The Importance of the Coming Private Space Travel Industry

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1 Introduction - the need for private space investment

The most valuable role for government differs between countries, but wherever they provide budgets to develop space technology, these clearly should be used in ways that benefit the economy. This is especially clear in a country such as Japan in which the government debt is at world record level, and growing rapidly. Benefiting the economy means to develop services which the public wish to buy. However, in the present era it has become clear that governments' expenditures on non-military space activities have very little economic value, despite their extremely high cost. This can be seen clearly in several ways.

1.1) Shrinking space industry employment

The spontaneous business activity that results from economically successful investment typically generates annual revenues equal to the amount invested, lasting over many years. However, to date OECD space agencies have spent some 1 trillion Euro-equivalents, but commercial space activities' annual revenues are only about 10 billion Euros/yr - and have been shrinking recently.

For example, Table 1 shows the recent fall in US space engineering employment, as reported by the FAA [1]. These very striking figures clearly do not show a healthy industry.

Employment	1999	2002
Launch vehicle manufacturing and services	28,617	4,828
Satellite manufacturing	57,372	31,262

Table 1: US space engineering employment [1]

1.2) Space travel cost stagnation

Another way of seeing the industry's economic failure is to note that, despite having spent 1 trillion Euro-equivalents, OECD space agencies have not reduced the cost of space travel at all. Three people have now paid to fly to orbit on the Soyuz rocket, which is still the cheapest means of traveling to orbit, despite having been designed 50 years ago! Such total stagnation in cost over half a century is probably unique in the history of human transportation. Moreover, OECD space agencies have no plans to change: Nasa's new plan, which other agencies support in principle, is to develop a new expendable launch system to send a few government astronauts to the Moon again, 50 years after Apollo 11.

1.3) Funding of least promising activities

A third way we can see the poor economic performance of space agencies is from the OECD report "Space 2030: Exploring the Future of Space Applications" [2]. Table 2 displays information from that report and other sources. Commercial launch revenues were $700 million in 2003 (having fallen from $900 million in 2002) [3]. Earth observation annual revenues are quoted as $230 million in 2002 [2, note to Figure 7.2]. Annual government investment in space transport and in Earth observation is shown as $6 billion and $4 billion respectively [2, Figure 10.4]. Roughly these rates of investment have continued for some 4 decades and 2 decades respectively, and so cumulative public expenditure on these activities can be estimated as about $240 billion and $80 billion respectively. The ratios between commercial turnover and cumulative public investment in both cases are therefore approximately 0.3%.

The OECD report quotes Nasa-funded estimates of the potential annual turnover of sub-orbital passenger flights as $700 million - $4 billion/year [2, p 122]. The investment needed to achieve

this capability has been quoted as $120 million for the case of the planned "SpaceShipTwo" [4]. The estimated ratio of revenues : investment for sub-orbital passenger travel is therefore some 580 - 3300%.

The development cost and annual revenues of the "Kankoh-maru" orbital tourism vehicle were estimated as part of the Japanese Rocket Society's 1993-2002 Space Tourism Research Programme as $12 billion and $17 billion/year respectively, for a fleet of 52 vehicles carrying 700,000 passengers/year [5]. These estimates have been broadly endorsed by experts on vertical take-off and landing vehicles in Europe and USA [6, 7]. Table 2 summarises this data and shows the ratio of commercial revenues to investment for each of these four activities.

	Investment	Commercial revenues	Ratio
Space Transport	$240 bn	$0.7 bn/yr	0.3 %
Earth observation	$80 bn	$0.23 bn/yr	0.3 %
Sub-orbital passenger travel	$0.12 bn	$4 - 0.7 bn/yr	580% - 3300 %
Orbital passenger travel	$12 bn	$17 bn/yr	140 %

Table 2: Ratio of Commercial Revenues to Investment for Selected Space Activities

The difference of more than 1,000 times in the ratio between annual commercial revenues and investment for existing space agency activities and for passenger launch vehicles is very striking. Even if these rough estimates were wrong by a factor of 10, the ratio of commercial revenues to investment for current space activities would probably still be less than 1% of those estimated for passenger space flight services.

