



MESTRADO

Gestão e Economia de Serviços de Saúde

AEROSPACE MEDICAL CENTER - AMC

Commercial Space Tourism Business Model – Health Factors

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COMMERCIAL SPACE TOURISM BUSINESS MODEL – HEALTH FACTORS

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“One day space travel will be as common as travelling by car”

Agradecimentos

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Abreviaturas

AeMC	Aviation Medical Center
AMC	Aerospace Medical Center
AME	Aviation Medical Examiner
ANAC	Autoridade Nacional de Aviação Civil
AsMA	Aerospace Medical Association
DLR	German Aerospace Center
ESA	European Space Agency
ESAM	European Society of Aerospace Medicine
FAA	Federal Aviation Administration (USA)
FAP	Força Aérea Portuguesa
ISS	International Space Station
JAXA	Japanese Aerospace Exploration Agency
LEO	Low earth orbit
NASA	National Aeronautics and space administration
NTSB	National transportation Safety Board
SFP	Space flight participants (SFPs)
SMAPOR	Sociedade Portuguesa de Medicina Aeroespacial
TAP	Transportadora Aérea de Portugal
UTMB	University of Texas Medical Branch
VG	Virgin Galactic

Abstract

We are on the edge of a new Space era, space race 2.0. In the near future, with the development of new technologies, space tourism activities could become a priority to space economy. If fifty years ago space exploration was done by state agencies and missions performed by selected astronauts, in the near future private companies will lead the space activity and regular people with diseases and comorbidity may want to participate in tourist space flights⁽¹⁾. At the moment there are no private space clinics that may perform specific aerospace medical examination and preparation to sub-orbital or orbital flights, nevertheless human factors are essential to space tourism development.

The objectives of this study are to analyze the current situation of aerospace medicine in space tourism and determine the potential of this activity economically and its viability, designing a first business plan canvas model for an independent Aerospace Medical Center -AMC. It is true that at the moment space tourism is just accessible to millionaires, however there might be a promising segment in opening space tourism to the masses is represented by the suborbital flights. That segment is dominated by a pioneer company - Virgin Galactic⁽²⁾. According to the research presented in this study, it is observed that there is a significant public demand for this kind of activity. With the entry of more operators, like SpaceX or BlueOrigin, such services as AMC is offering will be a necessity and with the increase of the consumer flow and economy of scale, demand will rise and prices will decrease and the space tourism sector will become one of the main tourist activities to generate profit, accompanied by aerospace medicine business. Space tourism becomes a growing industry, and that sort of precision medicine can improve the reach of private medicine. Tourists will most likely need to undergo thorough medical examinations to ensure they are able to withstand the rigors of space. Space flight participants will have to have a certain level of health before flight. Despite the uniqueness of the service offered, the AMC may compete with other Space Clinics, with new economic challenges. We can compare the beginnings of space tourism with those of aviation, where one hundred years ago, nobody would imagine that, millions of people will be traveling everyday such enormous distances by air in a very short time, safely and comfortably. Nowadays, we can speculate, that safe public access to outer space will lead to the development of aerospace medicine and technologies, bringing huge benefits to our society and transforming it in a way that is

unimaginable today⁽²⁾. Limitations to this work are evident but it wants to show that there is a new business market opportunity from which we may all benefit. This work is just a kickstart and there will be a need of more exhaustive studies in order to define the best business model to aerospace medicine.

Key words: space tourism, aerospace medicine, space market potential, suborbital flights, consumer behavior

1 INTRODUCTION

Sixty years ago, the Soviet Union launched the first artificial satellite into orbit, Sputnik. The event served as the starting pistol in what would come to be known as the Space Race, a competition between the U.S.S.R. and the United States for spaceflight supremacy. In the decades that followed, the first human reached space, a man walked on the Moon, and the first space stations were built. It ended with a handshake in space just 18 years later. The handshake was the start of many decades of international collaboration in space. But over the past decade there has been a huge change⁽³⁾.

The space environment is no longer the sole preserve of government agencies. Private companies have entered the exploration domain and are propelling the sector forward more vigorously. In recent years, a new Space Race has taken shape—Space Race 2.0. Rather than powerful nations guided by presidents the competitors in this race are tech startups and private businesses spearheaded by billionaire entrepreneurs. Tech's top five, FAMGA (Facebook, Apple, Microsoft, Google (Alphabet) and Amazon) now worth more than \$3 trillion, according to NGO Global Justice Now, 69 out of 100 world top economic entities are enterprises and 25 of them exceed GDP of many developed countries, such as Belgium or New Zealand. Moreover, the power of these companies goes beyond the value they create and many of them want to develop upcoming projects and create history in Space.

Space tourism is space travelling for recreational purposes. There are several different types of space tourism, including orbital, sub orbital and lunar space tourism. To date orbital space tourism has been performed only by the Russian Space Agency. Work continues towards developing sub-orbital space tourism vehicles and develop them into regular intercontinental commercial flights to transport people between cities on Earth via space making a New York to Sidney flight possible in less than 2 hours. This is being done by aerospace companies mainly based in US like Blue Origin, SpaceX and Boeing, but increasingly there are different companies developing new projects worldwide such as Virgin Galactic (UK) SpaceIL (Israel) or Axiom Space.

Space airports like Mojave Air and Space Port are already a reality and more are being constructed in other places of the globe. During the period from 2001 to 2009, the publicized price for flights brokered by Space Adventures to the International Space Station aboard a Russian Soyuz spacecraft were in the range of US\$20–40 million. Seven space

tourists made 8 space flights during this time⁽⁴⁾. Some space tourists have signed contracts with third parties to be subjects of certain research activities while in orbit.

A 2010 report from the Federal Aviation Administration, titled "The Economic Impact of Commercial Space Transportation on the U. S Economy in 2009" cites studies done by Futron⁽⁵⁾⁽⁶⁾, an aerospace and technology-consulting firm, which predict that space tourism could become a billion-dollar market within 20 years. These figures do not include other private space agencies such as Virgin Galactic, which as of 2014 has sold approximately 700 tickets priced at \$200k or \$250k dollars each and has accepted more than \$80 million in deposits⁽⁷⁾.

Aerospace travel seems to be the next disruptive transformation in worldwide and interplanetary transportation. Nevertheless, the growth projections of Civil Aviation sector for the coming years reveal some of the weaknesses of the industry regarding the global capacity to train new professionals that will meet the future needs of Human Resources at a technical, operational and management levels.

1.1 Aerospace medicine

Aerospace medicine plays an important role in the development of this industry that relevance comes not only from the safeguard of future space traveler's safety, either as customers or professionals, but also from the prevention of the economic impact that an accident or medical problem on board would have.

There is reliable information from last decades about the medical problems experienced in space, tested by professional astronauts, but we must not forget that these are carefully selected individuals, passing numerous tests, physical and psychological, and stages in their formation. Space medicine is different than other specialty, since an ordinary doctor is accustomed to treat people with comorbidities in a normal environment, and in this case, we have super fit individuals in totally adverse and extreme conditions, which totally changes the paradigm. However, commercial space travelers are not previously screened based on their physical condition and many of them may already have medical problems. This paradigm also needs to be changed. Commercial space travelers would have to pass different checkups and, depending on the type of flight, be physical and mentally prepared for G-force, acceleration, spacial motion sickness, hyperbaric chamber, muscular and bone loss, dehydrated food, vertigo, among others.

Since the first human spaceflight by Yuri Alekseyevich Gagarin in 1961, just 571 persons have flown in space. The vast majority were highly trained and rigorously selected astronauts in excellent physical condition and health. Currently, astronauts and other participants in spaceflights to the International Space Station must adhere to medical certification standards set by National Aeronautics and Space Administration (NASA) and its international partners⁽⁹⁾.

The emergence of privatized commercial spaceflight is expected to open the possibility of flying in space to paying customers, including those with preexisting health conditions. Prospective spaceflight companies and their medical departments will provide guidance for their suborbital participants and will also increasingly depend on health documentation from clinicians who may not be familiar with the specific challenges of various activities and mission profiles related to spaceflight. This is an area where regulation or standardization is absent.

Current U.S. law, enforced by the Department of Transportation's Federal Aviation Administration (FAA), Office of Commercial Space Transportation, mandates that prospective spaceflight participants provide written informed consent after having a clear understanding of the inherent risks of the flight⁽¹⁰⁾. Nevertheless, until now the FAA does not have a mandate to regulate passenger health or preflight medical screening on the proposed commercial space flights⁽¹¹⁾⁽¹²⁾. Guidelines for screening SFPs have been published by the international space medicine community and societies⁽¹³⁾; yet it is uncertain whether or not commercial operators will/have to implement them. but a system of medical clearance is highly recommended for these space tourists. It is Aerospace Medical Associations' purpose to establish guidelines for use by private businesses, medical providers, and those planning to be a space tourist. Consequently, a Task Force was organized by the Aerospace Medical Association (AsMA) for the purpose of facilitating safety of passengers, fellow passengers, crew, and flight operations⁽¹²⁾.

Although pilots flying various privatized commercial space vehicles are required to hold a second-class FAA or EASA medical certificate with its attendant medical requirements⁽¹¹⁾⁽¹⁴⁾ there are currently no medically binding criteria for determining a participant's suitability for prospective commercial spaceflight, beyond guidelines from several aerospace specialty organizations.

To create an aerospace medical center of reference – AMC - that would prepare commercial space travelers for different kind of sub-orbital or orbital flights and evaluate its economical impact and viability is arguably fundamental. If AMC reduces the likelihood of a premature shuttle return or a medical incident onboard according to x cost, is likely, to result in cost savings. Decision analysis is a useful tool for use in priority setting in aerospace medicine.

With increased utilization, the probability of an on-board medical event increases. While the preventive approach to reducing the risk of significant illness and injury has been effective, some believe it is a matter of time before there is a medical emergency in space. In addition to the career astronauts and cosmonauts living and working in space, a new generation of space flight participants (SFPs), or space tourists, have been visiting the space station since 2001 ⁽¹⁵⁾.

Extending the opportunity to visit the International Space Station (ISS) to space tourists challenged the space medicine community to decide whether or not a similar approach to pre-flight medical screening would be used for the SFPs. While these individuals were paying millions of dollars for the privilege of visiting the ISS, a significant on-board medical event could have a profound mission impact and it was decided that a pre-flight medical assessment was needed as a risk mitigation strategy. Seven SFPs have visited the ISS, and, up to date, no significant medical events have been reported ⁽¹⁵⁾.

The future of human spaceflight will likely include increased accessibility and utilization of low earth orbit for commercial ventures and continued use of the ISS, ultimately leading to a transition back to exploration missions potentially involving lunar return or missions to Mars.

The expansion of commercial space operations to include SFPs and potentially career astronauts flying on commercial spacecraft in suborbital and orbital flights presents a number of potential issues to the space medicine community. While the majority of these events include space adaptation syndrome, motion sickness, back pain, musculoskeletal problems and disrupted sleep, the potential for a more significant medical event exists. For this reason, there has been considerable interest and research in developing and testing innovative medical centers to evaluate and study the future space travelers ⁽¹⁶⁾. This raises a number of questions about defining the appropriate level of care, the effect of longer signal transmission to Earth on crew autonomy and the role that new technologies will play in the delivery of healthcare during the different phases of the mission.

For this reason, a comprehensive assessment of the likelihood and impact of potential medical conditions should be conducted based on a combination of historical data, expert opinion, analogue studies and epidemiological studies from other related high-risk occupations to facilitate development of future medical protocols ⁽¹⁷⁾.

