Διαστημικός Τουρισμός
"*De la Terre à la Lune*"

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Περίληψη

Έχετε σκεφτεί ποτέ να ταξιδέψετε πέρα από τη Γη; Να εξερευνήσετε το Διάστημα με τα μάτια ενός ταξιδιώτη; Την ευκαιρία αυτή σας προσφέρει ο τομέας του Διαστημικού Τουρισμού ο οποίος θεωρείται ο πλέον ανερχόμενος στο χώρο της Διαστημικής βιομηχανίας. Η έρευνα αυτή στοχεύει στην ενημέρωση και πληροφόρηση των συνέδρων για το ζήτημα αυτής της πρωτοεμφανιζόμενης μορφής τουρισμού. Μέχρι τον Αύγουστο του 2022, με ποικίλες δυνατότητες "διαδρομών" , 49 άτομα υψηλής οικονομικής επιφάνειας επισκέφθηκαν τον εξωγήινο χώρο. Οι δημοφιλέστεροι τρόποι να ταξιδέψεις είναι: Πλήρης τροχιά (Orbital) και Μερική τροχιά (Suborbital). Ενδεχομένως να ακούγονται ομόηχα όμως περικλείονται διαφοροποιήσεις που αφορούν τη ταχύτητα του ταξιδιού, τη θέα που θα απολαμβάνει κάποιος κατά την εκτόξευση και τη διαμονή καθώς και τη διάρκεια. Γίνεται αντιληπτό ότι η κοστολόγηση των εισιτήριων εξαρτάται είτε από το κόστος κατασκευής του πυραύλου είτε ανάλογα με το βάρος/ $ (payload) . Στο χώρο του πυραυλικού design η πρωταρχική σκέψη όλων εστιάζεται στο υψηλό κόστος χρησιμοποίησης αυτών. Ωστόσο, δεν πρέπει να παραβλέπεται και η τακτική επαναχρησιμοποίησης τους η οποία αν και φαίνεται δαπανηρή (ως προς το R&D), μακροπρόθεσμα οδηγεί σε ραγδαία ελαχιστοποίηση των εξόδων.

Ας μην ξεχνάμε ότι για να υλοποιηθεί οποιοδήποτε Διαστημικό σχέδιο είναι καθοριστική η σύμπραξη τόσο του Δημοσίου τομέα (ο οποίος υπήρξε και πρωταρχικός χρηματοδότης) όσο και του Ιδιωτικού (ο μόνος δραστηριοποιημένος τομέας αυτή τη στιγμή). Μάλιστα, στον Ιδιωτικό επικρατεί άκρατος ανταγωνισμός που αποδίδεται στο ενδεχόμενο υψηλού ποσοστού κέρδους για κάθε εταιρεία την οποία ενδιαφέρουν οι προοπτικές ανάπτυξης και καθιέρωσης στην αγορά. Αυτό οφείλεται επίσης και στο ότι οι σύγχρονές τάσεις της παγκόσμιας οικονομίας είναι όλες στραμμένες στο Διάστημα. Έτσι, αποδίδονται και τα υψηλά ποσά που δαπανώνται στην Έρευνα και Ανάπτυξη (R&D). Όσον αφορά τη ζήτηση, οι επιχειρηματίες του κλάδου πιστεύουν ότι υπάρχει ένα ικανό μερίδιο ανθρώπων που εκδηλώνουν ενδιαφέρον για το Διαστημικό ταξίδι γεγονός που αποδεικνύεται από τη συνεχή άνοδο του αριθμού των ανθρώπων που το αναζητούν.

Κάθε ταξίδι είναι μια πρόκληση για αναζήτηση καινούριων κόσμων και εμπειριών. Σίγουρα όλοι μας γνωρίζουμε ότι το Διάστημα κρύβει πολλά από αυτά και προσδοκά από τον καθένα μας να του ανοίξει τη πύλη του. Φυσικά υπάρχουν δυσκολίες, και ίσως ανακύψουν πολύ πιο περίπλοκες στη πορεία, αλλά πρέπει πάντα να τις προσεγγίζουμε με μια διαφορετική οπτική. Γιατί το όνειρο του παρόντος είναι η πραγματικότητα του αύριο…

***Λέξεις-κλειδιά**: Οικονομικά, Τουρισμός, Διαστημική, Επιχειρηματικότητα*

1. Introduction

It was 1865, when Jules Verne published the book "*From Earth to the Moon*", with the original title "*De la Terre à la Lune*". Jules Verne described with a lot of imagination along with humor something that was practically impossible for the given time period, due to the fact that the Space science had not been developed. And what was that? The first manned flight to Space! For this reason, we can agree that Jules Verne spoke prophetically as hundreds of years later the Public and Private sector of the Space Industry managed to transform his book from Science Fiction into Reality… From Apollo to New Horizons and from Yuri Gagarin to Jeff Bezos, we can say with certainty that Man has made universe his secondary home.

However, this wasn't the first time the Man questioned himself how he can find himself in space. The sky, the universe, the space are concepts that always picked people's interest from ancient times until nowadays…

2. Chronology

Starting from Ancient Greeks and their myths, we need to highlight the well-known story of Icarus, who tried to travel to Space with feathers made of wax. Unfortunately, the consequences of his action were tragical. Years passed and science has shown that there are completely different ways to pursue such a thing.

Greek Astronomers like Aristarchus of Samos and Hipparchus formed the basic principles of Astronomy and Space industry. Centuries later, treatises like "Investigations *of Outer Space by Rocket Devices*" of Konstantin E. Tsiolkovsky attested the fact that we have entered a new era of Aerospace. Then, Robert Goddard proved that flying could be done with the help of missiles. In March 1926, the first rocket in the world history was launched developing a speed of 94 km/h. In Germany, Hermann Oberth and his student Johannes Winkler carried out a study on the speed of missiles. Winkler managed to launch the first European missile, on March 1931.

All these inventions were aimed at the good of mankind, but even so some countries adopted them for military purposes. When the World War II came to an end, America and Soviet Union tried to improve the technology of the missiles in order to use them for both military and peaceful purposes. It was the right time for Soviet Union to finally make the first move and be the pioneer of Space Exploration. By launching Sputnik 1, on October 4th 1957, the decisive step was made and the first artificial satellite was launched. A year later, it was America's time to "get to Space". Their satellite Explorer 1 was launched which signified the start of Space Race.

On the 12th of April 1961, at 09:07΄ Russian local time, Yuri Gagarin became the first human in Space (outside earthly atmosphere) with Vostok 1. A trip which lasted 108 minutes, completed 1 orbit around our planet. As he said before the launch: "Am I happy to be starting on a space flight? Of course, I am. In all times and all eras man's greatest joy has been to take part in new discoveries, Poyekhali! (Let's go!)". Meanwhile, on 5th of May, Alan Shephard followed the Gagarin's steps and had a suborbital flight reaching 186 km.

However, Verne's story came to fruition by Apollo 11. On the 21st of July 1969, Nil Armstrong became the first human who stepped on the surface of the Moon. "One small step for a man, one giant leap for mankind" are the words that till this day can make any human feel proud. And that was just the beginning…

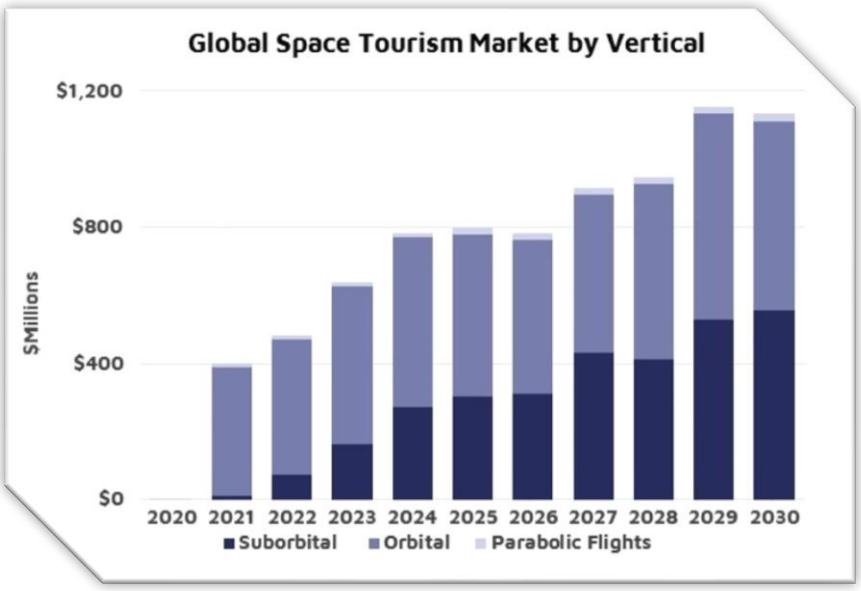
3. Space Tourism

3.1 Definition

Space Tourism is a special segment of aviation industry which aims at Space Travel for recreational purposes. It can be categorized in Orbital, Suborbital and Lunar Space Tourism. Since 2001, only 28 people have taken the role of a Space Traveler.

