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# The Role of Balloons in the Future Development of Space Tourism

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# THE ROLE OF BALLOONS IN THE FUTURE DEVELOPMENT OF SPACE TOURISM

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## Abstract

The space tourism industry is at an early stage of development. In order to better understand how space tourism will progress into a full-fledged profitable industry, it is helpful to examine the early developmental stages of other industries that faced similarly high financial barriers. Many of the mature industries of today, like energy or air travel, have grown by following the steps previously taken by government projects. The early history of human space flight can also provide insight on how space tourism commercial ventures may succeed in the following years. An analysis of this history shows that, a long time before the first manned sub-orbital rockets were launched, a very different technology had been already used to lift people to the edge of space. From the thirties to the sixties, and using high altitude balloons, the USA and the Soviet Union got involved in a first space race, a search for record balloon heights. A small group of military officers from both countries were the first men to reach the heights where the most impressive visual features that we today associate with space travel were clearly visible.

At a height of 40 km from the ground the sky is almost indistinguishable from the one seen in space, the curvature of the earth is clearly visible and the atmosphere seen as a delicate thin bluish layer. The possibility of enjoying this view with the naked eye is one of the main benefits that clients will look for in space tourism services. The technologies involved in ballooning are relatively cheap and readily available with respect to sub-orbital ballistic rockets. Furthermore the health and comfort risks that derive from the accelerations and the space motion sickness syndrome are not an issue in balloon flight. This paper discusses the technical and legal feasibility of a business model based on space balloons. Besides, the business model has been valued applying a discounted cash-flow method to a series of probability-weighted scenarios that account for the uncertainty in the demand. The initial results show fine prospects for profitability. Space balloons can be a next feasible and cost-effective step to bring space closer to people and create the market that will eventually evolve into orbital or interplanetary travel. This paper concludes that balloons can readily provide the main benefits looked after in space tourism, both from the customer and the investor points of view.



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## A Bit of History of Manned Spaceflight

Up to now only a handful of commercial space passengers, or space tourists, have enjoyed orbital spaceflight. Furthermore the first commercial suborbital flight is yet to happen. Thus we can assume that the space tourism is at an early stage of development. The nature of the challenges ahead is diverse, however the market and financing issues have been found to be of paramount importance. [1,2,3] In order to better understand how space tourism will progress into a full-fledged profitable industry, it can be helpful to examine the early developmental stages of mature industries that once faced similarly high financial barriers. Two examples are energy and air travel. The development of nuclear reactors, solar energy, jet engines and wide body aircraft was intensely financed by governments. In addition commercial activities have followed closely the steps first taken by government projects. This is especially patent in the aviation world where commercial developments were often preceded by military research.
A look at the early history of government-sponsored manned space flight can also provide insight on what are the logical steps space tourism commercial ventures should follow. It is conventional to consider the flight of Yuri Gagarin as the beginning of manned spaceflight. Recognizing the importance of that feat, it is pertinent to look at the issue in a broader perspective. From the thirties, a long time before Sputnik, the Soviet Union and the United States of America were already involved in a manned space race. [4] It consisted on a series of balloon flights soaring to the upper layers of the atmosphere. The men that staffed these missions saw a view no one had ever seen. This view had many of the features that we now associate with space, like a marked curvature of the horizon and the sun shining in a pitch-black sky. The following table [4,5] summarizes some facts about this less widely known part of human exploration of the cosmos.

| Year | Milestone |
|---|---|
| 1927 | 19 Km ascent (Prokoiev) |
| 1933 | 18.7 Km ascent (Settle and Fordney) |
| 1956 | 31.2 Km ascent and parachute jump (Kittinger) |
| 1961 | 34.7 Km Ascent, current world record (Ross and Prather) |

It is not by chance that the record height in a balloon dates from the same year as Gagarin's flight. Apparently public interest shifted from ballooning to rocketry. It should be noted that the drivers for this change were not necessarily identical to the ones that will drive the development the space tourism industry. For instance low cost considerations are important for space tourism and were not essential at that time.

## Some Insight on the Demand for Space Tourism

In order to provide appropriate space tourism products it is important to analyze what makes flying to space attractive. Many studies [5,6] have looked at the issue and found out that the view of the earth and the sky are the most valued features in a space tourism product, followed distantly by weightlessness and prestige. One easy way to imagine the relative value of each feature is via the following thought experiment. How much would one be willing to go on a flight to space if one had to go blindfolded? Obviously, the interest in such a trip is narrow. On the other hand, going to space in a ship with artificial gravity and no chance to float is not a bad deal. Similarly, going to space secretly and therefore not being able to enjoy the social prestige is not that terrible and, for many wealthy people discretion can be an advantage.