Consequently Table 2 shows that, from the point of view of contributing to economic growth, space agencies' policy not to invest in developing vehicles suitable for sub-orbital passenger travel services, while investing heavily in activities which are economically much less promising, has greatly reduced the economic value of public investment in civil space activities. Moreover, coommercial sub-orbital space travel services could have started 30 years ago, and the investment needed to develop even orbital passenger flight services is less than a single year of OECD space agency expenditure today. The JRS research programme suggested that a market of $100 billion/year could be reached within 30 years [8].

Monopoly costs

The problems described above raise the question *why* space agencies perform so poorly. The major reason seems to be because they are effectively monopolies, and are near-monopoly sources of advice on space policy to the governments which fund them.

In this connection it is worth noting that governments have recognised for centuries that monopolies are extremely damaging, in two ways in particular: they raise costs and they suppress innovation. As a consequence, monopolies are illegal, and are usually permitted only in special situations, and only then for a limited time. Niskanen's explanation that only when they experience popular pressure through supplying services to large numbers of the public do government organisations perform efficiently in the interests of the public, also seems to apply to space agencies [9].

As a consequence, some people argue that private companies should develop systems to supply solar power from space to Earth, and that governments should not do this work. However, in that case space agencies' waste of resources would continue, and it would take far longer than necessary to develop space solar power.

2 Energy supply - potentially the most economically valuable use of space

In principle, for the space industry to justify receiving investment, whether from government or from industry, it must promise corresponding profits. In other words, it must develop some services which it can sell profitably to customers on Earth; otherwise it could not earn profits to repay the investment.

Today the only substantial services which the space industry sells to customers on Earth are information services. For more than 30 years, researchers have been considering participating in the much larger industry of energy supply. This is currently responsible for the majority of the CO2 pollution of the atmosphere which is causing accelerating climate change and threatens to destroy the Earth's ecosystem. However, research on the feasibility of power supply from space has received only minimal funding from space agencies.

The most recent such study took place in Europe through 2003-2004, and resulted in the report [10]. Among other conclusions this study showed that space solar power is highly complementary to terrestrial solar power. SPS rectennas would need only about 5% of the land area of the large desert solar installations that would be needed to enable terrestrial solar power to supply a significant fraction of human energy use today. Solar power delivered from space would also be largely impervious to the major systemic risk of all forms of terrestrial solar energy, namely climate change. Power delivery from space could even offer the prospect of Japan becoming an energy exporting country.

However, Esa, like Nasa and Jaxa, is not responsible for energy policy. Consequently, despite the potential benefits of increased investment in research, it provides only minimal funding for SPS research. It is not necessary to believe that solar power from space will surely become a competitive source of energy in the future in order to support funding for research to find out whether it could. There are many promising directions for research into reducing CO2 emissions: to not do research on any of these eliminates that option from the possibilities available.

Since government space agencies are not performing significant research on power from space, it is desirable for companies to invest in advancing the subject. It is widely agreed that an essential step is a multi-MW demonstration satellite operating in LEO. For example, Nasa's 1995 report stated: "The driving assumption is that the non-recurring costs for all of the SSP concepts would be based on flight testing a 10MW demo version of the particular concept in LEO" [11].

The "SPS 2000" project initiated and led in Japan is the largest study to date of a 10 MW demonstration satellite designed to operate in low equatorial orbit [12]. As a joint research project with the project leader Professor Nagatomo and Professor Matsuoka, the author has visited almost all the equatorial countries. In each country researchers and government representatives were keen to join the project, identifying candidate sites for "SPS 2000" rectennas and proposing various means of collaboration.

The main technical problem facing the SPS 2000 system is its 100% dependence on automatic self-deployment. Consequently, the joint Esa-Russia project to launch Soyuz from Kourou will in principle enable crew-tended deployment as necessary, thereby eliminating the main risk in the project, and making SPS 2000 a very desirable international collaborative project [13].