High-fidelity medical simulation has been suggested as an effective tool to assess the performance of high-level medical systems on interdependent medical center. Beyond its use in research and testing, medical simulation is also an ideal platform for providing medical education and training opportunities for passengers who may not be exposed to the required breadth of clinical experience necessary to support a space mission.

While the objectives of human space travel will differ between the government and commercial groups, there will be a shared interest amongst practitioners of space medicine in developing the best approaches to prevent and treat illnesses and injuries during a mission.

National Aeronautics and Space Administration - NASA has identified five levels of care as part of its approach to medical support of future missions depending on different factors. To implement an effective medical risk mitigation strategy for exploration class missions, modifications to the current suite of space medical systems may be needed, including new crew medical officer training methods, treatment guidelines, diagnostic and therapeutic resources, and improved medical informatics ⁽¹⁸⁾.

There are many concerns about screening and certifying passengers for future space-flight. Efforts by several organizations to propose such screening are cited. The problem with some of these proposals, which treat all types of spaceflight as the same, is that they are so restrictive that too few people would be eligible for space travel to have a viable tourism industry.

However, not all types of spaceflight are the same, so the distinctions between them need to be clarified. Of the five types of spaceflight NASA described, one is proposed as the most likely to be the first significant phase of space tourism: long-term microgravity flight in low Earth orbit - LEO. But because of human problems with long-term exposure to microgravity, this phase requires rather conservative screening and extensive training. However, prior to discussing the passenger issues related to this early phase of space tourism, the reasons why and where to do this tests and screening are still to develop.

At the moment there is none private Aerospace Medical Center (AMC) of reference to prepare, study, train, and screen commercial space travelers.

1.2 Space economy

At the macro level, we are entering a new phase dubbed Space 2.0 — the first phase was governments investing in space exploration, phase 2.0 is billionaires investing in commercial viability of space. In current global market conditions space is not only expensive, but it is dangerous. Most space entrepreneurs are either billionaires in their own right (Bezos, Musk and Branson) or have partnered with governments to launch their businesses and research development and it's not common that science take precedence over commerce. In capital markets between 2012-2017, venture capitalists invested over \$10.2BN in the sector ⁽¹⁹⁾.

The size of the space economy is far larger than many may think. In 2015 alone, the global market amounted to \$323 billion ⁽²⁰⁾. The FAA has noted that while the commercial launch sector has not grown dramatically in the last decade, there are indications that there is latent demand that may catalyze an increase in launches and growth of the wider space economy in the next decade. Space tourism, in particular, may become a large part of that industry. Its viability rests on a range of factors, including costs, future regulation, international problems, and assumptions about technological development.

1.3 Key trends

Space exploration is increasingly a key trend. The 1967 Outer Space Treaty was signed by 129 countries, but it makes no mention of commercial space activities. There are a lot of unanswered questions about what new trends could disrupt/destroy the needs for the space venture. Technological advancements have allowed for greater data collection, faster and farther travel, reusable rockets and a vast number of increasing satellites and orbital devices. Now, we may have reached the time to use the technology to focus on using space for earth's benefit, for another home for mankind or for developing extraterrestrial technology for use on earth and beyond. Innovation plays a special role in that goal.

Exhibit 1: Space Age 2.0 in a nutshell



Figure 1 | Space Race 2 – Space Industry ⁽²¹⁾

1.4 Innovation

Innovation is generally hard to predict. Some new technologies seem to come out of nowhere and others only take off when paired with a new application. It is difficult to predict the future, but it is reasonable to expect that a growing space economy would open opportunities for technological and organizational innovation. In terms of technology, the difficult environment of outer space helps incentivize progress along the margins. Because each object launched into orbit costs a significant amount of money—at the moment around \$54,500 per kg, though that will likely drop in the future ⁽²²⁾—each reduction in pay-load size saves money. At the same time, the ability to fit more participants capability into a smaller spaceship opens outer space to actors that previously were priced out of the market. This is one of the reasons why startup, “low budget” are increasingly pursued.

At the moment, this traveler’s experiences beyond Earth’s orbit to the moon or Mars, for example are unmanned. Manned missions introduce another dynamic. Current regulation allows “informed consent” for spaceflight participants ⁽¹¹⁾. This means that private companies may focus on regulations around launch systems and have passengers use waivers to

acknowledge the risks. But this informed consent system currently only lasts until 2025. Until then, the FAA is limited in the passenger regulations it can enact on the space industry ⁽¹²⁾. Regulations on human travel, both in-orbit and beyond, will soon be an area of interest ⁽¹⁴⁾. If space tourism takes off, some types of space travel may become more similar to common carriers, such as atmospheric planes and ships, than experimental missions. If there are enough space tourism trips passing overhead, the U.S. government may be pushed to shift to a more hands-on regulatory approach ⁽²³⁾. There are parts of the space industry that are pushing for making the informed consent approach permanent. They argue that there are several justifications for such a move, including: the current system is working and fostering innovation; the manned space market is still in early stages, and so needs protection from draconian regulation; At the same time, the pace of regulation will likely be attached to the pace of viable manned space travel. The next decade may see technological breakthroughs that greatly reduce costs. It may not be that far in the future before regulators take a more heavy-handed approach to manned space-flight. That approach will need to balance safety and innovation, and understand the nuances separating mature and developing technologies, as well as the different types of travel.

Innovation is not smooth. In history there are periods of rapid change and periods of relative stagnation, arising from a variety of causes. It is a fundamental point that development of commercial passenger space transportation is the key innovation needed to create an economical space transportation and that, in the near future, commercial passenger space transportation will generate an economic return on the hundreds of billions of dollars invested in developing space capabilities to date. Passenger space travel is itself likely to grow to a turnover of tens of billions, but it will have further major economic benefits by reducing the cost of space transportation to an extent that no other activity will, due to its large scale ⁽²⁴⁾.

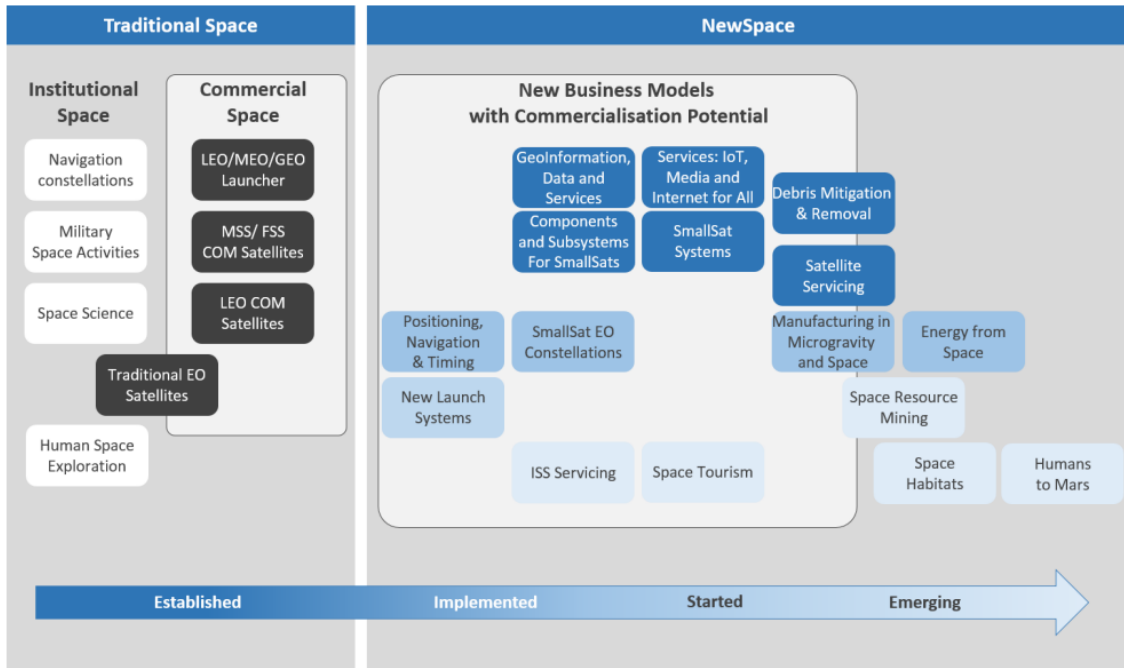


Figure 2 | New business models will disrupt old space industry (25)

2 MOTIVATION

The million dollar question when talking about space tourism is: Why? why are we risking lives to make it happen? Well, the answer seems to be simple: innovation. As a species, we have always been very creative and have consistently since the industrial revolution, been pushing forward to explore new and dangerous opportunities. Many consider space exploration simply the next step in the advancement of the human race, and worth the risk – so why haven't we already conquer the space tourism? Safety!

The aim is to show there is a potential new market in space industry where space medicine will play a role. It will contribute to help hundreds and then millions of people to escalate to the next level, the final frontier and travel across the Milky Way. There will be a need of Space medical clinics of reference – AMC. This is one of the factors necessary to the development and success of the space tourism it hasn't been studied yet.

If AMC reduces the likelihood of a premature shuttle return or of medical incidents on-board it results in cost savings.

My motivations are about the future of humanity, astronauts of today will be compared as Vasco da Gama or Fernão de Magalhães were five centuries ago. In few years space travel will be as common as travelling by airplane in these days.

As I had the opportunity to study aerospace medicine in NASA and UTMB– University of Texas Medical Branch and to be in contact with this “special world” and the preparation that is being done for astronauts, and I do belong to the executive board of SMAPOR – Portuguese Aerospace Medical Society which studies the human space factors. .

The idea would be to create a conceptual model of aerospace medical center – AMC - for future commercial space travelers and to present an economic and business rationale for why this is a field that deserves increasing attention by entrepreneurs and decision-makers.

3 MAIN QUESTION

Economic viability and advantageous impact of an implantation of an Aerospace Medical Center; AMC Business Model Canvas

3.1 Objective

This paper has two main objectives. First, it proposes a set of research dimensions for the further investigation of a potential creation of an Aerospace Medical Center in the emerging space tourism industry; and, second, it examines the perceptions of potential space travel participants on key factors that influence their motivation, behaviour and decision-making.

The first objective is to introduce a business rationale for the inception of a Aerospace Medical Center that could be used by Tourism Space Companies to clinically evaluate and prepare the commercial space flights participants to be fit to fly in sub-orbital or orbital flights.

To design a model for check-in, accommodation, medical care, physical and psychological preparation, food, logistics and development potential, that could be used by space companies to prepare passengers for different kind of suborbital or orbital flights, and its economic value and viability.

The main goal consists in analyzing if the Aerospace Medical Center – AMC – would be economically viable and what would be the potential costs of the process inherent to the service and necessary infrastructure through the use of indicators and available data in order to lead to their optimization and continuous improvement.

Space tourism is a natural, but complex, extension of today's worldwide tourism industry. Instead of traveling around the world, tourists go to space. Anyone will be able to buy a ticket. No astronaut training is needed. This has not happened yet, but a lot of activities are taking place in the world today to make it come true.

Space tourism may be the missing link of space travel that we have been trying to discover for so many years. With the help of space tourism, we can build an infrastructure in space and radically decrease the launch costs. There can be hundreds of thousands of space tourists flying each year, creating a giant market. Through this infrastructure, other commercial ventures will also be possible. Space will finally be opened up for business.

