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Public-Private Financing of Space Settlements

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ABSTRACT

Airline subsidies, the Overseas Private Investment Corporation (OPIC), and the Federal National Mortgage Association (FNMA or "Fannie Mae") were established in the 20th century to support private enterprises and capital markets developing America's airline industry, housing market, and US foreign policy and interests in emerging economies. This paper will provide an overview of the applicability of similar public-private financial solutions in support of private Space travel, infrastructure development, and eventual Space settlement.

Overview

In the past 5 years, the world has witnessed what many have called a Space "Renaissance". Jeff Bezos, the Founder & CEO of Amazon Inc., is a very well-known advocate for Space settlement and has several times disclosed his vision of a "future where people are able to live and work in Space". With several billionaires (Bezos, Elon Musk, Sir Richard Branson, the late Paul Allen) investing in commercial Space transportation, growing international interest in Space exploration and settlement (European Union, UAE, India, China), renewed impetus by the USA to land humans back on the Moon by 2024 and maintain a permanent human presence on the Lunar surface, and the proliferation of new technologies and capabilities in the Space industry (reusable rockets and spacecraft, robotics, 3D printing, high bandwidth communications, in-orbit repairs & construction, ISRU), everything is culminating in widespread Space settlement becoming more and more technologically feasible, with its commencement within the next few decades.

Widespread Space settlement is contingent upon the existence of four necessary "pillars": technological capability, regulatory clearance, economic activity, and financing. This paper addresses the financing aspect of Space settlement with direct ties to stimulating necessary economic activities for the long-term viability of Space settlement.

The world currently owns approximately $317T of wealth, with $98T belonging to the US. Even 1% of the total wealth in the world, if appropriated towards facilitating human Space settlement, would have a tremendous impact on the maturation of key Space enterprises, technologies, and seeding of human Space settlements. It is not that the world does not have enough capital to make Space settlement a reality; the world doesn't yet have the right framework of long-term economic incentives tied to long-term financing infrastructure.

The US Secretary of Commerce recently stated that we need "strong participation from all levels of capital structure", i.e. the big banks, insurance companies, and investment funds of the world. Although Secretary Ross' statement on lack of major participation by major institutional capital is accurate, major financial institutions will not participate in financing of major Space development activities until technological and business risks are mitigated and timelines to liquidity of investments and loan paybacks are reduced. In this paper we evaluate three concepts for public-private financial "infrastructure" that can help reduce the barrier of entry for major financial institutions by spreading financial risk across the capital markets via government-sponsored financial support and securitization of Space enterprises. Furthermore, the proposed public-private financial infrastructure has the potential to facilitate the seeding of fundamental economic activities, which in turn provides incentives for increased human presence in outer Space, resulting in further positive feedback of more Space-based economic activities, more humans in Space, and eventually, the economic sustainability of Space settlements.

The proposed public-private financial infrastructure mirrors elements of public-private paradigms that supported the growth and sustainability of the US airline industry, the US housing market, and US economic development interests in developing countries in the 20th century. We propose the establishment of the following three public-private financial structures:

- The **Space Transportation Trust Fund** (STTF), that mirrors the airline industry subsidies paradigm and the Airport and Airway Trust Fund, to subsidize commercial Space transportation of humans for the purposes of Space tourism and eventually Space settlement
- The **Outer Space Private Investment Corporation** (OSPIC), that mirrors the Overseas Private Investment Corporation, to provide loan guarantees and risk insurance in support of ecosystem-enabling infrastructure projects in outer Space
- The **Outer Space Settlement Financing Association** (OSSFA), that mirrors Fannie Mae, to finance US Space settlers for relocation to permanent or limited duration lodging in Space settlements

The three proposed organizations have the potential to radically transform the availability of and flow of private capital into the development, maturation and sustainment of outer Space industrialization and human Space settlement.

Driving down the costs of transporting humans to Space

Prior to World War 2, the newly established airline industry was niche, expensive, and dangerous. After almost a century of technological advancements in aviation along with the proliferation of commercial airline companies, the global air travel industry today is radically different (widely used, cheap, and very reliable) as compared to 80 years ago. How? The US government alone has invested over $750B (2019 dollars) in the US airline industry since 1918, with the majority (~$637B) invested from the Airport and Airway Trust Fund to support key enabling organizations such as the FAA, the construction and maintenance of airports around the country, and to provide other necessary infrastructure and services to the commercial US airline industry. Although airline subsidies were a contentious topic in Congress in the decades preceding the establishment of the Airport and Airway Trust Fund, it is undeniable that they helped steer an uneconomical industry towards widespread adoption into everyday life for billions of people. Could subsidies and the establishment of a Trust Fund in support of commercial Space travel similarly assist the development of an economical and widely used human Space transportation industry?

