From Space Exploration to Commercialisation

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The research described in this thesis has been carried out at the European Space Agency (ESA)-ESTEC at the Commercial Promotion Office (CPO).

To my Mum

Abbreviations

ATV Automated Transfer Vehicle

BF Business Function

CA Commercial Agent

CET Commercial Evaluation Team

CIAC Canadian ISS Access Company

CPO Commercial Promotion Office

EAC European Astronaut Centre

EDR European Drawer Rack

EMCS European Modular Cultivation System

EPA External Pallet Adapter

ESA European Space Agency

ESFR European Synchrotron Radiation Facility

EVA Extravehicular Activities

FSL Fluid Science Laboratory

GDP Gross Domestic Product

H-IITV H-II Transfer Vehicle

ICT Information and Communication Technology

IGA Intergovernmental Agreement

IPCD ISS Partners Direct Competition Scenario

ISIS International Sub-rack Interface Standard

ISPR International Standard Payload Rack

ISS International Space Station

IVA Intravehicular Activities

JAXA Japanese Aerospace Exploration Agency

JEM Japanese Experiment Module

JIBF Joint ISS Business Function Scenario

MAP Microgravity Applications Programme

MC Marginal Cost

MCG Multilateral Commercialisation Group

MDL Mid Deck Lockers

MFC Microgravity Facilities for Columbus

MOU Memorandum of Understanding

MR Marginal Revenue

NASA National Aeronautics and Space Administration

NOAA National Oceanic and Atmospheric Administration

PPP Public Private Partnership

RPC Research Partnership Centres

RSA Russian Space Agency

SWOT Strengths Weaknesses Opportunities Threats

TDRSS Tracking and Data Relay Satellite System

USSR Union of Soviet Socialists Republics

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Chapter 1

Introduction

1.1 Research Background

Space exploration has captured the imagination and dreams of many scientists, engineers and visionaries. It has become a symbol of human ability to break the boundaries of science and technology; and now business. Yuri Gagarin's launch into space in 1961 opened a new era of exciting, daring and priceless scientific, technological and industrial achievements. Over the past decades this early promise has been realised, through the Apollo 11 landings on the Moon in 1969 and the creation of space stations in microgravity, such as the International Space Station (ISS). In the early days of human space exploration, the colonisation of Mars and frequent visits to the Moon were anticipated to take place by the beginning of this century. Instead, human space-flight became an area presently neglected by the public, with tragic accidents capturing attention. The reason could lie in the fact that access to human space exploration was always reserved to space agencies. However, the first commercial activities, on-board the Mir space station in the 1990s showed there are new markets and frontiers to be explored by private companies. These frontiers continue to be discovered by entrepreneurs, such as those who have successfully built and flown "Space Ship One" designed for space tourists.
The American President Ronald Reagan initiated the creation of the ISS in the mid 1980s, with the objective of building a space station to meet American science needs. In the early days of the ISS design, the need for international cooperation became apparent. As a result of international cooperation between the National Aeronautics Space Administration (NASA), the Russian Aviation Space Agency (RSA), the European Space Agency (ESA), the Canadian Space Agency (CSA) and the Japanese Aerospace Exploration Agency (JAXA) referred to as the ISS partners, the station became a reality in 1998. The finished station is expected to host six crew members, has a lifetime expectancy of 15 years and has a mass of around 450 tons, orbiting around the Earth at an altitude

of 370-460 kilometers. The ISS offers opportunities for long-duration human space-flight and provides a unique microgravity environment for scientific research and technology demonstrations. Private companies from non-space sectors can exploit these opportunities through ISS commercialisation. This is the process by which ISS products and services[1] are sold to private companies, without ISS ownership transfer to them.
In 2000 ESA requested an investigation into the opportunities for the creation of a collaboration between space agencies and private companies opportunities and the description of the current and expected developments in ISS commercialisation.
ISS commercialisation will allow private companies to develop and test their products and processes in space and encourage human space exploration. In this way the ISS partners technology push for more effective ISS utilisation can change into a market pull for new ISS products and services development. Commercialisation of space technology will bring benefits to society in the areas of science, environment protection (e.g. climate change), disease prevention (e.g. osteoporosis) and technology innovation. This thesis will investigate the opportunity for selection and implementation of a collaboration to market ISS products and services and will describe and predict strategic and market developments for ISS commercialisation.

1.2 Personal Motivation

ISS partners have already recognised the importance of commercial utilisation and have allocated a percentage of their ISS commercial products and services[2] for commercialisation and put in place policies which encourage ISS commercialisation development. Europe plays an important role in building, operating and exploiting the European components of the ISS. These are the Columbus Module and the Automated Transfer Vehicle (ATV).
The successful commercialisation of ISS products and services depends upon the creation of an environment where potential suppliers and customers are brought together and where new markets are created. ISS market development is still an innovative process and market uncertainty is high because commercialisation is still a recent initiative.

[1] Product is anything that is offered to a market for attention, acquisition [94], use or consumption and ISS products for this thesis will be considered ISS facilities. While service is any activity or benefit that one party could offer to another, it is essentially intangible and does not result in ownership of anything.

[2] Under the Memorandum of Understanding (MOU), the ISS partners' quotas, roles and responsibilities were defined. Their quotas are different, corresponding to their ISS investment. NASA, ESA and CSA have all allocated ISS products and services for commercialisation. NASA has allocated 30% of its 55% quota, CSA has allocated 50% of its 2.3% quota and ESA has allocated 30% of its 8.3%. The RSA ISS quota is around 20% and that of JAXA of 15%, but both RSA and JAXA have not allocated any ISS products and services for commercialisation, however RSA actively sells its ISS products and services.

My personal motivation to start this research is because of the following observations:

- Commercialising a space station, built for scientific and not for commercial activities, is a challenging and difficult process
- Cost overruns by NASA have resulted in an overall reduction of ISS products and services, endangering the allocation of commercial ISS products and services by the other ISS partners
- The lack of marketing and sales experience by the ISS partners may constrain successful ISS commercialisation. ISS market development could be constrained due to the lack of yet undefined ISS products and services
- There is a lot of room for development of ISS commercial opportunities that can be explored by non-space customers
- ISS markets are currently underdeveloped and the customer benefits from ISS commercial opportunities are largely undefined
- The continuous changes of the ISS assembly and on-board ISS products and services by NASA could negatively influence ISS commercialisation
- Tragic accidents, such as the loss of the Columbia space shuttle in 2003, resulted in strategic and political effects on the ISS partners' programmes and lead to launch delays of the ESA Columbus Module. Trust and confidence in NASA's ISS program will have to be regained and as a result customers will be more confident in flying commercial payloads to the ISS
- The ISS partners are the only 'suppliers' of ISS services and products, and have to strike a balance between their non-profit and institutional activities and their commercial activities
- The lack of a clear long-term vision on commercialisation of space technologies, e.g. future human Moon and Mars missions, could constrain ISS commercialisation development

Based on these observations, research questions will be derived addressing ISS commercialisation development.

1.3 Research Questions and Objectives

The opportunities for private companies from ISS commercialisation as discussed in section 1.1 and the observations discussed in section 1.2 resulted in the following research objectives:

- **Objective 1:** To select, develop and propose a collaboration between space agencies and commercial partnerts to be used to market ISS products and services to commercial customers
- **Objective 2:** To describe, analyse, judge and predict strategic and market developments (processes) for ISS commercialisation

The investigation into the creation of a collaboration between space agencies and private companies opportunities and the description of the current and expected developments in ISS commercialisation was requested by ESA. The main assumption behind the objectives is that in order to commercialise ISS products and services the ISS partners will have to collaborate with private companies. Space agencies have scientific, research and strategic objectives for space exploration. They do not have the organisational structure, marketing and sales knowledge, resources or capabilities to market ISS products and services directly to commercial customers. Critics of this statement could argue that the Russian experience of commercialising their space technology and the Mir space station shows otherwise. The Russian space industry established various collaborations with American and European companies for the commercialisation of their space-based technology (see section 3.6.1). The creation of a collaboration between space agencies and companies will lead to the identification of markets and customer needs, which in turn will lead to successful marketing and sales of ISS products and services. It may well encourage the development of new markets, the recovery of the ISS partners' incurred costs and contribute to increased sales of ISS products and services. The research questions resulted from the observations from section 1.2, observations on the ISS commercialisation and analyses of ISS partners collaborations for selling ISS products and services. The above objectives will be investigated by the research questions below, the answers of which will directly contribute to achieving the research objectives.

1. What are the current market and strategic developments in ISS commercialisation? - Objective 2
2. Is there a need for a collaboration between space agencies and commercial partners to facilitate successful ISS commercialisation? - Objective 1
3. How will ISS partners' commercial activities encourage or discourage ISS commercialisation? - Objective 2

4. How are ISS products and services going to be marketed and sold? - Objective 1
5. What are the expected future market and strategic developments in ISS commercialisation? - Objective 2
6. Within what type of markets would a future collaboration operate? - Objective 2
7. What are the necessary steps for the development and implementation of a future collaboration ? - Objective 1
8. What type of future collaboration could be proposed between space agencies and commercial partners? - Objective 1

The analysis of the above research questions will raise considerations for the strategic and market developments in ISS commercialisation, that will become a basis for the hypotheses of this thesis. The analysis of these questions will start with the examination of current market and strategic developments in ISS commercialisation. Questions 1, 3, 4 and 5 will be answered through the identification of a market structure and analysis of the ISS partners commercialisation policies, which will support the description of the current and future ISS commercial environment[3]. Questions 2, 7 and 8 will be answered through the use of a collaboration creation introduced in section 1.4. Question 6 will be answered by the development and analysis of a number of scenarios for the future ISS commercial environment. Question 8 will be addressed through the selection of a collaboration under high, medium and low market demand for ISS products and services.

1.4 Research Methodology and Process

The research methodology and process described in this section will contribute to achieving the research objectives and answering the research question, from section 1.3. The research process of this thesis ended on 31.03.2004 and therefore certain figures in Chapters 3 and 5 are from 2002. The methodology used in this research is typically case-based, because the information provided by the ISS partners, ISS products and services is so limited, that statistically sound analysis cannot be made. The research objectives from section 1.3, the availability of research data and literature and the research questions on ISS commercialisation pointed to the direction of the use of case based research. Descriptive research are not considered due to the above limitation. The cased based research used in economics, sociology, political science and business and allows investigators to analyse the holistic and meaningful characteristics of real-life events, such as life cycles, organisational and

[3]ISS commercial environment is the environment in which the ISS products and services are sold to commercial customers, by either the ISS partners directly or by present or future business functions.

managerial processes and the maturation of industries [104]. The case study[4] investigates technically distinctive situations in which there will be many variables of interest, relies on multiple sources of evidence and benefits from the prior development of theoretical propositions in the data analysis [104].
As the research is related to the ESA Commercial Promotion Office (CPO), there are also elements of "action research" especially for the description and analysis of ESA ISS targeted markets, ISS products and services and pricing policies and commercialisation programs. The action research is also referred to as participant-observation and permits case study data collection and as discussed by [104] it provides an opportunity to assume a variety of roles within a case study and actually participate in the events being studied. The observations of the author on ISS commercialisation will support the validation of the research results and the selection of a collaboration that will take as an example ESA ISS commercialisation.
Collaboration creation is chosen as a research process for this thesis. The use of a hypothetical collaboration (i.e. business function in section 2.2) will permit the creation of a collaboration and a description of ISS commercialisation. The investigation of the business functions[5] relationships in section 2.2 will be described through the use of market structure theories, followed by hypothesis development. The identification of a market structure will support the description of the current ISS commercial environment and will also identify considerations for the future ISS commercial environment. These considerations are subsequently transformed into three hypotheses. The validation of the above hypotheses is done through the use of market structure theories under a number of ISS future scenarios[6] for the future ISS commercial environment (see Figure 1.1). Based on the analysis of these scenarios, it will be possible to select a scenario or scenarios under which the creation of a business function will be considered relevant. The analysis of the various collaboration models (i.e. public private partnership (PPP), strategic alliance, licensing agreements, etc.) showed the importance of market demand for the selection of a collaboration. The resulting considerations are subsequently transformed into two additional hypotheses, which are also presented in Figure 1.1.The above mentioned hypotheses, will contribute to selection of a collaboration for a business function under high, medium and low market demand. Literature review and data collection from publications, documents and observations will result in description of ISS commercialisation, as this description is necessary, in order to

[4]According [104] there are at least five different applications of case studies; 1) to explain causal links, 2) to describe an intervention and the real-life context in which it occurred, 3) to illustrate certain topics within an evaluation, 4) explore different situations and 5) evaluate a study.

[5]Present business functions are the existing ISS partners' collaborations and agreements for selling ISS products and services to customers. Future business functions are the collaborations that will be proposed by this research.

[6]In this thesis scenarios and case studies have the same meaning.

answer Questions 1 and 3 from section 1.3. Figure 1.1 illustrates the undertaken research methodology and process in this thesis.

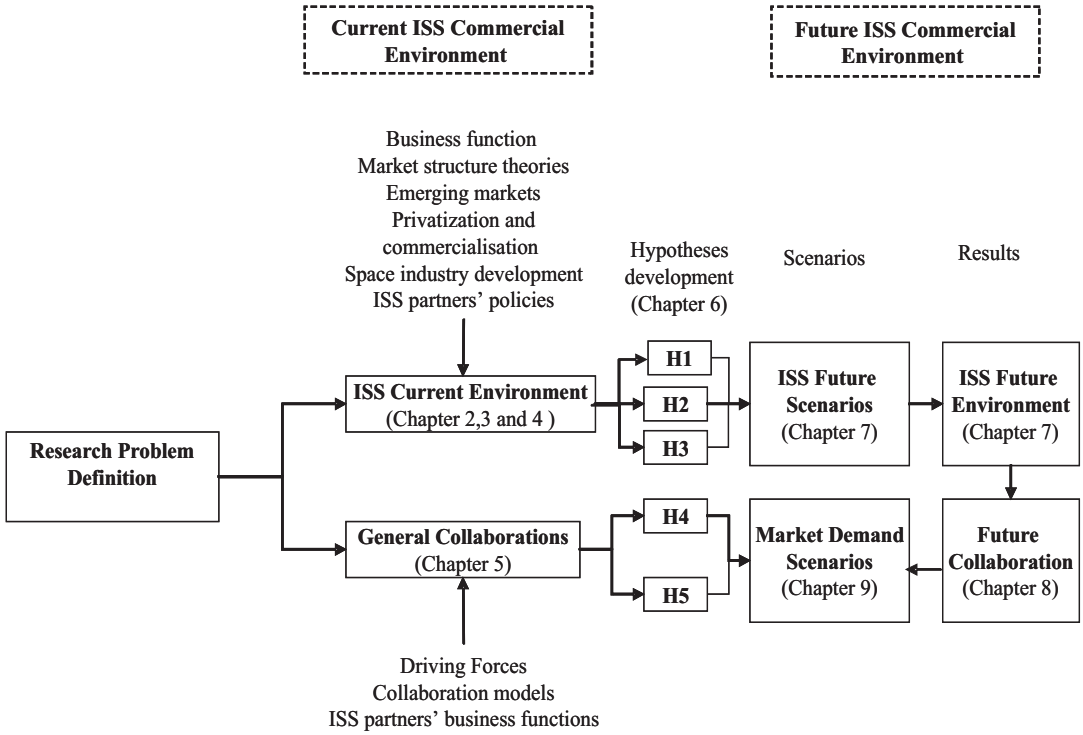

Figure 1.1: Research Process

Figure 1.1, shows how the research problems are addressed with respect to the strategic and market developments in ISS commercialisation and creation of collaborations under high, medium and low market demand for ISS products and services. The observations made in section 1.2 on the various opportunities and challenges from ISS commercialisation point of view to the identification of expected results. Results, as the identification of an oligopoly as the market structure for current ISS commercialisation will allow a generalisation of certain conclusions on ISS partners pricing policies, targeted markets and ISS products and services. Due to the ISS partners international cooperation certain recommendations on ESA commercialisation policies are also applicable for the other ISS partners for encouraging future commercialisation of space technology for Moon and Mars missions. Furthermore, the creation of collaborations for a future business function could be relevant to other ISS partners' programmes, such as navigation, earth observation and technology transfer programs or future interplanetary human and robotic missions.

1.5 Layout of the Thesis

Chapter 2 provides a description and analysis of the strategic and market developments in the current ISS commercial environment. They are described through the use of market structure theories whilst investigating the market evolution of the present ISS markets. In addition, an overview is made of the characteristics of privatisation and an example from the biotechnology sector is made, serving as background information for supporting the identification of conditions for encouraging ISS commercialisation development. The results from this Chapter will aim at answering research Question 1, 2 and 3, from section 1.3. **Chapter 3** describes the influence of space industry market trends on the development of ISS commercialisation. These market trends could encourage or constrain the successful market and strategic developments of ISS commercialisation. The results from Chapter 3, will address research Questions 1 and 5. In **Chapter 4** there is an analysis of lessons learnt from the Mir space station, ISS partners' commercialisation objectives, pricing policies and Strengths Weaknesses Opportunities Threats (SWOT) analysis of present business functions. The results of the analysis in this Chapter will support answering research Questions 3 and 4. **Chapter 5** provides an analysis and selection of the significant driving forces in ISS commercialisation, conditions and reasons for the creation of collaboration between space agencies and commercial partners. This is followed by an overview of various collaborations and an analysis of significant aspects that should be considered in the implementation of a future business function. The results from the collaborations overview will address research Questions 2 and 7, from section 1.3. **Chapter 6** gives a description of the considerations and development of the hypotheses and therefore, addressing research Questions 3, 5 and 6. Follows by scenario development for identifying predictions for the strategic developments (i.e. competition, collusion) in the future ISS commercial environment and hypotheses validation in **Chapter 7**. The results from this Chapter will be directly linked to research Questions 3, 5 and 6. **Chapter 8** continues the research in this thesis with the proposal for a business function with a description of the objectives, functions, targeted markets, products and services, potential founders and execution partners. The proposal of a business function will address research Question 7. Furthermore, the selection and proposal of a collaboration for a future business function is a result of the analysis of the high, medium and low ISS market demand scenarios, presented in **Chapter 9**. The proposed collaboration for a business function directly addresses research Question 8, from section 1.3.
In **Chapter 10** the conclusions on the current and future ISS commercial environment and future collaboration are summarised.

Chapter 2

ISS Market Developments

2.1 Introduction

ISS markets will be created when potential suppliers are brought together with potential customers. The objective of this Chapter is to describe the current ISS commercial environment. Research Questions 1, 2 and 3, from section 1.3 will be addressed:

- What are the current market and strategic developments in ISS commercialisation? - Question 1
- Is there a need for a collaboration between space agencies and private companies to facilitate successful ISS commercialisation? - Question 2
- How will ISS partners' commercial activities encourage or discourage ISS commercialisation? - Question 3

The first question is described through the analysis of the supply and demand sides of the current ISS commercial environment. The relationships between the different players, such as the ISS partners or customers in the current and future ISS commercial environment will be described through the analysis of the relationships of a hypothetical collaboration (i.e. business function) in section 2.2. The business function is an intermediary between an ISS partner and customers and the analysis of its relationships will be performed throughout the whole thesis.
On the supply side of the current ISS commercial environment information is available on the number of players [1] ISS products and services and market entry barriers. Therefore, the supply side relationships are investigated through the use of comparison with market structure theories (i.e. monopoly, oligopoly) and result in the identification of a market structure which describes the current ISS commercial environment. The selection of a market structure can be used to explain the current and future ISS partners' behaviour

[1] For this Chapter, players refers to the ISS partners and their present business functions.

and strategic and market developments in ISS commercialisation. On the demand side of the ISS commercial environment, there is a lack of information on the number of players, products and market entry barriers. Therefore, market structure theories cannot be used to describe the demand side of the current ISS commercial environment. This limitation can be overcome through a comparison of the demand side with the characteristics of emerging markets and an analysis of the ISS markets evolution.
The results from the above analyses will support answering research Questions 1 and 2, while the analysis of the driving forces in privatisation and commercialisation in other industry sectors, as background information for supporting the identification of conditions for encouraging ISS commercialisation development and contribute to answering research Question 3. The analysis in this Chapter will support the predictions for future strategic and market developments in ISS commercialisation.

2.2 Research Relationships

In this section relationships are introduced which are used for the description of the current ISS commercial environment and the analysis of the future strategic and market developments in ISS commercialisation. As already presented in section 2.1, the relationships of the different players (i.e. ISS partners, customers, etc.) in the current and future ISS commercial environment will be described through the analysis of the relationships of a hypothetical collaboration, referred to as the business function. The business function is an intermediary between ISS partners and customers who are willing to buy ISS products and services. Relationships are the connections between the players (i.e. ISS partners, space companies, etc.) and represent not only the way they connect but also how they influence each other in the ISS commercial environment. As presented in Figure 2.1 in the ISS commercial environment there are present and future business functions. Present business functions are the existing ISS partners' collaborations and agreements for selling ISS products and services to customers. Future business functions are the collaborations that will be proposed by this research. Figure 2.1, outlines the network of relevant players in the ISS commercial environment and their relationships to the business function. These players operate on supply and demand sides of the ISS commercial environment. The ISS partners and the space industry[2] operate on the supply side, whereas commercial customers[3] reside on the demand side of the business function.

[2]Space companies are on the supply side of the current ISS commercial environment because they are contracted by the ISS partners to build the different modules of the ISS.

[3]The customers for ISS products and services are from R&D and emerging markets. The R&D markets are the biotechnology, health, food, environment and new materials markets, while the emerging ones are the education, sponsorship, broadcasting, space flight and infrastructure services markets. For detailed information on the above ISS markets see section 4.3.4.

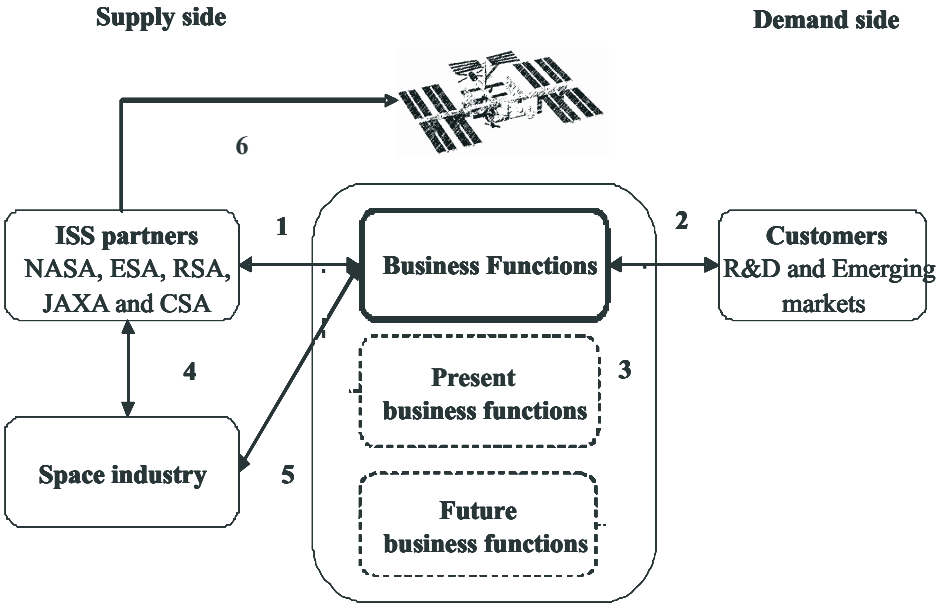

Figure 2.1: ISS commercial environment

Relationship 1: ISS Partners and Business Function (BF) - the relationship between the ISS partners and the present and future business functions is the most relevant one. It is investigated in the context of the ISS partners' roles and activities for encouraging the creation of present and future business functions.
Relationship 2: Business Function and Commercial Customers - commercial customers can come from space or non-space industries. This relationship is also critical, because market demand for ISS products and services will lead to the successful development of ISS commercialisation. This relationship is investigated in the context of the current ISS commercial environment and of the selection of a future collaboration for the business function in Chapter 9.
Environment 3: Business Function Environment - this environment represents the current and future developments of the present and future business functions. This environment will also represent the internal[4] and external[5] business functions' environments that are further investigated in Chapters 5 and 8. For the current ISS commercial environment, there are three present ISS partners' business functions and one planned one. Hereby, there is a short overview of the present business functions:

[4]The internal environment represents the business functions objectives, level of integration between founders, ownership and phases of development.

[5]The external environment representation of the business function includes the driving forces that result of its market structure, market environment, economic process and industry.

- NASA participates in 17 Research Partnership Centres (RPC). These centres (i.e. operational)are partnerships between agency, universities and industrial partners
- In 2001 ESA signed a Co-operation agreement (i.e. operational) with 11 aerospace companies for the provision of general ISS promotional activities. ESA and these companies allocate different products and services to the agreement, such as payload integration and testing for non-space customers
- In 2004 ESA signed a contractual agreement with ISS Lab Ruhr GmbH, referred to as a commercial agent (i.e. operational). It will sell ISS products and services in the biotechnology, health and food non-space sectors
- RSA sells its ISS products and services directly to commercial customers and therefore its commercial activities with customers are considered under the present business functions
- JAXA has planned to implement an ISS Business Forum, which will sell Japanese ISS products and services to commercial customers

Relationship 4: ISS Partners and Space Industry - this relationship is investigated in the context of market trends within the space industry that will influence ISS commercialisation.
Relationship 5: Space Industry and Business Function - this relationship will be investigated in the context of the space companies roles in the present business functions.
Relationship 6: ISS Partners - this relationship investigates the issues that arise amongst the ISS partners, as a result of their international cooperation on the ISS programme.
For this Chapter the analysis of the relationships between the ISS partners (Relationship 6) and the business functions (Relationship 1 and Environment 3) will contribute to describing the supply side of the current ISS commercial environment, while the analysis of the relationship of the business function with customers in Relationship 2 will support the description of the demand side of the current ISS commercial environment.

2.3 Market Structure Theories

In this section is an overview of the market structure theories which will be used later for the description of the current ISS commercial environment. Part of the following research Question 1 will be addressed: *What are the current market and strategic developments in ISS commercialisation?*. The market structure theories will be used in this discussion, as mentioned earlier in section 2.1 the ISS partners' access, pricing and sales policies will provide sufficient information for the description of the supply side of the current ISS commercial environment. The description of the ISS commercial environment on the supply

side, through the use of market structures, has barely been reported in published literature[6]. Market structure theories (i.e. oligopoly, monopoly) have not been widely used in the analysis of ISS commercialisation. This is not surprising because this process was initiated just a few years ago. The market structure theories incorporate Perfect Competition, Monopolistic Competition, Monopoly and Oligopoly theories. These theories present an environment under conditions of certainty, because they set clear competition, objectives and market entry conditions. Under the market structure theories, companies have different objectives, market power, products and competitors. The market structures define a company's ability to set prices, maximise its profits[7] and enter markets. In a competitive environment, companies' decisions on the above aspects will influence the performance of the other companies in the market. Therefore, there is a "causal chain" from a market structure to the performance of an industry sector [55] and to the player's behaviour and performance in a certain market structure. This causal chain can be used to explain and predict the player's behaviour on the supply side of the current ISS commercial environment. Figure 2.2, shows how the identification of the market structure on the supply side of the current ISS commercial environment will result in the description of the ISS players' (i.e. ISS partners) behaviour and lead to identifying predictions for the strategic developments (i.e. competition, collusion) in the current and future ISS commercial environment.

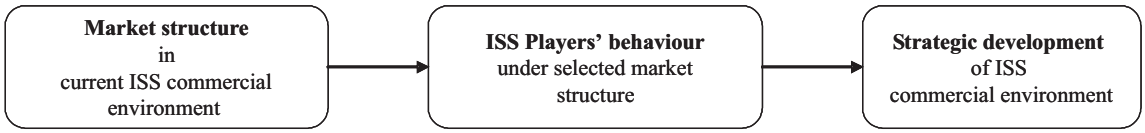

Figure 2.2: Causality chain of the ISS commercial environment

For the supply side of the current ISS commercial environment information exists about players, products, services and market entry barriers. There are currently few sellers of ISS products and services: there are the ISS partners and their present business functions. The present business functions have to face different market entry conditions from the ISS partners if they want to sell ISS products and services, and the characteristics of the supply side of the complies with the monopoly and oligopoly theories. The monopoly

[6]For example [63] used market structures in the analysis of the European space industry. The analysis of the oligopoly concentration ratio for the European Space Industry showed a resemblance to an oligopoly market structure.

[7]Profits are maximised when a company sells a quantity at which the marginal revenue equals the marginal cost (MR=MC). The marginal revenue is defined by the change in the total revenue of a company, resulting from selling an extra unit. The marginal cost is the change in the variable cost, as the result of producing an extra unit. The behaviour of a company in a certain market is determined by the market structure under which it operates.

theory assumes there is only one seller[8], there are no substitutes for its goods and the seller influences prices for a certain product or services, as it has market power[9]. Monopoly existence is not possible in the current ISS commercial environment, because of the ISS partners' independent ISS commercialisation policies and different quotas of allocated ISS products and services for commercialisation. Thus, customers have the choice of buying ISS products and services from the ISS partner they choose. The above aspects are discussed in more detail in Appendix B, section B.1.However, in the future ISS commercial environment its existence can be possible. Furthermore, oligopoly is a market structure where there are few sellers, many buyers[10] and products are either homogenous or differentiated. The oligopoly theory and ISS commecialisation are further discussed in Appendix B, section B.2. The monopoly and oligopoly theories will be further analysed for the supply side of the current ISS commercial environment.

2.3.1 ISS Partners' Interdependence

In this section the ISS partners' cooperation in the context of their interdependence in ISS commercialisation development will be described. The interdependence of companies in a certain market means their market activities are influenced by competitors actions. This interdependence is typical in markets with few sellers and high entry barriers. If one company changes its prices or sells more products or services it will impact the other companies. The ISS partners' cooperation in building, operating and maintaining the space station, shows that political, technical and strategic interdependence is relevant for their current cooperation. This is defined by every space agency having a percentage or quota of the ISS products and services, derived from their financial participation and ownership rights. Under the Memorandum of Understanding (MOU), agencies are politically and strategically linked. The space station is an international project built and operated by five space agencies. If one agency reduces its number of astronauts, this will have an influence on the other ISS partners. For example when NASA incurred cost overruns of around $4 billion in 2001 [58] it resulted in part of the European ISS exploitation budgets being frozen in 2001. Moreover, because of NASA and RSA transportation capability and high resource quotas, changes in their prices or their allocated ISS products and services will influence the other ISS partners (i.e. ESA, CSA, JAXA). In 2001 the ISS partners' formed a common commercialisation group, referred to as the Multilateral Commercialisation Group

[8]The monopolist company can influence the price of the product, and does not consider competition, as it is the only company on the market offering a certain product without any substitute.

[9]A company has market power when it can set prices above marginal cost and earn a profit.

[10]There are high market entry barriers and companies selling under Oligopoly can be price setters. In contrast to companies in monopoly market structures, companies under this market structure usually pay careful attention to the actions of their competitors. In an oligopoly market there are extremely high barriers to entry, from legal barriers, economies of scale, exclusive ownership to governmental intervention.

(MCG) [69]. Its objective is to to coordinate ISS commercial activities and to develop and maintain recommended guidelines for commercial activities in the following market sectors: sponsorship, entertainment, research and development, merchandising and space travel (e.g. space tourists flights).
As a result the coordination of their commercial activities and the sales conditions under which they offer access to ISS products and services seem to be quite similar. Based on the above observations it can be concluded that:
The strategic, political and technical cooperation of the ISS partners creates an interdependence among them in ISS commercialisation
This interdependence [11] on the supply side of the current ISS commercial environment will influence the following relationships, from section 2.2, Figure 2.1:
Relationship 6: ISS Partners - the ISS partners will probably aim to create an environment of "non-price competition", because they are dependant upon each other for accessing and sharing ISS products and services (see Table 2.1). The prices for transportation services to the ISS are only set by NASA and RSA, so that the other agencies (i.e. ESA, JAXA, CSA) take them as given. Therefore, space agencies with smaller ISS quotas (i.e. ESA, JAXA, CSA) are limited in taking important decisions for the future of their commercial utilisation programme, such as ISS pricing and access policies. These agencies will limit themselves to generate extra revenue from customers willing to pay higher prices. In contrast, NASA and RSA will have the opportunity to generate extra revenue from commercial activities on board the ISS.
Relationship 1: ISS Partners and Business Function (BF) - the present business functions will have to offer ISS products and services to their customers, at prices set by the ISS partners, because NASA and RSA have defined prices for the transportation services to the ISS (see Table 2.1). The present business functions will be forced to become price takers for mass, astronaut hours and power.
The ISS partners' interdependence will influence their ISS commercialisation programmess and present business functions.

2.3.2 Market Structure Identification

In this section follows the selection of a market structure that best describes the supply side of the current ISS commercial environment. So far two key observations of the monopoly and oligopoly theories have been established. Monopoly existence is not possible in the current ISS commercial environment, as observed in section 2.3. The ISS partner's interdependence suggests that certain ISS partners and present business functions can become price takers while others become price setters in the current ISS commercial environment,

[11] The ISS partners interdependence is also visible in their common sales conditions, as presented in Appendix A, section A.3.

as observed in section 2.3.1. These observations do not provide sufficient evidence to identify the market structure for the supply side of the current ISS commercial environment. The four types of market structures are built upon three assumptions:

- Number of Players - in the analysis in this section will be considered, as players the ISS partners and present business functions
- Product Differentiation [12] - comparison of the ISS partners' products and services in section 2.3.4, Table 2.1 will show whether the ISS products and services are differentiated or homogenous. The ISS partners' products and services will be used for the comparison, because the present business functions' products and services are quite different [13]
- Market Entry Conditions - are the ISS partners' policies for letting private companies to sell their ISS products and services and also include their sales conditions[14] for commercial customers

The number of players, ISS products and services differentiation and the market entry barriers will be further analysed in detail.