4 METHODOLOGY

The methodology adopted in this study involved collecting quantitative and qualitative data gathered by extensive bibliography research and interviewing and formal and informal meetings with key informants connected to the aviation sector, aviation physiology, space tourism industry including: Virgin Galactic, FAA, EASA, AsMA, SMAPOR, ANAC, FAP, TAP Air Portugal, Centro de Medicina Aeronáutica do Hospital Lusíadas Porto, with whom I have met or worked with as a aerospace doctor in TAP Air Portugal and AME EASA to understand their views on people's motivations, perceptions and the future of the industry.

*

5 INNOVATIVE CONTRIBUTIONS – DIFFERENCE FROM OTHER WORKS

On the edge of a disruptive business, this work intends to show some of the necessary resources and factors needed to the kickstart of space tourism. There is a new market to be explored and an opportunity for private space medicine to develop. This business model canvas pretends to open the door to estimate the values and costs involved in this activity. Those facts have not been studied and this study should be looked as a kickstart to future works and decision-makers.

It will allow to innovate and improve in Aerospace Medicine Economics.

6 BUSINESS MODEL

To evaluate the business potential of an Aerospace Medical Center, I have based my analysis on the commercial space flight business model of Virgin Galactic ⁽⁷⁾⁽⁸⁾. Results from prospective projects and future markets are always difficult to consider. Projections fail many times, and in this case, that is boosted by the fact that we are dealing with totally uncertainty. As the data is not available yet, this worked is based on the Virgin Galactic projections for space tourism. Virgin Galactic, along with two other companies (SpaceX and BlueOrigin), has taken advantage of the new regulation and has filed for and received the required permits to provide suborbital space tourism. Virgin Galactic is considered to be a first mover in this field and an example to follow. Their customers, according to the research done by the Futron Corporation for NASA, fall in a very specific range of people in the U.S.: millionaires that are employed full-time (61%), are married (100%), are mostly men (94%) and with an average age around 54. There is an estimated 5.6 million people that fall within the first requirement of being able to pay for the flight. Of these, only 10% have an interest in space flight and it is estimated that 10% of these will actually take a flight into space ⁽¹⁵⁾.

This gives us a potential 56,000 customers eager to fly into space and who can afford it. Virgin Galactic is planning on sending 600 of these customers a year into space.

The other companies that have filed for and received permits are Space Adventures, SpaceX, Blue Origin and Incredible Adventures. The latter has been around for a while and is currently providing customers with other tours. Virgin Galactic's primary advantage over these competitors is its plan to offer more than just the space flight. It plans on offering a full first-class vacation, along with the needed training and medical testing for a cost of \$200,000 to \$250,000 ⁽⁸⁾⁽²⁶⁾⁽²⁷⁾.

VG Business Plan joke

Don't know how long this project's going to last, don't know when the product's going to be delivered; don't know what it's going to look like; don't really know much about what it's going to be like for you on board; don't whether you're going to be eligible to fly, because don't understand too much about the fitness requirements... but if you want to join, we need \$200,000 to \$250,000 up front!

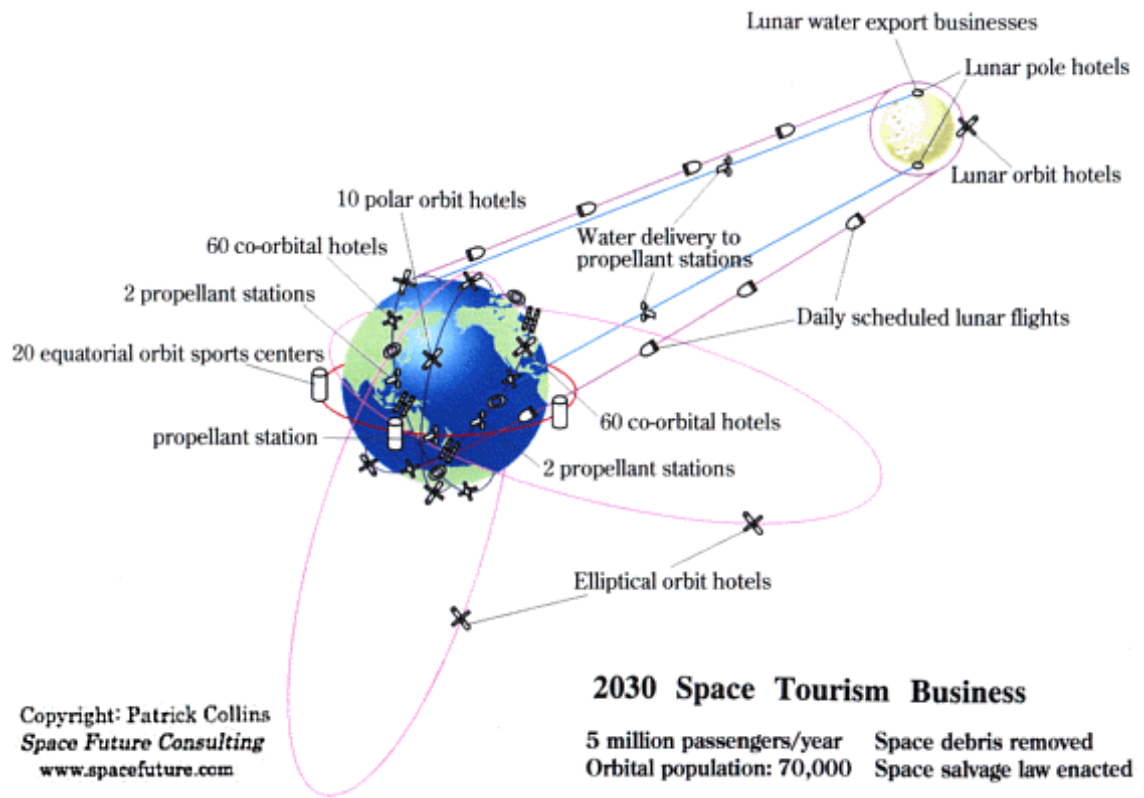


Figure 3 | Space tourism future (2030) business ⁽²⁸⁾

7 BUSINESS MODEL CANVAS

Table 1 | Business Model Canvas

Business Model Canvas		Designed for: AMC	Designed by: Pedro Caetano	Date: 08-2019	Version: 1.2
Key Partners Space Companies State Agencies Universities Medical Clinics Insurance Medical Suppliers Investors Tech companies	Key Activities Health Care Resort Training Partnerships Human Space Management Key Resources Expertise Employees Tech Talent	Value Propositions Solve a necessity Problem solving Cost-effective Specialized Human Space Flight Safety	Customer Relationships Partnerships Direct Protocols Unique experience Channels Partnerships Medical Community	Customer Segments Space companies State Agencies Participants (SFP) Universities Space Tech companies	
Cost Structure Infrastructure Hospital Professional service Expertise medical professionals Medical equipment and supplies Maintenance Employees Utilities R&D Taxes			Revenue Structure Usage fee, Subscription Billing from ticket trip Fixed Pricing: List Price, Customer segment dependent,		

8 BUSINESS PLAN CANVAS

8.1 Key partners

The first key partners for an AMC would be space tourism companies such as Virgin Galactic, SpaceX or BlueOrigin in USA or Space Adventures in Russia or Israel. Those companies will include in their package the medical evaluation prior to fly. It's a necessary step and as the space companies need to guarantee that everything goes as planned, including human health factors, to consider the comorbidities of their customers is a must do. It will be a requirement to do a medical check-up, training and preparation to in-flight health problems and pos-flight rehabilitation. Consequently, all the companies related with space tourism business would be partners by inference.

The institutional space Agencies as NASA, JAXA, Canadian Space Agency, ESA, Portugal Space, would also play a major role in the activities establishing collaborations on research and development.

Strategic partnerships have to be created so that private and institutional companies can use the AMC as a Space Clinic in order to send their customers to pre-flight evaluation, in-flight countermeasures and pos-flight rehabilitation if needed and for research purposes.

Investors and Venture Capitalists would play a big role in the development and construction of AMC and could have a share of the profits.

The medical scientific community would be a great asset as AMC would be the center of reference to whom the doctors would recommend their patients.

Regulators, such as the FAA and ESAM have to provide guidelines and regulation in order for passengers to be fit to fly.

Third party suppliers and health equipment's auxiliary suppliers would have to be taken in consideration for the normal function of a Space Clinic.

Research and Academic institutions like Kings College, Mayo Clinic, UTMB and other Universities as well as Life Science companies can collaborate directly with AMC with PhD and Pos-Doc in human factors space research fields

Health insurance companies will be very important as most of the forecasted participants will be millionaires with huge life insurance policies ⁽²⁹⁾ and although those companies will

probably be reluctant to participate in such a risky business, there will be scope to charge high premia.

The issue of insurance is one of the most crucial and most frequent problems. Insurance premia will be quite expensive and might not even be initially available to the space industry. The liability is so great that most insurance companies would not want to risk being exposed to such an environment⁽²⁹⁾⁽³⁰⁾. Standards are an important part of space tourism; licenses, certifications, safety requirements and building codes must be established to create rules under which governments, businesses and space tourists will function. Within space tourism, risk perception is not entirely accurate; the activity is perceived much riskier than it actually is. It is not to say that there are not real risks involved, yet risk perception by investors and the public seems to be greater than necessary.

Collaboration with the local government (example. Azores) of major tourism attractions and buy their land to place the AMC.

Tv, radio, internet, printed material channels covering or featuring lifestyle/travel editorials.

Think as a B2B where probably partnerships with space companies would be the major part, but in case of not happening by one or more space tourism company (if one included the pre-flight check-up the others will follow because health is a big concern for their customers)⁽³¹⁾ it could be possible to do it B2C because participants and customer segments are worried by their health conditions would look by themselves for the AMC.

There are many different motivations for these partnerships:

Health factors play a major role and are big concern for all space community, safety and prevention should be the standard in commercial space flights.

There is a need of a specialized clinic, to evaluate and prepare for an extreme environment and also as it happens in other health economic field's sometimes "offer/supply provides the demand".

Space tourism companies could save costs outsourcing their Medical Clinic instead of having their own with all the costs, time and resources necessary to do it, so it would be more cost effective.

8.2 Key activities

There are several key activities that an AMC value proposition require.

Quality in health care prevention and training and value of safeness are the most important. There is no doubt that SFP don't want to take risks. To be secure that participants are having the best up to date medical examination in this field is a must, in order to minimize any health problem that could occur. This specialized clinical care would also make SFP to feel less anxious about their radical activity and to feel safer during the flight.

Nevertheless, first class customer experience for this segment has to be an asset, the participants would probably be used to a high-class facilities and services, and to be a reference these aspects should be considered.

The core service of AMC is a health check-up and preparation for a tourism space flight to an apex beyond Earth's atmosphere, wrapped in a three-day/week astronaut experience.

For a low price of \$200,000 Virgin Galactic is offering its customers a exclusive space flight experience⁽³⁰⁾.

Prepare to this flight is necessary and should cost between \$8500 to \$11500 to the AMC and \$15000 to \$18000 to space companies.

Research and development will be a very important issue in the AMC reputation and quality because of the top class technology demands on this business. Medical science and to be able to lead research programs in this business will be a way to capture the best brains to develop even more the clinic and to outstand the competitors. Together with data analysis/database of customers it would turn this industry safer for the community. Medical community is also a great way to boost their awareness and customer consideration level

Alliances and partnerships with space companies, institutions, universities and media will be essential, because as the more the registered customers and companies, the more the cost-effective the center will be.

Search history data from Google, Yahoo, Bing can be used to spot potential new users.

Endorse big-name celebs: a way to hype up and deliver credibility.

Photos and videos of training and space suits would be also necessary to turn a medical check-up in a keen experience.

