public has a right to know about" (Orlando Sentinel Editorial Board, 2019).

Also, while not a critique, it is interesting to note that most people vastly overestimate the budget allocated to NASA. In general, NASA's budget has generally been approximately 1% of the total federal budget, peaking at around 3% between 1965 and 1967 (Launius, 2003). However, the public generally tends to overestimate how much money NASA is granted. During the 1990s, the majority of people thought it was higher, and in 1997 the average estimate was around 20%(Launius, 2003). This actually shows an interesting relationship; even though a significant portion of the population overestimated the funds available to NASA, the majority still held a high regard for it. This may indicate that if the general public was made aware of the true budget, their esteem of it may greatly increase.

Now that a more developed picture of how the public views NASA and how that has evolved over time has been established, we shall do the same for some private companies to help set the foundation for our discussion later. However, there are less readily available poll indications, similar data, and/or opinions as per the previous section, so a more unconventional metric has been applied to get a rough view. Due to a lack of concrete polls, and since I cannot conduct such surveys due to a limited time frame, the metric of analyzing public interest in the a selection of private companies is composed of reviewing their status on social media, how they are portrayed in the media, an analysis on their stocks (if public), and if they have received any acclamation due to their achievements. While I am aware that this is far from a rigorous, concrete analysis on how the public view them, this is sufficient for the scope of this report.

First up, we shall review the various modes of social media some of these companies, which are SpaceX, Boeing, Blue Origin, and Virgin Galactic, are engaged in. This is done by

reviewing four specific platforms in general, which are as follows: Instagram, Facebook, Twitter, and YouTube. In regards to Instagram, the leader of the group is SpaceX with 5.7 million followers. This is 4.3x larger than the runner-up, which is Boeing at 1.3 million followers. Following that is Virgin Galactic with 245k followers, leaving Blue Origin in last with 99.5k followers. Thus, here we can see SpaceX outclassed the other 3 by a large margin. However, in regards to Facebook, it is not as impressive. Boeing is in the lead here, with 1.49 million likes and 1.46 million people who follow the page. Then there is Virgin Galactic with 219k likes and 229k followers. Trailing close behind is SpaceX with 153k likes and 163k followers, and in last is Blue Origin with 14k likes and 18.6k followers. In regards to Twitter, SpaceX is back in the lead with 9.7 million followers. This outclasses the remaining three companies, as the runner-up, Boeing, is 17x smaller than SpaceX's following at 570k followers. Then we have Virgin Galactic at 216k followers with Blue Origin close behind at 203k. Lastly, in regards to YouTube there is no large gap unlike the previous case. Here, SpaceX is in the lead with 2.79 subscribers and a maximum view count of 25 million on one video. Following them is Boeing who has 577k subscribers and a maximum view count of 16 million. Next up is Blue Origin with 135k subs and a max view count of 5.5 million. And lastly there is Virgin Galactic with 68.7k subs and a maximum of 1.3 million views. The key takeaway here is that SpaceX appears to be the most popular, leading in 3 out of 4 of the examined social media platforms. Boeing appears to be the second most popular company, followed by Virgin Galactic and then Blue Origin, who placed last in all but one of the cases. However, it should be stated that all 4 of these companies were outclassed when looking at similar statistics for NASA. NASA holds an impressive record of 54.2 million followers on Instagram, a number 10x larger than SpaceX and 545x larger than Blue Origin. On Facebook, they have 21.9 million likes and 22.4 million followers, more than 10x

larger than Boeing who holds the lead among the companies. On Twitter they have 35.2 million followers, which corresponds to more than 3x larger than SpaceX's followers. And lastly in regards to YouTube, they have the most subscribers at 5.13 million, but only has a maximum of 12 million views, landing it in 3rd place overall, behind SpaceX and Boeing. However, as we can see they dominated in every other field. And since they hold a minimum approval rating of 70%, it may be safe to say that each of the companies may have a public approval rating that is less than that.