2.3.3 Number of Players

There are five ISS partners responsible for the design, construction and operation of the ISS. The present business functions are ESA's Co-operation agreement, commercial agent and NASA Research Partnership Centres (RPC), as presented in section 2.2. While RSA sells its ISS products and services directly to commercial customers. In addition to the three present business functions, there were plans to sell ISS products and services to commercial customers, through a Non Governmental Institute (NGI), Canadian ISS Access Company (CIAC) and a Japanese ISS Business Forum. None of these are currently operational, the CIAC company was canceled in 2001 due to the unsuccessful selection of an appropriate company for performing the CIAC functions.
On the supply side of the current ISS commercial environment there are five ISS partners and three present business functions (i.e. RPC, ESA Co-operation agreement, Commercial Agent (CA)) that offer commercial access to ISS products and services. This observation

[12]Michael Porter has identified features for differentiation. Some are design or brand image, technology, product or services features, customer services and dealer network [72].

[13]For example NASA RCP are focused on space product development as presented in section 5.6.1, while ESA Commercial Agent is focused on attracting customers from the biotechnology, food and health markets, as presented in section 4.4.4.

[14]The detailed overview of the ISS partners' sales conditions can be seen in Appendix A, section A.3, Table A.1.

suggests that the possible market structure on the supply side tends towards oligopoly market structure, due to the few players offering access to ISS products and services.

2.3.4 Product Differentiation

Companies employ product differentiation as a strategy to gain competitive advantage and market power over the other market competitors. Porter [72], defines brand, technology, customer services and network as some of the features for product differentiation. The comparable products and services [15] are those of the ISS partners, while, the present business functions have different objectives and activities [16] making their products and services incomparable. The information for the ISS partners' products and services is derived from their pricing policies. Table 2.1 presents an overview of ISS products and services offered by ISS partners, with the exception of the Japanese services, which are currently not available.

ISS products & services	NASA	ESA	RSA	JAXA	CSA
Transportation	Space Shuttle	Ariane 5	Soyuz, Proton	H-IIA	
Transfer vehicles	MPLM, Spacehab	ATV	Soyuz, Progress	HTV	
Astronauts services	IVA	IVA	IVA, EVA(1exit)		IVA
Power	yes	yes	yes		yes
Communications	yes	yes	yes		yes
Standard services	bundled	bundled			bundled
Advertising		yes	yes		
Entertainment	yes	yes	yes		
Sponsorship		yes	yes		
Guest mission			yes		
Training Programmes		yes	yes		

Table 2.1: ISS partners' products and services [17], [101], [80], [26]. NASA has bundled its services selling them into International Standard Payload Racks (ISPR). While, ESA has bundled its services and is selling them into Mid Deck Locker (MDL) and ISIS Drawers. CSA is also selling its services bundled under a MDL and External Pallet Adapter (EPA).

The ISS partners have divided the ISS products and services into bundled, premium, transportation and emerging services. These are services considered essential to transport

[15] A more detailed overview of the ISS partners products and services can be seen in Appendix A, section A.3, Table A.2. For an overview of the ISS partners' transportation and crew vehicles see Appendix A, section A.2, Figure A.2.

[16] The activities of ESA Co-operation agreement are related to promotional activities, as presented in section 4.4.4, while the activities of NASA's RPC are focused on space products development, as presented in section 4.4.1.

accommodate and fly commercial experiments (i.e. payloads) on-board the ISS. Each ISS partner sets its own price and defines its own emerging services (i.e. sponsorship). In Table 2.1 the astronaut services are divided into Intra Vehicular Activities (IVA)[17] and Extravehicular Activities (EVA)[18]. In Table 2.1 the ISS partners' transportation services are differentiated. The Russian and American transportation vehicles are completely different from each other. The Russian Soyuz carries a maximum of three astronauts, while the American Space Shuttle can carry 7 astronauts. The ISS partners with exception of CSA have transfer vehicles, such as ESA's Automated Transfer Vehicle (ATV), which is a "one-way" unmanned transportation vehicle to the station. The astronaut services of the ISS partners Intra Vehicular Activities (IVA) are similar, however, only RSA offers Extravehicular Activities (EVA). Moreover, RSA openly offers space guest visits (i.e. space tourists) to the ISS, while ESA offers astronaut training opportunities through a company called ProToura, which sells training opportunities in the European Astronaut Centre (EAC). The emerging services include services that are currently not reflected in the ISS partners prices (see Figure 2.3). These services are quite different for each ISS partner and will probably change depending on the customers needs. Basic services such as astronaut hours inside the ISS or power and communication are similar for all ISS partners. However, NASA, ESA and CSA services are bundled together, in contrast to the RSA services, which are not. The services offered can be categorised as being both homogenous and also differentiated. The classification of ISS products and services is currently quite complex and is difficult to use by non-space customers, due to the bundling of different products and services by ISS partners. The lack of an understandable classification of ISS products and services by the ISS partners is in fact quite natural due to the public nature of space agencies. The lack of a clear definition of ISS products and services also highlights the difficulties ISS partners' have in creating, classifying and developing attractive ISS portfolios. Business functions with experience in business development can provide a more understandable classification of ISS products and services and an ISS portfolio that reflects customers' needs. This is one of the reasons why the ISS partners, will have to establish collaborations with private companies to access customers and develop ISS portfolios. The above conclusion directly answers research Question 2, from section 1.3.

[17]Intra Vehicular Activities of astronauts or cosmonauts refer to their activities inside a space station or other spacecrafts, such as the Space Shuttle.

[18]Extravehicular activities of cosmonauts and astronauts refer to space walks during which astronauts maintain and repair space stations, satellites or assemble structures. For example the assembly and maintenance of the ISS will require up to 40 EVA or around 300hrs. to 400hrs. per year [24].

2.3.5 Market Entry Conditions

The analysis of the market entry conditions in the current ISS commercial environment will support the identification of a market structure for its supply side. In this section the analysis is focused on the market entry conditions provided by the ISS partners, as part of their sales conditions [19]. To describe the present market entry conditions a classification of the types of market entry conditions is necessary. This classification is based on [72] the following aspects are considered:

- ISS products and services availability - the present business functions can access 30% of ESA's 8.3% of the ISS, while NASA's RPC can access 30% of NASA ISS products and services. RSA and JAXA have not yet defined the ISS products and services allocated for commercial utilisation, while CSA allocates 50% of their 2.5% of ISS products and services
- Product Differentiation - NASA, RSA and ESA offer differentiated and homogenous ISS products and services, as already presented in section 2.3.4, Table 2.1
- ESA Geographical Return Rule [20] - this rule is relevant only for the European commercial customers, wishing to obtain promotional support from ESA
- ISS Partners Commercial Proposals - all ISS partners have similar sales selection requirements for commercial proposals, as presented in Appendix A, section A.3, Table A.1
- Exclusivity rights and Intellectual Property Rights (IPR) - ESA offers exclusivity rights to one of its present business function (i.e Commercial Agent (CA), see section 2.2) for the sales of ISS products and services for the biotechnology, health and food markets. ESA also offers full Intellectual Property Rights (IPR) to commercial customers who finance 100% of their commercial projects

The above market entry conditions cover a wide range of activities that will lead to the creation of a complex environment for the present business functions willing to sell ISS products and services, implement, commercial proposals and attract potential customers. These conditions confuse not only the present business functions, but also commercial customers. The ISS partner's complex and high market entry conditions create the need to

[19] The description of the ISS partners' sales conditions are in Appendix A, section A.3, Table A.1.

[20] The geographical-return rule is applied by ESA when granting contracts to national industries. This means that the value of contracts granted to national industries from ESA has to correspond to the the percentage of investment by their national governments in ESA. Customers of member states contributing to the ISS exploitation programme may apply for ESA deferred payments and for the timing of use [87]. ESA Member states contributing to the ISS exploitation program, are Belgium, Denmark, France, Germany, Italy, The Netherlands, Spain, Norway, Sweden and Switzerland.

establish collaboration between space agencies and private companies, such as the present and future business functions. In order to ease the access to ISS products and services, the present and future business functions can support customers by preparing commercial proposals [21] for their projects, as also further discussed in section 4.3.3. The ISS partners interdependence, the few players at the supply side, the ISS homogenous and differentiated products and services and the high market entry barriers are all characteristics closely associated with an oligopoly market structure. The supply side of the current ISS commercial environment is described as **oligopoly** market structure. The ISS partners' interdependency, existence of non-price competition and similar sales procedures, suggest resemblance to cooperative oligopoly. The above conclusions directly contribute to answering research Question 1 from this Chapter and section 1.3. The analysis of the supply side of the current ISS commercial environment will continue with further investigation of the Cartel and Price Leadership theories. These two theories are cooperative oligopoly ones.

2.3.6 Cartel Theory

In this section is an analysis of the relevance of the cartel theory for the supply side of the current ISS commercial environment and addressing research Question 1. The results of this analysis will also support the predictions for the future ISS commercial environment in section 7.6. Cartels are usually created between companies that agree to behave as if they were a monopolist in a specific market. They agree to have the same cartel price for the products or services, to divide the market among themselves and to capture the benefits that usually exist for monopolists. They achieve this by reducing production while increasing artificially prices. The ISS partners have quotas allocated corresponding to their investment in the construction and operation of the ISS. Furthermore, they are presently the only ones with access to the unique microgravity environment. The existence of the ISS partners' interdependence as observed in section 2.3.1 may continue, but a creation of a cartel is unlikely for the following reasons:

- ISS partners are non-profit organisations - they are public organisations and serve the public need for space exploration. Through commercialisation they are only looking at achieving a partial cost recovery of their ISS investment. ISS partners have developed and implemented their own ISS access and pricing policies

- ISS partners have the freedom to allocate and manage their percentage of their ISS products and services for commercialisation

[21] The commercial customer submits his/her idea in the form of a commercial proposal to ESA. In this proposal he/she describes the project objectives, scenario and schedule. The commercial proposal needs to consist information on the technical, ethical and financial aspects of the customers'project. For more information on on the selection process of commercial proposals see section 4.3.3.

- The ISS partners target different markets, for example ESA targets customers from both the R&D and emerging markets. For the R&D markets, such as the biotechnology, food and health sectors (see section 4.3.4) and for the emerging ones; sponsorships, broadcasting and astronaut training [87]. RSA targets customers for space flight tourism, scientific research and advertising [101], while NASA has focused on space product development in the areas of biotechnology, food, new materials and combustion in space

- National governments have antitrust and competitive policies, both in the EU and the US and these policies are intended to restrict cartel creation

For these reasons the cartel creation is unlikely on the supply side of the current ISS commercial environment. Despite this, cartel problems such as cost disclosure, market demand, negotiation problems and market entry barriers still exist[22] and are compared to some of the problems of the ISS partners.The following problems associated with ISS commercialisation are derived from the Cartel Theory:

- Market Demand Identification - this problem arises from the unique character of ISS products and services and the fact that ISS commercialisation has just started developing. Reliable market demand information on the quantity of services or products sold by the ISS partners is not available

- Negotiation Problems between ISS Partners - the ISS programme is a result of international co-operation between five ISS partners. Any negotiation problems between the ISS partners could lead to long-term negative effects on the ISS commercial environment, resulting in delays in accessing, selecting, pricing and launching commercial payloads by the ISS partners with transportation capabilities. The negotiation problems can hamper ISS commercialisation by creating a negative image of the process in front of customers. Both the ISS partners and present business functions can be significantly affected by loss of customers, markets and profits

- Cost Disclosure and Accuracy Problems - are relevant problems for the ISS partners and the space industry as a whole, because cost overruns influence the ISS partners and lead to direct ISS products and services reduction, such as NASA cost overruns in 2001

To summarise, the ISS partners' commercialisation policies and the freedom to sell ISS products and services, as well as the different markets they target, show that cartel creation is unlikely in the current ISS commercial environment. However, the ISS partners might experience cartel problems, such as difficulties in identifying market demand, experiencing negotiation and cost disclosure problems, that could constrain ISS commercialisation.

[22]For more information on Cartel Theory see Appendix B, section B.2.1.

2.3.7 Price Leadership Theory

The Price Leadership theory is one of the cooperative oligopoly market structures. One dominant firm (i.e. price setter) sets the price and the others (i.e. price takers) take the price as given. Relating price leadership theory to the ISS partners' behaviour will promote a greater understanding of the ISS partners' roles in the current ISS commercial environment. This theory is relevant for the current ISS commercial environment, because:

- ISS partners with the highest resource quotas and transportation capabilities have set prices - NASA and RSA have provided ESA, JAXA and CSA transportation prices for Space Shuttle or Soyuz flights, as presented in Figure 2.3. Therefore, the ISS partners with smaller resource quotas accept prices for ISS products and services as given. NASA and RSA can meet market demand. For example NASA has allocated 8 racks (i.e. ISPR) for commercial utilisation, whereas CSA has allocated 4 lockers (i.e. MDL) and 1 external pallet adapter (i.e EPA) for commercial utilisation. NASA and RSA have sufficient on board ISS products and services to meet market demand for commercial payloads

- ISS partners with smaller ISS quotas (i.e. ESA, CSA, JAXA) do not compete with NASA and RSA in the ISS commercial environment - this is demonstrated by ESA and CSA, as discussed in section 2.3.1 who have not reduced their prices for ISS products and services or initiated competitive advertising against other ISS partners

These observations show that the price leadership theory is relevant for describing ISS partners' behaviour in the current ISS commercial environment. Three types of dominant companies can operate in a cooperative oligopoly; dominant price firm[23], barometric leader[24] and low-cost leader[25]. As ISS commercialisation continues, if one ISS partner becomes a price leader, this will lead to a ISS partners influencing prices for ISS products and services for the other ISS partners and present business functions. The prices for ISS services in Figure 2.3 are based on public information from the ISS Commercialisation Congress in Bremen 2001, with the exception of CSA prices. The CSA prices are also taken from 2001, but are prices as presented in their commercialisation policy [17]. Any price changes or withdrawal of commercial prices from the ISS partners for ISS products and services are not reflected. The price levels[26] presented in Figure 2.3 show the ISS partners' prices. In 2001 JAXA did not set any ISS prices for their Japanese ISS products and services.

[23]The company determines prices, other firms accept price as given.

[24]The company changes its prices under the right market conditions.

[25]The company has cost advantages over its competitors, is concerned about a price war and prefers to adjust its prices.

[26]For a detailed overview of the ISS partners' bundled prices see Appendix A, section A.3, Table A.2.

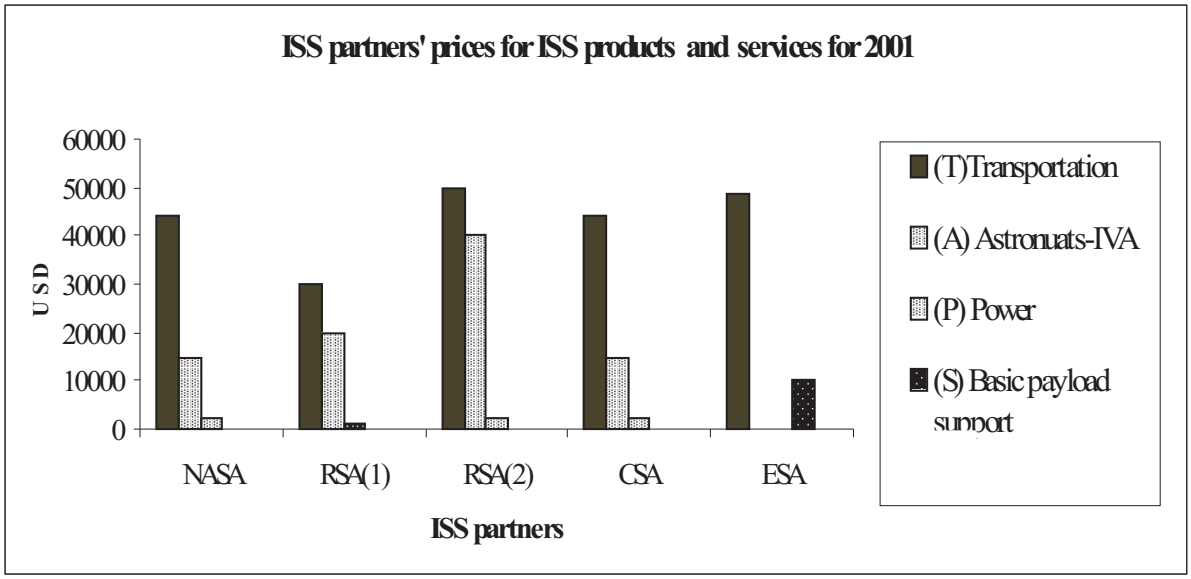

Figure 2.3: Prices for ISS products and services for 2001 [80], [17] , [101], [26].The RSA prices are based on a range, in this figure there is an RSA (1) and RSA (2) for ISS services.

The ISS partners have similar prices for ISS products and services with the exception of RSA, which has the lowest ISS price range (i.e. RSA(2)). This price similarity is not surprising and is explained with the ISS partners' interdependence in ISS commercialisation and concerns that NASA and RSA are price setters in the current ISS commercial environment, as observed in section 2.3.1. It is possible that NASA starts to behave as a dominant price leader while the other ISS partners become price takers. For example, in 2001 CSA prices were based on NASA's pricing policy [17] and changes to NASA prices will directly influence CSA prices. CSA is thus a price taker and NASA is a price setter. The only current RSA price discussed in the public domain is for flying space tourists to the space station at a price of $20 million per week [14]. The current lack of prices for the Russian ISS products and services shows that the RSA pricing approach lacks transparency and hinders price calculations for existing and potential customers. The above observation reveals RSA's can negotiate and set prices with higher margins and set prices from scratch with customers and apply price descrimination to different customers. The ISS partners do not have competitive prices to match the Russian prices. As a result, commercial customers, attracted by their lower prices, may prefer access to Russian ISS products and services rather than the other ISS partners. RSA is in a position to become a low-cost leader and obtain cost advantages due to lower labour costs than its European or American counterparts. The existence of a dominant price leader in the current ISS commercial environment will influence the ISS partners' relationship and their relationship

with the present business functions (see Figure 2.1).
Relationship 6: ISS Partners - the supply side of the current ISS commercial environment is dominated by a price leader (i.e. NASA, RSA), who has the power to change ISS prices. This will directly influence the other ISS partners' commercial policies, pricing and promotion policies. The ISS partners selling RSA ISS products and services to their customers can suffer uncompetitive prices, loss of commercial customers and damage to their image. ISS partners who are price takers may consider withdrawing their support for ISS commercialisation.
Relationship 1: ISS partners and Business Function (BF) - the dominant price leader will directly influence the present business functions' costs for flying commercial payloads to the ISS and thus result in their ISS prices increase. This will result in fewer customers, reduced profits and a lower market share for the present business functions. Therefore, this can encourage the present business functions to sign a direct agreement with the dominant price leader (i.e. RSA, NASA) to access ISS products and services. This could endanger the successful development of ISS commercialisation for the other ISS partners.
The supply side of the current ISS commercial environment is considered a cooperative oligopoly, see section B.2. The lack of clear definition of ISS products and services, coupled with the high market entry barriers creates a complex environment for customers. Therefore, the ISS partners should encourage the creation of collaborations for selling ISS products and services. The analysis of the cartel and price leadership theories showed that the cartel theory is not relevant for describing the current ISS commercial environment, in contrast to the price leadership theory. NASA and RSA are price setters and NASA could behave as a dominant price leader while RSA could behave as a low-cost leader. ESA, CSA and JAXA can become price takers due to their increased dependency on NASA and RSA for transportation services to the ISS and their smaller quota of ISS products and services. The present and future business functions will be forced to become price takers and experience increased ISS prices, resulting in fewer customers, reduced profits and a lower market. The lack of a transparent RSA pricing policy will influence ESA, JAXA and CSA pricing approaches, resulting in uncompetitive prices, a loss of commercial customers and damage to the ISS partners (i.e. ESA, JAXA, CSA) image. Inevitably these considerations contribute to answering research Questions 1 and 3.

2.4 ISS Emerging Markets

The ISS partners realised that ISS commercialisation is a process that encourages the creation of new markets and achieve a partial ISS cost recovery of their ISS investment. This section will continue to address research Question 1; *What are the current market and strategic developments in ISS commercialisation?* and research Question 2; *How will*

ISS partners' commercial activities encourage or discourage ISS commercialisation?. To answer these questions is a description of the demand side of the current ISS commercial environment and the ISS partners' roles in commercialisation. The lack of information on potential customers, on the products that can benefit from the ISS and market entry barriers in non-space markets make the use of market structure theories difficult for the description of the demand side of the ISS commercial environment. There will be a synopsis of scenario development and Porter's emerging industries characteristics. This analysis will be followed by an additional overview of McKinsey's phases of market evolution for the demand side of the current ISS commercial environment. The above approaches are chosen because they are widely used for analysis of emerging markets and industries.
Scenario development[27] offers a range of future options for issues related to the demand side of the ISS commercial environment, but does not provide a general overview of the evolution of the ISS markets. Furthermore, the existence of strategic uncertainty, plus the lack of information on market demand and first time buyers means that a different approach is needed.
Porter's [72] description for the structural characteristics of emerging industries[28] will be compared to ISS commercialisation. Porter's emerging market characteristics[29] give a detailed description of the typical features of emerging markets and can easily be used for the analysis of the demand side of the ISS commercial environment.
McKinsey [2] presents different phases of emerging market evolution in combination with alliance strategies. This approach for emerging markets analysis gives a detailed overview of the features of each phase of market evolution and a company's alliance strategy. Based on this, it will be possible to make initial predictions and a description of the features for each phase of ISS market evolution. Moreover, for the objective of this section, Porters' approach will be used first to identify market characteristics, based on which it will be possible to position the ISS markets in the McKinsey market evolution.

[27]Scenario development is used for making predictions for the strategic and market developments in the future ISS commercial environment in section 7.3. For an overview of the different scenario types see Appendix F, Table F.2.

[28]Doering and Parayre [18] describe the early stages of technology development and the identification and assessment of emerging technologies. They analyse the strategic intentions of companies when assessing new technology and the difference between well-established and emerging technologies. Their classification is relevant to ISS commercialisation and from the perspective of non-space industries, the space station services and products can be considered as emerging technologies. However, Doering and Parayre classification will not be used, because it requires the provision of information on the gains from emerging technologies. At present there is only limited information on the number of patents from NASA's RPC and none for the other present business functions.

[29]Other authors, such as [97] have dealt with emerging markets and particularly the challenges of valuation in emerging markets and discuss the main difficulties by investing in emerging markets, the characteristics of investments, portfolios and approaches for best value investments.

At the beginning of 2001, several companies[30] were contracted by ESA to analyse ISS markets and they concluded there was a lack of awareness of ISS commercialisation among non-space industries of ISS and its commercialisation.
RSA first started exploring commercial opportunities, such as generating revenues from Pizza Hut placing adverts on a Proton launcher or flying vacuum packed space pizza, tested by the Russian astronauts [92]. Moreover, it was the first space agency to launch the first space tourists and allow interviews from the Mir space station. The Russian experience shows there is a market potential for the commercialisation of space station services and products. These few examples show that these markets are in their pioneering and innovative development stage. As discussed in the beginning of this section, the demand side features of the current ISS commercial environment are compared with [72] emerging industry characteristics:

- Market uncertainty and first time customers - there is a lack of market information on first time customers for ISS products and services, except for the number of space tourists to the ISS. Attracting first time customers is crucial for the success of ISS commercialisation.

- Technological uncertainty - the ISS construction is constantly changing because of NASA cost overruns and in 2001 the number of astronauts on board was reduced from seven to three. ISS technology uncertainty can lead to reduction in ISS commercial products and services, therefore to reduced ISS commercial access for customers and loss of profits.

- Strategic uncertainty - the constant changes of political and strategic power between NASA and RSA for access to ISS on-board products and services will result in strategic uncertainty for the other ISS partners and present business functions.

- High initial costs, steep cost reductions - currently the ISS partners for carry the initial costs for market development. Marginal cost pricing is applied by some ISS partners (i.e. NASA, ESA) as pricing policies will be further researched in section 4.3.2.

- Creation of embryonic companies and spin-offs - present business functions are being created, such as ESA Commercial Agent "ISS Lab Ruhr GmbH" see section 4.4.4. Private companies like Space Adventures are selling trips to the ISS.

- Co-financing projects - NASA, ESA and JAXA offer possibilities for co-financing commercial projects. For example, ESA offers promotional support in the form of reduced prices to certain commercial projects.

[30] ITM [64], Cranfield University, ACESS and Matrix [100].

- Access to distribution channels - the present business functions will facilitate customers' access to ISS products and services by providing support to customers in commercial proposal preparations.

The above characteristics show that the demand side of the ISS commercial environment has similarities with emerging markets. These similarities will influence the strategic and market development of the present and future business functions. Understanding the phases of ISS market evolution will provide greater insight into the characteristics of the demand side of the current ISS commercial environment.

2.4.1 ISS Market Evolution

In this section is an analysis of the McKinsey emerging market evolution for ISS commercialisation. The results from this section will address research Question 1. Emerging markets develop through different phases, including Nascent, Frenzied, Turbulent and Mature [2]. During the different phases of emerging market development, the environment of the present business functions will change, as will the objectives of the ISS partners. The earlier analysis in section 2.4 showed that the ISS markets are emerging and will be positioned in the "Nascent" stage of market evolution [119]. Figure 2.4 presents the relationship between emerging markets, the ISS markets and the ISS partners' investment in ISS market development.
This is due to the ISS partners' significant role in ISS commercialisation and strict control of ownership of ISS products and services by the ISS partners. Evidence of the ISS partners' significant roles are the ISS market entry barriers (see section 2.3.5) they have encouraged to be created for the present business functions and commercial customers. The ISS partners and present business functions operate under ISS emerging markets.
Relationship 2: Business function and Commercial Customers - the ISS market demand is unknown, customers are unknown and profits for the ISS partners or present business functions will possibly be low. As markets start to develop they enter the Frenzied stage of market evolution: ISS markets expand, profits rise and competition between players may increase, thus leading to increased profits for the present business functions. The present business functions will have to develop new ISS markets, invest in their developments and build awareness of existing ISS commercial opportunities.
Relationship 1: ISS partners and Business function(BF) - in the ISS markets commercial opportunities are unknown to most non-space industries or even to the ISS partners and the present business functions. The present business functions will aim at building awareness, attracting first time customers and investing in ISS market development. However, as the markets enter the Frenzied stage of development and ISS partners' investments will reduce. A reduction of the ISS partners' investment will encourage the creation of a competitive environment and relaxed regulation and mitigate the possible existence of a monopoly

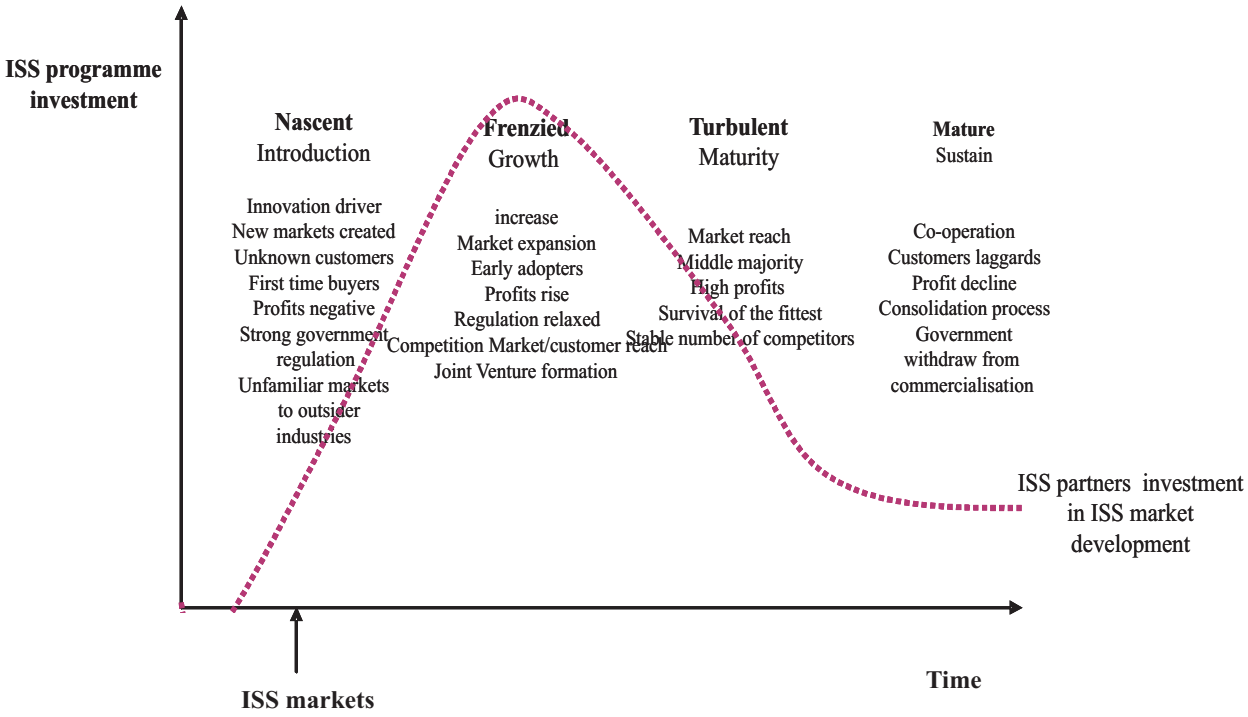

Figure 2.4: ISS market evolution [119]. Currently the ISS partners are the only major investors in the ISS programme and ISS markets development. However, as the process develops their investment in ISS market development can begin to reduce and they can withdraw from ISS market development

in the future ISS commercial environment. As the markets enter the Frenzied stage of development, competition will increase and profits will rise with their main strategies focused on expanding customer reach, through the creation of collaborations.

Relationship 6: ISS partners - ISS partners have initiated the commercialisation process and set-up access and pricing policies. Their current roles in the ISS emerging market are diverse and influential on the ISS commercialisation. Their current role is a nurturing one[31] of encouraging commercialisation, setting up ISS policies, building awareness, and implementing access and pricing policies, thus investing in the development of ISS markets. In order to encourage the further development of the ISS markets, the ISS partners will have to reduce their investment, regulation and influential role in ISS commercialisation. As the markets evolve the roles of the ISS partners will change from nurturing to institutional management [119], where the ISS partners will encourage the creation of collaborations,

[31]The ISS partners strictly regulate the allocation of ISS products and services, therefore they can constraint the implementation of certain commercial projects and thus, constraint ISS commercialisation. ISS partners regulative role is further discussed in section 7.9

and the implementation of policies for innovation and competition. As the ISS markets enter the Frenzied stage of development, the ISS partners will have a coordinating role, and the ISS partners can reduce regulation and investment in commercialisation or even withdraw from ISS commercialisation.
ISS partners and present business functions in the current ISS commercial environment operate under the Nascent stage of market development. If the ISS partners wish to access non-space markets and thus acquire customers, they need to collaborate with companies. The description of the demand side of the current ISS commercial environment, addresses research Question 1, from section 1.3. The roles of the ISS partners will be different in the ISS market evolution; the ISS partners have a nurturing role at present, but in the future can have institutional management one. The better understanding of the ISS partners roles contribute to addressing research Question 2, from this Chapter and section 1.3.

2.5 Privatisation and Commercialisation

The processes of privatisation and commercialisation of public properties and services is relevant to the processes of ISS commercialisation, as its analysis will lead to the identification of conditions that will encourage ISS commercialisation. This section addresses the research Question 3 *How will ISS partners' commercial activities encourage or discourage ISS commercialisation?*. To answer this question, the driving forces in privatisation are discussed, because similar driving forces can trigger ISS commercialisation. Furthermore, an example of commercialisation in biotechnology industry in section 2.5.1 will be given, as this example will provide some background for answering the above research question. This industry is selected because it incurs high costs, high debts,high operational and maintenance costs, high safety standards and require high R&D investments.
Privatisation, is the transfer of ownership and control of state-owned enterprises to private ones and is a major trend in industrial countries, transitional economies and emerging countries [8]. Commercialisation is the process by which public facilities are used by private companies for commercial activities without the transfer of ownership of these facilities. Privatisation processes began in the late 70s and early 80s and started with British Petroleum (1979) and was followed by British Aerospace (1981), Associated British Ports (1983), British Gas (1984), British Aerospace (2nd part) (1985) and British Steel (1988). From 1977 to 1997, 1,865 transfers of ownership, in more than 100 countries, worth approximately $750 billion were undertaken [8]. The collapse of the communist regimes in Central and Eastern Europe in 1989 also led to privatisation of state-owned industries. Poland, Hungary and Czechoslovakia were the first countries to initiate privatisation, followed by Bulgaria, Romania, Slovenia, the Baltic States and Russia. The privatisation processes in these countries marked the transformation from centrelised to open market economies.

The privatisation processes differed from those in the western countries. In reality Central and Eastern European countries were exposed to rapid privatisation processes, due to the need for structural changes towards market-based economies. Later it led to the fast liquidation of whole industry sectors and companies, high unemployment and corruption due to loopholes in privatisation policies. Central and Eastern European countries were unprepared for the drastic economic changes and the political, economic and structural impact of privatisation.
The driving forces behind privatisation can be similar to the ones of ISS commercialisation. This classification is similar to the driving forces identified by other authors, such as [31] and [55], and therefore, can be combined together into:

- Market Forces - competition, demand, supply and profit maximisation (i.e. stock market liquidity)
- Pragmatic Forces - increasing cost effectiveness of public services, escalating costs (i.e. hard budget constraints)
- Economic Forces - reduction of government dependency
- Ideological Forces - decreasing government role (i.e. political preferences)
- Commercial Forces - provision of business opportunities. Government spending is decreased by placing state-owned enterprises and assets with private companies
- Populist Forces - creating a better society by providing a choice of services

The pragmatic, commercial and ideological forces are relevant for ISS commercialisation and will be further investigated in section 5.3 and so here below there will be an initial analysis of their influence on ISS partners and their relationship with the business functions only.
Relationship 6: ISS Partners - ISS partners are exposed to pragmatic and ideological forces. Political preferences (i.e. ideological forces) and hard budget constraints[32] (i.e. pragmatic forces) are the most relevant forces behind ISS commercialisation. ISS partners are exposed to budgetary pressure and foresee revenue generation from ISS commercialisation as a way to partially recover their ISS variable costs. These forces are reflected in the ISS partners' ISS commercialisation objectives (see section 4.3.1), such as partial ISS cost recovery.
Relationship 1: ISS partners and Business Function(BF) - ISS commercialisation provides opportunities to develop and implement more cost-effective ways for ISS utilisation. Commercial forces (i.e. ISS commercial opportunities, market demand, competition) are

[32]Building and operating the space station for 10 years, is estimated to cost around $ 100 billion for 10 years [29]paid by the ISS partners' public budgets. The NASA cost overruns for the ISS in 2001 [58] and the increased costs for building the station, show that agencies can be exposed to budgetary pressures.

important for the present business functions and customers because they develop and implement more cost-effective ways for ISS utilisation as well.
The ISS partners and present business functions will be exposed to pragmatic, commercial and ideological forces of privatisation. For the ISS partners political preferences (i.e. ideological forces) and hard budget constraints (i.e. pragmatic forces) are the most relevant. The above conclusions contribute to a better description and analysis of the market and strategic developments in the current ISS commercial environment and to answering research Question 1.

