

Minutes of Commission III Meeting Jerusalem
10 October 2015
ICC Room 312

1. The Commission III meeting was opened by Professor LU Yu at 1315 hours on 10 October in room 312 at the ICC Jerusalem venue. Professor LU Yu introduced the Commission members and welcomed our guests.
2. The first item of business was actions left over from the Paris Spring meeting. There were no open action items.
3. The IAA Secretariat finally released the proposed leadership and membership of Commission III. The new membership is as shown below:

Chair:	Ramakrishnan S (India) (A-E)
Vice Chair:	Lenard R (USA) (P)
Past-Chair:	LU Yu (China) (P)
Secretary:	Genta G (Italy) (A)
Member:	FAN Ruxiang (China) (A)
Member:	Kawaguchi J (Japan) (A)
Member:	Razoumny Y (Russia) (P)
Member:	Huffenbach B (Germany) (A)
Ex-officio Member:	Tsuchida A (Japan) (A)
Member :	Pacheco-Cabrera Enrique (Mexico) (A)
Member:	Sweet Randall (USA) (A)
Ex-officio Member:	Giuseppe Reibaldi) (A-E)

P=Present
A=Absent unexcused
A-E=Absent excused

The last two names on the member list Mr. Pacheco-Cabrera and Randall Sweet were added by the SAC and were not nominated from within the Commission.

4. Report on major events subsequent to spring meeting.
 - 4.1 Constitution of Space Mineral Resources Governance Working Group.
 - 4.2 9th IAA Symposium on Future of Space Exploration – 7-9th July 2015, Torino, Italy.
 - 4.3 IAA Presentation at ISECG Workshop – 8th Oct. 2015, EAC, Cologne.

Roger Lenard provided a short synopsis on the above significant events.

5. Status of Study Groups

5.1 Studies completed & Reports published:

- SG 3.9: Private Human Access to Space – Vol. 1- Sub-orbital.
- SG 3.17: Space Mineral Resources. Mr. Art Dula presented a copy of the now published book to the SAC.

5.2 Studies in Progress:

- Study Group 3.14 Private Human Access to Space (Vol. II)-Ken Davidian/S.Di Pippo - awaiting integration of comments from Professor LU Yu, then it will be sent to the SAC.

- Study Group 3.15 Long-Term Space Propellant Depot- Prof Lu Yu/G.Saccoccia - Status presented by Dr. Wang - good progress being made. Study should be ready for review by Commission III by year end. (Attachment 2)
- Study Group 3.16 Global Human Mission to Mars-G. Genta - Has been sent to SAC for peer-review
- Study Group 3.18 Feasibility Study of Possible International Protocol to Handle Crisis/Emergency to Astronauts in LEO-S Ramakrishnan - Dr. Ramakrishnan was not present and there was no stand-in present, no presentation
- Study Group 3.19 Radiation Hazards-S. McKenna-Lawlor. SMKL presented a status. Phase I which is developing a standardized dose limit for Low Earth Orbit has a 50 page draft which will be available for review on TBD date. The second phase, which is biological response to high energy particles is in work. No presentation available.
- Study Group 3.21 Disposal of Radioactive Waste in Space- O. Ventskovsky . Mr Ventskovsky was not present, but has uploaded his latest version to the IAA website. No presentation available at meeting.
- Study Group 3.22 Next-Generation Space System Development Basing on On-Orbit-Servicing Concept- Y.Razoumny. Yuri presented the status of his study. Good progress being made. Copy of presentation included. (Attachment 3)
- Study Group 3.23 Human Space Technology Pilot Projects with Developing Countries- Giuseppe, F.Zhuang/G.Reibaldi no presentation as neither Mr. Reibaldi nor Zhuang were present.
- Study Group 3.24 Road to Space Elevator Era, A.Tsuchida. No presentation since Mr. Tsuchida was not present.

A key point for all Commission III members, there will be a meeting on May 24-26 in Moscow in preparation for the Heads of Agency meeting in 2017. Please be aware of the IAA website for announcements.

- 6 Proposals for new Study Groups
 - The Maintainability and Supportability of Deep Space Manned Spacecrafts - a good presentation made by Mr. Chuanfeng WEI, (included), recommended to SAC given Study # 3.25 (Attachment 4)
 - Technical Development of Efficient Management and Recycling of Space Fluid - will be presented in Paris for approval
 - Space Mineral Resources # II: National Authority for Extra-Terrestrial Resource Utilization and Beneficiation based on the Outer Space Treaty - Agreed to propose to SAC, given SG # 3.26. (Attachment 5)
8. IAC 2015, Jerusalem – Commission III Symposia status
 - A5 Symposium on Human Exploration of Solar System;
 - D3 Symposium on Building Blocks for future Space Exploration and Development;
 - D4 12th IAA Symposium on Visions and Strategies for the Future.

Upcoming conferences – IAA Commission III participation
May 24-26 Moscow conference preparation for HOA in 2017.

9 Report to the SAC

The report will be revised according to the content of this meeting.

10. Any Other Business: None

International Academy of Astronautics

Study Group 3.14

“Public/Private Human Access to Space

Volume 2: Earth Orbit and Beyond”

DRAFT Final Report

June 2015

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EXECUTIVE SUMMARY

Introduction

In 2012, the International Academy of Astronautics (IAA) established a volunteer study group to assess the probability of the emergence of potential human orbital space markets world-wide, from the perspectives of individual countries or regions. The chartered theme of the study group is “Public/Private Human Access to Space,” informally referred to in this report as the “Human Orbital Market” or the “HOM” study group.

The goal of the HOM study is to estimate the emergence of HOMs for different countries or regions around the world. This study employs a five-phase approach that incorporates multiple research methods. Due to the complexity of collecting meaningful data, and the inherent uncertainty of data in emerging markets, a primary focus is put on basic discovery activities (identifying relevant archival and statistical data) and qualitative assessments. The five analysis phases of the HOM study approach include:

- Phase 1. Target Market Assessment: Identifying the specific human orbital space markets being targeted.
- Phase 2. Literature Review: Conduct a search of the open, available literature (publicly available, for free or for a fee) of relevant reports and articles.
- Phase 3. Entrepreneurial Environment Assessment: Identify relevant political, legal, capital, historical and cultural factors and structures.
- Phase 4. National HOM Industry Competitiveness Assessment: Identify the set of industries that comprise, support, or are related to the identified human orbital space markets, using a standardized methodology.
- Phase 5. HOM Industry Emergence Assessment: Qualitatively evaluate the likelihood that these industry clusters are sufficient for the eventual natural evolution of human orbital space markets.

The list of countries and regions investigated in this study is shown below. The intention of this study is to ultimately investigate all the countries and regions on the list as researchers and resources become available.

- Africa (Region)
- Australia
- Canada
- China
- Europe (Region)
- Europe: Benelux
- Europe: France
- Europe: Germany
- Europe: Italy
- Europe: Portugal
- Europe: Spain
- India
- Israel
- Japan
- Nigeria
- Norway
- Russia
- South Africa
- United Kingdom
- United States
- World-Wide (Region)

Conclusions

In general, the major observation of this report is that the entire analysis, including all five phases was only conducted for a single country, the U.S. The conclusions from each of the five analysis phases are summarized below.

Phase 1. Target Market Assessment

The HOM target markets are listed here and described in detail in chapter 3 of this report.

Demonstrated Near-Term HOMs

- LEO Tourism
- Domestic Gov't Crew Transportation
- Flight of Foreign Astronaut Corps

Potential Near-Term HOMs

- Research & Development
- Cis-Lunar Tourism
- Cis-Lunar Government Crew Transportation
- Media and Promotion

Potential Far-Term HOMs

- Resource Extraction
- Energy Generation
- Deep-Space Vehicle Support Services
- Residential Space Station Operation
- In-Space Construction
- Business Travel Services

Phase 2. Literature Review

This activity included a prolonged and continuously on-going search for relevant reports, articles, and other relevant historical archive (secondary) data pertaining to the space industries of all the countries included in the analysis. As documents were found, any relevant information was included into this study. The complete list of literature results is given in Appendix A. It is noted that no documents were found for some of the most prominent space-faring countries, including Australia, China, India, and Japan.

Phase 3. Entrepreneurial Environment Assessment

This analysis phase represents a “first of its kind” in the space industry. Although the theoretical framework employed was developed in 1994 (and is detailed in Chapters 1 and 2), it had never been applied to the industry of space-faring countries. Preliminary results for a single country (the U.S.) were available for the release of this report. These results are presented in Chapter 3. Analyses based on the same methodology of more countries and regions are still underway (for Russia and Japan). When they become available, those results will be incorporated into future versions of this report.

Phase 4. National HOM Industry Competitiveness Assessment

This is the most extensive of all the five analysis phases included in the HOM study. As with the previous study phase, this analysis, the Porter “Diamond” of International Competitiveness, also represented a “first of its kind” for the space industry despite the fact that it is not a new model (dating back to 1990). Details of this model are provided in Chapters 1 and 2. An in-depth study using this methodology was conducted for the U.S. HOM space industry and results are provided

in Chapter 3. This specific analysis has yet not been performed by any other country. It is hoped that future iterations of this report will include these analyses.

Phase 5. HOM Industry Emergence Assessment

This analysis phase integrates the information from all five HOM analysis phases using a list of industry infrastructure elements¹ required for the evolution of a high-tech industry (such as HOMs) listed against the possible space industry actors who are contributing to those infrastructure elements (as described in Chapters 1 and 2). Although this type of analysis is also a “first of its kind,” it is also an original analysis method developed specifically for this IAA study. Because this phase of the overall analysis is highly dependent upon the results of Phase 4, this methodology has been conducted only for the U.S. HOM space industry at this time. Results are provided in Chapter 3. Once the “Diamond” analysis has been performed for other countries, this analysis phase will be performed for those countries. It is hoped that future iterations of this report will include these analyses.

Recommendations for Future Work

Of all the recommendations listed above, the highest priority recommendation of them all is to conduct the Porter “Diamond” analysis for the major space-faring countries, including: China, Europe, India, Japan, and Russia in Phase 4. This analysis takes the most time and would provide quite a bit of information with which to perform the remaining analysis.

¹ The word “infrastructure” is being used in the organizational theory sense, referring to supporting elements for industry viability. This can be easily confused with “infrastructure,” typically referring large, immobile facilities and sites shared by launch providers, such as launch sites and spaceports.

INTRODUCTION

Background

In 2012, the International Academy of Astronautics (IAA) established a volunteer study group to assess the probability of the emergence of potential human orbital space markets world-wide, from the perspectives of individual countries or regions. The chartered theme of the study group is “Public/Private Human Access to Space,” informally referred to in this report as the “Human Orbital Market” or the “HOM” study group.

The goal of the HOM study is to estimate the emergence of HOMs for different countries or regions around the world. To this end, the HOM study group developed a research program for the identification and analysis of relevant factors and frameworks that would influence the emergence of HOMs. Using the defined research methodologies, this report is the aggregation of individual analyses performed at the national or regional levels by a large number of diverse individuals.

Typical approaches to analyzing space markets, may include the following methodologies (Hertzfeld, 2012):

- Developing a "business case," or cost models for specific technical designs or market assumptions.
- Using business economics to assess the financial, technical and political risks. This method identifies prices that may maximize profit while allocating resources in a socially efficient manner. Inclusion of noneconomic influencing factors are minimized because they are hard to assess and predict.
- Employing economic theory, econometrics, and finance theory to maximize the present and future utility of production functions.
- Attempting to encompass the noneconomic, nontechnical factors in an holistic approach. Because the factors being considered are difficult to identify, quantify, and predict, a qualitative methodology is employed.

Normally, market study reports have adopted one of the first three methodologies identified above. Those studies focus on necessary technologies, skills, or quantitative studies to identify a "business case" for a given market. While these types of studies can be helpful and important, they are of limited value in emerging industries where no or little data exists.

Based on historical analyses of economic conditions and developments spanning the ancient to modern times, it is clear that differences exist in the social acceptance, form and formation of enterprise, innovation and entrepreneurship when compared across regions (typically categorized by their geopolitical boundaries as countries) (Bakker, 2010). Cultural influences on entrepreneurial development within a society are manifest through many of a civilization's

institutions and customs. In many cultures throughout history where levels of production were barely above bare subsistence, the accumulation of wealth was discouraged and gains of an individual would result in sharing the benefits with the entire community. Within the legal domain, enterprise of a civilization was directly impacted by the laws of contracting, inheritance, intellectual property, the creation and control of capital markets, taxation, and many other areas. Government involvement in the establishment of private enterprise also varies country-by-country and, not surprisingly, has an enormous influence on the ability of a population to demonstrate “entrepreneurial” tendencies.

Because (1) the relationship of culture, society, and history on enterprise, innovation and entrepreneurship is typically not addressed in “business case” studies, and (2) the global scope of this analysis puts a primary focus upon these noneconomic factors, the HOM study group employed the holistic methodology to perform this analysis.

This approach is admittedly prone to imprecision, but because any analysis of emerging, prospective markets would include large uncertainties, this methodology was estimated to be more inclusive of major influencing factors without unduly decreasing the resulting accuracy or precision.

Because HOMs are still emerging, it is hoped that future iterations of this study will be conducted that can (1) describe the dynamic nature of the HOMs' emergence, and (2) build upon, expand, and improve the accuracy and precision of all the analysis results included in this report.

The results presented in this document include information from status reports and preliminary results given at previous conferences and congresses as well as new and updated analyses performed more recently.

Approach

This study employs a five-phase approach that incorporates multiple research methods. Due to the complexity of collecting meaningful data, and the inherent uncertainty of data in emerging markets, a primary focus is put on basic discovery activities (identifying relevant archival and statistical data) and qualitative assessments.

This approach relies less on the quantitative methods of econometrics, and leans toward a more qualitative, sociological perspective, consistent with the contention that "economic sociology must be introduced as a 'fourth fundamental field to complement' economic history, statistics, and theory, even though this necessitates going beyond the 'mere economic analysis' embodied in these three" [from John Elliott's introduction to (Schumpeter, 1934)].

In this light, the HOM study group identified influencing factors of policy and law, society, economy, history, education, proprietary functions, financial and non-financial resources, supporting institutions, and contributing actors that can influence the possible emergence of HOMs world-wide.

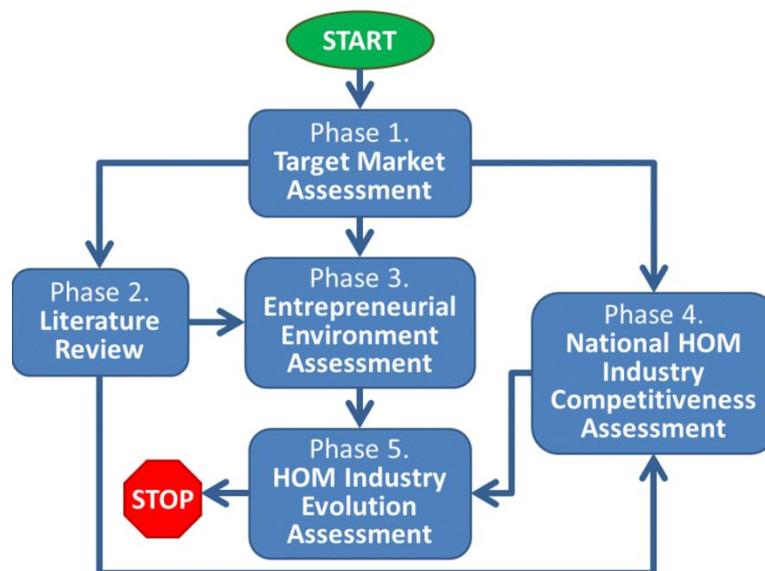
To assess this wide variety of influencing factors, the HOM study group has attempted to stimulate the execution of specific analyses in five discrete phases at the national and regional levels. The five analysis phases of the HOM study approach include:

- Phase 1. Target Market Assessment: Identifying the specific human orbital space markets being targeted.
- Phase 2. Literature Review: Conduct a search of the open, available literature (publicly available, for free or for a fee) of relevant reports and articles.
- Phase 3. Entrepreneurial Environment Assessment: Identify relevant political, legal, capital, historical and cultural factors and structures.
- Phase 4. National HOM Industry Competitiveness Assessment: Identify the set of industries that comprise, support, or are related to the identified human orbital space markets, using a standardized methodology.
- Phase 5. HOM Industry Emergence Assessment: Qualitatively evaluate the likelihood that these industry clusters are sufficient for the eventual natural evolution of human orbital space markets.

Phase 1 is independent of the country or region being analyzed and was performed only once and applied as a starting point for all subsequent country and regional analyses. The target markets identified in phase 1 were investigated for different countries and regions in analysis phases 2 through 5.

Because of the large number and high complexity of the influencing factors listed above for each country or region to be analyzed, the first four analysis phases were necessarily conducted before the probability of emergence can be assessed for any HOM in Phase 5. The relationship between the five analysis phases are depicted graphically in Figure 1 below.

Figure 1. Relational Depiction of Five HOM Analysis Phases



Some countries included in this report have not completed all four country/region-specific analysis phases. In these cases, the final analysis phase cannot be completed at present. It is hoped that subsequent versions of this report will include these missing analyses.

Scope

The list of countries and regions investigated in this study is shown below. The intention of this study is to ultimately investigate all the countries and regions on the list as researchers and resources become available.

- Africa (Region)
- Australia
- Canada
- China
- Europe (Region)
- Europe: Benelux
- Europe: France
- Europe: Germany
- Europe: Italy
- Europe: Portugal
- Europe: Spain
- India
- Israel
- Japan
- Nigeria
- Norway
- Russia
- South Africa
- United Kingdom
- United States
- World-Wide (Region)

If given an option for providing research direction, a priority would be given to the nations and regions with demonstrated human space transportation experience, including (in alphabetical order) China, Russia, and the United States. Subsequent priority would be provided to countries or regions with strong space programs, namely Europe, India, and Japan. Remaining countries and regions with space program experience could then be analyzed.

However, because this study is primarily a volunteer effort, the countries included reflect the willingness and ability of the individual researchers and contributors. It is hoped that future versions of this report will include and complete the analyses for all the countries mentioned here and more.

As of the final release of this report, the only country for which all five analysis steps have been completed (to varying degree of depth) is the United States (US).

The level of analysis required by this research project to assess the possibility of the emergence of one or more HOMs is necessarily high-level to encompass the many groups of industries involved and the broad social aspects of the topic. Using the social ecology scale of analysis levels (see Figure 2), this study primarily focuses on the community level of analysis.

A community is comprised of multiple industries. The unit of analysis is a given industry. For example, the HOM field (a collection of communities) contains the “Propulsion” community, which consists of two populations: the solid rocket motor and the liquid rocket engine populations (“industries”). Each population is comprised of individual organizations (or “firms”). Analysis levels above “field” and below “population” exist but are outside the scope of the HOM report.

Structure

This report is structured to provide the reader with a description and the results of the five phase analysis without belaboring the theoretical underpinnings of the research. It was the estimation of the report editors that the academic foundation for each of the applicable analysis phases would not be of immediate interest to the typical reader. In that regard, a brief synopsis of the theory for each analysis phase is included in Chapter 1. Since the literature search analysis phase does not have an accompanying theoretical foundation, its practical basis of best practices is described instead.

Figure 2. Research Study Levels of Analysis



The first chapter of this report describes the research and analysis methodology utilized for each of the study phases.

The second chapter gives the results of analysis phase one, setting the starting assumptions of what is meant specifically by "Human Orbital Markets" in terms of specific "end use markets." These target markets are common to all countries and regions included in this report.

The third chapter differs from the second in that it describes results from each of the remaining analysis phases that are specific to the country being analyzed. National differences in entrepreneurial environments and HOM industry capabilities will result in different probability estimations of HOM emergence.

The fourth chapter summarizes the results of the second and third chapters, draws conclusions based on these results, and provides recommendations and suggestions for future work.

A list of references and reports used to support this study is provided following chapter four. A set of four appendices are provided thereafter, including a list of HOM study group participants,

a comprehensive literature review list (by country or region), a table of acronyms and abbreviations, and the academic/theoretical synopses for each study phase.

CHAPTER 1. THEORETICAL SYNOPSES

This appendix provides a brief overview of the theoretical foundations for each of the HOM study analysis phases. Cited references are provided for a more complete treatment of the theories presented below.

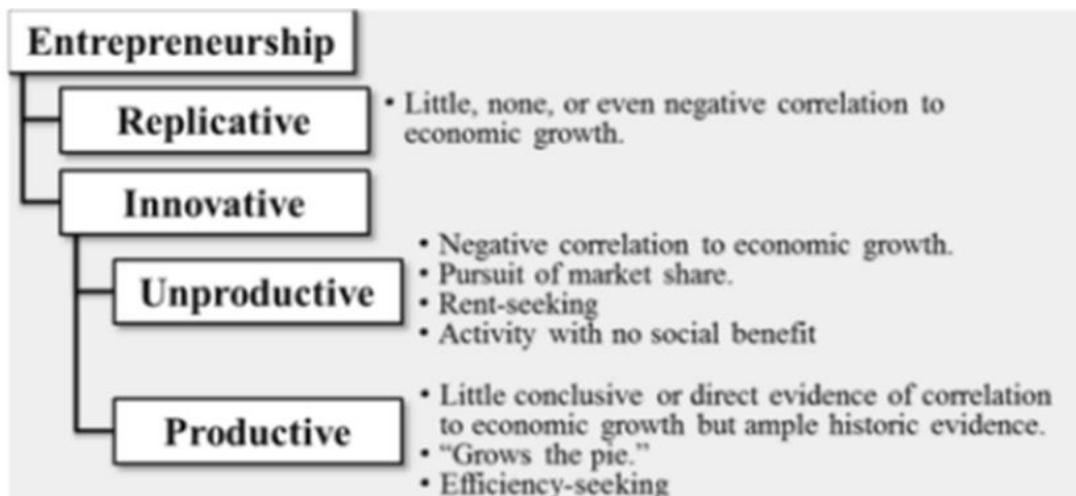
Phase 1. Target Market Assessment

Over the entire history of government-led civilian and military space programs as conducted to date, no human orbital market (HOM) has yet been created or has evolved naturally that is viable and self-sustaining independent of government customers. Assuming that the repetition of past practices will not increase the probabilities that a viable HOM will naturally emerge in the future, it is reasonable to conclude that new firms, employing different approaches to commercial success (and enabled by new government policies and acquisition strategies), will be needed to achieve that goal.

In a general context (not specific to HOMs), the creation of new firms is the goal of entrepreneurship. Entrepreneurs, whether a single person or a small group of enterprising individuals, use innovation as a tool to achieve this goal.

In its broadest context, entrepreneurship has multiple facets and sub-facets. As shown in Figure 3 below, there are two categories of entrepreneurship: replicative and innovative (Baumol & Strom, 2010). “Replicative entrepreneurship” is commonly manifested in the form of a new business (small or large) entering an established industry segment and employing well-established products and processes. There is conflicting data regarding whether this type of entrepreneurship leads to economic growth since it pursues market share at the expense of companies already operating in the same industry segment (i.e., incumbent firms). Replicative entrepreneurship is sometimes considered “rent-seeking” (Baumol & Strom, 2010).

Figure 3. Categorization of Entrepreneurship (Baumol & Strom, 2010).



Government-funded agencies and their private-sector counterparts have developed the ability to go to space and operate complex space systems since 1957. Despite this admirable technical and operational heritage, and despite the fact that commercial “spin-off” of these capabilities could have been in the commercial interest of these organizations, no viable independent HOM industry has emerged to date.

Space transportation is similar to the history of the nanotechnology field in that an established and dominant incumbent firm (IBM) developed technologies that would be vital to nanotechnology commercialization (the scanning tunneling microscope and the atomic force microscope) but ultimately failed to monopolize on the commercial potential (Woolley, 2010). Based on the multiple examples provided by economic history, there is no rational reason to expect the incumbent space organizations, who have possessed space faring capabilities for over 50 years, to suddenly develop a private HOM industry through commercial pursuit of those same capabilities. It is for this reason that, although an HOM may already be demonstrated, the category of replicative entrepreneurship resulting in a new firm that uses identical or very similar technologies, processes and organizational forms is deemed to be unlikely to occur and, thereby, of little interest to the IAA study group.

In contrast to “Replicative Entrepreneurship” is “Innovative Entrepreneurship” and, in the broadest context of the word, is comprised of two types: unproductive and productive. “Unproductive Innovative Entrepreneurship” is any type of activity (not necessarily a traditional “business”) that is anti-social and destructive in nature, also described as “unproductive enterprise, asset stripping, and hoarding in pursuit of the market share.” As in the case of “Replicative Entrepreneurship,” there is no evidence that this type of behavior leads to economic growth and is also of no interest to the IAA human orbital markets study group.

The second form of “Innovative Entrepreneurship” is labelled “Productive”. Fortunately, this type of entrepreneurship results in the establishment of organizations and businesses employing new or different products and/or processes, sometimes entering established markets and sometimes pursuing entirely new ones. The behavior of these organizations may be considered “efficiency-seeking” by creating new sources of wealth, thereby increasing the overall size of the market to be shared by all firms of that industry segment. Although there is little quantitative evidence that “Productive Innovative Entrepreneurship” leads to economic growth (due partly to the extreme difficulty of collecting meaningful data to show the correlation), there is ample historical evidence to support this conclusion (Baumol & Strom, 2010).

As mentioned above, any HOM included in this study that has already been demonstrated will probably not be created by new firms replicating the traditional approaches of incumbent government agencies or non-government organizations. If a demonstrated HOM emerges, it will be due to the actions of new firms, based in innovative, productive entrepreneurship, with an adaptation of an old technology, process, or organizational form, or (less likely) an entirely new space transportation technology, process, or organizational form.

Given this definition of “entrepreneurship” and our initial conclusion that the probability that the emergence of a human orbital space market will depend on a combination of established technologies and operational capabilities, and new or different approaches, it is also clear that only the last form described, “Productive Innovative Entrepreneurship,” is of interest to the IAA human orbital space markets study group.

Therefore, a goal of this study will be met by estimating whether productive innovative entrepreneurial activity is possible in a given country or region for the target HOMs. This is the subject of Phase 3, as discussed below.

Phase 2. Literature Review (Practical Foundations)

The foundation of a literature search is not theoretical, but practical. This phase of the overall analysis is to ensure that any available work that has been conducted in an equivalent, or complementary, field of analysis is discovered and used to the maximum practicable extent.

As mentioned later in the methodology report section regarding the literature search performed, the review of relevant literature has been a continuous process, searching for even more resources to be included in this study. The HOM study group welcomes any corrections or new additions to the list of references already assembled.

Phase 3. Entrepreneurial Environment Assessment

The ultimate goal of HOM study is to identify the qualitative probability of new firm creation in HOM target markets for a given country or region. New firm creation is the ultimate goal of entrepreneurs who, by definition, use innovation to perform acts of enterprise.

The objective of this analysis phase is to assess the entrepreneurial environment of a given country (or region). To accomplish this objective, the HOM study evaluates the effects of social and historical factors on that country or region’s level of enterprise and innovation. Based on past management research, the model used in this study (Gnyawali & Fogel, 1994) identifies five factors that are necessary for an increased likelihood for enterprise and new firm creation in a given country or region, as shown in Table 1 below.

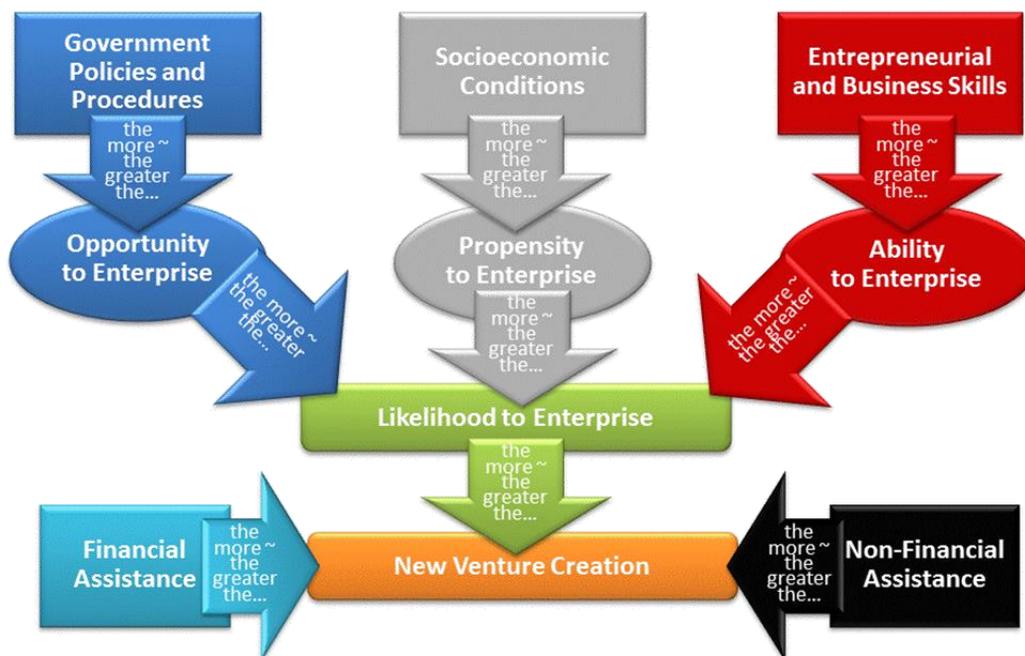
Table 1. Factors of Entrepreneurship and New Firm Creation (Gnyawali & Fogel, 1994)

Table 1. Factors of Entrepreneurship and New Firm Creation (Gnyawali & Fogel, 1994)

<p><u>Opportunity to Enterprise</u></p> <ul style="list-style-type: none"> • Restrictions on imports and exports • Provision of bankruptcy laws • Entry barriers • Procedural requirements for registration and licensing • Number of institutions for entrepreneurs to report to • Rules and regulations governing entrepreneurial activities • Laws to protect proprietary rights 	<p><u>Propensity to Enterprise</u></p> <ul style="list-style-type: none"> • Public attitude toward entrepreneurship • Presence of experienced entrepreneurs • Successful role models • Existence of persons with entrepreneurial characteristics • Recognition of exemplary entrepreneurial performance • Proportion of small firms in the population of firms • Diversity of economic activities • Extent of economic growth 	<p><u>Ability to Enterprise</u></p> <ul style="list-style-type: none"> • Technical and vocational education • Business education • Entrepreneurial training programs • Technical and vocational training programs • Availability of information
<p><u>Financial Support</u></p> <ul style="list-style-type: none"> • Venture capital • Alternative sources of financing • Low-cost loans • Willingness of financial institutions to finance small entrepreneurs • Credit guarantee program for start-up enterprises • Competition among financial institutions 	<p><u>Non-Financial Support</u></p> <ul style="list-style-type: none"> • Counselling and support services • Entrepreneurial networks • Incubator facilities • Government procurement programs for small businesses • Government support for research and development • Tax incentives and exemptions • Local and international information networks • Modern transport and communication facilities 	

The relationship between the five factors and the likelihoods of enterprise and new firm creation are shown in Figure 4 below.

