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To my Daughter

Preface

The objective of this book is to introduce commercial space activities and commercialization processes in the last 15 years and to give an idea of the future challenges NewSpace companies are bound to face when developing commercial space markets. What is new and what has happened in these markets during that period? Is there a business case for private companies for commercial space? What are the targeted commercial space markets? Could the targeted markets of NewSpace companies alone encourage the development of orbital commercial space transportation services? Who are the future customers for commercial space transportation markets? How can NewSpace companies attract investors? Is there an existing business model that encourages this evolution, and what is it? Can we learn lessons from the traditional space industry or other industries? What are the lessons learnt from ISS commercialization for encouraging the creation of sustainable NewSpace markets?In what way has the last 15 years made a difference in the evolution of space markets? Is there a future for the commercialization of space station services? These are some of the issues which will be discussed in this book.

Commercial Space Activities

Over the past 20 years, space agencies have been exploring ways to encourage private companies to get involved in the development of commercial space markets. Commercial launch services, space tourism, in-orbit satellite servicing, space debris mitigation and space-based resource exploitation are some of the markets worth exploring.

During those years, space agencies have learnt that commercialization of space technology, built for scientific purposes, is challenging and difficult. Yet it also holds the promise of new market opportunities, the development of new space transportation vehicles and new space applications.

In the early days of ISS commercialization, space agencies set up common objectives and policies for encouraging the commercial utilization of the ISS on-board resources by non-space companies (e.g. Pharma, Biotech, Medical Device companies, etc.). However, in recent years, the ISS partners (e.g. NASA, Roscosmos, ESA, JAXA, CSA) have undertaken vastly different approaches towards commercial space activities.

The USA decided to follow the path of encouraging the development of a competitive commercial space transportation industry and of strengthening US leadership in space-related science, technology and industry. This led to the creation of a "robust and competitive commercial space sector" to enhance capabilities for assured access to space (National Space Policy of the United States of America, 2010, 28th of June). This encouragement was driven by the Shuttle retirement in 2012, NASA's expensive dependency on Roscomos for flying US astronauts to the ISS and budgetary constraints.

Through implementation of the NASA COTS and CCDev programmes, the USA fostered the development of a commercial space transportation industry and the development of orbital (e.g. Dragon, Cygnus, CST-100 Starliner) and sub-orbital transportation vehicles (e.g. XCOR Lynx, etc.). This successful path continued when NASA encouraged the implementation of similar programmes for future lunar missions (e.g. Lunar Catalyst programme), future Mars missions or asteroid mining missions, such as the Asteroid Redirect Mission (ARM).

In Europe, the ESA undertook a "bottom-up" approach towards implementing a space exploration user-driven exploitation strategy driven by objectives related to "science, economics, global cooperation and an inspirational dimension". Therefore, the envisaged strategic partnerships with the private sector in the space and non-space industry may lead to products or services with the longer-term objective of commercial viability (ESA, Call for Ideas, Space Exploration as a Driver for Growth and Competitiveness: Opportunities for the Private Sector, 2015, 1/03/2015).

Fig. 1 The first Cygnus commercial cargo spacecraft built by Orbital Sciences Corp. is photographed by an Expedition 37 crew member on the International Space Station during rendezvous and docking operations and SpaceX Dragon cargo grappled by the Canadarm (Credit: NASA)

This "bottom-up" approach for gathering ideas will help ESA create future programmes that will encourage the development of sustained exploitation of ISS research utilization (e.g. lower cost, shorter time to access, increased number of commercial companies, etc.), further evolution of Space 4.0[1] and regular ISS access for the European user community. In response to the changing environment in the global space arena, in 2017, ESA launched the Grand Challenge which is an initiative to generate ideas, foster innovation, support cost-effective R&D and encourage the development of new space applications.

Over the past 35 years, Europe has emerged as a recognized player in the commercial space satellite launch market because of the successful Ariane launcher. In order to sustain this competitive edge, Europe is now developing the Ariane 6 launcher, which offers Ariane launch reliability which is coupled with a competitive price advantage (Rumpf 2015). The European space industry will have to find a balance between political and market forces, due to increasing competition from US NewSpace companies in the commercial space transportation markets. Nevertheless, implementing a " bottom-up" approach for gathering ideas for the European space exploration strategy will result in new concepts that will offer unique commercial market opportunities, not only to space companies but also to non-space industries (e.g. Pharma, Biotech, etc.).

Background

The successful assembly of the ISS encouraged space agencies to start looking at various ways to secure low-cost access to the station and to encourage the development of new ways to utilize microgravity environment.

In recent years, the USA changed its strategy towards commercial human spaceflight and focused on setting up goals for recapturing leadership in the commercial space transportation market by reducing launch costs, thereby ensuring a sustainable and efficient access to space (National Space Policy of the United States of America, 2010, 28th of June).