This shows that Human Race draws closer to achieving its goals by taking advantage of its capabilities. Which are the goals? To learn and explore our surroundings. Followed by the movement of Research and Development in the Space Technology sector, Space Tourism is becoming a powerful commercial pillar of the Space Industry. (Ultra-)High Net Worth Individuals who see the prospects of getting into such activity, are already making moves to become members of this global innovative business. The triggering factor of the Space Tourism investment was the joint success of Roscosmos and Space Adventures. In the early 21st century, both Space Adventures and Roscosmos achieved a short flight to the International Space Station (ISS). More specifically, in 28th April 2001, Dennis Tito "took a trip to Space" for 8 days. It is worth noting that he was the first to invest his own money, flew with Soyuz TM-32 and completed the mission "ISS EP-1", the cost of the ticket amounted to $20 million. This and other missions consolidated this massive interest among the investors, which also ultimately led to the rise of companies like the Virgin Galactic, SpaceX etc.

With current data, enterprises that focus on Space Tourism are consistently progressing towards achieving their ambitious goals and today's technology is making it possible to shape commercial plans. According to NSR's latest Space Tourism forecast, this industry will generate revenues worth $7.9 billion by the end of the decade.



Graph 1. Estimation for World's Space Tourism revenues (2020-2030)
***Source**: NSR (2021)*

It is on the verge to develop into the strongest commercial Space market verticals by 2031. The significant rise in demand for Mars missions is also paving way for private activities to solidify their presence in the market for the next decades. Simultaneously, this movement is helping several Space and Satellite companies to participate and innovate on new markets. As expected, several challenges have emerged against the execution of these ambitious plans. Even so, in the upcoming years, it is readily apparent that the Space Tourism market will also present multiple opportunities for investors aiming not only to the travel part but also to construct habitats on the Moon and Mars.

Moreover, this branch of Space Market can also be an opportunity for several companies and agencies to increase their investment outlook in the Space technology segment. For example, the rise of SpaceX's Dragon, a reusable spacecraft, has made USA less dependent on the Soyuz for the ISS activities. Therefore, Russia's developing interest in Space Tourism can be considered as a strategic move to revamp its launch business. The future of Space Tourism looks promising, yet the execution of the plans laid out for actual launch by several agencies and companies, will shape the future investment landscape of this sector. Russia reached the point in which they halted orbital space tourism in 2010 due to the increase in the International Space Station crew size, using the seats for expedition crews that would previously have been

sold to paying spaceflight participants. Orbital Tourism flights were set to resume in 2015 but the planned flight was postponed. Russian space "customers" eventually managed to go to space with the launch of Soyuz MS-20 in 2021. NASA announced that, in 2020 the organization aims to start allowing private astronauts to go on the ISS, with the use of the SpaceX Crew Dragon spacecraft which is planned to be priced at $ 35.000 per day for 1 astronaut and $ 50 million for the ride to Space and back.

"The market is driven by suborbital tourism, which will accelerate once Virgin Galactic and Blue Origin launches take place in late 2021. While the high-visibility orbital space tourism market, where movie stars and wealthy individuals are paying over $55 million dollars for a ride, will rake in the highest tally cumulatively" as NSR stated.

There are many orbits we can "catch" in order for us to enjoy the Earth's view through our spaceship window. But are they so different that it is worth pointing out?

3.2 Types of Orbits

→ Suborbital

Suborbital are flights in which the spacecraft launches from Earth and travels to outer space, without completing an orbital revolvement. To be considered a suborbital flight the spacecraft should travel higher than *Karman* Line. *Karman* Line is the geometrical location of points 100 kilometers above the surface of the sea. It's a safe and reliable option with plethora of investments running this time.

→ Orbital

Orbital, on the other hand, are flights in which the spacecraft travels with a speed of 7,8 km/sec. This is the required speed in order to remain in space for at least 1 orbit around the Earth. It might be in its infancy stage but it has potential to reach the Suborbital's popularity level and overcome it.

There are, of course, other types of "flights" following completely different orbits that can be executed by humans. Despite of them being achieved, only the 2 mentioned above are going to be comprehended in this report. Nevertheless, a brief reference is given below.

→ Lunar

Or otherwise, Selenocentric, is the orbit in which an object rotates around Earth's natural satellite. It can be divided into Lunar orbit insertion (this was undertaken by spacecrafts to complete Apollo program) and Low lunar orbit. To take on this orbit, the spaceship must be 62 miles above the Moon surface. It is crucial for humans to continue benefiting from that kind of action because we get to observe the Moon from a new angle. Per contra, as far as the Low orbit

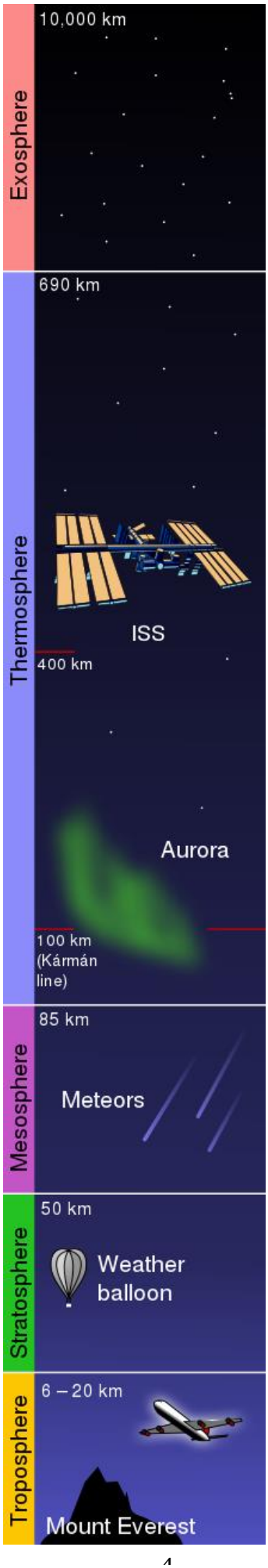


Figure 1. Earth's atmosphere levels (with the Karman line standing out)

is concerned, there are also financial-business risks due to strong gravitational forces. Any Space company may have to cope with difficult situations such as losing a rocket due to a crash. This means: Financial consequences (loss of hyper-expensive equipment) but also loss of lives (in case the mission is manned). On account of this situation, life safety gets involved.

→ **Parabolic Flights**

It's the most alike thing to Space flights that someone can find by the reason of you travelling for several seconds without the feeling of gravity. The pilot performs 31 specific maneuvers at specific places which make people feel like they are outside Earth's atmosphere. This weightless situation lasts for 22 seconds.

The altitude of the aircraft right before it carries out a parabolic maneuver is 6000m above surface. When the airbus noses up for 20 seconds, it gets into the "gravity free" phase and then it goes back down.

The revenues of the Parabolic flight sector will reach 170 million $ by 2031 while the number of passengers will be approximately 30 thousand people. It is worth pointing out that the estimation of the revenue contribution will be lower compared to Orbital and Suborbital markets. Also, the R & D costs aren't in the top levels but one thing that keeps Parabolic "activities" in the business is the interest that consumers show towards them.