However, in addition to needing a satisfactory demonstration project, the feasibility of solar power supply from space also depends on reducing launch costs by about 99%. In order to achieve this, reusable launch systems are of course required. In addition, a large launch market - much larger than the satellite launch market - is also required, in order to achieve the benefits of "airline operations". This is discussed next.

3 A second economically valuable use of space - tourism

It now seems clear that the activity which offers the best prospect of generating a launch market sufficiently large to reduce costs sharply is carrying passengers. The cost-range needed for SPS to be competitive is the same cost-range as that needed for space tourism to flourish [14].
In 2004 "SpaceShipOne" showed that the potential for cost reduction in sub-orbital flights is at least 99% below expendable launch vehicles, and probably more. However, like power supply from space, space agencies have funded almost no work aimed at realising passenger space travel.

As seen in Table 2, even by space agencies' own estimates, passenger space travel is a much more economically promising activity than their preferred activities of satellite launch services and surveillance satellites. Consequently their failure to invest even in feasibility studies is contrary to space agencies' legal responsibility to contribute to economic growth.

An important result of the Japanese Rocket Society study was to clarify that the civil aviation

industry is a much better model of how space tourism services will evolve than space agencies' activities [15]. Aviation organisations including the FAA in the USA and the JAA in Japan are already working to realise it, though with not even 1/1,000 of space agencies' resources.

Over the past few years there has been growing coverage in the media of activities to realise space travel services for the general public, due to its wide popularity. In addition to several companies planning sub-orbital services, others are starting to plan orbital services. In Japan, Takafumi Horie has said he will invest in reviving the Almaz capsule to provide short orbital flights at about $5 million/head, or some 75% below Soyuz - the first reduction in 50 years. In the USA, t/Space Inc's "CXV" vehicle, which needs investment of some $500m, is also expected to reduce the cost of flying to LEO to $5 million/person by 2010 [16]. Also in the USA, Bigelow Aerospace Inc has announced plans to start hotel operations in orbit in 2010 if these or other companies can supply passenger transportation [17]. In 2005 Russian engineers announced plans for a lunar orbital trip at a cost of $100 million.

If even a few percent of OECD space agencies' annual budgets of some $20,000 million was invested in these projects, rapid progress would be possible. For governments to continue their existing space spending without including these economically much more beneficial activities would be a serious policy error.

4 The "Uchu-maru" project

From 1993 until 2002 a group of members of the Japanese Rocket Society (JRS) carried out the JRS Space Tourism Research Programme, which led to the publication of a large number of papers and reports on different aspects of the feasibility of developing, manufacturing and operating "Kankoh-maru" orbital passenger vehicles.

A major conclusion of the study was that "Kankoh-maru" was feasible, and funding of 1.4 trillion Yen would be sufficient to start passenger services to orbit within about 10 years, after which the price of a return flight to LEO could fall to less than 3 million Yen/person. Another conclusion was that a smaller-scale demonstrator vehicle was required first. A sub-group then focussed on a small sub-orbital vehicle, to carry about 5 passengers to 100 kilometres altitude. This has become the "Uchu-maru" project [18].

The development cost of Uchu-maru is estimated at 10 billion Yen "plus alpha", where alpha will depend on the government. Technically, Uchu-maru could start flying within 3 years of funding becoming available. However, the regulations which it must follow will depend on government.

The current situation is that work is under way to build a mock-up of Uchu-maru, to be used for educational purposes. For the development of a prototype, if the government officials responsible for aviation are supportive, the project could be a great success, technologically, commercially, and popularly. However, if the government continued to be obstructuve, it could easily prevent Japanese manufacturing industry from playing a significant role in this exciting new industry.

5 Japan's potential role

In the 2005 Japanese general election a majority of voters voted for change, particularly in government's role in the economy - focusing initially on privatisation of the post office system. However, wider political change is needed in Japan in order for government spending to be of more economic benefit for the general public. The vested interest groups that dominate government decision-making on public spending on public works, energy, space and other fields are currently preventing this, by maintaining a pattern of spending established decades ago in a very different economic and technological environment.

