Measuring the Economic Impact of Space Tourism Activities

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BIOGRAPHY

Stella Tkatchova is a Space Business Engineer at Rhea System S.A., a Belgian aerospace company. She is currently working on developing new business opportunities and projects related to Galileo navigation and Earth observation space missions. She holds a PhD from the Industrial Engineering group of the Faculty of Aerospace Engineering at TUDelft, the Netherlands and a Master of Science in Space Studies from the International Space University (ISU). In parallel to her PhD research she worked for several years as a contractor at ESA-ESTEC on the cost drivers for the Metop-A in the Cost Analysis Division and on industrialisation and marketing of the ESA ISS on–board facilities in the Commercial Promotion Office (CPO). Stella has developed a strong passion for the commercialisation of space-based technologies for future interplanetary space missions and believes that space-technology can offer unique opportunities to develop new markets. Her passion has lead her into setting up a discussion forum in the International Journal of Space Technology Management and Innovation.

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INTRODUCTION

With the recent development of space tourism, the successful launch of several space tourists to the ISS, the development of sub-orbital vehicles, such as SpaceShipTwo and the emergence of new space tourist companies (i.e. Space Adventures and Virgin Galactic), space tourism is projected to become a billion dollar industry. In recent years, space tourist companies have successfully diversified their services and increased their investment in new market development. For example, market studies indicate that there is over $300 Million of annual NASA funding dedicated to sound rocket science, space life science and aeronautics that can be targeted by Space Ship Two (Faust, 2009). This diversification may result in the need for long-term investment, unknown customers, high business risks and longer “time-to-market”. Therefore, companies will need to perform cost benefit analysis for measuring the profitability of their diversification.

This paper presents an overview of the direct and indirect benefits used in aviation industry, and proposes their adaptation and use to the space tourism industry. Some of the considered direct benefits will be employment, new markets, revenues from sales and indirect ones, such as free publicity, technology innovation, safety, environment protection and international partnerships.

We illustrate the value of cost-benefits analysis of space tourism with a case study. The case study presents a Net Present Value (NPV) model to evaluate the monetary benefits for stakeholders of space tourism activities on board of the ISS. The case study has several novel features. First, we evaluate not only the net cash flows associated with space tourism to the ISS for the participating space agencies for the period between 2010 and 2020, but we also propose that after 2020, the ISS will be contributed by the space agencies to form a joint

venture with a private space tourism company that will operate the ISS as a dedicated space tourism facility. The value of the stake in this venture owned by the space agencies is projected to be $4.5 Billion under conservative assumptions. Second, we convert our NPV results into an annual reduction of the ISS budget and find that the cash flows from space tourism can defray between 9 and 30% of the annual budget of the ISS until 2020. Last, we posit that forming a joint venture with a private partner is only one of several options for future use of the ISS and that the space agencies will choose the most valuable alternative depending on the market conditions in 2020. Although we do not explicitly value this flexibility to respond to future developments, we argue that our NPV results provide only a lower bound to the real monetary benefits associated with orbital tourism and suggest avenues for future analysis to estimate the value of flexibility and add it to the no-flexibility NPV.

Our case study provides guidance how companies can perform the cost benefit analysis of their planned diversification into new space tourism markets. Our analysis also contributes to a better quantification of the benefits for stakeholder in the industry, such as space agencies, private investors, and regulatory bodies.

SPACE TOURISM MARKETS

In recent years, space tourism companies have not only expanded their portfolio, but have also diversified their services and increased their investment in new market development. For example, Space Adventures has diversified its services by offering direct parabolic flight services and is currently looking at developing their own scientific program for attracting companies to launch small payloads to LEO. In addition, Virgin Galactic is considering the use of WhiteKnightTwo, which is going to launch SpaceShipTwo, to carry earth observation sensors launch micro-satellites, and perform parabolic flights. Virgin Galactic, in cooperation with Surrey Satellite Technology Limited, has been targeting the launch of 200kg earth observation or telecom satellites that will cost no more than $2 Million.