3.3 Differences between Orbital & Suborbital

These two terms are frequently used in the Spaceflight industry. They sound alike but the meanings behind them hide massive differences. As Space Ventures Investors marks: "If Suborbital is the flight to your destination, then Orbital will be the hotel or resort!". The market right now is driven by Suborbital flights and this is happening thanks to Virgin Galactic and Blue Origin 's activities. But when commercial launches to ISS took place in May 2020, it pointed that Orbital flights will take the lead!

The first big difference is the height above Earth. Suborbital flights are programmed to reach an altitude of 80-100km (Mesosphere). The shuttle barely touches the edge of space whereas the Orbital ones are meant to travel/fly in Space. They reach 400km and they pass Thermosphere which allows them to get out of Earth's layers of atmosphere.

The second difference is the speed. As far as Suborbital is concerned, the engine burns for about a minute. It reaches the top of the route and then it falls back down to Earth. On the other hand, the rocket accelerates for 9 minutes till it reaches the speed of 28000km/h. That is exactly the aim because you need to travel fast enough to continue to orbit around the planet. Orbital rocket's speed is obviously higher than the suborbital's, although the speed you need to have there is higher than a commercial's plane. More specifically, orbital velocity is the speed that an object needs to maintain in order to keep itself to orbit. Accordingly, this is what makes them so expensive!

Also, the view is really important. During Suborbital, you have a few minutes to look down and see the sight of our planet (but basically there is nothing more to see than the place you took off at the first place). Orbital gives you the chance to revel in the view from many different angles as you go around. The view is always changing as you circle around. You get to enjoy the sight of oceans, weathers systems, aurora, the Moon as well as sunsets and sunrises.

Last but not least, it is the duration. The time period of an average suborbital "trip" lasts a few minutes. But in the case of an orbital, the flight can take from a few days up to 2 weeks.

3.3.1 Costs

The differences between Orbital and Suborbital Space Tourism are obvious. As expected, they also have consequences on their financial aspects. The cost part has been an obsession for many investors either they are already existing in the Space Industry or they desire to enter it. And this is explained by the insanely high price of Space transportation. For many years, the cost to orbit has been considered the biggest impediment especially as far as Space Shuttles are concerned. Civil Space agencies and entrepreneurs may have different plans and targets but one of them is common. The reduction of the transporting payload costs. The cost to get to an orbit differs not only by the distance but also by the weight of the element that is being transported and also by the "means of transport".

There isn't only one way to approach or calculate the cost to get into an orbit.

The first way to study the cost of Space transportation is analyzing the cost of the launch vehicles.

It is convenient when you are interested in the technical part but it can mess up your research. And this is because rockets can differ from one another. Not only in terms of technical characteristics but also, due to the production country, costing comparison is complicated and time consuming. For example, Pegasus XL rocket is much cheaper than Ariane 5 but it is also much smaller. Not to mention that the first one is constructed in the USA whereas the second one in Europe.

The second way is to study the cost of the payload. The weight of the element (in kilos) that is going to be set in orbit. The price per kilo can vary per customer (requirements, budget) and also due to the Supply and Demand forces, negotiation issues and of course the number of the elements per launch. Moreover, every orbit has its own price. In geocentric orbits, the launches take advantage of economies of scale by sending bigger vehicles, which mean maximum use of payload capacity. One drawback is that the real price of the launch cannot be determined due to unpublication issues. Without launch contracts getting publicly announced, the calculation can be inaccurate sometimes. What payloads include are the crewed spacecraft, robotic spacecrafts, rovers, landers, satellites and much more.

Both metrics have their points of inaccuracy. The first one is when you are interested strictly in technical issues. Unfortunately, you cannot compare different vehicles through this metric. It is all about the overall launch vehicle cost. This is why "price per kilo" has been developed. To normalize launch costs and to permit comparisons among vehicles of different capabilities.

People used to take a technical approach to solve the price "problem" without seeing any results. Launch vehicle reuse was implemented as it seemed the most effective way to cut the cost but they weren't any results either. After all, missiles are created for maximum performance and not for minimum cost. They need to be reliable and tested. Any inexpensive systems may be tempting but they shouldn't be used. But why are Space launch costs so expensive?

There are numerous reasons:

1. Need for high reliability: The considerable amount of money, the studies which are very expensive and the distances that are examined which cannot be perceived by the human brain create stress and pressure for success. This can be ensured at a high percent by investing very large sums so that any possibility of error can be eliminated. SpaceX 's advantage is that they have undertaken the process of engineering and manufacturing. They know their product from scratch.

2. Lack of competition (strongly in the past): The United State Launch industry was a monopoly for a very long period and an oligopsony at the same time. Since the only costumers they had were NASA, the Military and the United States government. What took its spot were Arianespace and Russia. It is important to note that these were heavily subsidized by their governments.

3. Product improvement/Maintenance of capability

4. Staff costs/ Launch operation costs: As it was stated above, there must be assurance as to the outcome. But sometimes this is where the functional simplicity is lost. Employing 10000 workers and 1000 state employees just to move the enterprise, costs a lot of money. To be more specific, it covers 1/3 of total operation costs.

There have been some technical problems which led to high prices but luckily, they got identified after a long delay. They have affected every single feature of Space planning. Also, the development of commercial launch systems reduced the cost. This decline in launch costs has removed a major barrier and will give light to human plans for exploration and exploitation.

"These ultra-high launch costs result in intense pressure to make every kilogram of the spacecraft pack worth it" as Wertz said. Space hardware must be very light (on the verge of fragility) which can be dangerous during launch. Weight removal is a complicated move and the vehicle engineers should do an extensive analysis and testing. Reduced launch cost will directly allow heavier content and let's not forget our main long-term goal: A better performing spacecraft. It would be ideal if commercial launches could be afforded by everyone. This would change our lives. We would have an astounding amount of entrepreneurial activity in Earth's orbits and beyond. At this point we all sit back and wait for a reliable, first of all, and affordable access to Space.

4. Launcher Market

The economics of Space Launch are driven by business demand. The cost of Space launch eventually declined during the Space Age but it still remains high. During the last decade, the commercialization of rockets lowered the prices in the Space launch industry. The key to cost reduction was the suppliers who bypassed the traditional "Government/ Public rocket builder". The market is full of active players who react, invest, buy and sell. The, now, reduced costs will lead to more and better missions.

A launcher/carrier rocket is a vehicle which is used to carry payload to Geocentric orbits and beyond. The majority of them are manufactured on behalf of National Space Programs. They are classified in 3 mass classes: Small, Medium and Heavy. Also, they may differ if they are reusable or not. The expendable vehicles are designed for one time use and the reusable are meant to be reused. The way to distinguish them is to know if the boosters separate from their payload or not. In the case of expendable, the boosters disintegrate during reentering the atmosphere whereas, the reusable's boosters are designed to be recovered and "ready to go" again.

As for launch events, they can be divided into two types: The commercial and the Non-commercial. A commercial launch is when the payload's launch is open to competition from any suitable launch service provider. Conversely, a non-commercial launch is a launch activity where the orbital transport service of the payload is not subject to market competition. It is worth pointing out that a commercial launch can be performed by either a private launch service provider or a government.

There is also a partition in payloads.

A commercial payload is when the payload operator is a private firm or the payload is government-funded but it provides services through a semi- or totally private company. Non-commercial payload, on the other hand, may come from civil or military backgrounds and it is for scientific exploration reasons.

The cost model of a launch ($\mathbf{C_{Launch}}$) consists of 4 sub-costs. More specifically:

1. Cost of Development ($\mathbf{C_{Development}}$): It is the amortization cost per launch of the development cost the vehicle. This cost is expected to be higher for reusable vehicles than expendables since there are many more items to develop.
2. Cost of Vehicle ($\mathbf{C_{Vehicle}}$): It is the cost of the vehicle and it is represented by the Learning Curve.