Figure 4. Factors of an Entrepreneurial Environment Assessment(Gnyawali & Fogel, 1994)



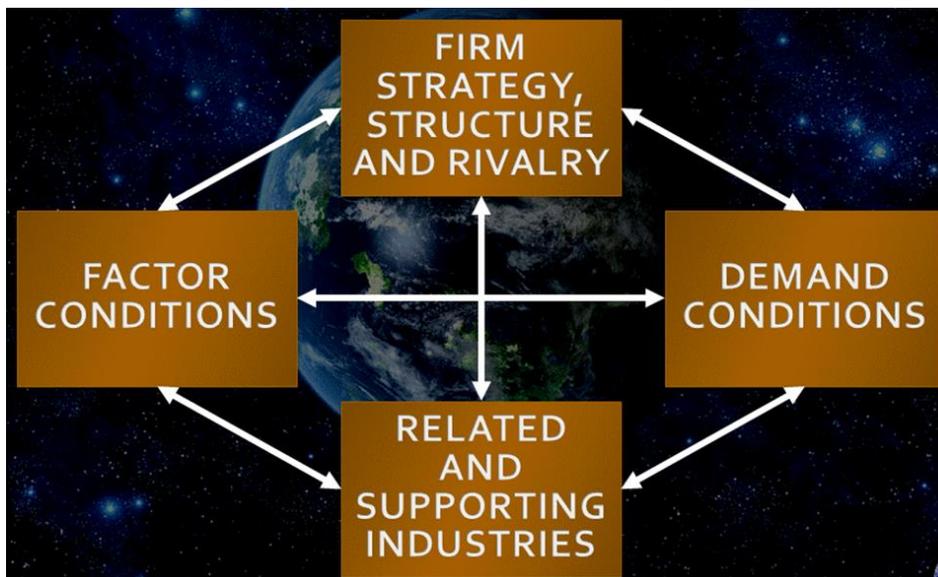
Phase 4. National HOM Industry Competitiveness Assessment

The IAA HOM study is based on the analysis of the space industrial base of each nation (and region) by applying well established and academically based, international frameworks of industry structure and national competitiveness.

A system of competitive determinants, referred to as the "diamond" (Porter, 1990), states that the level of national competitiveness in an industry is built upon four broad attributes of a nation's business environment (shown in Figure 5), including:

- **Factor Conditions:** Comprised of five broad categories, including human resources, physical resources, knowledge resources, capital resources, and infrastructure. Factors can be general or specialized, basic or advanced. “Firm Strategy, Structure and Rivalry refer to the domestic environment that influences entrepreneurial activity and the operations of existing firms. The legal regime, cultural standards and business norms all impact this determinant, and the match between these factors and the nation’s opportunities for competitive advantage determine national success.” (Autry, Huang, & Foust, 2013)

Figure 5. Michael Porter’s “Diamond” (Porter, 1990).



- **Demand Conditions:** Home demand for an industry's product can be described by composition (including segment structure, level of buyer sophistication and demand, and anticipation of foreign buyers' needs), the size and pattern of growth, and the transmission mechanisms by which this demand is conveyed to foreign markets. “The demand conditions of the domestic market drive several factors that determine the competitiveness of a nation’s industry. These include: the sophistication of the domestic customer, the compatibility of domestic demand with the desires of international consumers, as well as the sophistication and compatibility of the distribution system with international norms.” (Autry et al., 2013)

- **Related and Supporting Industries:** Industries that share value chain activities or transfer proprietary skills. “Porter notes that parallel industries can be important to the success of the industry under analysis by providing additional support to the supply chain. A supply chain with more than one client industry to support demand is likely to be more efficient, dynamic and robust. Absent supply constraints in basic input factors, increased demand from parallel industries drives economies of scale in component production, reducing costs for the industry under consideration. Having multiple client industries also protects producers from the cyclical variances in demand and crises in any one industry. This risk reduction constitutes a cost savings that can be passed on to all downstream industries. Incremental improvements and significant innovations that occur in a parallel industry also improve the quality and performance of components from the shared supply chain.” (Autry et al., 2013)
- **Firm Strategy, Structure, and Rivalry:** The way firms are "created, organized and managed as well as the nature of domestic rivalry" (Porter, 1990). “Factors of production are the inputs required of any particular industry. Factor conditions are the environmental determinants that contribute to national competitive advantage. This report will consider both the natural endowment of factors as well as the process of factor creation and enhancement as it relates to commercial human spaceflight. The Porter model is not unaware of comparative advantage, but recognizes that logistical costs, border tariffs, trans-cultural costs, and political risks are far from zero. Therefore the possession of absolute advantage in factors or supply are of undeniable advantage to any nation. Further, possession of such advantage in no way precludes access to the efficiencies of global supply.” (Autry et al., 2013)

For a given industry, nations with a "diamond" of attributes that are mutually reinforcing (since the effects of one determinant can influence the status of the others) are considered to be more favorable, and will help those industries be more likely to succeed.

Government and chance are two additional variables that can influence the level of national competitiveness.

Stages of Competitive Development

Porter’s theory defines four stages of competitive development based on a nation’s source of advantage: Factor-Driven, Investment-Driven, Innovation-Driven and Wealth-Driven. The first three of these reflect increasing degrees of economic competitiveness based on upgrading of a nation’s productive capacity (Porter, 2011: lc. 9643). The last stage reflects drift and decline in competitive advantage.

- **Factor-Driven:** “In the factor-driven stage, nations derive their competitive advantage from the basic inputs to simple production. Such factors include raw materials, arable land and the nation’s labor pool. Nations endowed with significant natural resources often export these for production elsewhere and nations with few resources typically specialize in low cost production of labor-intensive items. There is relatively little value-add in either model and the average standard of living is usually low.” (Autry et al., 2013)

- **Investment-Driven:** “Nations in the investment-driven stage increase their productivity through investments in larger scale facilities and infrastructure with funds retained from their factor output or foreign investments. While they may improve upon foreign supplied technology, this stage does not reflect significant innovation of basic new technologies or products. Competitive advantage for nations in this stage is based on production efficiencies and incremental improvements in the performance and quality of existing products. Added value is multiplied by investment and drives a rise in living standards.” (Autry et al., 2013)
- **Innovation-Driven:** “In the innovation-driven stage, nations invest in the education, research and development necessary to create entirely new processes or products. Competitive advantage derives from primary access to valuable, domestically produced intellectual property that adds value to products or enhances productivity. Innovation-driven economies utilize all the determinants of the full Porter diamond model in a wide range of industries. Innovation creates substantial value and therefore standards of living are high in innovation-driven economies.” (Autry et al., 2013)
- **Wealth-Driven:** “It can be argued that the economy of the United States of America has advanced through the first of these three stages and is currently transitioning from the innovation-driven stage to the wealth-driven stage.” (Autry et al., 2013)

Since different nations have different goals and approaches, the competitive posture of nations and regions active in space industry segments must be assessed separately. By evaluating the level of competitiveness for each country or region analyzed in the HOM report, the likelihood of HOM industry success in that country or region can be assessed.

Phase 5. HOM Industry Evolution Assessment

The academic foundation for the last analysis phase is based on research that has identified an initial framework of major “infrastructure”² elements necessary, but not sufficient, to support the creation of emerging, high-tech industries (Van de Ven, 1993b). The required elements are:

- Proprietary functions, including proprietary (private) R&D, converting intellectual property into a marketable product (aka “production”), and market creation.
- Resource endowments of public R&D, financial capital, and human resources.
- Institutional arrangements of governance and regulation, legitimization (cognizant and socio-political) and technical standards.

By expanding on and highlighting the market-related activities by separating it from the proprietary functions of the initial framework, an extended version of this framework increases the number of major elements to four (Van de Ven, 2005), including:

² The word “infrastructure” is being used in the organizational theory sense, referring to supporting elements for industry viability. This can be easily confused with “infrastructure,” typically referring large, immobile facilities and sites shared by launch providers, such as launch sites and spaceports.

- Proprietary activities, including product development, business functions, and research channels.
- Resource endowments, including science & technology, financing & insurance, and competence training and accreditation.
- Institutional arrangements, including legitimization (cognizant and socio-political), laws and regulation, and standards.
- Market consumption, including cultural norms, market creation & demand, and competition.

Since both frameworks have only demonstrative differences, the simpler, initial iteration will be used for presentation in this report. However, all components of the extended framework will be included for the sake of completeness.

In contrast to the economic definition that an industry is “a group of competitors producing products or services that compete directly with each other” (Porter, 1990), this study adopts the social ecology perspective of populations that include both governmental and non-governmental actors. Furthermore, “new technologies and related institutions coevolve and reflect the institutional practices and social norms of the cultures in which they are socially constructed” (Van de Ven, 2005). As with non-governmental organizations, governmental institutions play many roles in the emergence of a new industry (Autry, 2013).

The generic framework to characterize the many different entities that contribute to the industry infrastructure development include two major categories, each with two minor divisions. These are:

- Non-Market Sector: National Security and Civil Subsectors
- Market Sector: For-Profit and Not-for-Profit Subsectors

It is recognized that, in reality, non-governmental organizations may lie somewhere on a spectrum ranging from truly independent of government control at one extreme, to entirely subject to government control at the other. Because it lies outside the scope of this study, the extent of government control of non-governmental organizations is not a part of this analysis.

Although specific actors and their contributions to the industry infrastructure will be identified for each country or region analyzed in this study, the theoretical frameworks will be common to all countries and regions included in the HOM study.

The combination of these two academic frameworks allows the creation of an evaluation matrix that can be used to accomplish the final two goals of this analysis phase (Figure 3, shown in the Methodology chapter).

CHAPTER 2. STUDY METHODOLOGY

Phase 1. Target Market Assessment

HOMs under primary consideration by the IAA study are a subset of all possible future markets. Those identified future HOMs were further categorized as “previously demonstrated” or “potential”³. Far-term potential markets (estimated to be realistic in greater than ten years’ time) were identified but not included in this study. A detailed analysis was performed to identify these markets (Autry et al., 2013).

Demonstrated target HOMs include the following activities of low Earth orbit (LEO):

- Recreational (e.g. “tourism” to the International Space Station)
- Transportation from Earth to LEO for US government crews and foreign spaceflight participants.

Potential target HOMs include the following activities:

- Commercial on-orbit research and development (R&D)
- Cis-lunar recreation (Space Adventures Ltd., 2015)
- Cis-lunar government crewed transportation
- Media/promotion.

Although not included in this report, far-term potential HOMs are listed here for the sake of completeness:

- Resource Extraction
- Energy Generation
- Deep-space Vehicle Support Services
- Residential Space Stations
- In-Space Construction
- Business Travel Services

These targeted HOMs were uniformly applied to all countries and regions included in this HOM study. If future regional studies identify additional demonstrated or potential target HOMs, the study results will be updated accordingly.

Target markets identified in analysis Phase 1, were used to inform the results of analysis Phase 4, National HOM Industry Competitiveness Assessment.

³ “potential” is defined as estimated to be demonstrable within ten years’ time

Phase 2. Literature Review

A review of the literature, comprised of many concerted, continuous and sometimes serendipitous searches, were conducted by multiple researchers at various times during the study period and consisted of web searches using public-facing, free search engines such as google.com, bing.com, and scholar.google.com. In some instances, reports that required purchase were also obtained.

Different search terms were used, including “space industry [country name]”, “industry structure [country name]”, etc., for example.

The current list of reports found during this activity covers 11 countries or regions and includes 63 reports and studies, including:

- Africa
- Europe: France
- Portugal
- United States
- Canada
- Europe: Italy
- Russia
- World-wide
- Europe
- Norway
- United Kingdom

Appendix B at the end of this report is a list of the resources identified to date. Web links to studies that have been found in the public domain can be found on the Study Matrix page of the IAA HOM wiki (IAA HOM Wiki, 2015). The list of US-specific space industry reports can be found on the web as well (Commercial Space Wiki, 2015).

The majority of publicly available studies found in this analysis phase include an assessment of the economic impact of space-related activity in different countries. Often these reports are overviews of the aerospace industry in its entirety, with space being a small subset of the overall activity. This limits the relevance of these reports to the HOM study group report. Some studies take a worldwide perspective instead of focusing on a single country. Again, this limits the inclusion of these particular reports in the HOM report.

Another category of available studies include qualitative assessments of a given country’s recent space-related activities and markets. This type of information can be useful to the HOM study group and has been incorporated whenever possible.

To date, a limited amount of material has been found in the publicly-available literature regarding the structure of the space industrial supply chain of different countries, but where it does exist and has been discovered by this literature review, it has been included into this report. The HOM study group is continuously searching for even more resources to be included in the list above and welcomes any corrections or new additions to the collection already assembled.

Resources identified in analysis Phase 2, Literature Review, were used to inform the results of the rest of the study.

Phase 3. Entrepreneurial Environment Assessment

The objective of this analysis phase is to assess the overall entrepreneurial environment of a given country (or region). To accomplish this objective, the HOM study evaluates the effects of

social and historical factors on that country or region's level of enterprise and innovation. Based on past management research, the model used in this study (Gnyawali & Fogel, 1994) identifies three factors, opportunity, propensity, and ability, that are all necessary for an increased likelihood for enterprise in a given country or region:

- The opportunity to enterprise is influenced by and directly related to government policies and procedures.
- The propensity to enterprise is influenced by and directly related to socioeconomic conditions.
- The ability to enterprise is influenced by and directly related to entrepreneurial and business skills.

The model also provides a fourth relationship linking the overall likelihood to enterprise with the ultimate goal of new firm creation:

- New venture creation is influenced by and directly related to three factors: the aforementioned likelihood to enterprise, plus additional factors of financial assistance, and non-financial assistance.

Greater detail of this framework for entrepreneurial environment assessment is provided in Appendix E.

Analyses of the entrepreneurial environments of each country or region that contributed to this report were performed by individuals or groups of researchers. In all cases, researchers relied on sources of existing academic literature for relevant histories and/or web searches for applicable elemental examples of the relevant factors that influence a country's or region's entrepreneurial environments (delineated above).

The results of analysis Phase 3, Entrepreneurial Environment Assessment, were used to inform the results of analysis Phase 5, the HOM Industry Evolution Assessment.

Phase 4. National HOM Industry Competitiveness Assessment

The objective of this analysis phase is to assess the overall industrial capability of each country or region. The IAA HOM study is based on the analysis of the space industrial base of each nation (and region) by applying well established and academically based frameworks of industry structure and national competitiveness developed to be internationally applicable.

A system of competitive determinants, referred to as the "diamond" (Porter, 1990), determine the level of national competitiveness in an industry. As shown in Figure D-3, the diamond is built upon four broad attributes of a nation's business environment, including:

- Factor Conditions
- Demand Conditions
- Related and Supporting Industries
- Firm Strategy, Structure, and Rivalry

Further details of Porter's diamond theory are provided in Appendix D and in the cited reference (Porter, 1990).

The four broad attributes of national competitiveness (listed above) were described to identify their respective characteristics. For example, the factor conditions were assessed for their level of specialization (from general to specialized) and advancement (from basic to advanced). Demand conditions were also assessed according to their composition (as described in Appendix D).

For each country or region analyzed, the chain of HOM industries were identified, categorized in "tiers," and evaluated for their level of national competitiveness. The chain begins with the identification of necessary natural resources and progressively includes different tiers of industry, including the manufacturing, subcomponents, components and services that are all required to satisfy the needs of the HOM end use markets.

The level of analysis for this study phase is the community of industries and the unit of analysis is a given population (or industry). For example, the box labeled "Propulsion" in the depicted industry chain graphic has two subcomponents: the solid rocket motor and the liquid rocket engine industries. Each of these industries is comprised of individual firms.

To complete the analysis from the broader perspective of the complete industrial diamond, industries that support or are related to the "end use" HOMs were also identified, evaluated, and categorized within the industry chain. For example, the civil aviation and automotive industries may be supporting industries to the industries that support the HOMs because of similarities of vehicle subcomponents, components and systems.

Although it is expected that the industry chains for different countries will bear some resemblance to each other, there may also be a fair amount of difference between industry chains for the same HOM end use.

Because of the international nature of this study, the HOM industrial chain analysis can be used to identify gaps within a national chain and to see which other nations or regions are filling those gaps.

This very complex and detailed assessment (1) is not expected to be easily or inexpensively conducted to the desirable level of detail or completion in this first iteration of the HOM study, and (2) was not attempted or performed for each country. Despite these shortcomings, results of the national HOM industry competitiveness assessment are presented in this report regardless of their level of completeness or detail.

The results of analysis Phase 4, National HOM Industry Competitiveness Assessment, were used to inform the results of analysis Phase 5, the HOM Industry Evolution Assessment.

Phase 5. HOM Industry Emergence Assessment

After identifying the requirements of an emerging industry, the goals of this phase of the HOM study include the following:

- Identify the HOM industry actors (i.e., the participating communities of non-governmental organizations and the relevant governmental institutions) who could potentially contribute to the necessary HOM industry emergence.
- Qualitatively assess the contributions of the HOM actors) to each element of the HOM industry infrastructure for given countries or regions.
- Make an overall qualitative assessment of the possible emergence of an HOM industry for a given country or region based on the combination of all industry infrastructure element contributions by all HOM industry actors.

Identification of HOM Industry Actors and Their Contributions

The identification of critical industry infrastructure elements and sub-elements (Van de Ven, 1993a, 1993b, 1993c) was described in chapter 1. The general categorization of market actors (with for-profit and not-for-profit sub-sectors) and non-market actors (including sub-sectors of national security and civil) (Pearce, 2001) was identified in Appendix D and is applied to all countries and regions analyzed in the HOM study. Actors in both categories that are specific to each country and region analyzed in the HOM study were identified by individual researchers and the results are presented in Chapter 3 of this report. With the identification of the industry infrastructure elements and industry actors that are common to all countries and regions of the HOM study, an evaluation matrix can be constructed into which qualitative assessments of the contribution of each actor can be tabulated. The evaluation matrix is shown in Figure 6 below.

The goal of this portion of the study is to identify and qualitatively assess the HOM actors contributions to each element of the HOM industry infrastructure for given countries or regions. Adjectival ratings (e.g., “none,” “weak,” “moderate,” or “strong”) and influence direction (e.g., “positive” or “negative”) will be assigned to each “actor class-infrastructure element” cell in the matrix. This was performed by individual researchers and the results are presented in Chapter 3 of this report.

In each case, the contribution direction is evaluated, either positive (+) or negative (-), as is the magnitude (weak indicated by one +/- sign, moderate indicated by two +/- signs, and strong indicated with three +/- signs). This is a source of uncertainty due to perspective bias that could be minimized by incorporating the inputs of multiple researchers or expert advisors.

It should be noted that the effect of government regulation in the development of industry infrastructure is a double-edged sword: any regulation is a potential burden to new firm creation, however the lack of regulation creates regulatory uncertainty that subsequently increases financial and proprietary R&D uncertainties. Therefore, unless there is specific evidence that regulations are having a negative effect on industry (e.g., ITAR in the US), the default contribution direction will be positive.

Figure 6. HOM Industry Emergence Assessment Matrix

Industry Infrastructure Elements ^{1,2}	HOM Actors ^{3,4}			
	Non-Gov't Orgs		Gov't Institutions	
PROPRIETARY FUNCTIONS	PROFIT	NON-PROFIT	CIVIL	MILITARY
Proprietary R&D (Invention)				
Production (Innovation)				
Market Creation (Diffusion)				
RESOURCE ENDOWMENTS	PROFIT	NON-PROFIT	CIVIL	MILITARY
Non-Proprietary R&D				
Financing				
Human Resources				
INSTITUTIONAL ARRANGEMENTS	PROFIT	NON-PROFIT	CIVIL	MILITARY
Governance				
Legitimization				
Technical Standards				

Overall Assessment of HOM Industry Emergence

Make an overall qualitative assessment of the possible emergence of an HOM industry for a given country or region based on the qualitative actors' contributions assessment described above. This assessment was performed by individual researchers and the results are presented in Chapter 3 of this report.

The following qualitative scale is used in the overall assessment of HOM industry emergence:

- Very Unlikely: There is practically no chance of the emergence of an HOM industry in country X.
- Unlikely: There is a small chance of the emergence of an HOM industry in country X.
- Likely: There is a high chance of the emergence of an HOM industry in country X.
- Very Likely: There is a high likelihood of the emergence of an HOM industry in country X.

An example of a research result might be "In consideration of historical, social, political, cultural and industrial factors of technology, innovation and enterprise, the probability that country X could sustain a viable HOM is likely."

In most cases, analysis results do not uniformly favor or discourage, but give mixed results of the likelihood of HOM industry viability for a given country or region. In these cases, the qualitative results will be harder to discern and defend.

Despite the perceived shortcomings of qualitative assessments, the accuracy of the current study results is most likely as good as any attempt of quantification could hope to be. An attempt to make deterministic or probabilistic quantitative forecasts is most likely beyond the abilities of

modern forecasting methods due to the lack of reliable data of the emerging human orbital markets and the inherently non-linear nature of market behaviors.

As this study evolves and matures, it is planned that this analysis phase will include more detailed qualitative conclusions and explanations supported by evidence from the previous study phases.

CHAPTER 3. ANALYSIS RESULTS

This chapter lists the analyses that were performed that support the IAA HOM study and describes the subsequent results. Many of the analyses for phases 3 through 5 of this study were described in reports presented at past International Astronautical Congresses. Table 2 below provides an overview of the study phases and countries that are included in this chapter.

Table 2. Summary of Study Phases Conducted for Which Countries and Regions

Country	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Africa		X			
Australia	X		X	X	
Canada		X			
China	X		X	X	
Europe	X	X	X	X	X
Europe: Benelux	X		X	X	
Europe: France	X	X			
Europe: Germany	X		X	X	
Europe: Italy	X	X	X	X	
Europe: Portugal	X	X			
Europe: Spain	X		X	X	X
India	X			X	
Israel	X		X	X	
Japan	X		X	X	X
Nigeria	X		X	X	
Norway	X	X			
Russia	X	X			
South Africa	X		X	X	X
United Kingdom	X	X			
United States	X	X	X	X	X
World-Wide	X	X			

Phase 1. Target Market Assessment⁴

The HOM study group presumes that the human orbital spaceflight market is global in nature and therefore the analysis is best conducted at the global level rather than national level. This study does not directly survey U.S. market demand. Based on the assumptions of the IAA study and the results of previous surveys we assume that a commercial market for human orbital spaceflight will emerge with sufficient demand to support a number of international players in a generally free market economy.

Existing Market Studies

There have been several market studies and surveys of human spaceflight and related markets.

⁴ This entire section was taken verbatim from (Autry et al., 2013).

The most thorough survey to address HOM demand is the 2002 Space Tourism Market Study by Futron/Zogby. This study indicated significant demand for orbital flights, with 35% of the high net worth individuals being “definitely likely” or “very likely” to participate in orbital travel when price was not a factor. As expected, participation rates dropped with price. At a price of \$25 million only 6% were willing to participate. At \$1 million the participation rate rose to 30%. Futron noted that an important factor in the development of a successful commercial market was the presence of a commercial destination for tourists (other than ISS). This study projected demand for over 400 tourism only passengers per year by 2020 with industry revenues of \$297 million.

The Adventurers Survey of Public Space Travel conducted by Spaceport Associates in 2006 concluded that 47% of self-identified adventure tourists would be interested in orbital flight.

A 2013 study conducted by students at the University of California, Irvine suggests that 35.3% of respondents would “pay any price they could afford” for an orbital flight, very closely paralleling the earlier Futron results.

A 2011 statement by Space Adventures, the only firm that has delivered orbital tourism trips, estimated that by 2020 more than 140 private individuals would have made a trip to space.

NASA’s Commercial Market Assessment for Crew and Cargo Systems study did not include a survey but did analyze the non-governmental markets addressed in this study. NASA conservatively concluded that the upper-end demand for all non-governmental orbital human flights was approximately 350 over a ten-year period.

Figure 7. Identified Human Orbital Markets

	Near-Term (< 10 Years)	Far-Term (> 10 and <50 Years)
Demonstrated Markets	<ul style="list-style-type: none"> • LEO Tourism • Domestic Gov’t Crew Transport • Foreign Astronaut Corps Flight 	NA (by definition)
Potential Markets	<ul style="list-style-type: none"> • R&D • Cis-Lunar Tourism • Cis-Lunar Gov’t Crew • Media and Promotion 	<ul style="list-style-type: none"> • Resource Extraction • Energy generation • Deep-Space Vehicle Support Services • Residential Space Station Operation • In Space Construction • Business Travel Service

History of Human Orbital Markets

Governmental space programs have already demonstrated several commercial markets and have revealed potential demand in others. Figure 3 lists markets identified in this study. The history of other disruptive technologies suggests (Christensen, Anthony, Roth, & Kaufman, 2004; Christensen & Raynor, 2003; Christensen, 1997a) that many applications of commercial human

orbital spaceflight have not been identified. It is possible that the market driving application has yet to be identified.

For the purposes of this study, a demonstrated market is defined as one in which there have been re-occurring (more than once) and sustained (still on-going) revenues. A potential market is one in which open interest has been expressed by parties capable of paying the fare and in which limited transactions may have occurred.

The existence of demand for profitable transportation to Low Earth Orbit has been conclusively demonstrated in the markets for Tourism, U.S. Domestic Crew Transportation and Foreign Astronaut Corps flights by the Russian and U.S. government manned space programs.

Tourism

The first paid flight to space by a tourist was the notable case of Dennis Tito. Tito first arranged for a trip to the Mir space station on a Russian Soyuz vehicle via an arrangement with the American firm, Mir Corp. Despite significant opposition from the American space agency, Tito eventually paid \$20 million for a trip to the International Space Station in 2001 booked through another U.S. firm, Space Adventures (Dubbs & Paat-Dahlstrom, 2011).

Following Tito's mission there were several additional space tourism flights, including two flights commissioned by Microsoft billionaire, Charles Simonyi. Since 2009 there have been no tourism flights available, as the retirement of the Space Shuttle along with an increased ISS crew standard has resulted in the available supply of Soyuz seats being consumed by NASA astronauts. However, demand remains demonstrated by the \$51 million trip to ISS planned by British singer, Sarah Brightman.

Both Space Adventures and British based Excalibur-Almaz have announced plans for circumlunar commercial flights based on updated Soviet space technology. In 2011, Space Adventures announced that one ticket had been sold at a price of \$150 million.

U.S. Domestic Crew Transportation

During the development of the International Space Station project, NASA anticipated utilizing the Russian Soyuz spacecraft for crew transportation and negotiated a bilateral agreement for crew exchanges. NASA assisted in the specification and funding of modifications to the TMA version of Soyuz designed to accommodate a wider variety of passenger sizes.

Following the loss of the Columbia Orbiter, shuttle launches were suspended (February 1, 2003 - July 26, 2005), and continued concerns with the shedding of foam from the shuttle's external fuel tank precipitated a second suspension (August 9, 2005 - July 4, 2006). These suspensions and a reduced flight schedule required NASA to schedule a number of U.S. astronaut flights on Soyuz. Initially unable to pay Russia directly for space hardware or services due to provisions of the Iran, North Korea, and Syria Nonproliferation Act, NASA made other indirect transfers of considerable economic value, including the clearing of a debt of flight service hours valued at up

to \$60million. Congress provided for direct payments to Russia for spaceflight services with the passage of special legislation in 2005.

Following the retirement of the U.S. shuttle fleet (July 21, 2011), NASA negotiated a bulk contract with Roscosmos for 12 passenger seats at a cost of \$753 million (\$63 million per passenger). In 2013, it extended this contract with an additional six seats at a cost of \$424 million (\$71 million per passenger). Following the public announcement of that contract extension, the NASA administrator, Charles Bolden, explicitly expressed support for the President's goal of "American companies launching our astronauts from U.S. soil."

A market in transporting American astronauts to and from the ISS has been clearly established and a successful U.S. commercial firm could generate several hundred millions in revenue annually from this market.

Astronaut Corps of Foreign Nations

The transportation of astronauts from non-spacefaring nations to low earth orbit has been demonstrated by many flights of foreign nationals aboard both U.S. and Russian spacecraft. The first such flights were the launch of cosmonauts from Czechoslovakia, Poland and East Germany by the former Soviet Union in 1978.

Research and Development

In 1984, NASA accepted \$40,000 to fly McDonnell Douglas engineer Charles David Walker on STS-41-D so that Walker could operate a space pharmaceutical manufacturing experiment known as the Continuous Flow Electrophoresis (CFES) device. Walker made two further flights in connection with this work. Though the fee was clearly a token economic transfer, it did suggest that firms were willing to pay for human orbital flight in support of research and development. The Challenger disaster of 1986 ended NASA's experimentation with paid spaceflight.⁵

Media and Promotion

In 1990, the Tokyo Broadcasting System paid \$28 million to fly Japanese reporter Toyohiro Akiyama to Spacestation Mir for a series of one-week television specials.

In 1991, Helen Sharman was flown to the Mir as part of a program called "Project Juno." Juno was originated by a consortium of firms intent on creating publicity surrounding the first British citizen in space. Though the consortium failed to deliver the funds, the Soviets flew Sharman anyway (Dubbs & Paat-Dahlstrom, 2011).

During her stay on the International Space Station in 2006, Female Space Tourist, Anousheh Ansari became one of the world's most popular bloggers.

⁵ Walker, C. D. (2006, November 7). Interview with Charles D. Walker. (S. Johnson, Interviewer) *NASA Johnson Space Center Oral History Project*.

This study concludes that while there has been some demonstrated demand for promotional and media-related spaceflight, it is unclear if it is sufficient to support an HOM market.

Future Markets

At least two firms, Planetary Resources and Deep Space Industries, have been founded with the goal of extracting mineral resources from asteroids. Such operations might involve human transport to robotically captured asteroids brought into Earth orbit. NASA has also proposed a demonstration mission of this nature.

Since the foundational work of Gerard K. O'Neill in the 1970s (O'Neill, 1978), many proposals have been made to locate populations, power stations and manufacturing plants in Earth Orbit. Such facilities would likely require human assembly and possibly maintenance. With the establishment of significant industry in space it is likely that managers will conduct review visits at space facilities and may eventually establish an onsite presence, driving a future “business travel” market in space. While highly speculative at this time, such a market, being driven by more direct economic returns, would be more robust and sustainable than existing markets.