Conversations with astronauts [7,8,9,10] about what they most liked about going to space have further convinced the author that the view is the single most enjoyable and unique utility in the manned spaceflight experience.

Weightlessness is something readily available on parabolic flights; liftoff accelerations are effectively reproduced on centrifuges, etc.

A further analysis of the elements that compose the view is relevant. It can be broken down into motion (fast translation of the ground below), color (blue earth and sunny black sky) and geometry (the shapes of the geographical features and the curvature of the earth).

Interestingly, the view from a balloon at an altitude of 40 km shares both the color and a similar geometry with the one that can be seen in Low Earth Orbit. Of course the match between both views is not perfect, in particular because the motion of the ground is slower. Balloons drift in the stratosphere at a typical speed of only 30 m/s[11].

A calculation of the brightness of the day sky at 40 km indicates that it is 130 times fainter than the clean dark sky seen from the top of the Everest. This allows seeing some of the brightest stars and planets at noon. Furthermore the color of the sky is black all day because most of the scattering that makes the sky blue takes places in lower and denser layers of the atmosphere. At 40 km of altitude the horizon extends to approximately 1200 km. Figure 1 shows the effect of height in the perception of the curvature of the horizon.

## About the System

Certainly, as evidenced by the history of government programs, it is technically feasible to send humans on balloons to 40 km and return them safely to Earth. This section will outline the technology needed and show that it is presently at hand. A pressurized gondola shall hold the passengers and two pilots. It would have to be fitted with comfortable seats, wide windows, a life support system, a satellite navigation system and a recovery system, among other systems. It is early to provide an accurate estimate of the weight of such a gondola. A first approximation can be obtained from flight Manhigh II in 1957. That mission reached a height of 30.95 Km. Including the pilot and scientific equipment; the Manhigh II gondola weighted 747 Kg in total. [12] It would be excessively conservative to say that a manned gondola of 2900 Kg, almost four times that weight, could fit only four people. Taking into consideration the great advances in materials, electronics and CAD that have taken

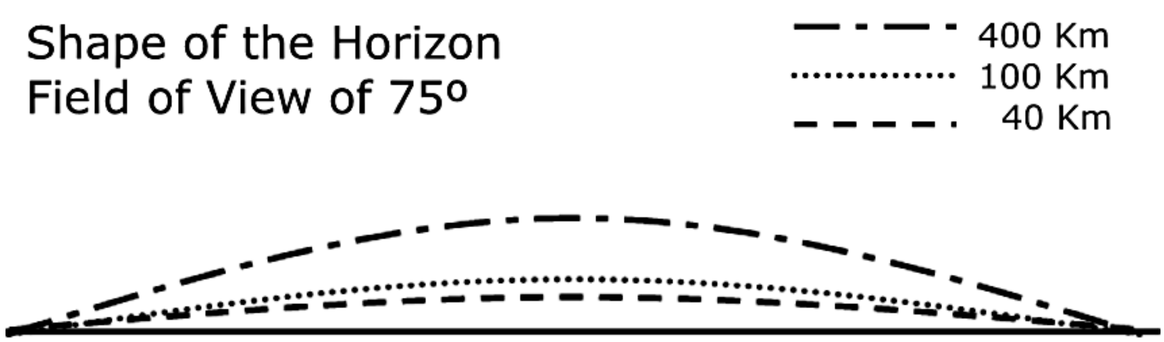


Figure 1

place in the last fifty years, it is probably reasonable to expect that a good design could make a fully loaded six-person gondola weight less than 2900 Kg.

The situation is even simpler for the case of the balloon itself. There exists a balloon that is currently used to lift a 2900 Kg payload to an altitude of 40 Km. It is used in a mission called PRONAOS. It consists of a telescope lifted by a Helium balloon that can inflate to 1.1 million $m^3$ [13].

Detailed studies would be needed to determine the optimum configuration of the family of vehicles that could best meet all the requirements in terms of cost and performance. Furthermore, many questions would have to be answered regarding the optimization of the operations of such a system. For example: what if the winds carry the balloon away from the foreseen landing zone? Which is the safest, or more attractive, way to perform the descent? Using a parachute? or by slowly maneuvering the craft? Still, solving these questions is almost certainly simpler than safely operating a rocket propelled suborbital tourism vessel.