2.5.1 Example of Biotechnology Commercialisation

In this section is an example of the commercialisation processes in the biotechnology industry. This example provides background for addressing research Question 3 and identification of conditions for successful ISS commercialisation in section 5.3.3. The biotechnology industry started its development in research laboratories and universities, scientific advancements being the driving force behind the emergence of the biotechnology industry. The biotechnology industry has high R&D expenditure[33], multi-disciplinary markets[34], long periods for return on investment[35] and has to meet high safety standards; features which are similar to those observed in ISS commercialisation. The payback period as a result of the commercial activities in space industry is also quite long. The long period necessary for drug development[36] (around 10 to 15 years), can be compared to the long period of planning, developing and implementing space missions[37].
The commercialisation processes in biotechnology started in 1976, when a venture capitalist Swanson persuaded Boyer, a biochemist from the University of California, to form Genentech; the first biotech company. Biotech companies can lose large sums of capital and do not achieve profitability for many years and therefore these companies have numerous collaborations with pharmaceutical companies. These collaborations play an important role in the success of biotech companies as they ensure access to private funding and new markets. Almost half of the biotech R&D funding for 2000 resulted from the collaboration of biotech companies with pharmaceutical companies. The driving forces behind the

[33]The R&D expenses of the global biotechnology industry for 2001, corresponded to around $ 15 billion and the revenues to around $ 35 billion [25].

[34]The Biotechnology industry has different applications and markets, such as health care, food, pharmaceutical, energy and environment.

[35]The process of new drug development takes on average 15 years and an investment of around $ 800 million till the drug candidate reaches patients [25].

[36]The drug development process through different phases of development: early discovery, Phase I, II, III and IV, followed by regulative approval for the new drug.

[37]Space missions have different phases of development: Phase 0 (purpose), Phase A (feasibility), Phase B (preliminary definition), Phase C (detailed definition), Phase D (production), Phase E (utilisation) and Phase F (disposal).

successful commercialisation of biotechnology have been identified by [25] as follows:

- Risk-taking culture which encourages entrepreneurial behaviour
- Competitive markets in which capital investment is at the forefront and has the potential for reward through market-driven product pricing mechanisms
- Protection of intellectual property ensuring temporary market exclusivity to product development investments
- Academic support for technology transfer and promotion of licensing of basic research discoveries from university laboratories to commercial development
- Government support, not only in the form of funding basic research, but also by local and national tax incentives
- Public regulatory systems that foster confidence in the safety and efficiency of new products

These driving forces show the conditions which were encouraged by governments for successful commercialisation of the biotechnology industry.
Relationship 1: ISS Partners and Business Function (BF) - the risk-taking culture in the aerospace industry is associated with achieving scientific and engineering excellence of space technology in the development of new space systems and launch of astronauts to the space station. These achievements in space exploration during the last 42 years have proved that the aerospace community can break the boundaries of science and technology, but today a different challenge has arisen from the necessity to commercialise space-based technologies. Therefore, ISS partners[38] will have to encourage the creation of a competitive environment for ISS market development in which business functions can market and sell ISS products and services. The ISS partners will not only implement "competitive bidding" for business functions willing to sell ISS products and services, but also offer commercial property protection. Consequently, the creation of a competitive environment result in reducing market entry barriers for companies willing to sell ISS products and services and encourage to break up the cooperative oligopoly. This will change the ISS partners' role in ISS commercialisation and they will have an institutional management role (see section 2.4.1). The ISS partners can implement policies that favour innovation and competition. The creation of a competitive environment, property protection and government support can be the conditions for encouraging ISS commercialisation development. These condistion will be used in the further analysis for the creation of future business functions and also contribute to answering research Question 3.

[38]For the European ISS commercialisation, commercial customers can keep their Intellectual Property Rights (IPR) from experiments. ESA has a commercial promotion program and offers promotional prices to certain customers as discussed earlier in section 2.3.7.

2.6 Results and Conclusions

The analysis of the supply and demand sides of the current ISS commercial environment addressed the research Questions 1,2 and 3 from section 1.3. To answer research Question 1: *What are the current market and strategic developments in ISS commercialisation?* the supply and demand sides of the current ISS commercial environment were investigated. The current market and strategic developments on the supply side of the ISS commercial environment resemble a cooperative oligopoly. These resulted from the limited number of ISS players, homogenous or differentiated ISS products and services and high market entry barriers, as concluded in section 2.6. Cartel creation is unlikely in the current ISS commercial environment because of the ISS partners' freedom to sell their ISS products and services. Price leadership theory shows that NASA and RSA behave as price setters, while ESA, JAXA and CSA as price takers, as observed in section 2.3.7. The ISS partners (i.e. ESA, JAXA and CSA) who offer Russian ISS products and services to their customers can suffer uncompetitive prices, loss of commercial customers and damage to their image. The lack of ISS price lists for the Russian ISS products and services, shows a lack of transparency and hinders price calculations for their customers. On the demand side of the current ISS commercial environment the ISS markets are currently emerging. New ISS markets are being created, ISS market demand and customers are unknown. ISS partners and present business functions operate under the Nascent stage. For the ISS partners, political preferences (i.e. ideological forces) and hard budget constraints (i.e. pragmatic forces) are the most relevant. Commercial forces (i.e. ISS commercial opportunities, market demand, competition) are important for the present business functions and customers. These are the current strategic and market developments in ISS commercialisation.
To answer research Question 2: *Is there a need for a collaboration between space agencies and private companies to facilitate successful ISS commercialisation?* there was an analysis of the ISS partners market entry conditions, ISS products and services and roles in the current ISS commercial environment. The ISS partners' lack of clear definition of ISS products and services, complex and high market entry conditions, as observed in section 2.3.2, confirm the need for a collaboration. Clearly the ISS partners have difficulties in creating attractive ISS portfolios and in accessing and acquiring customers from the non-space markets. Therefore, there is a need for the creation of collaborations, such as the present and future business functions that can undertake the above activities.
The answer to research Question 3: *How will ISS partners' commercial activities encourage or discourage ISS commercialisation?* is addressed through the description of ISS partners roles under the price leadership theory, emerging markets and the example of the commercialisation of the biotechnology industry. The analysis in section 2.3.7, showed that NASA and RSA are the dominant price leaders, while ESA, JAXA and CSA are price takers. NASA and RSA price dominance discourages ISS commercialisation development for the

other ISS partners and present business functions.
On the demand side under the ISS emerging markets the ISS partners have a nurturing role, of setting up and implementing ISS access and pricing policies. ISS partners policies encourage ISS commercialisation. As discussed in section 2.4.1 the ISS partners can start to have an institutional management role, followed by a coordinating one, by reducing their investment in ISS market development and influential role in ISS commercialisation. The biotechnology commercialisation example from section 2.5.1 showed that the creation of a competitive environment, property protection and government support are conditions that can encourage ISS commercialisation. ISS commercialisation provides opportunities to the ISS partners not only to recover their ISS incurred costs, but also to implement more effective ways to use ISS products and services.

Chapter 3

Market Trends in Space Industry

3.1 Introduction

Historically, the space industry has been largely dominated by political decisions, since space agencies as public organisations have been its major suppliers and customers.
This Chapter identifies space industry market trends that influence the market and strategic developments in ISS commercialisation and present business functions. The Chapter results are directly linked to the following research Questions 1 and 5 from section 1.3:

- What are the current market and strategic developments in ISS commercialisation? - Question 1
- What are the expected future market and strategic developments in ISS commercialisation? - Question 5

The above questions are addressed through the identification of positive and negative trends of space industry that influence the current and future ISS commercial environment. Positive trends are ones that encourage ISS commercialisation development and negative ones those that constrain it.
The space industry is defined by [36] as an industry that involves the design, development and production of space qualified space hardware and software. This includes ground segment equipment and related services such as satellite tracking, station keeping and launcher tracking. The space sector is defined by [85] as public and private bodies involved in the provision of space-enabled products and services. Since the latter definition is quite general the first definition of [36] will be used in this thesis as it gives a clear description of the space industry. With the growth of telecommunication, launch services and navigation markets, commercial customers have started to play an important role in its development. There is, in space industry, a well-segmented "institutional" market and a "commercial" one[1]. This division is necessary as it indicates how different driving forces dominate in a

[1]The institutional markets are characterised by demand from institutional customers (i.e. space agencies, institutes, etc.), high market entry barriers, strong regulations and high technical requirements. The

certain market. Changes in world space budgets (i.e. civil, military) will influence strategic and market developments in ISS commercialisation, because of the ISS partners nurturing role, as earlier observed in section 2.4.1. An overview of the launch services and space tourism markets will support the identification of trends that encourage or discourage ISS commercialisation development. The analysis of collaboration processes in the space industry will also provide indication of the market trends that will influence future ISS commercialisation.
The new Moon and Mars space exploration visions of US and Europe will influence ISS commercialisation and therefore will be further analysed. The results of the analysis in this Chapter will contribute to answering research Questions 1 and 5, from section 1.3.

3.2 Research Relationships

This section gives an overview of the business functions' relationships that will be investigated in this Chapter, as illustrated in Figure 3.1.

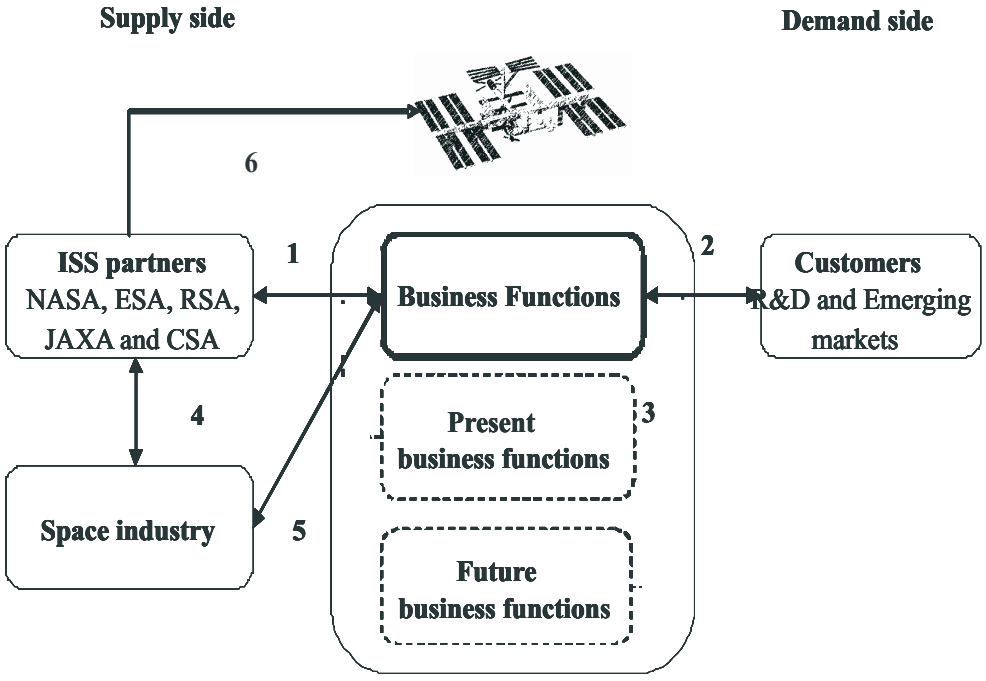

Figure 3.1: Relationships investigated in Chapter 3

institutional markets include customers from space agencies, national civil programmes and multi-lateral civil and military programmes. The products of the institutional markets include an important share of R&D and science [34]. The commercial markets are characterised by higher levels of competition, cyclical and abrupt changes, global demand and shorter lead times. Commercial markets include launch services, navigation and sales of space technology.

Relationship 4: ISS Partners and Space Industry - will be analysed for strategic and market developments in space institutional and commercial markets and their influence on ISS partners and present business functions.
Relationship 5: Space Industry and Business Function - will be analysed for trends from the collaboration and consolidation processes that influence ISS commercialisation.
Relationship 6: ISS Partners - this relationship will investigate the influence of the ISS partners' new space programmes for space exploration on the current and future ISS commercial environment.
The analysis of market trends in the space industry will support the identification of driving forces from space industry, which will in turn influence the market and strategic developments of ISS commercialisation.

3.3 World Space Budgets

This section analyses the world space budgets and continues to address research Question 1: *What are the current market and strategic developments in ISS commercialisation?*. To answer this question there is an overview of world space budgets and an analysis of civil and military budgets as a percentage of GDP. This analysis is necessary because the changes of the ISS partners' space budgets will influence their ISS commercialisation policies and relationships with space industry. The turnover of the world space sector in 2003 was estimated to be around €144 billion. The world institutional budgets for space programmes and activities for 2003, was estimated to be around €43.5billion [28]. Figure 3.2 illustrates the world space budgets of Europe, USA, Japan, Canada and Russia from 1999 till 2004. Both civil and military space budgets are included in world space budgets.
USA has the highest space budget, followed by Europe[2], Japan and China. NASA's expected budget increase[3] is around 5.6 % from 2004 to 2005 [13]. Changes in the world space budgets will influence the ISS partners' relationships
Relationship 6: ISS Partners - the US space budget shows that NASA will remain a powerful and dominant player in the space industry, as initially observed in section 2.3.7. NASA budget increase is expected for the future new space vision for Moon and Mars space exploration (see section 3.7.1). Europe has been much more cautious in its budget increases compared to the USA. Japan and Russia will push their space agencies to overcome budgetary constraints through commercialisation of space technology.
Relationship 4: ISS Partners and the Space Industry - the USA budget increases will

[2]For a comparison between US and European civil space budgets see Appendix C, section C.1.
[3]As a result of the newly introduced initiatives for human space exploration to the Moon and Mars by the year of 2020, as discussed in section 3.7.

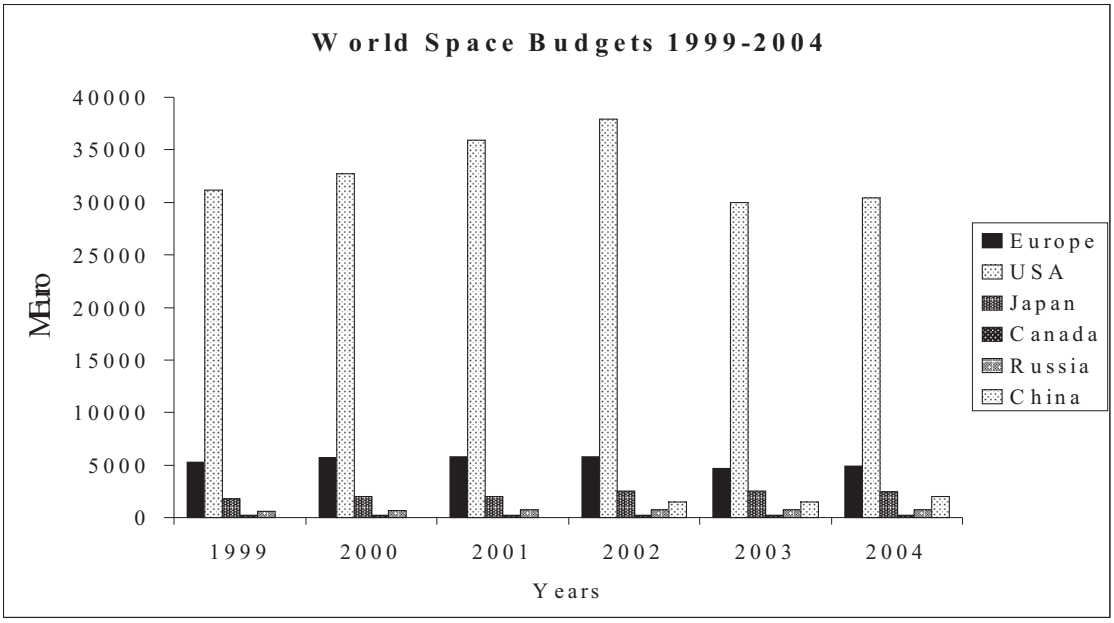

Figure 3.2: World Space Budgets from 1999 till 2004 [35]

in turn increase institutional sales of US space companies and these companies can restructure their activities, therefore, developing only the institutional markets and not the commercial ones. The European budgets, which are lower in comparison with the US ones as presented in Figure 3.2, show that European space companies have a strong incentive to attract commercial customers, and expanding their commercial markets. Thus, European space companies could exploit the ISS commercial opportunities. US and Europe different have different budgets and different needs for ISS utilisation and therefore, they are on different roads towards ISS commercialisation. This is a positive trend in the European space industry that will encourage the development of new markets for space applications and the creation of new collaborations.
US will remain a powerful player in the global space industry, while Europe, Japan and Russia will aim at developing the ISS markets. European space companies could exploit ISS commercial opportunities and these market and strategic developments contribute to answering research Question 1.

3.4 Launch Services

This section analyses the world space budgets and continues to address research Question 1: *What are the current market and strategic developments in ISS commercialisation?*. To answer this question there is an overview of the market trends and number of worldwide

commercial and non-commercial launches.

- Increased cooperation between Europe and Russia for ISS launch services
- Europe lacks the transportation capability and independence to launch astronauts to the ISS
- Expected Soyuz launches [114] from French Guyana[4]
- ESA "Taxi flights" to the ISS [113]
- Overcapacity of available launch services
- The US Federal Aviation Administration (FAA) granted to Mojave Aerospace Ventures (MAV) licenses for the five commercial suborbital launches of SpaceShipOne in 2004 [38]
- Internationally developed market segment with multi-national companies
- Expected ATV launches to the ISS
- Reduction of launches of commercial payloads [115]

The launch industry serves both institutional and commercial customers. Figure 3.3, illustrates the worldwide commercial launches for 2004. Russia is the leading country for non-commercial launches and US for commercial ones for 2004. Figure 3.3 shows that in 2004 non-commercial launches of 59 were dominating over only 17 commercial launches worldwide. This is a negative market trend that shows that there is a reduction of the demand for launches of commercial payloads. The launch market is very competitive, there are many countries offering launch services and an overcapacity of launch services could ensue. The launch industry may need to offer cheaper transportation services, with the ensuing reduced prices better meeting customers' needs. Increased cooperation between Europe and Russia[5] is a positive trend which on one side provides an unique opportunity for space station access for Europe and on the other will grant Russia access to European markets. European dependence on NASA will decrease but will increase on Russia. As a result of the Columbus launch delay, Europe will have to keep its industry teams for three more years [123] from 2004 until 2007. For European ISS commercialisation, ESA will provide also access to Russian ISS products and services. Thus, the European space

[4]France and Russia signed an agreement on opening Russian access to the ESA launch site in Kourou from 2006. Arianespace will cooperate with Russian Starsem for launching medium sized payloads, to meet the gap in its own product line [114].

[5]Europe and Russia are planning jointly to build the Clipper vehicle. This will be a vehicle to carry six astronauts [122] to the ISS.

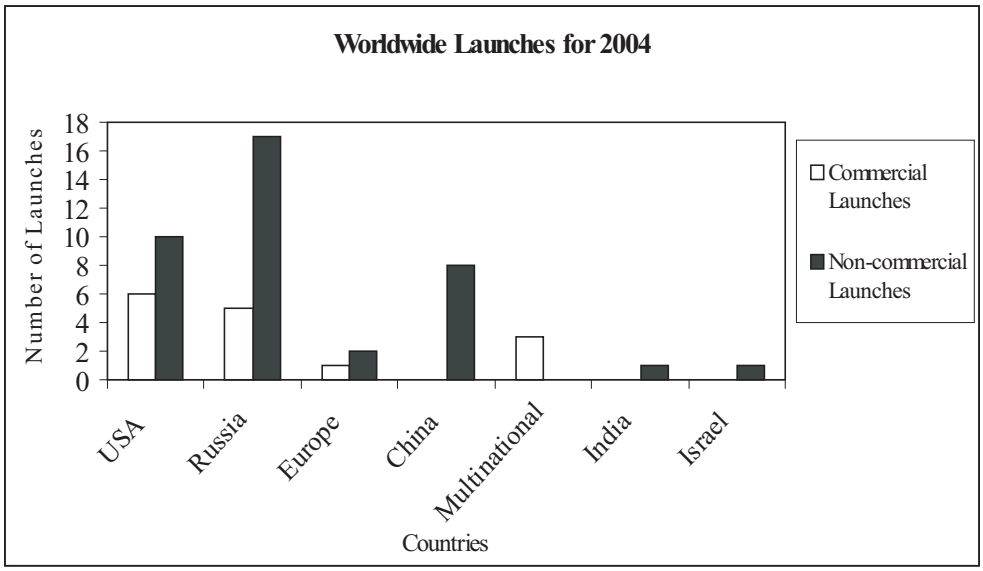

Figure 3.3: World wide commercial launches for 2004. Commercial launch is when the launch contract for the payload has been internationally competed. Non-commercial launches are considered government-civil, government-military or non-profit payloads [38]. Multinational launches are considered the launches made by the International Launch Services (ILS) company.

companies could aim at creating collaborations with Russian space companies as discussed in section 3.6.1 for sales of space technology and for development of ISS markets as further discussed. A positive market trend for European space industry for launch services can be observed in the ATV launches. ESA could offer its commercial customers and the ISS partners to launch their payloads to the ISS on-board the ATV.
Increased cooperation between Europe and Russia is a positive market trend on ISS commercialisation, as customers can access Russian ISS products and services. There is a reduction of the demand for launches of commercial payloads and an overcapacity of launch services. European dependance on NASA for access to the ISS will reduce but will increase on Russia. ATV production and launches is a positive market trend. The above market trends describe the current strategic developments in the current ISS commercial environment and therefore, contribute to answering research Question 1.

3.5 Emerging Markets

In this section is an overview of the emerging markets of space applications development. This section continues to address research Question 5: *What are the expected future market*

and strategic developments in ISS commercialisation?. To answer this question there is an overview of the market trends in emerging markets and market demand for space trips. Hereby, is an overview of the different types of emerging markets in space industry:

- Space tourism - started with the launch of the first space tourist Dennis Tito
- Space based solar power - aims at developing more low cost and efficient power
- Space movies - the creation of movies on board the space station, such as the IMAX
- Advertisement[6] - Pizza Hut developed a vacuum-packed space pizza, which was filmed [92] by the Russian cosmonauts on board the space station
- Sponsorship - private companies sponsoring launch missions or other experiments on board the ISS. (see an overview of global sponsorship spending in Appendix C, section C.2)
- Space based weather forecasting - contributes to forecasting the impact of increased radiation or solar wind on earth observation satellites and weather forecasts

This market is developing without ISS partners' investment and support, thanks to wealthy individuals who have a passion for space exploration and are ready to pay around $20 million for a seat on the Soyuz. In 2005 the third space tourist, G. Olsen, visited the ISS. The expansion of this market is expected to accelerate the development of privately funded transportation vehicles, such as SpaceShipOne. The creation of new vehicles is also encouraged by the X-prize[7], a prize of $10 million and recently won by SpaceShipOne. On the 4th of October 2004, the World witnessed the first commercial flights of a privately built spacecraft. SpaceShipOne built by B. Rutan, won the X-prize by completing two sub-orbital flights within two weeks, carrying the equivalent mass of two passengers [112]. At present in 2005, Russia is the only country with commercial experience in flying space tourists to the ISS. Figure 3.4 illustrates the percentage of positive responses to space travel of female and male respondents in the US to the question whether they are interested in becoming space tourists.
The activities of private companies such as Space Adventures, show that these companies are convinced of the potential and future of this market. The successful development of space tourism will result in continuation of this market including the development of markets such as MIG flights and astronaut training. The ISS partners present and future business functions will need to consider targeting ISS customers from this new emerging

[6]In Japan, Nissan Food Products the maker of Cup Noodle, is collaborating with JAXA to develop instant space noodles for astronauts on board the ISS [92].

[7]In 1995 Diamandis established the X-prize foundation which offered a $10 million prize for radical breakthroughs in space and other technologies for the benefit of humanity [95].

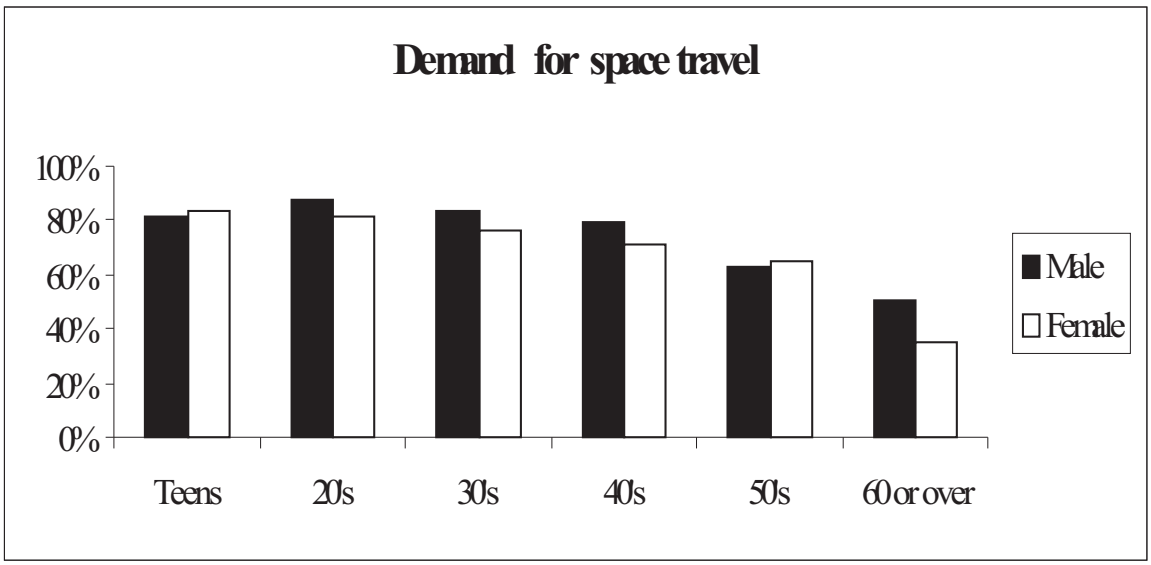

Figure 3.4: Market demand for space travel in the USA [91]

markets and therefore, develop ISS portfolios to attract them. The creation of a competitive environment for ISS markets and more space tourism companies are further investigated in section 4.3.4.
Space movies[8], advertising and sponsorship[9] are also new market segments with a demonstrated potential. According to IMAX Corporation, the large format space trilogy has led to $250 million being generated, and was seen by around 70 million people worldwide [47]. The continutaion of space tourists visits to the ISS, the expected growth of the space tourism and sponsorship markets and the creation of privately funded transportation vehicles, are positive trends that will result in increase of the recognition of ISS commercial opportunties. Furthermore, the ISS partners, present and future business functions will need consider targeting ISS customers from these new emerging markets and therefore, develop ISS portfolios to attract them. The above conclusions describe market developments in the current ISS commercial environment and contribute to asnwering research Question 1, from section 1.3.

3.6 Space Companies Collaboration Processes

The overview in section 3.6.1 of the international collaborations for launch services between European, Russian and American space companies will influence the current and future

[8]The Dream is Alive, Blue Planet and Destiny in Space.
[9]For more information on global sponsorship spending for 2001 see Appendix C, section C.2, Figure C.1.

strategic and market developments in ISS commercialisation and present business functions. Therefore, continuing to address again both research Questions 1: *What are the current market and strategic developments in ISS commercialisation?* and research Question 5: *What are the expected future market and strategic developments in ISS commercialisation?*, from section 1.3.

3.6.1 International Collaborations

This section presents an overview of collaborations between the Russian space industry with European and American space industries. These collaboration processes will influence the strategic developments in ISS commercialisation and result in increased access to ISS products and services for commercial customers.
After 1992, Russian space industry found itself in a very difficult situation following the fall of the Union Soviet Socialists Republics (USSR) and liberalisation of the national economy towards a market-based economy. The Russian space industry had symbolic budgets, yet had to face drastic changes to its structure and production and operation. Despite the increasing cost of space technology, it could only afford low labour rates and as a consequence it lost many highly qualified personnel. Despite the loss of unique knowledge, skills and technology, a situation common to many industry sectors in countries in a similar economic transition, the Russian space industry managed not only to survive, but also to gain new markets and become a major partner in many international space projects. For example, in 2000 the Russian space organisations earned $650 million by launching foreign satellites [84]. The Russian space institutes and companies were forced to commercialise their space technology and operate in a market environment to survive, in order to overcome the lack of sufficient budgets for operations of their space technology. As a result, Russia became one of the countries where commercialisation is a core process in funding space industry development. Table 3.1 presents an overview of the different international collaborations between Russian and European or American companies.
Mostly US companies participate in joint ventures with Russian organisations, followed by European ones. These companies also form collaborations with government organisations and institutes, such as the Russian Space Agency (RSA). An interesting observation is that most of these collaborations have been established over a short period of time, in the mid 90s onwards, as a wave of collaborations. This shows a positive market trend in the Russian space industry; opening up and creating conditions for collaborations and developing a strong ability to attract multi-national companies as investors, shareholders and partners. Table 3.1 shows that Russian collaborations are not restricted only to American and European organisations, but also include Ukrainian and Kazakhstani organisations. The Russian space industry is expanding its markets at a global level and is emerging as a leading player in the European and Asian markets. The Russian collaboration experience

Name	Partners and countries
International Launch Services (1995)	Lockheed Martin US, GKNPTs, Energia
STARSEM (1996)	EADS, Arianespace, Rosaviakosmos, Samara Space Center
Sea Launch (1995)	Boeing, RSC Energia, Aker Kvaerner, SDO/PO Yuzhmach
EUROKOT	EADS Space,Krunichev Space Center
KOSMOTRAS(1997)	RSA, Ukraine, Kazakhstan
United Start Corporation (1998)	Assured Space Access Inc., Puskovyue Uslugi
RD-AMROSS	Pratt& Whitney, NPO Energomass-RF
ISTI	Space Systems Loral, ARK USA, SEP, OKB Fakel, RF

Table 3.1: International Collaborations [20], [116], [61], [93], [60]. The first column presents the names of these collaborations and the second one presents the partners in them. These collaborations are primarily for commercial exploitation of Russian launchers.

will influence the relationship between the space industry and present business functions. *Relationship 5: Space Industry and Business Function* - as a result of the increase in collaborations, Russia could provide increased transportation access to the ISS for European customers, for both the R&D and emerging markets. Future business functions can form collaborations with Russian space companies to access the Russian ISS segment rather than the European one, thus, ignoring ESA ISS products and services. In order to ensure that its ISS products and services are also sold, ESA has to grant exclusivity rights[10] for sales of its ISS products and services to present and future business functions.
In the Russian space industry there are sound conditions for creating collaborations between Russian and European companies. ESA can offer to present and future business functions exclusivity rights for certain ISS markets as an incentive for them to sell ESA ISS products and services. The above conclusions contribute to answering research Question 1 and 5, from section 1.3.

[10]Exclusivity rights are rights that will not be shared by ESA with any other companies. For example if customers from the biotechnology industry approach ESA for flying their experiment to the ISS, ESA is obliged to send them to the commercial agent which operates in the biotechnology, nutrition and health ISS markets.

3.7 Future Space Exploration

Future space exploration visions, expressed by both NASA and ESA, for interplanetary travel to the Moon and Mars create new opportunities for research, technology and market development. These new space exploration visions influence the current and future ISS programmes and ISS commercialisation. The research results from this section will be used to answer research Questions 1: *What are the current market and strategic developments in ISS commercialisation?* and Question 5: *What are the expected future market and strategic developments in ISS commercialisation?*, from section 1.3.

