ESPI
European Space Policy Institute

ESPI PERSPECTIVES 26

Efforts, Motivation and Benefits of Spaceflight - A Brief Guide for Space Advocates and Decision-Makers

Markus SCHILLER, Schmucker Technologie

Spaceflight – manned and unmanned – is subject to a continuing struggle for sufficient funding. A wide variety of pros and cons, especially concerning the benefits of spaceflight, is used in this debate. A new approach that includes efforts, motivation and benefits results in a structured classification of space activities into three directions. The findings could support space advocates as well as decision-makers in recognising and advancing the real and unique benefits of spaceflight. This is particularly relevant in view of the planned European conference on space exploration hosted in October 2009 in Prague.

The Current Debate about Space Benefits

The fact that there is a continuous debate for many decades about the reasons why we should actually do spaceflight shows that there is no simple answer to this problem. But, perhaps due to its age, many aspects are ignored in this debate. For one thing, the real objective seems to have been lost during the years: Instead of searching for reasons why anyone should finance the costly endeavour of spaceflight, the majority of space advocates either tries to justify a general increase of the space agencies' budgets, or searches for arguments to convince politicians of the scientific and inspirational values of manned versus unmanned missions to secure funding for their favourite space applications. A good part of the debate developed towards – or retreated to? – the justification of human spaceflight, using arguments beyond utility to increase governmental funding of manned missions.

Human spaceflight is just a small fraction of the present global space related activities. In 2007, only 5 out of 68 orbital launches were manned, and human spaceflight had a fraction of roughly 10 % of global space budgets.

Justifying continuation of existing governmental space budgets should not be the priority of the debate. Starting from scratch, simple interrelations could show an alternative way to advance the case of spaceflight.

A New Approach

Any proposal is only realised if someone is willing to finance the venture. This is usually the case if this 'someone' has an advantage from it. This means that someone has to be identified who benefits sufficiently from the proposed activities that he is willing – and able! – to pay for it.

Spaceflight is special in a way that it is extremely demanding. It requires a minimum of efforts to actually do anything in space, and these efforts have to be overcome to create any benefits of spaceflight. And if these benefits are – at least in the eyes of the financing entity – higher than the efforts, only then motivation to realise the proposed activity in space is given.

This means that three aspects must be considered:

- The *efforts* that are required to conduct a proposed activity in space.
- The *motivation* of someone who has the potential to realise the proposed activity by financial means.
- The *benefits* that are created by the proposed activity.

Efforts – Transportation and Hardware & Operations

Efforts can be divided into transportation *into* space, and the hardware and operations that are required to execute a given task *in* space.

For decades now, the focus is on the transportation segment. The vast financial means that were spent on development of space transportation systems have not resulted in significant cost reductions. Chemical propulsion is close to technical and physical limits, and the ever proposed cost reduction by reusable systems is questioned – transportation costs of the only existing system that is at least partially reusable, the Space Shuttle, are significantly higher than those of expendable launch vehicles. Other, more exotic means of transportation, such as space elevators, are far in the future – if they will ever be realised. As history has shown, significant cost reductions should not be expected for the foreseeable future.

But transportation is not the decisive cost driver and it is not an end in itself. Every object is transported to space for a certain reason: To perform a previously defined task. This requires hardware that is able to execute activities that are necessary to fulfil the given task, and this within the given hostile constraints of the space environment: microgravity or weightlessness, extreme temperatures, vacuum, extreme radiation, distance to Earth, unlimited space, small particles (micrometeoroids, dust).

To make use of one of these characteristics of space, all other characteristics must be mastered, as well as acceleration, vibration and other aspects during launch. This way, tasks that appear simple on Earth become extremely complicated missions if done in space. Examples are assembly or refuelling. And the extremely high requirements are mirrored by extremely high hardware and operations costs. On average, transportation is only 20 % of total mission costs.

It is important to understand that the costs of spaceflight will not change considerably even if transportation is for free.

The hardware and operations side dominates the mission costs, and lightweight design is not decisive for the high costs. Other requirements such as thermal control, power supply and management, communication devices, attitude and orbit control systems, propulsion, and many others will not disappear.

Motivation for Space Expenditures

Numerous national economic stimulus programs worth hundreds of billions of dollars are currently initiated to counter the effects of the global economic crisis. This vividly shows that there actually is an abundance of money – if there is a good reason to spend it.

A simple model of society is introduced to understand the motivation for funding. In this model, society consists of three elements: The sum of individuals (or households), the state (or government) and companies (or industry). Individuals do not have sufficient means to realise spaceflight on their own, but State and industry do. In the end, State and industry are financed by individuals in the role of taxpayer or customer, and thus they have to satisfy the needs of individuals.

The primary motivation of companies is to gain profits. All other aspects are secondary – research is only done to increase company profits. For the government, the motivation is to meet the national duties – and to succeed in the next elections. A view on the history of spaceflight identifies five major categories of motivation that were important for the development of spaceflight. Each category includes specific motives. The major categories are: adventure, fun and personal interest, national security, politics, science and research as well as commercialisation.