Next up is just a review of supplemental information which can help develop our picture a bit more. In 2010 SpaceX was awarded the "Popular Science Best of What's New award in Aviation & Space" for the Falcon 9 rocket, cited as the "The First Astronaut-Worthy Private Rocket In Orbit" (Brost, 2010). However, it is not the case that only good press is given in regards to SpaceX. They have been commonly criticized for their less-than-perfect track record, which is more so impactful due to the reliance of NASA upon using their products (Rothschild, 2018). Furthermore, their lack of communication has not improved the moods of anyone either, and on occasion has caused people to feel as if they are being secretive (Orlando Sentinel Editorial Board, 2019). In fact, they have even been accused of being "The Snake Oil Peddler Of The Twenty-First Century" by some critics (Rothschild, 2018). Thus, there is a mixture in the public in regards to their perception of SpaceX. On a different note, let us now analyze the stock pricings of some of these companies. Unfortunately, only Boeing and Virgin Galactic are public companies, thus they are the only 2 who we can analyze via stock pricings. First up is Boeing, which is currently priced at $338.30 per stock, with a maximum of $439.96 on Feb 28th, 2019 and a minimum of $2.30 on June 30th, 1982. Overall, the price averages out to $67.23. Virgin Galactic, on the other hand, is currently priced at $37.35 per stock, which happens to correspond

to its all-time maximum, while its minimum was $7.25 per stock. Overall, the price averages out to $11.20. Thus, we can see that Boeing is rated higher than Virgin Galactic in regards to stock standings. In conclusion, based on all of the information gathered above, it is evident that the public does indeed have "fond" feelings for certain companies involved in the commercial space industry, with SpaceX apparently at the head of the pack. However, it also appears that the public holds NASA in higher regard than any of these companies at the moment, which will be helpful in the discussion next section.

The quest of determining how the public will react to NASA as the growth of the commercial space industry continues in not one that has a straightforward path, and any answers that are deduced during it are certainly speculative at best. There is no way of knowing with precision how people will react in general, so to attempt to do so for a nebulous topic such as the space industry is futile. Thus, the decision to analyze this issue via the Wicked Problem Framework was made. Still, this does not allow for a specific decision to be made, but it allows for a more informed "answer" by acknowledging the complex issue at hand, and offers methods of approaching them. Thus, with that information in mind, the general answer to this research question is that the public will not, as a whole/collective, act in any specific way. However, that is not to say that the public will not change their perceptions of either NASA or the commercial space industry; in fact, to say so would be to misunderstand the public entirely. What will (most certainly) happen is as follows: certain sects of the public will continue to hold NASA in high esteem, some portions will be unaffected, while others will have diminished support of NASA. In the following sections, each of these cases are analyzed and discussed further.

Based on the gathered information that was discussed in previous sections, it is apparent that the general public holds NASA in high regard; in fact, the general public now has a higher

support of NASA than it did in the 1960s, the so-called "peak" of NASA. Following successful missions, especially those conducted for the first time (i.e. Apollo 11), public support reaches even higher heights. The only recent times that public support dwindled in a noticeable manner were following the two disasters that took the lives of the crew, which were the Columbia and Challenger disasters; even then, support was only lowered temporarily. Thus, from all of this information, it is logical to conclude that, in the event that the commercial space industry continues to grow to its projected rates, public support of NASA is not likely to be diminished to a great capacity. It is likely that the majority of people would continue to support NASA and continue to hold it in high regard. Furthermore, it is possible that some sects of the general population will begin to gain a higher respect for NASA as spaceflights and launches become more commonplace. As seen in the last section, both NASA and private companies have significant followings on social media; thus, it is possible that as more significant events occur and as more events are heralded as such spectacular events, general interest may rise. It may even be the case that the rise of the commercial space industry will improve the public's feelings on governmental ventures in space.