The Learning curve is a visual representation of the required time period to acquire new skills or knowledge. In business, the slope of the Learning Curve represents the rate in which learning new skills translates into cost saving for a company (Kagan, 2020)

Let's assume that there is a Launch Service provider named "*Mission Space Inc*"

The Learning Curve mathematical expression is: CQ= a * Qb where:

- CQ: Production cost of the Q-th piece
- Q: The number of pieces we produced
- a: Production cost of the 1st piece
- b: The Learning factor, rate of reduction of unit production costs[=(logLR)/log2]

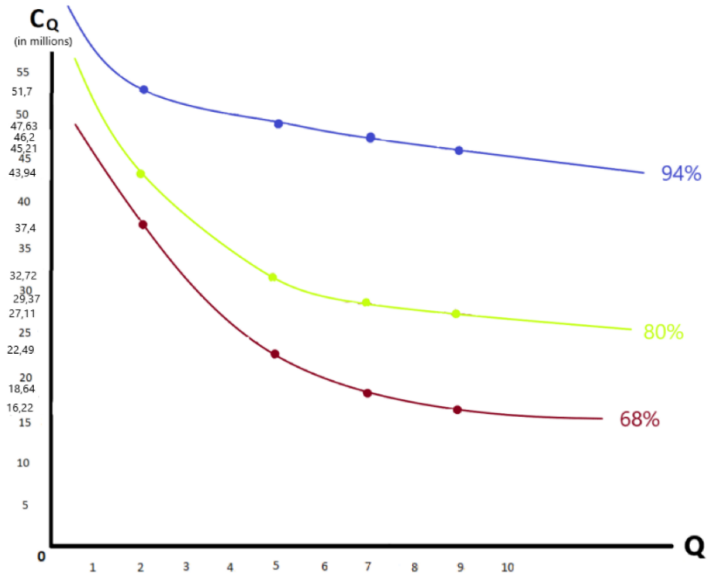
Supposing that "*Mission Space*" 's production cost of the first unit is $55 million, we will calculate the production cost of the 2nd, 5th, 7th and 9th product with learning percentages of 68%, 80% and 94%.

Initially, we calculate b, for a learning percentage of 68%:
b= logLR/log2= log0,68/log2= -0,16749/0,30103= **-0,556**.
Next, is learning rate of 80%: b= logLR/log2= log0,8/log2= -0,09691/0,30103= **-0,322**.
As for a learning percentage of 94%: b= log0,94/log2= -0,02687/0,30103= **-0,089**

Table 1. Learning Percentages/ Pieces Produced

		Learning Percentage		
		68%	**80%**	**94%**
Pieces produced	2nd	37,4	43,945	51,7
	5th	22,495	32,725	47,63
	7th	18,645	29,37	46,2
	9th	16,225	27,115	45,21

All of these graphically presented, will look like:



Graph 2. Learning Curve

"*Mission Space*" 's Learning Curve leads us to the conclusion that as the number of the rockets increases, the cost gets reduced. The cost of the 2nd unit will be 20% less than the first one when the Learning rate is 80%. Similarly, when the Learning rate is 68%, the cost reduction will be 32%, whereas for a 94% rate it will be 6%. The reliability of the company is going to grow and they will finally pay back the development costs.

We can see in the graph, that the first unit of the production is the most expensive. After the first one, each vehicle will be less expensive. Generally, the Learning curve is based on unhurriedly gained experience and in Economies of Scale (for example: Buying rocket parts cheaper in larger quantities).

3. Cost of Recovery ($\mathbf{C_{Recovery}}$): This will be included in the $\mathbf{C_{Launch}}$ model only if the vehicle is reusable. This particular cost is analyzed further in Reusability section.

4. Cost of Insurance ($\mathbf{C_{Insurance}}$): This cost can include the replacements of the spacecraft plus the "opportunity cost" of having the payload available in the near future. However, these costs depend strongly on both the spacecraft cost and the importance of having the system available on orbit. A competitive spacecraft needs to have reliability and an insurance cost higher than the current vehicle fleet.

The cost model of launch vehicle will be:

$$\mathbf{C_{Launch} = C_{Development} + C_{Vehicle} + C_{Recovery} + C_{Insurance}}$$

But who provides the launchers?

Let's take things from the beginning! In 1950, launcher services were strictly national and were held by governments. Soviet Union and United States were the reason why Space technology initiated. The European Space Agency (ESA) was founded in 1975 and successfully followed the same pace. The Chinese Space Agency also made its appearance laying their foundation for the future. But this was to change because after decades, the private sector became a crucial customer of launch agencies.

Times have changed and today not only individuals "stepped their game up" but private launch providers emerged. The incentives aren't so political oriented. Contrariwise, companies are facing economic

incentives while the dramatic decrease of prices unfolds in front of our eyes. These helped with the invention of new patents noting that we have entered the next big era in the Space launch market.

As for market competition, a small amount emerged inside of many national markets before the 2000s. There was a global commercial competition between public/ national providers of various nation states for international commercial satellite launches. Within the US at late 2006, the high-cost structures built into government contractors (DeltaIV and AtlasV) launch vehicles didn't give any significant commercial opportunity for US launch providers. On the other side, low-cost Russian boosters based on Cold War military technology faced many opportunities.

But as researchers have stated the Launch industry was developed in a world where Space funding was provided by governments. That leaded into a steady foundation for Space activities. The problem is that the money had been secure and did not encourage risk-taking in the development of new space technologies. Until the private sector blossomed…

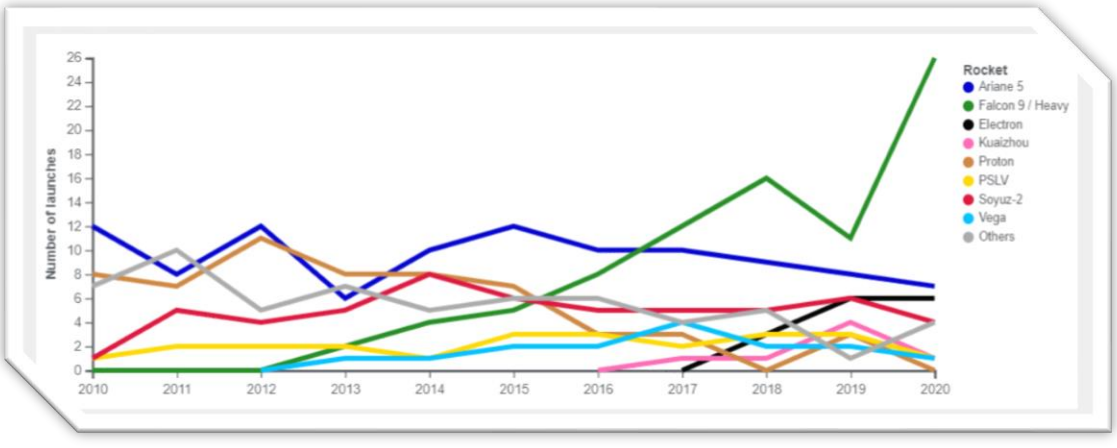
4.1 Private Sector Development

In 2006, Worden said "One bright point is the emerging private sector, which (was then) pursuing Suborbital or small lift capabilities. Although these vehicles support very limited US Department of Aeronautics Spaceflight needs, they do offer potential technology demonstration stepping stones to more capable systems needed in the future."

And he was right! Private sector showed that technology has advanced adequately in the last 20 years to enable new game changing approaches to Space access. The Washington Post has stated that the changes occasioned from multiple competing service providers resulted in innovations.

Private investments were modest prior to 2015. The amount of money that had been invested from 2000 to 2015 was only $13,3 billion ($1,8 billion being 2015 alone). After that 15-year time period, things started to change. The new private options emerged and created a price pressure in the market. The governments used to be the driving forces (Apollo Program, International Space Station etc.). But now, commercial activities are setting the pace by possessing 76 % of the global Space economy as for 2016. For example, Ariane 5 dominated the launch market internationally during 2004-2010 by holding over 50% of the world's market. And in November of the same year, they announced the new pricing flexibility. This was their response to SpaceX's success in the global lunch market. SpaceX development of Falcon Heavy and Starship without any government financing being provided shows that the private incentive is going to do big things in the next 50 years! ULA also attempted to develop a rocket strictly with private funds. Japan made an important move in 2015 considering legislation in order to provide a more official way for private companies to enter the launch business and accelerate Japanese Space launch attempts.

