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Status of International Lunar Decade

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Abstract

ILD [1] is a global decadal event designed to provide a framework for strategically directed international cooperation for permanent return to the Moon. To be launched July 20, 2019, the 50th anniversary of the giant leap for mankind marked by Neil Armstrong's first step on the Moon, the ILD launch will include events around the world to celebrate space exploration, science, and the expansion of humanity into the Solar System.

The ILD framework links lunar exploration and space sciences with the development of enabling technologies, infrastructure, means of financing, laws and policies aimed at lowering the costs and risks of venturing into space. Dramatically reduced costs will broaden the range of opportunities available in space and widen access to space for more states, companies and people worldwide. The ILD is intended to bring about the efflorescence of commercial business based on space resources from the Moon, asteroids, comets and other bodies in the Solar System.

Broad international collaboration is key to the potential success of ILD. The International Geophysical Year 1957-58 (IGY), that provided the framework for the launch of the space age, engaged over 60 countries - large and small, developed and emerging – in the first global study of the Earth. IGY made possible the understanding of climate change and other global physical processes. ILD addresses the creation of permanent operations beyond the Earth. A decade is necessary because space activities are costly, complex and planning is required for multiple interrelated steps. A decade is also sufficient to demonstrate the feasibility of permanent human presence in space by following a roadmap that drives the emergence of a self-sustaining space economy. The demonstration of feasibility of a self-sustaining space economy will be followed by increasing private investment.

Roadmap

2017 – ILD a topic at multiple conferences

2018 – Endorsement of ILD by G20, UNISPACE+50, UN General Assembly

2019 – July 20 – Launch of ILD at many locations involving international organizations, national organizations, research universities, science museums, space businesses, other in New York, Paris, Moscow, Beijing, Tokyo, Seoul, New Delhi, Istanbul, Brussels, London, Mexico City, Canberra, Berlin, Rome, Kiev, Brasilia, Riyadh, Ottawa, Addis Ababa, Jakarta, Abuja, Abu Dhabi, Copenhagen, Oslo, Stockholm, Helsinki, Tallinn, Riga, Vilnius, Warsaw, Bucharest, Prague, Athens, and many other cities.

2020-2030 The International Lunar Decade

ILD Implementation

Most ILD activities will take place through existing organizations. Overall governance will be provided by the ILD Council that will report to UN COPUOUS and the G20. The Secretariat of the ILD Council will work with national contact points in each participating country. Activities within each state will be funded through state funding but ILD funding will be available on a competitive basis to advance key ILD objectives.

Coordination and secretariat functions including the annual ILD conference and the national contact point system will require funding. Preliminary estimates can be calculated based on funding for programs like the 2015 International Year of Light.

Achieving identified milestones crucial to meeting the strategic goals of ILD will require funding. If the program could be managed through a central function modeled on the EU Horizon 2020 program, then competitive selection of projects could be made involving experts from around the world. Determining budget allocation will require general agreement on the ILD roadmap with gaps identified. Some gaps could be responded to by national space agencies or programs. Others could engage business, particularly SMEs in competitive tenders. Insofar as many activities in ILD ultimately lead to economic results we can expect most work will be conducted by states and their research organizations and firms. However, some work that involves general infrastructure or capabilities, or the development of standards and policies would benefit all players would be performed by projects funded through competitive tenders.

Coordination and outreach activities. Seminars, workshops, videos, educational materials – preliminary budget estimate $10 million per annum - $100 million over the decade donations sought from governments, foundations, corporations and crowdfunding.

Milestone goals – Designed to engage states with modest space achievements as well as advanced partners. Competitive projects would be structured to promote cooperation among multiple countries as a condition of funding. $1 billion per annum - $10 billion over the decade. National space agencies, ESA and major business would fund own priority projects.

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Space strategy for Europe and the International Lunar Decade

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Abstract

The International Lunar Decade (ILD) is a framework for international cooperation to achieve a self-sustaining space economy through lunar and cislunar development. At present space exploration is funded totally by governments and is subject to political decisions that are determined more by election cycles than by logical resource allocation to meet long term objectives. In a self-sustaining space economy wealth generated from space resources becomes the primary source of funding for further space exploration and development. At present, no wealth is generated from space resources. There is no feasible business case for any space venture beyond Earth orbit. Even how to achieve this in the foreseeable future is not clear. However, a megatrend is emerging marked by advances in many technologies promising significant reductions in the cost of operations in space as well as of a broadening range of opportunities engaging a widening circle of billionaires like Musk and Bezos in ventures to mine asteroids, and build reusable spacecraft that promise to drive down costs and risks while widening the range of space business opportunities.