In the last few years, the space tourism market has emerged as one of the most promising space business markets that may potentially reach up to $1 billion by 2021 (Futron, 2002). The space tourism market includes orbital, sub-orbital, and parabolic flights and other services like astronaut training, and MIG flights. Sub-orbital tourism is expected to attract the highest number of tourists reaching up to 15,000 tourists in 2021, generating revenue of around $700 million, while orbital flights can reach around 60 tourists by the same year (Futron, 2002).

Up to May 2010, there have been at least 8 spaceflight participants (i.e. space tourists) who have visited the ISS for 12 days trips. Virgin Galactic states that around 340 future tourists have subscribed for sub-orbital trips on SpaceShipTwo (Virgin Galactic, 2010). Prices for one orbital trip to the ISS range between $20 and $35 million; although, it is possible that prices will change in 2011 after the retirement of the Shuttle, because it is doubtful that the Russian space agency will be offering lower prices for space tourists and higher prices of $55 million for NASA astronauts. Therefore, in 2011 prices for one orbital trip to the ISS could reach up to $55 million. Prices for sub orbital flights are much lower. For example, a sub-orbital flight with Space Adventures will cost around $102,000 per ticket and one with Virgin Galactic around $200,000 per ticket (Virgin Galactic, 2010). However, at present there is not much information on the sub-orbital vehicles that Space Adventures will use; in contrast, Virgin Galactic's Space Ship Two has already performed several test flights. Finally, parabolic flights are most affordable and passengers can buy a ticket for around $4,950 (Space Adventures, 2010)

The *stakeholders* in the emerging space tourism will change with the market evolution of the space tourist markets and their newly targeted markets in which they will diversify their activities. The list of stakeholders includes:

1) End-customers – could be rich individuals and private companies, often the expression space tourist is exchanged with spaceflight participant;

2) Private investors – corporations, private equity groups, and business angels;

3) Service Providers – often referred to companies that provide private space exploration opportunities, such as Space Adventures, Virgin Galactic and others;

4) Space Tourism Operators – companies such as Incredible Adventures, Pro Toura Space and others that offer bookings for zero g flights, MIG flights and others;

5) Manufacturers – companies that are responsible for the manufacturing of the space transportation vehicles such as EADS Space Transportation and Daussalt, Bristol Spaceplaces, the Space Ship company and Armadillo Aerospace;

6) Launch services providers – these are companies that will be willing to provide low cost launch services such as the Falcon 1 and the use of the Space-X Dragon capsule;

7) Regulatory Bodies – these are public organizations responsible for civil aviation safety such as the US Federal Aviation Administration (FAA), the European Aviation Safety Agency (EASA), and the International Spaceflight Organization (ISFO);

8) National Space Agencies – these are setting up programs and allocating budgets for encouraging the development of commercial crew and cargo services (for example, NASA has set-up NASA COTS program for encouraging the development of commercial crew and cargo services and NASA 2011 budget has allocated around $5.9 billion (Space Travel, 2010) for encouraging the development of new technologies);

9) Space Insurance companies – these are companies that are involved in providing insurance to payloads, satellites, and space tourists flying on board the ISS; and

10) National governments – providing tax benefits to companies that are investing in spaceports constructions.

The above stakeholders will generate benefits from new market development, revenues from sales, technology innovation and international partnerships. However, the space tourist markets are still in their nascent stage when technology innovation is the main driver, new markets are being created, first time buyers are joining in, customers are still unknown and there is strong government regulation. Companies offering space tourist services are focused on creating a market, targeting customers and marketing. Through the different phases (i.e. nascent, frenzied, turbulent, mature, etc.) of market development, stakeholders and the benefits they generate will change.

SPACE TOURISM DIVERSIFICATION TRENDS

The development of new applications for the use of sub-orbital vehicles in addition to their space tourism uses will result in benefits for the space companies and also increased investors interest. Diversification of space tourism activities started in the early days of MIR commercialization, when the Russians flew in the early 90s the first space journalist to MIR –Toyohiro Akiyama. Furthermore, they had the Pizza Hut logo on top of a Proton launcher, and a company called MirCorp sponsored a flight to the station. The first ideas for launching a space tourist came from MirCorp, which was created with the objective to attract private citizens for flights on board of MIR with the idea to generate enough private funding to keep the station operational. The ideas for launching space tourists, a private space station for space tourism, and a TV show were quite innovative. Unfortunately, the de-orbiting of MIR ended the fruition of these ideas. Nevertheless, the Russian space commercialization activities set the foundation for space tourism and demonstrated the importance of market diversification.