The following table illustrates the role of these categories for the three elements of society and their financial means. This must be considered if interest in space is to be aroused.

	Individual	**State**	**Industry**
Adventure, fun, …	X	-	-
National security	X	**X**	-
Politics	(X)	**X**	-
Science and research	(X)	(X)	-
Commercialisation	(X)	-	**X**
Financial means	-	X	X

Topics that can create profits for companies and topics that are of political interest for the State or help the State in meeting its national duties have the best chances of realisation.

Benefits – Overview

The standard approach to evaluate topics for spaceflight should be: $M = B - E$ with motivation M, benefits B and efforts E. Efforts can be quantified in financial means. But there are numerous types of benefits that are not easily quantified. Therefore, topics for spaceflight should be divided into four categories regarding to the benefits they create: subjective benefits, quantifiable benefits, benefits as a By-product and potential benefits.

Subjective Benefits

Most justifications of spaceflight, especially human spaceflight, regard topics that directly touch society and human individuals. The resulting benefits exist, but they cannot be quantified in an economic sense. They are subject to varying personal judgment, thus complicating a neutral statement. Most of them can also be referred to as trans-utilitarian benefits.

Quantitative comparison of efforts and benefits for a clear result is impossible for this category of benefits. This rules out profit oriented companies for realisation, and leaves the State as a primary actor, thus requiring public funding.

The focus of literature clearly lies on this category of benefits. The efforts are usually ruled out, resulting in the simple equation: $M = B$. In this case, benefits B and motivation M are usually seen as equivalent, and thus motivation of the state to finance *any* type of space activities should be given – a widespread view among space advocates and scientists. That the efforts still have to be met is simply ignored.

Subjective benefits can justify limited national (and international) space activities with public funding, but they are not sufficient to motivate a government to significantly increase its current level of space expenditures. Because the required efforts for spaceflight will probably remain at the current level for the foreseeable future, spaceflight that is motivated by subjective benefits will also remain at the same level.

Quantifiable Benefits

The benefits of commercial activities in space can be clearly quantified as revenues. If the applications are feasible, if there are no political restrictions, and if profits are expected, then companies will carry out these promising activities.

For these topics, the identified evaluation method can easily be applied: $M = B - E$. If the benefits (revenues) outweigh the efforts (expenditures), motivation is given, and investments will be made. The prime actors are companies, the State is secondary and might contribute with start up financing. Nonetheless, motivation is only given if, in the long term, profits can be expected.

Analysis of numerous potentially commercial topics for spaceflight shows that “distance to Earth” is the only relevant aspect of the space environment that is commercially exploitable. All other aspects seem to be interfering. To give some examples, this is true for satellite communication, Earth observation, burial in space or disposal of nuclear waste.

Only very few concepts of commercial space utilisation seem to be economically sound, and those who are suffer from other restrictions, for example political aspects for the proposed disposal of nuclear waste in space. As long as no new and promising commercial space applications are emerging, considerably increased commercial engagement in space activities cannot be expected. But only identification of such an application can lead to an extension of spaceflight activities.

Benefits as a By-product

The terrestrial application of technologies, processes, services, and products that were originally developed for space is an often cited justification of spaceflight. Any type of spaceflight activities may randomly produce by-products – no special mission objectives must be declared. Common terms for these by-products and their creation are spin-off and technology transfer, but the term by-product better reflects the undirected character of these benefits, and it correctly implies that any activity creates by-products – this effect is not limited to spaceflight!

The benefits of by-products can be quantified and compared to the efforts. But this is actually not necessary. The by-products are created

anyway by any type of space related activities. This category of benefits is a worthwhile supplement to support argumentation by other categories, but it cannot justify spaceflight on its own, as it cannot justify any other field of high technology on its own.

It is not a sufficient justification to engage in spaceflight activities only to potentially create by-products, neither for companies nor for governments. But the by-products that are created at national space engagements, and the catalytic effect of spaceflight for terrestrial applications both contribute to the relevance of a space programme of leading industrial nations.

Potential Benefits

There are benefits with a low probability of occurrence, but once they occur, their impact is extremely high, and could even reach global scale. In other words, spaceflight helps to create *potential* benefits.

The topics that create these benefits deal with threats that are difficult to estimate. The probability of occurrence seems low, but the potential negative effect might be high. Threat is hereby defined as a product of probability and effect: *Threat = Effect x Probability.* The created benefit is reduction or neutralisation of the expected threat and its consequences by reducing the effect, the probability of occurrence, or both.

The considered threats are aimed at any individual, thus awaking interest in every single citizen, and their prevention is part of national duties, thus placing the state as prime actor for threat reduction.

Some topics of threat reduction have the characteristic of an infinite zero problem, with effect approaching infinity and probability approaching zero. A clear and unambiguous classification of the actual threat is therefore impossible, thus complicating advice on their urgency. The most prominent example is asteroid deflection.