This paper addresses the implications of a self-sustaining space economy and how Europe can benefit from taking a leading role in the ILD process from 2020 to 2030.

The EU Commission is planning a Joint Technology Initiative for cutting-edge space projects under the EU's next multiannual financial framework (MFF) for 2021-2027. JTI's are focused on a specific technical challenge. The Clean Sky JTI objective is "To develop environmentally-friendly and cost efficient aircraft." The ILD can provide a unifying theme for a JTI focused on achieving permanent European presence on the Moon.

A challenge facing the E.U. space sector for activities beyond communications satellites is that it has been largely the realm of government with some contracting to select private industry. Horizon 2020 and the SME instrument as well as ESA BIC and other instruments are having welcome change, but the 450 billionaires in the E.U. do not include highly visible people like Bezos, Musk, and others that are committed to space settlement. Reusability and other innovations by these space pioneers are driven by the necessity to drive down costs and create revenue generating opportunities to fund greater capacity to permanently reach space.

Thus far the dominant factor in the space sector has been space launch. For various reasons Europe has not developed rockets that can launch human crews or very large payloads into space. Ariane is not a competitor to the American SLS. However, as asteroid mining and lunar development get underway numerous other technologies will come into play. Here the EU will be on a more even playing field with its extensive R&D and industrial capabilities.

The EU space JTI needs a theme that provides comparable motivation for the European space sector as Bezos and Musk for their companies that can drive relentless reduction of costs and widening of opportunities to create a booming, self-sustaining space economy.

The resources of the Moon, asteroids and beyond vastly exceed that of the Earth. But the cost of using these resources has been so high that private industry has had no role. Dramatic reductions in costs can open up space opportunities to industry, but governments need to be involved to provide the incentives to guide pre-commercial development. The ILD can provide the framework to drive this process through competitive international projects through Horizon 2020 and its successor FP9. An ILD framework for the space JTI can drive the E.U. space sector to be among the leading competitors in space in the coming decades. The EU has the human, technical and final resources to be a

global leader in space development beyond large rockets that will become relatively less important space mining, ecological engineering and other domains grow in importance. The EU as a union of sovereign states has unrivalled capacity to engage international partners.

This paper will present a European space strategy for beyond 2020 and how this can mesh with the International Lunar Decade.

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"Journal of Space Economics – theoretical and practical considerations"

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Abstract

The emerging field of space economics appears to include multiple subdisciplines that draw on analogous disciplines in the terrestrial realm – economics of space development (developmental economics), space resource economics (resource economics), economics of human/autonomous-robotics systems (information economics), lunar economics, Martian economics, multi-planetary economics (macro-macroeconomics?), and more. The range of economics issues to address is considerable. But thus far there is no academic publication devoted to the study of the myriad issues that can arise in space economics or to the theoretical base for research in the field.

This paper will address theoretical and practical considerations for the emerging field of space economics and propose an editorial policy for a journal of space economics to provide a forum for the discussion of space economics issues. It is anticipated that initially the *Journal of Space Economics* will operate from two different nodes one offering a European perspective (University of Latvia) and the other a U.S. perspective (University of Wisconsin at Milwaukee).

The first edition of the Journal of Space Economics will focus on issues likely to arise during the course of the International Lunar Decade 2020-2030.

- Economics of a domain constrained by the Outer Space Treaty and the prohibition of claims of national ownership implicitly of real property rights.
- Money in the space domain
- Economic choice in an environment of human and autonomous robotic agents
- Economics of the space commons
- Review of the Moon Treaty from the perspective of economics

If economics has value on Earth economics to provide guidance in the management of the economies of the Earth, then economics should have value in managing the emerging space economy. If there is a self-sustaining space economy, then it is a subject of economic analysis.

Internationally recognized economists in key sub-disciplines will be invited to serve on the editorial board of the *Journal of Space Economics*. The first edition is targeted for release prior to the UNISPACE+50 Conference 20-21 June, 2018.

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Rationalisation of the Solar System exploration

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Abstract

Present attitude to space exploration is often a result irrational political pressure. The better cooperation between space agencies could be beneficial for the space exploration and for national space programs.