On August 29 the Nikkei newspaper reported that Jaxa Head Tachikawa said:

> ". . space commercialisation.. ..is not possible for at least 10 years, and so taxpayers must continue giving Jaxa $2 billion/year" [19].

In the same article, Space Activities Commission Head Oguchi claimed:

> ". . there is no popular support for developing passenger vehicles, and so taxpayers must continue paying for loss-making satellites" [19].

The government officials responsible for space policy have been repeating such statements for decades, while pending some 4 trillion Yen of taxpayers' money. However, these cliches are no longer true. Unfortunately the journalist interviewing these two officials did not question them about why the Japanese government refuses to invest in sub-orbital passenger vehicles.

Just a few days later the Daily Yomiuri reported:

> "Nasa intends to allow the private sector to use the ISS for space tourism. . . Japan's space programs . . likely will be subject to drastic review" [20].

And on August 25 a meeting was held about the prospects for space tourism in Hokkaido by the Hokkaido Aerospace Science and Technology Incubation Centre (HASTIC). Thus it may be that movement towards developing passenger space travel in Japan is going to beginning to accelerate anyway, with or without central government support.

Concerning power from space, the SPS 2000 project remains the most fully worked-out next step towards its early realisation. Just 1% of the Japanese government's public works budget, much of which is wasted on environmentally-damaging "make-work" projects, would be enough to build such a 10 MW, low orbit operational demonstrator over a few years, and would make both space policy and energy policy far more economically valuable than they are today. By contrast, continuing to spend approximately 500 billion Yen every year on nuclear power subsidies, while refusing any substantial budget to research the potential of power from space, is not justifiable by any objective assessment of the relative merits of these energy systems. It is merely the continuation of a policy decided decades ago, which senior bureaucrats do not wish to change, but which they refuse to discuss openly.

6 Importance of space tourism for the 21st century world

Some critics claim that space tourism will be no more than a pastime of a small number of very rich people, and hence is of no importance. However, this criticism seems mistaken for at least two reasons.

1) The available evidence about both the potential demand and the potential for cost reduction suggest strongly that space tourism customers will not be limited to the very wealthy, but will come to include most of the middle classes as the costs fall progressively.

2) In order to understand potentially how important this is, it is necessary to consider the long-term implications for world economic development. Creation of a major new industry in this way would be particularly valuable today in view of the high level of unemployment worldwide, as discussed in [21]. Moreover, by sharply reducing launch costs it would make solar power delivery from space economically viable, with potentially great benefit for the global environment.

6.1) Two competing world-views - Hell or Heaven.

To illustrate how important to humans' future the development of passenger space travel may be, the phrase made infamous by the then President of the EU, Jacques Delors is useful:

> "..the coming 21st century resource wars."

The phrase was used within a few years of the end of the cold war, and expresses well the outlook of what can be called the "cold war generation" of political leaders, the greater part of whose careers has been spent within the paradigm that the "western world" was under threat of destruction by an "evil empire" of massive global capability. The phrase "cold war" expresses how these leaders saw the world as little more than a battle-ground to be fought over in order to obtain resources needed for survival. This world-view led to the development by the rich nations of massive arsenals of nuclear weapons, subsidised by government investment of some 2 trillion Euro-equivalents in “peaceful nuclear power”.

Delors' phrase expresses how this ideology has been replaced by the idea that the rich countries need to be able to subdue the far more numerous poor peoples, in order to maintain access to resources, especially fossil fuels, while making minimal investment in environmentally benign technologies and systems. However, although "cold warriors" pride themselves on their "realism" about the true harshness of human life, in fact their thinking is "Pre-Copernican". Their traditional military viewpoint centres on the concept of capturing territory in order to obtain access to the

resources therein.

It is said that ". . to a hammer, all problems look like a nail". From this viewpoint all issues reduce to the military consideration of controlling territory with underground fossil fuel resources. An important assumption underlying this viewpoint is that all valuable resources are on or under the ground. It is of course the exploitation and combustion of these underground fossil fuels which is causing pollution and destruction of the environment, notably in the form of accelerating climatic change.