8.2.1 AMC Service

For sub-orbital space tourism, after the ticket is booked the space company operator will direct the customer to the AMC in order to perform a pre-flight medical examination. For sub-orbital medical examinations, the requirements are not as stringent as with orbital flights. The moment the participant arrives to the AMC should be felt as a luxury one-of-a-kind preparation experience.

It would begin with an extensive medical check-up, dietary work-up and informative pre-flight familiarization. The purpose of these checks is to medical evaluate and ensure that a customer does not get sick or at risk during the flight.

In cases where customers fail a medical examination, they may appeal or be referred to another medical specialty to receive treatment or preparation.

The standard medical exam should include the following tests:⁽³²⁾:

- Vision: tests are performed for near vision, intermediate vision and colour vision;
- Hearing: should be able to distinguish a conversational voice within a range of 2 meters;
- Pulse rate: will resolve if there are any imbalances within the cardiovascular system;
- Blood pressure: if on average it is greater than 155/95 mm Hg, it might have to be treated;
- Psychiatric evaluation: if a customer experiences psychosis, bipolar disorder, severe personality disorder, epilepsy or similar disorders, they would not be eligible to participate;
- Dental examination: customer provides X-rays not older than 2 years.
- A customer would be considered inapt and immediately disqualified from participating in a space flight if suffering from any of the following conditions: ⁽³²⁾
- Illegal substance abuse: abuse of substances such alcohol, sedatives and/or illegal drugs in the previous to 2 years;
- Diabetes mellitus: customer requiring hypoglycaemic medication used in type 2 diabetes, which is resistance to body's secreted insulin;
- Coronary heart disease: customer suffering build-up of plaque in coronary arteries, which may result in angina or a heart attack;

- Myocardial infarction: irreversible necrosis of the heart muscle, which may result in heart stroke or heart attack;
- Cardiac valve replacement: customer had heart surgery to replace heart valves;
- Permanent cardiac pacemaker: customer had heart surgery and a pacemaker implanted due to an irregular or slow heart beat;
- Heart transplant: customer had surgery to replace their heart;
- Severe psychosis: if a customer experiences psychosis, bipolar disorder, severe personality disorder, epilepsy or similar disorders, they are no longer eligible⁽³²⁾.

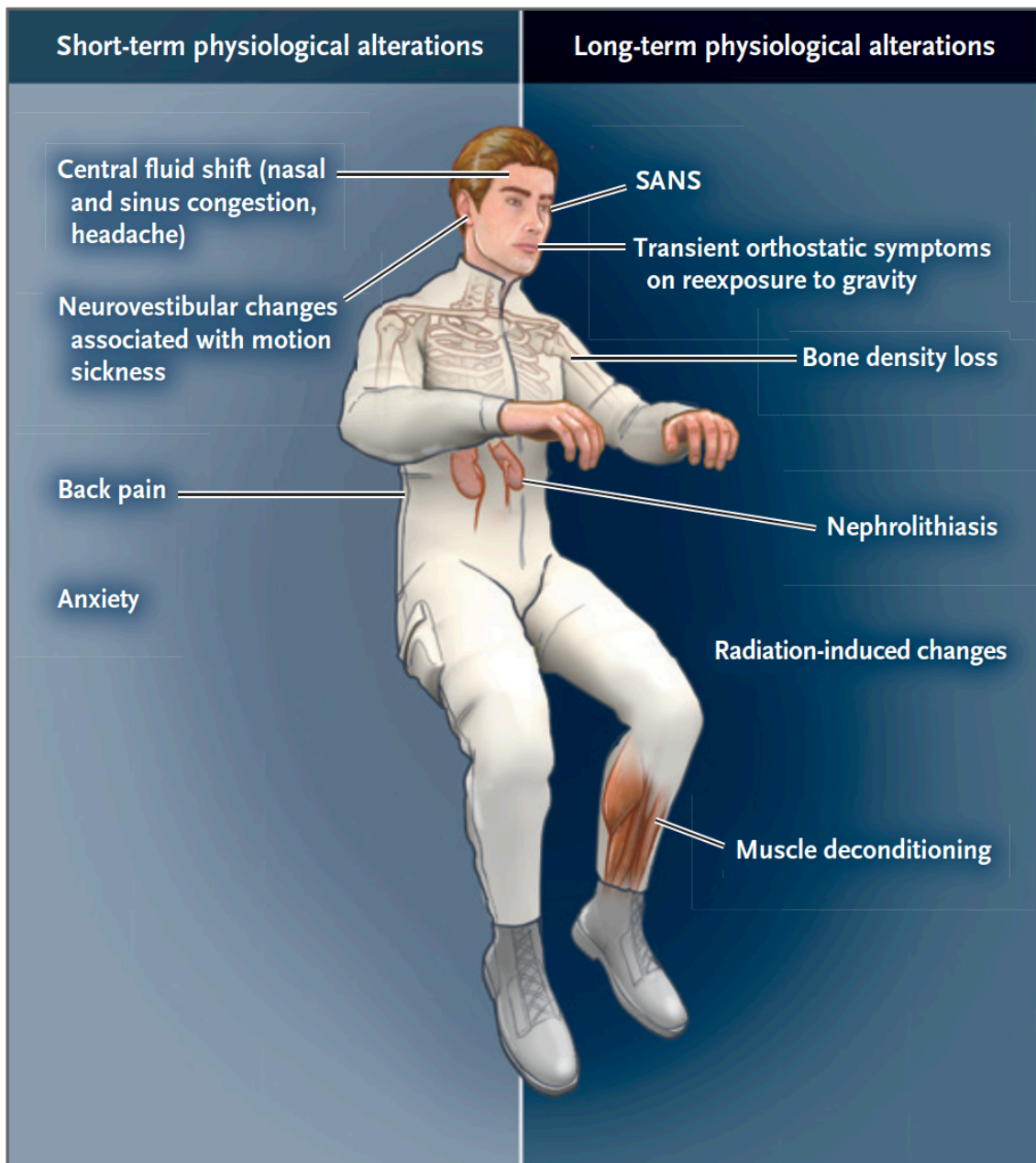


Figure 4 | Health Conditions ⁽¹⁶⁾

After a customer passes the medical requirements, the training period may begin.

The type of training is greatly influenced by the type of spacecraft the operator uses. For instance, Virgin Galactic does not require any type of space suits and has no emergency egress procedure, while other sub-orbital operators might have one. The general outlook of sub-orbital training would encompass familiarity with the spacecraft, the space environment and the crew as well as passengers.

Consequently, the space flight procedure manual would be studied in detail. At this moment, the education on space activity would begin. Future space flight participants would study things such as the history of the first astronauts, space flight theory and rocket engines, how the vehicle performs and more specific technical details. Further knowledge would be acquired in physiology, survival training and high-altitude functions. The last part of the training would be concluded with the g-tolerance experience. ⁽³²⁾

The whole training process would be a combination of studying the given material, performance tests and lectures by professionals, who might even include some famous astronauts.

To be truly well-prepared for the upcoming space flight the high-altitude training will deal mostly with emergency protocol and recognizing the signs of such an event; this is probably one of the most important parts of the entire program.

So, the entire program should include:

- 1- an upper-class flight transportation from the airport to the space resort will be on one executive jet;
- 2- customer arrives at the space clinic/resort, they will begin the flight preparation. This includes G-Force Tolerance training, talking to the experts in the space industry, flight simulation experience and then dinner with other flight customers;
- 3- customer will have the opportunity to experience negative gravity, ride in fast jets and watch other launches leave the Earth. Some passengers may even get a parabolic flight and watch another group of tourist rocket into space ⁽³³⁾.

After training, when a customer passes the test, they will receive a Space Flight Medical Certificate and be eligible to partake in the flight. Video and photographic images of the customer's moment in space training will be given to them to share with family and friends.

All those activities are important the in terms of distribution channels, customer relationships and revenue stream.

8.3 Key resources

The most important resources for AMC business are expertise and network. Due to the differentiation of this service, to have the best human and technological resources would be an asset. First because would represent more confident, performing all the examination and training during check-up and preparation, and would lower the risk of failure. Second because to be a reference in this area would be a important competitive factor with other clinics.

To summarize as we pretend a differentiated health care facility, employees will play a very important role. Creative and innovative professionals who can deliver trust, quality and a trustful image from preparation and the training to make sure AMC has the best space medical care.

Network with partners and state institutions would be essential to the business. To make protocols with the space companies to deliver our service is the key to AMC to be successful and good connects with those directors and space industry would help to ensure passengers would be directed to this space clinic.

Together with regulators (FAA and EASA) a protocol should be established with minimum medical standards for passengers and crew, and a proper accreditation of AMC should be obtained⁽¹¹⁾.

To be an impartial independent clinic will help to create reputation and to differentiate from other competitor clinics. Location and independence would also be relevant criteria. If the AMC is established in a good location, with easy access, independent from governmental main players as US or Russia and relatively close to a spaceport (less than 6 hours flight), between USA and Europe to provide a base for both continents would be an advantage. (Azores, Portugal; Alcantara, Brazil or Kourou French Guiana), or (Christmas Islands, Australia) and (Tanegashima, Japan) for Asia/Oceania might be considered as good locations.

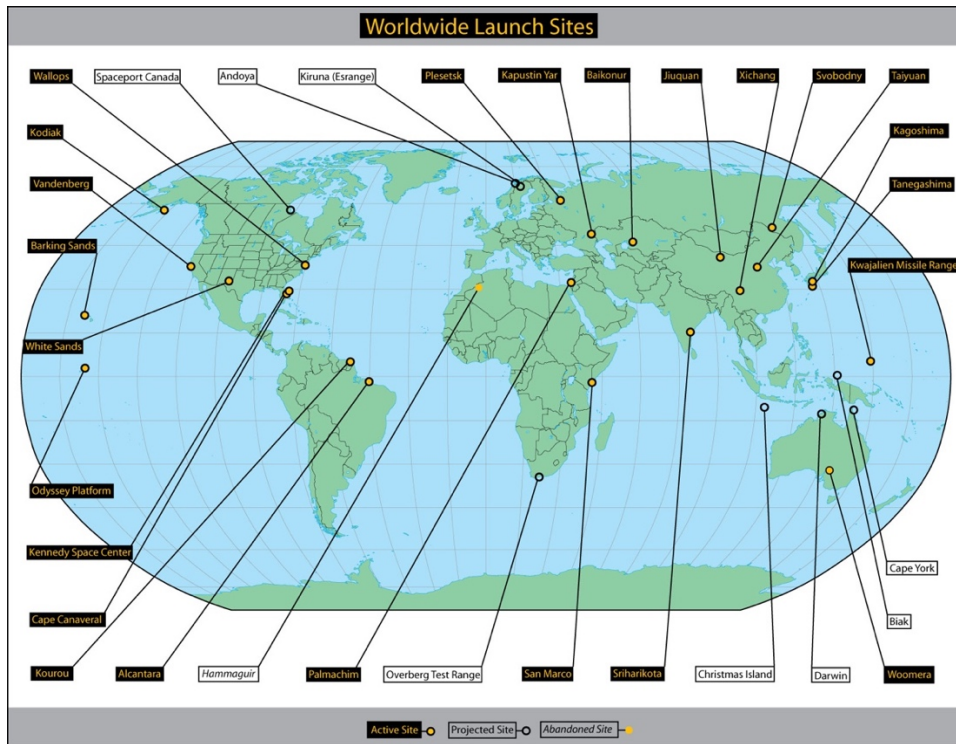


Figure 5 | Launch locations ⁽³⁴⁾

8.4 Value proposition

AMC will offer three essential attributes: accessibility, quality, and safety.