One can assert that the NASA Commercial Orbital Transportation Services (COTS) program was a form of subsidy to support emerging commercial Space transportation capabilities. SpaceX was a beneficiary of the COTS program and, in less than 10 years, has managed to drastically reduce their price per kilogram of payload to Low Earth Orbit. NASA continues to enable commercial Space enterprises with contracts to advance their capabilities and provides future guaranteed revenues by being an "anchor customer". However, additional support is needed to reduce costs associated with the safe transportation of humans as well as the provision of reliable life-support and habitats for survival in a Space (orbital or planetary) environment. Current normalized costs for sending humans to and keeping them alive in Space vary approximately from $70M to approximately $20M per human, depending on the purpose (government vs. commercial), duration of stay, and service provider.

The Finsophy PBC team conducted a survey in May 2019 to determine the price elasticity and potential addressable market demand in the US for short-term (i.e. Space tourism), long-term, and permanent Space settlement as a function of the price for relocation. We concluded that the maximum relocation or travel price that would enable widespread interest in Space settlement is $2M per person, inclusive of travel costs, basic lodging at the Space habitat or settlement, life-support, and basic necessities. An overview of the survey results with respect to the maximum price Americans are willing to pay for Space settlement is shown in Table 1 below. In addition, we acquired data on the maximum net worth of a household that an individual may consider utilizing to pay for the price for relocation; these results are shown in Table 2 below.

Table 1: Price elasticity and potential addressable market for Space settlement

POTENTIAL ADDRESSABLE MARKET FOR SPACE SETTLEMENT (max price method)			
Price	**Response Rate**	**Potential Addressable Market (# of Americans)**	**Potential Addressable Market ($)**
$5M	0%	-	-
$2M	1%	734,057	$1.5T
$1M	8%	4,771,367	$4.8T
$500K-$750K	11%	6,239,480	$3.9T
$100K-$250K	30%	17,250,328	$3.0T
$50K-$99K	49%	27,894,148	$2.1T

Table 2: Potential addressable market for Space settlement by estimating the total US net worth that could be appropriated towards Space settlement

POTENTIAL ADDRESSABLE MARKET FOR SPACE SETTLEMENT (net worth method)		
Net worth range	**Response Rate**	**Potential Addressable Market ($)**
1-2%	20%	$117B
3-4%	8%	$106B
5-9%	12%	$335B
10-20%	29%	$1.7T
21-30%	10%	$945B
31-40%	3%	$353B
41-50%	11%	$1.9T
51% or more	8%	$2.3B
	TOTAL	**$7.8T**

The current price barrier ($20M per person, best case) is at least 10X higher than where the industry needs to be to enable the proliferation of sustainable market demand for commercial transportation of humans to Space and viable adoption of Space settlement. Utilizing "learning curve" theory and analysis, and historical launch information from the past two decades, we have developed a predictive model with Emerging Futures LLC on how Space transportation, life-support and habitat costs ought to decrease as a function of increased utilization. In some cases, if orbital Space tourism demand reaches 1,000 people per year for example, that increased utilization alone could reduce overall industry prices for transportation and life-support by 2X or more.

We therefore conclude that, similarly to the US airline industry in the 20th century, a **Space Transportation Trust Fund** (STTF) should be established to help the Space industry reduce costs, increase the supply of available human-rated Space transportation, and unlock sustainable market demand for Space tourism and eventual short-term, long-term, and permanent outer Space settlement. The STTF could be capitalized in various ways:

- An initial US government appropriation to seed the STTF and commence operations
- Monetization of the NASA "brand" via mission sponsorships and advertising rights in partnership with commercial partners
- Collection of fees from commercial Space transportation activities (payloads, constellations, cargo and/or human transport)
- Collection of fees from US spaceports

The STTF would have the charter to:

i. Purchase excess capacity for human-rated commercial Space transport to generate reliable and low-cost human Space transportation supply
ii. Construct, develop, and maintain critical infrastructure and services in support of human Space transportation

Ultimately, the STTF would first enable the proliferation of orbital and cislunar tourism, reducing costs of human transportation, short-term habitats, and life-support, and eventually pave the way for economical Space settlement.

Building critical infrastructure in free Space and planetary outposts

In the past 10 years the industry has witnessed a plethora of emerging business cases in support of bold yet whole-ecosystem-enabling Space infrastructure and enterprises. From asteroid mining to orbital fuel depots, orbital hotels, and Space-based solar power, the opportunities for economic growth and profits are enormous, yet the "investability" of these endeavors remains low. The primary reason for mainstream institutional capital aversion to such investments: extremely long investment horizons (15+ years) with unpredictable market demand.

The Overseas Private Investment Corporation (OPIC) was established in 1971 as a means to enable private investment capital to support US government and commercial interests in emerging economies, where investment payback timelines were long and market demand was unpredictable and risky. To address the funding gap associated with long timelines and risky Space infrastructure and enterprises, we endorse the establishment of the **Outer Space Private Investment Corporation** (OSPIC), as proposed by a NSS position paper in December 2018, as a non-profit, government-sponsored financing corporation.