3.7.1 NASA Space Exploration Programme

At the beginning of 2004 the US President introduced a new NASA concept for human space exploration to the Moon and Mars, starting with a return to the Moon by the year 2020 and preparation for human exploration of Mars [82]. The objectives for the US space exploration are to:

- Implement a sustained and affordable programme to explore the solar system
- Extend human presence across the solar system
- Develop innovative technologies, knowledge and infrastructures
- Promote international and commercial participation in exploration to further scientific, security and economic interests

The US will continue its commitment to the ISS program but is planning to retire the space shuttle fleet in 2010. Figure 3.5 illustrates NASA strategy for long-term space exploration. This US vision provides an ambitious concept for the future of manned space exploration. However it also underlines that the USA will not support future development and operations of space stations after the end of the ISS. A shift in focus towards the development and implementation of interplanetary missions will have a negative impact on ISS commercialisation, such as an absence of a space-based laboratory for the development and testing of new technologies, combined with lost training opportunities for extended human missions in microgravity. ISS commercialisation will be negatively influenced as the R&D and emerging markets will be just entering a Frenzied stage of market development, as earlier discussed in section 2.4.1. NASA will focus on promoting its new space exploration program and overshadowing the promotion of the ISS commercial opportunities. This is an ambitious concept which requires extensive funding to achieve its objectives. Further investigation of the consequences of this future vision on ISS commercialisation will be presented. A shift in focus towards the development and implementation of interplanetary missions will have a negative influence on ISS commercialisation, for the successful

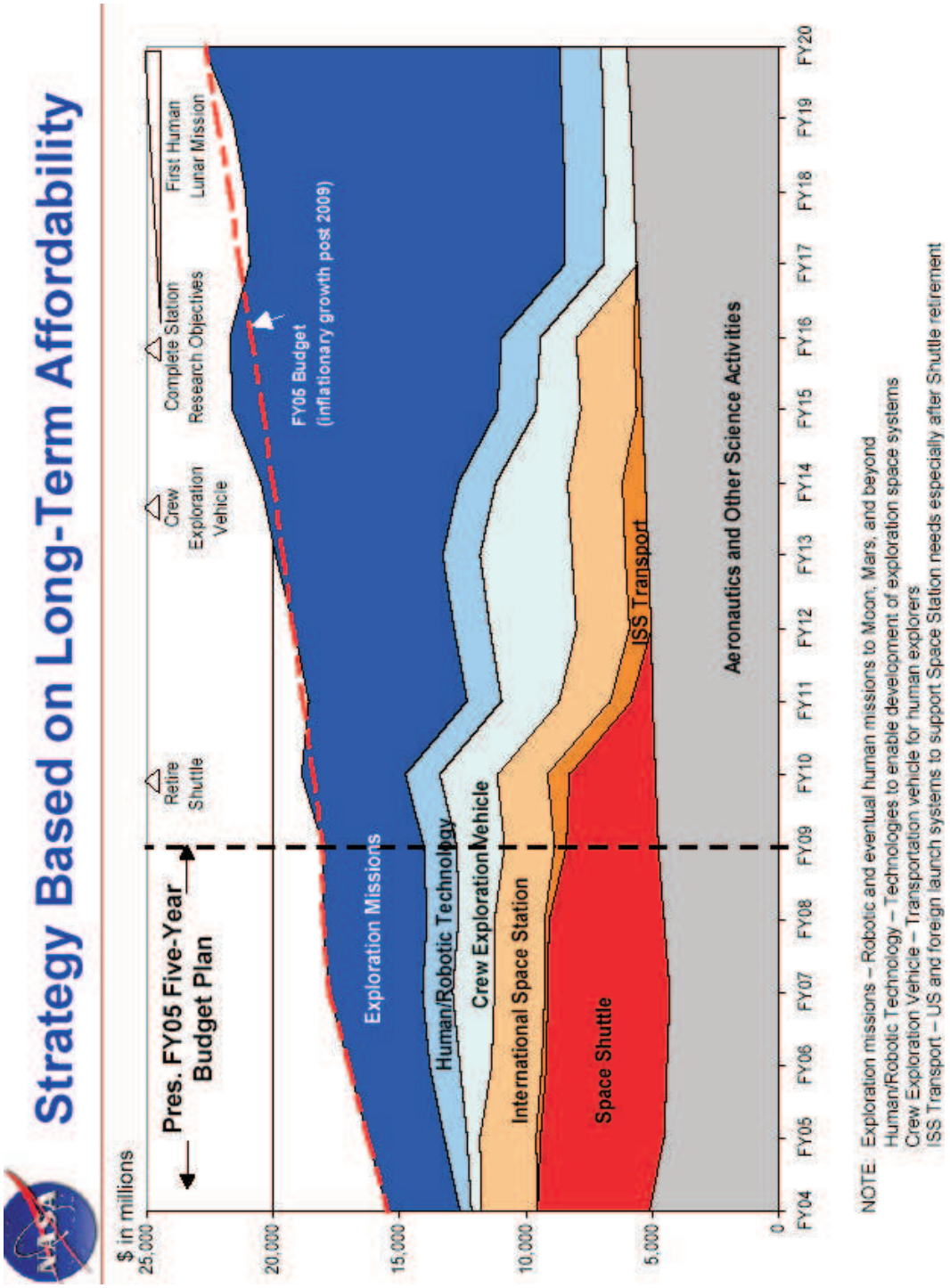

Figure 3.5: NASA space exploration program [82]

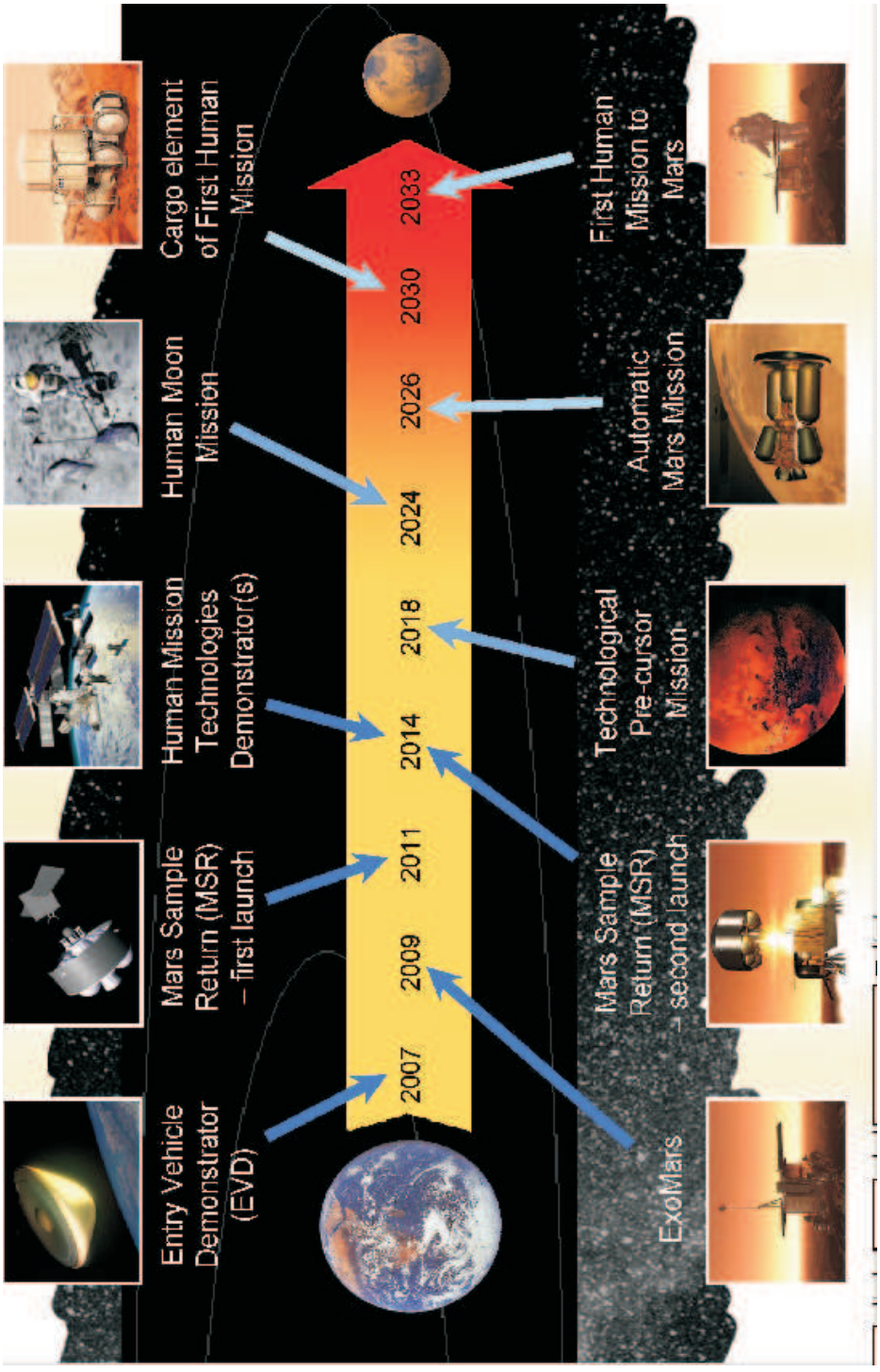

Figure 3.6: ESA Aurora program [74]

development of the ISS markets and the promotion of the ISS commercial opportunities. Therefore, the above conclusions provides an insight of the expected developments in ISS commercialisation and thus, addressing research Question 5.

3.7.2 ESA Space Exploration Programme

Interplanetary exploration was also proposed by ESA in 2001 and initiated by the implementation of the Aurora Programme [74]. The objectives of the European space exploration vision are to:

- Explore the solar system and the Universe
- Encourage innovation, research and technology
- Extend Europe's human space flight programmes
- To inspire young people

The European programme includes robotic missions to the Moon and Mars until 2015, followed by a decision on a human mission to the Moon by 2024 and to Mars by 2033. Like the US programme, the Aurora programme does not include the construction of new space stations and focuses on interplanetary exploration through robotic missions and later though human exploration. As illustrated in Figure 3.6 there will be a time gap of around 7 years between the end of the ISS and the first human Moon mission. European astronauts and scientists will have no opportunity to perform experiments under long-term microgravity conditions for 7 years. A lack of space stations in the future will have negative consequences for ISS commercialisation and give rise to a situation in which there are markets for space-based resources, but no actual commercial space resources.
NASA's and ESA's vision for interplanetary exploration give rise to concerns about the cost of programmes, the future commercialisation and the lack of future space stations and addresses research Question 5.

3.7.3 Financing Future Missions

The implementation of the new space exploration objectives will cost tens of billions of dollars/euros to US and European taxpayers. The cost of developing the necessary spacecraft, lunar bases and Mars bases are difficult to substantiate, with estimates varying between $ 50 billion to $1 trillion spread over 16 years. The cost for an earlier US plan for a crewed Mars mission, initiated in 1989 by the first President Bush, had a cost estimate at that time of $600 billion [53]. These are extremely high budget requirements and the Congress never approved the plan. In contrast to the past proposal, the most important method

of funding the US concept would be by NASA freeing up current resources by "holding up programmes that do not support the vision, retiring the space shuttle and focusing on innovations that reduce the cost of sustained space operations" [82]. Many programs do not contribute to this vision and these may be cancelled. This could lead to some high profile science missions, such as the Hubble Space Telescope, being sacrificed. The cost of ESA's Aurora programme is currently estimated at around €900 million for the early phase of development from 2005 to 2009 [74]. The actual implementation of the NASA and ESA programs will require extensive funding from space agencies. The current experience of ISS partners show that large ISS cost overruns can easily and significantly affect large and complex space projects. Strict financial control over the allocated budgets for these concepts of future space exploration will therefore be a necessity. A lack of sufficient private funding could find the space agencies in a situation similar to the present ISS, where the ISS partners could be pressured by budgetary constraints into developing commercialisation activities and attracting additional financial resources. NASA and ESA may generate revenues from commercial activities and thereby obtain additional, non-public funding. Early considerations for attracting funding from venture capitalists, banks and corporations will prove beneficial for long-term interplanetary missions to the Moon and Mars.
Through such commercialisation possibilities, these private companies could generate a return on investment, based on increased technological innovation, new market development and product leadership.

3.7.4 Commercial Activities

Commercial exploitation of new technologies and resources for Moon and Mars exploration is not a prime objective of the plan for future exploration by the USA. Commercialisation is mentioned in the following context, "pursue commercial opportunities for providing transportation and other services supporting the International Space Station and exploration of missions below LEO" [82]. In the proposed concept it is also vaguely mentioned that "NASA will seek use of existing or new commercial launch vehicles for cargo transport to the Space Station and potentially to the Moon and other destination" [82]. These statements confirm that the commercialisation of space technology is not a prime priority for the USA and NASA will actually be looking more for the use of non-space technologies. The implementation of Moon and Mars visions will cost billions because new technologies have to be developed and tested. A real long-term vision on the commercialisation of interplanetary missions has not been developed. This lack of a clear vision on commercial exploitation can result in the loss of financial opportunities and customers. The ISS partners may risk repeating the approach of the ISS programme, namely first building a space-based facility, and only later, in the final stages of construction, initiating the

commercialisation process. Potential customers for commercial activities on board future missions may have different needs than the space agencies. Customer needs should be integrated early in the planning stages of future missions and contributions should be made to both finance and to the effective use of these future interplanetary space missions.
Commercialisation has been partially considered in the US space exploration visions. The lack of a clear vision on commercialisation will result not only in loss of profits for the ISS partners, but also in not considering customers needs in future missions and thus, answering research Question 5.

3.7.5 ISS Markets after the end of the ISS program

The current European and US visions for future space exploration do not include the creation of new space stations. The lack of a space station and space shuttle after 2010 (see Figure 3.5) could lead to a situation in which there are markets for commercial, space-based activities, but insufficient commercial space resources. The ISS markets are emerging and only at the end of the lifetime of the ISS these may enter their growth stage (i.e. Nascent). At that time, profits and market demand could be rising, but further growth of commercial initiatives may be constrained. This constraint result in a loss of customers and profits and the present business functions may start to focus only on short-term investments and implementation of small commercial projects. The future commercialisation process will be dominated by political decisions rather than market ones. To prevent the loss of potential customers and profits (see section 3.7.4) and the ISS partners will have to integrate customers' needs into the visions for Moon and Mars exploration. Commercialisation could be extended to missions to the Moon and Mars, and thereby partially help to finance these projects [120]. These issues could influence ISS partners' relationships, the space industry and present business functions.
Relationship 6: ISS Partners - NASA's $1.2 billion budget on research programs that do not contribute to the US exploration vision, will be cancelled [10]. There is a possibility that NASA will withdraw its funding for the ISS and stop supporting ISS commercialisation, which, in this early stage of market development, will deny any chances for commercial space exploitation. After the retirement of the Space Shuttle in 2010, the ISS partners will find themselves relying fully on the RSA for manned transportation and on ESA for payload transportation to the ISS. The ISS can potentially become an assembly platform and technology test bed for the future space-based technologies for future Moon and Mars missions. Thus, focusing on institutional utilisation and not commercila one.
Relationship 1: ISS Partners and Business Function(BF) - NASA RPC centres (see section 4.4.1) will focus on the development of space technologies only for the Moon and Mars missions and will be interested to attract only insitutional founders in them. The Commercial Agent could become reluctant to establish long-term collaborations with ESA and

develop ISS self-sustainable markets[11]. Commercialisation can result in increased synergy between space-based and ground-based technologies, leading to the development of technologies, such as medical devices or biotech bioreactors, which could be useful for long-term manned Mars and Moon missions.
Relationship 4: ISS Partners and Space Industry - the new European and US vision for space exploration will have a positive influence on the development of the space industry. The space companies will increase their lobbying activities[12] and their interest in winning institutional customers, as already earlier observed in section 3.3. The future of the business functions is quite uncertain, because of the current lack of a long-term commercialisation strategy.
There are several reasons for considering commercialisation of future missions. The high costs for implementing space missions to the Moon and Mars as well as the potential necessity for attracting private funding are obvious. Other important reasons for considering commercialisation on board interplanetary space missions are the development of new self-sustainable markets, as the lack of a long-term labotary can results in short-term investments in ISS markets from the present business functions.
The analaysis of NASA and ESA future space exploration visions, contribute to describing future strategic and market developments in ISS commercialisation and therefore, address research Question 5.

3.8 Results and Conclusions

The analysis of the positive and negative market trends in the space industry provided an insight into the trends that influence ISS commercialisation. The results from this Chapter directly contribute to answering research Questions 1 and 5, from section 1.3.
The answer to research Question 1: *What are the current market and strategic developments in ISS commercialisation?* is sought through an analysis of the world space budgets, collaboration and consolidation processes in space industry. The total dependence on Russia for regular ISS access are trends that influence ISS commercialisation. USA and Europe have different visions towards ISS commercialisation. Europe will have to keep its industrial teams operational until the Columbus module is launched. The above are negative trends that will constrain ISS commercialisation. Because of reduced ISS products and services and increased ISS prices for customers.
To answer research Question 5: *What are the expected future market and strategic devel-*

[11]ISS self-sustainable markets do not need to rely on public support for their development. These are markets that continue to develop after the end of the life time of the ISS.

[12]In 2004 the US aerospace industry (i.e. Boeing, Lockheed Martin, etc.) created a Coalition for space exploration that lobbies infront of the US Congress for the successful implementation of the US Moon and Mars space exploration vision [15].

opments in ISS commercialisation? an analysis was carried out on world space budgets, international collaboration processes and future space exploration visions. Reduced ISS products and services for commercial customers and increased cooperation between Europe and RSA, are expected future strategic developments. Expected growth of space tourism, sponsorship markets and the creation of privately funded transportation vehicles (i.e. SpaceShipOne) are some of the expected market developments. Present and future business functions need to consider targeting customers from these new emerging markets. The analysis of NASA and ESA future space exploration visions showed that interplanetary missions have a negative influence on the successful development of ISS markets. There is a lack of clear vision on the role of space commercialisation in Moon and Mars exploration missions. To prevent the end of ISS commercialisation and loss of potential customers and profits, the ISS partners will have to be careful not to repeat the mistakes of the ISS programme. The high costs for implementing space missions to the Moon and Mars and hence the potential necessity for attracting private funding is obvious. Other important reasons for considering commercialisation on board interplanetary space missions are the development of new markets and the creation of self-sustainable ISS markets. The early integration of customer needs in future missions is a strategic development. The lack of a long-term space laboratory results in the need for short-term investments in ISS markets by the present business functions.

Chapter 4

ISS commercial Environment

4.1 Introduction

Commercialisation of the International Space Station (ISS) is an innovative and pioneering process. This Chapter will aim at addressing the research Questions 3 and 4, from section 1.3:

- How will ISS partners' commercial activities encourage or discourage ISS commercialisation? - Question 3
- How are ISS products and services going to be marketed and sold? - Question 4

Analysis of the Russian experience in the commercialisation of Mir will support the identification of activities that the ISS partners could implement in order to encourage ISS commercialisation. In addition, an analysis is made of the ISS partners' commercialisation objectives and pricing policies. These pricing policies will be analysed in detail, as the ISS price changes by one ISS partner could influence the other ISS partners and present business functions.
In this Chapter, there is an overview of the ESA ISS commercial proposal selection, targeted markets and products and services. This overview will support the creation of a future business function proposal in Chapter 8. Analysis of the present business functions will support the identification of market opportunities for the future business function and also describe the way certain ISS products and services are sold. The findings in this Chapter will contribute to answering research Questions 3 and 4, from section 1.3 and establishment of predictions for the future ISS commercial environment in Chapter 7.

4.2 Lessons Learned from the Mir Space Station

This section addresses research Question 3: *How will ISS partners' commercial activities encourage or discourage ISS commercialisation?*. To answer this question there is an analysis of the commercialisation of the Mir space station. As earlier discussed in section 3.6.1, symbolic space budgets triggered the commercialisation of the Russian space technology. Mir commercialisation was not initiated by choice by RSA[1], but by the need for survival. The Mir station was operational for 15 years (1985-2000), with visits of around 100 cosmonauts and astronauts from 12 countries during which time 20,000 experiments were undertaken. For example, in 1988 the second Bulgarian cosmonaut Alexander Alexandrov[2] carried out 14 experiments [86]. In 1991 the economic transition in Russia imposed unavoidable economic conditions for development of the Russian space industry. It faced symbolic space budgets, high inflation, industrial restructuring, liquidation of organisations and high levels of unemployment, these being economic processes taking place in all Central and Eastern European countries in the early 1990's. The Mir space station was caught in the waves of history and commercialisation was the only solution to keep it operational. The first commercial activities started in the early 1990's, with the launch of the first Japanese reporter on board Mir. He made daily TV reports and the Russians were paid $28 million for a one-week flight on board the station [108]. Commercial activities on board the space station continued with the creation of an international company called MirCorp [71]. In 2000, the company funded the first commercial space flight sending cosmonauts Sergei Zaloytin and Alexander Kalery to the Mir station. The Russians were exposed to budgetary and political pressures to de-orbit the Mir station in the early stages of ISS construction in the late 90s. The main concern of the ISS partners was that the Russians could hardly keep Mir operational and meet their ISS financial and construction commitments to the ISS. As a result of the de-orbiting Mir the Russians suffered direct and indirect losses, as identified by [16]. The main direct loss was the loss of experimental equipment on board the station and the indirect losses were missed commercial opportunities for space tourists and foreign astronauts. Indirect losses included the competitive position in the market for services carried by the station and projects based on international cooperation [16]. After de-orbiting of the Mir station the Russians transferred their commercialisation activities to the ISS. The first space tourist, Dennis Tito, arrived on

[1]RSA offers for commercialisation: 1) space-based products and services (e.g. launch of payloads, communications, TV broadcasting, remote sensing, navigation, facilities), 2) space activities (e.g. experience on long-duration flights, methods for material production in a space environment), and 3) sales of space technologies (e.g. propulsion units, on board nuclear power sources, electric propulsion units, actuation devices for the motion control systems, docking systems, carbon composite materials, alloyed steels) [102].

[2]Space research in Bulgaria started in 1969, as a result of the active role of space science in the strategic development of Bulgaria. The country launched its first cosmonaut George Ivanov in 1979, on the Soyuz-33 spacecraft.

board the station in 2001 and the second Mark Shuttleworth, shortly followed in 2002. It is obvious that for ISS creation and operations, the Russians are an indispensable partner for the other ISS partners. Due to their impressive space station experience in development and operations.
Anfimov [77] makes the following recommendations for ISS commercialisation successful development:

- creation of a user-friendly environment for customers
- minimal period of time from user's proposal to project implementation
- simple and clear processes for proposal review and selection
- transparent pricing policy
- provision of confidentially and IPR rights for commercial projects

The first recommendation on the creation of a user-friendly environment and the last recommendation are similar to the minimum conditions for encouraging ISS commercialisation identified in the analysis of the biotechnology commercialisation in section 2.5.1. Preserving confidentiality and IPR rights will be further considered as a condition for the creation of a future business function in section 5.3.3. ESA has also implmented a IPR policies[3] for encouraging ISS commercialisation. The above recommendations are not limited to the ISS programme, but could also be used by other space programmes to commercialise their space based services, such as earth observation, navigation or even technology transfer. The overview of the Russian commercialisation experience shows the effects on the public, the new markets development and the creation of a competative environment for the sales of space station products and services. These effects are further studied in more detail in the sections to follow.

4.2.1 Public Awareness

The commercial activities on Mir encouraged companies such as Space Adventures and MirCorp to offer opportunities to fly to the ISS or undertake astronaut training. These new commercial activities increased public awareness of space exploration and life in space. The successful development of ISS commercialisation can encourage the creation of collaborations between space agencies and companies, for selling ISS products and services to non-space customers.

[3]IPR rights are given to customers who fully (i.e 100%) finance their commercial projects.

4.2.2 Competitive Environment

The Russian commercialisation processes led to the creation of new markets for space flight services, such as space tourism as already discussed in section 3.5. Showing that successful ISS commercialisation could also result in the creation of unexpected markets (i.e. space tourism) for ISS partners and competitive environment in the space tourism markets. Today a private citizen wishing to fly to the ISS or to experience astronaut training, can choose between several companies. These companies are constantly developing new markets and have a portfolio of ISS products and services. The competitive environment can also encourage the creation of companies developing and building privately financed spacecrafts for space tourism. A good example is the creation of SpaceShipOne, the sub-orbital spacecraft designed by B. Rutan with the objective of carrying space tourists, and which, during test flights and its X-prize winning flight, already reached an altitude above 114 km. The estimate is that by 2020, they will be able to carry space tourists at a price of $100,000 per ticket [111]. The successful flight of SpaceShipOne will encourage a competitive environment between companies selling SpaceShipOne seats, such as Space Adventures. In 2004, Richard Branson signed a deal with Burt Rutan to license SpaceShipOne's technology to build the first private space vehicle [40]. The expected price to be paid by future space tourists could be around €170,000 per flight [110]. Branson has already started creating a strong brand name for Virgin Galactic, by linking it to the Volvo [127] automobile. Furthermore, in 2005 Virgin Galactic signed an agreement to form The Space Ship Company that will manufacture launch aircraft and spacecraft and market them to spaceline operators [40].The emergence of a competitive environment in space tourism markets will, in turn, result in more companies offering access to ISS products and services and constructing and building privately funded spacecraft.
Mir commercialisation showed that economic transition and budgetary constraints encourage space station commercialisation. Resulting in increased public awareness of space exploration, new markets and creation of a competitive environment. Creation of a user-friendly environment, transparent, simple procedures for proposal selection and the provision of confidentiality and IPR rights for commercial projects are conditions learnt from the Mir commercialisation. The ISS partners must encourage the implementation of similar conditions to achieve successful ISS commercialisation. Mir commercialisation showed how a space agency can encourage ISS commercialisation and thus contribute to answering research Question 3, from section 1.3.

4.3 ISS Commercialisation

This section aims at addressing both research Question 3: *How will ISS partners' commercial activities encourage or discourage ISS commercialisation?* and Question 4: *How are*

ISS products and services going to be marketed and sold?. These questions will be answered by an analysis of the the ISS partners commercialisation objectives, pricing policies, ESA commercialisation policy, commercial projects selection process and targeted markets.

4.3.1 ISS Partners' Commercialisation Objectives

The ISS partners'excluding JAXA objectives show their intentions, motivations and expectations for ISS commercialisation:

- Creating new sustainable markets, using free market principles
- Generate revenues to sustain utilisation of the ISS [67]
- Achieving partial cost recovery and revenue generation
- Reduction of governmental costs for the ISS Russian Segment operations [103]
- Enhancing industries national competition

These objectives show the ISS partners motivation and political will to implement ISS commercialisation. They understand that the success of the commercialisation process depends on free market principles, but they are also willing to encourage and support competition in national industries. This means that certain ISS partners apply certain protectionist policies[4] giving preference to national companies as commercial customers. RSA is an exception to this possible approach, as they provide ISS access to all customers willing to pay.

4.3.2 ISS Partners' Pricing Policies

This section describes the pricing policies of the ISS partners. ISS partners' prices analysis results in a better understanding of whether the ISS partners pricing approaches encourage or discourage ISS commercialisation, thus linking the results of this subsection to research Question 3.
In section 2.3.7 the ISS partners' prices[5] were investigated in the context of the price

[4]For example, ESA offer promotional support (i.e. reduced ISS prices) for companies which come from countries that contribute to the ISS Exploitation Programme, as further discussed in section 4.3.3.

[5]A price is the amount of money charged or paid for a product or service. Theoretically price covers the costs for the production of a product or service. Authors such as [75] analyse prices from a different perspective. They view it as a customers' value perception of the product or service. The price is a variable which can be changed depending on the customer. This price variance gives an opportunity for companies to sell multiple products and services, bundled or unbundled. The price of a product or service provides visibility for a company. The price also sends a signal to customers about value, image, product availability, demand conditions, exclusivity and other features [75].

leadership theory. Analysis showed that NASA and RSA are price setters and influence the ISS prices of ESA, JAXA and CSA could consequently have uncompetitive ISS prices and lose commercial customers. NASA and ESA apply marginal cost-based pricing approaches[6] for ISS products and services.

- NASA's market based prices show its upper bound value for ISS products and services as perceived by customers. The lower bound to market price is NASA's marginal cost (the lowest price NASA would be willing to accept under normal market conditions [12]). Marginal costs[7] of a commercial payload will include only those costs that NASA would incur directly, because of the decision to fly the commercial project [12]. NASA's pricing structure is for setting prices on a rack (i.e. ISPR), as a bundle of services, as presented in Appendix A, section A.3, Table A.2.

- ESA practices the marginal cost-based pricing approach. The prices in US dollars refer to services provided by NASA and are subject to its pricing approach. Additional ISS products and services, such as media and communication services prices are defined on demand [26]. The ESA price structure is to set prices for MDL and ISIS Drawers (see Appendix A, section A.3, Figure A.2), as already discussed in section 2.3.7 and presented in Appendix A, section A.3, Table A.2.

- RSA pricing approach for different projects depends on: a) experiment: content of experiment, power, crew time, volume, mass, training b) space tourist: depending on the visitor's programme, c) advertisement on a case-by-case basis and d) entertainment depending on the project and ISS products and services required [101].

- The CSA price is based on the cost to end user which is the sum of the royalties, the locker-site, resources, transportation and other services [17]. CSA prices are similar to NASA's and their prices show the extent of their dependence on NASA for ISS access.

The RSA pricing approach, as concluded in section 2.6 lacks transparency and hinders price calculations for customers. Customers can be charged different prices and RSA can generate higher revenues from different margins for the same services. Pricing structures by the ISS partners[8] are normally either premium (i.e for extra services) or bundled services. RSA's prices and their pricing formula for ISS products and services are not currently available in the public domain. The ISS partners' pricing approaches are different, complex and

[6]In this approach, the prices of ISS products and services are based on marginal costs, which are only the costs that the agencies will incur directly as a result of their decision to fly a commercial payload.

[7]The marginal cost does not include fixed and sunken costs for the ISS.

[8]The ISS partners prices for separate ISS products and services could be seen in section 2.3.7. The detailed overview of the ISS partners prices for ISS products and services is presented in Appendix A, section A.4, Table A.2.

lack transparency. The ISS partners do not clearly present price promotions or discounts, which they could offer to first-time commercial customers and their pricing approaches do not encourage further ISS commercialisation. NASA's pricing structure indicates that the agency targets large customers and companies. These prices are for the ISPR, but not for the Mid-Deck Lockers (MDL). This lack of prices for MDL, could result in NASA potentially losing customers willing to fly smaller commercial payloads. ESA's pricing structure for lockers (i.e MDL) and drawers (i.e. ISIS Drawers) shows that the agency will aim at targeting medium and small-sized companies. In 2001 ESA prices (i.e. transportation, power, etc.) were highly dependent on NASA prices, but after the accident in 2003, they are influenced by RSA ISS prices for flying commercial payloads to the ISS. ESA can improve its pricing structure[9] by setting discount prices for first time customers, combined with a clear description of payment conditions.

Current ISS markets are emerging, there are new market opportunities and the environment is uncertain and complex, as observed in section 2.4.1. Flexible and pricing approaches by the ISS partners will encourage ISS market development. As the ISS markets develop there will be a need for market-based, flexible and risk-assumptive pricing approaches for pricing space technology resources for future Moon and Mars missions. Entrepreneurial pricing, as noted by [75] is reflected in the use of value-based pricing[10]. The ISS partners' do not employ pricing strategies, such as skimming, penetration[11] and price leadership, but they may consider these once the markets develop by also setting up prices for the R&D and emerging markets, and by establishing discount payment structures for commercial customers. Current ISS prices send a signal to the market that price changes can occur under political pressure and that market demand for ISS products and services and product availability is low.

The ISS partners' pricing approaches are different, complex and lack transparency. The ISS partners do not clearly present price promotions or discounts, which they could offer to first-time commercial customers. The ISS partners will need to change their pricing approaches to be more market-based, flexible and proactive, once the ISS markets develop these new approaches could be used for future Moon and Mars missions. The ISS partners pricing approaches do not encourage further ISS commercialisation and thus addresses research Question 3.

[9]The retirement of the Space Shuttle after 2010 is another consideration, as ESA may have to increase the usage of ATV, as already discussed in section 3.7.

[10]Value-based pricing is when the price of a certain product or service is defined based on the value it offers to the customer.

[11]Skimming pricing is an approach in which a company charges a higher price initially from customers willing to pay more for the privilege of possessing a new product, while market penetration pricing is an approach in which a company sets lower prices for its product in order to obtain a large market share in a certain market.

4.3.3 Commercial Project Selection

The overview of the process of ESA selection for commercial customer projects will support a better understanding of the services needed from the present and future business functions and contribute to answering research Question 4:*How are ISS products and services going to be marketed and sold?*. The ISS partners' sales conditions are compared in Appendix A, section A.3 and are very similar, as all of them request the submittal of detailed commercial proposals. ESA commercial proposal selection process is described, because of the availability of information on the process. Customers can submit their idea to ESA in the form of a commercial proposal, but if customers also want to apply for ESA promotion support by paying lower prices, they will also have to submit a business plan of their project.

Figure 4.1 illustrates an overview of the ESA process for commercial project selection. Once a commercial proposal meets ESA requirements[12] , the Commercial Promotion Office (CPO) sets up a Commercial Evaluation Team (CET). This team gathers space experts who assess the technical, ethical and financial feasibility of the project. Once the project is approved, ESA and the customer negotiate and sign the contract. After the contract has been signed ESA becomes 100% responsible for the phases of payload development, as presented in Figure 4.1. This means that ESA accepts[13] the commercial payload and signs an agreement with one of the ISS partners for transportation services (i.e. Soyuz, Shuttle) to the ISS. Figure 4.1 presents the commercial proposal selection process. ESA offers pre-flight, in-flight and post-flight support to commercial customers for the implementation of their commercial projects.

Commercial proposal selection is a complex internal process for ESA, because a commercial payload is treated as a space experiment and needs to meet all requirements for payload qualification [14]. For the commercial customer the preparation of a commercial proposal can be difficult, because ESA requires customers to present technical information on the customers' payloads interface with the ISS and the launcher safety. Furthermore, it requests customers to indicate which ESA on-board and on-ground facilities and services will be necessary for the implementation of their project. The information they have to provide could be quite complex for a non-space company wanting to become a customer of ESA.

[12]ESA requirements are technical, ethical and financial. For selecting a commercial project that is eligible for ESA promotion support, there are additional requirements. Such as competitive advantage of the proposed product or services, credibility of the market analysis and adequacy of the companies promotion and marketing strategy. ESA evaluates the companies financial planning for the commercial project [87].

[13]There is still an approval required for the acceptance of a commercial project from the ESA Independent Commercial Activities Board (ICAB). This board defines the ethical requirements on commercial projects.

[14]Before selection, commercial payloads will have to pass through testing, qualification and integration processes for transport to the ISS.

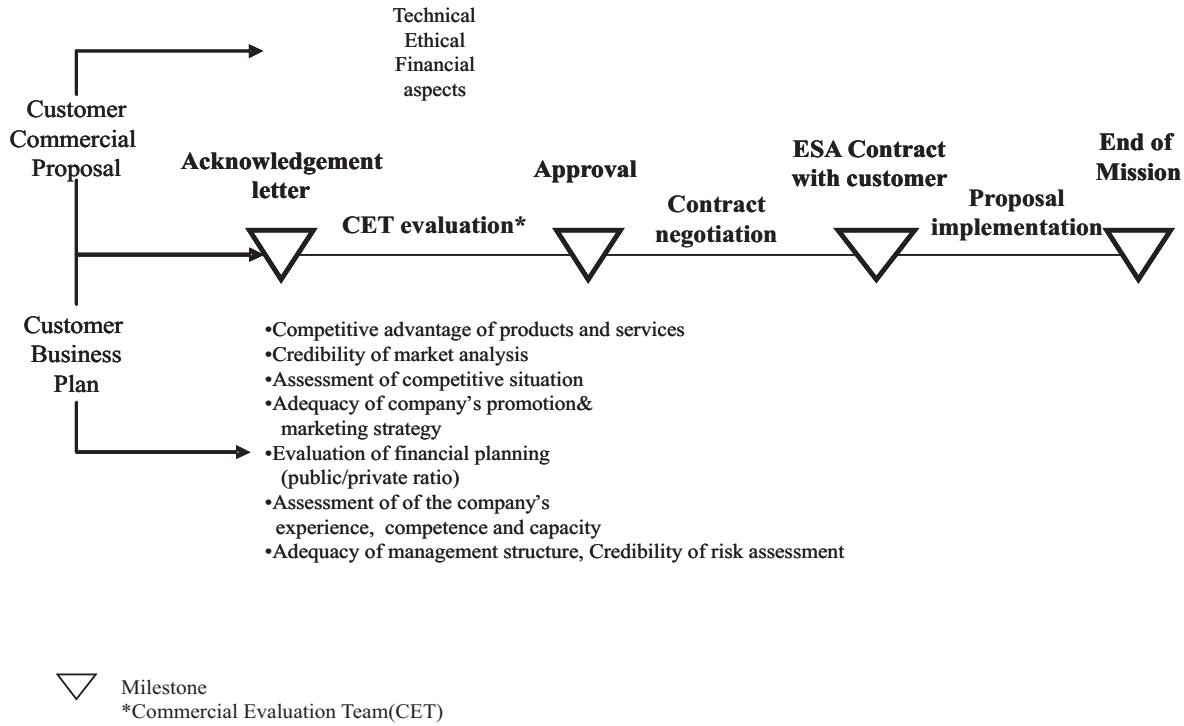

Figure 4.1: ESA Commercial Project Selection Process

The agency could either simplify commercial proposal requirements or introduce step-by-step detailed information on the ISS products and services to the customer. Customers could also need technical and commercial support in their proposal and the preparation of their business plan. This support has to be provided to the customer from either the present or future business functions.
Commercial proposal selection is a complex process and for a customer the preparation of a commercial proposal can be difficult. ESA either can simplify its proposal requirements or introduce a step-by-step information on ISS products and services.
Present or future business functions have to provide technical and commercial support to customers' commercial proposal. The above conclusions contribute to answering research Question 4.