The organization will be easily accessible to the SFP giving him the best way to perform the medical examination and preparation, scheduling with him the best time and being 24h there for any doubt that may have. Accessibility will also give space companies a chance to have common people with comorbidities looking for space travelling, while before just very selected people would manage to go.

AMC will exhibit solid quality health care. It will be referred by different actors, including being the main Space Health Center to medically examine and prepare SFP to the Space tours.

AMC should manufacture a solid brand. As the principal health facility effectively investigate space travel, it is entrenched and surely understood. It would increase further noticeable quality through its relationship with other institutional agencies and universities.

The main goal of AMC is to be a safe and secure medical examination and preparation health facility service to check if participants are fit to fly and to give clearance to the space tour. That service is the need that we are satisfying to the space customers.

As the space-faring population shifts from highly screened astronauts to lay participants who may have preexisting medical conditions, there will be a shift in the medicolegal considerations and liability for the space industry as a whole.

Although the goal of the commercial spaceflight industry has been to expand access to space and aim for inclusiveness in participation, there is some concern that persons with a clinically significant medical history may not be able to tolerate the stressors of flight.

There is a need to balance the desire to protect laypersons who have medical conditions by restricting their access to spaceflight with respect for their autonomy in making decisions regarding risk, informed consent, and participation despite potential adverse outcomes.

Participants would feel better knowing their health condition and that they are fit to fly.

One-of-a-kind stay experience where they have their needs satisfied with the best possible stay experience

The Futron survey attempts to measure the respondent's perception and participation of risky activities. The reason for this is that space travel is intrinsically risky.⁽³⁰⁾ When asked to rank where space travel fell in the above listed activities, the respondents ranked it third (Skydiving and Mountain Climbing came in higher than spaceflight)⁽³⁵⁾.

Space tourism faces many challenges to be resolved ⁽³⁶⁾. There are significant obstructions to healthy development of space tourism and at the same time to making it a profitable industry.

It is a on-demand business nature and both sides get what they want (safeness and clearance to fly) with great matching by the two parties. The proposition is to be Europe's leading space medicine operator and, if possible, the world's largest space medicine services provider, with an innovative approach to the participant delivering high quality differentiated health care service on a once in a lifetime experience.

In this model we don't expect economies of scope but as more partnerships are created with other companies are created we can think about the advantage of the economies of scale.

The objective is also to be a leader in advanced medical research with projects and services for research and health care due to the creation of partnerships with state agencies, academic universities, research institutions and start-up companies that want to develop their business.

It should have the convenience to be also a resort experience for future passengers and their families and the number one clinic to be referred to by space companies when participants are planning the sub-orbital or orbital flight or having a post-flight incident.

To summarize this proposition will be unique from current solutions because it would be designed and specialized for that activity and to maintain its competitive advantage in the future once new competitors enter the marketplace should stay updated with the latest innovation in space medicine and technology and to gain reputation after few years for one hand for being a first mover and there is of course a learning curve.

The main attraction for this service is in differentiation as the AMC would offer a complete medical specialized space medicine check-up/vacation/training package, something that the direct competitors are not offering yet. Moreover it could have costumers from all commercial space companies, turning into a main point of the pre-flight, and a reference center.

8.5 Customer relationship

Our customers are our partners this is a B2B business. The provided service that AMC is offering is an essential service to their business. Based on health considerations standards and in which a regulation basis may also contribute to this routine, participants should think it as step necessary in order to complete the tour. Of course users' experience and previous stays, does a great job recommending a one-of-a-kind place for users, Since it is essentially a B to B platform, it is supposed that can easily get into communication with both parties⁽³⁰⁾.

AMC is offering a “forward thinking healthcare” with a specialized expertise of a clinic/hospital operator, with hotel customer experience based on quality and trust between partners. Since it is essentially a B to B platform, it is supposed that can easily get into communication with both parts.

It should add effort to be recommended by medical community, and be a global center used by customers from different parts of the world, providing also an intercultural experience.

Should also aim technological automated tools and services and advertise their development.

Promotions and loyalty program will not be implemented as it should be an inelastic-price service.

Social Media would be great at generating awareness and hyping up the brand via social media channels.

8.6 Distribution channels

In terms of reaching the customers and participants, the main distribution channel will be the space companies, by corporative contact. Participants will have to have clearance and due to that they will be send for evaluation.

The medical examination and preparation is to be included in the price of the trip as a package. Nevertheless, space tourists can do it by themselves if willing to or even would want to be accompanied by their family to make them be part of the experience (the preparation and the time spend in the Space Clinic Resort would be an experience by itself), but it won't be the norm, although some insurance companies might have a demand themselves.

Basically, customers will be reached because it is a necessary step in order to complete their goal, it will integrate in customers and space companies' routine.

Hospitals and universities will have their own way to communicate with the AMC, by institutional relationships.

AMC should also have some complementary assets and establish links with the following industries: media, communications, transportation, tourism, publishing, retailing and financial services. Offering an array of different products in and from different industries with world-wide name recognition will facilitate AMC's goals and capabilities⁽³⁰⁾.

Media can assist in advertising at a low cost and offer the ability to reach already existing customers. The publishing division can assist in bulletins, and articles in local and national papers and magazines. Spending such a high rate for a once-in-a-life time experience, customers will be looking also for memorabilia (space snack packs/pictures).

Financial services can assist AMC by offering customers the ability to finance the health check-ups and training and trips if needed and thru that profiting from the interest adds margin not only to the space tourism industry but to AMC's financial industry as well.

Transportation allows AMC the ability to either include flight to and from site as part of a package deal or separate travel.

AMCs complementary assets set them apart from the competitors and the key factors to continued success.

8.7 Customer segments

We can consider it is mainly a B to B nature where space companies are the most important customer although the final customer are the space travelers, so in the end our customers would be participants in sub-orbital or orbital touristic space flights, and they will be the ones who evaluates the service.

Preventive medicine stands good for health concerned space travelers and whom simply needs a check-up and training to the tour. People need to feel safe to do a risky activity.

The answer to why would space companies “buy” AMC services is simple. The medical evaluation and training “problem” is what AMC propose solving for the space companies. They may outsource the clinical activity, because it’s not their core value and they can concentrate in their main activities, space travel, it has to be with cost-opportunity and cost-effectiveness.

Based on preventive medicine the AMC is solving a potential problem because physical health of the potential tourist (astronauts) is crucial to space travel where there is limited capability to provide medical support.

Moreover future commercial space flights passengers will be willing to do it as safely as possible, as it is a considered risk activity as Futron studied showed ⁽²⁹⁾

As we are leading with regular people with comorbidities, physical fitness and training preparation are essential to accomplish the goal.

8.7.1 Physical fitness

Flying into space takes very high speeds and may also demand high accelerations depending on the type of rocket used. The early astronauts were test pilots in excellent physical shape, because no one was sure of what they would experience.

5 G is about the maximum a person can take standing up. Beyond that the blood pressure in the head is so low that there will be a shortage of oxygen supply to the brain.

Space sickness, sometimes when astronauts are in space, they feel sick and may even vomit. This is called space sickness and is caused by the same reasons that people get sick while riding in a car or on a boat. A conflict arises between what the eyes are telling the brain and

what the inner ear is telling the brain about the bodily position. Inside a ship you may not see that you are moving but your inner ear tells you that you are⁽³³⁾⁽³⁷⁾.

The reasons for space sickness and other similar illnesses are not fully understood. Nevertheless, it is believed that it can be treated to a sufficient level with some kind of motion sickness medicines. This may be enough for space tourists to enjoy their flight.

Table 2 | Medical and Environmental Challenges According to the Type of Spaceflight⁽¹⁶⁾

Mission Profile	Medical Challenges		Environmental Challenges
	Short-Term	Long-Term	
Suborbital spaceflight	Anxiety, psychological factors, space motion sickness, hypocapnia	Minimal	Noise, vibration, acceleration forces, confinement, microgravity
Low Earth orbit			
Short sojourn (<48 hr)	Anxiety, psychological factors, space motion sickness, hypocapnia	Minimal	Microgravity adaptation: fluid shifts resulting in headache, congestion; low back pain from spinal elongation
Longer sojourn (≥48 hr)	Altered T-cell function, plasma-volume shifts, neurovestibular deconditioning, cardiovascular deconditioning, SANS	Mild radiation-induced changes, SANS (risk proportional to flight duration)	Microgravity
Beyond low Earth orbit			
Lunar (1–2 wk)	Neurovestibular deconditioning, cardiovascular deconditioning, plasma-volume shifts, SANS, radiation-induced changes	Radiation-induced changes, SANS	Microgravity, radiation, isolation
Planetary (>12 mo)	Radiation-induced changes, altered nutritional status, neurovestibular deconditioning, bone and muscle loss, renal-stone formation, plasma-volume shifts, SANS, altered immunity	Radiation-induced changes, altered musculoskeletal system, SANS	Microgravity, radiation, isolation

8.7.2 Preparation

There is much to be done before a flight launches into sub-orbit or orbit. Depending on the space operator and type of the vehicle used, the procedure should be more or less the same as the preparation for space flight. Upon contacting a tourist agency or an operator directly and making a booking, the customer will have to go through medical examinations and a training procedure. The training one receives, would last from 3 days to 2 weeks for sub-orbital trips, while for orbital trips at present the training is anywhere from one year to two years. In the future, orbital flights will require such training to be less time consuming as to appeal to a wider variety of customers. Those who will sign up for an orbital trip are presumably rich as the trip itself is quite expensive, and these individuals tend to have time constraints which need to be taken into account⁽³³⁾⁽¹²⁾.

The FAA is responsible for the regulation of commercial space transportation in the United States and has commissioned studies of human health and performance in commercial spaceflight⁽³³⁾. During training the participants will be subjected to centrifuge tests simulating the acceleration profiles (+Gx and +Gz) that are expected to occur on suborbital spaceflights. The participants may range from all ages and have a large variety of stable medical conditions that are prevalent in the general population, including hypertension, pulmonary disease, stable coronary artery disease, and diabetes; some of the participants might take medications to treat their disorders. Participants with well-controlled medical conditions will be able to physiologically tolerate the acceleration profiles in the centrifuge without difficulty.

The importance of gathering and publishing data from the training of prospective spaceflight participants in order to inform and enhance safety and mitigate risks cannot be overstated. Even so, it is likely that many advances in our understanding of how the average person performs during spaceflight will be achieved only after commercial spaceflight becomes more commonplace and aggregate data are gathered and reported in the medical literature.

The challenge for space medicine professionals' rests in the limited amount of time they will be able to spend with commercial spaceflight participants, whereas members of the medical support staff work closely with professional astronauts and spend many months training as a team. The Code of Federal Regulations stipulates that the training of prospective spaceflight participants is to be focused on their ability "to be able to respond in case of an emergency." There are no specified training requirements beyond that generic statement⁽¹⁶⁾⁽³⁷⁾.

In research business, a strong collaboration among future spaceflight participants, the clinicians who care for them, and the industry operators is necessary to understand the risks for individual participants, their capacity for informed consent, and their training needs in order to ensure an appropriate response in the case of an emergency.

The preparation and training will certainly be less rigorous for a short suborbital flight than for an extended stay in low Earth orbit or a lunar mission.

Participants in suborbital spaceflight will need some degree of team training and practice of emergency procedures; they also will possibly need training in an analogue environment,

such as centrifuge exposures, parabolic flights, and altitude-chamber training, to become familiar with environmental stressors and life-support systems.