Other Markets

Other markets, of unknown potential that have been suggested include: zero gravity medical treatment, spiritual-religious travel and end-of-life travel.

Phase 2. Literature Review

The basis of all research is a review of the existing literature and this study is making a concerted effort to identify all the relevant research reports that are publicly available on the topic of the space industrial base and economic impact of space-related activities in each of the countries and geographic regions studied. Appendix B provides a listing of the reports identified in support of this study, and web links to these studies can also be found on the Study Matrix page of the IAA HOM wiki (IAA HOM Wiki, 2015).

The majority of publicly available studies assess the economic impact in different countries of space-related activity. Oftentimes these reports are subsets of the aerospace industry in its entirety, with space being a small subset of the overall activity. Some studies take a world-wide perspective instead of focusing on a single country. Other available studies include qualitative assessments of a given country's recent space-related activities and markets.

To date, not much material has been found in the open literature regarding the structure of the space industrial chain of different countries. Some information about the space industrial base of certain countries (the U.S. in particular) is available but is only marginally relevant.

One of the greatest contributions the IAA HOM study will provide is to conduct these types of studies and then make them publicly available as the basis of future research.

Phase 3. Entrepreneurial Environment Assessment

The objective of this analysis phase is to assess the overall entrepreneurial environment of a given country (or region). To accomplish this objective, the HOM study evaluates the effects of social and historical factors on that country or region's level of enterprise and innovation. Table 3 below lists the reports and studies pertaining to this analysis phase for specific countries.

Table 3. IAA HOM Study Phase 3 Supporting Analyses

Country	Phase 3 – Socio-economic Factors
Australia	(Davis, 2014; Vaccaro, Clement, Fuller, & Christensen, 2011)
China	(W.-H. Dong, Liu, & Lan-Juan, 2011; Z. Dong & Zhifu, 2011; Wenjie & Donghao, 2014)
Europe	(Bernede, 2013; de Hauteclocque, 2012; Lu, Svoboda, Maier, Hou, & Shaghaghi, 2013; Szalai, Detsis, & Peeters, 2012; Vööras, Eerme, Cohendet, Lillestik, & Sepp, 2013)
Europe: Benelux	(Prado, Kiang, Van Dorenmalen, & Maier, 2014)
Europe: Germany	(Maier, Bernede, Schmidt, & Svoboda, 2014; Maier, 2013; Weber-Steinhaus, 2011)
Europe: Italy	(Ainardi, Luise, & Sabino Titomanlio, 2012; Ciccarelli & Pavone, 2013; Graziola, 2013; Piperno, Ciccarelli, Pavone, & Ciavoli Cortelli, 2011; Sciortino, 2010)
Europe: Spain	(C. J. Lauer, Harillo, & Onuki, 2013)
Israel	(Tepper, 2013)
Japan	(Onuki, Ito, Watanabe, & Lauer, 2009; Onuki, 2012b)
Nigeria	(James, Akinyede, & Halilu, 2011)
South Africa	(Guthrie, Sharpe, Hinds, Orloff, & Christensen, 2011; Makapela & Majaja, 2011)
United States	(Autry et al., 2013; Davidian & Autry, 2014)

The results from each analysis will be described here for each country.

Australia

Australia's Role in the Global Space Industry (Davis, 2014)

In 2013 the Australian Government announced its Satellite Utilisation Policy, the most important space policy statement for over a decade. This paper examines the implications of the statement for Australian industry and sets out the response of the Space Industry Association of Australia. It also examines the potential for greater Australian involvement in the global space industry together with the associated challenges.

Benchmarking Australia as a User of Space Products and Services (Vaccaro et al., 2011)

Following a period of dormancy, Australia has begun to revisit its national space policy. A major theme of this renewed focus is maximizing the benefits of space utilization for the Australian government, armed forces, commercial industry, educational institutions, and society as a whole.

As it considers space policy decisions, the Government of Australia has recently completed a benchmarking study to evaluate its current usage of space resources along three lines: development, sophistication, and efficacy. The study examined the state of Australian space usage, including asset-to-user applications flows, for five application areas:

- Earth Observation and Resource Management
- Natural Disaster Management
- Global Positioning System (GPS) Navigation
- Satellite Communications
- Weather and Meteorology

To benchmark Australia in these five application areas, the study compared and contrasted Australian space usage with that of seven other peer (or near-peer) nations, selected due to similar economic, regional, or science and technology attributes:

- Canada
- India
- Indonesia
- Malaysia
- Singapore
- South Africa
- Thailand

Using a combination of quantitative and qualitative indicators, this study ranked Australia relative to these other nations as a user of space products and services. This helped pinpoint Australian strengths and weaknesses in space utilization.

The lessons derived from this study suggested where Australia can improve its development, sophistication, and efficacy as a user of space products and services, and will assist in informing Australian policy choices as it shapes its national space strategy.

China

A CGE Analysis for the Impact of Chinese Aerospace Program on China National Economy (W.-H. Dong et al., 2011)

China is a space power. The Shenzhou manned spaceship project and Chang'e lunar exploration project has made remarkable achievements in the world. Investment in aerospace program is tremendous, the Shenzhou manned spaceship project and Chang'e lunar project has invested 18.0 billion RMB, and 2.3 billion RMB respectively. The input-output ratio of aerospace investment is alarming, the U.S. Apollo program input:output ratio is 1:14. Many industries has driven by the aerospace program. The industry, such as new material, new energy, telecommunications, equipment manufacturing, will benefit from the investment of aerospace program. This paper focus on the impact of aerospace program investment on China national economy and other

Industries. We constructed a CGE(Computable General Equilibrium) model, which can describe the macro economy system, can simulate the impact of aerospace program investment on national economy and other industry. This paper constructed a SAM (Social Accounting Matrix) which based on 2007 China statistics data. The SAM is a base data set for CGE model. The paper simulate the output of industries by the shock of aerospace program investment. At last, we give policy advice for China.

Development of Commercial Space in China: From an Industry Perspective (Z. Dong & Zhifu, 2011)

Commercial space enterprises' participation in the development of system-level space products will facilitate technical development of space industry, which is essential to a quantum leap forward in China's space development. In recent years, China's defense industry is facing transition from planned economy to market economy and the government has issued a series of policies to encourage commercial enterprises' participation in defense industry construction. However, the existing commercial space enterprises can only serve as small element or component level space product providers. Based on the study of these policies, the basic requirements for a private enterprise to become a system-level contractor in China's space industry are proposed. By comparison of a successful case in the U.S. and the status of Chinese private space enterprises, the principal difficulties for commercial space development in China are analyzed. To address these problems, some pieces of advice from the industry perspective are given.

The Analysis to the Present Situation and Prospects of China Space Tourism (Wenjie & Donghao, 2014)

Space tourism is the result of rapid developing world space economy. With the rapid growth of China economy, Chinese living standard also has been improved greatly, more and more rich Chinese begin interested in space tourism. This paper gives an exact analysis of the present situation, opportunities, challenges and prospects of China space tourism.

Europe

Entrepreneurship and Innovation in the European Space Sector: Overview and Impacts of European Space Agency and European Union's Initiatives (Bernede, 2013)

Undertaking long term space programmes require strategic non-dependence in cutting-edge and critical technologies as well as affordable mission and procurement costs for the customer. This requires innovation and competitiveness among the stakeholders of the space industry.

The academic and professional literature assesses that the implementation of sustainable space strategies and ambitious space programmes' needs, on one hand, an integrated industry able to support important risks and, on the other hand, smaller entities such as Small and Medium Enterprises (SME), perceived as having structurally a higher faculty to adapt.

Following this statement, space-faring nations adopt policies to support their industry in order to develop and foster key space capabilities. To ensure growth and sustainable innovation in the European space sector, the European Space Agency (ESA) and the European Union (EU) have elaborated policy measures dedicated to the space industry and service providers. Additionally, these programmes often pay special attention to facilitate new business opportunities for SME by sharing risks and investments, encouraging them to take part in research and development or services activities.

This paper aims to analyse the current framework programmes implemented in Europe to foster the capabilities of the space industry. On one side, the ESA addresses R&D as well as spin-in and spin-off activities, among others through the General Support Technology Programme (GSTP), the Business Incubation Centres (BIC), the Technology Transfer Programme (TTP) and the Integrated Applications Programme (IAP), addressing both the industrial and the service segments. On the other side, the analysis presents the EU initiatives which contribute to this dynamic in its own way, through the Framework Programmes FP6, FP7 and Horizon 2020. In the study, similarities and differences between ESA and EU approaches to support the industry, and especially the small entities, are analysed.

Looking at the conceptual approaches behind these framework programmes and at their implementation, the paper will extract opportunities as well as potential paradoxes for the space sector. From this perspective, this study will look at two parallel tendencies in the space industry supported by the public sector: the strong vertical integration and the support to develop SMEs. The study, based on selected literature, interviews, analysis of policies and financial documents will expose the current challenges to foster entrepreneurship as well as maintain a strong space industry in Europe and the key role played by small entities in this context.

Prevision and Prospective To Forecast in the Space Economy - Application to the European Space Sector (de Hauteclocque, 2012)

The value of investing in space depends largely on our vision of the space sector future. So the space economy needs instruments to provide private and public actors with forecast information on the short term and long term horizon. This paper, based on a PhD research in space economics, presents a methodology and its application to the European space sector for both short term (prevision) and long term (prospective) evaluation of the future.

For the Prevision, we design a typical chain model of the space sector “From budget to employment”. This model is transformed in a system of time series equations. The parameters of this multiple equations system are computed through econometric recent algorithms implemented in EVIEWS software commands. Using Eurospace data, we generate a forecast until 2015.

Prospective, long-term oriented and complementing the prevision, does not produce predictions but seeks to envisage the possible futures. To do so we use a three phases methodology based on advanced works in prospective: 1- Construction of the analytic base (research of key variables of

the system through structural analysis), 2 - Scanning the scope of possibilities with morphological analysis, 3- Generation of final scenarios.

Applied to the European space economy for 2030-2040, three classical synthesis scenarios emerge: grey (pessimistic), blue (trendy) and pink (optimistic).

In conclusion we promote the necessity to rationalize the “uncertainty of the future”, thus avoiding the temptation of 'science fiction' in predicting space perspectives.

Identification and Analysis of National and Regional Industry Clusters of the European Space Industry (Lu et al., 2013)

Industry models play a central role in understanding industries and processes on a macroeconomic scale and are indispensable as a support for politico-economic as well as corporate strategic decisions. A model particularly suited for the analysis of competitiveness and the development of regional and national industrial strengths and advantages is the one described in the book *Competitive Advantage of Nations* by Michael E. Porter, depicted in a “diamond” of interconnected factors. The space industry clearly reflects several of the elements described by Porter, among them: a tendency towards geographically concentrated industry clusters, caused by a strong dependence on high-quality suppliers, strong dependence on a skilled labor force and the necessity of exchange with research institutions. Large portions of the space industry are highly influenced by governments, be it through governmental/intergovernmental institutions acting as customers, through national research strategies or through governmental influence on factor conditions. Especially in Europe, this influence is scattered out to a number of institutions, including national and regional governments, the European Commission and the European Space Agency. Since their policies are a main influence and potential driver for the space industry and economic growth in this sector, it is especially important to take politico-economic and strategic decisions on the right basis. The first step in Porter's analysis of the national/regional diamond is the identification and description of national/regional clusters of different industry subgroups. While other researchers focus on cluster identification in the United States of America, this paper will conduct an identification of clusters for the European space industry. Beyond the identification, it will analyze details concerning the nature of the clusters and especially the role of political strategies and environments in shaping them.

ESA Space Spin-Offs Benefits for the Health Sector (Szalai et al., 2012)

Humanity will be faced with an important number of future challenges, including an expansion of the lifespan, a considerable increase of the population (estimated 9 billion by 2050) and a depletion of resources. These factors could trigger an increase of chronic diseases and various other health concerns that would bear a heavy weight on finances worldwide. Scientific advances can play an important role in solving a number of these problems, space technology; in general, can propose a panoply of possible solutions and applications that can make life on Earth easier and better for everyone. Satellites, Earth Observation, the International Space Station (ISS) and the European Space Agency (ESA) may not be the first tools that come to mind when thinking of

improving health, yet there are many ways in which ESA and its programmes contribute to the health care arena. The research focuses on quantifying two ESA spin-offs to provide an initial view on how Space can contribute to worldwide health. This quantification is part of the present strategy not only to show macroeconomic return factors for Space in general, but also to identify and describe samples of 'best practice' type of examples close to the general public's interest. For each of the 'best practices' the methodology takes into account the cost of the space hardware/software, a number of tangible and intangible benefits, as well as some logical assumptions in order to determine the potential overall returns. In conclusion, the study recommends a way in which ESA's spin-offs can be taken into account early on in the development process of space programmes in order to generate higher awareness with the general public and also to provide measurable returns.

Ex Ante Assessment of Economic and Societal Effects Induced By Space Investments in a Small Emerging Space Country (Võõras et al., 2013)

During recent years, an increasing number of countries and organisations have paid attention to the space sector's contributions to national economies. Although the impact may vary widely from country to country, OECD has estimated that revenues generated by institutional investments in space over a decade have led to a multiplier effect of between 4.5 and 6.2 when considering the value chain and indirect effects only, and between 8.5 and 9.7 including the societal effects. Also, several smaller ESA (European Space Agency) Member States (Norway, Denmark, Ireland, Portugal) have lately performed ex post evaluations to study the returns from space investments. These studies mainly consider the value chain and indirect effects of space investments with the respective calculated multiplier effects indicating that space investments contribute to growth, employment and competitiveness in many sectors of the economy. Since 2009, a number of very small countries with relatively limited tradition of space activities – Estonia (1.3 million inhabitants), Slovenia (2.0 million), Latvia (2.0 million), Lithuania (3.0 million), Cyprus (0.8 million), and Malta (0.4 million) – have embarked on a path to join ESA. Concomitant financial contributions to ESA budget shall put additional stress to the public finances of the acceding countries that are currently implementing austerity measures. There is a need for tools for ex ante assessment of the potential benefits of joining ESA in order to provide rationale for public investments in space activities. A methodology designed for very small emerging space countries for studying potential aggregate economic and societal impacts of space investments is elaborated. It is evident that from the viewpoint of such countries, the positive indirect effects from joining ESA would very strongly depend on single success stories, attributable, for example, to FDI inflows to an emerging space industry, break-through of a start-up (spin-off) company, integration of a company to global aerospace industry's value chains, or other similar effects that can be linked with consolidation of dispersed human resources for the purpose of the implementation of ESA contracts. We argue that multiplier effect representing the minimum estimate of the volume of direct and indirect effects to private sector would exceed 1 in the acceding countries making space investments desirable considering accompanying societal

effects. For countries with ambition to join ESA it gives suggestions how to justify space investments for government and society in general. The results of this paper are valuable to (space)policy makers, especially in small countries throughout the world.

Europe: Benelux

The Structure of the European Space Industry – Current and Historical Analysis of Industry Clusters in the Benelux (Prado et al., 2014)

A comprehensive understanding of a particular industry is imperative as a basis for policy decisions to foster this industry or a segment of it. In this sense, the Space Generation Advisory Council's Commercial Space Project Group strives to support the International Academy of Astronautics' study group on "Public/Private Human Access to Space" by providing a description and analysis of the European space industry. As a precursor to this paper, the main industry clusters in the European space industry have been identified along with their basic characteristics. This paper builds on that analysis by describing the space industry clusters in Belgium, the Netherlands and Luxembourg (Benelux) in more detail and examining their individual constitution in tandem with other external influences, e.g. academic research institutions and military and government bodies. Special emphasis is placed on reviewing the historical development of each cluster in the context of its current state (culturally, structurally, politically and economically). As this work is conducted in collaboration with other researchers who are focused on other European countries, the end goal of this research is to obtain a comprehensive picture of industry clusters all over Europe. This will help build an overall understanding of the European space industry and the roles individual nations play in it. Moving forward, a good understanding of how the European Space Industry has formed will give new insight into possible growth opportunities, e.g. strengths and advantages. This particular work will use Porter's analysis method described in his book "Competitive Advantage of Nations" to present a more detailed description of the active players within the Benelux space sector. Porter's model represents the influencing factors on industry in a diamond to illustrate the relationship between them and the resulting influence on industry competitiveness. Additionally, this paper will take into account socio-political factors set up by governments and policy makers, examining their role in the industry's past and continued development.

Europe: Germany

The Structure of the European Space Industry – Current and Historical Analysis of Industry Clusters in Germany (Maier et al., 2014)

In late 2012, after observing new developments in the private space sector, the Space Generation Advisory Council (SGAC) established a project group to gather inputs and to conduct research into commercial space activities. In this capacity, the group is currently supporting a study group of the International Academy of Astronautics (IAA) on "Public/Private Human Access to Space" that aims to assess the viability potential of human orbital commercial space markets. For the

long-term politico-economic decisions the study group intends to support, a solid knowledge of industrial and macroeconomic structures is necessary. This proper understanding of industries and their structure relies not on the consideration of a single influence or driver, but on a comprehensive examination of cultural, structural, political, economic, and historical drivers and environments that affect industries and their development. In order to fully comprehend the interactions and results of these forces, existing market data must be visualized using industry models. One model particularly suited to provide information on background and development of regional and national industry strengths and advantages - and therefore, the reasons for today's industry structure - is the model developed by Michael E. Porter in his book 'Competitive Advantage of Nations.' As the basis of his analysis, Porter uses industry clusters as highly connected building blocks that can be individually analysed. Accordingly, in a precursor work for this paper, the main industry clusters of the European space industry and their basic characteristics have been identified. This paper builds on that analysis with a detailed description and analysis of the space industry clusters in Germany made by examining their individual makeup, macroeconomic determinants, and other external influences. As previous work on the influences of cultural and historical backgrounds on industry development in Germany has shown, the structure of the space industry in the country depends highly on historical developments due to a strong tie of the German space and aerospace industries to political institutions. This paper therefore puts a special emphasis on examining the historical development of each cluster and comparing the historically founded forces with the current economic determinants. This work is part of a larger research project at SGAC that focuses on the detailed examination and definition of industrial clusters in relevant European countries. The ultimate goal is to obtain a better understanding of the European space industry as well as the roles individual nations play within it.

Historical and Cultural Assessment of Entrepreneurship and Investment in Germany (Maier, 2013)

The rise, development and continuance of industrial sectors and regions are dependent on numerous factors and their complex interactions. However, an understanding of basic correlations is essential to support sustainable politico-economic as well as corporate strategic decisions. Therefore different models have been developed and are used to describe dynamics of markets and industry, taking into account factors such as demand conditions, rivalry, infrastructure and available workforce, support industry availability, and regulatory regimes. However, many of these factors evolved over time, in a distinct way for every region, leading to distinct sets of factor characteristics and industry situations. Furthermore, cultural backgrounds of individuals in the industry, in the industry's home base and of policy makers play an important role in shaping markets and industries that is often undervalued. Due to, for example, common laws and regulations, and a partly shared history, it is convenient to choose individual nations as underlying regions for an analysis of historical and cultural influences. While other researchers

focus on different regions, this paper will therefore conduct an assessment of the historical and cultural context underlying the development of entrepreneurship and investment for Germany.

Germany's Role within the European Space Policy: Encouraging National Versus European Space Industry Applications (Weber-Steinhaus, 2011)

National governments are aware of the need for investment in space. In the European Union (EU), the new European Space Policy is being developed as a tool to further input in space experimentation and research across all member states and the union. This article discusses the novel interdependencies between clear national and now supranational space policies, using the examples of the German national space policy and that of the EU Lisbon Treaty. Germany is one of the most proactive space-focused member states of the EU. However, the differences in the affiliation of member states to national as well as regional space agencies such as the European Space Agency and the novel structure of supranational government organization of the EU can lead to issues of demarcation. The article focuses on the EU space policy, especially on Article 189 of the Lisbon Treaty, and offers some reflection on the effect of the EU's involvement in the space domain.

Europe: Italy

Space Entrepreneurship in Italy: The Role of Regions (Ainardi et al., 2012)

This article investigates the role of entrepreneurship and SMEs in the Italian space industry. After a first section where entrepreneurship is defined in the different segments of the space sector, the article identifies the different stakeholders in the Italian space entrepreneurship. The Italian space entrepreneurship is analyzed both from a quantitative or financial perspective and from a qualitative one (regulatory aspects, policies, incentives and sources of funding for the space entrepreneurship). A perspective on the trends, evolutions and challenges in the coming decade is provided based, on interviews with key actors in the Italian space entrepreneurship landscape (SMEs, districts, ASI, associations, financial players...)

New Trends in the Italian Space Industrial Landscape: SMEs and Technology Districts As Drivers of Space Economy (Cicarelli & Pavone, 2013)

This paper provides an overview of the initiatives implemented by the Italian Space Agency (ASI) to support national space industry and specifically SMEs. The industrial context in Italy experienced an evolution process during the last decade, more oriented towards the European context. On the other side, the economic crisis is having a significant impact on the real economy, including a decrease in the budget managed by ASI and devoted also to industrial activities. Besides that, the aerospace sector experienced more recently an increasing role played by the Technology Districts and local administrations (Regions in particular, that are expressing the intention to invest in space activities for the benefit of their territories). In some cases ASI is also investigating the opportunity to make specific agreements with "Spacefaring Regions" in order to share economic resources and create economies of scale through the expertise of ASI,

the financial resources of Regions and their capability to valorize the skills, the knowhow and the relationships of specific geographical areas.

The Role of Italian Space Industry Policy: Past Experience and Present Perspectives (Graziola, 2013)

Italian space industry and policy have passed by now half century of life and their interplay has significantly changed since their beginnings. For an industry characterized by an intense rate of technical and organizational innovation and a related high potential of technological spillovers, and in which competition is often hard among relatively few firms and centered on product innovation in a highly segmented space market, there is clearly a role for an industrial policy, in furthering its efficiency. This should be of course coordinated with the policy for the public demand of space services: science, defence and security, global public goods. In Part 1 we look at the evolution of the relationship between industry and policy in Italy since the birth of its space industry in the early 1960's. For this purpose we shall describe the main trends in space policy, the fundamental demand driver, and in the industrial structure. We shall find that this relationship has been, especially in the 1960's and 1970's, one of interplaying rather than one of one-way from policy to industry trends. In so doing we shall also have a preliminary look at how that interplaying has influenced the growth of Italian space industry (ISPI). In Part 2, focusing on the latest years for which consistent series of data are available from different sources, we will attempt to examine the influence of public policies (demand, R&TD subsidy, integrated financing, cluster support and other innovative tools) on the Italian space sector and its trends, in terms of turnover, employment, productivity. We shall do so both in general as well as separately for each technical subsector (Launchers, Downstream, Manned Spaceflight, etc.), also describing the possible developments according to ASI's Strategic Vision 2020. We shall finally examine three specific critical and cross-cutting aspects of the Italian space sector that need to be targeted by the public powers in order to ensure maximum efficiency of public expenditure and a long lasting development: the weight of public demand on turnover, the insufficient development of the Downstream subsector, the underexploited role of SMEs. All data on Italy will be compared with the corresponding European averages (and in some cases with single countries') from qualified sources (ESA, Eurospace) pointing out, and if possible making up, differences in metrics, in order to offer a permanent set of indexes for the yearly monitoring of all of the said general and specific trends and aspects.

Space Policies Towards SMEs Implemented By The Italian Space Agency (ASI) - Industrial Associations Cooperation Initiative To Encourage Innovative Space Applications And Services In Italy (Piperno et al., 2011)

This paper offers a contribution of how space industry applications and services are encouraged in Italy. The Italian Space Agency (ASI) has been implementing a specific policy mainly focused on space SMEs that are a strategic portion of space industry in Italy, able to fulfill very well the requirements of the demand of innovative applications and services, both institutional and

private. For this reason ASI is engaged in a three-year cooperation agreement with the national Space Industry Associations (namely AIAD, AIPAS and ASAS), with the aim of promoting an effective industrial policy for the development and growth of Italian SMEs. The framework of reference of this cooperation agreement is wide and ranges from the periodical issue of thematic ITTs (according to a co-funding pattern) specifically reserved to SMEs to a detailed analysis of the population of space SMEs in Italy: competences, geographical distribution, organization in clusters (namely Space Technology Districts, an evolution of the more traditional experience of Industrial Districts), international cooperation, etc. This paper analyzes the effects of these policies on the involved space SMEs at the end of the first year of the cooperation agreement (February 2011), mainly through the identification of quantitative and qualitative indicators of growth and market development (new and already existing markets both public and private) of space services and applications: pre-competitive prototype technologies/products/services development, ex-post analysis of the economic sustainability and permanence of these markets, industrial competitiveness at the international level (both at the ESA/EU and extra-European countries level). This ASI-Associations platform is strongly engaged also in the involvement of the Large System Integrators community, the Italian Government (specifically the Presidenza del Consiglio) and the local communities (Technology Districts, Regions and Municipalities) in order to create a coherent national system aiming to support the growth and development of Italian Space SMEs.

The Role of “Integrated” Financing in the Development of Italy’s Space Sector (Sciortino, 2010)

Italy’s space sector is third in the UE and therefore remarkable, also for the side-effect that it can have on the national productive system, struggling to expand high technologies. According to ASI’s index, turnover in 2007 was well over 1000M€ with 4000 workers, a highest concentration and an extreme preponderance of large enterprises. SMEs’ share was 57M€ with 551 employees. On the other hand there is a highest R&D intensity, both in terms of enterprises’ investment and the turnover itself, which is influenced strongly by public spending on R&D contracts. Thanks to this, Italy possesses a wide array of competencies.

Public budget restraints threaten the space sector in its capacity to keep the pace. That’s why the “Integrated” financing approach becomes important. It means aggregating outside resources (also in kind) from partners on cooperative projects. This practice is valuable, apart from its economic purpose, for its “multi-stakeholder” procedure, ensuring better control and project outcome. There are no restrictions as to subjects that can interface the Agency, even if public entities largely prevail. Only, these projects have to be tracked into a web “pipeline”.

The type of negotiable resource is variable: direct financing, parallel financing, third parties’ equity in purpose companies (as well as corresponding debt finance within PPP schemes). Dating from 2000, the yearly average of “integration” is 30M€. Just to mention, provisional data on 2009 concern two initiatives: 31M€ in equity obtained from a business partner into the Cosmo SkyMed data company E-Geos and 2M€ obtained from the EU as leader of a Mediterranean Sea Surveillance System.

These figures are increasing, also related to the rising demand of technologies and services from space for terrestrial applications: for example satellite images for environmental protection, agronomy, geology, pollution detection, archaeology, tourism, satellite positioning for sea, land and air transportation. There is in fact an interest from the 21 Italian “Regioni” and their powers to develop their own productive competencies – the so-called “Distretti” (made up mainly by SMEs). The “Regioni” see co-financing an opportunity to strengthen the texture of their SMEs in a hi-tech. An evidence of ASI’s respective good intentions is a long list of Agreements signed with the Regioni, and the allocation of 20M€ to cover 4 R&D tenders reserved to SMEs (the first two have already been let) in 2010, implying a contribution from the bidder on a 50/50 basis, that is an expected “integrated” financing of 20M€.

Europe: Spain

Spaceport Barcelona – A Public Private Partnership to Create the First Commercial Suborbital Spaceport in Europe (C. J. Lauer et al., 2013)

As suborbital spaceplanes move through the engineering process and get closer to flight testing and commercial flight operations, more and more locations in the US and around the world are investigating the feasibility of hosting suborbital spaceflight operations at existing airports. The driver for this effort is clear and easy to understand – to capture a share of a new technology market and high-end tourism revenue for local economic growth. Secondary drivers include support of space based research activities, small satellite development, and for education and STEM curriculum promotion and outreach. The proposed Spaceport Barcelona flight operations location is the new Lleida Alguaire Airport which is located about an hour from central Barcelona and easily accessible by the Renfe AVE high speed trains on the Barcelona – Madrid main line. The airport was developed by the Catalonia government as an economic stimulus project for the Lleida region and opened in spring 2010 at a total project cost of 130 million euros. The original business model was to attract low cost air carriers and operate as a second commercial airport for the Barcelona region. However, the main Barcelona Airport still has ample unused gates and operating capacity and to date Lleida Alguaire Airport only has a few charter flight operations per week and some seasonal private aircraft landings during ski season in the Pyrenees. The Catalonia Airport Authority operates this airport, and is not able to even cover operating costs based on current air traffic. The concept of adding a dual-use spaceport operations overlay use to this airport has been embraced as a way to provide an economic return on the Catalonia taxpayer investment. The Lleida location also benefits from its location in a less populated agricultural area, a superb flying weather climate, and can also take advantage of the Zaragoza restricted military airspace for the supersonic and rocket powered segments of the suborbital flight profile. This paper will describe the current work by a public-private partnership team consisting of several suborbital vehicle operators; local entrepreneurs; the Catalonia regional government and the Spanish federal government to create a commercial suborbital spaceport using the US FAA/AST regulatory model and to position Barcelona as a premier commercial spaceflight hub for the European market.

Israel

New Israeli Civil Space Policy to Boost R&D and Commercial Space Industrial Base (Tepper, 2013)

Israel's space industry emerged of defense necessity, having its first launch in 1988. State budget was always low and mostly defense related, lately US\$ 76M of which only 3 for the civil program administered by the Israeli Space Agency (ISA). The US\$ 3M was highly leveraged as 80% of the investment in space related R&D in Israel so far came from foreign governments interested in cooperation and joint projects, resulting in agreements with over 10 space agencies. Despite low budgets, achievements so far are remarkable: Israel was ranked #1 in terms of publication per capita on aerospace engineering and has demonstrated capabilities and products in space infrastructure, products and services, with leading optical equipment and small satellites. Space industrial base includes around 20 corporations employing 2,000-2500 workers driving annual sales of US\$ 800M, world's eighth largest.

Following a series of studies on the impact of the space industry on the Israeli economy, Israel adopted a new Civil Space Policy, increasing civil budgets eightfold to a yearly US\$ 24M. The goal is ambitious – with the new cash injection, and capitalizing on its lucrative defense, communications and IT industries as a solid base, Israel plans on boosting its civil space industry, placing it amongst the top 5 leading nations in space, with yearly sales of US\$ 6-10 billion, representing 3-5% of the global space market. Success will make the space industry a driving force for economic growth. The lion's share of the budget will be allocated to international cooperation and projects. The two other major allocations are to industrial R&D and basic research.

A key element launched by a Directive promulgated in December 2012 is a targeted program by which state financial support will be provided to innovative commercial space R&D, considering mainly the novelty and uniqueness of the product / technology; their expected achievements and capacity to enhance and upgrade satellites' utility and performance; and their market. Support will amount to 50-85% of the project's budget, not exceeding US\$ 5.3M, unless for ground-breaking projects. Considering past achievements with small budgets, this is a significant stimulus. Successful projects will pay the state royalties as percentage from future income (3-6%), if such is generated, until full repayment of the grant, thus having the state bearing most of the project's risk.