4.3.4 ISS Target Markets

In this section is a short analysis of ESA targeted R&D and emerging markets. This analysis will be a basis for identifying the future business functions targeted markets in section 8.3 and also will contribute to answering research Question 4, from section 1.3. The overview of ISS targeted markets, will be further used for ISS products and services

classification in section 4.3.5 and identification of the future business functions markets in section 8.3.
ESA commercialisation activities target customers from biotechnology, health, food, environment and new materials sectors in the R&D markets and from the emerging markets: sponsorship, broadcasting and edutainment as presented in Figure 4.2. The industrial applications are derived by ESA experts who investigate potential industrial applications of ESA ISS research activities under the Microgravity Applications Programme (MAP)[15].

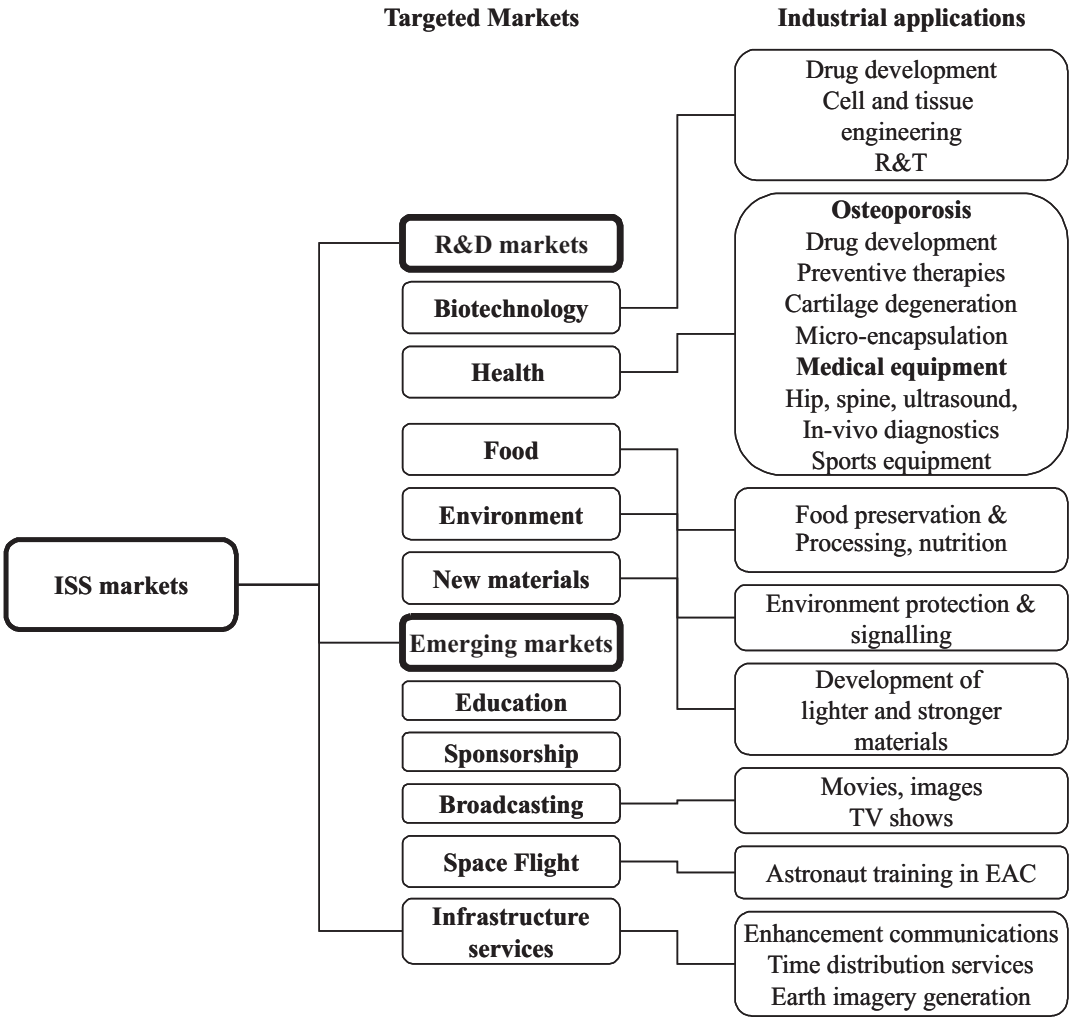

Figure 4.2: ESA Targeted Markets [120], [67], [87]

[15]The MAP programme is the research program of ESA for the institutional 70% of ESA ISS products and services. The program was founded in 1995; the main objective of the program is to support fundamental research, in areas such as biology, biotechnology, human physiology, environment, combustion, fluid physics and material science.

As Figure 4.2 illustrates, the ISS markets are varied and cover a wide range of scientific disciplines. Commercial customers can perform research and develop and test their instruments or products, on-board the ISS. Alternatively, commercial customers could decide to sponsor activities on board the station.
The R&D markets of biotechnology, health and food could be interrelated and ESA targets customers from more than one market sector. For example in biotechnology, the space environment provides new opportunities for scientific research in biomedical engineering, tissue engineering, osteoporosis, biomedicine, cell growth, cartilage degeneration and micro-encapsulation [68]. The absence of gravity could speed up the selection of drug candidates for new drug development, while companies can test biological models and their technology, such as bioreactors. During space flight, astronauts experience health problems[16] such as loss of bone and muscle mass which allows for research in the area of osteoporosis. Astronauts lose around 1% of bone mass per month, and this bone loss in microgravity is faster than that of osteoporosis patients on the ground and therefore, it is possible to observe the processes taking place. For osteoporosis patients, medical solutions could be found to support ground-based osteoporosis research, for example by the development and testing of bone scanning instruments on astronauts and administering new drug development for osteoporosis. These medical devices developed for bone scanning in osteoporosis could, for example, be successfully flown and tested on board of the ISS. Companies flying commercial payloads may be interested in broadcasting images of their instruments working on the ISS. Potential customers can be offered a bundle of services from R&D and emerging markets. For R&D markets the successful development of biotechnology, health, food and new materials markets could result in the development of industrial applications (see Figure 4.2) that can benefit both non-space industries and space agencies. Through the exploitation of existing commercial opportunities, companies could increase their competitive advantages, sales, technology innovation and expand their markets and increase their product leadership. The successful development of these industrial applications (i.e. osteoporosis) could be beneficial for future space missions. The development of preventive therapies for osteoporosis for astronauts, the development of new techniques for food processing and preservation and the development of lighter and stronger materials could become of major importance to the success of future human Moon and Mars missions [120].
For the emerging markets commercial customers may be interested in acquiring market-

[16]Microgravity affects various systems of human physiology: cardiovascular, respiratory, nervous, human sensory and balance, result into bone mass loss, muscle atrophy, changes in the metabolism, body posture and others [105].

ing rights[17] for "space proven"[18] products from the ISS or in buying promotional movies and images of the daily lives of astronauts. Customers can also gain benefits through increasing their technology innovation, development, sales and profits as a result of the access to unique space networks. The sponsorship and space tourism markets have the undoubted potential to develop successfully, as noted in section 3.5. ISS partners could miss market opportunities and profits and lose customers, if they do not get involved in the space tourism market. The space tourism market may be a targeted market for the future business function in section 8.3.
The ISS products and services can be marketed to customers from the R& D and emerging markets. The R&D markets can be drug development, preventive therapies for osteoporosis or development of lighter and stronger materials. For the emerging markets, customers can be targeted for sponsorship or for having space proven products and also for astronaut training. The ISS products and services can be marketed and sold to both the R& D and emerging markets and therefore, answer research Question 4.

4.3.5 ISS Products and Services Classification

In order to describe the way ISS products and services that are marketed and directly answer research Question 4, from section 1.3, in this section is an overview of ESA ISS products and services. ISS products and services offered by the ISS partners are quite complex and not very clear for most commercial customers, as identified earlier in section 2.3.4. Therefore, the need for description and classification arose from the desire to better understand what type of ISS products and services commercial customers and present business functions can access. The analysis of ESA targeted markets in section 4.3.4 is used as a basis for the ISS products and services classification. The present business functions objectives, activities and targeted markets are different as further discussed in section 4.4 and therefore, are not comparable. In this thesis, an ISS product can be defined as anything that is offered to a market for attention, acquisition, use or consumption and are exploited on the present ISS facilities, this definition is based on [94]. The service is any activity or benefit that one party can offer to another which is essentially intangible and does not result in ownership of anything [94].
Figure 4.3, ESA products and services are classified into *technology, marketing, sales, management and property rights*. This division is necessary to clearly distinguish between on-board and ground facilities and the services offered by ESA.

[17]Marketing rights are those rights concerning the act or process of promoting and selling products or services. Marketing rights are mainly rights in the areas of copyright and trademark, that are subject to negotiations in sponsorship and advertising contracts. Should a customer wish to take pictures or videos on board the ISS, marketing rights will be a matter of negotiation [87].

[18]Space proven is any product that has been flown on board of a space vehicle (i.e. Space Shuttle) or to the ISS and then returned to Earth.

The *technology* section represents ISS facilities and technical services required for the implementation and operation of payloads that are flown on board the ISS. The *marketing and sales* section incorporates the CPO services offered to commercial customers for commercial projects and payloads implementation, for both research (i.e. R&D markets), technology demonstrations, sponsorship and edutainment (i.e. emerging markets) The *management* section includes activities such as access provision by the CPO; access to ISS products and services of the ISS partners; and access to commercial project management. The *property* rights section incorporates IPR, marketing rights and the sponsorship rights customers can buy as a result of the implementation of their commercial projects on board the ISS, in the area of research, technology demonstration, sponsorship, broadcasting and space experience [87].

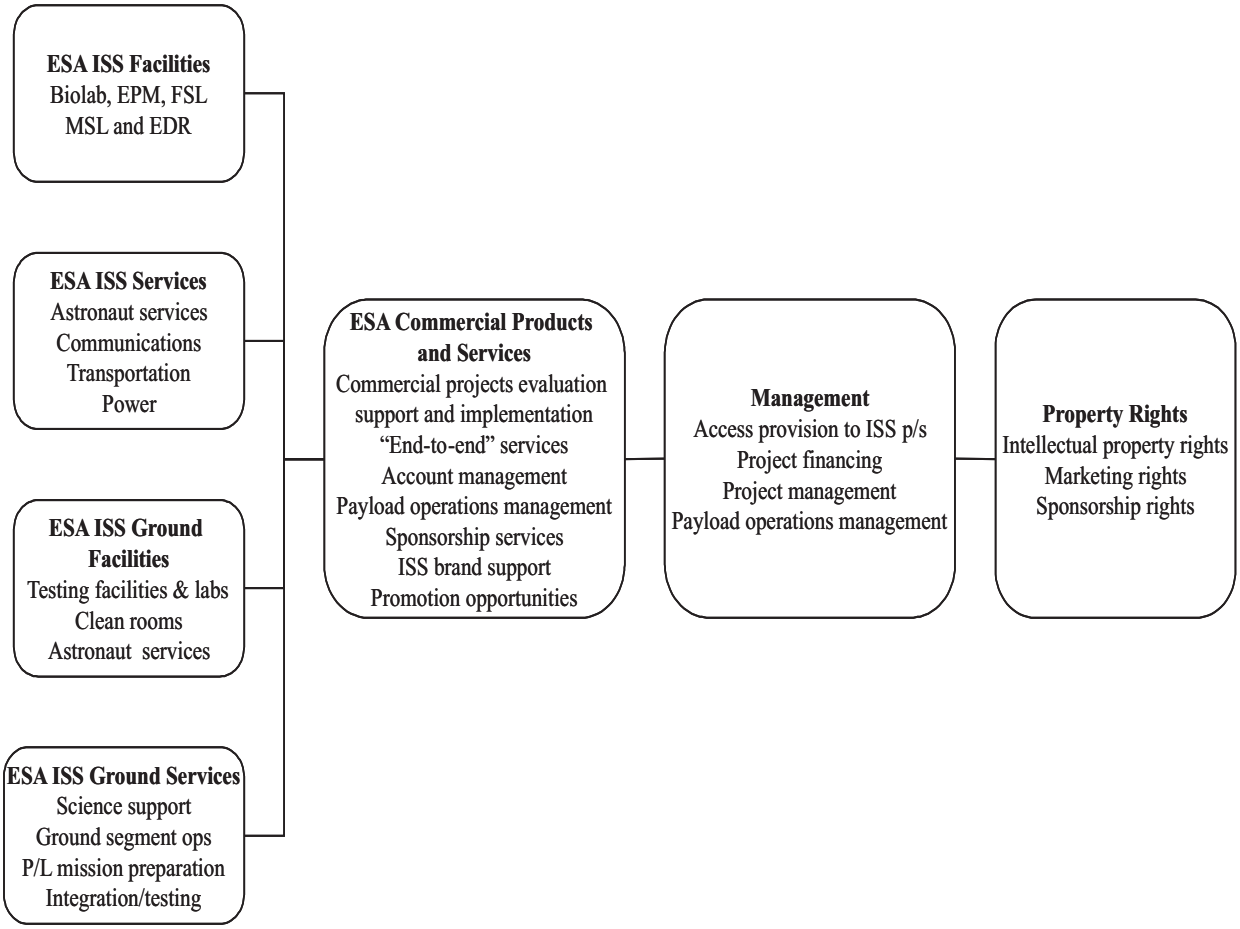

Figure 4.3: Classification of ESA ISS products and services

The inseparability of ISS facilities and services needs to be described to the present and future business functions and to customers. The ISS partners can use the above classifi-

cation for their ISS products and services, because of their ISS partners' interdependence (see section 2.3.1) and similar ISS products and services (see section 2.3.4). The above classification can be used by the other ISS partners' ISS products and services. In Figure 4.3 on board the ISS show that some services provided by means of the facilities are inseparable (see Appendix A, section A.4), such as launch, astronaut time and power and communication services (see section 2.3.7, Figure 2.3). ISS ground facilities and services are offered by ESA, as a result of cooperation with the 11 aerospace companies, under the ESA Co-operation Agreement. The above classification of ESA ISS products and services (see Figure 4.3), will allow potential customers[19] to identify the type of services they need for their commercial projects. In contrast, another customer may want to perform technology demonstration and qualification of their products, like flying medical instruments on board the ISS.
The marketing and sales services offered by ESA could result in a conflict between ESA and present business functions, therefore duplication should be avoided and business functions' activities should be clearly defined. Services such as project management financing and operations, offer direct customer support and could be developed by the present and future business functions will be able to better reflect customers' market needs. A future business function could offer services such as commercial proposal and payload preparation to customers, which will comply with ISS partners (i.e. ESA) requirements for flying commercial projects and payloads to the ISS, as will be discussed in section 8.4.
This classification of ISS products and services in technology, marketing, sales, management and property rights, shows the inseparability of ISS products and services. Certain services that offer direct customer support and could be developed by the present and future business functions, thus avoiding duplication with ESA services. The above conclusions directly contribute to describing how the ISS products and services are marketed and sold and thus answer research Question 4.

4.4 Present Business Functions

In this section an analysis of the features and activities of the present business functions is carried out. This description contributes to answering research Question 4: *How are ISS products and services going to be marketed and sold?*, from section 1.3. Furthermore, this analysis will be complimentary to the earlier analysis of the need for a business function in section 2.6 and the identification of the need for a future business function in section 5.6. In summary, this analysis of the present business functions will also enable the development of a proposal for the creation of future business function in Chapter 8. First, there will be

[19]For example, a potential customer can be interested in only sponsoring one experiment on board the ISS, but also acquire sponsorship rights.

a description of the objectives, partners and activities of the present business functions, followed by a SWOT analysis. This description (i.e. objectives, partners etc.) is chosen, because it gives a simple and clear overview and also describes the resources, the activities and the expected results of a business function. This description is based on the Chiesa [126] approach[20] for describing R&D strategic alliances. SWOT analysis has been chosen over Porters' five forces analysis, the McKinsey/GE Matrix and PEST analysis[21]. As it best supports the identification of opportunities and threats for the development of the present business functions. Figure 4.4 shows the ISS partners and their operational and planned present business functions. These are the same as described in section 2.2.

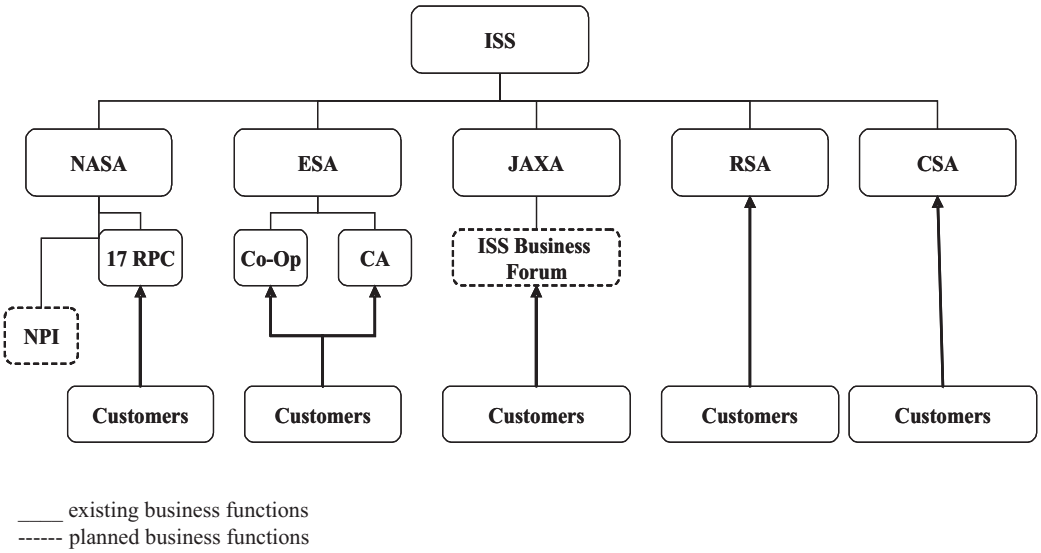

Figure 4.4: ISS partners' Present Business Functions [120]

Figure 4.4 shows that commercial customers can access ISS products and services, either directly through an ISS partner or through the present business functions. This general observation of the present business functions raises the need to consider the consequence of having two levels of direct and indirect ISS access. Some ISS parters are offering direct access to ISS products and services to commercial customers, that also can access the ISS products and services indirectly to the present business functions. The aspects of direct and indirect customer access to the ISS will be investigation in the future ISS commercial environment in section 7.8. The ISS partners and present business functions commercial customers may lose interest in access to ISS commercial opportunities, when there are too many ISS access points. This complexity could negatively affect emerging ISS markets and

[20]Chiesa's approach analyses four elements of collaborations, namely founders types, resources, activities and results.

[21]For more information on the research approaches see Appendix F, Table F.2.

result in confusion for commercial customers in accessing the space station. To mitigate the potential of possible confusion, the present business functions will have to clearly define their responsibilities.

4.4.1 NASA Research Partnership Centres

NASA has seventeen Research Partnership Centres (RPCs), which are non-profit collaborations between NASA, industrial partners and universities. Their activities are space research and product development in the areas of material science, biotechnology and combustion [81]. The Research Partnership Centres' objective is to "support US business (to) explore the potential and reap the rewards of doing business in space" [81]. The partners include non-profit organisations and leading consortia of commercial, academic and government entities [39]. As of 2001, nearly 120 companies have been partners in the various Research Space Centres, currently referred to as RPCs. The companies include 33 biotechnology, 7 Agritech, and 50 companies in the areas of materials and processes. As a result of RPC activities there have been 18 patents and six licenses in the field of biotechnology, three in agritech licenses and six patents and five licenses in the field of materials and processes rewarded. In addition, the activities of the RPC resulted in nine ground-based patent applications [1] and re-structured to develop space products for future Moon and Mars missions (see section 3.7.5). Indeed, the main results of the RPC activities are patents and licences of companies involved in these centres. These results show that these centres already represent value-for-money by patents and licences. The resources allocated by the partners are financial, technological and physical. NASA in 1999, allocated $1 million per year for each RPC [39], with industry partners supplying the remaining financial resources. Public funding may be reduced, due to NASA's focus on the manned Moon and Mars missions. Non-NASA funding to the RPC's for 1999 corresponded to $51.2 million [39]. The areas not considered by NASA are sponsorship, entertainment and space tourism markets, which implies that NASA may not support the development of the emerging markets. In 2005 NASA was planning to implement a 'Non-Profit Institute' (see Figure 4.4) to lead ISS scientific, technology and commercial research. It is estimated that by 2007 the institute will have a workforce of approximately 350 employees and a budget of $90 million [78]. However, as a result of the Columbia loss and the grounding of the shuttle fleet, the implementation of the institute might be delayed.
The SWOT analysis of the NASA RPC's in Appendix D, section D.1 shows that NASA is spreading its financial resources into too many RPC. The RPCs are at risk of increased inefficiency in commercial project implementation and development, because of the difficulties in identifying the actual needs of industrial partners as observed by [121]. This could result in the underdevelopment of ISS markets and an inability to meet customers' needs. The long-term space product development of 2 to 3 years [121] may be considered

a too-long period for a product to enter the market and reducing the incentive for RPC partners to invest. NASA claims their approach is industry driven [121], but a conflict of interest between public and industry partners could arise, because of differences in their objectives and expectations. The strength of NASA's approach lies in the fact that new centres can be established based on commercial interest in new product developments [79], providing an opportunity to create a wide network of players.
NASA's present RPC could be exposed to inefficiency, conflict of interest and confidentiality problems. Their activities could be re-structured towards the development of space products for future Moon and Mars missions and ground-based industrial applications.

4.4.2 JAXA ISS Business Forum

Information on current collaboration activities and strategies of JAXA in 2004 is not readily available and therefore this section describes their business function as in 2001. JAXA planned to set up an ISS Business Forum, with its main objective the development of commercial business with the ISS, the space shuttle and other space infrastructures [83]. The organisation is intended to be a non-profit one, managed by an executive committee formed by major Japanese space companies including companies such as JAMSS, Mitsubishi Corporation, NEC and insurance companies [83]. The total committee[22] will be around 60 members, plus non-space companies, such as Honda and Densu. The investment for commercial projects will come from public funding. The Forum will coordinate and select proposals from the private sector for JAXA and the government. It will aim at developing commercial business with space-based technology and promote it to non-space companies in the Asian region. Through the ISS Business Forum, Japanese commercial users' requirements will be communicated to the other ISS partners.
The SWOT analysis from Appendix D, section D.1 shows that the ISS Business Forum, does not target customers in emerging markets. The non-profit nature of the forum and reliance on public funding will expose the collaboration to political forces (see section 2.5), which will increase its dependence on public budgets. The government's investment in commercial projects could be reduced or even canceled due to economic slowdown. Commercial customers may well be unwilling to invest any money and prefer public funding for project implementation. The strength of their approach is that the ISS Business Forum will be willing to develop business with other space technologies[23] (i.e. Space Shuttle). This indicates the ISS Business Forum will aim for a customer-oriented approach. JAXA's approach is flexible and simple; it could encourage successful ISS market development,

[22]The JAMSS, JHI and MHI companies will provide technical services, and Tokyo & Marine Insurance will provide legal services [83].

[23]They offer many opportunities for their commercial customers such as the integration of commercial projects and payloads in the other ISS partners' modules.

and the industrial experience of the company members on the Forum committee could be beneficial. Their experience in new market penetration, development and customer access would be extremely valuable for the development of the ISS markets. The above ISS Business Forum, could change depending on customer needs and the actual Japanese business function could be quite different from the planned one. As the ISS Business Forum is not yet operational, JAXA can consider implementing the future business function of Chapter 8.
JAXA's approach is flexible and simple; it will encourage ISS market development, and the industrial experience of the Forum committee members will be beneficial. The ISS Business Forum can change once it becomes operational and be quite different from the planned one.

4.4.3 Russian Space Agency

RSA offers direct access for commercial customers to the Russian ISS products and services. Customer needs and requirements are directly integrated into space missions to the ISS and space tourists, such as Mark Shuttleworth, were able to negotiate the terms of their missions. In the public domain, there is little information on the RSA collaboration strategy, however there is information available on companies selling access to Russian ISS products and services, such as Space Adventures. This access to ISS products and services for commercial customers and at the same time through a collaboration will be investigated in section 7.8. As analysed in Appendix D, section D.1 the lack of transparency of its collaboration strategy reveals the threat that RSA aims at not only maintaining strategic, but also market power. The lack of clearly transparent pricing (see sections 2.3.7 and 4.3.2) suggests that any price level can be negotiated. Its behaviour suggests it could aim at becoming a price-discriminating monopolist, an observation first made in section 2.3.7. RSA can become an unbeatable market leader in ISS markets.
RSA lack of transparency on their collaboration strategy reveals that they intend to maintain strategic and market power in the ISS markets development.

4.4.4 ESA Co-operation Agreement and Commercial Agent

ESA has set-up two agreements: one is the Co-operation agreement and the second is with the Commercial Agent, as already introduced in section 2.2. In 2001, ESA set up a Co-operation Agreement with 11 companies[24] and in 2004 with the Commercial Agent (CA). The primary objective of the first agreement is to provide general promotional ac-

[24]The 11 aerospace companies members of the Co-operation Agreement, are Alenia Spazio, Altec, BEOS, Bird &Bird, Bradford, Contraves Space, Dutch Space, EADS, Kayser Threde, Kesberg, Butfering&Partner, OHB Space [87].

tivities and specific project support in the form of "end-to-end" services to commercial customers [27]. Among these 11 companies is a legal company, which as a non-space company will offer legal advice to customers. A future business function could also consider legal companies as potential founders (i.e. creators). Within the framework of the ESA Co-operation Agreement, partners could participate in various promotional activities together with ESA and offer support to commercial projects and payloads. This is a general agreement that has no legal entity responsible for its activities and where the partners meet when there is a commercial project that requires the "end-to-end" services[25] of Co-operation Agreement partners.
The SWOT analysis of the ESA Co-operation Agreement brings into consideration that ESA's collaboration strategy aims at obtaining wide market coverage for both R&D and emerging markets. At present ESA deals directly with customers for the emerging markets. The opportunities of the Co-operation Agreement can provide valuable services to non-space companies. As analysed in Appendix D, section D.1, the Co-operation Agreement partners currently have little incentive to be active players in ISS market development, as the agreement is "promotional" and most of the companies have aerospace expertise. Their role should be re-assessed so that they offer services primarily related to their core aerospace activities, instead of being limited to promotional activities. The Co-operation Agreement poses more threats than opportunities. These are low incentives for the partners to develop the ISS markets, dual role and dependency on ESA. A weakness of the agreement is the lack of a clear definition of products, services, ownership rights and roles, reducing the incentive to be active players.
The Commercial Agent agreement is a type of short-term exclusivity contractual agreement with ESA for European ISS products and services. The Commercial Agent was selected through an open tender. The company, selected in October 2004, is ISS Lab Ruhr GmbH and was specifically created by Enterprise Management Technology Transfer GmbH (EMBL-EM), the French Institute for Space Medicine and Physiology (MEDES) and the AGT group from Italy. ESA pays a fee to this newly-formed company for its services and is not a founder in this company. However, ESA will provide access to ISS products and services and exclusivity rights. The objective of the Commercial Agents agreement is to market and sell ESA ISS products and services in the biotechnology, health and food targeted R&D markets (see Figure 4.2). The Commercial Agent is expected to offer market coverage, customer access and project management. Additionally, the Commercial Agent is expected to attract private funding and to provide support in the exploitation of IPR rights generated by commercial utilisation [87]. The Commercial Agent has more opportunities for ISS market development, because it has much wider market coverage and establishes unique relationships with non-space industries. The Commercial Agent,

[25]The "end-to-end" services under the ESA Co-operation Agreement are payload design, development, integration and testing [87].

as a legal and profit-oriented entity will have the freedom to develop certain markets and perform activities that are prohibited to ESA as a non-profit agency, such as merchandising. The Commercial Agent agreement is far more flexible. Commercial Agent provides the easiest market and customer access to ISS products and services. The Co-operation Agreement and the Commercial Agent do not target emerging markets and therefore these markets could remain underdeveloped unless they are directly developed by ESA. To mitigate this risk ESA and the Co-operation Agreement partners will have to re-define their roles and activities under the agreement. ESA could consider withdrawing from the Co-operation Agreement, if the Commercial Agent agreement is operational. The existence of a Co-operation Agreement and the Commercial Agent could lead to ESA ISS products and services being spread over too many agreements increasing inefficiency in customer acquisition and ISS market development.
NASA RPCs could be exposed to inefficiency and confidentiality problems and can be re-structured towards performing activities such as products development for future Moon and Mars mission. As JAXA is not operational it could consider implementing a business function similar to the one outlined in Chapter 8. RSA lacks a transparent collaboration strategy and aims at strategic and market power in the ISS markets, while ESA has spread its ISS products and services over too many agreements. ESA could consider withdrawing from the Co-operation Agreement, once the Commercial Agent agreement is successfully implemented, as the later provides the easiest market and customer access. Analysis of the present business functions show how certain ISS partners market and sell their ISS products and services and thus contribute to answering research Question 4.

4.5 Results and Conclusions

The analysis of the ISS partners's objectives, pricing policies, ESA commercialisation policies and present business functions contributes to answering research Questions 3 and 4, from section 1.3.
To answer research Question 3:*How will ISS partners' commercial activities encourage or discourage ISS commercialisation?* an analysis of the Mir commercialisation, ISS partners'objectives and pricing policies was done. It showed that economic transition and budgetary constraints encourage space station commercialisation. ISS partners need to create a user-friendly environment: transparent, simple procedures and IPR rights for commercial projects thus encouraging ISS commercialisation development.
The ISS partners' pricing approaches are different, complex and lack transparency. The ISS partners do not clearly present price promotions or discounts. The ISS prices send a signal to the market that price changes can occur through political decisions, low market demand and ISS product and services availability. Therefore, these ISS prices discourage

ISS commercialisation. To encourage customer to buy ISS products and services, the ISS partners will need to implement market-based, flexible, risk-assumptive and proactive pricing approaches.

The answer to research Question 4: *How are ISS products and services going to be marketed and sold?* was done through an analysis of ESA commercial proposal selection, targeted markets, products and services and present business functions. Commercial proposal selection is a complex process, and for customers the preparation[26] of a commercial proposal is difficult. Due to the lack of ISS partners marketing and sales capabilities. Therefore, ESA either can simplify its proposal requirements or introduce a step-by-step procedures for ISS products and services. This lack of clear definition of ISS products and services highlights the difficulties ISS partners have in creating, classifying and developing attractive ISS portfolios. These difficulties can be overcome by present and future business functions that can offer certain services, such as technical and commercial support for commercial proposal preparation.

The ISS products and services are sold to customers from the R&D and emerging markets. R&D markets are drug development, preventive therapies for osteoporosis or development of lighter and stronger materials, while, some of the emerging ones markets are education, sponsorship and space tourism. The ISS partners and present business functions market and sell ISS products and services. There are three operational present business functions; the ESA Co-operation agreement, the Commercial Agent and NASA RPC. NASA RPCs are exposed to a inefficiency and could be re-structured towards performing activities products development for future Moon and Mars mission. RSA lacks a transparent collaboration strategy and aims at strategic and market power in the ISS markets, while, ESA has spread its ISS products and services over too many agreements. ESA could consider withdrawing from the Co-operation Agreement if the Commercial Agent agreement is successfully implemented, as the latter provides easiest market and customer access.

[26]Present or future business functions have to provide technical and commercial preparation for customers' commercial proposals and business plans.

Chapter 5

Collaborations Overview

5.1 Introduction

Companies collaborate with each other to keep pace with rapid market changes, remain competitive, reduce costs and share risks. The ISS partners collaborate with present business functions to encourage the commercial use of space-based ISS products and services. In order to propose and select a collaboration for a future business function in Chapters 8 and 9, there is the need to understand the characteristics of collaborations. This need will be addressed in this Chapter. In this Chapter, research Question 2 and 7, from section 1.3 will continue to be addressed:

- Is there a need for a collaboration between space agencies and private companies to support successful ISS commercialisation? - Question 2
- What are the necessary steps for the development and implementation of a future collaboration? - Question 7

In order to answer research Question 2, there is a summary of the driving forces relevant for collaborations creation, derived from the previous chapters. Based on these driving forces, reasons and minimum required conditions for the creation of future business functions will be derived. At the same time, the classification of various collaboration, such as a public private partnership (PPP), licensing agreements, joint ventures and consortiums will address research Question 7. Furthermore, there will follow a description of the important characteristics of collaborations, covering issues of ownership, decision makeing and phases of development of collaborations. The identification of selection criteria for the assessment of present business functions will support the creation of a future business function that meets these criteria in Chapter 8. This Chapter is the toolbox for the implementation of a future business function.