SpaceX's first orbital launch in December 2013 added credibility in their low prices. Competitors saw SpaceX's demand and as a result they felt the market pressure and lowered their prices. This is one of the reasons why ESA asked European governments for additional financial support in 2014. SpaceX's rocket, Falcon 9, in 2013 was the cheapest in the industry. It was $15 million less than CZ-3B. The Chinese government on the other hand couldn't face the competition and made a policy decision that launch prices aren't going to exceed $70 million.



Graph 3. Launchers' popularity during the last decade
***Source**: Wikipedia*

This market competition also affected ULA which strategically replaced the AtlasV and DeltaIV with Vulcan launch vehicle. ULA 's main goal is to build a reusable and lower-cost launch system. Meanwhile, SpaceX continued taking market share from Arianespace. That was achieved by reducing even more the costs through economies of scale. But European's next move was to design Ariane 6. It was designed to be cheaper to build and then to operate. Later, it was found to be uncompetitive with SpaceX. The Court of Audit said that the only thing that will be achieved is the predication upon annual subsidies from the European Agency. This would only help cover the rockets inability to sustain commercial orders. By mid-2018, with Proton carrying out only 2 launches in an entire year, Roscosmos announced they would retire the launch vehicle due to technical problems and intense competition from lower-cost launch alternatives. That wasn't an ideal situation because Russian market was projected to shrink about 10% of the world's commercial launch market. SpaceX's share of the commercial market has grown from 0% in 2009 to a 65% for 2018.

Jefferies had analyzed that launch costs to satellite operators using Falcon 9 launch vehicles may decline by about 40% of SpaceX's typical $61 million per launch. SpaceX, themselves, had only forecast an approximately 30% launch price reduction from the use of a reused first stage by early 2016. Talking about price reduction, Arianespace was also projecting a launch price of €90–100 million, about one-half of the 2015 Ariane 5 per launch price!

Partnerships like ULA's and Blue Origin's in order to develop a BE-4 engine for a low-cost booster show the power of public-private interaction. Previously the launch market belonged to a limited number of governments supported entities possibly more concerned with military capability and national prestige. Now, the commercial rocket business has provided a different engineering business model that has greatly reduced costs. ULA announced that they will restruct the process to decrease launch costs by half. Again, this was because of competition from SpaceX. But there are people like Jeff Bezos who sees competition as a great thing that boosts the industry and will get millions of people living and working in the Outer Space.

Although launch competition in the early years after 2010 occurred only in and among global commercial launch providers, the US market for launches began to experience multi-provider competition in 2015. The US government began to diverge from their previous monopoly arrangement with ULA for military launches. By 2018, the ULA monopoly on US Space launch had dissolved.

The private sector's supremacy can be also seen in Human exploration. By 2021, the monopoly previously held by nation states to be the ones to fund, train, and send astronauts for human space exploration was ending as Inspiration4 was held. The first mission with exclusively private citizens was launched in September 2021. The rocket for the flight and the training were all provided by private entities outside of the traditional NASA / civil process that had held the US monopoly since the early 1960s. Not to mention that the project was all privately funded.

Besides all of that, it's common that when we have a large vehicle, it will have a lower price due to economies of Scale whether it has been developed by the civil or the private sector. Also, non-western (Chinese, Russian and Ukrainian) vehicles tend to be cheaper than western ones because of lower infrastructure and lower wage costs. This may sound simple but there are key advantages such us treating launch vehicles like commodity items when this isn't the case. Simply because there isn't any Fixed price.

But still, how is it possible for private firms to have such low costs? The best example is SpaceX's strategy. Its' low costs come from it being vertically integrated. Besides that, it has a huge in-house construction of the rockets' features. Everything is completed by the company. This allows the executives to have complete control over the financial part of the designing/engineering. Aside from all of that, SpaceX invested in its workforce. Their motivation and their willingness are impressive. Afterall, in every industry the worker is the one who puts his effort and "spirit" to the product.

A great comparison is the development cost of Falcon 9 by NASA 's and SpaceX 's side. NASA compared what SpaceX spent to develop Falcon 9 to what NAFCOM model predicted as its cost. It was estimated that the cost of the private launch provider would have been $443 million. On the other hand, this project would

have costed NASA approximately $1,383 million by using of course traditional constructing. We are talking about a 68% reduction from NASA method! So, we can conclude that SpaceX keys to lower costs are in-house development, strong workforce, automated manufacturing (they were the first to introduce automation in the launch vehicle industry) and modern management. Their simplicity, and not overloaded with workforce projects like NASA, and reliability concluded to their low costs. "SpaceX president Gwynne Shotwell told the Space Symposium conference that the cost of refurbishing the Falcon 9 rocket that originally flew the CRS-8 Space Station resupply mission last year for SES-10 was "substantially less than half " what it would have cost to build a brand new one." (Morris, 2017)

The development of the players in the market present that it has the potential to have immense growth in the upcoming years.

And this isn't the end of new entries in the industry. Further next-generation engineers will enter the Space Tourism market to take advantage of the opportunities that emerge and make innovative moves. This will eventually decrease the barriers to entry which will increase competition, will lower the costs, and ultimately democratize Space Travel for medium class "amateur astronauts".

4.2 Reusability

The reusability of the Space vehicles is one of the most effectual ways to reduce the cost long-term. A reusable vehicle is designed to be able to take off from anywhere in the World, enter the desirable orbit, release its payload, get away from the orbit, land at the place it took off from to be launched again after a quick turnaround. The launch vehicles are very expensive due to manufacturing and development costs. Longtermly, the concept of using them not only provides much more drastic rocket cost reductions but also decreases the cost of each payload. If rockets are used like airplanes, then the cost of access to Space will be reduced to the cost of an airplane ticket! The Space transportation will become something similar to air transportation.

This is something that has not remained unnoticed by Space launch providers. On the contrary, the majority of them are investing and developing in reusable Space technology. It has become one of the major technologies that the industry is focusing on. Elon Musk believes that the new Raptor engine can achieve full reusability of all rocket stages and "a two order of magnitude reduction in the cost of spaceflight" to $10 per pound by 2025. (Wang, 2016). SpaceX alone had invested about $1 billion in order to advance the capability to reuse boosters. As the years were passing by, the issue of reusable rockets came into the table. It wasn't "there" from the beginning…

The reusable systems allow the companies to reduce costs as well as operate the system for several missions "at once". For example, currently, the price to launch a satellite has declined to about $60 million from $200 million by using reusable rockets. A potential drop could be as low as $5 million. And this will lead to satellite mass production cost decreasing from $500 million per satellite to $500.000!

The first attempt was in 1981 when Space Shuttle was produced but unfortunately it exceeded the costs of expandable launchers. It is worth noting that the Research and Development cost was $47 billion. That did not discourage them to continue working on the project but what pulled them back was the "Challenger" tragedy. The costs eventually dropped to $766 million with "Discovery" being the most flown shuttle ever.

In order to enjoy the economic benefit of reusable technology to the fullest level, the reuse needs to be hasty and complete. This means that the reusable vehicle will be ready to launch again without any widespread and overpriced refurbishment period.

The cost of the refurbishment represents the cost of vehicle recovery and the return to launch site where the equipment will be refurbished. The cost range here can be extremely large. The cost determination will depend also on where the vehicle lands. Vehicles that land in the water need a completely different treatment from those which land on land. It is natural for all machinery systems that refurbishment costs increase as they age. Thus, constructors can expect that more components will need to be tested or even replaced as the reusable vehicles get older. Recovery cost includes the replacement costs for components which may be destroyed as time goes by and the vehicle get used over and over again. Furthermore, the minimization of margin costs in the reusable vehicle is necessary in order to increase the efficiency and at the same time improving reliability in order to annihilate any failure possibilities.