Several diversification trends can be recognized today. First, sub-orbital transportation vehicles are being used for micro-satellite launches and parabolic flights – in 2004 the idea was to use SS2 only for space tourist activities. In addition, Virgin Galactic has recently signed an agreement with NOAA for carrying earth observation sensors on board of SS2 and in the future to use it for parabolic flights. Second, space tourism service providers such as Space Adventures, which started initially with parabolic flights and offering trips to the ISS, are now offering sub-orbital flights, astronaut training and considering launching their own science programs. Third, the ISS may be used as a space tourist base and after 2020 private launch services providers, such as Space-X may provide low cost launch services to the ISS. Last, space tourism activities may encourage the creation of a secondary market for space fashion, sports, and virtual gaming.

Space tourism companies may be driven to *diversify* due to the need for *long-term investment*, *unknown customers*, *high business risks* and *longer "time-to-market"* for the development of the traditional space tourist markets. Furthermore, diversification may provide service providers, operators and manufactures not only the entrance in new markets, but also the opportunity to generate technology innovation and "economies of scale".

Some stakeholders may generate cost effective solutions or expand their markets by signing long term secure government contracts. Due to the pioneering nature of the space tourism, governments, space agencies, private investors, space tourism service companies, insurance companies and manufacturers may face some of the following problems faced by MIR and ISS commercialization: 1) assuming there is a *market* and its creation is easy; 2) *failure* to understand the complexity of space based technology; 3) *unknown* customers, markets and strong safety regulations; 4) risk that tragic accidents will create *negative publicity*; 5) *'time-to-market'* may be too long for commercial customers to wait; 6) *competition* from terrestrial technologies and solutions; and 7) *diversification may occur too early* when stakeholders are not ready for the process.

With the expected end of the ISS in 2020, space tourism companies may increase their diversification activities and also aim at funding the development of a private space station or securing access (via a joint venture, leasing or other contractual agreements) to only certain parts of the ISS. Therefore, space tourism services providers and operators will need to perform cost benefit analysis for measuring the profitability of their diversification. New market development, free publicity and international partnerships may be some of the expected benefits.

REASONS FOR IDENTIFYING AND EVALUATING POSSIBLE BENEFITS

Private investment in the development of low cost launchers, sub-orbital transportation vehicles, inflatable space stations and transportation vehicles will require a wide range of utilization, demonstrations of a viable business case and reliable market analysis. Therefore, investors and space tourist service provides will have to assess the initial need for diversifying based on the benefits it will bring and benefits versus cost drivers. They will need to assess their investment decisions and the expected profitability from their diversification activities.

The space tourist operators and services providers will also have to *assess* and *compare* various opportunities for diversification. The process of defining the expected benefits from diversified projects will help to identify the benefits that cannot be economically valued and monitor the performance of the diversified project. Some of the reasons behind defining the benefits can be:

1) perform NVP modelling and sensitivity analysis and define the rate of return;

2) identify markets that will bring potential economies of scale;

3) define the unique selling point (USP) of the diversified project;

4) convince end customers to contribute financially to a project;

5) identify the Strengths, Weaknesses, Opportunities and Threats (SWOT) of a project and manage various risks that are associated with it.

Quantifying and *qualifying* the expected benefits from the diversification projects will permit manufactures to integrate end-user requirements in the sub-orbital vehicle design. For example, when designing SS2, Virgin Galactic took under consideration end-user requirements and changed the ship's final design. Furthermore, they aimed at designing a more environmentally friendly vehicle. Benefits definition is crucial for helping end-users define the expected benefits and for convincing end-customers and private investors to financially to contribute to the diversified project.

AVIATION INDUSTRY BENEFITS VS. SPACE INDUSTRY BENEFITS

The aviation industry has extensive experience in providing safe, profitable and reliable services. It is an industry owned and operated by private and government-owned companies responsible for airline operations, maintenance and operations. Therefore, it is very possible that future space tourism companies, in particular those involved in the provision of sub-orbital flights, may build their business models based on the aviation ones. For this reason we overview some of cost-benefits analyses used in the aviation industry.