5.2 Research Relationships

In this section is a description of the relationships that will be investigated in this Chapter as presented in Figure 5.1.

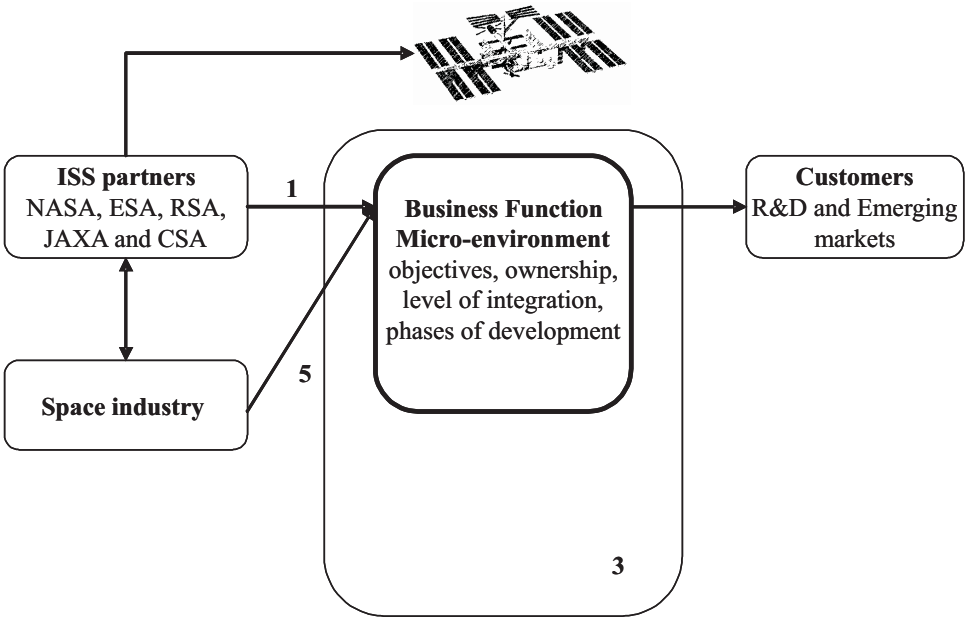

Figure 5.1: Relationships investigated in Chapter 5

Relationship 1: ISS partners and Business Function(BF) - this relationship is investigated in the context of the driving forces that influence the ISS commercialisation development and present and future business functions. Furthermore, this relationship will be further analysed for the allocation of ownership rights by the founders (i.e. creators) of a future business function.
Environment 3: Business Function Environment - this environment will be divided into internal and external environments for a future business function. This division is necessary to facilitate the selection of a collaboration for a future business function. The internal environment covers aspects such as objectives, ownership allocation and level of integration between the potential founders of a collaboration. It also includes an initial proposal of possible phases for a future business function. While, the external one covers driving forces that influence the current ISS commercial environment and present and future business functions. The results of this Chapter will support answering research Questions 2 and 7, from this Chapter and section 1.3.

5.3 Driving Forces in ISS Commercialisation

Earlier analysis in Chapters 2, 3 and 4, has shown that a number of driving forces that directly influence the supply and demand sides of the current ISS commercial environment. The analysis of the driving forces[1] will directly contribute to identify the need for collaborations creation and therefore answering research Question 2: *Is there a need for a collaboration model between space agencies and private companies to support successful ISS commercialisation?*. Furthermore, this analysis will support the identification of reasons and minimum conditions for the creation of a future business function.
SWOT analysis is used for the identification of opportunities and threats for the ISS partners and present business functions in connection with ISS commercialisation. The driving forces are derived from the earlier analysis in section 2.5[2], section 3.8[3]and section 4.5. Other ways to analyse the driving forces could be as Porter's five forces[4] analysis [72], McKinsey/General Electric Matrix[5] and PEST[6].
Driving forces relevant to ISS commercialisation were initially identified in section 2.5 and were forces; such as political preferences, hard budget constraints and commercial forces (i.e. ISS commercial opportunities). The above driving forces are integrated in the major driving forces in the ISS commercial environment:

- Political and strategic driving forces are initiated by national governments, ISS partners and national agencies (e.g. increased political cooperation between Europe and

[1]Driving force is considered one that has a strong influence on the strategic and market developments in ISS commercialisation and makes ISS partners, present and future business functions to take certain policy or business decisions.

[2]The cooperative oligopoly on the supply side and ISS emerging markets on the demand side of the current ISS commercial environment, as observed in section 2.6 will result in various driving forces.The results in section 2.5 identified the importance of budget constraints, commercial forces and of political preferences as driving forces behind space station commercialisation.

[3]The results in section 3.8 show that future Moon and Mars visions influence ISS commercialisation.

[4]Porter's five forces analysis is a useful analysis of the 1) threat of entry from other companies,2) the power of buyers and suppliers, 3) the threat of substitutes and 4) competitive rivalry in an industry. It is only applicable to developed markets. At present, information on buyers of ISS products and services is almost non-existent due to the emerging nature of ISS markets. For this reason his approach for analysing the driving forces is irrelevant for the time being.

[5]The McKinsey/GE matrix approach is an analysis of the factors that affect market attractiveness. It requires detailed information on market size, growth, profitability, customer loyalty and other factors. This matrix could become relevant once the ISS markets develop and this information becomes available. Present and future business functions could then use this as a tool for developing growth strategies and for analysing their business portfolios.

[6]PEST analysis [66] investigates the marketing environment of an organisation by analysing the factors influencing its internal and external environment. For the general analysis of the driving forces in the current ISS commercial environment this approach is insufficient, because it doesn't provide an overview of the opportunities and threats from ISS commercialisation.

Russia in space industry see section 3.6.1)

- Economic and budgetary driving forces occur as a result of economic growth or slowdown. Budgetary forces result from budgets cuts and cost overruns of the ISS programme

- Market and commercialisation driving forces occur from the demand and supply for ISS products and services and illustrate the need for potential customers in the ISS markets (see section 2.4.1). Commercialisation forces result from the introduction[7] of new technology in new markets

- Resource and space industry driving forces could be also divided. Resource driving forces occur as a result of the availability of on-board ISS products and services for commercial customers and as a result of changes in the ISS assembly. Space industry driving forces occur from market and strategic development in space industry, such as overcapacity of launch services (see section 3.4) and the implementation of the Moon and Mars Programs

The SWOT analysis of the driving forces in the current ISS commercial environment is described in Appendix E, section E.1, Table E.1. The strengths and weaknesses have been already analysed throughout the earlier chapters and therefore, hereby is a summary only of the opportunities and threats on the supply side of the current ISS commercial environment:

- Opportunities - ISS partners can win political support, achieve ISS cost-effective utilisation and create a user-friendly environment to encourage ISS commercialisation (i.e. political and strategic forces). They can achieve partial ISS cost recovery and generate revenues from ISS commercialisation (i.e. economic and budgetary forces). The ISS partners can encourage the development of ISS markets (i.e. market and commercialisation forces) and cooperate with Russian space industry (i.e. resource and space industry forces)

- Threats - the ISS partners are exposed to the continuous change in the balance of power between NASA and RSA, complex negotiations for ISS access (i.e. political and strategic forces), as a result of their high level of resource dependency on NASA and RSA. NASA cost overruns resulted in a 60% ISS ESA Exploitation budget freeze in 2001 (i.e. economic and budgetary forces). There is a threat of ISS price increase, due to low ISS products and services availability or existence of a dominant price leader

[7]For example, the introduction of ISS products and services to non-space markets (i.e. biotechnology, health), can result in non-space customers creating technology innovations and achieving profit maximisation.

(i.e. economic and budgetary forces). The ISS emerging markets are unexplored, unknown and uncertain, as observed in section 2.4.1 and there is a threat of ISS market failure, loss of ISS partners' investment in ISS market development and wrong market analysis (i.e market and commercialisation forces). The ISS assembly changes, the cancelation of commercial payloads due to the lack of ISS products and services and the Columbus Module not being launched to the ISS (i.e. resource and space industry driving forces), are threats that endanger successful ISS commercialisation.

The ISS partners are exposed to more threats than opportunities from the supply side of the current ISS commercial environment. The ISS partners will be exposed not only to political, budgetary and resources threats, but also to economic and market ones. If the ISS partners continue to market and sell their ISS products and services directly to commercial customers, the threats that exist on the supply side of the ISS commercial environment show, once again (see section 4.5), the necessity for a business function between agencies and private companies.
The opportunities and threats on the demand side of the current ISS commercial environment were analysed in detail in Appendix E, section E.1, Table E.2 and are the following:

- Opportunities - customers can make use of ISS promotion prices (i.e. economic and budgetary forces). There are new ISS market opportunities, that will allow business functions to be first on the market. Commercial customers can improve their competitive advantage by increasing the quality of their products and services. Customers can benefit from their intellectual property rights and marketing rights (i.e. market and commercialisation forces). Present and future business functions could offer customers services for the preparation of commercial proposals and business plans, as identified in section 4.3.3.

- Threats - customers lack knowledge of ISS commercial opportunities (i.e. political and strategic forces). ISS prices are cost-based, standardised and lack price promotions or discounts for customers (i.e. economic and budgetary forces). Unknown customers, market demand for ISS products and services and complex requirements for implementation of commercial customers' proposals (i.e. market and commercialisation forces). The threat of having reduced ISS products and services, can result in high ISS prices and short-term investments in the development of the ISS markets by the present business functions (i.e. resource and space industry forces).

On the demand side of the ISS commercial environment, present business functions and customers can gain more opportunities from ISS commercialisation. These opportunities result from the market and commercialisation forces that are on the demand side of the current ISS commercial environment, thus present and future business functions can capture new ISS market opportunities.

On the supply side ISS partners and space companies are exposed to more threats from ISS commercialisation than opportunities, threats such as ISS cost overruns and market failure. To reduce these threats there is a necessity for a business function between the ISS partners and private companies. On the demand side of the current ISS commercial environment there are more opportunities for present, future business functions and customers. The above results contribute to answering research Question 2, from section 1.3.

5.3.1 Important Driving Forces

This section identifies the driving forces that will influence the reasons for the creation of and minimum conditions required for a future business function. Therefore, the results from this section will contribute to answering research Question 2. As already discussed in section 5.3, the threats on the supply side of the current ISS commercial environment, result from the economic, budgetary and resource forces. These threats will encourage ISS partners to become founders (i.e. creators) in a business function. The opportunities on the demand side of the current ISS commercial environment result from market and commercialisation forces, encourage private companies to become founders in business functions.
Economic and budgetary forces such as high ISS costs (see section 4.5) and the necessity for partial cost recovery will have the strongest impact on ISS commercialisation. At the same time, new market opportunities (see section 2.4.1) and the introduction of space technology in non-space markets are market forces that will have the strongest influence on business functions and on the demand side of the current ISS commercial environment. Due to its emerging nature, ISS markets require the use of assumptions on market demand because of the absence of historical information. The increased market demand for ISS products and services could result in profit-maximisation, ISS portfolio expansion and market share increase for present and future business functions. This increased market demand for ISS products and services will require certain resources, such as sales and marketing capabilities from the business functions. These aspects of the market demand influence on a future business function will be further investigated in section 6.4.
Economic, budgetary and market forces will also influence the reasons for the creation of a future business function, thus addressing research Question 2, from section 1.3.

5.3.2 Reasons for the Creation of a Business Function

In this section is an overview of the reasons[8] for creating a collaboration between ISS partners and private companies, thus contributing to answering research Question 2, from

[8]The conclusions from section 2.6 showed that the ISS partners will need to collaborate with other companies to achieve market access and to acquire customers.

section 1.3. To address this question there is an overview of the reasons[9] for the creation of a future business function, as a result of the SWOT analysis of the driving forces in section 5.3 and the the analysis in section 5.3.1. The participation of the founders (i.e. creators) in the future business function will depend on the threats from the driving forces they are exposed to (see section 5.3) and their order of significance (see section 5.3.1). The reasons below are relevant for the founders of future business functions (i.e. ISS partners, non-space companies):

- ISS partners can win political support (i.e. political and strategic forces) from their national governments, achieve ISS cost-effective utilisation and create user-friendly environment to encourage ISS commercialisation
- The future business functions founders can make use of ISS promotion prices. ISS partners can reduce the threat of ISS price increase due to low ISS products and services availability or existence of a dominant price leader (i.e. economic and budgetary forces). Furthermore, ISS partners can achieve partial ISS cost recovery
- The founders of business functions (i.e. non-space companies) aim at exploiting new ISS market opportunities (i.e. market and commercialisation forces), so they can be first on the market and make use of ISS promotion prices. ISS partners can share with the business function the threat of the ISS market failure, loss of ISS partners' investment in ISS market development and wrong market analysis, through collaborating with founders on providing market and customer access.
- The ISS assembly changes (i.e. resource and space industry forces), the cancelation of commercial payloads due to the lack of ISS products and services and the Columbus Module not being launched to the ISS. Show that the ISS partners will need to secure regular access to the ISS products and services, in order to prevent the cancelation of commercial payloads.

The above reasons provide a sizeable incentive to become founders of a future business function within the ISS commercial environment. The above reasons for the creation of a business function will support the identification of objectives, functions and necessary resources for its implementation in Chapter 8.
New ISS market opportunities achieve partial ISS recovery and to be first on the markets are reasons for the creation of a future business function. The reasons may change with future developments of ISS commercialisation, but the above reasons answer directly research Question 2, from section 1.3.

[9]Booz, Allen and Hamilton [52] have analysed general reasons behind the creation of collaborations. They included such reasons as risk sharing, economies of scale , market segment access, technology access, funding constraints and management skills. Several of these reasons, such as risk sharing, market access and funding constraints, may have relevance when assessing the creation of a future business function.

5.3.3 Required Conditions for Creation of a Business Function

Collaboration between a space agency and private companies require an environment that encourages creation of a future business function. In this section is a summary of the necessary conditions for the business functions implementation. The analysis in this section will directly contribute to describing the necessary steps for collaborations creation and thus answering research Question 7, from section 1.3.
These conditions are classified into conditions to be fulfilled firstly by the ISS partners and secondly by the future business functions. This division is necessary, as the ISS partners, are owners of part of the ISS products and services and have the power to provide or refuse ISS access. The political will of the ISS partners might not be sufficient to encourage the creation of collaborations, such as the future business function[10] can satisfy several conditions before being allowed to sell ISS products and services. The conditions results from the earlier example of the biotechnology industry in section 2.5.1 and the analysis of the Mir commercialisation from section 4.2. The minimum conditions to be met by the ISS partners are:

- ISS partner's political approval - is essential, because the ISS partners are the owners of ISS products and services and have the authority to constrain ISS access to commercial customers

- Access provision to ISS products and services - ISS partners need to provide availability and access to ISS products (see section 2.3.5) and services. The ISS partners need to secure fast, simple and clear commercial proposal selection as analysed in section 4.2 and implement more market-based, flexible and proactive pricing approaches as concluded in section 4.3.2

- Implementation of a competitive commercial policy - to encourage ISS commercialisation development, as observed from the example of biotechnology from section 2.5.1

- Risk-sharing[11] and preserving confidentiality - confidentiality is very important to commercial customers and ISS partners should continue to ensure that confidentiality on commercial projects is preserved

The minimum conditions to be met by the future business functions are:

[10]The selection of a collaboration for a future business function in Chapter 9 will take as an example the ISS products and services classification from section 4.3.5. However the predictions for the future ISS commercial environment in Chapter 7, the proposal of a business function in Chapter 8 will not be limited only to the ESA ISS commercialisation.

[11]The ISS partners and business functions can share the risks of ISS commercialisation development and the implementation of the above conditions.

- Attract start-up capital - the ability to meet this condition means that the business function should show their business case is feasible or not and of interest to investors or not
- Attract first time ISS customers - the multi-disciplinary character of research on board the ISS offers the opportunity to target multi-disciplinary markets (i.e. biotechnology, food) and attract customers from these markets (see section 4.3.4)
- Meet market and customer requirements - the future business function will have to be a customer-focused organisation and fully integrate customer needs through the development of a flexible portfolio of ISS products and services (see section 2.3.4)
- Investment and risk sharing - the emerging ISS markets are complex and carry much uncertainty, as observed in section 2.4.1. The future business function therefore has to share among its founders both the investments and the risks associated with new market development

The above conditions will be further used for the identification of predictions for the future ISS commercial environment in Chapter 7. Some of the above conditions could also be relevant for the present business functions. For example NASA could request future partners in its Research Partnership Centres (RPC) to meet the aforementioned conditions. JAXA could also require the future Japanese ISS Business Forum to meet these minimum conditions.
Political approval, access to ISS products and services and implementation of ISS commercial policies are minimum conditions required by the ISS partners for setting up collaborations. While attracting start-up capital, attracting first-time ISS customer and meeting customer needs are the conditions the business function will need to meet. These minimum conditions are necessary in order to facilitate the creation of a collaboration or encourage the ISS partners by the development of present business functions, thus contributing to answering research Question 7.

5.4 Classification of Collaborations

Licensing agreements, joint ventures and consortiums, are some examples of collaborations that could be created to remain competitive and gain market and technology access. In this section is a classification of collaborations and an example of emerging industries collaborations, thus, identifying initial recommendations for a collaboration for a future business function. The results of this section will contribute to answering research Question 7: *What are the necessary steps for the development and implementation of a future collaboration model?*, from section 1.3.

Collaborations can be classified in various ways Porter [73] classifies the collaborations by activities in the value chain, for example collaborations for technology, operations, marketing, sales, services and multi-activities.
McKinsey classifies collaborations according to the different alliances during the Nascent, Frenzied, Turbulent and Mature phases of market evolution [2].
Chesia classifies the collaborations by activity in a similar manner to Porter, such as marketing and R&D [126] and [99] classifies them by public and private partnerships.
Gomes-Casseres classifies collaborations according to alliance strategies [11] and [51] provides a classification of collaborations based on the degree of integration between founders.
Grossman classification has been chosen for further use, as the other classifications based on activities, markets or objectives, are of little relevance to the ISS emerging markets. The proposed classification allows for further analysis of collaboration integration, ownership rights and phases of development for the business functions.
In this section the classification used is an increasing degree of integration between the founders of collaborations as presented in Figure 5.2 from the weakest type of collaboration through to the strongest, such as merger or acquisitions. The degree of integration can be contractual, collaborative or by mergers and acquisitions (M&A), as presented in Figure 5.2. This classification gives an overview of a wide range of collaborations and a more detailed description see Appendix D, section D.2.

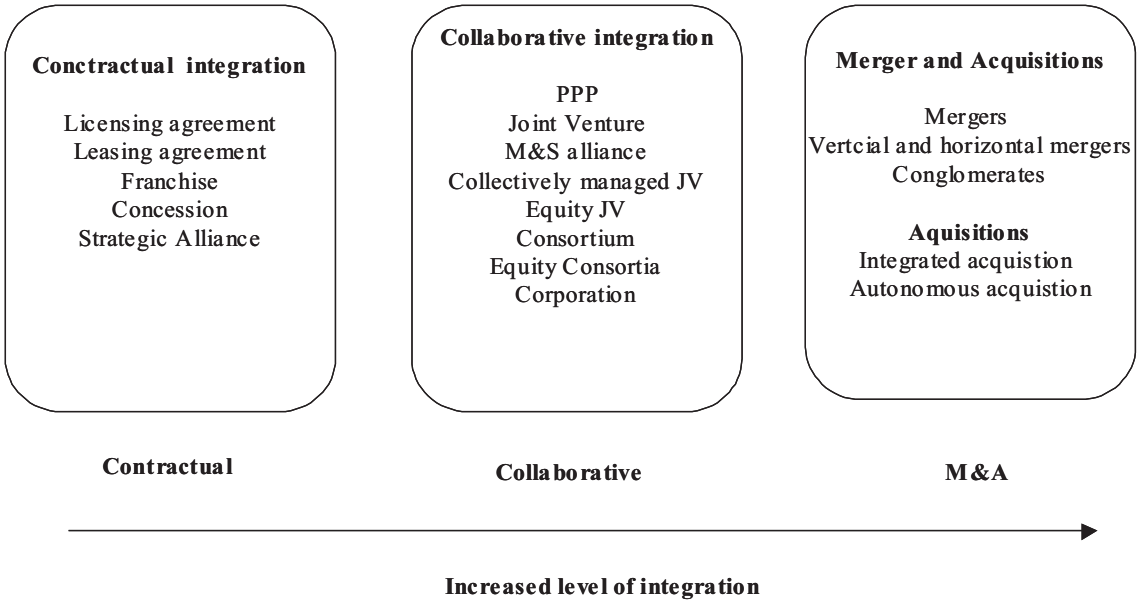

Figure 5.2: Collaborations [51], [99]

Collaboration founders (i.e. creators) could integrate their ownership rights, products and services and activities[12] at different levels of integration. Contractual integration is defined as when companies integrate only part of their activities on a non-equity basis. Companies aiming at joint production or R&D, which does not require ownership, could form strategic alliance agreements or create licensing agreements[13]. Collaborative integration which is an equity-based collaboration, occurs when founders integrate their ownership rights, their resources (i.e. financial, marketing, etc.) and their activities. Founders could allocate marketing, technical and sales resources. Mergers and acquisitions in Figure 5.2, refers to the process in which two organisations merge and form one company or one company acquires another. The mergers could be vertical or horizontal[14]. Vertical integration is applicable for collaboration between an agency and private companies, because ISS partners, as an owner of ISS products and services and a space agency with science and technology resources, could integrate their resources with marketing and sales collaboration in a future business function. The ISS markets are in an emerging state of development, suggesting that present business functions will have to be flexible yet robust enough to operate in an environment of uncertainty and complexity.

The degree of integration between founders[15] will be influenced by market demand conditions and will be further investigated in section 6.4. The market demand for certain ISS products and services will depend on their characteristics [59] (i.e. industrial applications)[16]. Thus, the customers' choice of ISS products and services will depend on the relevance of these characteristics to their own processes and products. The targeted markets for the further business function and the proposed industrial applications of the ISS products and services are further analysed in section 8.3.

In such emerging markets, founders will initially aim at forming a contractual, rather than a collaborative type of integration. To form initial recommendations at the level of integration between the founders (i.e creators) of the future business function and contribute to addressing research Question 7, here follows an example of the biotechnology indus-

[12]The products and services could be financial, technological, marketing and sales, as already discussed in section 4.3.5

[13]An example of a licensing agreement is where a government licenses a facility to a private company, and in return, receives royalties. It is an agreement used by companies who want to enter new markets and share investment risks.

[14]Vertical integration is companies producing different products merge their activities into one company [57]. Horizontal integration is when there is a merger between companies that have similar products or services.

[15]Founders are the creators of the future business function. They could be ISS partners or companies willing to commit resources to a future business function.

[16]As defined by [59] a good number possess certain properties, but because not all of the properties are relevant to the customers choice of a certain good. Characteristics are used to describe only the relevant properties to the choice of customers. Characteristics have dual relationships with customers, the first being one of technical relevance and the second one of human relevance (i.e. customer preference).

try. It is given in order to provide a viewpoint from another emerging industry. In the biotechnology industry, biotech and pharmaceutical companies form collaborations for the development of new drugs. Most of these collaborations occur in the later stages of drug discovery and development which are processes taking approximately 10 years to come to fruition. The cost for new drug development are very high and the payoffs of successful drug development can spread over 25 years [44]. Figure 5.3 presents an overview of the different types of alliances between biotech and pharmaceutical companies for 2001 and 2002.

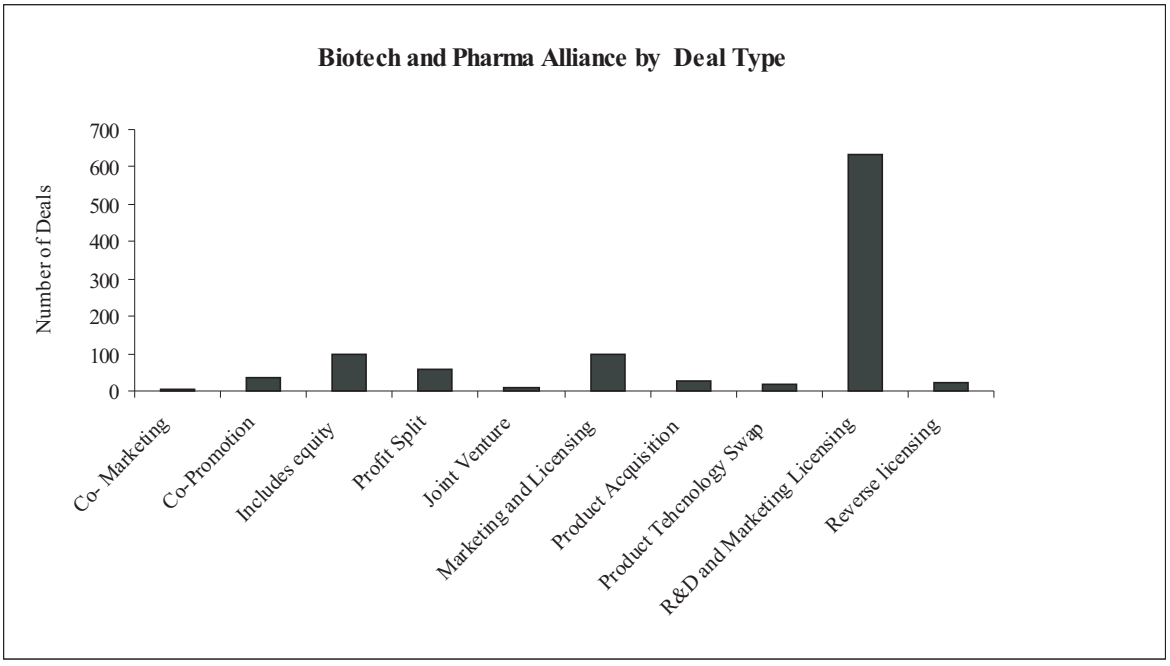

Figure 5.3: Biotechnology and Pharmaceutical Alliances 2001-2002 [5]

Figure 5.3 shows that emerging industries generally have a contractual level of integration and hence for R&D, marketing and licensing contractual agreements, are the most popular type of collaborations. It can also be observed that in the biotechnology industry the main reasons for collaboration are similar to those of ISS commercialisation, that is to say, marketing and sales activities (see section 6.4). The above observations are relevant for the present and future business functions (see Figure 2.1).

Environment 3: Business Function Environment - the development of the emerging ISS markets create an environment in which licensing and strategic alliances as presented in Figure 5.2 are most appropriate for the future business functions. Once markets start to develop, the level of integration between founders could enter the collaborative stage. The level of integration between founders and market demand will determine the selection of the

most appropriate collaboration for a future business function. Figure 5.3 highlights that the potential contractual level of integration can be considered if the ISS markets are still underdeveloped. In the current ISS commercial environment, ISS partners could consider creating a contractual level of integration for NASA's NGI and JAXA's ISS Business Forum (see section 4.5). In the first 2 to 3 years after its creation, the future business function could have a contractual level of integration. A current example is the present contractual agreement between ESA and ISS Lab Ruhr GmbH (i.e. Commercial Agent) for the sale of ESA ISS products and services to the biotechnology, nutrition and health markets. If the ISS markets develop towards the Frenzied stage (see Figure 2.1), the level of integration may increase to become of a collaborative type between founders of the business functions. In the current ISS commercial environment a contractual level of integration between ISS partners and private companies for NASA's NGI and JAXA's ISS Business Forum is recommended. Future business function can have a contractual level of integration for the first 2 to 3 years of operations and thus, address research Question 7, from section 1.3.

5.5 Characteristics of the Business Functions

In order to identify the necessary steps for the implementation of a future business function, there is an overview of the ownership issues and phases of development of collaborations in this section. The analysis of the above aspects will support answering research Question 7: *What are the necessary steps for the development and implementation of a future collaboration?*, from section 1.3.

5.5.1 Ownership and Decision Making

In order to describe the steps necessary for the implementation of a future collaboration, there is an overview of ownership aspects for future business function and given below.
Grossman and Hart [106] define ownership[17] as the power and authority to exercise control over an asset. The process of integration between founders in a company is considered to be a way of reducing potentially opportunistic behaviour by the founders [89], as observed by Hart and Moore. However, [106] point out that integration between founders will also result in changes of control over these provisions not included in the initial contract between founders. The theory of incomplete contracts and property rights issues are relevant

[17]Ownership gives control over management and technical resources in an organisation. It brings dividends and authority, but [89] debates that a change of ownership also brings costs as well as benefits for the owners.

in this context, as ownership, residual rights[18], level of integration[19] and investment could become important for a future business function. The future returns from ownership are investigated by [89] and analyse the consequences of incomplete contracts resulting in future returns of the owners depending on the marketability or bargaining position of the company tomorrow.
For ISS commercialisation, ISS partners could increase incentives for founders to invest in ISS commercialisation by offering them control over the present business functions, similar to the case of the present ESA Commercial Agent (see section 4.4.4). The founders will have to be indispensable[20] for the future business function resources and ISS commercialisation and will have to provide services and competencies not available in the agency, such as marketing and sales. Hart and Moore's analysis of ownership allocation could be relevant for ISS commercialisation, from which the following observations can be made for the future business function environment:
Environment 3: Business Function Environment - the founders of a future business function could allocate unique resources, such as marketing and sales resources, access to markets and first time customers and transform themselves into an indispensable partner to ISS partners. As a result the future business function could become indispensable to the ISS partners.
Relationship 1: ISS Partners and Business Function - currently ISS partners are the sole owners of ISS products and services. They have direct control over the allocation of ISS products and services and are indispensable to the process of ISS commercialisation, because they provide ISS access to commercial customers. On the other hand the present business functions (see section 4.4) could have a low incentive to develop ISS markets, due to the lack of ownership rights. Therefore, for this relationship, the notion of residual rights of control over the allocation of ISS products and services to the future business function is a very relevant aspect. In his research on incomplete contracts and the theory of the firm [88] identifies that ownership of an asset with the possession of residual rights of control over the assets, is the right to use the assets in ways other than those stated in the initial contract. In some, but not all contracts, there are specifications for the performance of certain control actions. As a result of these inconsistencies, potential founders in a future business function will probably demand certain exclusivity and ownership rights

[18]These are the rights to use the asset in any way, except to the extent to which the specific rights are included in the initial contract between two parties. This is a result of the contracts between parties being incomplete, with certain gaps.

[19]Hart [88] develops the concept that integration between founders is likely to be important in situations where relationship-specific investments are large. This observation has been reported by [88] in the analysis of integration in the context of incomplete contracts and the theory of the firm. Investments by the founders in a collaboration will be more valuable inside the relationship than outside.

[20]According to Hart and Moore dispensable partners are those with no investments and therefore no decision rights [89].

for certain ISS products and services. If they do not receive these rights, the founders will have little incentive to invest in the creation of a future business function and in ISS market development.
An issue that could arise is whether ISS partners that are founders of the business function will aim at retaining strategic power in the decision making of a newly formed future business function. If an ISS partner retains the power in marketing and sales decision making, it is possible that future business functions would be dominated by an agency. This could result in a conflict of interest between the public agency (i.e. ISS partners) and the founders (i.e. non-space companies) and ultimately could result in collaboration failure. To avoid this conflict ownership between the business functions founders, a balanced ownership structure will need to be established. The incentive to develop ISS markets could result in business functions identifying additional ways to commercialise the ISS products and services, which are beyond the boundaries of the contract. Therefore, a future business function will have the incentive to exploit residual rights from their activities.
Ownership rights allocation for the business function need carefully to be considered. The business functions can become indispensable partners to the ISS partners by allocating marketing and sales resources that differ from those of the ISS partners.
ISS partners have direct control over the allocation of ISS products and services and are indispensable in the ISS commercialisation, while, present business functions have low incentives to develop ISS markets, due to the lack of ownership rights. Therefore certain exclusivity rights over the sales of ISS products and services will need to allocated to present and future business functions. The ISS partners' decision-making capabilities in a future business function could result in conflict and to avoid this balanced ownership between founders[21] will need to be proposed. The above conclusions contribute to answering research Question 7.

5.5.2 Collaboration Phases of Development

This section identifies the phases for development of a future business function and therefore, contributes to answering research Question 7, from section 1.3. Collaboration development passes through different phases of development (see Figure 5.2). Firstly, there is summary of the phases of development identified by various authors and then a proposal for the future business functions phases of development.
Dyer, Kale and Singh [50] classify the life cycle of collaborations into five phases: 1) alliance businesses, 2) partner assessment and selection, 3) alliance negotiation and governance, 4) alliance management and 5) assessment and termination.
These phases are relevant for the creation of a future business function as they assess essen-

[21]The ownership structure of the business function will be investigated for the high market demand scenario in section 9.3.7 and the medium one in section 9.4.7.

tial aspects for creating a future collaboration and will be further considered in section 8.7. Another classification of collaborations development is made by Booz Allen and Hamilton's [43], that divides collaborations development into four phases: 1) identification of strategy and objectives, 2) selection of founders and opportunities, 3) negotiations between founders and 4) implementation of integration planning of the collaboration. These phases make a clear distinction between the preparation and implementation of collaboration and identify the aspects (i.e. objectives, founders) that the business function will need to address.
The future business function phases of development are divided into preparation and implementation. In the **preparation phase** the founders will have to identify:

- needs and objectives
- roles and activities
- resources allocation
- investments allocation

The preparation phase will be used further on for the business functions proposal in section 8.7. In the business function **implementation** phase the founders will have to deal with collaboration negotiations, governance and management similar to those identified by [62]. Founders will need to take into account the ISS lifetime in 2017, as some founders may wish to terminate their business functions participation, while other might aim at the continuation of business function activities transferred to the commercialisation of other space-based technologies. Therefore, it is important to have a wide definition of the objectives in the future business functions preparation phase in section 8.2 in order to leave opportunities open for technology commercialisation beyond the ISS programme.
The future business function phases of development are divided into preparation and implementation. Founders of a future business function will need to give a wide definition of its objectives, so it can continue to be operational also after the end of the ISS. The above conclusion directly contributes to answering research Question 7.

