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Reusable Rockets: A Shift to the Future (REVISION)

In April of 2001, California millionaire Dennis Toto left Earth for the International Space Station aboard a Russian Soyuz spacecraft. But his journey was not an act of an organization of government: he paid for it. Toto, known for being the world's first space tourist, paid $20 million for his trip; something that is not in the budget of the average person. Space tourism, even today, remains a dream that can only come true for astronauts and millionaires… for now. Because developments in reusable rocket technology are recently gaining traction, space transportation will soon become commonplace in ordinary life. The aforementioned trip is possible because aerospace organizations, like SpaceX and Blue Origin, are working to replace expendable rockets with reusable ones. This change from expendable to reusable reflects an economic and efficient consciousness in the aerospace industry. One which will promote an increase in space-related activities, improve reliability and design of spacecraft, and will affect the goals of engineering forever.

Even though this revolution has picked up traction recently, the change from expendable to reusable was greatly investigated from the late 1960s to the 1990s. The rocket that took man to the moon in 1969, the Saturn V, is an example of an expendable rocket. According to NASA, the Apollo program as a whole operated a variety of rockets, all in which involved stages. The first flights used a Saturn IB rocket. This had two stages; this means it

breaks up into two parts. “When the first stage ran out of fuel, it dropped away from the other and burned up in Earth’s atmosphere. The other Apollo flights used the Saturn V rocket, which included three stages. The entirety of Saturn V was as tall as a 36-story building” (Dunbar). According to a report by the California Space Institute, NASA planned to create a fully reusable spaceplane in the 1970s. However, when it proved to be overly expensive and complex, the design was scaled back to use reusable solid rocket boosters and an expendable external tank (California Space Institute). According to the *New York Times*, Ronald Reagan, in 1986, promised: “a new Orient Express that could, by the end of the next decade, take off from Dulles Airport and accelerate up to 25 times the speed of sound, attaining low-earth orbit or flying to Tokyo within two hours.” The first experimental version of this ship, known as the X-30, was stalled with severe technical issues and was canceled in 1994 (Chang).

It wasn’t until 2012 that efforts to create a reusable rocket launch system became successful. That year SpaceX started a flight test program with experimental vehicles, like the Grasshopper rocket. It made eight successful test flights, where it generally ‘hopped’ and hovered above the ground. This displayed progression in lifting a rocket off and landing it. Blue Origin followed closely behind with the New Shepard rocket. It reached a maximum altitude of 329,839 feet (100.5 kilometers) and a speed of Mach 3.72, or about 2,854 mph (4,593 km/h) before landing back on Earth’s surface. This mission marked the first time a suborbital booster rocket had returned from space to make a successful vertical landing. (Cofield). But it wasn’t until a few years later, according to SpaceX, that history was made. The Falcon 9 rocket, whose first stage was landed and recovered from launch in 2015, was used for a second time the same

year. Since then, SpaceX has been routinely recovering its first stages after launches ("Falcon 9").

Considering the rising popularity of this innovative technology, it is critical to question why aerospace companies are rapidly working toward developing it. The answer lies in economics. When developments in technology occur, then costs less for companies to supply the same number of products as before. Consequently, they can now sell their products at a lower price. A further result is a higher demand for that product. These economic principles are what leads businesses to realize the application of reusable rockets is beneficial. It will have a tremendous effect on space transportation as a whole. According to the *New York Times*, the amount in which they will be cheaper is yet unknown. However, Gwynne Shotwell, a SpaceX executive, suggested that reusable rockets could knock 30-50% off the usual $62 million price tag on launches (Chang). This is significant for the aerospace industry, as cheaper flights will lead to more opportunities for space-related activities. According to KAR Enterprises' Engineering Cost Office, reusable systems will be used in missions such as mass-carrying launches, in-space transportation, and cargo and manned returns. A strategic plan to take advantage of lower prices could include developing, deploying, and operating an LEO high-speed internet constellation requiring development and replenishment of multiple thousands of satellites (Webb).

Another exciting avenue for development is space tourism. According to the *New York Times*, NASA had announced that, for the first time, it will allow private citizens to fly to the International Space Station (ISS), the only place where people currently live off the planet. The cost of such adventure is about $35,000 a night, not including rocket flights to and from space

(Chang). With the development of reusable rockets, perhaps getting to the ISS will be as easy as hopping on the bus. According to *The Space Review*, by 2024, transportation from NASA's supporting infrastructure for Moon and Mars missions will be a commercial service. Several companies are developing concepts for commercial transportation between the Earth and the Moon, and potentially throughout the solar system ("The Space Review").

In addition to the economic standpoint, efficiency is a prime motive for developing reusable rocket systems. According to the National Space Society's paper on Access to Space, a re-useable, flight-proven vehicle is anticipated to be much more reliable than an expendable vehicle. This is because most problems typically appear during the first usage of a new vehicle. "The level of risk for a flight-proven vehicle can be expected to follow a risk profile typical of other re-usable vehicles as the vehicle ages, allowing for appropriate pricing modifications. (This is similar to the idea that) a car with 100,000 miles on it does not carry the same reliability expectations as a car with 10,000 miles on it." (NSS). This ability to confidently depend on spacecraft will allow organizations and companies to deploy a considerable number of launches.