In the aviation industry, a widely used method for assessing investment decisions for sustaining safety and reliability and securing services to manage the expected traffic growth is cost benefit analysis (CBA) (Eurocontrol, 2000). CBA is used for economic assessment of projects' costs and benefits and for calculating their NPV, cost/benefit ratios and internal rates of return. Based on CBA, governments, service providers and aircraft operators can compare and prioritize projects. Before investing in the development of new markets and diversifying, space tourist companies will have to perform market analyses, develop business cases and perform cost benefit analyses for prioritizing their investment in diversification. Table 1 lists the quantitative and qualitative benefits of CBA in the aviation industry.

Table 1 CBA quantitative and qualitative benefits

Quantitative Benefits	**Qualitative Benefits**
Cost Savings	Safety
Capacity	Environmental
Reliability	International commitments
Delays	Contingency
	Upgradability

Decision makers use the benefits listed in Table 1 to get a better understanding of the project trade-offs, the measurement of value added in economic terms, the stakeholders and the expected costs. From the above benefits, cost savings, capacity and technology reliability will be relevant for space tourist companies. They could be also combined with employment, revenues from sales and new markets. At the same time, the qualitative benefits can include safety, environmental and international partnerships in combination with free publicity and technology innovation.

A HYPOTHETICAL CASE STUDY

To illustrate some direct and indirect benefits of space tourism, we present an NPV analysis of space tourism to the ISS. We take the point of view of the space agencies that operate the ISS. We abstract from some institutional details like the exact ownership stakes in the ISS by the different space agencies (NASA, ESA, FSA, JAXA and CSA) and value the combined cash flow benefits to all agencies that own the ISS. In practice, it is likely that most benefits from space tourism will accrue (at least initially) to the Russian Space Agency, because it currently operates the most reliable vehicles for human orbital flight.

We assume that the ISS will be operated by the ISS partners until the year 2020 and evaluate only the annual cash flows from ISS tourism that accrue to the space agencies. We project these cash flows as follows. We denote the net cash flow from space tourism to ISS in 2009 as CF_{2009}. We project the cash flows for Years 2010-2020 as a function of two factors – the growth in the global tourism market, denoted by g_{market}, and the growth in the market share of ISS tourism in the total tourism market, denoted by $g_{mktshare}$. Based on these definitions, we calculate the net cash flow from ISS tourism for the space agencies in each year in the 2010-2020 period as:

$$CF_{year} = CF_{2009}\left(1+g_{market}\right)^{(year-2009)}\left(1+g_{marketshare}\right)^{(year-2009)} \quad (1)$$

To estimate CF_{2009}, we take into account that two space tourists went to the ISS in 2009 and assume that these tourists generated net cash flow for the Russian Space Agency of \$25 Million each. Thus, CF_{2009}= \$50 Million. From Datamonitor (2010), we obtain g_{market} = 6.4%. The size of the global tourism market is \$542 Billion. In contrast, CF_{2009} equals only \$50 million, which translates

into less than 0.01% market share of orbital tourism in the global tourism market. We expect that this tiny share can grow at a relatively high rate. In the base case we assume a conservative value for $g_{mktshare}$ of 10%. We also perform sensitivity analysis of our results using values for $g_{mktshare}$ ranging from 5 to 20%. Figure 1 presents the number of space tourist projected under 5%, 10%, and 20% growth rates. Even at $g_{mktshare}$= 20%, the number of space tourists to ISS in 2020 is expected to be only 21, which is well below the projections by Futron (2002).

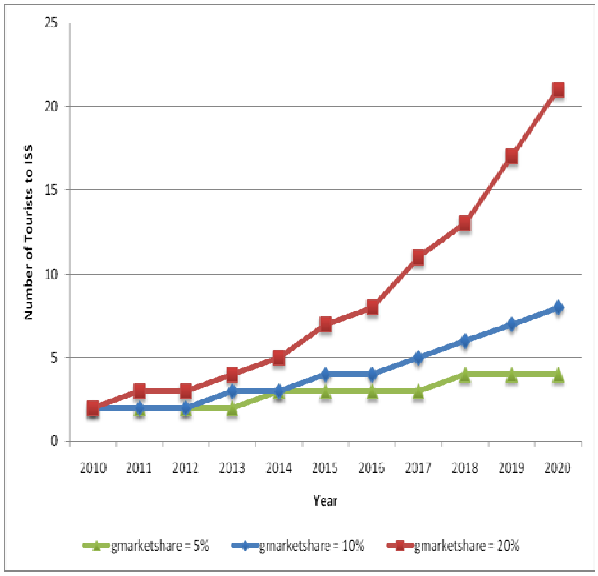

Figure 1. Projected number of tourists to ISS under different growth Scenarios.