5.6 Selection Criteria of Business Functions

In this section is an overview of selection criteria that will be used in the assessment of the present business business functions. The results from this section will contribute to answering research Question 2: *Is there a need for a collaboration between space agencies and private companies to support successful ISS commercialisation?*, from section 1.3. This section will identify and apply selection criteria to the present business functions. The [99] identifies three major criteria to be considered when creating collaborations:

- Protecting social equity investment projects: it must be determined by public interest
- Value-for-money and quality: identifying the most cost-effective way to secure high quality service
- Clear accountability and transparency of collaborations creation

These criteria reflect the UK experience in creating collaborations, such as a PPP, but could also be relevant for the present business functions, because the ISS partners are non-profit public organisations that participate in some the present business functions. Therefore, the criteria of value for money and political transparency are relevant. The ISS partners can assess whether the present business functions meet the criteria of value for money by the number of patents registered (see section 5.6.1) or commercial projects implemented per year. The criteria of political transparency is more subjective, it can be measured by the availability of information on the ISS partners ISS commercialisation policies. For example ISS partners can implement simpler procedures for commercial proposal selection, as discussed in section 4.2.
Porter [73] proposes six criteria[22] for selection of founders, from which only competitive advantages will be relevant. In the ISS partners decisions to participate in their present business functions, ISS partners can use the Porter criteria, combined with those of the UK Commission. The criteria of value for money, political transparency and possession of complementary resources can be used as initial assessment criteria for the ISS partners for evaluating present and future founders. Additional criteria to be added are risk and profit sharing for new ISS market development which will provide the future business function with a robustness for dealing with ISS market uncertainty, unknown customers and high ISS prices. The later criteria will measure whether all the founders in a business function share the same market risks. The criteria above are used in the analysis of the present business functions in the next sections 5.6.1, 5.6.2 and 5.6.3.
However, once the future business function is operational, different criteria will be needed to monitor its activities. The [49] and [118] approach for assessing operational collaborations is chosen as it offers an opportunity for a detailed assessment of the activities of collaborations. These are as follows:

- Strategic criteria - measures the market share of business functions in the ISS markets. These will also measure its competitive positioning, access to new markets and customers worldwide

[22]Porter's criteria for selection of collaboration founders are the following: possession of a source of competitive advantage, need for a complementary contribution from the firm, compatible view on international strategy, low risk of becoming a competitor, pre-emptive value as a partner vis--vis rivals and organisational compatibility.

- Financial criteria - measures the annual sales turnover from different markets, cash flow and net income. This permits the calculation of Net Present Value (NPV), Internal Rate of Return (IRR) and profitability
- Managerial criteria - measures the suitability of the selected collaboration type for effective management of the planned activities
- Partners' compatibility - measures culture fitness and common trust between partners, which are essential for successful implementation. Public and private partners will have to find a balance between each others' objectives

The above criteria will support the identification of potential business risks in the implementation phase that will accompany the operations of a future business functions. Therefore, in the early creation of a business function, strategic and managerial criteria can be most important for the strategic and market decisions by its founders. The initial selection criteria of value-for money, political transparency, complementary resources and risk and profit sharing will facilitate the set up of future business functions. Once operational, the future business functions' performance and activities can be assessed through the use of operational criteria which will support early identification of business risks. Therefore, in the early creation of a business function strategic and managerial criteria can be most important for the strategic and market decisions by its founders. The use of criteria creates clear guidelines for the assessment of the performance of present and future business functions. The analysis of the present business functions against the initial selection criteria will support the proposal of a future business function. The criteria are value-for-money, political transparency, complementary resources, and profit and risk sharing. The above conclusions contribute to answering research Question 7.

5.6.1 NASA RPC

The RPCs analysed in section 4.4.1, meets the value-for-money criteria, because of the number of patents and licenses resulted from their activities. The RPCs have political transparency, however they are not risk and profit sharing collaborations, and they do not target customers from emerging markets, as observed in section 4.4.1.

5.6.2 JAXA ISS Business Forum

The Japanese ISS Business Forum analysed in section 4.4.2 has not yet been created, so it is difficult to assess whether it represents value-for-money. Political transparency of the ISS Business Forum can only be observed once the model is implemented. The non-profit nature of the ISS Business Forum shows that it will not be a profit and risk-sharing collaboration.

5.6.3 ESA Co-operation Agreement and Commercial Agent

The Co-operation Agreement offers political transparency and aims at risk and profit sharing of investment for new project development. As the agreement pools only necessary services from the partners for certain projects. However, the value-for-money criterion of the collaboration is difficult to assess, because of the current lack of projects initiated under this agreement.
The Commercial Agent was selected by ESA after the implementation of a politically transparent process. At the present time, it is too early to assess the criterion of value-for-money of the ISS Lab Ruhr GmbH. company, created in November 2004. The criteria of profit and risk sharing between agency and collaboration for the Commercial Agent are not relevant, because ESA is not a founder (i.e. creator) in the contractual agreement with the commercial agent.
The present business functions do not meet all the four criteria and therefore there is a need for a future business function that meets them all. The above results show the need for collaborations and thus, address research Question 2.

5.7 Results and Conclusions

The analysis of the driving forces of ISS commercialisation and the characteristics of collaborations, the results from this Chapter address research Questions 2 and 7, from section 1.3. A SWOT analysis of the driving forces in the current ISS commercial environment has been used to answer research Question 2: *Is there a need for a collaboration model between space agencies and private companies to facilitate successful ISS commercialisation?*. Based on this analysis reasons were identified for the creation of a future business function. On the supply side ISS partners and space companies are exposed to more threats from ISS commercialisation than opportunities, threats such as complex negotiations, ISS products and services availability and ISS cost overruns. To reduce these threats there is a need for a business function between the ISS partners and private companies. On the demand side of the current ISS commercial environment there are opportunities from ISS commercialisation, such as ISS market opportunities, use of property and marketing rights. Exploitation of new ISS market opportunities, achieving partial ISS recovery and being first on the markets are some of the reasons for the future founders to create a future business function. The analysis of the present business functions (i.e. NASA RPC, ESA Co-operation agreement, Commercial Agent) showed that the present business functions do not meet the selection criteria[23]. Therefore, there is a need for a collaboration, such as

[23]The initial selection criteria were of value-for-money, political transparency, complementary resources, and profit and risk sharing. NASA's RPC does not meet the risk-profit sharing criterion, ESA Co-operation agreement does not meet the value-for money criterion and the Commercial Agent does not meet the risk

the future business function.
To answer research Question 7: *What are the necessary steps for the development and implementation of a future collaboration model?* the conditions, phases of development and selection criteria for development of a collaborations were identified.
Political approval, access provision to ISS products and services and implementation of ISS commercial policies are minimum conditions identified in section 5.3.3 for the ISS partners for setting up collaborations. Attracting start-up capital, first-time ISS customers and meeting customer needs are the conditions the business functions must meet. In the current ISS commercial environment a contractual level of integration between ISS partners and private companies for the NASA's NGI and JAXA's ISS Business Forum is recommended. A future business function can have a contractual level of integration for the first 2 to 3 years of its operations.
Two phases of collaboration development were selected; preparation and implementation phases. Future founders of a collaboration first have to prepare and identify their needs, objectives, activities and roles (i.e. preparation phase) and then deal with negotiations, governance and management (i.e. implementation phase).
Value-for-money, political transparency, complementary resources, profit and risk sharing are the criteria used to evaluate the present business functions. The main steps for the successful implementation of a collaboration are, checking whether it meets the conditions for its creation, undertaking the necessary phases of development and meeting the initial selection criteria.

and profit sharing criterion. For RSA and JAXA collaborations there is little information available.

Chapter 6

Hypotheses Development

6.1 Introduction

In this Chapter hypotheses for the future ISS commercial environment and future business function will be defined. The analysis of the current ISS commercial environment in the earlier Chapters addresses the research questions from section 1.3 and become the basis for hypotheses development. In this Chapter, research Questions 3, 5 and 6, from section 1.3 are addressed:

- How will ISS partners' commercial activities encourage or discourage ISS commercialisation? - Question 3
- What are the expected future market and strategic developments in ISS commercialisation? - Question 5
- Within what type of markets would a future collaboration operate? - Question 6

To answer research Question 5, there is a summary of the monopoly and oligopoly considerations from Chapter 2. These considerations are derived from the analysis of the supply side of the current ISS commercial environment from section 2.3 and result in three hypotheses. The validation of these hypotheses, will show expected strategic and market developments in ISS commercilisation. Furthermore, the classification of collaborations as discussed in section 5.4 will result in considerations for the market demand role on collaborations creation. The validation of the hypotheses contributes with predictions on the strategic and market developments in the future ISS commercial environment[1], thus answering research Question 5 and supporting the selection of a collaboration for the future business function.

[1]The future ISS commercial environment is the future environment where either the ISS partners or their business functions or the space industry will sell ISS products and services to commercial customers. The future ISS commercial environment is divided into supply and demand sides.

6.2 Monopoly Considerations

The analysis of the supply side of the current ISS commercial environment in section B.1, showed the lack of a monopoly, but the existence of an oligopoly market structure. Monopoly existence in the future ISS commercial environment is possible. This is because there are only two space agencies, NASA and RSA, who possess the necessary transportation capabilities[2] and are price setters as observed in section 2.3.7. As a result of the accident with the Space Shuttle in 2003 and the reduced number of Shuttle flights in 2005, RSA is currently the only ISS partner that offers regular flights to the ISS. The lack of information on their prices (see section 2.3.7), indicates that RSA may aim at becoming a price discrimination monopolist[3]. In this position RSA is able to achieve the maximum possible price for each kilogram it flies to the ISS and to generate monopoly profits. This situation is considered to be temporary, lasting only until NASA resumes regular Shuttle flights to the ISS. The Space Shuttle is fully booked with assembly flights and there is no room for commercial payloads. The creation of a monopoly in transportation services to the ISS can hamper successful ISS commercialisation. Future commercial customers may be reluctant to pay high prices for transportation services and the monopolist may aim at generating monopoly profits. Therefore, the above considerations result in underdevelopment of ISS commercialisation. This will be investigated through the validation of the following hypothesis:

H1: If space agencies sell all their ISS products and services through only one business function, referred to as a monopolist, this will lead to the underdevelopment of ISS commercialisation.

This hypothesis is validated in section 7.4.6, which examines the creation of a monopolist business function in the future ISS commercial environment. The results from the validation of this hypothesis will also describe the ways ISS partners' encourage or discourage ISS commercialisation and the expected market and strategic developments in the future ISS commercial environment. Therefore, these results will address research Question 3 and 5, from section 1.3.

[2]For more information on transportation vehicles see section 2.3.4, Table 2.1.

[3]RSA provides access to ISS products and services to both institutional customers (e.g. NASA, ESA) and commercial customers, such as D. Tito, M. Shuttleworth and G.Olsen (i.e. space tourists). The second degree of discrimination occurs when the seller charges the same price for a specific quantity, but reduces the price for additional quantities of a product. The third degree of discrimination occurs when the sellers charge different prices in different markets.

6.3 Oligopoly Considerations

The description of oligopoly considerations and hypotheses contribute to answering research Question 5 and 3, from section 1.3. Competition or cooperation between the ISS partners will not only influence ISS commercialisation but also influence the business function. Earlier analysis of the supply side of the current ISS commercial environment in section 2.3.2 showed the existence of an oligopoly market structure in the current ISS commercial environment. The ISS partners' interdependence in ISS commercialisation and non-price competition as observed earlier on in section 2.3.1 and section 2.3.7, showed a resemblance to a cooperative oligopoly in the current ISS commercial environment. This interdependence and non-price competition can continue and encourage the creation of collusive oligopoly in the future ISS commercial environment. To analyse whether the cooperative oligopoly will become the market structure in the future ISS commercial environment, the following hypothesis is proposed:

H2: Political, strategic and technological interdependence of the ISS partners will lead to the creation of a cooperative oligopoly in the future ISS commercial environment.

The above hypothesis is validated in section 7.6.6 and the results from its validation will describe the expected strategic developments in ISS commercialisation and thus addresses research Question 5. The ISS partners can decide to offer direct access of ISS products and services to commercial customers and compete with each other. This assumption is based on the fact that RSA has already offered direct access to ISS products and services to three space tourists [14], despite the initial disapproval of NASA. The continuation of such ISS partners' competition, may lead to disagreements between the ISS partners on ISS commercialisation and lead to the break-down of cooperation between ISS partners. Thus, constraining ISS commercialisation development.
The ISS partners also implement different ISS commercial policies as was further investigated in section 4.3 and have differentiated some of their ISS products and services as already analysed in section 2.3.4. This means that they will offer access to ISS products and services, and ISS partners with transportation capabilities will have the power to constrain ISS access for commercial payloads for the other ISS partners and the following hypothesis is proposed:

H3: Direct competition between the ISS partners could lead to a non-cooperative oligopoly and subsequent underdevelopment of ISS commercialisation.

This hypothesis will be validated in section 7.5.5. The validation of the hypothesis will re-

sult in the identification of predictions for strategic and market developments in the future ISS commercial environment. The validation of the above two hypotheses will contribute to answering research Question 3 and 5, from section 1.3. The results of the hypothesis validation will also contribute to selecting a market structure for the future ISS commercial environment and thus, answering research Question 6.

6.4 ISS Market Demand Considerations

The analysis of the important driving forces in ISS commercialisation in section 5.3 and the collaborations classification in section 5.4, resulted in recommendations on the role that market demand for ISS products and services plays in a future business function. When considering the the significant driving forces from section 5.3.1 and the reasons for creation of a business function from section 5.3.2, the importance of the market and economic forces and of market demand must be raised. Unfortunately, there is a lack of historical information on market demand for space station products and services (see section 2.3.6), due to the fact that it is an innovative process and that the ISS markets are not yet developed, as concluded in section 2.4.1. Therefore, it is difficult to establish recommendations for the required level of integration between founders of future business function. For this reason some assumptions will have to be made on the level of market demand impacting on the level of integration of founders in a future business function. In the case of high market demand for ISS products and services, the founders will need to provide more ISS products and services to their commercial customers. Therefore, an increased level of integration and a stronger commitment by the founders will be necessary to meet customers' needs. In the case of medium market demand, the founders' needs will be different, and the resources required for selling ISS products and services to commercial customers will be less. The **market demand** for ISS products and services will be the major driving force for the successful commercialisation of ISS products and services and for determining the level of integration between the business function founders. The use of percentages for describing the market demand for ISS products and services is necessary to give the founders the opportunity to make a choice for the necessary level of integration. Furthermore, constant changes of the ISS assembly since 1998, renders it difficult to use an exact number of lockers (i.e. MDL) as presented in section 2.3.4 or drawers (i.e. ISIS Drawers) for the ISS products and services. These considerations lead to the following hypotheses which are related to the level of integration and market demand:

H4: High market demand of 50% to 100% for ISS products and services, requires a collaborative level of integration between business functions' founders.

H5: Medium market demand of 10% to 50% for ISS products and services, requires a contractual level of integration between the business functions' founders.

H4 will be validated in section 9.3.8 and H5 in section 9.4.8 and the results of the validation will describe future market developments in ISS commercialisation and thus contribute to answering research Question 5. In Chapter 9, there will be an analysis of three scenarios for market demand; high, medium and low[4] for ISS products and services. From the identification of the level of integration between business function founders, it will be possible to narrow the scope of the future collaboration models and support the selection of the most appropriate one for each market demand scenario (i.e. high, medium, low). The validation of the above hypotheses will support the identification of expected market developments in the future ISS commercial environment and therefore research Question 5, from section 1.3 will be addressed.

6.5 Results and Conclusions

The summary of the hypotheses considerations and hypotheses in this Chapter, contribute to addressing research Questions 3, 5 and 6 from section 1.3. To answer research Question 3: *How will ISS partners' commercial activities encourage or discourage ISS commercialisation?* there will be an analysis of the monopoly hypothesis in section 6.2 and two oligopoly hypotheses from section 6.3. The validation of these two hypotheses will also be complemented with a description of how the ISS partners in the future ISS commercial environment can encourage or discourage ISS commercialisation.
To answer research Question 5: *What are the expected future market and strategic developments in ISS commercialisation?* the monopoly, oligopoly and market demand hypotheses from section 6.2, section 6.3 and section 6.4 are validated. The results of their validation contribute to predictions on strategic developments of future ISS commercial environment, thus answering research Question 5.
To answer research Question 6: *Within what type of markets would a future collaboration model operate?* the market structure in the future ISS commercial environment will be identified as a result the monopoly and oligopoly hypothesis validation.
The validation of the market demand hypotheses will support the selection of a collaboration for the future business function and identification of expected market developments in the future ISS commercial environment.

[4]Low market demand is when there is a demand of less than 10% of the 30% of ISS products and services.

Chapter 7

ISS Future Environment Scenarios

7.1 Introduction

The analysis of the current ISS commercial environment in Chapter 2 highlighted the need for an analysis of the role of competition or collusion in the future ISS commercial environment. The objective of this Chapter is to predict strategic and market developments in the future ISS commercial environment through the development of ISS future scenarios. The results in this Chapter address the following questions:

- How will ISS partners' commercial activities encourage or discourage ISS commercialisation? - Question 3
- What are the expected future market and strategic developments in ISS commercialisation? - Question 5
- Within what type of markets would a future collaboration model operate? - Question 6

The above questions were investigated for the current ISS commercial environment[1], but not for the future one. The necessity for the development of the ISS scenarios was initiated by the need to describe future players' behaviour under different market structures[2] as identified in section 2.3. The ISS future scenarios resulted from the monopoly considerations in section 6.2 and oligopoly considerations in section 6.3. The analysis of RSA

[1]Question 3 was investigated in Chapters 2, 3 and 4. The analysis of the ISS partners prices and roles in ISS markets were researched in Chapter 2 and lessons learned from Mir commercialisation contributed to answering the question. Question 5 was also partially investigated in Chapter 3, in which the analysis of the world space budgets and the influence of the future Moon and Mars visions on ISS commercialisation contributed to answering Question 3.

[2]The analysis of the current ISS commercial environment in Chapter 2, showed the existence of cooperative oligopoly on the supply side and emerging markets on the demand side of the current ISS commercial environment, as presented in section 2.6.

collaboration strategy in section 4.4.3, resulted in a "two-way" ISS access scenario in section 7.8 in which customer can access ISS products and services either through an ISS partner or through a business function.
Each scenario will be verified whether there the necessary conditions are met for the creation of a future business function under competition or collusion. The selected future scenario's influence on the macro environment of the future business function will be considered in section 9.2. The analysis of the ISS future scenarios will contribute to conclusions on market and strategic development of the future ISS commercial environment and thus, will answer research Question 5 and Question 6, from section 1.3.

7.2 Research Relationships

In this section is an overview of the relationships that will be further investigated in this Chapter. Figure 7.1 illustrates the different relationships. An additional Relationship I is introduced, because because of the ISS future scenario that considers direct competition between ISS partners.

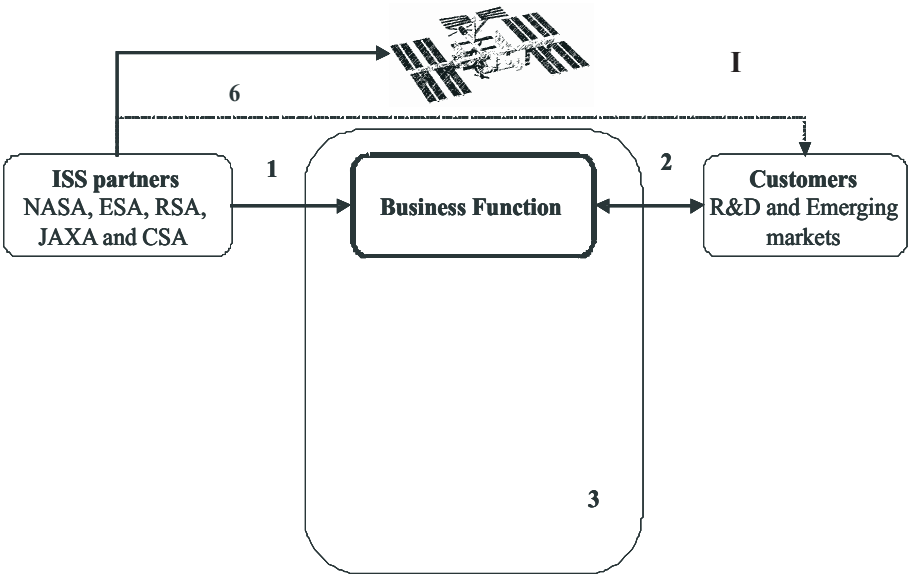

Figure 7.1: Relationships investigated in Chapter 7

Relationship 1: ISS Partners and Business Function - investigates ISS partners' roles, interest and power positions in the ISS future scenarios.
Relationship 2: Business Function and Commercial Customers - analyses the influence of ISS partners' roles, interests and power positions on the ISS future scenarios.

Environment 3: Business Function Environment - researches the competition or collusion of business functions for each ISS future scenario.
Relationship 6: ISS Partners - analyses competition or collusion of the ISS partners in the future ISS commercial environment.
Relationship I: ISS Partners and Commercial Customers - this relationship is introduced to analyse the consequence of direct access to ISS products and services by customers.
The above relationships present the boundaries of the analysis for the future ISS commercial environment.

7.3 ISS Future Environment Scenarios Creation

This section provides an overview of the approach for the development of the ISS future scenarios. Scenarios are chosen as they allow for a range of strategic developments such as competition and collusion, to be analysed in the context of their influence on ISS commercialisation. Five ISS future scenarios will be investigated, in which the three scenarios resulted from; H1 monopoly hypothesis from section 6.2, H2 and H3 oligopoly hypotheses from section 6.3. From the left two ISS future scenarios one describes a non-cooperative oligopoly situation and the second one of a space agency that either markets its ISS products and services directly to customers or through a business function. The last scenario was inspired by the analysis of the Russian space collaboration strategy from section 4.4.3. The five ISS future scenarios are:

- Joint ISS Business Function (JIBF) - in this scenario one business function has exclusive rights to sell the ISS products and services of all five ISS partners, as considered in section 6.2

- ISS Partners Direct Competition (IPDC) - in this scenario there are no business functions and all the ISS partners sell their ISS products and services directly to commercial customers. The ISS partners are in direct competition for customers

- Collusion - in this scenario business functions collude with each other in the ISS markets, as considered in section 6.3

- Competition - this scenario presents an environment in which future national business functions are in direct competition with each other for customers

- Two-way ISS access - this scenario presents a situation where a space agency offers access to ISS products and services to customers, either directly or through its national business function (see section 4.4.3)

More ISS future scenarios are not considered, because of the lack of sufficient considerations for investigating other situations.
The scenario method founded in 1950 by Herman Kahn [56], provided the following initial definition "a hypothetical sequence of events constructed for the purpose of focusing attention on causal process or decision points". Different methods that can be used for scenario development and more detailed overviews than the approaches below can be seen in Appendix F, Table F.2:

- The Delphi method as defined in [42] for structuring a group communication process of individuals to deal with a complex problem. The key characteristics of the method are the structuring of information flow, regular feedback and anonymity of the participants [128]

- The Cross-impact method was developed by Helmer and Fowles and is built on opinions obtained through the Delphi method by considering interactions (interdependence) between trends and events in a certain industry [6]

- Shell Direct Scenario building requires the identification of strategic concerns and decision needs and clarifies companies' priorities under different future conditions [22]

- Constructing Industry Scenarios are proposed in [72]. It is based on a set of plausible assumptions about the important uncertainties that can influence an industry structure

- Scenario Planning is proposed by Wharton University [18]. It can be used to calibrate both the nature and the extent of commitment a firm should make in pursuing a particular set of technologies, products and markets

The **Delphi method** as described by [128], imposes the ideas of the interviewer, ignores disagreements and does not allow contributions from other perspectives. The nature of the ISS emerging markets (see section 2.4.1) means that few respondents are aware of the ISS partners' commercialisation opportunities. In addition, the multi-cultural diversity of the ISS partners in the space industry in general could cause problems as similar questions may be treated differently. This method will not contribute to answering the research Questions 3, 5, and 6 because of above limitation. A more complex approach is the **Cross-impact method** as observed by [6] as it considers the degree of impact of a certain trend or even estimates the intensity of the impact of a trend in each year. The driving forces in the current ISS commercial environment (see section 5.3) combined with the uncertainty, complexity and emerging nature of the ISS markets (see section 2.4.1), makes it difficult to use this method for the future ISS commercial environment. The **Shell Direct Scenario Building method** requires the identification of strategic concerns and decisions. Changes

in the ISS assembly from 1999 to 2004 came as a result of NASA cost ISS overruns in 2001 and the irregular space shuttle flights after the accident in 2003. The above reasons have altered the power positions of NASA and RSA with regard to the other ISS partners on the supply side of the current ISS commercial environment, so the strategic concerns of the different ISS partners for ISS commercialisation are continuously changing. Therefore, the ISS partners' needs from ISS commercialisation are also changing and hence, this method will also not be used to achieve the objectives of this Chapter.
The **Porter approach** in constructing industry scenarios identifies and describes the uncertainties that influence industry structure and determines the causal factors. However, the ISS emerging markets and the diversity of the ISS targeted markets (see section 4.3.4) makes it difficult to use this approach. The **Direct Scenario building approach** of Wharton University is considered as most relevant one, because it supports the creation of scenarios in emerging markets. It will contribute to the description of players' behaviour, driving forces and trends in the ISS markets. The scenario building approach is built upon ten steps, as presented in Appendix F, Table F.2. In order to analyse the collusion or competition in the future ISS commercial environment this approach has been simplified by the author.

- Step 1 - presents the major assumptions for each ISS future scenario, which have been derived from the earlier analysis of the market structure theories in section 2.3.
- Step 2 - investigates the ISS partners' and business functions' roles, interests, power positions and behaviour under the assumptions from Step 1
- Step 3 - analyses the future driving forces in each scenario, due to competition or collusion from step 1. The description and SWOT analysis of the driving forces in the current ISS commercial environment from section 5.3 will support the analysis of the future driving forces for each scenario
- Step 4 - presents an analysis of the future market trends resulting from the driving forces in Step 3. These market trends are analysed in the context of their future influence on the ISS partners and a future business functions
- Step 5 - the selection of the preferred ISS future scenario for the creation of a future business function. The selection process uses the "minimum conditions"[3] from section 5.3.3 to select the relevant scenario for the creation of a future business function creation

[3]The "minimum conditions" for ISS partners are: 1) political approval, 2) access provision to ISS products and services, 3) commercial policy for a competitive environment, and 4) risk sharing and preserving confidentiality. The business function will have to meet the following "minimum conditions": 1) attract start-up capital, 2) gain market positioning and attract first-time customers, 3) meet market and customer requirements and 4) investment and risk sharing.

The data used for the construction of these scenarios comes from literature, reports and direct observations from the author on the current ISS commercial environment. All five selected scenarios will contribute with predictions for future strategic developments in ISS commercialisation and thus, answer research Questions 3, 5 and 6, from section 1.3.

7.4 Joint ISS Business Function (JIBF) Scenario

The JIBF scenario is built on the assumption that the five ISS partners sell all their ISS products and services through one company called Joint ISS Business Function (JIBF). This assumption was derived from the monopoly considerations in section 6.2. The conditions in the current ISS commercial environment will allow RSA to apply perfect price discrimination and RSA is able to achieve the maximum possible price for each kilogram it flies to the ISS and to generate monopoly profits. The JIBF scenario will be further investigated using the five-step analysis.

7.4.1 Major Assumptions - Step 1

The JIBF scenario assumptions are the following:

- JIBF will be the only seller of ISS products and services, as all ISS partners will allocate their commercial ISS products and services to it
- JIBF will offer unique ISS products and services to customers, with no substitutes. The monopolist will face little competition because it will be the only company with commercial access to a long-term microgravity environment (i.e. ISS)

The ISS partners have political and technical interdependence (see section 2.3.1) and the JIBF will have the market power. Even if the ISS partners and the JIBF agree on the sales prices for ISS products and services, through a contractual agreement, the JIBF will still have the opportunity to generate profits similar to that of a monopoly, due to its residual rights[4]. For certain projects, the JIBF will have the opportunity to set higher prices for ceratin ISS products and services. The JIBF target customers from the national countries of the ISS partners. Figure 7.2, presents an overview of the JIBF scenario.
This scenario illustrates that the ISS partners allocate their ISS products and services to the JIBF. The ISS partners are the owners and the technical managers of the ISS. The JIBF will become the commercialisation manager of the ISS products and services. As a result of a probable exclusivity agreement with the ISS partners, the JIBF will have sole access to the unique ISS products and services. Consequently as no other companies

[4]Residual rights are for the use of an asset in any way, except to the extent specific rights are included in the initial contract between two parties.

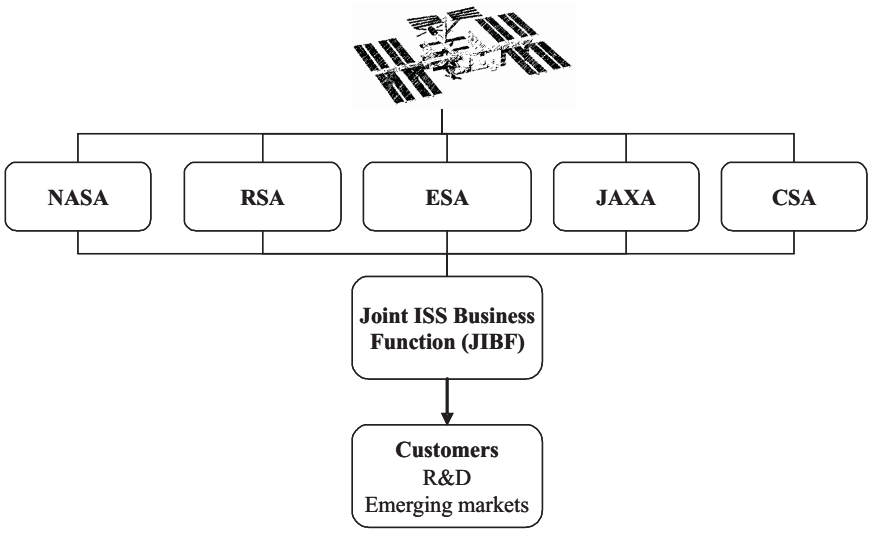

Figure 7.2: Joint ISS Business Function (JIBF)

will sell ISS products and services, this situation can be defined as a monopoly market structure. The JIBF could aim at generating monopoly profits[5] or "rent seeking"[6] rather than aiming at developing the emerging ISS markets. The creation of a monopoly will influence the strategic and market development of the future ISS commercial environment, the ISS partners, JIBF and commercial customers. This will be investigated further in Step 2.

7.4.2 ISS Partners and JIBF roles, interests and power positions - Step 2

The description of the ISS partners' roles in this section will directly describe how the ISS partners in this scenario discourage or encourage ISS commercialisation and contributes to answering research Question 3, from section 1.3.
Relationship 6: ISS Partners - the ISS partners control of ISS products and services allocation. Political driving forces will be similar to those observed in the current ISS commercial environment in section 5.3 and could encourage the increase of international cooperation. Previously identified interdependence between the ISS partners (see section 2.3.1) will increase. Potential conflicts of interest can arise if the political decisions of one ISS partner

[5]Monopoly profit for single seller in a market is when the seller charges a price above the marginal cost.
[6]Rent seeking as defined by [96], as the action of individuals and groups who spend resources to influence public policy in the hope of redistributing (i.e. transferring) income to themselves. These resources are not spent in the production of goods and services, but in transferring income. Economists consider this activity as socially wasteful, because these resources are not spent on the production of goods or services [96].

for the development of a certain ISS market segment will be relevant for the markets of another ISS partner. The ISS partners can be exposed to increased threats[7], similar to those in the current ISS commercial environment in section 5.3. The relationships between the ISS partners and the JIBF will be influenced by the monopoly market structure, Relationship 1 and Environment 3 are therefore analysed together.

Relationship 1: ISS Partners and Business Function and Environment 3: Business Function Environment - the JIBF will have market power and exclusive access to ISS products and services, as the only vendor of ISS products and services. The JIBF may charge different prices to commercial customers and generate monopoly profits and apply price discrimination[8] to achieve a maximum price for each unit of ISS products and services. JIBF could also generate income from residual rights resulting from the contractual agreement with the ISS partners and "incomplete" contracts (see section 5.5.1). For example the JIBF could target customers from markets that are not specified in its agreement with the ISS partners and aim at rent seeking.

Relationship 2: Business Function and Commercial Customers - first-time customers will become price takers for ISS products and services to a monopolist. The monopoly market structure could add additional confusion to the current lack of information on the ISS opportunities. The lack of public knowledge on ISS commercial opportunities, the ISS emerging markets and the fact that a monopolist is selling ISS products and services could have a negative influence on customer choices. Customers may be reluctant to buy ISS products and services from one company, that could charge a high price and this possibly leading to the underdevelopment of ISS markets and the break up of the JIBF.

ISS partners would preserve their right to ISS ownership and products and services allocation. They would be exposed to a variety of threats (i.e. ISS market uncertainty, cost overruns) and additional increased ISS partners interdependence with the JIBF. The ISS partners political decision for the creation of a monopoly can discourage ISS commercialisation.

The JIBF has market power to generate monopoly profits, implement price discrimination and aim at rent seeking. The JIBF customers will become price takers and be reluctant to pay high prices to access ISS products and services and this can lead to the underdevelopment of ISS commercialisation. By not objecting to the existence of a monopoly, the ISS partners effectively discourage ISS commercialisation and thus, research Question 3 is addressed.

[7]Threats, such as ISS products and services availability and ISS cost overruns.

[8]Price discrimination occurs when the seller charges the highest price for a certain unit of product or service.

7.4.3 Driving Forces - Step 3

The driving forces for this scenario are derived from the monopoly market structure (see Appendix B, section B.1) and the analysis of the driving forces in the current ISS commercial environment, from section 5.3 and the monopoly theory. The ISS partners could be exposed to a regular change of power between NASA and RSA. The increased ISS partners' interdependence in the current ISS commercial environment showed in section 2.3.1 that cost overruns (i.e. budgetary forces) lead to budget freezing and had direct effects on the ISS partners programs. Reduction of ISS products and services and changes in ISS assembly could create a "domino effect" spreading across the ISS partners. In this situation the JIBF can disproportionately affect the ISS partners with smaller ISS quotas (i.e. ESA, JAXA and CSA), also in the future ISS commercial environment. The JIBF should have global market coverage, as the ISS partners probably require the JIBF to encourage competitiveness of their national industries. Providing market power to JIBF, as a result of allocating all ISS products and services to a monopolist, will result in that company having the power to negotiate for further funding and requests to ISS partners for lower prices for ISS products and services. The JIBF will become an indispensable partner for all ISS partners and aim at rent seeking to influence the ISS partners' commercial policies in order to derive benefits. These activities of the JIBF will encourage underdevelopment of ISS commercialisation. The JIBF will have market and negotiation power, thus becoming an indispensable partner to the ISS partners and aim at rent seeking.