1. Introduction

Current efforts of investigation of the Solar System are often the subject of irrational political pressures often resulting from nationalist motives. This causes huge scientific losses, but also, contrary to appearances, political losses.

For several years an example of a new approach to astronautics is SpaceX. Its success is not however an example of a unique genius approach. It is a result of simple application of common sense to the problem. Similar breakthroughs have been observed many times when a technology has become so mundane that a simple economic approach can be applied to it. An example of many years ago is Ford's approach to car production.

A similar way went SpaceX using a simple technology for space rockets. Merlin engines represented initially fairly average levels compared to technological miracles achieved by US or Russian space agencies. But the use of a relatively small uncomplicated engine proved to be one of the sources of the company's success. It allowed for their serial production which lowered their price and the price of the whole rocket.

The success of SpaceX in the development of space rockets still seems be ignored by decision makers.

Similarly, the success of one space agency seems to be ignored by other agencies. Instead of buying technology, we see senseless independent attempts at repetition of technology.

The rationalization of space expenditures would allow a significant acceleration of the planetary research. I believe that with a small increase in spending by the space agencies with a decisive increase of cooperation, it is possible to achieve several Mars rovers (of the Curiosity range) on Mars, Titan or Enceladus.

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Commercial Lunar ISRU for the Space Launch Industry: Cruder is Better

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Abstract

Lunar ISRU scenarios typically focus on making relatively high-added-value products (such as solar PVs) for off-Earth use only. Discussion of space mining in general focuses on high-value trace substances (e.g. platinum group metals) as exports to Earth, and hydroxyls and other volatiles for use only in space. This paper considers two potential bulk commodities with high availability on the lunar surface: space-weathered basalt fines and the oxygen in metal oxides. Basalt fiber can be produced by a simple process, and is strong enough that a tapered rotating sling could propel payloads at lunar escape velocity. Basalt aerobrakes could be flung to LEO depots to aid in aerocapture, reentry, and thermal protection of upper stages. Lunar oxygen (O_2 being most of the mass of most liquid-fueled rockets) could aid in powered descent. In short, abundant substances on the Moon could make cost-saving exports possible sooner than later, for the satellite launch industry.

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Commercial Lunar ISRU for the Space Launch Industry: Cruder is Better

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Abstract

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"The Resurrection of Malthus: space as the final escape from the law of diminishing returns."

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Abstract

If there is a self-sustaining space economy, which is the goal of the International Lunar Decade, then it is a subject of economic analysis. Economics is a field with many sub-fields. We make the case for space economics as a field defined by the physical and temporal attributes of the space domain (distant, long duration, boundless) coupled with the virtual absence of human agents and very limited laws and conventions governing actions of economic agents. The Outer Space Treaty proscribes sovereign ownership of cosmic bodies and defines them as a commons – the common heritage of mankind.

The immediate challenge of space economics then is to conceptually demonstrate how a space economy could emerge and work where markets do not exist and few human agents may be involved, in fact where human agents may transact with either human agents or robotic agents or robotic agents may transact with other robotic agents.

1. Background

In 1798, Thomas Malthus predicted humans had approached a precipice and were set to drop over its edge. Population growth was set to intersect with the limits of nature (law of diminishing returns). Yet, precisely at the point of his prediction, a set of contingent variables were in play that launched humans in the opposite direction (toward unprecedented expansion and for many, prosperity). Today, we find ourselves at the Malthusian moment again. Will we find answers to the law of diminishing returns? Humans will either escape the gravitational pull of nature's limits and challenges to innovation, or they will fail the test of thriving into the future. Space provides both the means by which we can overcome our new Malthusian moment. The challenges will be how to find the political will to do so and the related problem of how to pay for it.

The two chief challenges facing us going forward, are the end of cheap nature and the productivity crisis. Ultimately, both can be solved by accelerating our return to space. The political will must be found for doing so, but so must ways of financing it.

Innovation is hampered by the materials needed for creating productivity and quality of life enhancing technologies. Many of these materials require rare earth metals that could block the development and spread of new technologies. Asteroids and other astral bodies contain minerals that could solve material constraints imposed by nature. Moreover, the vast technological challenges to accessing the wealth of space would require innovations that later could be commercialized, thereby advancing both productivity and quality of life.