After 2020, our analysis assumes that the station will be converted to a dedicated space tourism facility, which will be operated by a joint venture. This joint venture will be 50% owned by the original participating space agencies and 50% owned by a private space tourism company. In the formation of the joint venture, the space agencies will contribute the ISS, while the private company will commit to provide all transportation of tourists, station resupply, training and other services. Possible candidates for the private partner in the joint venture include companies currently developing commercial crew and cargo transportation technologies under the NASA COTS program such as Space-X that is developing the Falcon 1 vehicles and the Dragon capsule and Orbital that is developing the Taurus–II. These vehicles are expected to provide low cost cargo transportation as early as 2016. Having a privately-operated human orbital transportation vehicle by 2020 is feasible.

The value of the 50% stake of the state agencies in the space tourism joint venture is calculated using standard discounted cash flow valuation techniques. We start by projecting the revenue of the joint venture for each of the five years from 2021 to 2025 using Equation (1). Equation (1) does not directly provide the value of net cash flows for the joint venture, because on one hand, the joint venture has to pay transportation and training costs, but on the other hand it can charge tourists higher prices than the assumed prices that were paid to the Russian Space Agency for transportation only. We assume that the relation between the cash flow values provided by Equation (1) and the actual net cash flow of the joint venture is driven by a single scaling factor, which we set to a conservative value of 0.5.

In Year 2025, we also compute the terminal value (TV_{2025}) of the joint venture, assuming it is a growing perpetuity as:

$$TV_{2025} = \frac{CF_{2025}\left(1+g_{steady}\right)}{\left(cost_{capital}-g_{steady}\right)} \qquad (2)$$

We assume that g_{steady} = 3% (the long term growth rate of GDP in the developed world). The cost of capital of the venture, $cost_{capital}$, is estimated using the Capital Asset Pricing Model (CAPM), developed by Sharpe (1964) and Lintner (1965). The CAPM equation states that the cost of capital for an all equity firm will equal:

$$cost_{capital} = r_f + ERP * beta \qquad (3)$$

Where r_f denotes the risk-free rate, which we assume equals 5%, and ERP denotes the equity risk premium (the expected return on the market over the risk free rate). In our estimation we use ERP = 7%, which is the number currently used by Bloomberg. The beta of the joint venture is difficult to estimate ex ante. In our base case we use beta = 1.5, and present sensitivity analysis for values of beta ranging from 1 to 2.5 in Table 3.

Let $Stake_{2020}$ denote the value of the 50% ownership stake by the space agencies in the joint venture in year 2020. $Stake_{2020}$ then equals:

$$Stake_{2020} = 0.5 * \left(\sum_{year=2021}^{2025} \frac{CF_{year}}{\left(1+cost_{capital}\right)^{(year-2020)}} + \frac{TV_{2025}}{\left(1+cost_{capital}\right)^{5}} \right) \qquad (4)$$

We are now ready to calculate the NPV of space tourism to ISS for the space agencies as:

$$NPV = \sum_{year=2010}^{2020} \frac{CF_{year}}{\left(1+r_f\right)^{(year-2009)}} + \frac{Stake_{2020}}{\left(1+r_f\right)^{11}} \qquad (5)$$

Equation (5) makes the important assumption that the space agencies use the risk-free rate (5% in our base case) to discount future cash flows. This assumption is warranted due to the state ownership of all space agencies and their reliance on government funding, which is obtained at the risk-free rate.