Japan

Spaceports for Space Tourism in Japan - The Nearest Place from Space Which Contributes To Economic Activities (Onuki et al., 2009)

The US has been creating commercial spaceports for almost ten years now and the number of licensed spaceports continues to grow. Now there is a new trend for spaceport development all over the world in such locations as Sweden, Spain, Dubai, Singapore, Curacao and so on.

Recently this trend has also come to Japan including locations in Hokkaido, the northern island, and Kanto, the middle of the main island. These proposed developments fill a market need to match demand for spaceflight with the views from space of familiar places close to home and birthplace. This paper will review the global trends in new spaceport development and consider the processes needed to realize commercial spaceport development and commercial human spaceflight in Japan including the issues of licensing and regulatory matters which need to be dealt with.

User Community Development for Suborbital Space Flight Opportunities in Japan (Onuki, 2012b)

The general public is interested in suborbital vehicles because they will take us up to space at an affordable cost. In addition to space tourism, suborbital vehicles are also affordable for on-board utilizations such as microgravity experiments, engineering test and qualifications, ignerosphere science and observation, etc. The first suborbital users panel was held at the largest domestic space symposium in Japan in December, 2011. This was the first step to build up the suborbital users community in Japan. Suborbital flight opportunities will be helpful to make the best use of ISS as precursor missions. Suborbital space flight is the new platform which will open space opportunities with frequency, reasonable cost, easy access, late access, on board operation and so on. This paper will review the current status of the microgravity user community in Japan and other Asian markets, and provide a regional market perspective and a roadmap for international collaboration in suborbital flight research opportunities.

Nigeria

The Nigerian Space Programme and Its Economic Development Model (James et al., 2011)

The Nigerian space programme is managed by the National Space Research and Development Agency (NASRDA). The space policy was approved in May, 2000. The mandate of the Agency as encapsulated in the policy is to vigorously pursue the attainment of space capabilities as an essential tool for the socio-economic development of the nation and the enhancement of the quality of life of Nigerians. For a space programme to be sustainable in emerging space-faring countries, there is need to develop and implement a space economic development model. This study examines the Nigerian space programme and its economic development model. Findings from this study indicate that the space economic model adopted in Nigeria is the public-private-partnership model that involves the short, medium and long term plans. Within the short term plan, the Government is responsible for all investments in space technology development. In the medium term, the Government implements the partial commercialisation of NASRDA's products and services developed during the short term economic development plan. In the long term plan, the Government partners with the private sector to implement the public-private-partnership framework for the space programme. Consequently, within the short term economic development plan, six research Centres and two companies were established. The research Centres include Centre for Remote Sensing, Jos; Centre for Satellite Technology Development,

Abuja; Centre for Geodesy and Geodynamics, Toro; Centre for Space Transport and Propulsion, Epe; Centre for Basic Space Science and Astronomy, Nsukka; and Centre for Space Science and Technology Education, Ile-Ife. The two companies are: the Nigeria Communication Satellite (NigComSat) Limited and the GeoApps Plus Limited (previously called Nigeriasat Imageries and Consultancy Services Limited). NigComSat Limited was set up in April, 2006 to market products from the Nigerian communication satellites. Similarly, GeoApps Plus Limited was established in September, 2007 to market products from the Nigerian Earth observation satellites. It suffices to say that NASRDA is currently implementing its medium term economic development agenda.

South Africa

South Africa Space Industry Indicators and Analysis (Guthrie et al., 2011)

This paper summarizes the results of a study conducted with the cooperation of the Foundation for Space Development South Africa to define and characterize the space industry in South Africa. Unique access to the industry through the Foundation, in combination with research and analysis from The Tauri Group contribute to an authoritative introduction and overview. A version of these results will be distributed to all IAC 2011 conference attendees. The methodology of the study includes exhaustive open source data review, combined with targeted interviews with leaders in the South African space industry. The results will be compiled and presented in both quantitative and qualitative terms. The industry is depicted in terms of:

- Overall South African Economy
- GDP, GNP, overall investment, budget, and natural resources
- Major technology sectors
- Employment and labor force data
- South African Space Industry
- Government space budgets
- Commercial space revenues
- Key commercial, civil, and defense policies
- Infrastructure
- Products and services
- Labor force data
- Profiles of major space companies
- Directory of government organizations and personnel with space responsibilities

Additional qualitative sections will summarize particular areas of innovation and interest in the South African space economy. Primary among those are development activities like the Square Kilometer Array radio telescope. Profiles of existing and development activities are characterized by budgets, customers and consortium partners, and their competitive space relative to other options.

South Africa's Initiatives to Enhance Growth of the Space Industry for Socio-Economic Development (Makapela & Majaja, 2011)

The government of South Africa encourages involvement of the private actors in space activities through public-private partnerships in order to develop national commercial capabilities. The development and launch of the South African remote sensing micro satellite demonstrated the required cooperation between public and private sector. However, investment in space activities has not been optimally realized as space activities in the past have been disjointed without the mandatory accountability for the development and leadership of a coherent national space programme. According to the National Space Policy, the domestic industry is encouraged to pursue appropriate strategic international industrial partnerships, as one of the means of enhancing industrial competitiveness. A number of government initiatives and programmes that are intended to leverage economic benefits and support the development of the South African industry have been established. These include the Aerospace Industry Support Initiative (AISI), National Industrial Participation Programme (NIPP) and Support Programme for Industrial Innovation (SPII). There is a need for a focused approach to streamline these initiatives and utilise them effectively and efficiently. South Africa constitutes a variety of institutions and programmes with diverse space activities, however the industry is very small and there is less documented information about the size and growth of the space sector than other sectors of the economy. This is due to the reasons that the economic data on many components of the space sector are normally combined with related industries such as Aerospace and Defense and the industry is characterized by dual-use products and services. Consequently, even though there has been a research on the space sector, this research does not define space as a separate industry. In order for South Africa to reach its vision in terms of the National Space Strategy, which is to be among the leading nations in the innovative utilisation of space science and technology that enhances economic growth and sustainable development in order to improve the quality of life for all, there is a need for better utilisation of the government initiatives for industry growth. The purpose of this paper is to analyse South Africa's Space activities and how they impact on economic growth and development. The paper will also analyse the government's initiatives in support of the industry and how these initiatives could be utilised effectively in order to enhance innovation and technology towards knowledge economy.

United States

The following discussion of relevant social factors that may influence the emergence of a US HOM industry is broken into categories that reflect these four relationships. It is interesting to remember that events that took place centuries ago can still have some level of influence on present day perceptions and actions.

Opportunity to Enterprise

Significant US government policies and procedures that affect the opportunity to enterprise were rooted in the writing of the US Constitution in 1789 and have undergone many variations and

cycles in the country's 240 year history. Major contributing policies in commerce, private property and contracting, patent protection, business incorporation, antitrust posture, and land ownership are briefly listed below.

Commerce, Private Property and Contract Policies

From the outset, Article 1 of the US Constitution set the foundation for binding contracts, the explicit protection of property rights and encouraged interstate commerce by prohibiting restrictions on such trade.

Commerce was further protected with passage of the 1887 Interstate Commerce Act ensuring fair railroad transportation rates.

Patent Protection Policies

Authors and inventors were given exclusive rights to their creations by Article II, Section 8 of the US Constitution. In 1790, Congress passed the first patent law. A system of invention examination was established in 1836 to assist potential investors to evaluate increasingly complex inventions. Domestic trademark legislation was passed in 1905. All these policies began "closing" the innovation system.

Business Incorporation and Antitrust Policies

Prior to the early 1800s, only businesses that served a special purpose benefiting the state needed to be incorporated, requiring that each state legislature grant incorporation on a company-by-company basis. The first law allowing general incorporation was passed in the state of New York by 1811, but such a law was not common nation-wide until the 1870s.

Business incorporation was a mechanism that permitted companies to transact with the government and held an assumption of monopoly status for the business until a ruling of the Supreme Court in 1836 denied that long-held implication.

Unsuccessful attempts at the formation of cartels after 1860 in the railroad and other industries led to the passage of the Sherman Antitrust Act in 1890. Antitrust legislation and policy was reinforced with passage of the Clayton Antitrust and Federal Trade Commission Acts in 1914, although it was not always systematically enforced. In the 1930s this changed and, although it was eased during the Second World War, antitrust legislation was emphasized until the 1970s.

Globally, not just in the US, major changes to the patent system were implemented during the Uruguay Round of the General Agreements on Tariffs and Trade in the 1980s. This led to expanded patent duration and scope and provided renewed stimulus for patent "trolls" that further closed the innovation system (Mirowski, 2011).

Land Ownership Policies

Even before passage of the Constitution in 1789, Land Ordinances of 1785 and 1787 defined the details of land ownership, setting the foundation for entrepreneurship (i.e., the control of productive resources). Further land development and improvement was promoted by creation of

the Department of Agriculture and passage of the Homestead Act in 1862. The latter gave settlers ownership of 160 acres of public land on condition that they live there for a minimum of five years.

Over the next five decades (between 1870 and 1920), over 50 million acres of public land were claimed by farmers who settled on their land instead of in adjoining villages. This relative seclusion and ownership of the land provided increased opportunity to innovate as farmers' families had to have their own workshops for mechanical repairs and labor-saving inventions.

Similarly, the US Geological Survey was established in 1879 and explicitly bestowed ownership upon discovery and working of ore deposits found on public land.

Propensity to Enterprise

Social and economic conditions have a major influence on the likelihood that entrepreneurship will occur. This section briefly describes the evolution of two socioeconomic factors that affect entrepreneurial propensity: economy structure and social stature of entrepreneurs.

Structure of the Economy

The structure of the national economy can be an important factor in the likelihood for a society to be entrepreneurial.

In America's first century of business history, industries predominantly consisted of few, evenly matched, highly competitive firms. This changed drastically over the past two centuries as multiple merger movements occurred, the first taking place in the 1895-1904 timeframe, most notably in the petroleum, cordage, whiskey, lead, sugar, linseed, and cottonseed oil industries. This movement resulted in markets that were more organized. It was during this merger movement that small-firm trademarks were jeopardized by the dominant firms that emerged, thereby prompting passage of the 1905 domestic trademark legislation mentioned in the section on Patent Protection above.

A second merger movement occurred in the 1920s and resulted in a need for companies to compete on the basis of scope (by differentiating their existing product lines) or innovation (by creating new products) since competition on the basis of increasing scale and price was no longer feasible .

Organizational structure of the firm underwent a fundamental change during the decades of the 1940s through the 1970s, referred to as the "Golden Age of the Chandlerian Firm" (Mirowski, 2011). During this time, the multi-divisional, or M-form organizational structure was widely adopted that had negative effects on a company's ability to innovate.

During this "Golden Age" a third major conglomerate movement occurred in the 1960s-1980s that further impeded the large corporation's ability to innovate by further bureaucratizing the entrepreneurial processes, in part with the addition of influential, risk intolerant, investment bankers to the companies' board of directors .

The 1970s-1990s saw a reduction in the US productivity growth rates as the service economy emerged and the manufacturing economy was lost to international competition on the basis of price, quality, and performance, most notably in the automobile, electronics, and consumer electronics industry.

Social Stature of Entrepreneurship

Societal perceptions of the entrepreneur play a major role in determining the propensity to innovate and have changed over time.

From the outset, the land that was to become the United States was settled by individuals who were entrepreneurs (Gartner, 2008), highly enterprising, willing to take risks, leave their extended families and homelands, for the uncertain promise of colonizing an untamed frontier. Descendants of these colonists possessed similar characteristics and encoded this philosophy into the Constitution in 1789.

Colonial enterprise was high and is personified by individuals such as George Washington and Benjamin Franklin. Individual entrepreneurs were held in high esteem throughout the nineteenth century.

By the time of the 1900s and through to the 1950s, individual entrepreneurs were associated with eccentric individuals and their social status diminished. This was, in part, due to adoption of “the Scientific Method” of management and the rise of corporate research activity described later in the Ability to Enterprise section.

From the 1950s-1970s, corporate research and innovation was encouraged by government funding driven primarily by military needs. During this period, for reasons described more fully in the “Research & Development” section below, individual entrepreneurs were held in suspicion.

Starting in the 1980s, the social perception of individual entrepreneurs began to improve, driven by a growing mistrust of big business’ use of technology beginning with the 1960s consumer rebellion demanding greater ecological and product safety regulation.

Ability to Enterprise

The ability to enterprise is influenced by and directly related to entrepreneurial and business skills. The many successful industries that emerged and thrived in the US are a testament to these skills. In this context, this section outlines the evolution of multiple major US industries and concludes with a description of US R&D activity through multiple open and closed innovation cycles.

Transportation Industries

Transportation industries in the US have consisted of roads (c. 1800s-1830s), steamboats (c. 1815-1860s), canals (c. 1815-1860s), railroads (c. 18130s to the present), automobiles (c. 1890s

to the present), and aircraft (c. 1900s to the present). The latter two were high-growth industries in the twentieth century, rooted in technology, and primarily fostered to meet military needs.

Communications Industry

The 1792 Post Office Act was passed to stimulate postal service use by providing subsidies. Within the next five decades, between 1790-1840, the number of business press firms grew by a factor of 140. The telegraph industry also grew substantially between the c. 1830s-1860s.

Manufacturing Industries

In addition to the invention of the cotton gin in the late 1790s, an active US industrial policy called “the American System,” helped develop the cotton textile industry through the 1830s. Established by Alexander Hamilton with his report on manufacturing to Congress in 1792, and characterized by interchangeable parts, standardization, and the division of labor, this system quickly spread to other industries: the small arms industry grew with the incorporation of interchangeable parts from the 1800s until the 1840s, inanimate sources of power were adopted widely between the 1850s and 1880s, and the sewing machine industry evolved between 1850 and 1900.

Agriculture Industries

In the agriculture industry, innovation evolved in the 1800s through the 1830s starting with the Newbold iron plow and ending with the Deere steel plow. Reaper development emerged between the 1830s and 1860s.

In addition to the Homestead Act mentioned above, the 1862 Morrill (Land Grant College) Act and 1887 Hatch Act led to increased rates of agricultural innovation and diffusion, especially with passage of the 1914 Smith-Lever Act that established the agricultural extension service.

Electrification/Motorized Appliances and Consumer Electronics

As with automobiles and aircraft, the electrification and consumer electronics industries were based in high-technology and experienced high growth rates as a result of wartime interests in the early 1900s. The iconic example within this industry is the evolution of the radio industry, starting with the government takeover before World War I and continuing with the formation of the Radio Corporation of America as a patent-pool administrator.

Research & Development

Each of the industries mentioned above developed and demonstrated the ability to enterprise. Innovation was the essential act of entrepreneurship (Schumpeter, 1939) and, in the early twentieth century, science-based innovation was the focus of both individual and corporate entrepreneurs.

During the second half of the nineteenth century, innovation was “open” and conducted primarily in small labs, mills, and studios by eclectic groups of technical staffs encompassing many disciplines. Leading up to World War I, the primary industry challenges were in the areas of uniform, food, munitions and vehicle manufacturing.

After the second industrial revolution (c. 1880-1900) a wave of mergers led to passage of antitrust legislation. To insulate themselves from suspicion of collusion, corporations pursued intrapreneurship efforts, becoming more secretive, and effectively “closing” the innovation system. Following the emerging scientific management trends at the time (Stewart, 2009), in-house R&D projected “science-based efficiency.” By the mid-1930s, and encouraged by government funding and increased antitrust enforcement, R&D became increasingly institutionalized, and increasingly “closed.”

A major milestone that drove the closure of innovation was the 1947 Procurement Act that codified “cost plus” government contracts. The major emphasis during this time was to optimize production of existing manufacturing facilities by innovating on process rather than on product (as during the World War I era). This type of contract provided large amounts of funding for technology-based and university entrepreneurs, drastically limiting the financial risk associated with innovation, and was a mediator toward corporate in-house R&D. High-growth industries of this time were information appliances (i.e., “calculators”).

The mid-forties was characterized as an era of “Big Science” where “dual-use” or “crossover” technologies and infrastructures were justified, at least in part, as meeting military requirements. Although there was a trend of decreasing government spending on research into the late 1950s, this trend was reversed with the Soviet launch of Sputnik in 1957.

A renewed reduction of government R&D funding began in the late 1960s and is continuing to the present day.

Despite the long-term trend toward a closed innovation system prompted by the increased antitrust enforcement between the 1930s and 1970s, notable counterexamples to this trend did exist, including Texas Instruments and the Xerox Palo Alto Research Center in the 1970s.

Legislative actions were taken in 1980 (Bayh-Dole Act, providing intellectual property rights to universities performing research with government funding) and 1984 (Bayh-Dole Act aimed at private companies) that began “opening” the US innovation system again. The open system is less controlled and drove a change from hierarchical to network organizations and emphasizes the importance of human and social capital.

New Venture Creation

New venture creation is influenced by and directly related to the likelihood to enterprise (influenced by the three factors described in detail above), plus two additional factors of assistance: financial, and non-financial. Below are brief descriptions of both forms of assistance for the US.

World-Class Financial System

The first US Secretary of the Treasury from 1789-95, Alexander Hamilton started a “financial revolution” in the US with the establishment of the following five market institutions:

- Stable public finance and debt management

- Stable money
- Functioning bank system
- Effective central bank
- Active securities markets
- Level of Government Regulation

Classical economics perceives governmental regulation as a barrier that firms must overcome. The level of US government regulation has varied over time as briefly described below. When the regulatory levels are lower, this could be interpreted as a form of non-financial assistance that enables new venture creation.

From 1780 to 1890, most federal, state, and local government regulations were moderate at best. Because firms became too strong economically by 1890, the states had given up their role as regulator. Over the next three decades, known as the “Progressive Era,” businesses began growing in size and the federal government instituted an increasing amount of social and regulatory policies against “antisocial aspects of greed,” including passage in 1906 of the Food and Drug Act, and the Meat Inspection Act.

During President Roosevelt’s “Second New Deal,” 1935-36, the antitrust laws already on the books were enforced with renewed vigor, and new regulations were added.

Later, in the 1960s, government increased regulations in some areas (environmental and product safety) but decreased regulations in other areas (airlines, communications, and utilities). The deregulated industries attracted investment from venture capitalists (VCs).

Venture Capitalism

Financial assistance from the government has been mentioned multiple times above, but here, the history of non-government financing is summarized.

Prior to the 1940s, start-up funding for firms was predominantly made available by private banks and wealthy individuals. Creation of Small Business Investment Companies (SBICs) by passage of the 1958 Small Business Act provided long-term loans for growth-oriented firms.

By the 1960s, VCs were attracted by the industry deregulation of the time. In the 1970s, former SBIC employees formed VC firms and provided the additional benefit to the funding recipients of business expertise.

With passage of the Revenue Act of 1978 that increased the capital gains tax exclusion and the 1979 Employee Retirement Income Security Act, a statute that permitted a greater percentage of higher risk investment in pension funds, VCs began maturing from an institution to an industry. As the industry matured by the 1990s, the risk tolerance of VCs began to diminish.

Summary of Relevant Social Factors

This section demonstrates a large variety of supporting policies, industries, legislation, and other developments that support a strong sense of enterprise woven into the social fabric of the US.

Despite the fact that popular sentiment and governmental policies have oscillated over time, the likelihood of enterprise and new venture creation in the US is high because the nation’s fundamental character and governing philosophy were supportive of commerce and enterprise from the outset.

Phase 4. National HOM Industry Competitiveness Assessment

The objective of this analysis phase is to assess the overall industrial capability of each country or region. As shown in the table below, the following reports and studies were identified that pertained to this analysis phase for specific countries. Not all reports and analyses followed the preferred methodology of the industrial “diamond” (Porter, 1990).

Table 4. IAA HOM Study Phase 4 Supporting Analyses

Country	Phase 4 – Industry Structure
Australia	(Vaccaro et al., 2011)
China	(Z. Dong & Zhifu, 2011)
Europe	(Bernede, 2013; de Hauteclocque, 2012; Hemsell, Aprea, Gallagher, & Sadlier, 2014; Lu et al., 2013)
Europe: Benelux	(Prado et al., 2014)
Europe: Germany	(Maier et al., 2014)
Europe: Italy	(Ainardi et al., 2012; Ciccarelli & Pavone, 2013; Graziola, 2013; Piperno et al., 2011; Sciortino, 2010)
Europe: Spain	(C. J. Lauer et al., 2013)
India	(Khan, 2012; Khurana, 2014; Lionnet, Deutscher, & Perrier, 2010; Murthi & Rao, 2014)
Israel	(Tepper, 2013)
Japan	(Onuki et al., 2009)
Nigeria	(James et al., 2011)
South Africa	(Guthrie et al., 2011; Makapela & Majaja, 2011)
United States	(Autry et al., 2013; Davidian & Autry, 2014)

Australia

Benchmarking Australia as a User of Space Products and Services (Vaccaro et al., 2011)

Following a period of dormancy, Australia has begun to revisit its national space policy. A major theme of this renewed focus is maximizing the benefits of space utilization for the Australian government, armed forces, commercial industry, educational institutions, and society as a whole.

As it considers space policy decisions, the Government of Australia has recently completed a benchmarking study to evaluate its current usage of space resources along three lines: development, sophistication, and efficacy. The study examined the state of Australian space usage, including asset-to-user applications flows, for five application areas:

- Earth Observation and Resource Management
- Natural Disaster Management

- Global Positioning System (GPS) Navigation
- Satellite Communications
- Weather and Meteorology

To benchmark Australia in these five application areas, the study compared and contrasted Australian space usage with that of seven other peer (or near-peer) nations, selected due to similar economic, regional, or science and technology attributes:

- Canada
- India
- Indonesia
- Malaysia
- Singapore
- South Africa
- Thailand

Using a combination of quantitative and qualitative indicators, this study ranked Australia relative to these other nations as a user of space products and services. This helped pinpoint Australian strengths and weaknesses in space utilization.

The lessons derived from this study suggested where Australia can improve its development, sophistication, and efficacy as a user of space products and services, and will assist in informing Australian policy choices as it shapes its national space strategy.

China

Development of Commercial Space in China: From an Industry Perspective (Z. Dong & Zhifu, 2011)

Commercial space enterprises' participation in the development of system-level space products will facilitate technical development of space industry, which is essential to a quantum leap forward in China's space development. In recent years, China's defense industry is facing transition from planned economy to market economy and the government has issued a series of policies to encourage commercial enterprises' participation in defense industry construction. However, the existing commercial space enterprises can only serve as small element or component level space product providers. Based on the study of these policies, the basic requirements for a private enterprise to become a system-level contractor in China's space industry are proposed. By comparison of a successful case in the U.S. and the status of Chinese private space enterprises, the principal difficulties for commercial space development in China are analyzed. To address these problems, some pieces of advice from the industry perspective are given.

Europe

Entrepreneurship and Innovation in the European Space Sector: Overview and Impacts of European Space Agency and European Union's Initiatives (Bernede, 2013)

Undertaking long term space programmes require strategic non-dependence in cutting-edge and critical technologies as well as affordable mission and procurement costs for the customer. This requires innovation and competitiveness among the stakeholders of the space industry.

The academic and professional literature assesses that the implementation of sustainable space strategies and ambitious space programmes' needs, on one hand, an integrated industry able to support important risks and, on the other hand, smaller entities such as Small and Medium Enterprises (SME), perceived as having structurally a higher faculty to adapt.

Following this statement, space-faring nations adopt policies to support their industry in order to develop and foster key space capabilities. To ensure growth and sustainable innovation in the European space sector, the European Space Agency (ESA) and the European Union (EU) have elaborated policy measures dedicated to the space industry and service providers. Additionally, these programmes often pay special attention to facilitate new business opportunities for SME by sharing risks and investments, encouraging them to take part in research and development or services activities.

This paper aims to analyse the current framework programmes implemented in Europe to foster the capabilities of the space industry. On one side, the ESA addresses R&D as well as spin-in and spin-off activities, among others through the General Support Technology Programme (GSTP), the Business Incubation Centres (BIC), the Technology Transfer Programme (TTP) and the Integrated Applications Programme (IAP), addressing both the industrial and the service segments. On the other side, the analysis presents the EU initiatives which contribute to this dynamic in its own way, through the Framework Programmes FP6, FP7 and Horizon 2020. In the study, similarities and differences between ESA and EU approaches to support the industry, and especially the small entities, are analysed.

Looking at the conceptual approaches behind these framework programmes and at their implementation, the paper will extract opportunities as well as potential paradoxes for the space sector. From this perspective, this study will look at two parallel tendencies in the space industry supported by the public sector: the strong vertical integration and the support to develop SMEs. The study, based on selected literature, interviews, analysis of policies and financial documents will expose the current challenges to foster entrepreneurship as well as maintain a strong space industry in Europe and the key role played by small entities in this context.

Prevision and Prospective To Forecast in the Space Economy - Application to the European Space Sector (de Hauteclocque, 2012)

The value of investing in space depends largely on our vision of the space sector future. So the space economy needs instruments to provide private and public actors with forecast information

on the short term and long term horizon. This paper, based on a PhD research in space economics, presents a methodology and its application to the European space sector for both short term (prevision) and long term (prospective) evaluation of the future.

For the Prevision, we design a typical chain model of the space sector “From budget to employment”. This model is transformed in a system of time series equations. The parameters of this multiple equations system are computed through econometric recent algorithms implemented in EVIEWS software commands. Using Eurospace data, we generate a forecast until 2015.

Prospective, long-term oriented and complementing the prevision, does not produce predictions but seeks to envisage the possible futures. To do so we use a three phases methodology based on advanced works in prospective: 1- Construction of the analytic base (research of key variables of the system through structural analysis), 2 - Scanning the scope of possibilities with morphological analysis, 3- Generation of final scenarios.

Applied to the European space economy for 2030-2040, three classical synthesis scenarios emerge: grey (pessimistic), blue (trendy) and pink (optimistic).

In conclusion we promote the necessity to rationalize the “uncertainty of the future”, thus avoiding the temptation of 'science fiction' in predicting space perspectives.

A Business Analysis of a SKYLON Based European Launch Service Operator (Hempsell et al., 2014)

Between 2012 and 2014 an industrial consortium led by Reaction Engines conducted a feasibility study for the European Space Agency with the objective to explore the feasibility of SKYLON as the basis for a launcher that meets the requirements established for the Next Generation European Launcher. SKYLON is a fully reusable single stage to orbit launch system that is enabled by the unique performance characteristic of the Synergetic Air-Breathing Rocket Engine and is under active development. The purpose of the study which was called “SKYLON based European Launch Service Operator (S-ELSO)” was to support ESA decision making on launch service strategy by exploring the potential implications of this new launch system on future European launch capability and the European industry that supports it. The study explored both a SKYLON operator (S-ELSO) and SKYLON manufacturer as separate business ventures. In keeping with previous studies, the only strategy that was found that kept the purchase price of the SKYLON low enough for a viable operator business was to follow an “airline” business model where the manufacturer sells SKYLONS to other operators in addition to S-ELSO. With the assumptions made in the study it was found that the SKYLON Manufacturer with a total production run of between 30 and 100 SKYLONS could expect an Internal Rate of Return of around 10%. This was judged too low for all the funding to come from commercial funding sources, but is sufficiently high for a Public Private Partnership. The S-ELSO business model showed that the Internal Rate of Return would be high enough to consider operating without public support (i.e. commercial in operation, irrespective of any public funding of development),

even when the average launch price is lowered to match the lowest currently quoted price for expendable systems.

Identification and Analysis of National and Regional Industry Clusters of the European Space Industry (Lu et al., 2013)

Industry models play a central role in understanding industries and processes on a macroeconomic scale and are indispensable as a support for politico-economic as well as corporate strategic decisions. A model particularly suited for the analysis of competitiveness and the development of regional and national industrial strengths and advantages is the one described in the book *Competitive Advantage of Nations* by Michael E. Porter, depicted in a “diamond” of interconnected factors. The space industry clearly reflects several of the elements described by Porter, among them: a tendency towards geographically concentrated industry clusters, caused by a strong dependence on high-quality suppliers, strong dependence on a skilled labor force and the necessity of exchange with research institutions. Large portions of the space industry are highly influenced by governments, be it through governmental/intergovernmental institutions acting as customers, through national research strategies or through governmental influence on factor conditions. Especially in Europe, this influence is scattered out to a number of institutions, including national and regional governments, the European Commission and the European Space Agency. Since their policies are a main influence and potential driver for the space industry and economic growth in this sector, it is especially important to take politico-economic and strategic decisions on the right basis. The first step in Porter's analysis of the national/regional diamond is the identification and description of national/regional clusters of different industry subgroups. While other researchers focus on cluster identification in the United States of America, this paper will conduct an identification of clusters for the European space industry. Beyond the identification, it will analyze details concerning the nature of the clusters and especially the role of political strategies and environments in shaping them.

Europe: Benelux

The Structure of the European Space Industry – Current and Historical Analysis of Industry Clusters in the Benelux (Prado et al., 2014)

A comprehensive understanding of a particular industry is imperative as a basis for policy decisions to foster this industry or a segment of it. In this sense, the Space Generation Advisory Council's Commercial Space Project Group strives to support the International Academy of Astronautics' study group on “Public/Private Human Access to Space” by providing a description and analysis of the European space industry. As a precursor to this paper, the main industry clusters in the European space industry have been identified along with their basic characteristics. This paper builds on that analysis by describing the space industry clusters in Belgium, the Netherlands and Luxembourg (Benelux) in more detail and examining their individual constitution in tandem with other external influences, e.g. academic research institutions and military and government bodies. Special emphasis is placed on reviewing the

historical development of each cluster in the context of its current state (culturally, structurally, politically and economically). As this work is conducted in collaboration with other researchers who are focused on other European countries, the end goal of this research is to obtain a comprehensive picture of industry clusters all over Europe. This will help build an overall understanding of the European space industry and the roles individual nations play in it. Moving forward, a good understanding of how the European Space Industry has formed will give new insight into possible growth opportunities, e.g. strengths and advantages. This particular work will use Porter's analysis method described in his book "Competitive Advantage of Nations" to present a more detailed description of the active players within the Benelux space sector. Porter's model represents the influencing factors on industry in a diamond to illustrate the relationship between them and the resulting influence on industry competitiveness. Additionally, this paper will take into account socio-political factors set up by governments and policy makers, examining their role in the industry's past and continued development.