The rising developments suggest there is an enormous change coming soon. According to the World Economic Forum, many advances are expected in the space sector in years to come because of the greater access. "By 2030, the next wave of (space) stations in low-Earth orbit may be public-private partnerships, with a new economic development zone fueling a range of activities from space tourism to space manufacturing. Private-sector satellites will help keep the space above Earth clear, removing space debris and helping with refueling" (Stofan).

Indeed, this is an exceptionally promising outlook for the field of science and engineering. As new sciences, technologies, and industries emerge, society must train the next generation of engineers to handle such jobs. Present engineers must adapt, and professors will have to learn the new rocket technologies and strategies so that they may properly prepare their students for the world beyond our world.

With a new industry or even a set of industries, coming this way, a whole new job market will emerge. New jobs, new tourist attractions, new technology, all of it will get money circulating in new places. Every person will be affected by the advances that reusable rockets will bring to the world.

Even though the shift to reusable rockets is still in progress, it reflects a conscious awareness of the benefits of an economical and efficient approach to technological design. Since the beginning of the space race, reusability has been the goal. But alas, due to technical issues, lack of time, and a budget, it couldn't be attained. But even after the early 1990s, when the X-30 was designed and disregarded, reusability was not abandoned. This shows persistence. It shows drive. It shows a cut-throat motivation to do the impossible. And that is exactly what is seen today in the private sector of aerospace: Blue Origin, SpaceX, and Virgin Galactic, to name a few. Blue Origin is focused on making space more accessible so that future generations may harvest space’s resources easier. SpaceX is planning on putting people on Mars by 2024 and starting a colony. Virgin Galactic is proudly naming themselves the first commercial spaceline on Earth. Every one of these companies is scrambling to make reusable vehicles. They are fully aware of the benefits, and through patience and persistence, success is inching closer and closer.

In conclusion, the reusability of rockets is the pathway to a new era of space. Compared to previously used expendable rockets, it will lower the costs of launches and improve the reliability of space travel. It also shows there is a desire to get to space: something that will affect the world as a whole. Missions to Mars, space tourism, colonization, even faster internet, all will become more attainable or even more realistic, with more efficient and economic models of space transportation. This is something many people should be excited about. But not Dennis Toto. He should've waited for another couple of decades, as his space adventure would be significantly cheaper.

Works Cited

California Space Institute. Report on the Utilization of the External Tanks of the Space Transportation System: A Workshop Held at the University of California, San Diego, La Jolla, California, August 23-27, 1982. California Space Institute, 1983, https://books.google.com/books?id=58wZAQAAIAAJ. Accessed 30 Oct. 2019.

Chang, Kenneth. '25 Years Ago, NASA Envisioned Its Own "Orient Express" - *The New York Times*'. *The New York Times*, Web, 20 Oct. 2014, https://www.nytimes.com/2014/10/21/science/25-years-ago-nasa-envisioned-its-own-orient-express.html. Accessed 28 Oct. 2019.

Recycled Rockets Could Drop Costs, Speed Space Travel. *The New York Times*, 30 Mar. 2017. NYTimes.com, https://www.nytimes.com/2017/03/30/science/space-x-reuseable-rockets-launch.html. Accessed 29 Oct. 2019.

Want to Buy a Ticket to the Space Station? NASA Says Soon You Can. *The New York Times*, 7 June 2019. NYTimes.com, https://www.nytimes.com/2019/06/07/science/space-station-nasa.html. Accessed 29 Oct. 2019.

Cofield, Calla. *Blue Origin Makes Historic Reusable Rocket Landing in Epic Test Flight*. *Space.com*, Web, 24 Nov. 2015, https://www.space.com/31202-blue-origin-historic-private-rocket-landing.html. Accessed 28 Oct. 2019.

Dunbar, Brain. *What Was the Apollo Program?*, *NASA*. Web, https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-was-apollo-program-58.html. Accessed 28 Oct. 2019.

'Falcon 9'. *SpaceX*, Web, https://www.spacex.com/falcon9. Accessed 28 Oct. 2019.

NSS-Position-Paper-Paradigm-Shift-in-Access-to-Space-2017.Pdf. https://space.nss.org/media/NSS-Position-Paper-Paradigm-Shift-in-Access-to-Space-2017.pdf. Accessed 29 Oct. 2019.

Stofan, Ellen. *What Will 2030's New Space Economy Look Like?, World Economic Forum, Web,* 12 June 2017, https://www.weforum.org/agenda/2017/06/countdown-what-will-2030s-new-space-economy-look-like/. Accessed 30 Oct. 2019.

"The Space Review: The Future of Commercial Space Transportation". Web, http://www.thespacereview.com/article/3776/1. Accessed 29 Oct. 2019.

Webb, Richard. *Is It Worth It? The Economics of Reusable Space Transportation*. KAR Enterprises, Oct. 2016, https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20160013370.pdf. Accessed 30 Oct. 2019.