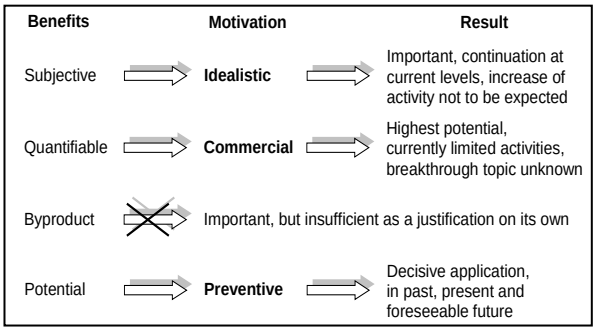
Other important applications to reduce threats on Earth are efforts to increase our understanding of Earth's weather and climate, prediction of and support during natural disasters, and possibly less popular but most important, the contributions of spaceflight to peacekeeping by military space. They might have had a significant part in preventing the Cold War from ever becoming hot.

The global character of spaceflight allows unique applications to reduce threats for every single individual and ensure security and safety. These applications were the actual reason that the means for spaceflight were initially developed. Identification and prevention of global perils for the safety of nations down to single individuals is essential for the preservation of our civilization, and spaceflight can – and does – contribute to this in unique ways.

Three Resulting Categories of Spaceflight

A revision of the four categories of benefits results in a classification of spaceflight regarding to the primary motivation.

Idealistic spaceflight tasks are performed by governments - and they also should be. But an increase in activities is not expected due to limited governmental funds and motivation.



Commercial spaceflight tasks are performed by companies, and financial means are virtually unlimited, but only if the revenues outweigh the investments. A promising, realistic commercial space venture is not yet identified due to the high investments required. But if it ever is, this would be the key to extensive spaceflight activities.

The combined insights demand a new phrase for "space*flight*" that shifts the focus from space *transportation* to *functionality and operations* in the space environment.

Preventive spaceflight tasks are performed by governments, and satisfy the most basic need of human individuals: The need for security and safety. Spaceflight offers unique ways to contribute to safety, ranging from the human individual to a global meaning. This was, is, and probably will be the most important motivation for spaceflight.

Space Exploration as Main Argument for Spaceflight

In this context, space exploration is in a difficult situation. The need to explore currently seems to be the main argument that is wielded to increase the public expenditures for spaceflight, especially human spaceflight. For that reason, achievements of great explorers of the past are often compared to the imminent exploration of space. Often cited examples are Christopher Columbus and Lewis and Clark. This is fundamentally wrong, though.

Columbus tried to find a new trade route to India. That and the prospect to exploit any lands that might be discovered on the way were the reason his expedition was funded by Ferdinand and Isabella of Spain. And Thomas Jefferson stated the objective of the Lewis and Clark expedition in a letter to Lewis as "to explore [which river] may offer the most direct & practicable water communication across this continent for the purposes of commerce."

Exploration on its own is a motive only for adventurers. The costly "exploration" expeditions of history were funded by governments only in expectation of trade and commerce that create quantifiable benefits. The known space environment that is in reach with current technology does not support trade and commerce: There is no trading partner in space, and promising commercial aspects of space are rare. The fascination of the unknown and the wish to explore are idealistic objectives that primarily create subjective benefits. These objectives never were sufficient to justify costly exploration on Earth. That this will be different for space seems unlikely.

Recommendations

Politics should accept the inspirational and scientific value of spaceflight, especially the public effect of human spaceflight, and give sufficient funds for visible and clearly understandable success. The European – and global – expenditures for spaceflight are insignificant compared to other financial efforts. Idealistic spaceflight should be continued, but the meaning of preventive spaceflight should be also understood, communicated to the public, and support for preventive space programs should be increased.

Industry should understand "Distance to Earth" as the most important aspect of spaceflight. Sensible commercial applications that make use of this aspect should be identified. The science community should remain in touch with the taxpayer, formulate scientific objectives that are widely comprehensible, and should not see science only as an end in itself with no need to justify the spending of public funds. Only this will enable broader public support and increased funding.

Space advocates should not waste efforts by their focus on reduction of space transportation costs. The hardware and operations side is the ultimate mission cost driver. Transportation costs are high, but negligible compared to the costs of the hardware that is required in space to execute certain predefined tasks. They should also accept that spaceflight has to answer for the same criticism as any other discipline. They should point out the strengths, especially the meaning of preventive spaceflight. This could give credible, convincing, and comprehensible arguments for the utilisation of space.

European Space Policy Institute

Palais Fanto
Schwarzenbergplatz 6

(Entrance: Zaunergasse 1-3)

A-1030 Vienna, Austria

Tel +43 1 718 1118 -0 / Fax -99

www.espi.or.at

The mission of the European Space Policy Institute (ESPI) is to provide decision-makers with an independent view and analysis on mid- to long-term issues relevant to the use of space.

Through its activities, ESPI contributes to facilitate the decision-making process, increases awareness of space technologies and applications with the user communities, opinion leaders and the public at large, and supports researchers and students in their space-related work.

To fulfill these objectives, the Institute supports a network of experts and centres of excellence working with ESPI in-house analysts.

ESPI Perspectives are short and concise thought or position papers
prepared by ESPI staff as well as external researchers.

Available for free download from the ESPI website
www.espi.or.at