The question is how to pay for it? Governments, as previously stated, the past four decades cut taxes, thus making less money available for research. Moreover, even as tax rates were lowered, offshore finance grew, thus further eroding public revenues. At first, tax cuts were funded by more public borrowing. But, as bond holders grew uncomfortable with this arrangement, governments eventually reduced spending. At the same time, supply-side policies were eroding wages under the banner of 'flexibility.' Thus, the puzzle was presented of how to sustain economic demand in an environment where both wages and public spending were under assault? The answer provided in the 1990s was expansion of private debt. This too inflated up to the point where it was no longer sustainable and saw its crescendo in the 2008 financial crisis. Thereafter, policymakers decided upon austerity: the twin contractions of both public and private debt. The effort worked imperfectly, ironically preventing total economic disaster, but well enough to slow growth. This economic environment can't provide the vast resources needed to fund science sustaining basic research at our universities, let alone the comparatively smaller resources needed for their application to building space hardware.

There are four possible means by which the return to space could be achieved:

1) Independent investors. We see some of this today, but it's mostly limited to a few billionaires as vanity projects and/or as expression of some genuine vision. While helpful, the sums required to accelerate the return to space far exceed the capacity of this group to alone fund both it and the basic research required to advance it.

2) New financial instruments. The challenge is how to make investment in space more profitable than, say, real estate, or financial markets flooded with quantitative easing produced cash. Such instruments would have to provide the means by which long-term investments in space, where the returns would take more than a generation to materialize. Of course, long-range investments are already funded, but one must convince markets that the returns would come and in quantities needed to justify investor returns now.

3) Modern Monetary Theory. If money can be created in the trillions of dollars and euros to fund global efforts to stabilize financial markets without generating inflation, then the same could be done to finance science and space. Given the limits of taxation in today's environment, it may be that governments simply begin funding infrastructure by creating credit on computer keyboards. Automatic triggers could be put in place to reign in this spending upon inflation hitting set targets.

4) Combinations of the above. Government guarantees coupled with outright grants parallel to public private partnerships as with COTS (Commercial Orbital Transportation Services) .

Conclusions

We are again at a Malthusian turning point. But the world is awash in capital seeking higher returns. Higher returns can be made possible through significant expansion in research and space development involving a combination of new financial instruments, monetary policy and billionaire entrepreneurs leveraging public resources to drive down costs and risks of activities in space while continuing to expand the range of opportunities for public and private investment.

Space economics is the study of commercial activities in space in an environment where all resources are defined by the Outer Space Treaty as an international commons to be utilized for the benefit of all mankind. This raises major challenges for a field that has largely evolved studying economic activity under varying degrees of private ownership and capitalism.

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MoonVillage: Frame & Opportunity for Space Economy

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Abstract

We shall discuss the frame and opportunity for space economy in the context of elaborating the concept of a Moon Village with the goal of a sustainable human presence and activity on the lunar surface [1-3] as an ensemble where multiple users can carry out multiple activities. This enterprise can federate all interested Nations and partners, in particular from terrestrial and non space commercial sectors .

Previous MoonVillage projects

The Moon represents a prime choice for political, programmatic, technical, scientific, operational, economical and inspirational reasons. COSPAR and its ILEWG International Lunar Exploration Working Group (created 20 years ago) have been supporting opportunities of collaboration between lunar missions and exchange on future projects [4-8]. A flotilla of lunar orbiters has been deployed for science and reconnaissance in the last international lunar decade (SMART-1, Kaguya, Chang'E1&2, Chandrayaan-1, LCROSS, LRO, GRAIL, LADEE). De facto, collaborative opportunities and elements of a Robotic Village on the Moon exist, as China landed in 2013 the Chang'E3 and its Yutu rover, and from 2017 other landers are planned (GLXP, Chang'E 4&5, SLIM, Luna 25-27, LRP, etc..)

Open MoonVillage

The ESA DG has declared: "The Moon Village is open to any and all interested parties, private or public – villagers of every nationality are more than welcome. There are no stipulations as to the form their participation might take: robotic and astronaut activities are equally sought after. One might envisage not only scientific and technological activities taking place there but also activities based on exploiting resources, and even tourism. It is precisely the open nature of the concept which would allow many nationalities to go to the Moon and take part while leaving behind them on Earth any differences of opinion they may have. Not only that, but you would no longer have to worry about the need for a common docking port." Previous roadmaps and technical studies held in international groups [4- 15] such as COSPAR, ILEWG, ISECG, IAF, IAA or national and regional groups (eg LEAG). We shall discuss the opportunities for developing space economy in the vision and implementation of a Moon Village.

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