Europe: Germany

The Structure of the European Space Industry – Current and Historical Analysis of Industry Clusters in Germany (Maier et al., 2014)

In late 2012, after observing new developments in the private space sector, the Space Generation Advisory Council (SGAC) established a project group to gather inputs and to conduct research into commercial space activities. In this capacity, the group is currently supporting a study group of the International Academy of Astronautics (IAA) on "Public/Private Human Access to Space" that aims to assess the viability potential of human orbital commercial space markets. For the long-term politico-economic decisions the study group intends to support, a solid knowledge of industrial and macroeconomic structures is necessary. This proper understanding of industries and their structure relies not on the consideration of a single influence or driver, but on a comprehensive examination of cultural, structural, political, economic, and historical drivers and environments that affect industries and their development. In order to fully comprehend the interactions and results of these forces, existing market data must be visualized using industry models. One model particularly suited to provide information on background and development of regional and national industry strengths and advantages - and therefore, the reasons for today's industry structure - is the model developed by Michael E. Porter in his book 'Competitive Advantage of Nations.' As the basis of his analysis, Porter uses industry clusters as highly connected building blocks that can be individually analysed. Accordingly, in a precursor work for this paper, the main industry clusters of the European space industry and their basic characteristics have been identified. This paper builds on that analysis with a detailed description and analysis of the space industry clusters in Germany made by examining their individual makeup, macroeconomic determinants, and other external influences. As previous work on the influences of cultural and historical backgrounds on industry development in Germany has shown, the structure of the space industry in the country depends highly on historical developments due to a strong tie of the German space and aerospace industries to political

institutions. This paper therefore puts a special emphasis on examining the historical development of each cluster and comparing the historically founded forces with the current economic determinants. This work is part of a larger research project at SGAC that focuses on the detailed examination and definition of industrial clusters in relevant European countries. The ultimate goal is to obtain a better understanding of the European space industry as well as the roles individual nations play within it.

Europe: Italy

Space Entrepreneurship in Italy: The Role of Regions (Ainardi et al., 2012)

This article investigates the role of entrepreneurship and SMEs in the Italian space industry. After a first section where entrepreneurship is defined in the different segments of the space sector, the article identifies the different stakeholders in the Italian space entrepreneurship. The Italian space entrepreneurship is analyzed both from a quantitative or financial perspective and from a qualitative one (regulatory aspects, policies, incentives and sources of funding for the space entrepreneurship). A perspective on the trends, evolutions and challenges in the coming decade is provided based, on interviews with key actors in the Italian space entrepreneurship landscape (SMEs, districts, ASI, associations, financial players...)

New Trends in the Italian Space Industrial Landscape: SMEs and Technology Districts As Drivers of Space Economy (Ciccarelli & Pavone, 2013)

This paper provides an overview of the initiatives implemented by the Italian Space Agency (ASI) to support national space industry and specifically SMEs. The industrial context in Italy experienced an evolution process during the last decade, more oriented towards the European context. On the other side, the economic crisis is having a significant impact on the real economy, including a decrease in the budget managed by ASI and devoted also to industrial activities. Besides that, the aerospace sector experienced more recently an increasing role played by the Technology Districts and local administrations (Regions in particular, that are expressing the intention to invest in space activities for the benefit of their territories). In some cases ASI is also investigating the opportunity to make specific agreements with “Spacefaring Regions” in order to share economic resources and create economies of scale through the expertise of ASI, the financial resources of Regions and their capability to valorize the skills, the knowhow and the relationships of specific geographical areas.

The Role of Italian Space Industry Policy: Past Experience and Present Perspectives (Graziola, 2013)

Italian space industry and policy have passed by now half century of life and their interplay has significantly changed since their beginnings. For an industry characterized by an intense rate of technical and organizational innovation and a related high potential of technological spillovers, and in which competition is often hard among relatively few firms and centered on product innovation in a highly segmented space market, there is clearly a role for an industrial policy, in

furthering its efficiency. This should be of course coordinated with the policy for the public demand of space services: science, defence and security, global public goods. In Part 1 we look at the evolution of the relationship between industry and policy in Italy since the birth of its space industry in the early 1960's. For this purpose we shall describe the main trends in space policy, the fundamental demand driver, and in the industrial structure. We shall find that this relationship has been, especially in the 1960's and 1970's, one of interplaying rather than one of one-way from policy to industry trends. In so doing we shall also have a preliminary look at how that interplaying has influenced the growth of Italian space industry (ISPI). In Part 2, focusing on the latest years for which consistent series of data are available from different sources, we will attempt to examine the influence of public policies (demand, R&TD subsidy, integrated financing, cluster support and other innovative tools) on the Italian space sector and its trends, in terms of turnover, employment, productivity. We shall do so both in general as well as separately for each technical subsector (Launchers, Downstream, Manned Spaceflight, etc.), also describing the possible developments according to ASI's Strategic Vision 2020. We shall finally examine three specific critical and cross-cutting aspects of the Italian space sector that need to be targeted by the public powers in order to ensure maximum efficiency of public expenditure and a long lasting development: the weight of public demand on turnover, the insufficient development of the Downstream subsector, the underexploited role of SMEs. All data on Italy will be compared with the corresponding European averages (and in some cases with single countries') from qualified sources (ESA, Eurospace) pointing out, and if possible making up, differences in metrics, in order to offer a permanent set of indexes for the yearly monitoring of all of the said general and specific trends and aspects.

Space Policies Towards SMEs Implemented By The Italian Space Agency (ASI) - Industrial Associations Cooperation Initiative To Encourage Innovative Space Applications And Services In Italy (Piperno et al., 2011)

This paper offers a contribution of how space industry applications and services are encouraged in Italy. The Italian Space Agency (ASI) has been implementing a specific policy mainly focused on space SMEs that are a strategic portion of space industry in Italy, able to fulfill very well the requirements of the demand of innovative applications and services, both institutional and private. For this reason ASI is engaged in a three-year cooperation agreement with the national Space Industry Associations (namely AIAD, AIPAS and ASAS), with the aim of promoting an effective industrial policy for the development and growth of Italian SMEs. The framework of reference of this cooperation agreement is wide and ranges from the periodical issue of thematic ITTs (according to a co-funding pattern) specifically reserved to SMEs to a detailed analysis of the population of space SMEs in Italy: competences, geographical distribution, organization in clusters (namely Space Technology Districts, an evolution of the more traditional experience of Industrial Districts), international cooperation, etc. This paper analyzes the effects of these policies on the involved space SMEs at the end of the first year of the cooperation agreement (February 2011), mainly through the identification of quantitative and qualitative indicators of

growth and market development (new and already existing markets both public and private) of space services and applications: pre-competitive prototype technologies/products/services development, ex-post analysis of the economic sustainability and permanence of these markets, industrial competitiveness at the international level (both at the ESA/EU and extra-European countries level). This ASI-Associations platform is strongly engaged also in the involvement of the Large System Integrators community, the Italian Government (specifically the Presidenza del Consiglio) and the local communities (Technology Districts, Regions and Municipalities) in order to create a coherent national system aiming to support the growth and development of Italian Space SMEs.

The Role of “Integrated” Financing in the Development of Italy’s Space Sector (Sciortino, 2010)

Italy’s space sector is third in the UE and therefore remarkable, also for the side-effect that it can have on the national productive system, struggling to expand high technologies. According to ASI’s index, turnover in 2007 was well over 1000M€ with 4000 workers, a highest concentration and an extreme preponderance of large enterprises. SMEs’ share was 57M€ with 551 employees. On the other hand there is a highest R&D intensity, both in terms of enterprises’ investment and the turnover itself, which is influenced strongly by public spending on R&D contracts. Thanks to this, Italy possesses a wide array of competencies.

Public budget restraints threaten the space sector in its capacity to keep the pace. That’s why the “Integrated” financing approach becomes important. It means aggregating outside resources (also in kind) from partners on cooperative projects. This practice is valuable, apart from its economic purpose, for its “multi-stakeholder” procedure, ensuring better control and project outcome. There are no restrictions as to subjects that can interface the Agency, even if public entities largely prevail. Only, these projects have to be tracked into a web “pipeline”.

The type of negotiable resource is variable: direct financing, parallel financing, third parties’ equity in purpose companies (as well as corresponding debt finance within PPP schemes). Dating from 2000, the yearly average of “integration” is 30M€. Just to mention, provisional data on 2009 concern two initiatives: 31M€ in equity obtained from a business partner into the Cosmo SkyMed data company E-Geos and 2M€ obtained from the EU as leader of a Mediterranean Sea Surveillance System.

These figures are increasing, also related to the rising demand of technologies and services from space for terrestrial applications: for example satellite images for environmental protection, agronomy, geology, pollution detection, archaeology, tourism, satellite positioning for sea, land and air transportation. There is in fact an interest from the 21 Italian “Regioni” and their powers to develop their own productive competencies – the so-called “Distretti” (made up mainly by SMEs). The “Regioni” see co-financing an opportunity to strengthen the texture of their SMEs in a hi-tech. An evidence of ASI’s respective good intentions is a long list of Agreements signed with the Regioni, and the allocation of 20M€ to cover 4 R&D tenders reserved to SMEs (the first

two have already been let) in 2010, implying a contribution from the bidder on a 50/50 basis, that is an expected “integrated” financing of 20M€.

Europe: Spain

Spaceport Barcelona – A Public Private Partnership to Create the First Commercial Suborbital Spaceport in Europe (C. J. Lauer et al., 2013)

As suborbital spaceplanes move through the engineering process and get closer to flight testing and commercial flight operations, more and more locations in the US and around the world are investigating the feasibility of hosting suborbital spaceflight operations at existing airports. The driver for this effort is clear and easy to understand – to capture a share of a new technology market and high-end tourism revenue for local economic growth. Secondary drivers include support of space based research activities, small satellite development, and for education and STEM curriculum promotion and outreach. The proposed Spaceport Barcelona flight operations location is the new Lleida Alguaire Airport which is located about an hour from central Barcelona and easily accessible by the Renfe AVE high speed trains on the Barcelona – Madrid main line. The airport was developed by the Catalonia government as an economic stimulus project for the Lleida region and opened in spring 2010 at a total project cost of 130 million euros. The original business model was to attract low cost air carriers and operate as a second commercial airport for the Barcelona region. However, the main Barcelona Airport still has ample unused gates and operating capacity and to date Lleida Alguaire Airport only has a few charter flight operations per week and some seasonal private aircraft landings during ski season in the Pyrenees. The Catalonia Airport Authority operates this airport, and is not able to even cover operating costs based on current air traffic. The concept of adding a dual-use spaceport operations overlay use to this airport has been embraced as a way to provide an economic return on the Catalonia taxpayer investment. The Lleida location also benefits from its location in a less populated agricultural area, a superb flying weather climate, and can also take advantage of the Zaragoza restricted military airspace for the supersonic and rocket powered segments of the suborbital flight profile. This paper will describe the current work by a public-private partnership team consisting of several suborbital vehicle operators; local entrepreneurs; the Catalonia regional government and the Spanish federal government to create a commercial suborbital spaceport using the US FAA/AST regulatory model and to position Barcelona as a premier commercial spaceflight hub for the European market.

India

Road map to the future of Private Commercial Space Industry in India: Vision for Space Entrepreneurship and Investment (Khan, 2012)

India is an emerging space faring nation with a space program driven by indigenous research and development spanning more than four decades. The National Space Program (with Indian Space Research Organization as the pivotal agency under the Department of Space, Government of

India) has strived to provide self-reliance to the country in space technology and is aimed to serve the citizens with various space applications. As an Industry, the space sector in India is still in a developing stage; Antrix Corporation, the Commercial wing of ISRO is the only dominant player (although there are support industries and agencies that provide inputs to ISRO and its various programs) that provides commercial space launches, operations and space related services in the country.

India is going through a phase of rapid and progressive development with an industrious economy powered by the large workforce of young entrepreneurs and professionals. These developments are yet to transpire into the space sector; however, it is to be expected to happen in the near future. In this paper, the authors provide an account of the state of the art of the space sector in India and a road map to the future of private commercial space industry in the country. Various factors including policy issues, laws of the land, socio-economic, political and strategic aspects are considered to lay-down a scenario based prediction. The authors provide recommendations that may be implemented in order to promote private investments, entrepreneurship and development in the space sector.

Private commercial space industry in developed space faring nations such as USA and EU has evidently provided great support to research and development. The authors compare the space industry in the developed nations to that in India to further emphasize the need of private players in the sector. The Far and near future beholds diverse applications of space technology including but not limited to sub-orbital and orbital flights, commercial launches, tourism, mining, colonization and deep space exploration. Private entities around the world are already showing interest in these activities, India is an emerging economy and it has sufficient advances in technology to invest in such activities. This paper provides a roadmap and vision for the future of Private Commercial space Industry in India, keeping in view the roadblocks, challenges and measures.

A Historical Overview and Cultural Assessment of Space Industry Policy and Decision-Making Procedures in India (Khurana, 2014)

In 2012, the International Academy of Astronautics (IAA) established a study group to report on the probability of the emergence of human orbital markets (HOM) worldwide. The study approach consisted of five analysis phases: identifying the target HOM markets, conducting a literature review, conducting an analysis of relevant historical and social factors for multiple countries/regions, assessing the national/regional competitiveness of HOM industries, and assess the likelihood of the emergence of a viable HOM industry for that country/region. This paper, together with the literature review, specifically conducted an assessment of the historical and cultural context underlying the development of entrepreneurship and investment in the commercial sector for space in India. It has been found out that India has very few mechanisms/procedures to incubate or fund small and medium enterprises (SME) in the space sector at the moment.

Space Industry Statistics, Methodology and Practical Approach: The Eurospace Example (Lionnet et al., 2010)

Since 1996 Eurospace, the association of European space manufacturing industry, promotes improved knowledge of space sector economics by performing an annual survey of space industry sales and employment in Europe. The survey report and data sets are published on the Internet and have become a preferred source of information on space industry economics in Europe for companies and policy makers in Europe and abroad.

In 2009 Eurospace statistics have been further improved thanks to a methodological change in the data collection phase, with the improvement of the consolidation model while preserving historic consistency for the establishment of long data series.

The paper presents the Eurospace methodology and definitions, reviews the main issues to address for a successful data collection and describes the methodological principles on which the economic model is built. The paper then presents the most recent data sets for the European space manufacturing industry.

India's Space Industry Ecosystem – Challenges of Innovations and Incentives (Murthi & Rao, 2014)

India's investments in space activities were mainly driven by the public policy and there had been steadily growing support for space technology developments and applications through investments by the government. Its space activities encompass diverse branches of space endeavours including space launches to applications to interplanetary scientific missions. As an integral strategy, the space industry development and promotion was pursued from the very early stages of development of India's space programme till now mainly to derive support for the public funded programme and also for creating necessary social and economic impacts. India's space industry role too had undergone an evolutionary process over the past three to four decades and certain epochs could be identified in tandem with the evolutionary phases in India's space activities and also changes in economic and social environment.

The entry of India's private sector into services which are based on space systems for over a decade was a major turning point that opened both growth and extension of value chain by industry. Although certain policy initiatives for industry roles including in the fields of satellite communications and remote sensing data distribution and applications were taken up more than a decade ago, the dynamic changes in market environment, specific nature as well as new advances in space technologies coupled with the issues regarding the harmony of public and private sector roles require policy responses to invigorate the role of space industry.

The opportunities and imperatives of domestic industries to relate to the global industry are also tempered by the policy environment, pointing to the need for periodically assessing gaps in policies and bridging these through a process involving all stake holders.

The paper analyses the state of space industry in India, the impacts created by it and their potentials for future, and, in that context identifies diverse policy innovation issues which need to be addressed. The analysis is structured to deal with different segments of value chain and also new areas of infrastructure and applications such as positioning which were hitherto not addressed. The paper also suggests possible improvements in policies and processes for further development and sustenance of India's space industry. A few cases of technology innovations by industry are indicated to highlight the environmental factors for innovation driven product/service development.

Israel

New Israeli Civil Space Policy to Boost R&D and Commercial Space Industrial Base (Tepper, 2013)

Israel's space industry emerged of defense necessity, having its first launch in 1988. State budget was always low and mostly defense related, lately US\$ 76M of which only 3 for the civil program administered by the Israeli Space Agency (ISA). The US\$ 3M was highly leveraged as 80% of the investment in space related R&D in Israel so far came from foreign governments interested in cooperation and joint projects, resulting in agreements with over 10 space agencies. Despite low budgets, achievements so far are remarkable: Israel was ranked #1 in terms of publication per capita on aerospace engineering and has demonstrated capabilities and products in space infrastructure, products and services, with leading optical equipment and small satellites. Space industrial base includes around 20 corporations employing 2,000-2500 workers driving annual sales of US\$ 800M, world's eighth largest.

Following a series of studies on the impact of the space industry on the Israeli economy, Israel adopted a new Civil Space Policy, increasing civil budgets eightfold to a yearly US\$ 24M. The goal is ambitious – with the new cash injection, and capitalizing on its lucrative defense, communications and IT industries as a solid base, Israel plans on boosting its civil space industry, placing it amongst the top 5 leading nations in space, with yearly sales of US\$ 6-10 billion, representing 3-5% of the global space market. Success will make the space industry a driving force for economic growth. The lion's share of the budget will be allocated to international cooperation and projects. The two other major allocations are to industrial R&D and basic research.

A key element launched by a Directive promulgated in December 2012 is a targeted program by which state financial support will be provided to innovative commercial space R&D, considering mainly the novelty and uniqueness of the product / technology; their expected achievements and capacity to enhance and upgrade satellites' utility and performance; and their market. Support will amount to 50-85% of the project's budget, not exceeding US\$ 5.3M, unless for ground-breaking projects. Considering past achievements with small budgets, this is a significant stimulus. Successful projects will pay the state royalties as percentage from future income (3-

6%), if such is generated, until full repayment of the grant, thus having the state bearing most of the project's risk.

Japan

Spaceports for Space Tourism in Japan - The Nearest Place from Space Which Contributes To Economic Activities (C. Lauer, Faulkner, French, Onuki, & Lindner, 2010)

The US has been creating commercial spaceports for almost ten years now and the number of licensed spaceports continues to grow. Now there is a new trend for spaceport development all over the world in such locations as Sweden, Spain, Dubai, Singapore, Curacao and so on. Recently this trend has also come to Japan including locations in Hokkaido, the northern island, and Kanto, the middle of the main island. These proposed developments fill a market need to match demand for spaceflight with the views from space of familiar places close to home and birthplace. This paper will review the global trends in new spaceport development and consider the processes needed to realize commercial spaceport development and commercial human spaceflight in Japan including the issues of licensing and regulatory matters which need to be dealt with.

Nigeria

The Nigerian Space Programme and Its Economic Development Model (James et al., 2011)

The Nigerian space programme is managed by the National Space Research and Development Agency (NASRDA). The space policy was approved in May, 2000. The mandate of the Agency as encapsulated in the policy is to vigorously pursue the attainment of space capabilities as an essential tool for the socio-economic development of the nation and the enhancement of the quality of life of Nigerians. For a space programme to be sustainable in emerging space-faring countries, there is need to develop and implement a space economic development model. This study examines the Nigerian space programme and its economic development model. Findings from this study indicate that the space economic model adopted in Nigeria is the public-private-partnership model that involves the short, medium and long term plans. Within the short term plan, the Government is responsible for all investments in space technology development. In the medium term, the Government implements the partial commercialisation of NASRDA's products and services developed during the short term economic development plan. In the long term plan, the Government partners with the private sector to implement the public-private-partnership framework for the space programme. Consequently, within the short term economic development plan, six research Centres and two companies were established. The research Centres include Centre for Remote Sensing, Jos; Centre for Satellite Technology Development, Abuja; Centre for Geodesy and Geodynamics, Toro; Centre for Space Transport and Propulsion, Epe; Centre for Basic Space Science and Astronomy, Nsukka; and Centre for Space Science and Technology Education, Ile-Ife. The two companies are: the Nigeria Communication Satellite (NigComSat) Limited and the GeoApps Plus Limited (previously called Nigeriasat Imageries

and Consultancy Services Limited). NigComSat Limited was set up in April, 2006 to market products from the Nigerian communication satellites. Similarly, GeoApps Plus Limited was established in September, 2007 to market products from the Nigerian Earth observation satellites. It suffices to say that NASRDA is currently implementing its medium term economic development agenda.

South Africa

South Africa Space Industry Indicators and Analysis (Guthrie et al., 2011)

This paper summarizes the results of a study conducted with the cooperation of the Foundation for Space Development South Africa to define and characterize the space industry in South Africa. Unique access to the industry through the Foundation, in combination with research and analysis from The Tauri Group contribute to an authoritative introduction and overview. A version of these results will be distributed to all IAC 2011 conference attendees. The methodology of the study includes exhaustive open source data review, combined with targeted interviews with leaders in the South African space industry. The results will be compiled and presented in both quantitative and qualitative terms. The industry is depicted in terms of:

- Overall South African Economy
- GDP, GNP, overall investment, budget, and natural resources
- Major technology sectors
- Employment and labor force data
- South African Space Industry
- Government space budgets
- Commercial space revenues
- Key commercial, civil, and defense policies
- Infrastructure
- Products and services
- Labor force data
- Profiles of major space companies
- Directory of government organizations and personnel with space responsibilities

Additional qualitative sections will summarize particular areas of innovation and interest in the South African space economy. Primary among those are development activities like the Square Kilometer Array radio telescope. Profiles of existing and development activities are characterized by budgets, customers and consortium partners, and their competitive space relative to other options.

South Africa's Initiatives to Enhance Growth of the Space Industry for Socio-Economic Development (Makapela & Majaja, 2011)

The government of South Africa encourages involvement of the private actors in space activities through public-private partnerships in order to develop national commercial capabilities. The development and launch of the South African remote sensing micro satellite demonstrated the required cooperation between public and private sector. However, investment in space activities has not been optimally realized as space activities in the past have been disjointed without the mandatory accountability for the development and leadership of a coherent national space programme. According to the National Space Policy, the domestic industry is encouraged to pursue appropriate strategic international industrial partnerships, as one of the means of enhancing industrial competitiveness. A number of government initiatives and programmes that are intended to leverage economic benefits and support the development of the South African industry have been established. These include the Aerospace Industry Support Initiative (AISI), National Industrial Participation Programme (NIPP) and Support Programme for Industrial Innovation (SPII). There is a need for a focused approach to streamline these initiatives and utilise them effectively and efficiently. South Africa constitutes a variety of institutions and programmes with diverse space activities, however the industry is very small and there is less documented information about the size and growth of the space sector than other sectors of the economy. This is due to the reasons that the economic data on many components of the space sector are normally combined with related industries such as Aerospace and Defense and the industry is characterized by dual-use products and services. Consequently, even though there has been a research on the space sector, this research does not define space as a separate industry. In order for South Africa to reach its vision in terms of the National Space Strategy, which is to be among the leading nations in the innovative utilisation of space science and technology that enhances economic growth and sustainable development in order to improve the quality of life for all, there is a need for better utilisation of the government initiatives for industry growth. The purpose of this paper is to analyse South Africa's Space activities and how they impact on economic growth and development. The paper will also analyse the government's initiatives in support of the industry and how these initiatives could be utilised effectively in order to enhance innovation and technology towards knowledge economy.

United States

The US HOM was analyzed using a standardized methodology (Porter, 1990) that is both academically rigorous and applicable internationally. Entire groupings of industries, referred to as "communities" in the terminology of social ecology theory (Astley, 1985), are identified. Each "community" is comprised of one or more "populations." Populations differ from "industries" in that they include organizations and entities in addition to for-profit firms, such as governmental agencies and non-governmental non-profit organizations. For example, the US HOM study identifies and analyzes a community called "Engines, Motors" that is comprised of two populations: liquid rocket engines and solid rocket motors.

Summary results and conclusions of the US HOM study are described in this section. The full report (Autry et al., 2013) is available on the FAA AST website and was also published in the New Space Journal (Autry & Huang, 2014).

US HOM Study Findings

The overall HOM industry chain, from the upstream industries (i.e., raw materials, identified as Tier 5 in the study) to the end use services, are shown in Figure 8. Although the US has a very strong competitive position, the weakest portion of the industry chain exists in the middle tiers (Tiers 2-4). The impact of this general weakness is masked to some extent by the very significant advantage the US provides in the supporting industries, including the civil space program and military aerospace sector.

Natural clusters of firms in the emerging commercial space field that could be members of the target HOMs are shown in Figure 9 (as of December 2013). It should be noted that only primary locations of individual firms are indicated on the map, so testing or operational facilities are not indicated leading to the interesting result of zero firms being located in the state of Florida, despite its long and intimate association with US civil and military space activities.

Figure 8. Industry Chain of the Target US Human Orbital Markets (Autry & Huang, 2014).

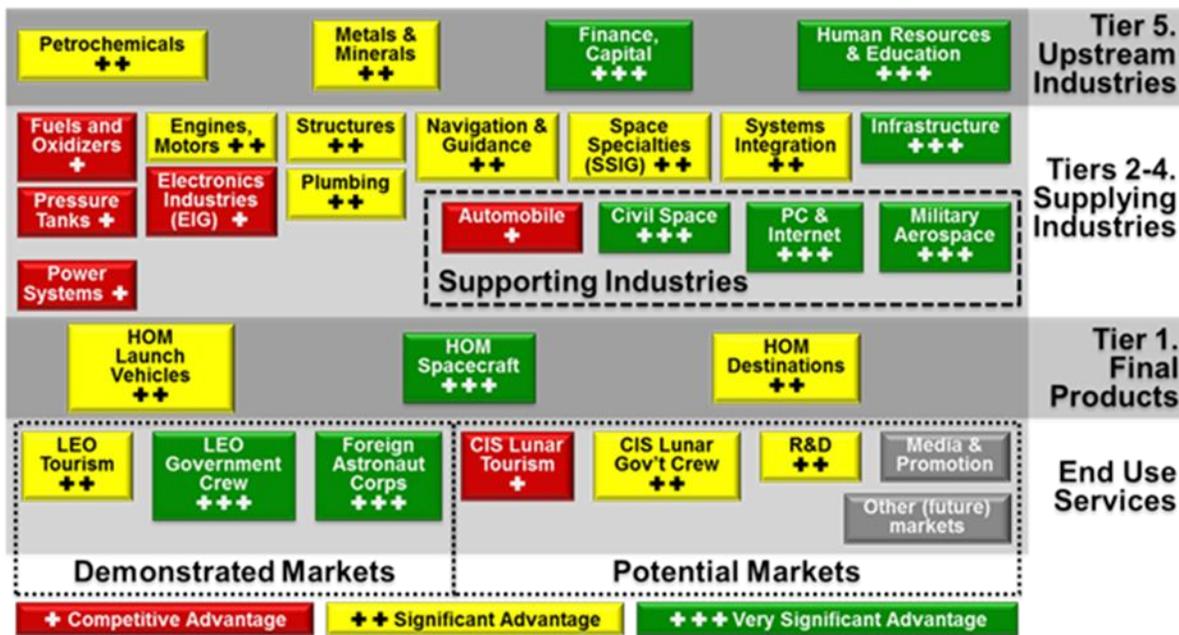


Figure 9. New Space Cluster Map (Total # Firms / # Failed Firms) (Autry & Huang, 2014)

US HOM Factors of Competitiveness

Important factors affecting national competitiveness from the US HOM analysis include the following:

- Trade Restrictions
- Small Shop Suppliers
- Supply of Senior Aerospace Engineers
- Supply of Skilled Production Workers
- US Military Budget Cuts
- Inconsistent Government Support and Competition
- Governmental Market Distortions Disrupt Clustering
- Critical Supply Chain Elements from Other Countries
- Solid Rocket Motors

Each of these is briefly discussed below.

Trade Restrictions



Based on anecdotal observation, the vast majority of commercial space executives feel that the International Trade in Arms Regulations (ITAR) unduly punishes US firms in the global market place and stimulates foreign competitors, particularly in regards to satellite manufacturing. ITAR also has been cited as a complication in accessing the global supply chain. In particular, this has

made it difficult to share design information required to facilitate the integration of major foreign assemblies into US vehicles.

A potential upside of ITAR is by reserving the world's largest space customer (the US government) for US suppliers, raising multiple barriers of entry for non-US entrants and creating a short-term advantage for domestic firms. Such a market/nascent industry protection strategy has been repeatedly demonstrated as effective by East Asian nations in many product categories.

Small Shop Suppliers

Interviewees⁶ expressed concern with the ability of their small parts suppliers to meet production schedules and maintain quality in the transition from low-volume specialty production to a rate-based model.

Supply of Senior Aerospace Engineers

Interviewees expressed concern with the supply of management-qualified engineers. While new engineers are now joining the industry there is a gap in engineers aged 30 to 50 who would normally fill management positions.

Supply of Skilled Production Workers

Interviewees expressed some concern that a general decline in US manufacturing capacity driven by offshoring of such work has resulted in a lack of experienced young machinists, computer numerically controlled operators and production engineers.

US Military Budget Cuts

The military aerospace industries are extremely important to the shared aerospace supply chain that feeds the HOM and other New Space industries. Continually shrinking defense budgets are driving what appears to be a permanent decline in this supply chain. Additionally, military R&D has long been an important source of innovation for commercial aerospace businesses and the military provides US New Space firms with important infrastructure and launch sites.

Inconsistent Government Support and Competition

Political conflicts and apparent regional favoritism have resulted in unpredictable budgeting for certain commercial space programs. This uncertainty creates business risk that is likely to dissuade investment in US space firms.

⁶ The foundational primary data for this project were interviews conducted on-site or by telephone with supply chain management at final, downstream, spacecraft and launch vehicle assemblers and operators. These "Tier One" firms included: Orbital Sciences Corporation (Dulles, VA); Space Exploration Technologies (Hawthorne, CA); United Launch Alliance (Centennial, CO) and Sierra Nevada Corporation (Sparks, Nevada). Additional interviews were also conducted with Michael Lopez-Algeria, President of the Commercial Spaceflight Federation (Washington, DC), the non-profit industry association that represents New Space manufacturers and operators. Lopez-Algeria is a former US astronaut with significant flight time and a strong familiarity with a wide variety of spaceflight systems. (One major human spaceflight firm declined to participate and another failed to schedule an interview in the time.) Follow-up discussions were conducted via email and telephone with each of the participants and/or their staff on both general and specific topics related to the supply chain.

Governmental Market Distortions Disrupt Clustering

As a legacy from the civil space program, the US political system has long favored spreading grants and contract awards across multiple states which results in a space infrastructure that is ineffectually distributed across the United States with long supply chains and logistical complexities, impeding the natural formation of industry clusters. State and local financial incentives have also distorted the natural formation of clusters.

Critical Supply Chain Elements from Other Countries

For companies that rely on a supply chain with international components, the HOM study notes that geopolitical relationships with multiple countries pose the risk of a supply chain interruption for US HOM spacecraft suppliers.