Using our base case assumptions outlined above, we calculate that space tourism to the ISS has a projected NPV of $4.1 Billion. The most important driver of NPV is the value of the 50% stake in the joint venture. $Stake_{2020}$ equals roughly $4.5 Billion. In other words, in

2020 when the ISS will cease any science-related operations, the agencies can form a joint venture and receive in exchange for the ISS an equity stake with an estimated value of $4.5 Billion.

Table *2* presents the results of our sensitivity analysis of the effect of changing $g_{mktshare}$ on NPV. As predicted, NPV is highly sensitive to the $g_{mktshare}$ input. The NPV at the highest considered value for $g_{mktshare}$ of 20% reaches roughly $13.5 Billion, which is a more than 200% increase over the baseline NPV of $4.1 Billion at $g_{mktshare}$= 10%. Note that a value of $g_{mktshare}$ of 20% is not wildly optimistic. Futron (2002) predicts that the number of orbital tourists in 2021 will be as high as 60, which translates into an implied value for $g_{mktshare}$ of 29%.

Table 2. Sensitivity Analysis of NPV as a function of Growth in Market Share of ISS (beta = 1.5)

$g_{mktshare}$	PV of Cash Flows ($ Million)
5%	$2,300.86
6%	$2,581.42
7%	$2,898.45
8%	$3,256.60
9%	$3,661.11
10%	$4,117.81
11%	$4,633.25
12%	$5,214.75
13%	$5,870.49
14%	$6,609.60
15%	$7,442.28
16%	$8,379.88
17%	$9,435.07
18%	$10,621.93
19%	$11,956.13
20%	$13,455.09

Table 3 presents the sensitivity analysis of the impact on estimates NPV from changes in Beta. The sensitivity of NPV to changes in the Beta parameter is not as high as changes in $g_{mktshare}$. When increasing beta to an extreme value of 2.5, the NPV drops from the baseline value of $4.1 Billion to $2.9 Billion, which is a reduction of about 30%. Such high value for Beta is unlikely to correspond to the market risk of orbital tourism, which is a high-end luxury service. In comparison, the beta of Tiffany & Co is 1.2, of Royal Caribbean Cruises – 1.7, and of Carnival Cruises – 1.2.

Table 3. Sensitivity Analysis of NPV as a function of Beta ($g_{mktshare}$=10%)

Beta	PV of Cash Flows ($ Million)
1	$5,524.51
1.1	$5,151.38
1.2	$4,834.42
1.3	$4,561.93
1.4	$4,325.24
1.5	$4,117.81
1.6	$3,934.58
1.7	$3,771.60
1.8	$3,625.74
1.9	$3,494.46
2	$3,375.72
2.1	$3,267.84
2.2	$3,169.41
2.3	$3,079.27
2.4	$2,996.42
2.5	$2,920.05

To further provide a measure of the importance of space tourism to the ISS for the space agencies, we allocate the NPV calculated by the model to the annual budgets for operating the ISS for each of the years 2010-2020. We assume that the annual operating budget of the ISS for 2010 is $4.5 Billion (GAO, 2008), and that this budget will grow at 3% a year. If the NPV is allocated in installments growing also at 3% a year, the value of space tourism will be able to cover 9% of the annual budget of the ISS until 2020 at the base case assumptions. In the mildly optimistic scenario when $g_{mktshare}$ = 20%, space tourism will be able to cover almost 30% of the budget.

The space agencies will generate direct benefits from cost saving and free publicity. At the same time, space tourism service providers will generate direct benefits such as revenues from ISS utilization, technology reliability and interoperability and indirect ones, such as free publicity and technology innovation.

The case study we present assumes that the ISS will be transferred to a joint venture in 2020, regardless of the demand for orbital tourism in the future. In practice, the ISS partners may investigate various options depending on whether demand for orbital tourism is high, medium or low. First, the ISS can continue current operations beyond 2020. That will be an optimal choice, if demand for space tourism is low and the ISS partners will determine that the scientific value of operating the station outweighs the benefit from remodeling the station as a dedicated tourism facility. Second, if demand is medium and growing at a steady pace, the space agencies may

consider a long-term leasing agreement, in which for a fixed annual fee they will let private orbital tourism operators use the ISS. Last, when demand is high and growing at highly variable rates, a joint venture becomes the optimal choice, because it significantly reduces the downside risk of the private partner while at the same time it allows the space agencies to benefit from the upside of possible tremendous growth of demand in the future.