Reusability is one of SpaceX 's key advantages and probably the reason why it has an enormous amount of Market share. In 2014, competitors weren't planning to develop reusable technology. SpaceX was a monopoly and created an elastic market on the demand side in order to justify the development of the rocket and the expenditure of private capital. They have already developed Falcon 9 and Starship. The single launch marginal cost for Starship is $2 million. More specifically, the $900.000 are for fuel replenishment and the $1.1 million for launch support. Reuse might provide much more drastic cost reductions.

At the same time, reusability doesn't necessarily have the same financial draw for companies building smaller launch vehicles. The point is to get the production cost as low as possible, make them easier to build and taking advantage of economies of scale. This is how Fixed costs will spread out and 200 launch events will take place per year.

5. Space Race: The competition in the industry

Richard Branson, Jeff Bezos and Elon Musk are using their brand power and capital to get established in the Space Tourism industry and expand the concept of Commercialized Space. Their goal is to generate a whole new era of tourism! But the world of business isn't made out of roses. The "spacial" businessmen are facing a lot of pressure from the external environment but also, they are very competitive. On the bright side, general market and competition could lead to further cost reduction.

There is a number of forces which affect the competitiveness and profitability of the industries. Below we will try to apply Porter's model in Space Tourism. In his model, Porter analyzes how each force (Barriers to Entry, Power of Buyers, Power of Suppliers and Substitutes) affect competition within each sector of the economy.

The first and most important force is the barriers to entry in the market. Barriers to entry are obstacles which make it difficult for new firms to enter a market. Space Market's competitive nature "obliges" current players to limit the entry of new ones in the market. This is because of the market's infancy stage. If they get in, they will withdraw part of the profits from the companies that are already in. Low barriers facilitate the entry of new businesses into the market. On the other hand, high barriers discourage new businesses from entering the market and investing.

High Capital Requirement

Commercial Space Tourism is an industry with high barriers to entry. Undoubtedly, the amount of capital required for the establishment, operation, research and development is a major obstacle for the entry of new companies in the sector. Even for the companies which are already in the market can be a little challenging sometimes but of course they have comparative advantages due to their long run presence in this market field. It is estimated that development cost reaches or even exceeds $ 500 million. Virgin Galactic's venture to develop a vehicle costed over $ 600 million.

Economies of Scope is an economic strategy, according to which the average cost is reduced by investments in a variety of products or services.

An obvious and well-known example of such an enterprise is SpaceX. It manages to gain a comparative advantage over other companies operating in the field of Space tourism. By which way? By constructing a very significant percentage of 70% of the components inside the business. In this way, the company manages to control the production costs, the quality of the products as well as the production time and avoids supply problems. This is how SpaceX obtains benefits from Economies of Scale and prevails over the rest that depend on other companies. The expenses of research and development can be amortized in other sectors and by this way, higher barriers are created for new firms to overcome.

The Power of Buyers

It is very important to understand the potential volume of buyers in order to evaluate any power that they may have on the competitive firms. Not everyone can afford the exorbitant cost of the ticket that reaches the height of $150000. These trips are destined and can become "fantasies fulfilled" only for High-Net-Worth individuals. Buyers have limited power and this can be seen in the increase of price of pre-sale tickets for Space travel. Virgin Galactic started selling tickets since 2005 at the price of $200000 and managed to sell 250 tickets by 2013. By 2016 they had received advances from over 700 customers. The increases continued, the price is $250000 and they continue selling tickets. Similar is the case of XCOR. They had sold 300 tickets at the price of $100000 and by January 2016 they increased the ticket price by 50%, $150000. As for the Blue Origin, they did not announce either the cost of the ticket or the number of those who showed interest. They were content to say that there was a significant demand.

Taking into account all of the high demand while the ticket price is increasing, we understand that buyers cannot influence the pricing policy of the companies.

Power Of Suppliers

Companies that are active in Space Tourism are facing issues such as quality assurance and the delivery time of the required spare parts. The spare parts which are required in this type of industry are highly specialized. The manufacturing cost of them is high and the suppliers have to face a very small market. And while this would logically give them the opportunity for more profit, on the contrary it leads to the verticalization of the productivity process.

The advantages of Vertical Integration

1. Better coordination and scheduling of activities
2. Upgraded quality
3. Protection from suppliers who may steal company secrets
4. Avoid problems of non-suitability with the specifications.
5. Avoid delays in the delivery of products, which can detriment the business by uncoordinating the production process.
6. Implementation of "Just in Time" system

As we mentioned earlier SpaceX is already implementing the verticalization with great success. Due to the limited number of companies which supply this market, their bargaining power has to be extremely high.

However, the fact that there are companies which have verticalized their production has resulted in suppliers losing this power.

Power of Substitutes

There is nothing that can completely replace Orbital and Suborbital flights. For future space travelers such trips are "wishes become reality". "Ever since I was five years old, I have dreamed of travelling to space", Jeff Bezos tweeted. The only substitute could be a high-altitude balloon, a Space Balloon. Already, companies like Zero2Infinity and Space Perceptive are working in this direction.

Zero2Infinitive's Balloon would carry up 6-man crew, to an altitude of 36 km, at a cost of $125000. It is a great alternative for people who can't get into a rocket (due to budget, high G forces etc.). It is very gentle as it travels at a speed of 12 miles/hour.

6. Space Economy

"The Space Report 2021 Q2" says that "In 2020 the global Space Economy rose to $447 billion, an increase of 4.4% from a revised 2019 total of $428 billion. This $447 billion Space Economy is 55% higher than a decade ago and part of a five-year trend of uninterrupted growth. Commercial Space activity grew 6.6% to nearly $357 billion in 2020, still representing close to 80% of the total Space Economy. Global government space spending fell 1.2% in 2020 to $90.2 billion from a revised 2019 peak of $91.4 billion. Nearly 58% of this total was allocated to Space activities by the U.S."

6.1 Private Sector Perspective

The Space Tourism sector may be in the process of prominence and emergence but it sure has a lot of potential. Right now, it is targeted only to prosperous societies who want to insight into a different way to travel around. It's well known that humanity always pushed the limits and sought new places. And one thing that we can all see eye to eye on, is that Space flights surely contain a lot of adventure. Space tourism is tourism's next massive growing trend.

There is every reason to believe that commercial Space travel will have a great impact in the economy, as multinational tourism, the following years even after such an economic downturn. The high number of demand for Space investments speaks for itself. Muruganandham declared that: "2020 was definitely a record year for space investments". This shows that the unwanted phase of economic inactivity has already begun to fade. We have already overcome the stage of returning to normality successfully. Public investments reached $71 billion in 2018. This means, besides current revenue, that there will be revenue in the future too. If investments are put together, the market is "moving", new machines are invented, companies are triggered to expand and all this together will result in even greater revenues in the future. Market's embryonic stage allows investors to get to see the market with enthusiasm and optimism. However, the times we live in gives them the chance to make their name known. Examples like Musk's commercial launch of a NASA crew and investors' chase for funding rounds proudly shows that they have taken their roles very seriously to the point where, the rise of SpaceX's reusable spaceship Dragon, has made United States less dependent on the Soyuz, Russia's spacecraft, for ISS events. As already quoted, unhappily such activity only concerns well-to-do people who want to see the Earth from above. And this because of the high cost of the ticket. The amount of the ticket speaks for itself. Despite that, the demand

and the private sector capacities constantly gets enlarged in order to satisfy the consumers in the coming years. And hopefully not be so "high-net worth" oriented so that it can appeal also to medium sized clients. But this is going to change any time soon because the Space industry is by its nature pretty transformative. It is predicted that it will be the highest annual growth market in the decade.

It seems achievable if we follow 2021 steps. More specifically, there has been an $9.8 billion investment activity running during the third quarter of 2021, $3 billion more than what was invested during the same time period of 2020. It certainly rebounded after last year's losses.