Oligopolies and Monopolies

The study notes that multiple supply chain industries are highly concentrated (meaning only two firms in competition as in the case of solid rocket motors) or even monopolies (as in the cases of RP-1 distribution and ammonium perchlorate production). Highly concentrated markets and monopolies present a supply risk, a national security risk, repress innovation and decrease economic efficiency through lack of competition. Industries that develop in domestic monopolies are less competitive in international markets.

Phase 5. HOM Industry Emergence Assessment

After identifying the requirements of an emerging industry, the goals of this phase of the HOM study include identification of the HOM industry actors, qualitatively assessing their contributions to the different necessary industry infrastructure elements, and making an overall qualitative assessment of the possible emergence of an HOM industry for each country or region. As shown in the table below, the following reports and studies were identified pertaining to this analysis phase for specific countries.

Table 5. IAA HOM Study Phase 5 Supporting Analyses

Country	Phase 5 – HOM Industry Emergence
Europe	(Hempsell et al., 2014; Szalai et al., 2012)
Europe: Spain	(C. J. Lauer et al., 2013)
India	(Khan, 2012)
Japan	(Onuki et al., 2009; Onuki, 2012a, 2012b)
South Africa	(Guthrie et al., 2011; Makapela & Majaja, 2011)
United States	(Autry et al., 2013; Davidian & Autry, 2014)

Europe

A Business Analysis of a SKYLON Based European Launch Service Operator (Hempsell et al., 2014)

Between 2012 and 2014 an industrial consortium led by Reaction Engines conducted a feasibility study for the European Space Agency with the objective to explore the feasibility of SKYLON

as the basis for a launcher that meets the requirements established for the Next Generation European Launcher. SKYLON is a fully reusable single stage to orbit launch system that is enabled by the unique performance characteristic of the Synergetic Air-Breathing Rocket Engine and is under active development. The purpose of the study which was called “SKYLON based European Launch Service Operator (S-ELSO)” was to support ESA decision making on launch service strategy by exploring the potential implications of this new launch system on future European launch capability and the European industry that supports it. The study explored both a SKYLON operator (S-ELSO) and SKYLON manufacturer as separate business ventures. In keeping with previous studies, the only strategy that was found that kept the purchase price of the SKYLON low enough for a viable operator business was to follow an “airline” business model where the manufacturer sells SKYLONS to other operators in addition to S-ELSO. With the assumptions made in the study it was found that the SKYLON Manufacturer with a total production run of between 30 and 100 SKYLONS could expect an Internal Rate of Return of around 10%. This was judged too low for all the funding to come from commercial funding sources, but is sufficiently high for a Public Private Partnership. The S-ELSO business model showed that the Internal Rate of Return would be high enough to consider operating without public support (i.e. commercial in operation, irrespective of any public funding of development), even when the average launch price is lowered to match the lowest currently quoted price for expendable systems.

ESA Space Spin-Offs Benefits for the Health Sector (Szalai et al., 2012)

Humanity will be faced with an important number of future challenges, including an expansion of the lifespan, a considerable increase of the population (estimated 9 billion by 2050) and a depletion of resources. These factors could trigger an increase of chronic diseases and various other health concerns that would bear a heavy weight on finances worldwide. Scientific advances can play an important role in solving a number of these problems, space technology; in general, can propose a panoply of possible solutions and applications that can make life on Earth easier and better for everyone. Satellites, Earth Observation, the International Space Station (ISS) and the European Space Agency (ESA) may not be the first tools that come to mind when thinking of improving health, yet there are many ways in which ESA and its programmes contribute to the health care arena. The research focuses on quantifying two ESA spin-offs to provide an initial view on how Space can contribute to worldwide health. This quantification is part of the present strategy not only to show macroeconomic return factors for Space in general, but also to identify and describe samples of 'best practice' type of examples close to the general public's interest. For each of the 'best practices' the methodology takes into account the cost of the space hardware/software, a number of tangible and intangible benefits, as well as some logical assumptions in order to determine the potential overall returns. In conclusion, the study recommends a way in which ESA's spin-offs can be taken into account early on in the development process of space programmes in order to generate higher awareness with the general public and also to provide measurable returns.

Europe: Spain

Spaceport Barcelona – A Public Private Partnership to Create the First Commercial Suborbital Spaceport in Europe (C. J. Lauer et al., 2013)

As suborbital spaceplanes move through the engineering process and get closer to flight testing and commercial flight operations, more and more locations in the US and around the world are investigating the feasibility of hosting suborbital spaceflight operations at existing airports. The driver for this effort is clear and easy to understand – to capture a share of a new technology market and high-end tourism revenue for local economic growth. Secondary drivers include support of space based research activities, small satellite development, and for education and STEM curriculum promotion and outreach. The proposed Spaceport Barcelona flight operations location is the new Lleida Alguaire Airport which is located about an hour from central Barcelona and easily accessible by the Renfe AVE high speed trains on the Barcelona – Madrid main line. The airport was developed by the Catalonia government as an economic stimulus project for the Lleida region and opened in spring 2010 at a total project cost of 130 million euros. The original business model was to attract low cost air carriers and operate as a second commercial airport for the Barcelona region. However, the main Barcelona Airport still has ample unused gates and operating capacity and to date Lleida Alguaire Airport only has a few charter flight operations per week and some seasonal private aircraft landings during ski season in the Pyrenees. The Catalonia Airport Authority operates this airport, and is not able to even cover operating costs based on current air traffic. The concept of adding a dual-use spaceport operations overlay use to this airport has been embraced as a way to provide an economic return on the Catalonia taxpayer investment. The Lleida location also benefits from its location in a less populated agricultural area, a superb flying weather climate, and can also take advantage of the Zaragoza restricted military airspace for the supersonic and rocket powered segments of the suborbital flight profile. This paper will describe the current work by a public-private partnership team consisting of several suborbital vehicle operators; local entrepreneurs; the Catalonia regional government and the Spanish federal government to create a commercial suborbital spaceport using the US FAA/AST regulatory model and to position Barcelona as a premier commercial spaceflight hub for the European market.

India

Road map to the future of Private Commercial Space Industry in India: Vision for Space Entrepreneurship and Investment (Khan, 2012)

India is an emerging space faring nation with a space program driven by indigenous research and development spanning more than four decades. The National Space Program (with Indian Space Research Organization as the pivotal agency under the Department of Space, Government of India) has strived to provide self-reliance to the country in space technology and is aimed to serve the citizens with various space applications. As an Industry, the space sector in India is still in a developing stage; Antrix Corporation, the Commercial wing of ISRO is the only dominant

player (although there are support industries and agencies that provide inputs to ISRO and its various programs) that provides commercial space launches, operations and space related services in the country.

India is going through a phase of rapid and progressive development with an industrious economy powered by the large workforce of young entrepreneurs and professionals. These developments are yet to transpire into the space sector; however, it is to be expected to happen in the near future. In this paper, the authors provide an account of the state of the art of the space sector in India and a road map to the future of private commercial space industry in the country. Various factors including policy issues, laws of the land, socio-economic, political and strategic aspects are considered to lay-down a scenario based prediction. The authors provide recommendations that may be implemented in order to promote private investments, entrepreneurship and development in the space sector.

Private commercial space industry in developed space faring nations such as USA and EU has evidently provided great support to research and development. The authors compare the space industry in the developed nations to that in India to further emphasize the need of private players in the sector. The Far and near future beholds diverse applications of space technology including but not limited to sub-orbital and orbital flights, commercial launches, tourism, mining, colonization and deep space exploration. Private entities around the world are already showing interest in these activities, India is an emerging economy and it has sufficient advances in technology to invest in such activities. This paper provides a roadmap and vision for the future of Private Commercial space Industry in India, keeping in view the roadblocks, challenges and measures.

Japan

Spaceports for Space Tourism in Japan - The Nearest Place from Space Which Contributes To Economic Activities (Onuki et al., 2009)

The US has been creating commercial spaceports for almost ten years now and the number of licensed spaceports continues to grow. Now there is a new trend for spaceport development all over the world in such locations as Sweden, Spain, Dubai, Singapore, Curacao and so on. Recently this trend has also come to Japan including locations in Hokkaido, the northern island, and Kanto, the middle of the main island. These proposed developments fill a market need to match demand for spaceflight with the views from space of familiar places close to home and birthplace. This paper will review the global trends in new spaceport development and consider the processes needed to realize commercial spaceport development and commercial human spaceflight in Japan including the issues of licensing and regulatory matters which need to be dealt with.

Space Entrepreneurship Challenges to Create Commercial Space Projects in Japan Engineering and Ideas to Open New Space Markets (Onuki, 2012a)

Space commercialization is now inevitable everywhere. Government space budgets are limited in every country; even NASA (with 70% of the total world space budget), has budget challenges for its programs. To perform space activities while conquering short budgets, more space commercialization is necessary. In this context, space entrepreneur companies have become active, especially in commercial human space development where there are many new players. Space commercialization with innovative ways is called NewSpace, and seeks for low cost, reusability, small teams, market oriented approach, profitability, human space activities and so on. Meanwhile, the Japanese space budget has been flat, with industry sales almost the same as the national space budget and a dramatic decrease in space employment. In 2008, a new Japanese space basic law was issued where policy is shifted from space development to space utilization. The new space law will encourage space commercialization, with total space sales in all sectors growing to \$180B from current \$90B within five years. There are still negative factors for entrepreneur companies such as small space budgets, no venture capital on space projects, no space entrepreneur success story, and slow return on investment. However, active regional space development, retired veteran experiences, unique technology, entrepreneurship in big companies, and self-funded space developments have been growing. To encourage space entrepreneurship in Japan, it is necessary to have a “following wind” with successful examples of regional collaboration, development of solid markets such as small satellite and microgravity experiments, PPP, technology transfer system, tax credit etc. JAXA continues to have a major role in PPP and technology transfer projects. This paper introduces examples of Japanese entrepreneur companies and projects to create commercial space markets in Japan. Also, issues for entrepreneur companies to perform their businesses are considered. Space should be profitable, and open for all of us.

South Africa

South Africa Space Industry Indicators and Analysis (Guthrie et al., 2011)

This paper summarizes the results of a study conducted with the cooperation of the Foundation for Space Development South Africa to define and characterize the space industry in South Africa. Unique access to the industry through the Foundation, in combination with research and analysis from The Tauri Group contribute to an authoritative introduction and overview. A version of these results will be distributed to all IAC 2011 conference attendees. The methodology of the study includes exhaustive open source data review, combined with targeted interviews with leaders in the South African space industry. The results will be compiled and presented in both quantitative and qualitative terms. The industry is depicted in terms of:

- Overall South African Economy
- GDP, GNP, overall investment, budget, and natural resources
- Major technology sectors

- Employment and labor force data
- South African Space Industry
- Government space budgets
- Commercial space revenues
- Key commercial, civil, and defense policies
- Infrastructure
- Products and services
- Labor force data
- Profiles of major space companies
- Directory of government organizations and personnel with space responsibilities

Additional qualitative sections will summarize particular areas of innovation and interest in the South African space economy. Primary among those are development activities like the Square Kilometer Array radio telescope. Profiles of existing and development activities are characterized by budgets, customers and consortium partners, and their competitive space relative to other options.

South Africa's Initiatives to Enhance Growth of the Space Industry for Socio-Economic Development (Makapela & Majaja, 2011)

The government of South Africa encourages involvement of the private actors in space activities through public-private partnerships in order to develop national commercial capabilities. The development and launch of the South African remote sensing micro satellite demonstrated the required cooperation between public and private sector. However, investment in space activities has not been optimally realized as space activities in the past have been disjointed without the mandatory accountability for the development and leadership of a coherent national space programme. According to the National Space Policy, the domestic industry is encouraged to pursue appropriate strategic international industrial partnerships, as one of the means of enhancing industrial competitiveness. A number of government initiatives and programmes that are intended to leverage economic benefits and support the development of the South African industry have been established. These include the Aerospace Industry Support Initiative (AISI), National Industrial Participation Programme (NIPP) and Support Programme for Industrial Innovation (SPII). There is a need for a focused approach to streamline these initiatives and utilise them effectively and efficiently. South Africa constitutes a variety of institutions and programmes with diverse space activities, however the industry is very small and there is less documented information about the size and growth of the space sector than other sectors of the economy. This is due to the reasons that the economic data on many components of the space sector are normally combined with related industries such as Aerospace and Defense and the industry is characterized by dual-use products and services. Consequently, even though there has been a research on the space sector, this research does not define space as a separate industry. In order for South Africa to reach its vision in terms of the National Space Strategy, which is to be among the leading nations in the innovative utilisation of space science and technology that

enhances economic growth and sustainable development in order to improve the quality of life for all, there is a need for better utilisation of the government initiatives for industry growth. The purpose of this paper is to analyse South Africa's Space activities and how they impact on economic growth and development. The paper will also analyse the government's initiatives in support of the industry and how these initiatives could be utilised effectively in order to enhance innovation and technology towards knowledge economy.

United States

The final analysis phase of the IAA HOM study is the qualitative assessment of the likelihood of the emergence of a HOM that has a high probability of long-term viability in a given country or region. For the purposes of this report, the probability of a US HOM that is viable in the long-term is being assessed from two perspectives, the factors of new firm creation, and the required industry infrastructure elements. The probability of HOM emergence will be assessed on a qualitative scale ranging from "very unlikely," "unlikely," "likely," to "very likely".

Factors of New Firm Creation

The creation of new HOM firms is a necessary (but not sufficient) requirement for the long-term viability of this emerging industry. A detailed discussion of new firm creation was given in the section describing Phase 3 of this report. With respect to support of an emerging HOM industry, US government policies have produced mixed results. The chilling effect of trade and hiring restrictions due to concerns of national security are countered by public funding for capability demonstrations and service appropriations. The net effect is estimated to be moderately positive.

The US socioeconomic conditions impacting enterprise have deep historical roots as described previously in Phase 3 of this study. The skill sets and competency levels necessary for the emergence of a HOM industry are abundant in the US and multiple approaches of economic development policy (Pages, Freedman, & Von Bargen, 2003) at the local, state, and national levels continue to be made available to the emerging commercial space entrepreneurial communities.

Required Industry Infrastructure Elements

Research on emerging high-tech industries has identified major industry "infrastructure" requirements (Van de Ven & Garud, 1993; Van de Ven, 2005; Woolley, 2014) as described briefly below.

- Proprietary functions, including proprietary (private) R&D, converting intellectual property into a marketable product (aka "production"), and market creation.
- Resource endowments of public R&D, financial capital, and human resources.
- Institutional arrangements of governance and regulation, legitimization and technical standards.

These industry infrastructure elements are provided or built primarily through long-term cooperative efforts of many HOM actors, including government institutions (military and civil) and non-government organizations, both profit and non-profit(Pearce, 2001). As with non-government organizations, government institutions play many roles in the emergence of a new industry(Autry, 2013).

An assessment of the probability for the emergence of HOMs that are viable in the near-term can be made by evaluating to what degree (or level) the members of the HOM communities exist and support the development of the identified industry infrastructure elements. The strength was qualitatively evaluated on an increasing scale from weak, through moderate, to strong, and the kind of contribution was evaluated as either positive (constructive) or negative (destructive). Table 1 presents this assessment for the US based on the collection of studies presented in this report.

The level of support by multiple non-government organizations for the various proprietary functions range from moderately to strongly positive. Many US for-profit firms are actively participating in the creation of proprietary research, new products and development of the target HOMs at present. Governmental participation has been led by NASA by encouraging the capability demonstration of new launch vehicles (with the Commercial Orbital Transportation Services program) and acting as an “anchor tenant” for the services these new vehicles can provide (with multiple contracts to resupply the International Space Station). For new entrant firms that can be considered disruptive to the established market (Christensen, 1997b), this kind and level of support is unequalled by any other government world-wide. A positive contribution is made toward market creation with the publication of market forecasts and annual informational reports by the FAA AST. Taken together, the proprietary functions are receiving moderate to strong levels of positive support from both governmental institutions and non-governmental organizations.

Resource endowments (as shown in Figure 10) are currently receiving weak levels of positive support in public R&D. Financial resources are evaluated as receiving mostly moderately positive support, coming from both private and public sources (NASA primarily). Human resource development is receiving a mix of weak to moderate positive support. Overall assessment of this infrastructure element is assessed to be between weak and moderate from both governmental institutions and non-governmental organizations.

Figure 10. Qualitative Assessment of US HOM Industry Infrastructure Support

Industry Infrastructure Elements	US HOM Actors			
	Non-Gov't Orgs		Gov't Institutions	
PROPRIETARY FUNCTIONS	PROFIT	NON-PROFIT	CIVIL	MILITARY
Proprietary R&D (Invention)	Strong +			
Production (Innovation)	Strong +		Moderate +	
Market Creation (Diffusion)	Moderate +		Weak +	
RESOURCE ENDOWMENTS	PROFIT	NON-PROFIT	CIVIL	MILITARY
Non-Proprietary R&D		Weak +	Weak +	
Financing	Moderate +		Moderate +	Weak +
Human Resources		Moderate +	Weak +	
INSTITUTIONAL ARRANGEMENTS	PROFIT	NON-PROFIT	CIVIL	MILITARY
Governance			Strong +	Moderate -
Legitimization		Moderate +	Strong +	Moderate +
Technical Standards	Weak +	Weak +	Weak +	

Support for institutional arrangements within the US is primarily positive from the governmental institutions. Governance and legitimization functions receive strong positive support by government institutions (the FAA and NASA) due to a mature regulatory framework for commercial space activities and a supportive posture with respect to the industry. There is a rare negative effect on governance from the US Air Force caused by added complexity of using federal launch ranges by non-government organizations, the chilling effect of ITAR on the industry as a whole, and the reality that policy decisions in the US tend to favor concerns of national security at the expense of commerce (Hertzfeld, 2011). Support for the creation of technical standards has weak support from members of the HOM communities primarily because of the early phase of HOM emergence and the lack of a dominant design around which standards can develop (Utterback, 1994). Overall the institutional arrangements infrastructure element is considered to be receiving positive support that is moderate to strong.

In summary, two of the three main infrastructure elements are considered moderately to strongly positive and the third is estimated to be weakly to moderately positive in strength. Overall, the probability of the emergence of a HOM that will be viable in the long term is qualitatively considered “likely” to “very likely.”

CHAPTER 4. CONCLUSIONS, RECOMMENDATIONS FOR FUTURE WORK

This chapter provides a brief overview of the conclusions for each of the five analysis phases that comprise this report. As appropriate, limitations of the research conducted are identified. This section concludes with a list of recommendations for future work pertaining to each analysis phase.

Conclusions

Phase 1 Conclusions

Phase 1 of this analysis, “Target Market Assessment,” was based on the assumption that all target markets would be common to all countries included in the HOM analysis. These markets are listed here and described in detail in chapter 3 of this report.

Demonstrated Near-Term HOMs

- LEO Tourism
- Domestic Gov’t Crew Transportation
- Flight of Foreign Astronaut Corps

Potential Near-Term HOMs

- Research & Development
- Cis-Lunar Tourism
- Cis-Lunar Government Crew Transportation
- Media and Promotion

Potential Far-Term HOMs

- Resource Extraction
- Energy Generation
- Deep-Space Vehicle Support Services
- Residential Space Station Operation
- In-Space Construction
- Business Travel Services

Phase 2 Conclusions

Phase 2 of this analysis was the literature review for the HOM study. This activity included a prolonged and continuously on-going search for relevant reports, articles, and other relevant historical archive (secondary) data pertaining to the space industries of all the countries included in the analysis. As documents were found, any relevant information was included into this study. The complete list of literature results is given in Appendix A. It is noted that no documents were found for some of the most prominent space-faring countries, including Australia, China, India, and Japan.

Phase 3 Conclusions

Phase 3 of this analysis, “Entrepreneurial Environment Assessment,” was an exciting aspect of this study because it represents a “first of its kind” in the space industry. Although the theoretical framework employed was developed in 1994 (and is detailed in Chapters 1 and 2), it had never been applied to the industry of space-faring countries. Preliminary results for a single country (the U.S.) were available for the release of this report. These results are presented in Chapter 3.

Analyses based on the same methodology of more countries and regions are still underway (for Russia and Japan). When they become available, those results will be incorporated into future versions of this report.

A number of reports and analyses were identified pertaining to this analysis phase, and the abstracts from those reports are provided in Chapter 3. The countries represented by these reports includes: Australia, Benelux, China, Europe (region), Germany, Israel, Italy, Japan, Nigeria, South Africa, and Spain. None of those reports, however, followed the study methodology selected for the HOM study. In order to maintain analytical consistency of the overall study, results of those papers need to be extracted and integrated into the defined HOM phase 3 analysis structure. That work was not able to be conducted in time for the release of this version of the report.

Phase 4 Conclusions

Phase 4 of this analysis, “National HOM Industry Competitiveness Assessment,” is the most extensive of all the five analysis phases included in the HOM study. As with the previous study phase, this analysis, the Porter “Diamond” of International Competitiveness, also represented a “first of its kind” for the space industry despite the fact that it is not a new model (dating back to 1990). Details of this model are provided in Chapters 1 and 2. An in-depth study using this methodology was conducted for the U.S. HOM space industry and results are provided in Chapter 3. This specific analysis has yet not been performed by any other country. It is hoped that future iterations of this report will include these analyses.

As was the case above for HOM analysis Phase 3, a number of reports and analyses were identified pertaining to this analysis phase, and the abstracts from those reports are provided in Chapter 3. The countries represented by these reports includes: Australia, Benelux, China, Europe, Germany, India, Israel, Italy, Japan, Nigeria, South Africa, and Spain. Again as before, none of those reports followed the study methodology selected for the HOM study. In order to maintain analytical consistency of the overall study, results of those papers should be included into the “Diamond” analysis for each country. That work was not able to be conducted in time for the release of this version of the report.

Phase 5 Conclusions

Phase 5 of this analysis, “HOM Industry Emergence Assessment,” integrates the information from all five HOM analysis phases using a list of industry infrastructure elements⁷ required for the evolution of a high-tech industry (such as HOMs) listed against the possible space industry actors who are contributing to those infrastructure elements (as described in Chapters 1 and 2). Although this type of analysis is also a “first of its kind,” it is also an original analysis method developed specifically for this IAA study. Because this phase of the overall analysis is highly

⁷ As was noted in Chapter 1, the word “infrastructure” is being used in the organizational theory sense, referring to supporting elements for industry viability. This can be easily confused with “infrastructure,” typically referring large, immobile facilities and sites shared by launch providers, such as launch sites and spaceports.

dependent upon the results of Phases 3 and 4, this methodology has been conducted only for the U.S. HOM space industry at this time. Results are provided in Chapter 3. Once the “Diamond” analysis has been performed for other countries, this analysis phase will be performed for those countries. It is hoped that future iterations of this report will include these analyses.

As was the case above for HOM analysis Phases 3 and 4, a number of reports and analyses were identified pertaining to this analysis phase and the abstracts from those reports are provided in Chapter 3. The countries represented by these reports includes: Europe, India, Japan, South Africa, and Spain. Again as before, none of those reports followed the study methodology selected for the HOM study. In order to maintain analytical consistency of the overall study, results of those papers should be included for each country. That work was not able to be conducted in time for the release of this version of the report.

Recommendations for Future Work

Hopefully, this document is not the “final” report on this topic. As was stated in the Introduction, it is hoped that future iterations of this study will be conducted that can (1) describe the dynamic nature of the HOMs' emergence, and (2) build upon, expand, and improve the accuracy and precision of all the analysis results included in this report.

Therefore, the following section lists some recommendations for future work to be conducted in future iterations of this report.

Phase 1 Recommendations

The following are recommendations for future work pertaining to HOM analysis phase 1:

- Reassess the HOMs included in each of the three market categories and revise the list as appropriate.

Phase 2 Recommendations

The following are recommendations for future work pertaining to HOM analysis phase 2:

- Continue literature search for publicly available, web-based archive data.
- Perhaps include reports and studies that require purchase.
- Redouble efforts to identify and include secondary data (archive documents) from prominent space-faring countries for which no information has yet to be found.

Phase 3 Recommendations

The following are recommendations for future work pertaining to HOM analysis phase 3:

- Analyze the identified reports pertaining to this analysis phase which do not conform to the analysis methodology, and extract the relevant results and integrate them into a report consistent with the selected analysis method.

Phase 4 Recommendations

The following are recommendations for future work pertaining to HOM analysis phase 4:

- Conduct the Porter “Diamond” analysis for the major space-faring countries, including: China, Europe, India, Japan, and Russia.
- Possibly conduct the Porter “Diamond” analysis for other space-faring countries, including: Africa, Australia, Benelux, Canada, France, Germany, Israel, Italy, Nigeria, Norway, Portugal, South Africa, Spain, and the United Kingdom.
- Analyze the identified reports pertaining to this analysis phase which do not conform to the analysis methodology, and extract the relevant results and integrate them into a report consistent with the selected analysis method.

Phase 5 Recommendations

The following are recommendations for future work pertaining to HOM analysis phase 5:

- Analyze the identified reports pertaining to this analysis phase which do not conform to the analysis methodology, and extract the relevant results and integrate them into a report consistent with the selected analysis method.

Closing Remark

Of all the recommendations listed above, the highest priority recommendation of them all is to conduct the Porter “Diamond” analysis for the major space-faring countries, including: China, Europe, India, Japan, and Russia in Phase 4. This analysis takes the most time and would provide quite a bit of information with which to perform the remaining analysis.

APPENDIX A. CURRENT LIST OF LITERATURE REVIEW RESULTS

The following reports are presented in alphabetic order by country to which they pertain.

AFRICA (Region)

- 2012-11-07: Futron reveals plans for proposed Uhuru Spaceport in East Africa
- 2012-11-02: East African Commercial Spaceport a Basis for Regional Economic Growth
- 2012-11: Africa: Poised To Leapfrog Space Technology + Applications
- 2010-10-19: Africa Joining the Space Race
- 2009-08-22: Africa Joins the Space Race

CANADA

- 2012 July - The State of the Canadian Aerospace Industry - Performance 2011 (Aerospace Industries Association of Canada (AIAC)List of Space Industry Sectors served by Canadian companies (AIAC)

EUROPE (Region)

- 2010 Facts & Figures (F&F) Report by Eurospace
- Booz & Company, INSEAD and EEC. "Growing Europe: The Competitiveness Imperative", Executive Summary 2013.

EUROPE: FRANCE

- Institut national de la statistique et des études économiques publications
- 2010 Oct - INSEE Report par Josiane Thurmel: La construction aéronautique et

spatiale: fleuron de l'industrie en Aquitaine

- Other INSEE Reports on the Space Industry in Southwest France
- Groupement des Industrie Française Aéronautiques et Spatiales Reports
- 2013 - Catalogue des écoles doctorales aéronautiques et spatiales
- 2013 Jan - L'Industrie Aéronautique et Spatiale

EUROPE: ITALY

- 2013 Feb 13 - I Dati In Questo Rapporto Sono Liberamente Citabili Purche' Se Ne Indichi La Fonte Completa (Autori E Titolo)

EUROPE: PORTUGAL

- 2011 Nov 2: Survey of the Economic Impact of Portugal's Participation in ESA from 2000 to 2009 (Adbridged version) by Clama Consulting

NORWAY

- 2012 July - Evaluation of Norwegian Space Programs, prepared by PricewaterhouseCoopers AS (PwC) for the specific use of the Ministry of Trade and Industry.

RUSSIA

- "Russian space programmes and industry: Defining the new institutions for new

conditions" by Yuri Makarov and Dmitry Payson.

- "Building The Institutional Environment Supporting New Commercial Players For Space Activities" by Dmitry Payson.

UNITED KINGDOM

- The Space Economy in the UK. An economic analysis
- The Size and Health of the UK Space Industry
- Economic impact analysis - Oxford Economics
- 2010 The Size and Health of the UK Space Industry. OECD iLibrary
- The Economic Impact of the UK Exhibitions Industry

UNITED STATES

- Industry Listings and Data
 - 2006.11.13 Top 100 NASA Contractors 2007.pdf
 - 2007.08.06 Top 50 Space Mfg & Service Cos.pdf
 - 2008.06.02 Personal Space Industry.pdf
 - 2008.07.28 Top 50 Space Mfg & Service Cos.pdf
 - 2009.07.06 Top 25 Fixed Satellite Service Operators
 - Commercial Space Industry Reports
 - 2013 Space Satellites Industry Report_Final.pdf
 - March 2011: Reusable Suborbital Market Characterization Prepared by The Tauri Group for Space Florida
 - Space Security 2010, Edited by Cesar Jaramilio, of spacesecurity.org.

- AIA's The Unseen Cost: Industrial Base Consequences of Defense Strategy Choices (July)
- The Economic Impact of Commercial Space Transportation on the U.S. Economy. FAA AST. (April)
- 2008 U.S. Commercial Space Transportation Developments and Concepts. FAA AST. (January)
- 2007 Space Planes and Space Tourism: The Industry and the Regulation of its Safety. Pelton, Joe. (April)
- Other Space Industry Base Reports
 - U.S. Department of Commerce, Bureau of Industry and Security (BIS) Industrial Base Surveys and Assessments
 - 2013 June 26 - Final Results
 - 2013-06-26 Space Deep Dive - NDIA 062113.pdf
 - 2012 Oct 31 - U.S. Space Industry 'Deep Dive' Preliminary Results and Findings
 - Report to Congress on the Solid Rocket Motor Industrial Base Sustainment and Implementation Plan (Redacted Version) (2011)
 - Under Secretary of Defense for Acquisition, Technology, and Logistics (May 2011)
 - SRM Industrial Capabilities Report to Congress (Redacted Version) (2009)
 - Under Secretary of Defense for Acquisition, Technology, Logistics, and Industrial Policy (June 2009)

- Annual Industrial Capabilities Report to Congress - 2011
- Department of Defense, Office of Manufacturing & Industrial Base Policy
- NASA Supplier Base: Challenges Exist in Transitioning from the Space Shuttle Program to the Next Generation of Human Space Flight Systems, GAO-07-940 (2007)
- NRO Space Industrial Base Study
- NRO response to congressional directed action on the state of the space industrial base (Feb 2010)
- Tipping Point: Maintaining the Health of the National Security Space Industrial Base (2010)
- AIA Report (September 2010)
- Defense Industrial Base Assessment: US Space Industry Final Report (August 2007)
- U.S. Industrial Base Analysis for Space Systems (2011)
- 2011 Study by the Tauri Group
- GAO-09-5 Department Of Defense: Department-wide Framework to Identify and Report Gaps in the Defense Supplier Base is Needed (2009)
- GAO-10-317R (2010) Briefing to the Senate Committee on Banking, Housing, and Urban Affairs, Subcommittee on Security and International Trade and Finance: DOD Assessments of Supplier-Base Availability for Future Defense Needs
- GAO-10-389 Defense Supplier Base: DOD Should Leverage Ongoing Initiatives in Developing Its Program to Mitigate Risk of Counterfeit Parts (2010)
- Ongoing study: Assessment of the U.S. Space Industrial Base Supply Chain (2012)
- 2012 Bureau of Industry and Security, U.S. Dept. of Commerce
- Ongoing study: NASA Industrial Base Post-Space Shuttle (2012)
- 2012 Bureau of Industry and Security, U.S. Dept. of Commerce
- NASA Human Space Flight Transition Plan
- Mayer, Donald C., "Status of Critical Technologies List," The Aerospace Corporation, (10 Jan 2010)

WORLD-WIDE (Region)

- OECD Space Economy at a Glance 2011 Summary And Full Publication

APPENDIX B. STUDY GROUP CONTRIBUTORS

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- Donghao, L.
- Lan-Juan, L. Z.
- Liu, L.-J.
- Wenjie, S.
- Zhifu, B.