Participants in longer-duration missions, especially persons with preexisting health conditions who are critically reliant on a healthy immune system, may also be subject to the known effects of the spaceflight environment (thought to be mediated by radiation and stress responses) on immune function. On the basis of current data, it is difficult to definitively discern which factors in humans appear to be the root cause for some of the alterations. Deliberate attention to these aspects in preparation for the spaceflight, medical assessment, and preventive strategies may be warranted. The diagnosis of any clinically significant allergies (e.g., food allergies) before prolonged spaceflights may be of particular importance as well⁽¹⁶⁾.

8.8 Customers

AMC may say it has two customer groups: space companies and space flights participants.

There are two main groups of people that will want to take a trip into space as a tourist:

- 1- people that have a lifelong dream of space travel
- 2- those who want to “be one of the first” to do something.

Both groups are limited by two main reasons:

- 1- by the ability to pay for the luxury of taking a trip into space
- 2- health conditions that may allow or not and should support an extreme environment⁽³⁵⁾.

The Futron Corporation performed its study in the U.S.A. with the purpose of projecting a 20year prognosis of sub-orbital space tourism. It interviewed 450 millionaires and the conclusions of the study were that there is a significant demand for sub-orbital space tourism and that it would continue to grow. 19% of respondents were interested in purchasing a flight to the sub-orbit, while 18% were interested in orbital space flight at price levels of \$20 million to \$25 million. The most interested candidates for sub-orbital flight had an average age of 50, while for the orbital flight the average age was a bit higher at 55 ⁽³⁵⁾.

Incredible Adventure’s study had a different approach to its market research. Through the Incredible Adventure’s website, a poll was offered that visitors to the site could participate in. As visitors to the website might not necessarily be their customers, the survey cannot be

used as a representative sample; however, it offers valuable insights nevertheless. There were 998 respondents; out of those, 14% were millionaires and only 7% actually registered for a sub-orbital flight, where the price in question was between \$100,000 and \$200,000. Moreover, 36% were willing to wait till prices dropped to around \$50,000 to actually buy a ticket, while 47% were willing to wait for advancements in technology for the decrease in price; most likely due to safety and consistency factors to be proved trustworthy. Safety 34 seemed very important to customers; in total 62% of respondents wanted to be assured of an acceptable price and proven safety before they purchased a ticket, nevertheless the study must not be taken at face value, but rather be considered as a rough estimate⁽³⁸⁾

The study also looked at alternative funding for space tourism, as the question in the survey asked if participants would be willing to participate in a lottery to win a trip on a suborbital space flight if the lottery ticket cost \$100. 31% of respondents were willing to try their luck to win a sub-orbital flight, which suggest a viable alternative for funding. Another interesting find was that if prices were disregarded, 56% of participants would choose a trip around the moon as their favourite type of space flight 47% would choose an orbital flight ⁽³⁵⁾⁽³⁸⁾.

After the Futron/Zogby and Incredible Adventure's studies, there was a more detailed and recent market research performed. EADS Astrium, a subsidiary of the Airbus Group, wanted to perform a feasibility study of the potential market for their sub-orbital Spaceplane⁽⁶⁾⁽³⁵⁾⁽³⁸⁾

Market research revealed that there are 5 main groups of space tourists ⁽³⁹⁾⁽⁴⁰⁾:

1. Enthusiastic Elite: group of wealthiest and most interested individuals;
2. Blase Group: almost as wealthy, yet see sub-orbital tourism as just another touristic opportunity for them and therefore are not as passionate;
3. AdventurersGroup: almost as enthusiastic as the Enthusiastic Elite, however it is not as wealthy;
4. Risk Averse Group: interested in the flight, yet concerned with the safety features of the flight and the group needs time for reassurance;
5. Low End High-net Individuals: not interested and concluded that they could not participate on the trip.

In the study shows that in the first year the research found that there would be between 600 and 750 customers while as the market would reach its maturation in 16 years, there would be about 43,000 to 85,000 customers annually ⁽³⁹⁾⁽⁴⁰⁾. These results are intentionally calculated

in the most conservative manner with the present day perception of sub-orbital tourism; many more people might be willing to participate in such space flights, especially after marketing campaigns are initiated and word-of-mouth spreads amongst the targeted population⁽⁴⁰⁾. The three studies have drawn companies to conclude that the market is viable for space tourism and that the demand should grow as prices decrease over time; revenues would also be positive and the business would be an operationally worthy venture. At first only the enthusiastic elite would be drawn to sub-orbital space tourism, as the feeling of being the first, experiencing new technology and being one of the privileged few would bolster their experience. Furthermore, studies have shown that not only is there interest in sub-orbital tourism, but also that customers are willing to spend at least up to three months salary for the experience. It seems that by nationality the most interested candidates are Americans and Chinese, while Europeans are the most risk averse. There are estimates that 20% of Americans who have a net-wealth between \$20 million and \$50 million would be eager to participate in sub-orbital flights and 50% of those with a net wealth above \$50 million would be⁽⁴⁰⁾.

The studies show that after the pioneering effect subsides and the safety factor is established, sub-orbital space tourism would be a tourist experience many would want, at least within the scope of luxury tourism; even those who cannot afford it would be willing to save up the necessary funds to be able to partake in it. Such type of tourism would apply to customers who perceive themselves as happy, adventurous, influential and privileged. These types of customers are looking for an experience that would either satisfy their social rank or experience something truly out of this world⁽²⁹⁾.

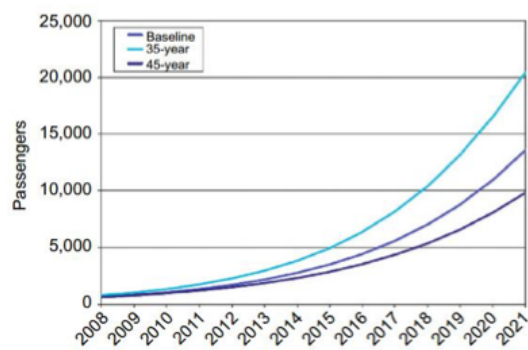


Figure 6 | Passengers demand⁽³⁶⁾

8.9 Competitors

Competitors: Governmental Organizations:

NASA, ESA, and more than 9 countries have manned missions orbital launch capabilities.

New Entrants: Private Companies such as SpaceX, Blue Origin, Virgin Galactic, Bigelow Aerospace, Stratolaunch, Rocket Lab, and Planetary Resources to name a few.

Supply Chain: NASA recently announced that the International Space Station will be open for commercial business for an approximate cost of \$52M. Starting in 2020, Astro-preneurs with deep pockets can use the ISS for off-earth research or tourism⁽⁴¹⁾.

We can analyze AMC supply chain and industry forces. Not only will other space companies and governments be able to take a ride, but anyone with the budget and a business plan, could launch a medical space business.

In this business model, the direct competitors are space tourism companies involved with space travel that already announced suborbital space tourism agreements and have estimated to start operational flights⁽⁴¹⁾.

There are other Space Medicine institutions that currently work in research programs (UTMB; MayoClinic; KingsCollege; DLR) that might have a word to say in commercial space health.

Also, there are other countries emerging as major providers of suborbital launch services, which include Norway, Japan, Brazil, India and Canada.

There are also the national institutions like NASA, ESA or JAXA, that may want to play a role with commercial business.

Based on the above criteria, the two direct competitors are Virgin Galactic, Space Adventures and Incredible Ventures as long with SpaceX and BlueOrigin. Although they are focus on the Space flights and their core business it's not the health preparation and support. At the moment there are not AMCs like the one it is proposed.

The following tables present the SWOT analysis for the three direct competitors.

Table 3 | Commercial Space Companies – SWOT Competitors

Commercial Space Companies	STRENGTHS	WEAKNESSES
	<ul style="list-style-type: none"> • Strategic partnerships: international reseller network, leading aerospace organizations and international government agencies⁷ • Early promotion to create solid customer base that includes corporate buyers, support from celebrity clients and media clients 	<ul style="list-style-type: none"> • Extensive and varied program • Pricing strategy: underestimating real cost • Focus: Space Tourism not health • No health care experience • Capacity: allowance of for their own flights • Are still in development
	OPPORTUNITIES	THREATS
	<ul style="list-style-type: none"> • US legislators regulatory framework facilitating increase interest in space tourism • Market for suborbital flight is open and unexploited • High level of investors interest in entrepreneurial ventures 	<ul style="list-style-type: none"> • Other companies may beat them and gain position and higher market share

Table 4 | State Agencies – SWOT Competitors

State/Governmental Agencies	STRENGTHS	WEAKNESSES
	<ul style="list-style-type: none"> • Strategic partnerships: international reseller network, leading aerospace organizations and international government agencies⁷ • Early promotion to create solid customer base that includes corporate buyers, support from celebrity clients and media clients⁸ 	<ul style="list-style-type: none"> • Extensive and varied program • Pricing strategy: underestimating real cost • Focus: Professional Missions • XCOR Aerospace technology not yet proven to public • No commercial business • Bureaucracy
	OPPORTUNITIES	THREATS
	<ul style="list-style-type: none"> • US legislators regulatory framework facilitating increase interest in space tourism • Market for suborbital flight is open and unexploited • High level of investors interest in entrepreneurial ventures 	<ul style="list-style-type: none"> • Other companies may beat state agencies to health market and gain position and higher market share • Commercial Space Companies

Table 5 | Health Clinics – SWOT Competitors

Health Clinics	STRENGTHS	WEAKNESSES
	<ul style="list-style-type: none"> • Core business experience • Working clinics 	<ul style="list-style-type: none"> • Pricing strategy: underestimating real cost • Capacity: allowance for their own treatments • No strategic partnerships with well established aerospace company • No innovation plan • Not focus on Space Medicine
	OPPORTUNITIES	THREATS
	<ul style="list-style-type: none"> • US legislators regulatory framework facilitating increase interest in space tourism • Expand business • Marketing and reputation for the clinic and other specialties • Market for suborbital flight is open and unexploited • High level of investors interest in entrepreneurial venture 	<ul style="list-style-type: none"> • Other companies may beat health clinics to health market and gain position and higher market share

AMC is the first mover in the SRLV health market. This gives them the advantage of setting the base for what a customer will expect in return for the costs paid. Therefore it is possible that potential entrants into the market will need to gain their competitive advantage through differentiation or taking the lead as the low cost leader in the market and a close substitute by offering a less luxurious package for the tourist⁽³⁰⁾.

Potential entrants may also have an advantage by not being the first mover. This is possible through their observation of AMC as the first mover, because there is a learning curve. It is the goal of entrants to catch and surpass the leader. These entrants will not only be able to learn from AMC in the advancement of their technology for the suborbital training but can look at their costs. Through observing the process of AMC, the competitors can learn and find ways to cut costs even more. If competitors can create a lower cost, new entrants will be able to enter the industry easier. However, new entrants must be careful not to cause saturation of the market. Too much saturation will leave the entire industry in a race to the bottom and companies will be struggling to keep hold of their market share.

AMC has something that its competitors do not, is a specialized clinic for that business. It would stand for its hip, value for the money, quality, innovation, fun, consumer-friendly image, exceptional service, and a sense of competitive challenge. As a result, AMC would be able to gain the attention and confidence from the media and the public in order to achieve its goals.

Also, based on multiple and varied businesses, AMC should be able to develop synergetic effects that has put the company in an advantaged position over its competitors, making deals and partnerships. Should use the resources of other companies, to achieve its marketing strategy at a lower cost than its competitors. Second, it depends on experienced doctors and health care providers to develop the training program. Some of these doctors worked in state institutes like NASA. Third, AMC should have a very successful businesses in traveling and entertainment that will allow it to offer a very high quality and attractive program at a much lower cost than its competitors.