A current example of the danger and short-sightedness of this approach, as early in the 21st century as 2005, Japan and China are already squabbling over a tiny gas-field that lies between their two countries, and which would supply at most a few weeks of energy. The same effort devoted to developing non-CO2 energy systems could earn many times the return, but their politicians are trapped in traditional, pre-Copernican squabbling over underground resources.

There is a very different perspective on humans' future, which contrasts sharply with the cold warriors' view described above. This is the viewpoint that humans live in a "cornucopia" of unlimited quantities of all resources - notably solar energy, all mineral raw materials, living space, a sink for noxious waste, and limitless room for adventure - capable of supporting a human population hundreds of times larger than the present population of Earth. This viewpoint merely requires humans to make the tiny investment needed to make access to space low-cost and routine; thereafter the ideas of "limits to growth" or the need to fight over "dwindling resources" will be seen to be absurd; they will be as fundamentally mistaken as the fears of "flat Earthers" that ships would fall off the edge of the Earth if they sailed too far.

But, although these two world-views are apparently vastly different - literally "Hell" or "Heaven" - in fact, the only difference between them is that they make a different assumption about one single number - this is the cost of getting to orbit.

Governments rely on the heads of their monopoly space agencies who claim that, having been $20,000/kg ever since 1957, launch costs will remain unchanged at this level for at least several more decades. Consequently the potential resources of space are not economically accessible, and humans are trapped in a closed eco-system with ever-growing population. Followed to its logical conclusion, this world view would lead to Hell on Earth.

In extreme contrast, space tourism advocates say that the cost of reaching orbit could be reduced to $200/kg or less with investment of less than one year of space agencies' current budgets. That is, space policy makers are wrong: in truth, by investing appropriately it is possible to have access to orbit at 1% of the cost of space agencies' launch vehicles. Consequently the current "Ruling Paradigm", that humans are "running out of resources", and must prepare to fight over the remains - is also wrong. Humans' future, both on Earth and beyond, is Heaven, not Hell. Given political leadership, it is technologically easy to ensure the possibility of ever-rising standards of living for all humans.

The potential value of such an outcome is clearly so high that even if the probability of success was objectively estimated as only 1 in 100 (and it seems to be much higher than that) then governments should spend a significant fraction of their space budgets - even 1% would be 200 million Euros/year - investigating the possibility. Even in Japan 1% would be 2 billion Yen/year. But government space agencies continue to spend nothing on trying to reduce the cost of space travel, although these ideas have already been worked out to an important level of detail.

7 Conclusions - the importance of space tourism

As humans' growing economic activities approach the limits of Earth's ecological carrying capacity, it has been explained convincingly that governments will become increasingly intolerant and repressive [22]. Indeed, this process is already clearly visible both in military clashes in the world today, and in the recent rapid reduction of civil liberties in USA, Britain and Australia, among other countries.

Since the "space option", that is the use of space resources, can overcome environmental limits to growth, it is clearly a severe failure of government policy that their space policy makers refuse

even to discuss the possibility of researching the feasibility of reducing the cost of travel to orbit! In turn, government economic policy-makers should know better than to rely on monopoly organisations for advice. Although they frequently refer to the speed of technological progress and the need for innovation, they do not seem surprised that the price of space travel has remained static for half a century.

In conclusion, the author does not agree that it is better to "leave SPS to the private sector" while space agencies continue their existing activities. Space agencies' existing activities are economically extremely wasteful, and are ignoring what is by far the most economically important subject - the urgent reduction of the cost of space travel. Government space spending should be urgently revised to include investment in both space power supply and passenger space travel, which offer a door into a world of unlimited growth quite different from the ever-more constrained and environmentally damaged world being created by the current world leadership.

However, once developed, space tourism should be operated primarily by commercial companies following the business model of civil aviation. Institutionally the organisation of passenger air travel can be readily adapted to handle passenger space travel - certainly far more easily than trying to reform space agencies. Appropriate government support through the civil aviation R&D subsidy system will have the additional benefit of creating competition for space agencies which will drive them to be more economically productive.

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