Driven by the need to have reliable and permanent low-cost transportation access to the ISS and to eliminate its dependency on Russian launchers, NASA launched two new programmes in 2005, COTS and CCDev programmes, discussed in Chap. 1.

With the launch of these programmes, NASA hoped to encourage the development of privately owned commercial space transportation vehicles and to boost the development of commercial space transportation markets. The successful evolution of these programmes in the last 10 years led not only to the development of new launchers like Falcon and Antares but also to the creation of the first commercial

[1]Space 4.0 is considered to be the evolution in the space sector into a new era, through interaction between governments, private sector, society and politics (ESA 2016d).

transfer vehicles Dragon and Cygnus. They were successfully docked several times to the ISS, transporting experiments and food to the ISS astronauts. All private companies involved in investing, developing and building orbital and sub-orbital space transportation vehicles or offering commercial services and products are referred to as NewSpace companies.

The emergence of commercial spaceflight activities are, however, not new to the international space community. For example, in the late 1980s and early 1990s in the USA, a private company known as Spacehab developed a commercial module to host experiments in the Shuttle Bay. In 1995, NASA signed a $54 million contract with the company in support to the Shuttle/MIR logistics flights (Spacehab 2015). In the mid-1990s, Russia's first attempts for commercial utilization of the MIR space station emerged from the need to attract funding in order to keep the MIR station operational[2]. The difficulties of the inevitable economic transition to a market economy pushed the Russian space industry to face symbolic space budgets. Russian space officials quickly identified new markets and encouraged the setup of space entertainment projects (Tkatchova 2011). A few examples include flying a Japanese journalist to the MIR space station in 1990, the launch of the Pepsi and Pizza Hut branding projects and others[3].

In Europe, the interest in commercial human spaceflight services started as a result of the US and Russian commercial activities on board the ISS. They had a potential promise, and in 2000, ESA set up a policy to encourage the commercial utilization of 30% of the ESA Columbus module. Several R&D projects were flown by ESA, linked to osteoporosis research (e.g. OSTEO facility), blood measurement instruments (e.g. BMI), a new generation of energy saving lamps (e.g. high-intensity discharge (HID) lamps) and some promotional products like the Mediet food tray (ESA, ESA Health Care Network 2005) using new food processing technology.

In contrast to the rest of the ISS partners, Japan started its commercial activities a bit later. In 2004, JAXA set up the JAXA Open Space Lab programme aimed at the creation of new projects and the development of a space brand[4]. The ASICS space shoes is an example of such a commercial project. Other interesting commercial projects are related to the development of space products, like space sake and space yoghurt that was flown on the Russian ISS segment. These commercial projects demonstrated the potential existence of commercial space markets, such as cargo/crew transportation markets, space tourism, in-orbit satellite servicing and micro-gravity R&D. Since 2000, commercial space start-up companies, or so-called NewSpace companies, have attracted over USD13.3 billion investment from over

[2]The MIR operations costs per year were between $220 million and $240 million (Astronautix, 1997). For more information, see Chap. 5.

[3]Denis Tito's flight was initially planned to be to the MIR station, however, with the de-orbiting of the station in 2001, Denis Tito flew on the Russian segment of the ISS.

[4]The space brand JAXA launch was called "JAXA Cosmode Project" which provided an official brand for certified space-related products.

80 angel investors and venture-based space companies (Group 2016). According to the same authors, in the early twenty-first century, an average of three space companies were started per year, while in the last five years, the number of new companies has averaged eight per year, with 2015 being the record setting year, with an investment of USD2.3 billion and hundreds of investors, over 66% of which being US-based and 34% being distributed in 25 countries. These optimistic figures may be questioned by European commercial space start-ups, who have difficulties accessing private venture capital in Europe. Certain companies will thrive in the competitive environment, while others like Rocketplane and Excalibur Almaz will have to announce the end of their activities.

Venture capitalists will be looking at a quick return of their investments, high profits and short times for space-based products and services to reach the markets. NewSpace companies will need to discover, identify and target commercial space markets and attract new customers rather than the traditional space agencies. Disruptive technology innovation will be the only way for these companies to win new markets and remain competitive. The use of an inflatable space station module (e.g. BEAM) on board the ISS and the launch of reusable vehicles are some of the examples of imagination capturing innovations taking place. Such an example is the return of a first stage of a rocket back to the launch site several minutes after launch as Space X achieved with their Falcon 9 rocket. These innovations are completely changing the business of the traditional space industry. The following questions arise: Will reusable launch vehicles be much cheaper to use? Will the refurbishing costs for the first stage of a rocket be sufficiently low to have profitability on each launch? Will there be sufficient demand for the reusable vehicles? What are going to be the environmental impacts from using these reusable rockets? Will venture capitalists understand and be willing to invest in the development of these vehicles and inflatable modules?