Each worker should share the same ideas; values; interests and goals; and is encouraged to work with the other companies in the group to solve problems and pass along solutions.

Financing is another core competence for AMC. Investors should be wealthy and can put as much funding as needed to ensure that AMC will succeed.

8.10 Cost structure (direct, variable, indirect)

As a clinic or resort, AMC would mostly have fixed costs that do no vary significantly with each new client.

Major fixed costs would include wages and benefits, amortization of the building and equipment, insurance and tech services. Advertising, utilities, taxes and interests would be next. To ensure the medical expertise professionals and quality medical tech equipment would be the biggest direct cost to the AMC as it is for other clinics and hospitals. That means that this business is heavily dependent on human resources: needs to keep those highly differentiated and specialized talents to sustain its success.

R&D would be the major variable costs as long with utilities.

Within staff there is a need for sales & marketing teams to work with the below segments

- 1) Key Partners - (Space Companies; Institutional Agencies)

- 2) Consumers - market our services and educate end users on the value of using our product.
- 3) Insurance Companies

Being a luxury industry, the quality of all resources, ranging from the health clinic to customer accommodations, has to be of the highest quality. This is true for the entire industry.

If companies like Virgin Galactic and others plans on putting many people into space each year, this will eventually drive down the costs of the check-ups and training as the technology and scale of market improves.

In many cases, the cost structure is going to be like that of a private clinic/hospital with a small resort. The fixed costs are the human resources (doctors, nurses, staff), the buildings for the resort, and the buildings for the space clinic and instruments.

The total investment cost is estimated to be around \$30,000,000⁽⁴²⁾, if we take \$1,500,000 “per bed” in a average hospital, although this AMC would be something between a hospital and a clinic, with special medical specialties for training and instruments as Barany Chair, Centrifuge, swimming pool, but without several departments as a normal hospital (ER; Obstetrics; Etc). It should be designed with high quality materials and high standard resort style, that might cost around \$15,000,000 to \$20,000,000 with an average of 20-25 suits/rooms⁽⁴³⁾. The total estimate price would be between \$25,000,000 to \$30,000,000.

The variable costs are those that are incurred by each participant and type of flight. There have been no hard numbers released, but it’s possible to make some projections.

Round-Trip Transportation of Tourist –outsourcing the transportation of the tourist to the resort to aviation companies. This will run the cost of a First Class ticket to AMC. This on average will be around \$1,000 to \$2,000.

Resort Stay – Many resorts cost the customer around \$3000 to \$6500 a week.

The cost to AMC, who owns the resort, would be below this cost, thus a conservative estimate would be \$1,500 to \$2,500 a person per week.

Training and Testing – The training would be similar to that of any high-tech training that lasts a week. This would be in the order of \$2,500 to \$3,500 a person. To perform the medical and stress test involved would double this, a conservative estimate would be in the order of \$5,000 to \$8,000 a person.

This gives us a conservative variable cost of \$8500 to \$11500 per participants, average \$10000.

Participant's family would pay the "resort space tourist experience" on around \$2500 per person.

Other less significant drivers would be research/improvement and deals/advertising, likewise settled expenses.

8.11 Revenue model

It is not tested and my assumptions are based on the cost and prices paid per ticket to Virgin Galactic that already sold 600 per \$200.000 for a sub-orbital flight ⁽⁷⁾.

Having a cost of \$8500 to \$11500 per participant, customers will be willing to pay around \$15000 to \$18000 per participant for space medical evaluation and training with a luxury standard.

8.11.1 Estimates of Annual Revenues

After start-up, Virgin Galactic plans on sending 50 people into space each month. As Virgin Galactic's ships are designed to carry up to five tourists on each ship and with five ships going into space twice a month, this would correspond to 600 tourists per year at a price of \$200,000 a person, thus a total yearly revenue of \$120 million ⁽⁷⁾⁽⁴⁴⁾. Other companies will have space ships carrying between 6 and 12 tourists.

According to Credit Suisse's latest global wealth report shows there are 42.2 million millionaires (measured in USD) worldwide in 2019. Therefore, if even one percent of these people are going to take a sub-orbital space flight, there is a potential pool of 420,000 people in the market ⁽⁴⁵⁾.

8.11.2 Break-Even Analysis

If the contribution margin for each tourist is $(\$17000 - \$10000) = \$7000$. The break-even point is 4285 $(\$30,000,000 / \$7000)$ passengers. Therefore, AMC will need to check approximately 4285 tourists into space before it covers its fixed costs. At 50 tourists a month, the estimated time-to-break-even point is approximately 85,7 months or just above seven years.

The above numbers are conservative. A more optimistic cost of exams and maintenance based on economies of scale provided by having five ships would be a total cost of only \$8500 per tourist, thus giving a contribution margin of \$10,000 per tourist. This would have a break-even point of 3000 tourist or a time-to-break-even at five years.

Recently VG said that it had plans to in 2023 launch a shuttle of passengers into space every 32h and to build a fleet of five space vehicles to scale it's space tourism business. Assuming every flight is fully booked it mean around 120 passengers per month⁽⁴⁶⁾.

More over AMC plans to cover no just VG but all the space companies, and if it is at full capacity the time-to-break-even would be half of that (3,5 years or 2,5 years accordingly).

Comparing with other space economic investments it has a ultra-fast break-even (figure 7).

Table 6 | Annual Revenue Scenarios providing service just to VG

	A	B
	50 passengers	120 passengers
Max. no. passengers per year	600	1,440
Medical Certification price	\$17,000	\$17,000
Contribution Margin	\$7,000	\$10,000
Annual revenue	\$10,200,000	\$24,480,000
Profit before taxes	\$4,200,000	\$14,400,000

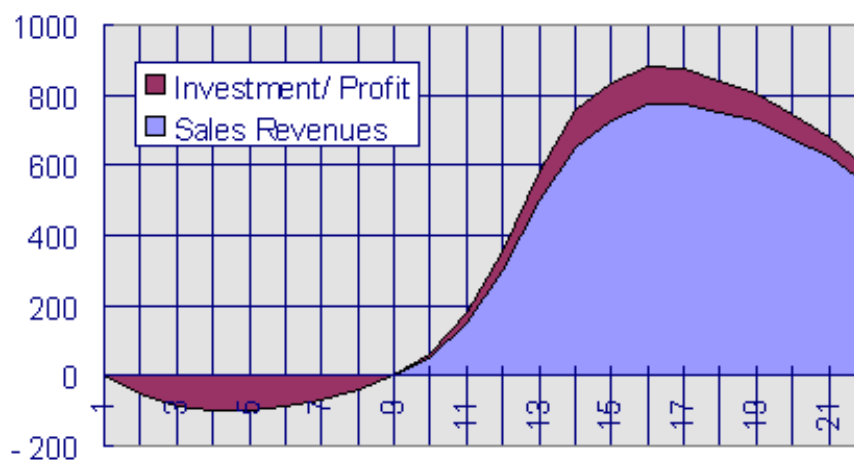


Figure 7 | Investment vs Sales Revenues Space Market

8.11.3 Risk Analysis

The biggest risk would be the major health condition during the space flight. This risk would not only be financial, but also, depending on the type of loss, a deterrent to potential client pool, even though the market surveys showed that the potential clients know the risks involved.

Most of the costs in this model are fixed; therefore, if sales drop, the time-to-break-even point will be pushed further out. The advantage that a company AMC would be to provide the experience to other non space tourists (as a Space Preparation Experience).

Another risk is that of new technology. When, not if, the technology to perform low-cost orbital flights or low-cost visits to the space station arrives, there will be a shift from this sub-orbital tourism to those technologies. AMC and others in the market need to be able to shift to the new markets as time progresses. More importantly, AMC with its resources needs to be the mover in these new technologies.

The above risks are financial. There is also a liability risk the company must face if a customer is injured, health problem or dies in an accident. This could be covered by the purchase of insurance.

As market forces, if space will truly become democratized the cost of space travel will dropped — sending up tourist will be almost as cost effective as buying a extravagant experience or a luxurious travel, but that will take long.

8.11.4 Revenue Streams

It has pretty simple revenue streams: companies or/and participants. Space companies will pay the billing cost of the standard check-up and participants the extra complementary diagnostic methods if needed. Insurance companies might have a word to say if planning to enter in space business.

8.11.5 Sale Attraction

The main attraction for this product is in differentiation and expertise, but AMC is offering a complete vacation/training package, something that the direct competitors are not offering. It should be more cost-efficient than each space company having their own medical center

8.11.6 Recurring Revenue

It is not expected that the average customer will repeat the sub-orbital space tour. Since the customers will be impressed with the sub-orbital trip, many will be prone to use Virgin Galactic's new services in the future. These services can include other space adventures such as going to the moon or visiting space stations. Therefore, the major recurring revenues will be from complementary products.

8.11.7 Effects on Purchase Behavior

Being strictly a high-priced luxury item, the general ebb and flow of the market and the economy will be a short-term modifying agent. As the technology evolves, the ability to do more than just a sub-orbital flight will emerge and the customers will expect more. For this reason, the market for sub-orbital tourism will quickly turn in orbital tourism in few years⁽³⁰⁾.

8.11.8 Revenue Model

The revenue model of AMC is similar to other partners. The major part would come from Commercial space companies' contracts.

The scale with several space companies would lead to a lower cost medical examination which would benefit both parts.

Service fees and billing from patients and insurance companies would also be taken in consideration as long as service for other medical companies and clinics.

Governmental service for space agencies would be a must because of the investment needed and power to growth.

Service for research programs it would play a minor part, and most would be invested again in R&D.

Like hundreds years ago, the past expansion of shipping between Europe and the Americas and other countries, the creation of economical transportation links between Earth and space will open up a range of new resources for business use. Together the activities described above could grow to a turnover of some \$120 billion/year by 2030, as shown in Figure 9. The development of these new commercial space activities will also generate substantial exports of advanced transportation services.