The NPV analysis does not consider the possibility of the space agencies to make optimal decisions, conditional on future market demand or other factors. The NPV assumes that the project proceeds as planned regardless of outcomes and as a result undervalues the true project which includes flexibility to respond to changes in market conditions. Such flexibility obviously has value, because it reduces future losses from bad market conditions (e.g. low demand), while at the same time preserves the future benefits from good market conditions (e.g. high demand). It is beyond the scope of this article to formally evaluate such flexibility using modern tools like Real Option Analysis. What we can only say is that usually the flexibility to pick one of many options increases significantly the value of a long-term risky project relative to the NPV value (see for example de Weck et al, 2004), which suggests that orbital tourism could actually add more benefits to the space agencies operating the ISS relative to the NPV estimates presented in our case study.

CONCLUSION

In the last few years, the space tourism market has emerged as one of the most promising markets that may potentially reach up to $1 billion by 2021. Space tourism service providers, operations, manufacturers, launch service providers and insurance companies are hoping to generate benefits from new market development, revenues from sales, technology innovation and international partnerships.

Today, sub-orbital transportation vehicles are being used for micro-satellite launches and parabolic flights – in 2004 the idea was to use SS2 only for space tourist activities. In addition, Virgin Galactic has signed an agreement with NOAA for carrying earth observation sensors on board of SS2 and in the future to use it for parabolic flights. Companies, such as Space Adventures started initially with parabolic flights and with offering trips to the ISS and are now offering sub-orbital flights, astronaut training and considering launching their own science programs. The ISS may be used as a space tourist base after 2020 and private launch services providers, such as Space-X may be provide low cost launch services. Space tourism activities can also create secondary markets for space fashion, gaming and sports.

Nevertheless, we should not forget that the space tourism market is still in its nascent stage of market development with unknown markets, technology innovation as a driver and therefore, space companies are diversifying their markets. Space tourist companies may be driven to diversify due to the need for long-term investment, unknown customers, high business risks and longer “time-to-market” for the development of the traditional space tourist markets.

Private investment in the development of low cost launchers, sub-orbital transportation vehicles, inflatable space stations and transportation vehicles will require a utilization and viable business cases and reliable market analysis. Therefore stakeholders will need to assess their investment decision and expected profitability from their diversification activities, assess the expected cost from diversification, perform NPV, SWOT and sensitivity analysis, and identify potential markets for economies of scale.

Lessons in quantifying benefits learnt from the aviation industry may be useful for future sub-orbital tourism activities. From the aviation industry the benefits of cost savings, capacity and technology reliability will be relevant for space tourist companies. These could also be combined with *employment, revenues from sales* and *new markets*. The qualitative benefits can be safety, environmental and international partnerships in combination with *free publicity* and *technology innovation.*

To illustrate the idea that space tourism can offset some of the costs of space agencies, in this paper we present a discounted cash flow analysis of space tourism to the ISS. Using our base case assumptions, we calculate that space tourism to the ISS has a projected NPV of $4.1 Billion, which is realized under the condition that in 2020, the space agencies operating the ISS will form a joint venture with a private space tourism company and receive an equity stake in the venture with an estimated value of $4.5 Billion. Furthermore, if the NPV is allocated in installments across the 11 years between 2010 and 2020, the value of space tourism will be able to cover 9% of the annual budget of the ISS until 2020 at the base case assumptions. In the mildly optimistic scenario when $g_{mktshare}$ = 20%, space tourism will be able to cover almost 30% of the budget. These estimates are rather conservative and do not take into account the flexibility of the space agencies to determine which is the optimal use for the ISS in 2020 depending on the market conditions at the time, especially the market demand for orbital tourism.

Our analysis shows that the space agencies will generate direct cash flow benefits from orbital tourism, which can be used to offset costs. At the same time, the proposed contribution of the ISS to a public-private joint venture between the space agencies and a private space tourism service provider will generate additional direct benefits such as revenues from ISS utilization beyond 2020. Indirect benefits from such joint venture include possible spillover effects for the development of new markets like space fashion and space sports, improved technology reliability and free publicity and technology innovation.

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