However, this rise or, at the very least maintenance, of support for NASA will likely only occur for a portion of the public, albeit likely a large one. There is also the case that people will have diminished views of NASA for a multitude of reasons. One such reason is one previously alluded to in earlier sections, which was the occurrence of people being critical of NASA and SpaceX when something unexpected and/or disastrous occurs without informing the public. As was the case with the "anomaly" of the Crew Dragon capsule, critics lambasted both agencies due to their lack of communication, fueled by the fact that all such missions are funded by taxpayer money (Orlando Sentinel Editorial Board, 2019). Thus, it is reasonable to expect that if

similar issues were to arise in the future, similar reactions will be held. Eventually, if these occurrences happen to a significant degree, there will undoubtedly be portions of the population that begin to have their view of NASA diminished. Furthermore, another reason that people may become less supportive of NASA is because they may perceive NASA missions as a "waste of resources", such as time and/or money. If companies began conducting missions and launches similar to that done by NASA, some people may feel as if NASA is simply wasting taxpayer money doing things that are already done by companies that do not rely upon their (taxpayers) money. However, it is difficult to gauge both how likely this is to occur and also how large of the population is expected to feel this way. Thus, it is more likely that a majority of the public will continue to support NASA, especially due to the historic public acceptance record it has held so far.

Conclusion

In conclusion, based on all of the available literature and metrics, it is likely that as the commercial space industry rises the general public will continue to support NASA and the governmental space industry. There will be possible changes in mindsets that may diminish its support in some sections of the general populace, but it is also likely that support of NASA will be elevated in other sections. Since NASA has had a minimal approval rating of ~70% over the past 60 years, it is not likely that the rating will be greatly diminished as more commercial companies get involved in the space industry. In fact, it may be the case that as the commercial space industry grows and becomes more commonplace a general interest in the space industry will increase, further raising NASA's approval rating.

Citations

Asteroid Mining. (n.d.). Retrieved from http://chview.nova.org/station/ast-mine.htm

Berger, E. (2018, April 27). NASA to pay more for less cargo delivery to the space station. Retrieved from https://arstechnica.com/science/2018/04/nasa-to-pay-more-for-less-cargo-delivery-to-the-space-station/

Boeing (2013, May 1). Boeing CST-100 Commercial Crew Transportation System. Retrieved from https://web.archive.org/web/20130501134630/http://www.boeing.com/assets/pdf/defense-space/space/ccts/docs/CCDev2%20Boeing%20CST-100%20Overview.pdf

Brost, K. (2010, November 17). Popular Science Names Falcon 9 Best of What's New in 2010. Retrieved from https://www.spacex.com/press/2012/12/19/popular-science-names-falcon-9-best-whats-new-2010

CBS (2015, August 6). NASA: Seats on Russian rockets will cost U.S. $490 million. Retrieved from https://www.cbsnews.com/news/nasa-seats-on-russian-rockets-will-cost-u-s-490-million/.

CBS News. (2015, August 6). NASA: Seats on Russian rockets will cost U.S. $490 million. Retrieved from https://www.cbsnews.com/news/nasa-seats-on-russian-rockets-will-cost-u-s-490-million/

Dunbar, B. (2017, January 31). Dream Chaser Model Drops in at NASA Dryden. Retrieved from https://www.nasa.gov/centers/dryden/Features/dream_chaser_model_drop.html

Federal Aviation Administration, Federal Aviation Administration Official Website (n.d.). Retrieved from https://www.faa.gov/about/history/milestones/media//Commercial_Space_Industry.pdf

Foust, J. (2018, July 5). A trillion-dollar space industry will require new markets. Retrieved from https://spacenews.com/a-trillion-dollar-space-industry-will-require-new-markets/

Foust, J. (2020, February 18). Space Adventures to fly tourists on Crew Dragon mission. Retrieved from https://spacenews.com/space-adventures-to-fly-tourists-on-crew-dragon-mission/

Heiney, A. (2019, August 14). Commercial Crew Program - Essentials. Retrieved from http://www.nasa.gov/content/commercial-crew-program-the-essentials

Henry, C. (2019, July 1). SpaceX targets 2021 commercial Starship launch. Retrieved from https://spacenews.com/spacex-targets-2021-commercial-starship-launch/.