The \$400 billions of cumulative investment over 30 years shown in Figure 8, the bulk of it starting in the later part of the period, is not a large amount within the world economy - an average of \$14 billion/year, reaching \$40 billion investment in the 30th year. ⁽⁴⁶⁾

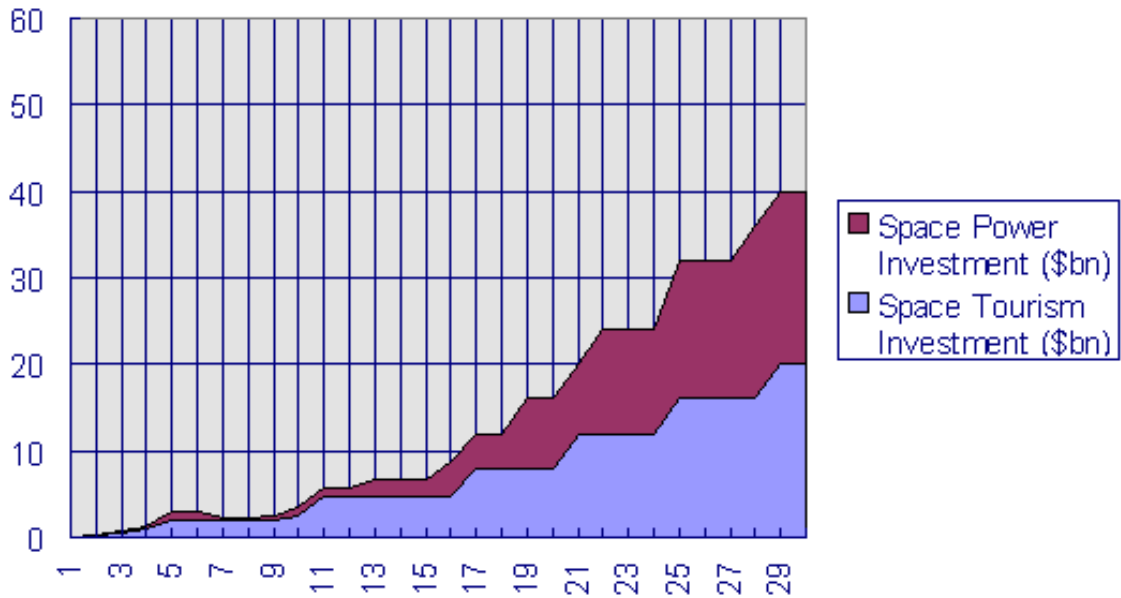


Figure 8 | Commercial space investment over coming 30 years ⁽⁴⁶⁾

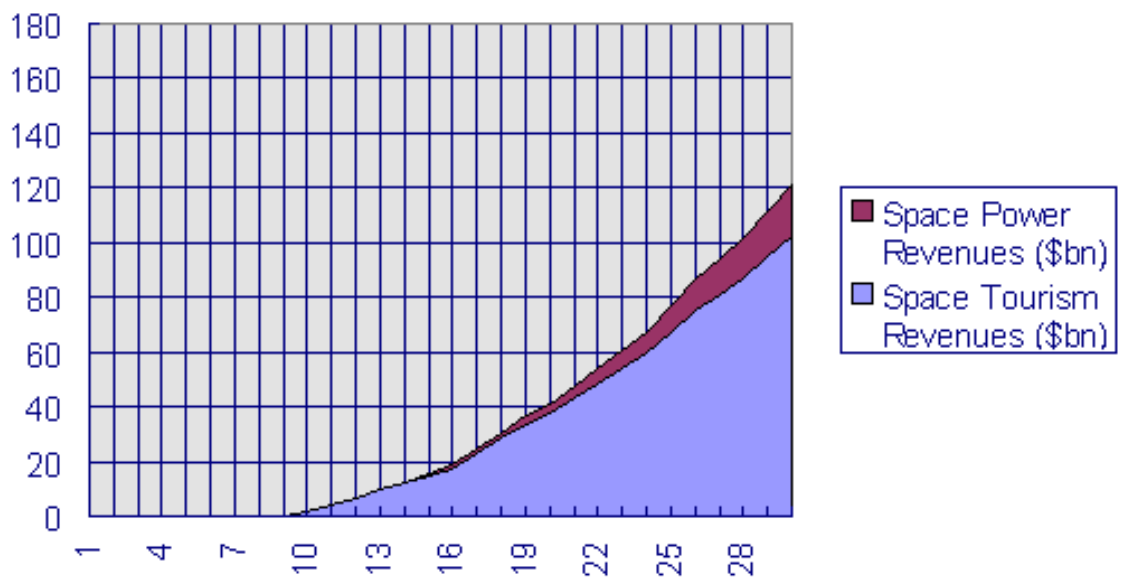


Figure 9 | Commercial space revenues over coming 30 years. ⁽⁴⁶⁾

9 AMC SWOT ANALYSIS

The following table presents us with the **SWOT analysis for AMC**.

Table 7 | AMC SWOT analysis

	STRENGTHS	WEAKNESSES
AMC	<ul style="list-style-type: none"> • Well established defined service • Cost-efficient partnerships • Strong financial support from ESA/Portugal Space/Investors • Support and publicity efforts from Portugal Space • People have confidence on real possibility of space tourism because it has licensed the AMC's health check-ups and training • Environmental friendly center • More efficient technology: use directed to the space industry • Safety is a number one objective • Low cost leader with expert experience • Firm commitment from suppliers • More realistic pricing approach than its future competitors • Focus on its service 	<ul style="list-style-type: none"> • Space tourism program needs to be outlined • Lost credibility if program is not successful • Lack of experience • Confidence as first-mover
	OPPORTUNITIES	THREATS
	<ul style="list-style-type: none"> • EU/US legislators regulatory framework facilitating increase interest in space tourism • Market for suborbital flight is open and unexploited • High level of investors interest in entrepreneurial venture • First-mover advantage • European country 	<ul style="list-style-type: none"> • Other companies may beat AMC to market and gain position and higher market share

10 STRATEGIC APPROACH

AMC represents a very different way to prepare to get into the space. It involves the best health care technology in an attractive specialized clinic with best expertise and health care providers in space medicine. Most of the complementary health methods and infrastructures are accessible to big health care groups and hospitals, although their core business and focus is completely different.

If AMC projects and works hard side by side with aerospace companies in the development of the first AMC space clinic and is able to start operating before other competitors, the company will maintain its first-mover advantages⁽³⁰⁾. AMC will be in a privileged position to achieve economies of scale and economies of learning, as more and more people are sent to the skies and provide feedback from their experiences. AMC will lead in research development that might also be useful for traditional medicine afterwards. AMC will also create entry barriers to new competitors, because of the investment and reputation required for market entrance.

Because of the valuable, uniqueness, rareness and hardness to imitate of AMCs core competences, like specialized center, the synergies within the aerospace companies' brands, or its brand name, the company is in the position of not only delivering a superior customer value but also of being a low-cost provider. As a result, AMC will focus on offering a service, a suborbital flight medical check-up and training adaptation, which is going to be a one-of-a-kind experience with full luxury medical evaluation treatment that some customers will consider to repeat it for \$15000 to \$18000, if travelling again. If any other competitor wants to provide exactly the same product, it will incur higher costs and will not be able to match AMC's price because it will come late to the partnerships, they will have to create their own protocols, and at the very least will be difficult to start the process from the beginning. They will not have the data (don't have a learning curve to adapt and overcome, neither the reputation created by first mover. Most of the time first movers have the power of staying on peoples mind while others are taken as a copy.

AMC would have to demonstrate it is in a position to allow it to appropriate much of the value that customers will enjoy. Health and safety are major concerns of the target market and a sign that its potential customers have very low bargaining power, and although travelling space is not indispensable, to be physical healthy and to be medical examined and

trained will be, customers will find the price inelastic because it will be necessary, it won't have a valid competitive substitute/alternative, and it will be restricted in market and time.

The market research funded by NASA, performed in the USA by Zogby Inc ⁽³⁵⁾, assumed high service prices. However, due to expected competition and low barriers to entry, it's not probable that initial prices of 100,000 - 200,000 USD/passenger will last forever. Nevertheless, the estimate of a potential market of billions of USD/year can happen at long term 30 to 40 years: due to the elasticity of demand, at a price of some 5,000 to 10,000 USD/passenger, demand might well grow to one million passengers/year. With that situation the prices of AMC should be reconsidered and adapt, and economy of scale should adjust.

To close its circle of power, AMC needs to implement an exceptionally designed promotional strategy that captures its potential customers' attention. Also, keep in touch with them, by regularly sending them information of the progress in the program and detailed bits of the final product.

Finally, in order to achieve a sustainable profitability, AMC will pursue a blocking strategy to prevent others from entering its suborbital tourism market. On the other hand, the large investment that is required to build a space clinic and build the facilities to service both clinic and tourist relatively is high⁽³⁰⁾.

Investors tend to be risk averse and proving the safety of space tourism is next to impossible, particularly due to the variety of dangers it faces. The cases of space health dangers, such as space radiation, health emergencies and other medical hazards pose serious risk to the investor and the company to be operating.

Health consideration is a prevalent obstacle when one discusses space tourism, particularly within the orbital type. Legal issues face another barrier to space tourism as they are undeveloped and legal framework is difficult to construct.

11 CONCLUSION

Space Tourism Health Preparation is a new field that has the potential to be a vast new market. Even at the high cost to start, there are tens-of-thousands of potential customers clamoring to take a flight into space and many potential companies to provide them the services they want ⁽³⁰⁾.

This report has outlined one of the possible business models that could be explored, through a necessity that leads to an opportunity, space clinics and shows how companies like Virgin Galactic or others in a similar position can make a go in this market.

This master's dissertation has confirmed the hypothesis that the creation of an AMC based on health space tourism is a viable future prospective. It seems that this factor in the space activity will be a profitable and successful future tourist niche, especially as orbital tourism establishes its regularity and continuity.

It has been shown that there is significant demand, even though ticket prices will be very expensive in the early stages of space tourism operations as the popular interest and pioneering effect of a suborbital trip will outweigh the price at the beginning. There is considerable demand for sub-orbital space tourism to establish itself as a dominant tourism niche, while at the same time paving the way for the development of orbital tourism and many other parallel activities along with it, such as space hotels. It has been found that investments in space tourism, transportation, space medicine and safeness and regulation of space tourism presents the biggest challenges in establishing a vital business; however, they are not significant impediments to the progression of such business practices and are already being overcome.

Data and experience accumulated from mission training and actual spaceflights will help determine the need for additional medical guidance for persons with certain medical conditions. A strong collaboration among practicing clinicians, space medicine specialists, and the aerospace community will ensure the safety of the participants in the expanding spaceflight industry ⁽⁴⁸⁾. Nevertheless, there is still great concern among passengers about the safety of these spacecraft, which will further influence demand, as well as regulation procedures and investor confidence ⁽³⁵⁾. The aforementioned depends on the success and safety record of the future voyages.

As the technology evolves, the model will either evolve or be replaced with a more extensive one. These models have a potential to provide a strong revenue flow that could cover the high fixed costs and thus a substantial profit. For this reason, this model is probably a worthy investment.

It has been shown that there is great interest in developing space tourism from the private sector. Virgin Galactic and SpaceX are leading the way, while others may follow them sooner rather than later and it is expected that while the initial investments are a heavy load to lift, in the long run the ventures will bring massive returns, particularly in the orbital space tourism segment.

Despite the uniqueness of the product offered, the AMC may compete with other Space Clinics, bringing new economic challenges. We can compare the beginnings of space tourism with those of aviation. One hundred years ago, nobody would imagine that, one day, millions of people will be traveling such enormous distances by air in a very short time, safely and comfortably. Nowadays, we can speculate, that safe public access to outer space will lead to the development of aerospace medicine and technologies, bringing huge benefits to our society and transforming it in a way that is unimaginable today. Space tourism would lead to much advancement in fields from engineering to medical science.

Human civilization is at a precipice of becoming an everyday space venturing civilization, in addition to being only a step away from becoming an interplanetary one. In hopes of these developments being successful, terrestrial civilization will experience not only new environments and knowledge, but greater awareness of itself, as well as easing the present-day burden on terrestrial industry⁽⁴⁹⁾.

The bibliography research shows that intentional need for adventure and exploration is the motivational force in space tourism. Willingness to undertake space travel is also influenced by the perception of the risk involved, which plays a central role in a potential tourist's behavior. Furthermore, factors such as type of space travel (orbital/sub-orbital), the required training, health, duration and insurance also seem to have some influence on the potential tourist decision-making process⁽³⁰⁾.

The paper pretends to show that there might be a new market and space medicine can play a very important role in the space business, that has to be explored. This could give us a reference number to an approximate cost and opens the door to further studies. It is a fact

that global research in Space Medicine is necessary and this is a first step to understand perceptions of the potential market.

Limitations to this work are evident but it wants to show that there is a new business market opportunity from which we may all benefit.

This work is just a kick start and there will be a need of more exhaustive studies in order to define the best business model to aerospace medicine.

What an exciting 21st century!

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