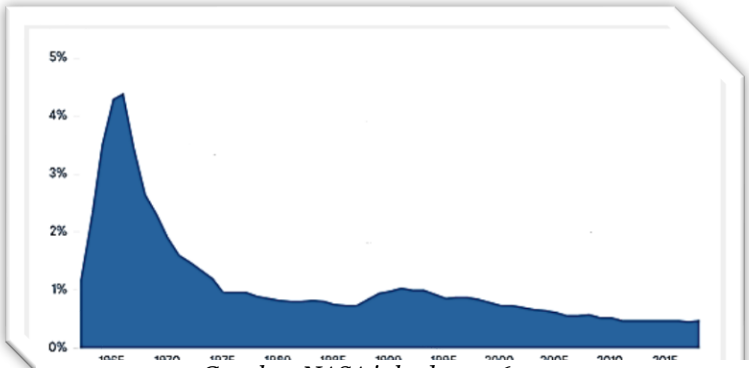
With launch costs getting slowly declined, with launch services revenues up to $6.4 billion and public's interest getting risen, it is believed that it will be the next trillion-dollar industry. This can be translated though the levels of private funding which have been less expensive (compared to previous decades) and more accessible (like Jared Isaacman, an entrepreneur who bought a SpaceX flight to orbit). There will also be a potential collateral growth in other Space fields because many segments are being covered like Satellite Broadband market, Launch market etc. but with Space Exploration being the most visible face. The good news is that these investments aren't always "private" initiatives…

6.2 Civil Perspective

As already mentioned, America and Russia developed their overall technology after the long period of War. The governments took advantage of this flourishing by introducing their space aspiration to their national programs.

Governments have an increasingly stronger presence in the field. The Space investment scene is dominated by Blue Origin, Virgin Galactic and SpaceX but an equilibrium takes place right between investment activity from investors and governments.

In 2019, United Space Command was established. This benefited the U.S. Defense department and the Aerospace sector. Also, the open and continuous collaboration that has NASA developed with SpaceX shows firstly, the progress of individuals power and the ambitions of the man for universe conquest and secondly, it represents an important milestone for the relationship between private enterprises and the U.S. government. The constant race of the countries for expansion in their space sectors and which is going to be the leader in the space field isn't particularly for the betterment of humanity. They are hidden interests and competition going on for the conquest of space. Let's comment the following diagram:

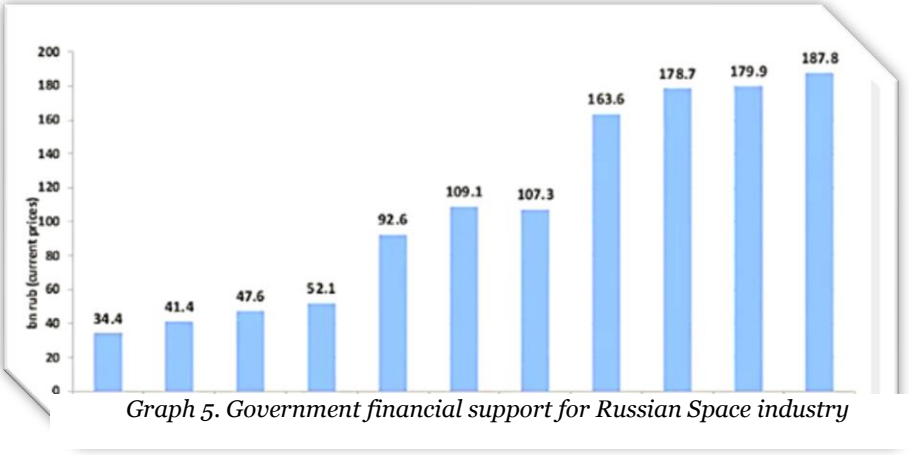


Graph 4. NASA 's budget 1960-2015

This graph presents NASA 's share of United States budget from 1960 to 2015. The story started in 1961 when President Kennedy stated while speaking to Congress: "I believe that this Nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth". This statement showed America's commitment to its goal and readiness to compete with powerful Russia, which was the first to send a human to space. This is when Government's expenditure started rising and reached 1% of the Federal budget. It peaked during the space race with Soviet Union, leading up to Apollo program which started in 1968. The first moon landing was in 1969 and the program was terminated in 1972 (1.6% USA budget). The funding was

steady for many years after that. But it was suddenly increased after the space shuttle Challenger was destroyed just 76 seconds after its takeoff. After 2011 the funding remained at 0.5%.

In contrast, Russia (USA's biggest competitor) has a remarkable growth because of the increasing support from the state. Even in the crisis years, Roscosmos (Russian Space Agency) has maintained their projects and stayed fully funded. Their current aims are the creation of the Russian orbital station (Russian segment of ISS) and formation of a new generation manned transport spacecraft that will be put in orbit by Russian rocket family, Angara.



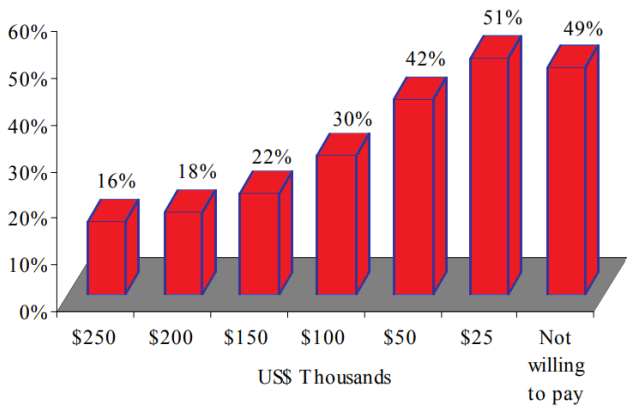
Graph 5. Government financial support for Russian Space industry

Moving forward to today, the Space Race continues with United States and Russia still being the elite. Yet there some other important players in the market of Space Economy, that controls Space Tourism. In 2020, USA is in the lead with a budget of $47,49 billion and the rising force being China with many plans for Space. It started with a budget of $2,66 billion and which increased over the years reaching $8,85 billion. On the flip side, Russia had planned an expenditure worth $ 4,39 billion but in the years it's getting decreased. In 2020, an amount of $3.58 billion dollars was scheduled.

7. Market Demand

The confidence in today's technology has grown and this market will take off sooner or later. The demand is undoubtedly high and it is going to get higher when the supply part will offer frequent and safe launches. According to an industry panel interviewed in October 2018, "An industry shakeout is expected between 2019 and 2021 due to the excess supply compared to demand. Prices should reach stability once the new entrants have demonstrated their capabilities."

Determining Space Tourism demand is the trickiest part of the market analysis. It is obvious that it concerns only wealthy individuals, at least for now. Only them will be able to afford the flights for 5 to 10 years from now. Any demand from less wealthy people will remain unsatisfied until the price levels get reduced. Also, we need to have valid responses of affluent customers to questions related to their interest in such activities. Speaking of statistically rational responses in 2002, Futron Corporation conducted a survey on the future demand for Space Tourism. More specifically, it digged into the potential Space tourists' willingness to pay for a ticket for both orbital and suborbital flights. The survey was based only on people whose family income was at least $250000. With this specific sample, the reliability of the results was ensured. It is worth mentioning that then, there were not any vehicles for such trips. They were under construction. The survey results for Suborbital tourism are presented in the bar diagram:

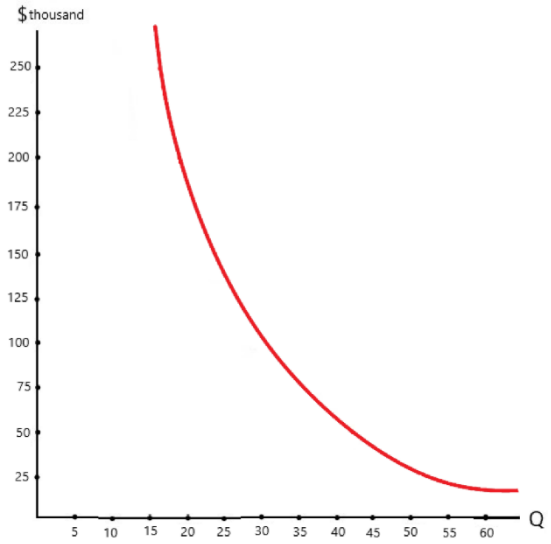


Graph 6. Willingness to pay for Suborbital Travel
***Source**: Futron (2002)*

We will calculate the elasticity of demand for each price unit:

Ticket Price in thousands ($)	Elasticities
25 - 50	-0,428
50,1 - 100	-0,8
100,1 - 150	-1,09
150,1 - 200	-0,888
200,1 – 250	-0,625

Table 2. Suborbital Tourism price elasticities

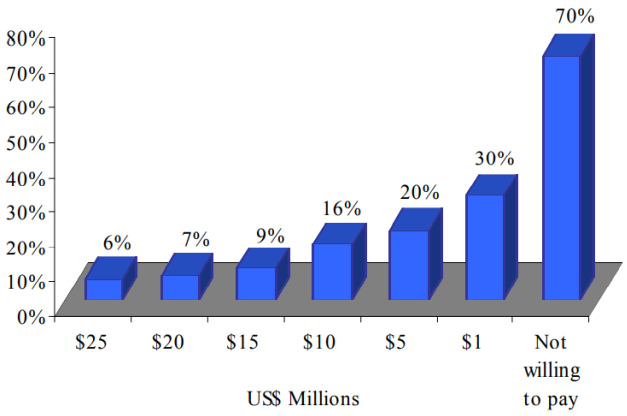


Graph 7. Demand Curve (Suborbital Tourism)

At a rate of 51%, responders were willing to pay from $25000 to $250000 for the experience of a Suborbital trip. As we can see by the results of the research, the law of demand applies on the Suborbital flights. When the price of a good decreases, the quantity demanded, increases.

As for the Orbital Space Tourism, the survey gave these results:

Graph 8. Willingness to pay for Orbital Travel
***Source**: Futron (2002)*

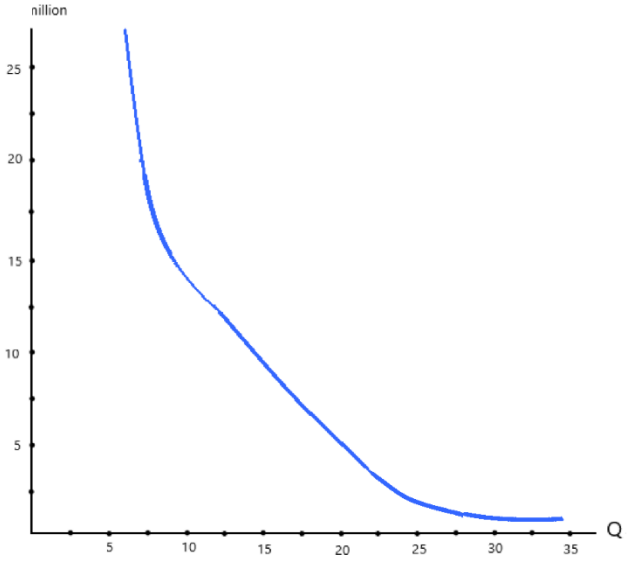


Again, the elasticities are:

Table 3. Orbital Tourism price elasticities

Ticket Price in millions ($)	Elasticities
1 - 5	-0,625
5,1 - 10	-0,5
10,1 - 15	-2,333
15,1 - 20	-1,143
20,1 – 25	-0,833

Graph 9. Demand Curve (Orbital Tourism)



There are some other factors that influence Space Tourism demand such as the health level (high G forces), available of time for training. But what if there is a big demand towards Space activities? A large demand, will lead to the decline of cost per launch. Hence, the number of flights will constantly get increased.

However, this process does not occur instantaneously. First, a new vehicle must be manufactured with significantly lower costs and then there must be created a trustworthiness "persona". Some changes in demand may occur over time.

8. R & D

R & D (Research and Development) is a company's sector which specializes in innovation and expansion. The company carries out activities with the aim of innovating and constantly increasing their profits. Through research, knowledge is achieved while development designs protypes to prove their feasibility and the innovative nature of the firm. All these actions combined expand the firm's profits. As for the Space sector, the majority of Space related companies is doing a lot of research in order to widen their brand. Their inventions are patented and a large proportion of them become innovations with an economic use.

For example, Research Value is the reason why **SpaceX** is so successful. Elon Musk is in the process of developing a vehicle that is going to change everything we know about space travel. The vehicle's name? Starship. It is a fully reusable vehicle, which is a combination of a rocket and a spaceship. It has been designed so that it can be fully reused and immediately take off, as long as it is supplied with a methadox fuel (liquid methane and liquid oxygen) which is not accustomed to rockets. However, methane creates the impetus needed to carry out the mission to the red planet. In addition, this fuel has the advantage of being able to be synthesized from the subsoil of Mars and from the carbon dioxide of the atmosphere. In this way this vehicle gains self-sufficiency as well as incredible cost reduction. Especially for trips to Mars, which is estimated to require a period of 9 months, Elon Musk is considering installing 40 cabins in the area of the payload as well as common areas and a shelter so that space tourists can be protected from the harmful particles of space. In addition, NASA has awarded a $2.89 billion contract to develop Starship in order to be used in the Artemis program on the moon. The universe is infinite, as are Elon Musk's ambitions, who envisions the transport of people to Jupiter, which of course is in the very long-term plans. The development cost of Falcon 9 was $300 million. *Falcon Heavy*, the World's most powerful rocket, took 7 years to develop with the development cost being $500 million. This is why they pushed the development of Falcon 9. They had financial help from the Commercial Orbital Transportation Services, the amount of which exceeded $278 million in 2006. In 2019, they earned $1.33 billion from 3 funding rounds.

Sir Richard Branson, was the one who successfully developed and made the first sub-orbital flight with a spacecraft. On 30/3/2021, the company presented the Spaceship II Imagine. It is a new, upgraded space aircraft with improved flight performance, which was designed to transport people and experiments in Sub-orbital space. It has started ground tests and will soon start Sub-orbital flights. However, Virgin Galactic does not stop. Through Spaceship Company, which is its subsidiary, is developing a new spaceship, the Inspire.

Blue Moon is the new challenge for **Blue Origin**. It is a robotic space cargo carrier and lander for Lunar cargo deliveries. Blue Origin has the know-how of the vertical landing as it has also used for the landing of New Shepard to its suborbital flight. The aircraft will be able to transport up to 4,500 tons. A significant innovation is the BE-7, a turbo machinery-based engine which uses LOX (liquid Oxygen) and LH2 (liquid Hydrogen). BE-7 has been developed privately, after years of research. "Our engine test series is steadily maturing what's needed to get Americans safely on the lunar surface as soon as possible. We are positioning to use the Moon's ice resources for rocket propellant, which will make exploration sustainable and open the Moon for commerce", according to the vice president of Advanced Development Programs, Blue Origin. By July 2014, investments reached $500 million. In 2016, he declined publicly announcing

the technology development fees. But in 2017 he said that he was selling $1 billion in Amazon stock to support Blue Origin plans. Moreover, in 2018 they made an agreement with USAF to receive up to $500 million. It is for the development of New Glenn rocket. They have already received $181 million.

Space Tourism is considered an industry which is "ahead of our time" but actually, it is in its infancy stages. Not much information has been published about the research that companies have done. Bezos, for example, has not said openly about the price of the ticket.

9. Conclusion

Space Travel is every man's dream. His exploratory nature and his need to discover the unknown came into life when the very first man raised his eyes and looked up at the night sky wondering what these bright signs were. The participation of over 50 private companies in the market shows the progress of human mind. They are bringing Space close to us! As Verne said "La distance est un vain mot, la distance n'existe pas!" Some suggestions for further expansion of the field are, in addition to the much-discussed colonization of Mars, Space Travel to outer planets such as Jupiter. But something like this is very challenging due to the Asteroid Belt, which is located between Mars and Jupiter and contains many irregularly shaped asteroids of many sizes. On top of that, another concept is the development of Space trips to Pluto which is exactly 50 Astronomical Units away from Earth. This of course will be very challenging because, apart from the endless flight hours, we also have fuel issues. Because if we run out of fuel in a trip, Pluto is so far away from the Sun and it cannot seize the solar energy.

But we should not see these difficulties as obstacles. We must try to approach them with a different perspective and solve them. And keep dreaming! Because the dream of today is the reality of tomorrow…

Acknowledgements

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