Europe

- Aprea, J.
- Bernede, N.
- Cohendet, P.
- de Hauteclocque, B.
- di Pippo, S.
- Detsis, E.
- Eerme, T.

- Gallagher, B.
- Hempsell, M.
- Hou, J.
- Lillestik, O.
- Lu, M. Z.
- Maier, P.
- Peeters, W.
- Sadlier, G.
- Sepp, J.
- Shaghaghi, M. A.
- Svoboda, J.
- Szalai, B.
- Vööras, M.

Europe: Benelux

- Kiang, C.
- Maier, P.
- Prado, M. A.
- Van Dorenmalen, K.

Europe: Germany

- Bernede, N.
- Maier, P.
- Schmidt, S.
- Svoboda, J.
- Weber-Steinhaus, L.

Europe: Italy

- Ainardi, M.
- Ciavoli Cortelli, L.
- Ciccarelli, S.
- Graziola, G.
- Luise, M.
- Pavone, R.
- Piperno, O.
- Sabino Titomanlio, I.
- Sciortino, G. P.

Europe: Spain

- Lauer, C. J.
- Harillo, R.
- Onuki, M.

India

- Deutscher, N.
- Khan, A. R.
- Khurana, S.
- Lionnet, P.
- Murthi, K. R. S.
- Perrier, P.-A.
- Rao, M. K.

Israel

- Tepper, E.

Japan

- Ito, K.
- Lauer, C. J.
- Onuki, M.
- Watanabe, K.

Nigeria

- Akinyede, J.
- Halilu, S. A.
- James, G. K.

Russia

- Payson, D.

South Africa

- Christensen, C.
- Guthrie, P.
- Hinds, E.
- Majaja, N.
- Makapela, L.
- Orloff, J.
- Sharpe, C.

United States

- Autry, G.
- Davidian, K.
- Huang, L.

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International Academy of Astronautics

IAA SG3.15

Long Term Space Propellant Depot

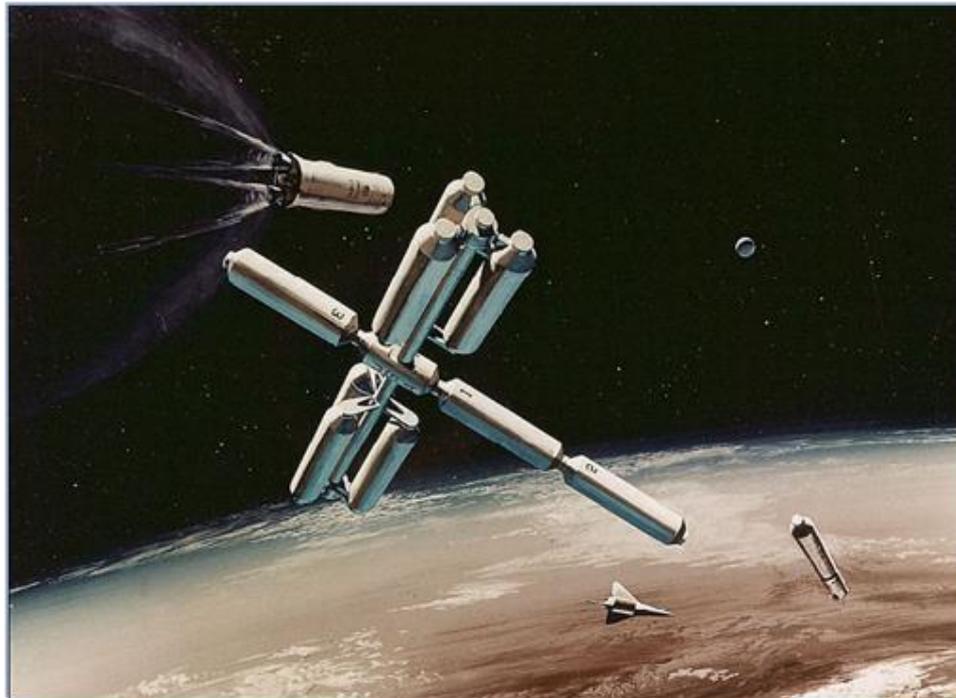
G.Saccoccia, LU Yu

Jerusalem, Israel

Oct. 2015

Goal:

Identify requirements, concepts and opportunities for future high energy propellant space depots, identify required key technologies and define the road map for this new capability.



Goal:

This study is also to determine the potential benefits of an in-space propellant depot infrastructure and to develop a technically feasible system at conceptual level. This was done by developing a space transportation concept that utilizing ELV systems and new reusable in-space vehicles, supported by propellant depots to the greatest extent possible, that could be developed gradually and put into practice over time.



Study Contents



International Academy of Astronautics

Introduction

Part 1-Feasibility and Missions

Design reference missions and space transportation systems

Scope and feasibility

Space environment

Part 2-Technologies

Key technologies

Part 3-Programmatic and Implementation

Roadmap for the implementation

Conclusions and Recommendations



The Report



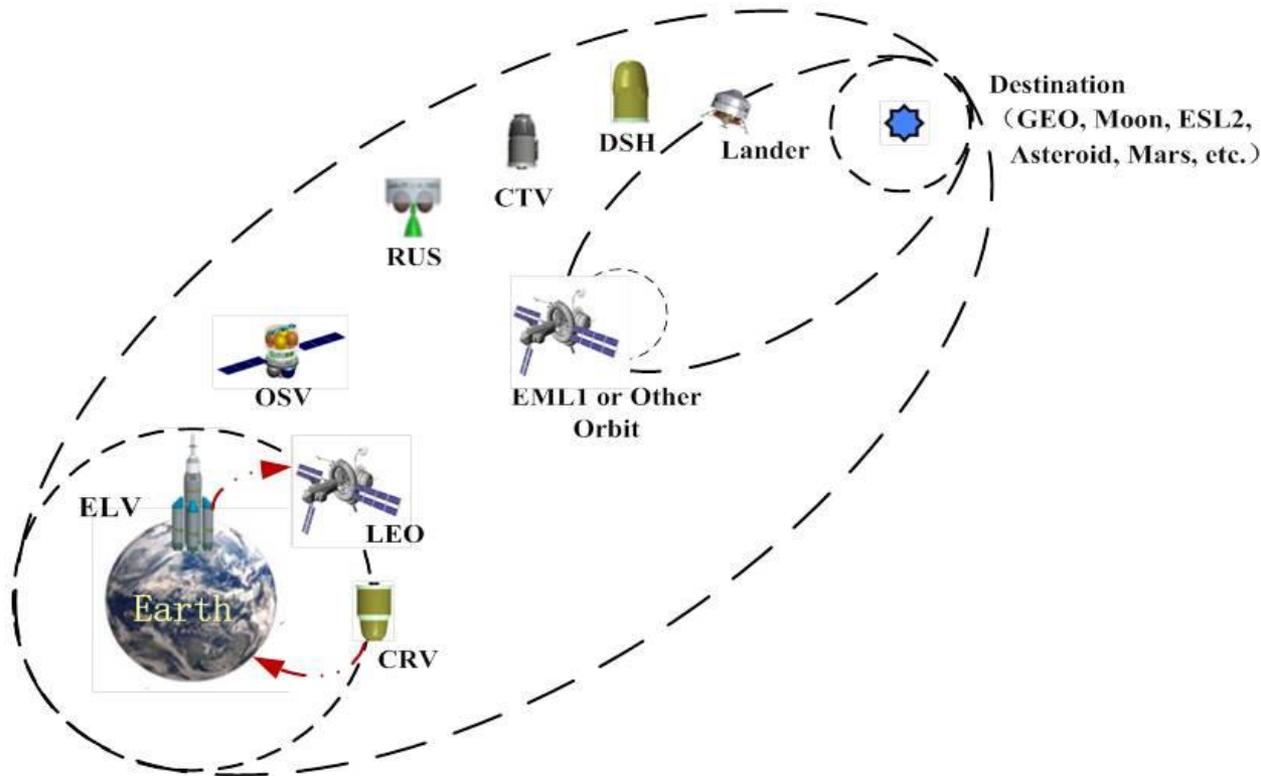
International Academy of Astronautics

Introduction

- a. Definition, background and requirements*
- b. Definition of goals with related criteria: Political, Scientific, Economical*
- c. Heritage of past experience*
- e. Operational Scenarios*

Operational Scenarios

To support future routine space exploration missions, an architecture concept based on depot is suggested in this studied. This system includes three parts: The ELV and CRV, the Depots and the Space Transportation Systems.



Introduction

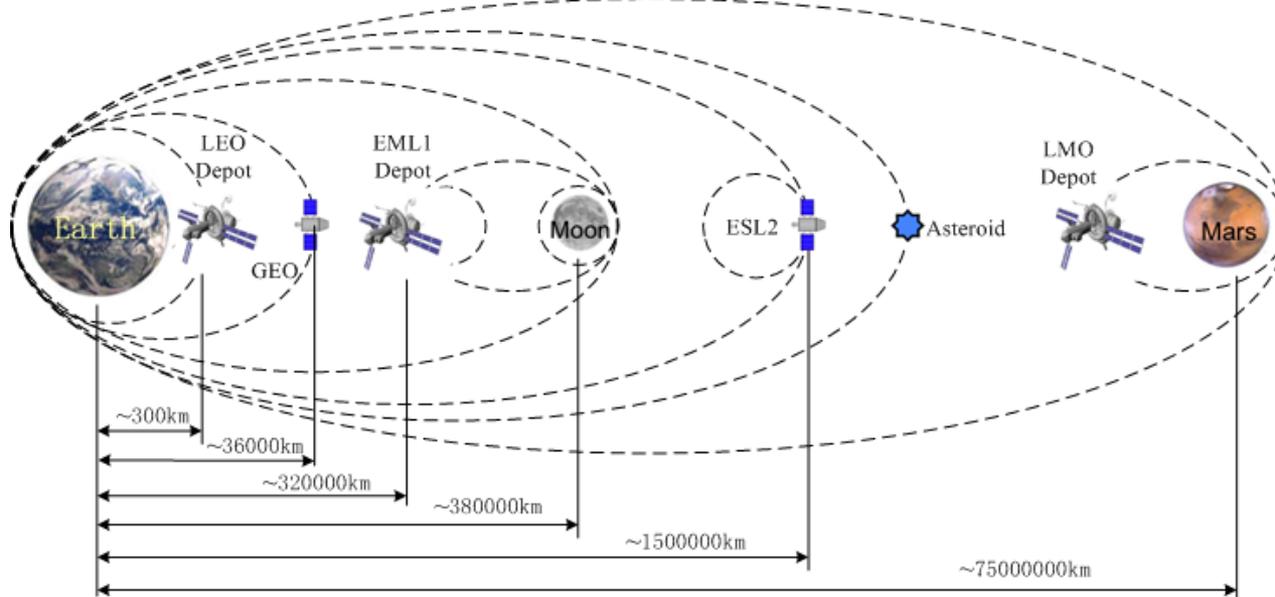
a. Definition, background and requirements

b. Definition of goals with related criteria: Political, Scientific, Economical

c. Heritage of past experience

e. Operational Scenarios

Three depots in LEO, L1, and Mars orbit are selected to support all foreseeable missions in the Earth-Moon vicinity and deep space out to Mars.



Part 1-Feasibility and Missions

Design Reference Missions and Space Transportation Systems

a. Earth Orbit Mission and Space launch systems (Earth to Orbit)

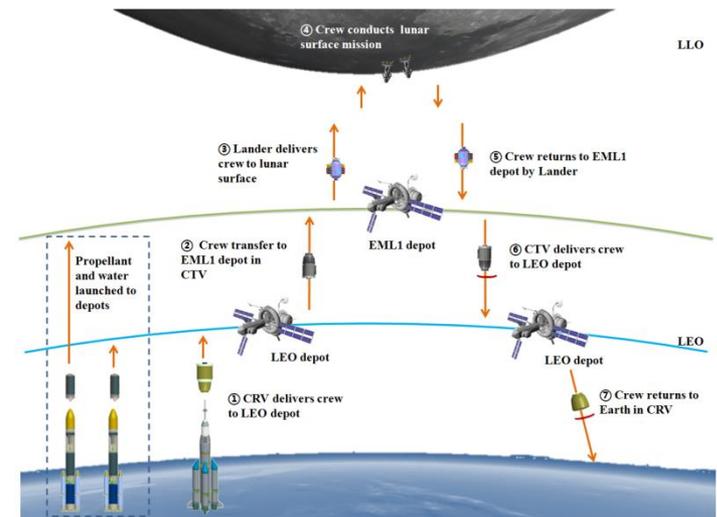
① *Human GEO Mission*

② *Robotics GEO Mission*

b. Human Lunar Mission and cislunar space transportation systems

c. Asteroid mission and space exploration systems

d. Mars Mission and space exploration systems



Part 1-Feasibility and Missions (cont.)

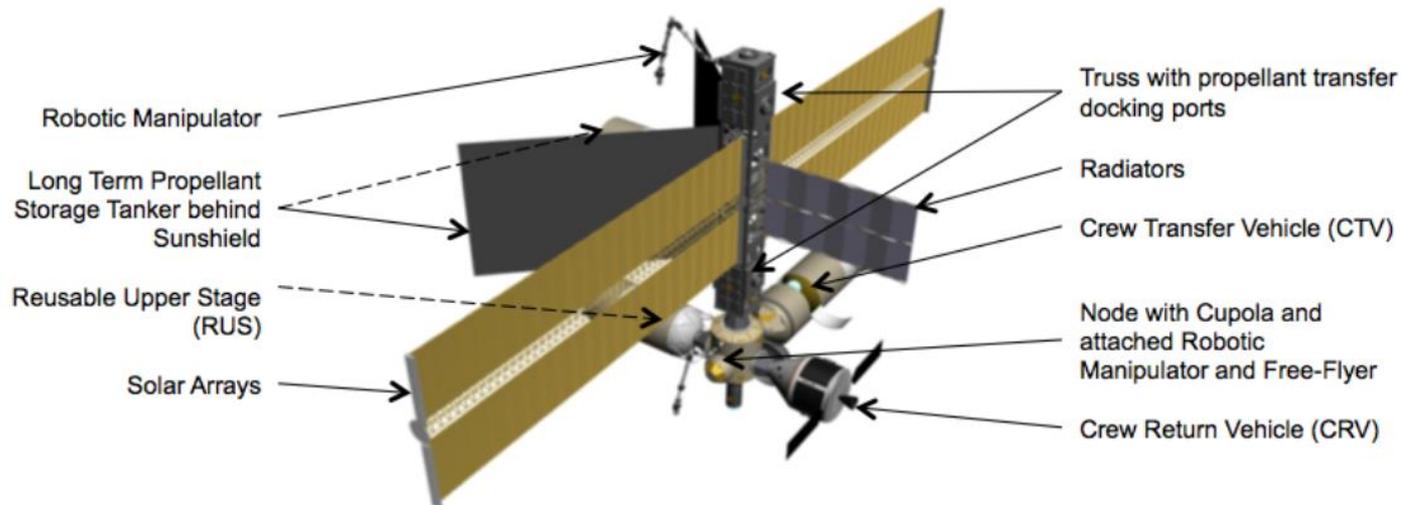
Scope and feasibility

a. The depot concept [1]

b. Propellant Sources

c. Order of Magnitude Scale

d. Costs



[1]. D. Smithermana, G. Woodcockb. Space Transportation Infrastructure Supported By Propellant Depots[C]. AIAA 2011-7160

Part 1-Feasibility and Missions (cont.)

Scope and feasibility

a. The depot concept

b. Propellant Sources

c. Order of Magnitude Scale

d. Costs

1. Cryogenic propellants launched from the Earth.

2. Electrolyse water or ice from the Earth, Moon, or Asteroids.

Part 1-Feasibility and Missions (cont.)

Scope and feasibility

a. The depot concept

b. Propellant Sources

c. Order of Magnitude Scale

d. Costs

Depot	Mission	Refueling requirement once(t)
LEO	Human GEO mission	53.2
	Robotics GEO launch mission	19.6
	Robotics GEO refueling mission	32.3
	Human lunar mission	21.5
	Human asteroid mission	21.5
	Human Mars mission	21.5
EML1	Human lunar mission	31.9
	Human asteroid mission	13.9
	Human Mars mission	78
MPO	Human Mars mission	88

Part 2-Technologies

Key Technologies

- a. List of the key technologies*
- b. Fundament and Status of key technologies*
- c. Spin-in and spin-off from non-space sectors*
- d. Risks assessment*
- e. Challenges*
- f. Potential solutions*
- g. Schedules and costs*

Part 2-Technologies

Key Technologies

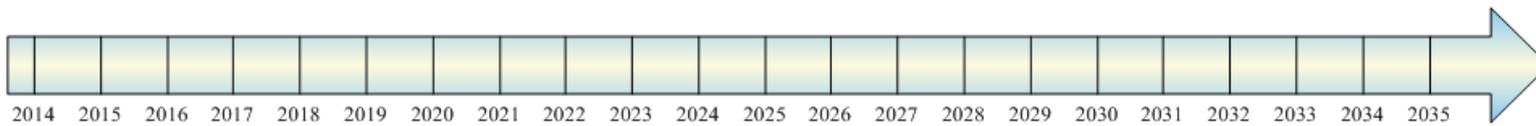
a. List of the key technologies

- 1. The cryogenic propellant boil-off control*
 - a) Passive insulation*
 - b) Reducing the structure heat load*
 - c) Cryocoolers*
 - d) Para-Ortho Conversion*
 - e) Sun Shield*
 - f) Subcooling propellant*
- 2. Cryogenic propellant transfer*
- 3. Tank pressure control technology*
- 4. Assembly attitude control for propellant refuelling*
- 5. Liquid sloshing and large structure coupled dynamic modeling and control*
- 6. Power supply and management*
- 7. Low acceleration settling*
- 8. Cryogenic propellant gauging*

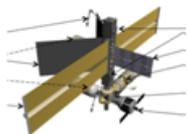
Part 3-Programmatic and Implementation

Roadmap for the implementation

- a. Private vs. institutional initiatives*
- b. International capabilities and possible contributions*
- c. Global set of requirements*
- d. Enabling technologies required with the required time frame*
- e. Programme and operational sustainability*
- f. Environmental impact*
- g. Outreach aspects*
- h. Cooperative framework*
- i. Decision roadmap***



2013



2013-2025
Technology demonstration

2025-2035
Depot building



2013 - 2025
LEO EELV / Reusable propellant carriers

2013 - 2023
LEO to GTO Reusable space transfer vehicles

2013 - 2028
LEO to EML1/EML2 and GEO Reusable space transfer vehicles

2013 - 2033
EML1/EML2 to Moon surface Reusable space transfer vehicles



2013 - 2035
Water to Lox/LH production capability on lunar surface

2013 - 2035
Lox/LH production from water in EML1/EML2



Schedule



International Academy of Astronautics

Oct. 2015

Finish the Commission review.

End of 2015

Finish the Academy review.



International Academy of Astronautics

Thanks!

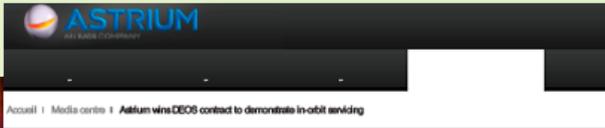
IAA Commission 3
Study Group 3.22

**Next-Generation Space System Development
Basing on On-Orbit-Servicing Concept**

By Prof. Dr. Yury Razoumny, Chair SG 3.22

October 10, 2015
Jerusalem, Israel

Satellite On-Orbit Servicing Activities in Different Countries



ASTRIUM
A world of possibilities

Actual | Media center | Astrium wins DEOS contract to demonstrate in-orbit servicing



On-Orbit-Servicing Activities within the German Space Agency



DARPA

Broad Agency Announcement
Phoenix Technologies
Tactical Technology Office (TTO)
DARPA-BAA-12-02
December 22, 2011

On-orbit Satellite Servicing "Status and Strategy of Japan"

May 2012
Mitsushige Oda (Prof. Dr.Eng.)
Japan Aerospace Exploration Agency (JAXA)
Tokyo Institute of Technology



KAYSER-THREDE



Swedish Space Corporation



SENER



ORBITAL
SATELLITE SERVICING

OLEV – AN ON-ORBIT SERVICING PROGRAM FOR COMMERCIAL SPACECRAFTS IN GEO

C. Kaiser, Kayser-Threde GmbH, Germany
J. Kugelberg, SENER, Spain



Market Interest in Fleet Management On Orbit Services – a Commercial Approach

NASA On Orbit Servicing Workshop
UMUC, 24 March 2010
Baard EILERTSEN – Swedish Space Corporation



MDR Robotics
a MacDonald Dettwiler company

17th Annual AIAA/USU Conference on Small Satellites
Technical Session IV - Extending On-Orbit Life

A Small Satellite Concept for On-Orbit Servicing of Spacecraft

Tim Reedman, Andrew Allen - MDR
Sinclair Interplanetary
August 12, 2003
Provo, Utah

Directions for the Development of Satellite On-Orbit Servicing

Direction I

Making satellites and satellite constellations serviceable

- a capability of docking with the serviced satellite
- a guaranteed access to the satellite components
- block-modular satellite structure
- detachable and installable blocks and modules
- unified detachable blocks (modules)
- standardized hardware and connectors
- functional partitioning of the blocks (modules)
- maximal complexation of missions on-board a single satellite
- selection of the satellite's period of use with regard to servicing
- **satellites orbits and constellation optimization using the concept of their on-orbit servicing**

Direction II

Creating servicing satellites and constellations for solving the tasks of satellite on-orbit servicing

- development of servicing methods and servicing systems, including the ones with the use of ISS, using experimental automatic satellites
- creation of the space complex for transferring satellites, upper stages and their fragments to the disposal orbits
- creation of the space complexes:
 - On the 1st stage - complexes for refueling and replenishing expendables
 - On subsequent stages:
 - complexes for the replacement of separate modules, devices and systems
 - upgrade of the purpose-designed equipment for the solution of new problems
 - dismantling out-of-order satellites and utilizing their elements
 - refueling upper-stages of the carrier rockets on the parking orbit so that they could be used as boosters for the injection of satellites into geostationary orbits and transfers to the Earth escape trajectories
- **servicing satellites orbits and constellation optimization**

Two Approaches to Orbit Selection and Constellation Design for Servicing and Serviced Satellite Formations

Problems to solve for making on-orbit servicing economically efficient	Solutions
1. Equipment for maintenance in space is in most cases rather costly	1. Implementing reusable equipment for servicing several satellites in succession, instead of a single satellite at a time
2. Orbital plane changing maneuver is known to be the most energy-demanding, hence, servicing maneuvers may be costly with regard to required delta-V (fuel) budget on-board the servicing satellite	2. "Clustering" of the orbits and constellations of serviced satellites, with a special selection of servicing satellites assigned to each cluster

Hence, two basic approaches to the selection of orbits and constellations of serviced and servicing satellites are considered:

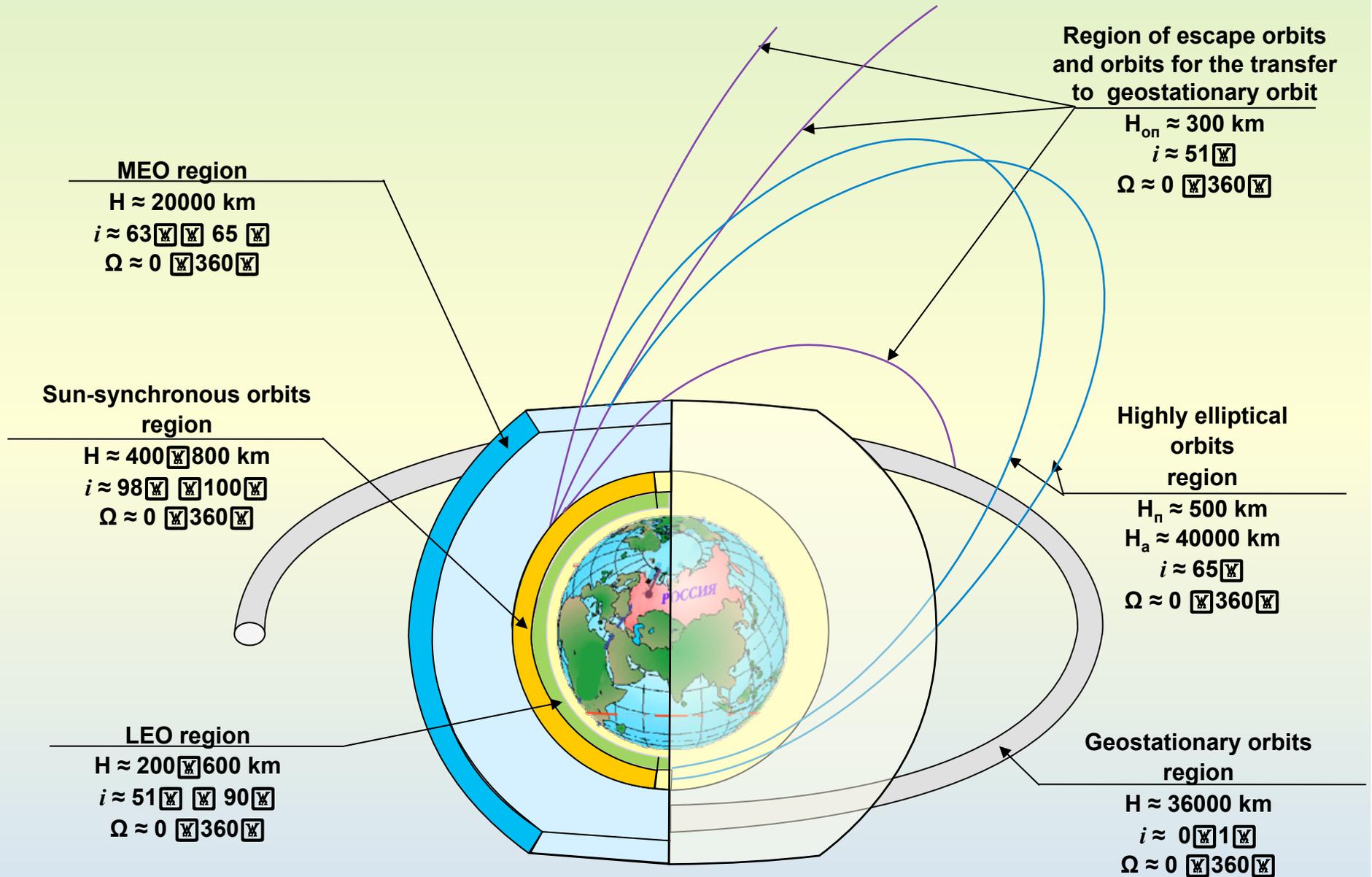
1) optimization of serviced satellites orbits and constellations basing on their "**rigid clustering**" with the distribution of servicing satellites in each cluster;

2) optimization of the servicing satellites orbits and constellation with regard to the criterion of the minimal cost (minimal required delta-V budget on-board a servicing satellite) of servicing operations for the "**unclustered**" (low "clustered") given formation of satellites , which is difficult for "rigid clustering".

Note: "Cluster" means a group of satellites, situated on the same orbit or on close orbits.

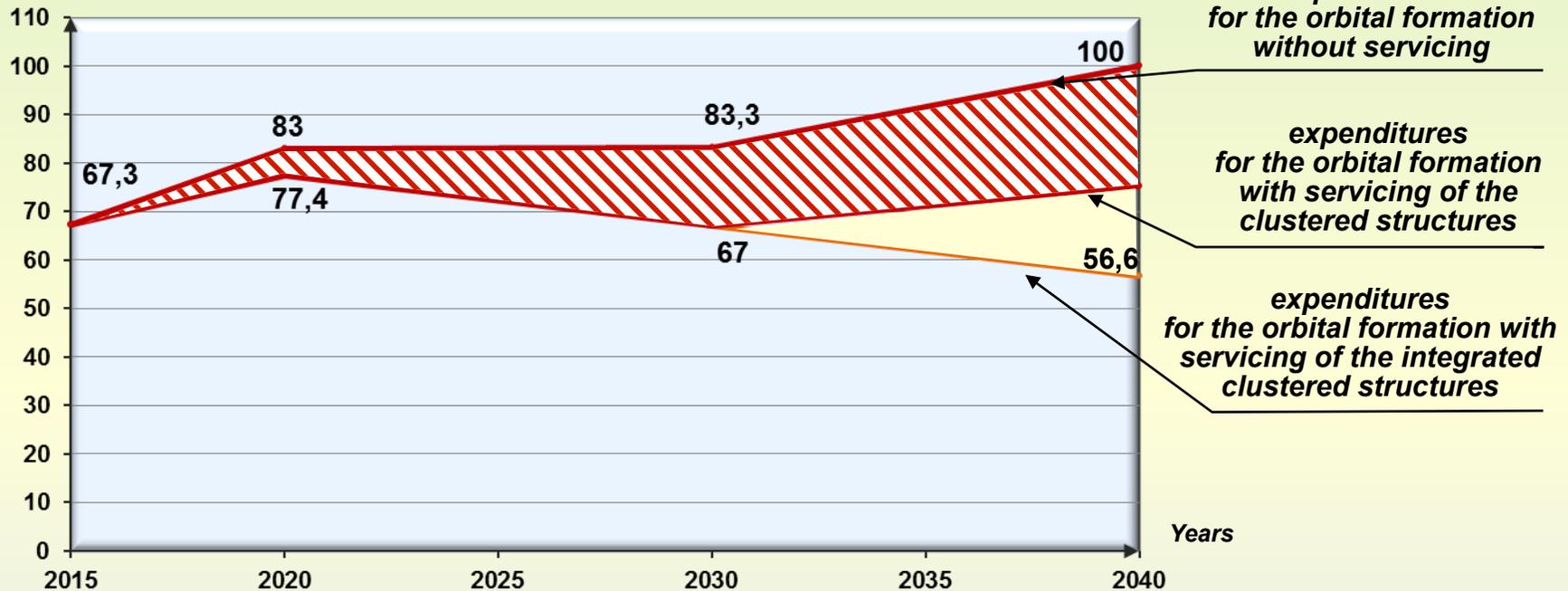
"Clustering" – the process of distributing the serviced satellites in separate groups ("Clusters").