OPIC began its operations in 1971 with $53.2B (2018 dollars) in political risk insurance and $1.1B in loan guarantees. To date, OPIC has supported more than $200B of private investments in over 4,000 projects in emerging economies worldwide. A testament to its success as a non-profit financing corporation is that OPIC has actually returned $3.7B in profits back to the US taxpayer the past 10 years. Mirroring OPIC's structure and services, OSPIC would offer the following services in support of whole-ecosystem-enabling Space infrastructure projects:

- Debt financing to support Space infrastructure with long-term paybacks (20 years) that other institutional investors deem as too risky
- Loan guarantees
- Political and regulatory risk insurance (e.g. Space mining ventures)
- Participation in private investment funds as a minority shareholder

The two primary benefits of the establishment of an OSPIC-like organization to Space settlement are:

i. Enable the development of critical multi-use infrastructure, such as orbital fuel depots, in-Space assembly and integration rigs, ISRU plants, power generation and storage, life-support, food production etc., that reduce the risk and costs for Space settlement
ii. Enable the development of an ecosystem of integrated Space activities and commerce that would provide economic incentives and work opportunities to future Space settlers

Financing settlers for relocation from Earth to their new home

The Federal National Mortgage Association (FNMA or "Fannie Mae") was established as a Government-Sponsored Enterprise (GSE) in 1938 to help the average American purchase a home. Prior to the establishment of Fannie Mae, home loans were short-term, required large down payments, and entrapped the home buyer with balloon payments at the end of the loan term. In addition, banks of the time were not in the business of providing reasonable mortgages to the average American. Fannie Mae solved that problem by providing short-term liquidity to banks via purchasing mortgages and securitizing them for resale into secondary private markets. As a GSE, Fannie Mae was able to leverage its high credit rating to reduce financial risk for private lenders and empower more average Americans to purchase homes.

Our proposed **Outer Space Settlement Financing Association** (OSSFA) is mirrored after Fannie Mae. Its two primary functions would be to:

i. Provide short-term liquidity to banks that finance individuals for their relocation costs to a Space settlement
ii. Securitize "Space settlement relocation loans" and resell them into secondary private markets, thus spreading the risk of Space settlement costs across the private capital markets with the support of its pseudo-government-backed credit rating

With an impending addressable market of millions of Americans desiring to relocate to a Space settlement for a short-term, long-term, or permanent stay (see Table 1 above), an OSSFA-like organization is critical to the financing of said individuals and/or families. Table 3 below summarizes additional results from Finsophy PBC's May 2019 survey with respect to the net worth of American households that individuals would be willing to acquire a loan against to finance their relocation to a Space settlement.

Table 3: Potential addressable market for financing of Space settlement by estimating the total US net worth that could be borrowed against towards Space settlement

POTENTIAL ADDRESSABLE MARKET FOR SPACE SETTLEMENT FINANCING		
Net worth lending range	**Response Rate**	**Potential Addressable Market for financing ($)**
1-2%	15%	$91B
3-4%	6%	$80B
5-9%	15%	$406B
10-20%	21%	$1.2T
21-30%	8%	$756B
31-40%	3%	$353B
41-50%	10%	$1.7T
51% or more	6%	$1.7T
	TOTAL	**$6.3T**

All in all, the purpose of OSSFA would be to financially assist settlers with relocation and housing in Space settlements and tie incomes generated off-world to terrestrial capital markets, hence creating a positive economic feedback loop between Earth and emerging outer Space economies in the Solar System.

Conclusion

In this paper, we have proposed three public-private organizations that have the potential to radically transform the financing landscape in support of long-term Space settlement:

- The **Space Transportation Trust Fund** (STTF), that mirrors the airline industry subsidies paradigm and the Airport and Airway Trust Fund, to subsidize commercial Space transportation of humans for the purposes of Space tourism and eventually Space settlement
- The **Outer Space Private Investment Corporation** (OSPIC), that mirrors the Overseas Private Investment Corporation, to provide loan guarantees and risk insurance in support of ecosystem-enabling infrastructure projects in outer Space
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These three organizations would collectively implement a strategy for:

i. Reducing the costs and increasing the reliability associated with commercial Space transportation of humans to Space
ii. Reducing the costs and increasing the reliability associated with keeping humans alive in the Space environment
iii. Increasing jobs (on Earth and in Space) associated with a burgeoning Space transportation, tourism, and eventually Space settler relocation industry
iv. Developing ecosystem-enabling infrastructure that reduces costs and risks for future Space settlement along with creating economic activities and jobs in outer Space
v. Financing millions of Americans to travel to and relocate to Space settlements