The market evolution of commercial space transportation markets may step up the demand for development of reusable launch vehicles and encourage the creation of self-sustainable commercial space markets.

With the implementation of the NASA COTS and CCDev programmes, the USA has demonstrated a new vision that encourages the transition from government-led to private industry-led human spaceflight activities in low Earth orbit (LEO). The development of commercial space transportation vehicles under the NASA COTS and CCDev programmes, in turn, will have a direct impact on the European space industry. This evolution may go in two directions: it may either create or constrain opportunities for the emergence of commercial space transportation services in Europe.

European customers needing launch services may choose to directly buy transportation services from US NewSpace companies due to their competitive prices and maturity of their launch vehicles. This in turn will increase the European space industry dependence on non-EU technologies. Understanding the challenges European stakeholders face in the development of emerging commercial space markets constitutes the first step towards analysing the risks and providing different ways of creating commercial space markets in Europe. On the other hand, European space companies may start collaborating with NewSpace companies to create joint

ventures, acquire new competencies and access new markets. In this way, they will reduce Europe's dependence on non-EU technologies.

The pioneering nature of developing new space transportation vehicles, the risks before NewSpace companies in developing commercial spaceflight markets, in defining the unique selling position of their solutions and dealing with the difficulties to attract private investors face similar challenges and risks that private companies and space agencies encountered in the space station commercialization (e.g. MIR, ISS).

Traditionally, space agencies are the biggest public investors in space station development and utilization. Historically, private investors had been reluctant to invest in space station commercial utilization and projects due to high market risks and long space qualification processes of commercial payloads. Private investors had mainly invested in the development of telecommunications, navigation and EO systems (e.g. DigitalGlobe, RadarSat, Deimos Imaging, exactEarth, Skybox). Traditionally, they have considered investments in launch systems and human spaceflight activities as risky and costly.

Conclusions

The commercial utilization of space technology has been a business challenge to the space industry from the early days of the Space Shuttle. For over 20 years, space agencies have been exploring ways to encourage and attract the involvement of private companies in the development of commercial space markets. During these years, space agencies have learnt that commercialization of space technology built for scientific purposes is challenging and difficult, yet it also holds the promise of new market opportunities, the development of new space transportation vehicles and new space applications.

The potential future commercial space markets comprise commercial launch services, space tourism, in-orbit satellite servicing, space debris mitigation and space-based resource exploitation. Since 2000, commercial space start-up companies have attracted over USD13.3 billion investment from over 80 angel investors and venture-based space companies. However, venture capitalists will be looking at the quick return of their investments, high profits and short times for space-based products and services to reach the markets. NewSpace companies will need to discover, identify and target commercial space markets and attract new customers rather than the traditional space agencies. Disruptive technology innovation will be the driver for providing competitive advantages. The use of an inflatable space station module (e.g. BEAM) on board the ISS and the launch of reusable vehicles are some of the examples of imagination capturing innovations taking place. These innovations are completely changing the business of the traditional space industry. The questions that arise are as follows: Will reusable launch vehicles be much cheaper to use? Will the refurbishing costs for the first stage of a rocket be sufficiently low to have profitability on each launch? Will there be sufficient

demand for reusable vehicles? What will be the environmental impacts from using these reusable rockets? Will venture capitalists understand and be willing to invest in the development of these vehicles and the construction of inflatable modules?

The current success of the NASA COTS and CCDev programmes provides a precedent in the US human spaceflight programme and creates possibilities for achieving the successful utilization of the ISS on-board resources. Other space agencies like ESA have undertaken a "bottom-up" approach for gathering innovative ideas for sustained exploitation of ISS utilization (e.g. lower cost, shortened time to access, etc.). The successful evolution of these programmes and the creation of self-sustainable commercial space markets may encourage space agencies to implement similar programmes for future Lunar or Mars missions.

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About the Book

This book analyses the commercial space activities and commercialization processes of the last 15 years and maps the future challenges that NewSpace companies will face developing commercial space markets.

What is new and what has happened in these markets up till now? Is there a business case for private companies for commercial space? What are the targeted commercial space markets? Who are the future customers for commercial space transportation markets? How can NewSpace companies attract investors? Can we learn lessons from traditional space industries or other companies in other areas? In what way have the last 15 years made a difference in the evolution of space markets? Is there a future for in situ resource mining, space debris services, in-orbit satellite servicing and sub-orbital transportation? What are the lessons learnt from ISS commercialization?

In addition the reader will find a synopsis of several space transportation programmes, commercial space markets, future Moon and Mars missions, in situ resource exploitation concepts, space debris mitigation projects and sub-orbital commercial markets. Major lessons learnt are identified, related to the attraction of first-time customers and long-term R&D funding, managing technological and market risks and developing new markets and applications.