Klotz, I. (2013, December 3). SpaceX Launches First Commercial Satellite Into Orbit. Retrieved from https://www.businessinsider.com/spacex-launches-first-commercial-satellite-into-orbit-2013-12

Kruse, R. (n.d.). Space Exploration Timeline. Retrieved from https://historicspacecraft.com/timeline.html.

Launius, R. D. (2003, July 12). Public opinion polls and perceptions of US human spaceflight. Retrieved from http://www.sciencedirect.com/science/article/pii/S0265964603000390

Leone, D. (2013, May 17). Commercial Space Advocates Want Bigger Role in Exploration as NASA Budget Shrinks. Retrieved from https://spacenews.com/35376commercial-space advocates-want-bigger-role-in-exploration-as-nasa-budget/.

Mann, A. (2017, July 23). So You Want to Be a Space Tourist? Here Are Your Options. Retrieved from https://www.nbcnews.com/mach/science/so-you-want-be-space-tourist-here-are-your-options-ncna784166

Orlando Sentinel Editorial Board. (2019, April 24). Public deserves less secrecy and more information about SpaceX capsule 'anomaly': Editorial. Retrieved from https://www.orlandosentinel.com/opinion/editorials/os-op-spacex-dragon-capsule-accident-secrecy-20190424-story.html

Pew Research Center. (2019, December 31). Public Expresses Favorable Views of a Number of Federal Agencies. Retrieved from https://www.people-press.org/2019/10/01/public-expresses-favorable-views-of-a-number-of-federal-agencies/

Pew Research Center. (2019, December 30). Majority of Americans Believe Space Exploration Remains Essential. Retrieved from https://www.pewresearch.org/science/2018/06/06/majority-of-americans-believe-it-is-essential-that-the-u-s-remain-a-global-leader-in-space/

Rothschild, B. (2018, January 16). Why SpaceX Is The Snake Oil Peddler Of The Twenty-First Century. Retrieved from https://thefederalist.com/2018/01/16/spacex-snake-oil-peddler-twenty-first-century/

Sheetz, M. (2019, May 16). Elon Musk says SpaceX Starlink internet satellites are key to funding his Mars vision. Retrieved from https://www.cnbc.com/2019/05/15/musk-on-starlink-internet-satellites-spacex-has-sufficient-capital.html

Shi, L. (2016, December 12). The Implications of the Privatization of Space Exploration. Retrieved from https://publicpolicy.wharton.upenn.edu/live/news/1619-the-implications-of-the-privatization-of-space

SpaceX. (2012, November 16). Falcon 9 & Dragon to Return Astronauts to Space. Retrieved from https://web.archive.org/web/20190727123855/https://www.spacex.com/falcon9

SpaceX. (2017, October 2017). Becoming a Multiplanet Species. Retrieved from https://web.archive.org/web/20171022193610/http://www.spacex.com/sites/spacex/files/making_life_multiplanetary-2017.pdf

Tate, K. (2012, April 26). Blue Origin's Secretive Space Vehicle Explained (Infographic). Retrieved from https://www.space.com/15406-blue-origin-private-spacecraft-infographic.html

Turnbull, N., & Hoppe, R. (2017, September 19). Problematizing 'wickedness': a critique of the wicked problems concept, from philosophy to practice. Retrieved from https://www.tandfonline.com/doi/full/10.1080/14494035.2018.1488796.

Wall, M. (2015, August 11). Asteroid Mining May Be a Reality by 2025. Retrieved from https://www.space.com/30213-asteroid-mining-planetary-resources-2025.html

Wall, M. (2019, November 6). SpaceX's Starship May Fly for Just $2 Million Per Mission, Elon Musk Says. Retrieved from https://www.space.com/spacex-starship-flight-passenger-cost-elon-musk.html.

Writer, S. (2018, May 31). Commercial satellite launch service market to hit $7B by 2024. Retrieved from https://www.spacetechasia.com/commercial-satellite-launch-service-market-to-hit-7b-by-2024/