Typical Regional Structure of the Satellite Formation (Basing on Russian Space Infrastructure)



Cost Estimation for Deployment and Keeping of Russian Orbital Formation (percent of predicted expenditures for the orbital formation in 2040 at 2013 values)

% of predicted expenditures
for the orbital formation
in 2040 at 2013 values



- cost reduction due to providing the servicing of clustered structures

- additional cost reduction due to providing the servicing integrated of clustered structures

Effect:

1. Servicing of clustered structures leads to reducing a cost of deployment and keeping of Russian orbital formation by 25%

2. Servicing of integrated clustered structures could yield a cost reduction up to 40%

Conclusion

1. Solid international experience of on-orbit servicing of large-scale, durable, unique manned orbital stations proved to be useful for developing new techniques for on-orbit servicing. At the same time creating the next-generation space systems basing on on-orbit-servicing concept leads to considerable reduction of the cost of deployment and keeping the space global infrastructure, but seems to be much more complex.
2. The cooperation of the leading world experts, provided on the base of IAA SG 3.22, for the sake of developing various technical aspects in respect of creation of next-generation space systems using the concept of on-orbit servicing gives a chance to minimize national expenditures for perspective space activities.

IAA Study Group Status Report

Responsible Commission: Commission III

Study Number and Title: 3.24 Road to Space Elevator Era

Short Study Description (repeat from Study Group Proposal):

This SG is the follow-up of the SG3.13 “Assessment of the Technological Feasibility and Challenges of the Space Elevator Concept” with the same baseline design assumptions.

Development of a unique space transportation system of the future, called a space elevator, should be accomplished with more international cooperation and should contribute to the overall development of space science and systems development. To accomplish these desires, projects are identified that can be accomplished in the near future leading to risk reduction and engineering enhancements. Specifically, the following practical on-orbit verification projects could be planned and promoted through this study group's activity.

- (1) Promotion of ISS (International Space Station) utilization and leveraging of Small Satellite (Cube, Micro, etc.) concepts to accomplish on-orbit verification; such as, advanced material research (ex. material exposure experiment) and development while extending tether technology development.
- (2) Promotion of space technology spin-out into industrial application (and vice versa) by the collaboration with civil engineering, architectural engineering, and space engineering experts.
- (3) Plan and execute precursor missions, leveraging existing technology, to demonstrate prototype space elevator segments. (ex. Marine Node for sub-orbital rocket launch; tether satellites for dynamics of deployment; movement around Earth-space with low thrust, high efficiency rocket motors demonstrating start-up activities.)

Progress in past six months:

- (1) 2 meetings was held in Paris (March, 2015) and in Seattle (August, 2015).
- (2) Several updates of Space Elevator Mission Definition Document (SEMDD) for IAA Study Development based on past IAA study result and other inputs from study group members. This product will be used as a tool for reviewing the advancement of critical technologies required to implement the Space Elevator.

Website Study Information update: (please give any update regarding Study Group Membership, documents, Study Plan and Schedule):

- (1) On the Activities, please add the following meetings:
-Study group meeting, Monday 12 October 2015, 08h00-09h00, Jerusalem, Israel

- (2) On the Activities below, please link minute of meeting file as Ms. Sakurako Takahashi provided by e-mail on 19 Sep as a response of “IAA status report form for study group 3.24 (IAC 2015 Jerusalem)”
- Study group meeting, Monday 23 March 2015, Paris, France
- Study group meeting, Thursday 20 August 2015, Seattle, USA

Issues requiring resolution? (recommend approach):

None

Product Deliveries on Schedule? (If modified explain rationale):

No change

Study Team Member Changes? (List any Study Team Members that you wish to discontinue, and provide names plus contact coordinates of any Members you wish to add on the second page of this Study Update form.) Note: Complete contact information including email, tel. and fax must be provided for all additions. Only Members with complete contact information will be listed and receive formal appointment letters from the IAA Secretariat.)

No change

Name of person providing Study Group Status (Study Group Chair or Co-Chair):

Mr. Akira Tsuchida

Status Report Date: September 27, 2015



The Maintainability and Supportability of Manned Spacecrafts in Deep Space

Prof. Hong YANG

Dapeng ZHANG

Prof. Chuanfeng WEI



中国航天科技集团公司五院 载人航天总体部
中国航天 Institute of Manned Space System Engineering , CAST , CASC

Contents



1 Requirements

2 Overall Goals

3 Technical Approaches

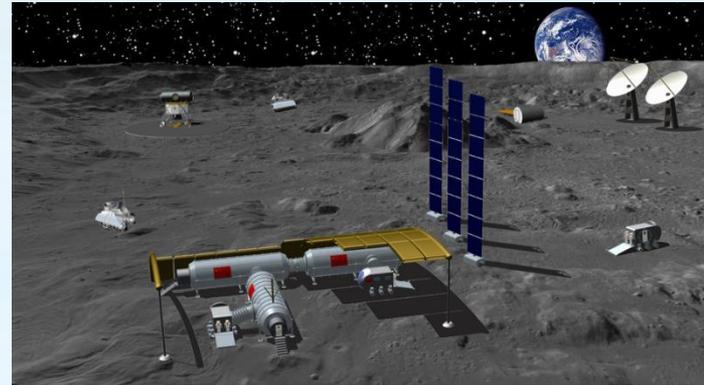
4 Performance of Manned S/C in Deep Space

5 Research Contents



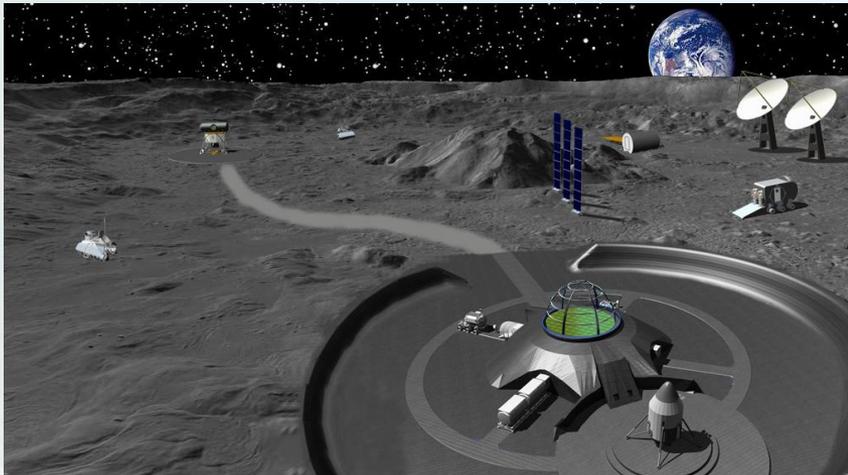
1 Requirements

During long-term flight for deep space manned spacecraft, the flight resources are limited. It is different to LEO space station whose repairs and maintenance can be ensured by regular supply from Launch Vehicle. And the number of astronauts is also limited to carry out repairs and maintenance by EVA in deep space.



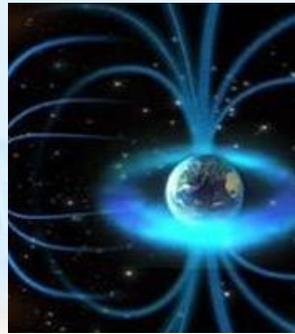
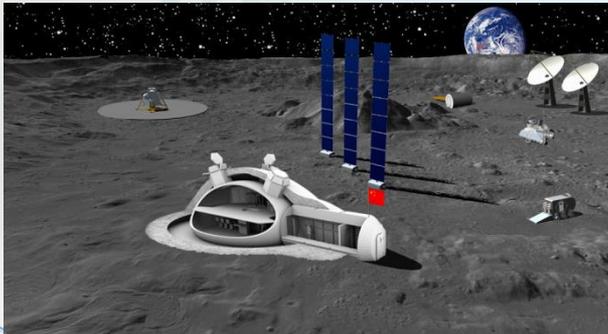
1 Requirements

Therefore, it is necessary to research the preventive maintenance and supportability of deep space manned spacecrafts with the flight constraints of limited flight resources.



2 Overall Goal

By analyzing the requirements and characteristics of manned deep-space spacecrafts on maintenance and support, it will be built which a new set of methods and solutions accommodate to manned deep-space missions, and the key technologies will be break through on the predictive supportability with limited resources, in-situ manufacture and repair, and space waste management and recycling.



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中国航天 Institute of Manned Space System Engineering, CAST, CASC

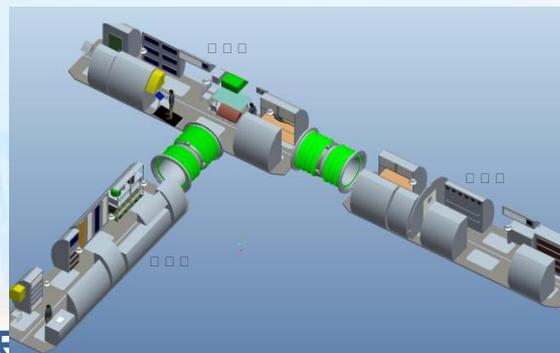
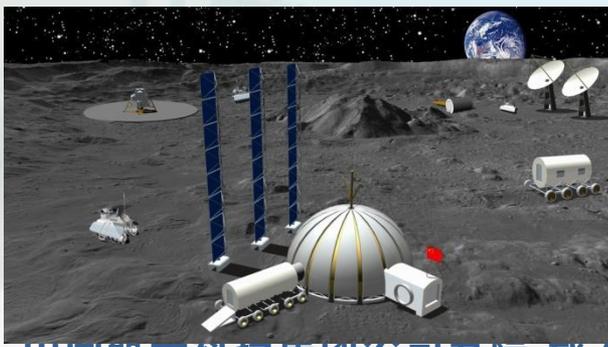
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3 Technical Approaches

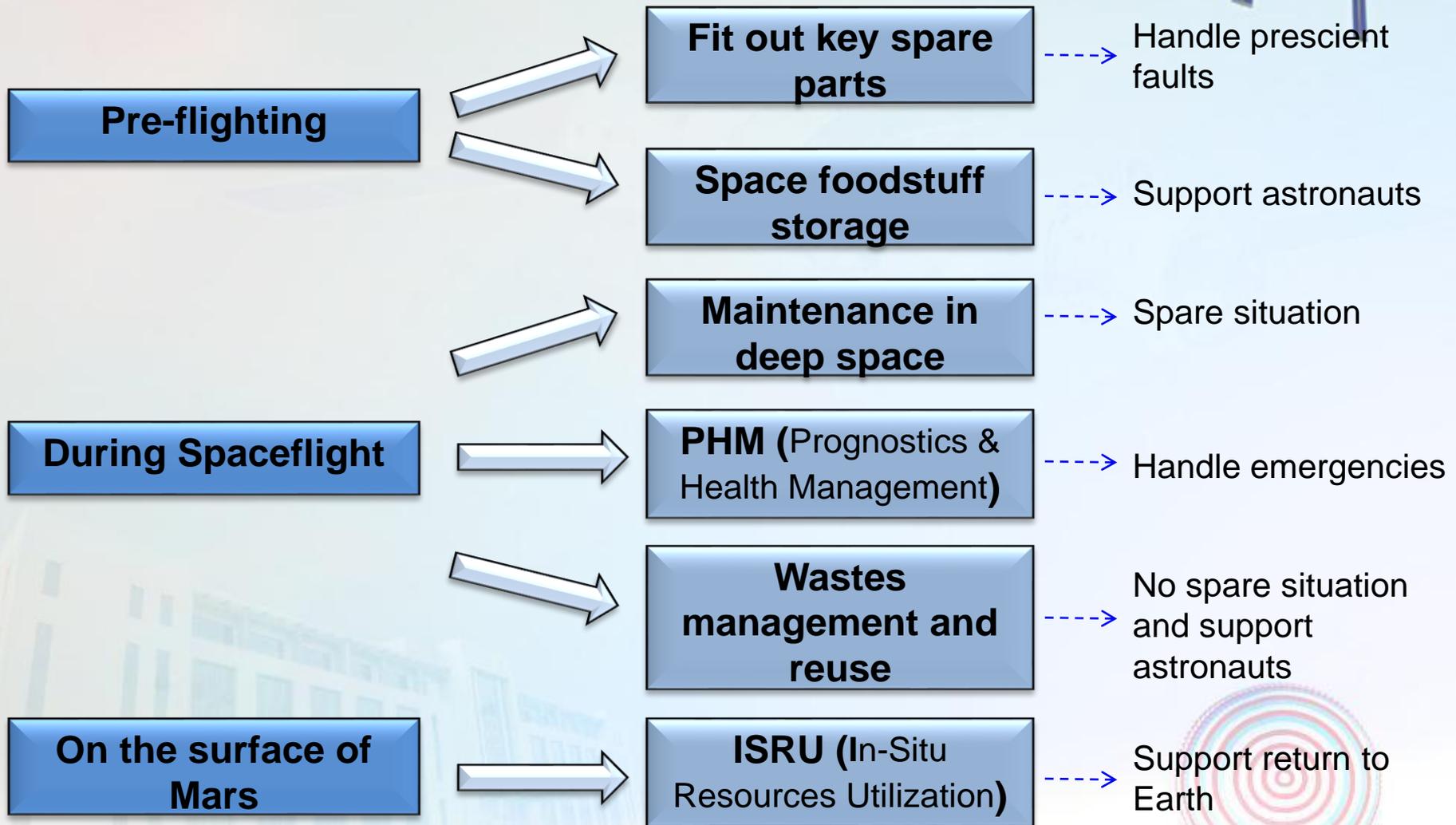


The object of our study:

Manned spacecrafts to Mars will be as the object, we will base on the mainstream scenarios of the international manned Mars programs, analyze needs of the maintainability and supportability in manned Mars programs and the more distant manned space exploration taken into account meanwhile, construct the maintainability and supportability system of deep space manned spacecrafts.



4 Performances of Manned S/Cs in Deep Space



5 Research Contents



1. System technologies

- To analyze the requirements and characteristics of manned deep-space spacecrafts on maintenance and support which is different to manned near Earth spacecrafts.
- To develop the process plan and strategies of the maintainability and supportability on manned deep-space spacecrafts.
- To analyze the adaptability of the maintainability and supportability with different manned deep-space missions.



5 Research Contents



2. Supportability technologies in deep space

■ To determine the prediction methods under the conditions of limited resources to confirm the necessary spare parts and raw materials.

- Space propulsion spares
- Space power spares
- ECLSS spares
- Avionics
-

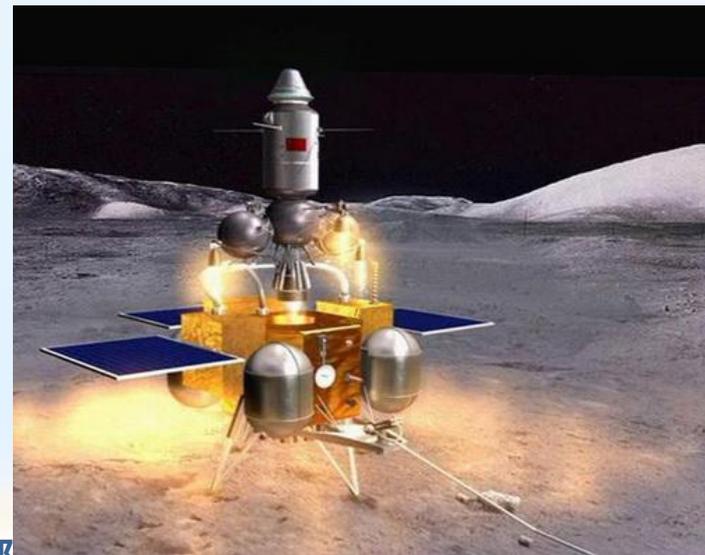


5 Research Contents



2. Supportability technologies in deep space

- To research the new methods of life support to astronauts, for instance: carrying on-board equipments to product space foods with raw materials will be analyzed and calculated form Earth or other celestial



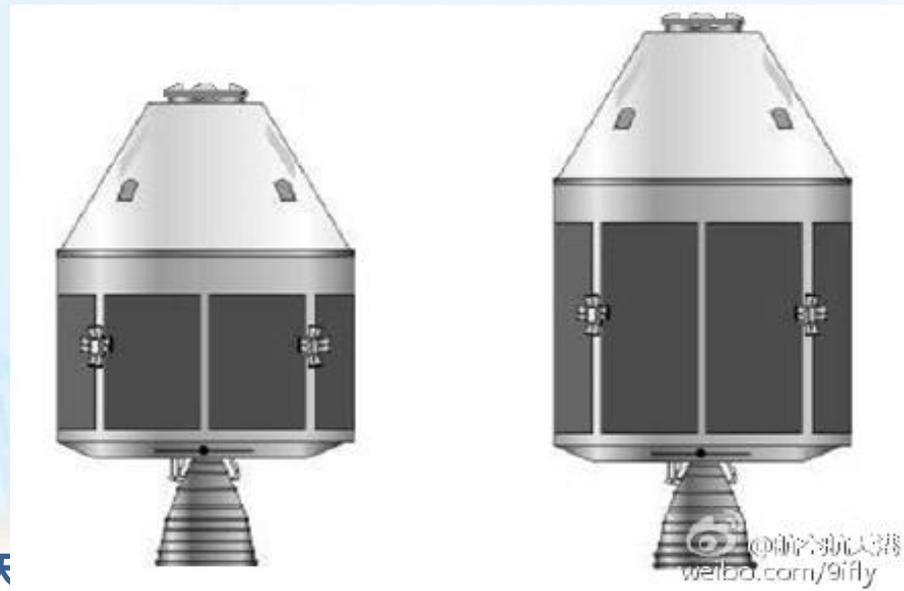
5 Research Contents



3. PHM technologies in deep space

■ To provide the prediction methods on the dynamic random failures during the flight, the evaluation and self-decision-making, as well as system formation autonomous and reuse technology.

- FMEA, FTA
- BIT
- FDIR
- Autonomy



5 Research Contents



4. Maintenance technologies in deep space

■ To collect the space maintenance and repair on manned deep-space spacecrafts.

- robots, humanoid robots, human-machine collaborative
- passive maintenance and fence
- active maintenance: space jointing, rapid prototyping

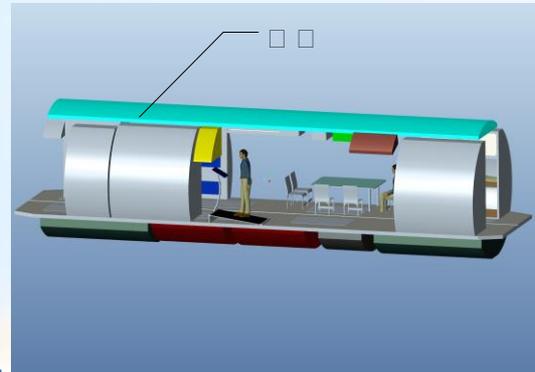
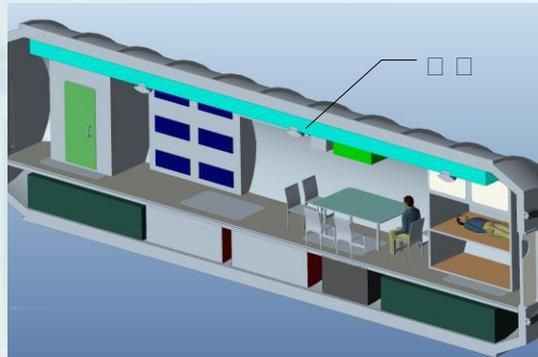


5 Research Contents



5. ISRU technologies

- To determine in-situ manufacture and repair on consumables and spares.
 - spacecraft consumables: propellant
 - life support consumables: foods, water.....
 - spare parts
- To research how to collect, break away, epurate, and store the in-situ resources on Mars surface.

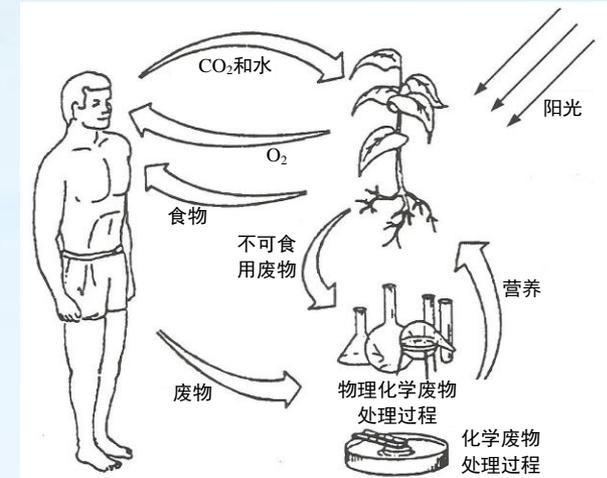


5 Research Contents



5. ISRU technologies:

- To determine space waste management and recycling.
 - epurate materials from wastes, maybe spare equipments, even abandoned spacecraft cabins
 - reproduction: spares, foods



Our Study Group



Proposer(s):

YANG Hong (IAA academician, chief designer of Chinese Space Station)

Members of Study Team

Chair(s): YANG Hong



Co-Chair(s): TBD

Secretary: ZHANG Dapeng



Our Study Group



Other Members of Study Team:

China: WEI Chuanfeng, ZHANG Dapeng, LI Zhihai

USA: Pedro Lopez Jr. (TBC), Eric Schultz(TBC), Bryan Mattfeld(TBC), Chel Stromgren(TBC)

France: Muriel Le Bozec(TBC)

Brazil: Terezinha Ribeiro de Carvalho(TBC)

Australia: WU Xiaofeng



Forming an IAA Study Group



IAA Commission Preference:
Commission 3

Methodology:

Establish a working website, E-mail, teleconferences, and face-to-face meetings.

Time Line:

2015.10: Set up our study group

2016.3: Outline of our study group

2017.3: a draft report to the IAA

2018.10: Submission of a Final Report to the IAA

Final Product:
Report



Contact Information



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qiumoonbird@163.com (ZHANG Dapeng)





Thanks for your Attention!

谢 谢!

一切为载人, 全力保成功



Proposal for Forming an IAA Study Group

Title of Study: Space Mineral Resources # II: National Authority for Extra-Terrestrial Resource Utilization and Beneficiation based on the Outer Space Treaty

Proposer(s): Roger X. Lenard, Arthur M. Dula, Zhang Zhenjum,

Primary IAA Commission Preference: Commission III

Secondary IAA Commission Interests: Commission V

(From Commission 1 to Commission 6)

Members of Study Team

Chair(s): Arthur M. Dula & Zhang Zhenjum

Secretary: Roger X. Lenard

Other Members:

Susan Lower McKenna

Peter Swan

Cathy Swan

George Nield

Short Description of Scope of Study

Overall Goal: To provide the appropriate approach for teams in the public and private sectors to progress into space leveraging the extra-terrestrial resources available. The investigation will look across the technological, legal, and programmatic challenges. Emphasis will be upon the Outer Space Treaty recognition of national authority and the ability to utilize resources in space for public and private activities. The concept is that humanity must move beyond low Earth orbit in a timely manner leveraging the strengths of each nation.

Intermediate Goals: Investigate and report upon:

- An updated Global Exploration Roadmap with commercial programs added to or leveraging government plans
- Available Technologies, launch, propulsion, space mining, transportation, storage, and transferring assets in-space, on asteroids, at the Moon, Mars, and beyond. The key is to identify technology readiness and risk reduction activities needed to progress off-planet.

- **Programmatic issues such as funding, cost to orbit, developmental times and investment potential for mining space mineral resources. This would show government investment planning and commercial economic models.**
- **Legal challenges and authorities based on the OST to exploration and utilization of resources beyond low Earth orbit, to include Asteroids, Lunar and Martian locations.**
- **Governance from the view of how to implement appropriate oversight for public and private projects. Expansion of the concept that the Outer Space Treaty provides the legal basis for national responsibility for each nation's space activities; to include, civil, defense, and commercial.**

Methodology:

Create Study Group – gain approval – IAC Israel Meeting [Oct 2015]

First Meeting by Paris 2016

Form Team – by Paris 2016

Create path to follow – by Paris March 2016

Work on study – March 2016 to October 2018

Develop study report – Mar 18 – Dec 18

Final study report approved by commission III Mar 2019

Academy Level peer review and then publishing by Sept 2019

Plenary at IAC and discuss findings in technical sessions

Time Line:

See above

Final Product Book Published Sept 2019

Target Community:

Commercial space scientific, technical and business community; mineral extraction, processing and marketing firms worldwide, space policy makers and officials responsible for assuring adequate future supply of critical minerals.

Support Needed: volunteer Academy members

International Academy of Astronautics (IAA)

-3-

Instructions and application form: see: "Scientific Activity" section at <http://iaaweb.org/content/view/256/393/>

Potential Sponsors:

To be returned to the IAA Secretary General Paris

*by fax: 33 1 47 23 82 16 or
by email: sgeneral@iaamail.org*

Date: 15 Oct 2015

Name: Roger Lenard

(No Signature required if document authenticated).

International Academy of Astronautics (IAA)

-4-

Instructions and application form: see: "Scientific Activity" section at <http://iaaweb.org/content/view/256/393/>

Follow-up Section for IAA use only

Initial Phase

Application received:

Commission Approved:

SAC Approved:

Web Site Section opened:

Members Formally Appointed by IAA:

Final Phase

Peer Review by Commission Completed:

Recommended by the Commission:

Final Report Received:

SAC Approved:

BOT Accepted:

Publisher Selected:

Study Published:



International Academy of Astronautics

SPACE DISPOSAL OF RADIOACTIVE WASTE

Study Group 3.21

REPORT ON STUDY PROGRESS

March 2015



SG 3.21 MEMBERS

On March 2015 members of the Study Group 3.21 “Space Disposal of Radioactive Waste” are:

Baranov Eugeni		Ukraine
Degtyarev Olexandr	M	Ukraine, Chair
Genta Giancarlo	M	Italy
Kostenko Victor		Ukraine
Kushnaryov Olexandr	CM	Ukraine
Pastor Vinader Miquel		France
Pyshnev Vladimir		Ukraine
Ramusat Guy	CM	France
Slyunyayev Mykola	M	Ukraine
Takahashi Sakurako		Japan
Ventskovsky Oleg	M	Ukraine
Antoni Ntorina		Greece

A number of specialists (who are not formally the Study Group members) will take part in preparation of separate sections of Final Report.



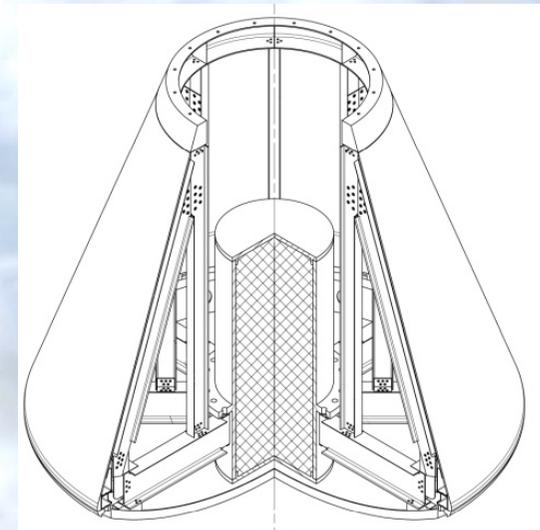
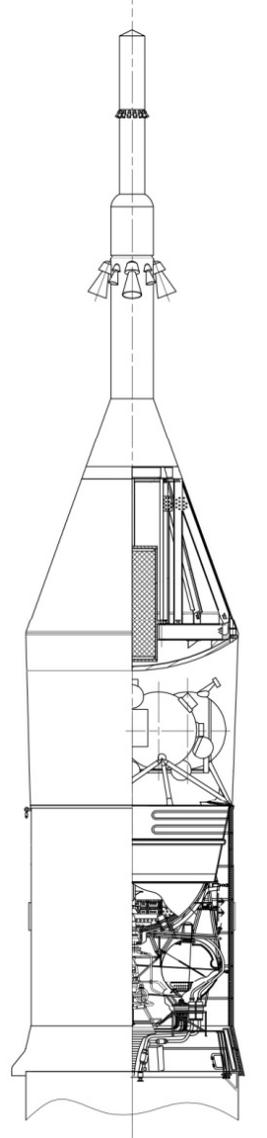
PROGRESS IN PAST SIX MONTHS:

Preparation of Draft Final Report materials is completed in general. Particularly:

- The approaches to selection of the target isotopes, subjected to the space disposal as well as capabilities of their conditioning and immobilization have been defined;
- Safety requirements at all phases of RW handling have been defined;
- The possible places for RW space disposal as well as possible methods of RW delivery into disposal places using the traditional launch vehicles (LV) or alternative methods have been considered;

PROGRESS IN PAST SIX MONTHS:

- Technical layout of Space Launch System for RW space disposal using the traditional launch vehicles has been defined;
- It is shown that the technical issues related to creation of Space Launch System and RW safe delivery to the target orbits can be resolved, despite the necessity of extensive complex of R&D works;





PROGRESS IN PAST SIX MONTHS:

- The risks associated with the RW space disposal have been defined; their technical composition has been estimated;
- The “Design Accident” concept for this project has been defined;
- It is shown that the RW space disposal safe technology can be used to delete any hazardous materials from the biosphere (biological, chemical etc.);
- A list of scientific and technical issues to be resolved for the project successful implementation has been defined;
- The volume of legal issues to be fixed in order to authenticate the RW space disposal conception is being defined.



PROGRESS IN PAST SIX MONTHS:

- **It is shown that RW space disposal using the traditional LV is economically disadvantageous at the present moment. It has been determined the cost limit of a unit of the RW to be injected at the intermediate Earth orbit, lower which the cost of the RW space disposal becomes comparable with the cost of RW deep geological disposal;**
- **Possible scientific-industrial cooperation necessary for RW space disposal project successful implementation is being defined.**

Draft Report will be sent round the study group participants after completion its translation.



PROGRESS IN PAST SIX MONTHS:

- **Ms. Ntorina Antoni joint as a member of the Study Group responsible for legal issues study;**
- **In-person meeting with study group 3.24 “Road to Space Elevator Era”, discussion of opportunity to use space elevator for RW space disposal took place at October 2nd, 2014 in the frame of IAC-2014 in Toronto, Canada.**