## Legal and Policy Issues

The boundary between atmosphere and outer space is an undefined legal issue. All the United Nations Committee On Peaceful Uses of Outer Space treaties are vague and unclear on this point. [5] There are many approximate definitions. One is the minimum altitude at which a satellite, without propulsion, can make a single circular revolution without reentering due to atmospheric drag. This is not precise since it depends on the mass and shape of the satellite. For the layman, space begins where the atmosphere ends, while, for an astronomer, the geocorona is a part of the atmosphere of the earth and extends many radii from the ground. The boundary of space is often arbitrarily placed somewhere around 100 km of altitude. These definitions are not based on the factors that make space attractive for tourism; therefore their application to space tourism is not well justified.

The ambiguity on the limits of airspace, and hence of a particular state's sovereignty, may offer an opportunity for freedom to fly on the upper stratosphere. Of course, provided that the flight does not compromise national interests of the over flown state. It should be noted, though, that few states have interests on this zone, nor the means to enforce control within the upper stratosphere. It is important to stress that what is relevant for the tourist is being able to enjoy the view, not technicalities about the definition.

A very important issue that is often overlooked when studying the future prospects for space tourism is the sensitivity of the technologies involved. This is especially dangerous in the case of suborbital rocket flights because they share a great deal of technology with ballistic missiles. The technologies needed to develop and operate a space tourism service based on balloons are less protected since its proliferation does not pose a major security threat.

## Valuation

The purpose of this section is to obtain a first estimate of the economic value of this activity.

Two factors make the valuation of space tourism companies especially hard. First comes the apparently endemic problem of cost overruns in space projects. The other one is that the demand for this totally new service is as potentially great as it is uncertain.

The complexity of constructing and safely operating a rocket propelled system, be it reusable or not, is likely to be a main contributor to this overruns. Due to their higher simplicity, this problem is attenuated in the case of balloons.

A simple and straightforward way with dealing with uncertainty is to use probability-weighted scenarios. [14] In this fashion, a set of financials from a hypothetical company has been estimated for three scenarios:

Scenario A is the most optimistic and it is based on the typical results of market surveys about public space travel. [15] After a five-year gradual development process, a rapid progress takes place. In the subsequent five years space tourism grows into a $10 Billion business. The average price per ticket of a daytrip on a spaceplane is $100000. There is a demand for about 100000 of those tickets annually. In this environment of general interest on space tourism services, the company offers daytrips on a balloon for $50000. This price tag is reached from an original $100000 in year 5. The company succeeds to capture 1% of the $10 Billion market, hence selling 2000 tickets annually. This Scenario is considered to be attractive but improbable. We assign a probability of 10% to Scenario A.

In Scenario B the first five years are similar to those of the previous Scenario, and are marked by a slow growth. The difference is that, afterwards, the business continues to grow slowly for the following five years. The ticket price is kept steady at $100000. While the number of tickets sold progresses from 12 in year 3 to 120 in year 10. This scenario implies that space tourism services remain a marginal part of the space economy. The probability of this scenario has been estimated to be 50%.

Finally, in Scenario C, the company is liquidated after five years of operation, the reason being an inability to capture enough customers. The investment would not be fully recovered. This third scenario is pessimistic but it has to be given a high probability, 40%, to be fair with the reality.

In order to avoid the complexity of adding financial risk to an activity that is risky enough by nature, in all three scenarios, all-equity financing is assumed. The cost of capital used in the calculations is the one suggested in [2] and equals 17.6%. The investment needed depends only slightly on the scenario and has been projected to be around $6.7 million. The following table summarizes the results for the three scenarios over 10 years. It includes the weighted average valuation as well as some financials from the three scenarios: Internal Rate of Return (IRR), Net Present Value (NPV), Present Value of Terminal Value (PV of TV) and full Value (V).

The figure of $8.41 million indicates fine prospects for profitability. Space balloons have been shown to be promising from an investor point of view. In addition, a company providing space ballooning services would be in an ideal position to better understand the future demand of space tourism services. Its operations would also increase the general awareness about public space travel.

Detailed hypothesis and calculations of the Discounted Cash Flows (DCF) for the three scenarios are available from the author upon request.

**Space Ballooning: Expected Value** ($ million)

| | IRR | NPV | PV of TV | V | Probability | Weighted Value |
|---|---|---|---|---|---|---|
| Scenario A | 50% | 13.02 | 30.75 | 43.78 | 10% | 4.38 |
| Scenario B | 33% | 3.63 | 6.91 | 10.54 | 50% | 5.27 |
| Scenario C | -24% | -3.10 | 0.00 | -3.10 | 40% | -1.24 |
| All $ in 2002 values | | | | | **Expected Value=** | $8.41 million |

## Conclusion

For space tourism to develop, it should benefit from the technologies and steps followed in the past by government projects. Before using rockets, governments lifted passengers to great heights using Helium balloons. A balloon flying at 40 km of altitude can provide many of the benefits looked after in space tourism both from the customer and the investor points of view.

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