7.4.4 Market Trends - Step 4

The market trends in this section are derived from the monopoly market structure described in section B.1. The ISS partners will continue a nurturing role rather than an institutional management role[9] because the ISS markets are emerging and the ISS partners will need to support the JIBF in new market development. Under the JIBF scenario there is no need to implement policies for the encouragement of innovation and competition by the ISS partners. The JIBF will be a new player in many markets and will have wide multi-disciplinary coverage, as presented earlier in section 4.3.4. As such the JIBF may have difficulties in entering the ISS targeted markets and gaining market position, while at the same time generating monopoly profits. The ISS emerging markets will therefore remain underdeveloped and therefore, constrain ISS commercialisation development. If one ISS partners decides to sell its ISS products and services through a different company because of low revenues, it will break up the monopoly. If the JIBF incurs losses, because of underdeveloped ISS markets, all ISS partners will lose potential income. Furthermore, international cooperation of the ISS partners for the ISS program could be negatively

[9]The institutional management role is described in section 2.4.

influenced and in the worst case broken up. JIBF could be exposed to risks[10] such as a limited number of customers, a weak business case, incorrect market analysis and charging high prices to commercial customers. The likelihood is that increased ISS interdependence of the ISS partners will create a slow, inefficient and inflexible organisation. This could constrain the development of the ISS markets and lead to the underdevelopment of ISS commercialisation. The JIBF as monopolist will not be under pressure to lower costs for its marketing and sales activities. The creation of a monopoly via JIBF may at first seem an attractive option for preserving ISS partners ownership control of ISS products and services and generating revenues for the ISS partners.
The monopoly can break down, result in incapability to develop the multidisciplinary ISS markets and in future revenue losses for the ISS partners. ISS commercialisation could be endangered from the existence of an inefficient and rent seeking monopolist. The above addresses the expected strategic and market developments in ISS commercialisation and thus, address research Question 5.

7.4.5 Business Functions Creation - Step 5

The assumption that for the scenario presented in section 7.4.1, only one company was selling ISS products and services. Nevertheless in this scenario there is collaboration between the ISS partners and the JIBF. The JIBF will have to meet the "minimum conditions"[11](see section 5.3.3) for creation of a future business function. On the supply side *political approval* and *access provision* are conditions the ISS partners will probably meet in order to create a JIBF. The ISS partners can be exposed to long negotiation processes and intensive lobbying by the JIBF. The requirement of *political approval* by the ISS partners will be met under the monopoly scenario, as they will have to agree on the JIBF creation and the contractual agreement between ISS partners and JIBF. The criteria for *access provision* will be met as the ISS partners will allocate their ISS products and services to the JIBF. Because of the resulting monopoly market structure, the condition of a *competitive policy* under this scenario is not met. Risk and profit sharing will be between the ISS partners and JIBF, so the ISS partners will not only be exposed to technological and political risks, but also to business and economic risks. Failing to meet the conditions for the creation of a business function and the implementation of the creation of a competitive environment, shows that the ISS partners discourage ISS commercialisation. In the case of JIBF failing

[10]For more information on the business, economic, political and environmental risks see Appendix C, section C.3.

[11]The selected "minimum conditions" for ISS partners are: 1) political approval, 2) access provision to ISS products and services, 3) commercial policy for a competitive environment, and 4) risk sharing and preserving confidentiality. The business function will have to meet the following "minimum conditions": 1) attract start-up capital, 2) gain market positioning and attract first-time customers, 3) meet market and customer requirement and 4) investment and risk sharing.

to develop ISS markets this will affect the ISS partners' commercialisation policies. On the demand side, there are minimum conditions for this scenario that need to be met by the JIBF. Private investors can be reluctant to invest in a JIBF created by the ISS partners due to the emerging nature of the ISS markets, unclear profits and uncertain returns. The condition of *attracting start-up capital* will be met, due to the JIBF monopoly position which could be seen as an attractive venture to investors. The JIBF can *gain market positioning* and *attract first-time customers*, due to the unique ISS products and services that it will sell. However, as a monopolist, the JIBF can also be inflexible and incur high costs, as a result of X-inefficiency, and therefore may not be able to meet market and customer needs. The ISS partners and the JIBF will share large-scale investments due to the need for global market coverage. The condition of risk and profit sharing could be met by the founders (i.e. creators) of JIBF, who may be willing to allocate investment share risk sharing among themselves.
The conditions for the ISS partners are not met and the above conditions encourage the creation of a natural monopoly. The above conclusion contributes to answering research Question 3, from section 1.3. As a monopolist the JIBF will be inflexible and seek X-inefficiency. Under this scenario, the existence of the present business functions would not be possible. The above conclusions contributes to answering research Question 5.

7.4.6 Validation of Monopoly Hypothesis - Step 5

In this section the monopoly hypothesis (H1) from section 6.2 will be validated. The lack of information in the public domain of the prices for the Russian ISS products and services and earlier considerations in section 2.3.7 show that RSA has the potential to become a price-discriminating monopolist (see section 4.3.2). Future commercial customers may be reluctant to pay high prices for transportation services, as already discussed in section 6.2 because the monopolist will aim at generating monopoly profits and price discrimination. These considerations are further investigated in this scenario that supports the validation of the following hypothesis:

H1: If space agencies sell all their ISS products and services through only one business function, referred to as a monopolist, this will lead to the under-development of ISS commercialisation.

The above hypothesis is validated by the observations derived from the JIBF scenario of section 7.4. This hypothesis will be accepted or rejected by the following reasonings:
Reasoning 1: JIBF has the opportunity to apply price discrimination and receive maximum prices for ISS products and services, as well as products and services from commercial customers, by exploiting the "incompleteness"(see section 7.4.2) of contracts between JIBF

and the ISS partners. This will result in a low incentive for customers to buy ISS products and services from a monopolist and lead to the underdevelopment of ISS markets.
Reasoning 2: The JIBF will be an indispensable partner to the ISS partners in commercialisation. It will probably aim at "rent seeking"(see section 7.4.2) and influencing ISS partners' policies for its own benefit, by using the ISS products and services in a non-productive way. Moreover, due to the lack of competition, it is exposed to X-inefficiency that encourages organisational bureaucracy and endangers the successful development of ISS markets. Furthermore, it would result in customers reluctancy to buy ISS products and services and thus ultimately constrain ISS commercialisation.
Reasoning 3: The JIBF will have market and negotiation power, thus becoming an indispensable partner to the ISS partners and aim at rent seeking (see section 7.4.3).
Reasoning 4: ISS commercialisation is endangered by the dominance of political forces (see section 7.4.4) resulting from the regular change of strategic power between NASA and RSA. The increased exploitation and transaction costs of the ISS partners which could increase due to the creation of the JIBF could result in the cancelation of ISS public funding for allocating commercial ISS products and services.
Reasoning 5: The ISS partners not meeting the conditions (see section 7.4.5) for the creation of a business function and the implementation of competitive policy, reveals that the ISS partners will discourage ISS commercialisation .
The acceptance of the above hypothesis as a result of the above reasonings confirm that the creation of a JIBF monopoly company will lead to the underdevelopment of ISS commercialisation. The creation of a monopolist will constrain ISS commercialisation development. The above conclusions describe what can be the expected market and strategic developments in ISS commercialisation and therefore, address research Question 5.

7.5 ISS Partners Direct Competition (IPCD) Scenario

In this scenario the ISS partners will be in direct competition with each other for commercial customers. This scenario is derived from observations on the Mir commercialisation activities in section 4.2 and the Russian collaboration strategies in section 4.4.3. The analysis of this scenario will provide information for the validation of the "direct competition" hypothesis (H3) (see section 6.3). The scenario is analysed by using the five-step analysis previously discussed in section 7.3. Direct competition between the ISS partners, will not permit the existence of business functions (i.e. intermediaries) and therefore, there is no further analysis of the relevance for the business function creation (step 5).

7.5.1 Major Assumptions - Step 1

The ISS partners are only vendors of ISS products and services. They will make the initial investments in ISS market development.

- The ISS partners' business departments will be responsible for developing the ISS markets
- The ISS partners will have to develop marketing and sales strategies, in order to acquire customers, expand market share and increase sales

Figure 7.3 presents the direct competition scenario. The competition between the ISS partners will expose them to market and competitive driving forces and will compete for commercial customers on both prices and services.

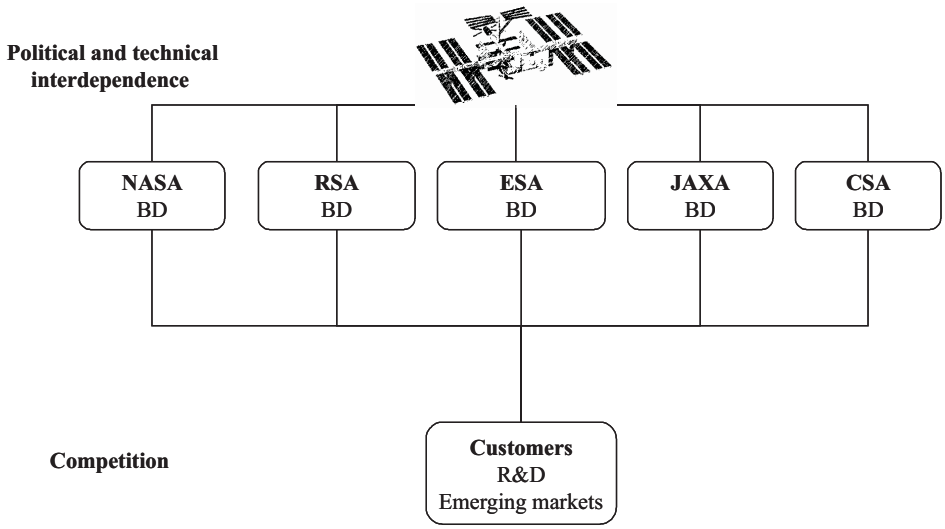

Figure 7.3: ISS Partners Direct Competition (IPCD)Scenario

The existence of few players (i.e. ISS partners) combined with the transportation capabilities of NASA and RSA will give them the market power to define prices and therefore, this scenario resembles non-collusive oligopoly.

7.5.2 ISS Partners' Roles, Interests and Power Positions - Step 2

The results of this section will describe the ISS partners roles in this scenario and thus, contribute to answering research Question 3, from section 1.3. The direct competition between the ISS partners (see Figure 7.3) will influence the established relationships among

themselves and with their customers.
Relationship 6: ISS Partners - the ISS partners will strive for market power and increased ISS products and services availability. The ISS partners will compete with each other by differences in price and ISS products and services that they will offer to customers. The ISS partners will create commercial policies designed to encourage easy and fast access to ISS products and services. Their business departments[12] will be under constant pressure to anticipate market demand changes, increase sales and generate income. The expectation of their own revenue generation could lead to cuts in public funding. These departments will then have to behave as private companies under the umbrella of non-profit organisations (e.g. ISS partners). Furthermore, it is possible that these departments target customers from their national economies and their business freedom[13] will be constrained. As the ISS markets start to develop, the ISS partners will have to provide a larger scale of ISS products and services. The lack of a business function will constrain the access to and acquisition of commercial customers.
Relationship I: ISS Partners and Customers - market and competitive forces, such as market demand for ISS products and services will drive the development of the future ISS commercial environment. The ISS markets (see section 2.4.1) will be unpredictable, uncertain and volatile and ISS opportunities will mostly be unknown to customers outside the space industry. Commercial customers could be reluctant to work directly with public organisations, as they fear bureaucracy, inflexibility and the slow provision of access to ISS products and services.
The ISS partners business departments will be under constant pressure to acquire customers, increase sales and generate revenues, but due to the lack of a business function access to customers will be difficult. The above conclusions show how the ISS partners can encourage or discourage ISS commercialisation and therefore, contribute to answering research Question 3.

7.5.3 Driving Forces - Step 3

The driving forces for this scenario are derived from the oligopoly theory in section B.2 and the important driving forces in the current ISS commercial environment in section 5.3.1. In this scenario, NASA and RSA have the strongest degree of competition, due to their manned transportation capabilities and their ability to meet current market demand for ISS products and services. The ISS partners (i.e. ESA, JAXA, CSA) with smaller ISS quotas will probably be exposed to competition between NASA and RSA. This will result

[12]The ISS partners business departments will need to have marketing and sales capabilities.
[13]For example in the European ISS commercialisation, customers from the member states of the ISS Exploitation Programme can be charged for ISS products and services, at promotional prices (e.g. lower prices).

in ISS prices, product and service changes and lead to the following consequences:

- NASA and RSA are dependent upon each other in setting competing prices for ISS products and services. They probably will create plans of action, based on price changes and on their belief as to which strategy their competitors will use. Due to this situation, their behaviour to companies can be characterised by the Game Theory[14]

- NASA and RSA choose commercial strategies, that will place them in a mutually inefficient outcome and set high ISS prices and thus, push away customers. In this situation they can find themselves in the Prisoners Dilemma

The above considerations will have to be investigated in the future once the ISS markets start to develop and the ISS partners commercialisation policies change, as a result of market development. There are two major consequences experienced by the ISS partners with smaller quotas (e.g. ESA, CSA and JAXA), as a result of competition between the ISS partners.

- The ISS partners (e.g. NASA and RSA) with transportation capabilities limit the provision of launch services and access to the ISS for commercial payloads of the ISS partners with smaller quotas

The lack of ISS products and services for customers could lead to ISS commercialisation failure for the agencies with smaller ISS quotas in the ISS program. For ESA, CSA and JAXA it would be important to set up clear rules with RSA and NASA to access the ISS.
Relationship I: ISS Partners and Customers - customers will have purchase power that could influence the prices of ISS products and services. For example, customers can request costly services (i.e. astronaut hours).
NASA and RSA as the agencies with the highest ISS quotas could be in situations similar to those described by the Game Theory and the Prisoners' Dilemma, as they have the power to constrain access to ISS products and services for commercial payloads of the ISS partners with smaller ISS quotas. All the ISS partners in this scenario will be exposed to competition and customers purchasing power. The above conclusions contribute to answering research Question 3.

7.5.4 Market Trends - Step 4

The absence of a business function in this scenario forces the ISS partners to develop the ISS markets. They have to deal with the uncertainty and complexity of these markets,

[14]Under the Game Theory NASA and RSA will set their strategies based on the change of the amount of ISS products and services they sell or the changes of the ISS price levels.

invest in customer acquisition and be exposed to strong competition from ground-based technologies[15]. There is a danger that the ISS markets (see Figure 4.3.4), remain underdeveloped, due to a lack of the ISS partners marketing and sales experience. The consequence might be failure of ISS commercialisation, due to the underdevelopment of the ISS markets. All the risks of commercialisation would be borne by the ISS partners and this could hinder ISS international cooperation for the finalisation of the ISS. Potential customers may at first perceive direct competition between the ISS partners in a favourable light, but the reality of this competition probably means that the ISS partners would carry the political and ISS market development risks (i.e. wrong market analysis, high prices) and strategic risks (i.e. failure of ISS cooperation). This competition may lead to a conflict of interest in the ISS markets between ISS partners, and to the break up of ISS cooperation, followed by the underdevelopment of ISS commercialisation. The ISS partners may face difficulties in achieving product differentiation of their ISS products and services, due to the similarity of ISS research objectives on board the ISS. There is a real danger that the only customers for ISS products and services will be space companies keen to gain additional contracts from the ISS partners. This situation will lead to the lack of self-sustainable ISS markets, and result in the potential failure of ISS commercialisation.
The only customers of ISS partners for this scenario could be space companies and disagreements between the ISS partners, can results in failure of international cooperation. Therefore, could be followed by the underdevelopment of ISS commercialisation. These conclusions contribute to answering research Question 5, from section 1.3.

7.5.5 Validation of Direct Competition Hypothesis - Step 5

The ISS partners may decide to offer direct access to ISS products and services and to compete with each other. As already discussed in section 6.3, the ISS partners are also implementing different ISS commercial policies (see section 4.3) and have differentiated ISS products and services (see section 2.3.4). Competition between the ISS partners may well endanger successful ISS commercialisation if there are disagreements between them. The analysis of the current ISS commercial environment, resulted in hypothesis (H3):

H3: Direct competition between the ISS partners, leads to non-cooperative oligopoly and subsequent underdevelopment of ISS commercialisation.

This hypothesis will be accepted or rejected by the following reasonings.:
Reasoning 1: The expected revenue generation of the ISS partners (see section 7.5.2),

[15]For example 10 years ago the growth of protein crystals was considered a major area in which microgravity conditions could contribute to the better growth of crystals. However, in recent years ground-based technologies can successfully grow similar protein crystals.

ISS products and services interdependency (see section 7.5.3) and the danger of the underdevelopment of ISS markets (see section 7.5.2), due to the ISS partners' lack of marketing and sales experience in the ISS markets.
Reasoning 2: The lack of a business function (see section 7.5.2) to access customers results in underdevelopment of ISS markets.
Reasoning 3: Competition between the ISS partners endangers their cooperation (see section 7.5.3) and result in the underdevelopment of ISS commercialisation, due to the reduced ISS products and services by NASA and RSA and the ISS partners exposure to political, business and strategic risks.
Reasoning 4: The competition between NASA and RSA results in agencies finding themselves in a Prisoners' Dilemma (see section 7.5.3) and therefore, undertaking actions that will be inefficient for both ISS partners and also constrain ISS commercialisation development.
Reasoning 5: Customer acquisition in R&D markets pose difficulties. Space companies could become the only customers, leading to the creation of a non-competitive environment (see section 7.5.3). A reminder of the example on the number collaborations in the biotechnology industry in section 5.4 can strengthen the reasoning, that without a business functions customers cannot be easily reached. Furthermore, the process of successful commercialisation of Russian space technology has been strongly supported by the number of its space industry collaborations as shown in section 4.2.
The acceptance of the above hypothesis, due to the above reasonings show that the ISS partners' direct competition in the future ISS commercial environment will result in the underdevelopment of ISS commercialisation. The above conclusions describe what can be the expected market and strategic developments in ISS commercialisation and therefore, address research Question 5. The validation of the above hypothesis shows how the ISS partners' commercialisation activities can discourage ISS commercialisation and therefore, answers research Question 3, from section 1.3.

7.6 Collusion Scenario

This scenario is built on the assumption that the ISS partners have allocated their ISS products and services to their business functions, that will sell the ISS products and services to customers. This scenario was encouraged by the analysis of oligopoly in the current ISS commercial environment in section 2.3.2 and the present business functions in section 4.4. The results from the analysis of this scenario will continue to address research Questions 3, 5 and 6.

7.6.1 Major Assumptions - Step 1

In the Collusion scenario, ISS partners sell their ISS products and services through the national business functions.

- The ISS partners allocate to the national business functions the exclusive rights to sell their ISS products and services
- The national business functions have to develop and attract commercial customers from the ISS markets
- The national business functions have to cope with ISS partners' interdependence and have to pay the ISS partners similar prices for their on board ISS products and services (see section 2.3.7). This ISS interdependence is similar to the one in observed in section 2.3.1
- This interdependence on ISS prices encourages business functions to collude with each other

National business functions could have similar interests in new ISS market development and will be careful not to compete with each other through price changes or advertising in the ISS markets. Figure 7.4, presents the collusion scenario.

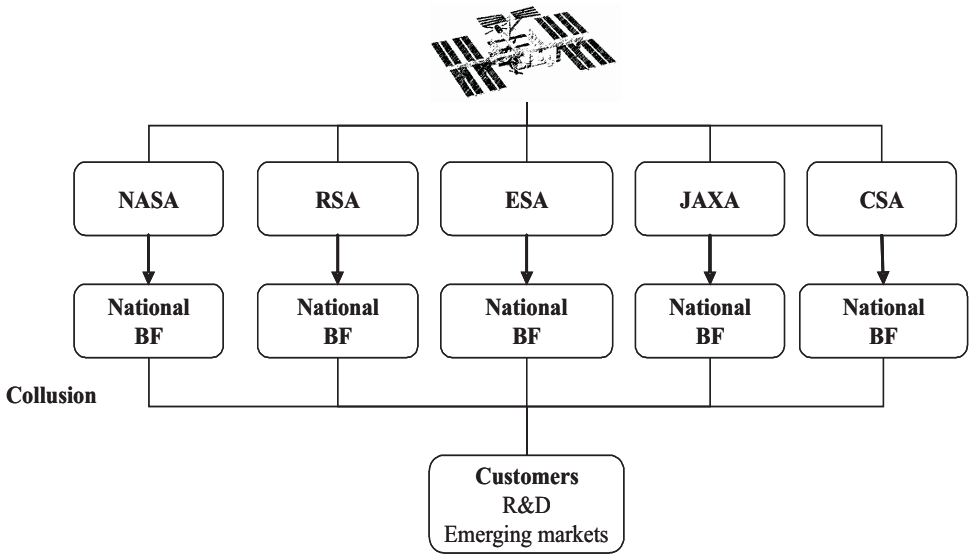

Figure 7.4: Collusion Scenario

In this scenario, as presented in Figure 7.4 there are five national business functions which sell similar or differentiated ISS products and services. The exclusivity rights of the national

business functions will result in high market entry barriers for new players wanting to sell ISS products and services. The future ISS commercial environment in this scenario will resemble a cooperative oligopoly and will stimulate national business functions to either form a cartel or behave as price takers or price setters under the price leadership theory. Both cartel and price leadership theories[16] will be considered in the analysis of this scenario, as theories of the collusive oligoppoly.

7.6.2 ISS Partners' Roles, Interests and Power Positions - Step 2

Collusion between national business functions will influence the ISS partners' relationship and their relationship with their commercial customers. As in the previous scenarios the analysis of the ISS partners roles will show whether they encourage or discourage ISS commercialisation and thus, answer research Question 3, from section 1.3.

Relationship 6: ISS Partners - the ISS partners not oppose collusion between national business functions, because it still allows the ISS partners to achieve their ISS commercialisation objectives (see section 4.3.1) and to generate revenues. By encouraging the creation of national business functions, the ISS partners would demonstrate to their national governments, they encourage national industrial competitiveness and create new market opportunities. The ISS partners may even harmonise their ISS commercialisation policies, to actually encourage collusion between their national business functions.

Relationship 1: ISS Partners and Business Function - because of the ISS partners interdependence, national business functions will have to pay similar ISS prices. As a result of the technological interdependence and common science objectives of the ISS partners, the business functions will sell their commercial customers similar ISS products and services in the ISS markets.

The ISS partners will not oppose collusion between their national business functions. They will encourage collusion and will harmonise their ISS commercialisation policies. These conclusions contribute to answering research Question 3.

7.6.3 Driving Forces - Step 3

The driving forces in this scenario are derived from the cooperative oligopoly theories in Appendix B, section B.2 and the driving forces in the current ISS commercial environment

[16] On the supply side of the current ISS commercial environment it was concluded in section 2.3.6 that cartel creation is unlikely, but the ISS partners could experience problems typical to cartel in ISS commercialisation, such as the lack of reliable market demand information or negotiation problems. In section 2.3.7 was concluded that the price leadership theory is the relevant one and RSA and NASA have the market power and ISS products and services to become price setters, while ESA, JAXA and CSA will become price takers in the current ISS commercial environment.

from section 5.3. The driving forces resulting from both cartel and price leadership theories will be considered in this scenario.
Relationship 6: ISS Partners - the ISS partners will be exposed to increased interdependence and political and strategic driving forces in their ISS commercialisation programmes will increase. The result will be similar pricing policies for ISS products and services and harmonisation of ISS commercialisation policies, as observed in section 2.3.7.
Environment 3: Business Function Environment - if the national business functions collude and decide to form a cartel to collect joint profits, they could create a market-sharing cartel or a joint profit maximisation cartel[17]. In both cases all five national business functions would sell their products and services without undercutting each other's prices. Through the creation of a cartel the national business functions would probably gain profits in a manner typically seen for a monopolist and this could result in price increases for ISS products and services. The national business functions could be exposed to similar driving forces as under the monopoly scenario in section 7.4, such as continuous changes in power between agencies and cost overruns.
The price leadership theory is also a theory of the cooperative oligopoly and is considered in this scenario. Under the Price Leadership Theory certain national business functions may become dominant price leaders and influence the prices of the other business functions. This ability to set prices will depend on market share and the ability to meet ISS market demand. For example, the Russian and American national business functions may be able to meet ISS market demand in the R&D markets and thus position themselves as price leaders. This will leave the European, Canadian and Japanese business functions to become price takers. Therefore, in both ISS markets there would be high market entry barriers caused by legal barriers, exclusivity rights and government policy.
The driving forces within a cartel are similar to those experienced to the monopoly scenario. In contrast under the price leadership theory, certain national business functions can become dominant price leaders, while others price takers. These conclusions contribute to answering research Question 5.

7.6.4 Market Trends - Step 4

The market trends discussed in this section are derived from the cartel theory in section 2.3.6 and the price leadership theory in section 2.3.7. The creation of a cartel based on quotas and agreed prices by the ISS partners will result in a scenario similar to the monopoly scenario in section 7.4. In the verification of the monopoly hypothesis (H1) in section 7.4.6, it was concluded that the creation of a monopolist in the ISS markets will

[17]Market-sharing cartel is when the dominant price leader sets common prices, while a joint profit maximisation cartel is when a central agency defines the prices in a cartel agreement. For a more detailed overview of the cartel profits see Appendix B, section B.2.1.

result in the underdevelopment of ISS commercialisation. For the validation of the hypothesis (H2) on cooperative oligopoly, the price leadership theory is used and not the cartel theory. In a cooperative oligopoly, national business functions could experience price undercutting and intensive advertising by the dominant price leader as it will have the market power to change prices in the future ISS markets. The ISS partners can also expose business functions to the risks of reduction of ISS products and services and ISS price changes, due to their own reduction of ISS products and services. National business functions can experience business risks similar to those of space companies that operate under oligopoly, such as market failure, incorrect market analysis (see Appendix C, section C.3.1), failure to anticipate competitors' actions, high prices and high market development costs. Unknown ISS customers are risks to which these national business functions would be exposed.
In the case of a cartel creation, ISS commercialisation would be underdeveloped, while under the price leadership theory price takers could be exposed to price undercutting and price changes from the price setters with market power in the ISS markets. These conclusions contribute to answering research Question 5.

7.6.5 Business Function Creation - Step 5

In this section the collusion scenario is compared with the selected "minimum conditions"[18] for the creation of a business function. These conditions will only be relevant only for the price leadership theory and not the cartel one, as already concluded in section 7.6.4. For this scenario the ISS partners will have strong political support from the ISS partners for providing exclusive rights to the business functions. The condition of encouraging a competitive environment is not met because ISS partners will encourage collusion as presented in section 7.6.1. However, the ISS partners will meet the conditions for *political approval* and *access provision to ISS products and services*, but not for implementing competitive policies. The condition of risk sharing and confidentiality will be met because the ISS partners share the risks of new ISS market development with the national business functions. The business functions, as private companies, could *attract investment* and create ISS self-sustainable markets. The business functions will share *risks and profits* and also share the risks also with the ISS partners. As a result of collusion, national business functions would be able to meet the conditions of *attracting start-up capital, gaining market position, attracting first-time customers, meeting market and customer requirements and having investment and risk sharing.*

[18]The "minimum conditions" for ISS partners are: 1) political approval, 2) access provision to ISS products and services, 3) commercial policy for a competitive environment, and 4) risk sharing and preserving confidentiality. The business function will have to meet the following "minimum conditions": 1) attract start-up capital, 2) gain market positioning and attract first-time customers, 3) meet market and customer requirements and 4) investment and risk sharing.

The minimum conditions in this scenario will enable the creation of a future business function. It will operate under a cooperative oligopoly under price leadership theory and become either a price taker or price setter. These two conclusions describe expected strategic developments in ISS commercialisation and thus, contribute to answering research Question 5.

7.6.6 Validation of Cooperative Oligopoly Hypothesis - Step 5

In this section is a validation of the cooperative oligopoly hypothesis from section 6.3. The technical, strategic and political interdependency of the ISS partners in the current ISS commercial environment, as analysed in section 2.3.1, may lead to the creation of a cooperative oligopoly in the future ISS commercial environment. To test whether cooperative oligopoly is the future ISS commercial environment, hypothesis (H2) is proposed.

H2: Political, strategic and technological interdependence of the ISS partners will lead to the creation of a cooperative oligopoly in the future ISS commercial environment.

The reasoning below supports the validation of the cooperative oligopoly. The hypothesis is validated through the use of the price leadership theory, the analysis of ISS products and services in section 2.3.4 and the analysis performed in this scenario.
Reasoning 1: The ISS partners' current and future interdependence will lead to the national business functions having similar costs for purchasing ISS products and services from the ISS partners (see section 7.6.2), due to the cooperative oligopoly in which they operate.
Reasoning 2: The Russian and American business functions will become dominant price leaders in the R&D markets, as they can meet market demand for ISS products and services (see section 7.6.3). They would have the market power to influence the price levels of the European, Japanese and Canadian national business functions.
Reasoning 3: The ISS partners services to customers are both homogenous and differentiated, similar to the ones in the oligopoly (see section 2.3.4).
It was concluded that a cooperative oligopoly in section 7.6.1 would be a relevant scenario for the future ISS commercial environment.
The accepted hypothesis shows that cooperative oligopoly is an appropriate market structure for the future ISS commercial environment because it meets most of the "minimum conditions" for the creation of a business function, as discussed in section 7.6.5. This market structure is the expected one for the future ISS commercial environment, because of the ISS partners political, technical and commercialisation interdependence. National business functions will operate in an environment with high market entry barriers and could become price takers for the ISS products and services.

The ISS partners will not oppose collusion between business functions. However, ISS partners have to oppose the creation of a cartel, as it will result in ISS commercialisation underdevelopment. The ISS partners interdependence in combination with the results from the above hypothesis show that the expected market in the future ISS commercial environment is a cooperative oligopoly and therefore, this result directly answers research Question 6.

7.7 Competition Scenario

In this scenario, it is assumed that the national business functions are in competition with each other for customers. This assumption is derived from the existence of oligopoly in the current ISS commercial environment, as discussed in section 2.6. This scenario is analysed by also using the five-step analysis from section 7.3 as in the previous scenarios. Similar to the other scenarios in this Chapter the results from the analysis of this scenario will contribute to answering research Questions 3, 5 and 6.

7.7.1 Major Assumptions - Step 1

The following assumptions are relevant for this scenario.

- Each ISS partner will allocate all its ISS products and services to one business function and give them exclusive rights to market their ISS products and services
- Each national business function will offer similar ISS products and services, due to ISS partners' interdependence
- The business functions will have the freedom to set prices for their products and services and sell it to the customers of their own choice

This scenario would have high market entry barriers for other companies wanting to sell ISS products and services. The ISS partners will deal with implementing commercial policies and have a more regulative role, similar to the one of the ISS partners in section 2.4.1. The ISS partners will sell ISS products and services at a certain price to the national business functions. These business functions will compete with each other, for product and price differences for similar services and for gaining markets and customers.
In this scenario, the national business functions would sell similar or differentiated ISS products and services, due to their interdependence previously discussed in section 2.3.1. The exclusive rights given to the national business functions will result in high market entry barriers for new companies wanting to sell ISS products and services. The assumptions in this scenario resemble a non-cooperative oligopoly.

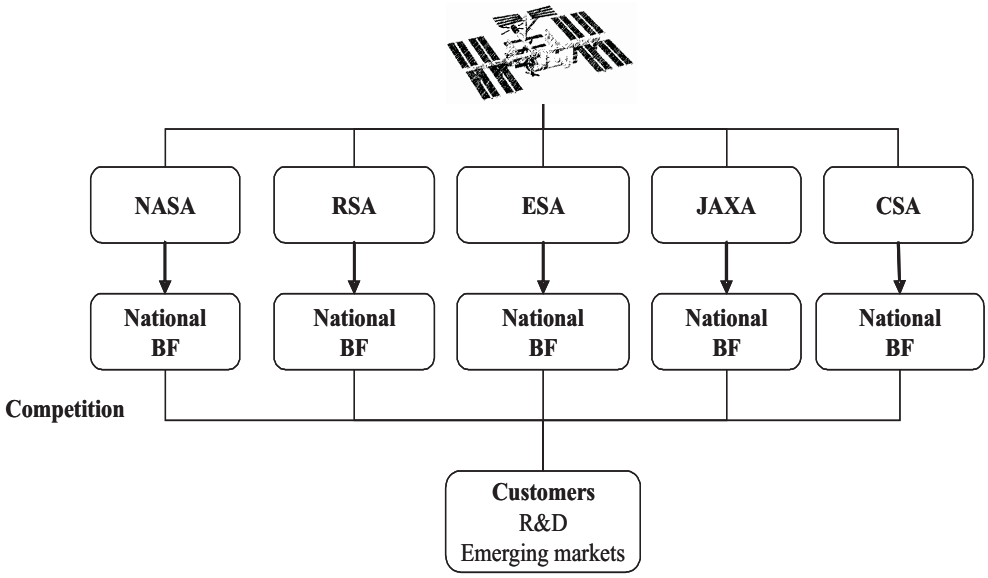

Figure 7.5: Competition Scenario

7.7.2 ISS Partners' Roles, Interests and Power Positions - Step 2

In this scenario the ISS partners will have different roles as analysed below. The description of the ISS partners' roles in this scenario will contribute to answer research Question 3, from section 1.3. The relationships investiagted below are presented in section 7.2, Figure 7.1.

Relationship 6: ISS Partners - ISS partners would establish commercial policies to stimulate the creation of a competitive environment in the future ISS commercial environment. These are commercial policies to encourage innovation and competition through ISS commercialisation and through the provision of exclusivity rights to the business functions and marketing rights to customers. The ISS partners would be required to terminate activities where they deal directly with commercial customers and their role will change into primarily an institutional management role[19].

Environment 3: Business Function Environment - the business function will develop the ISS markets, gain a market position and create a customer base. The business functions will aim at achieving profit maximisation and increased sales of their products and services. The national business functions activities are focused on developing new ISS markets and

[19]The ISS partners' institutional management role will require the ISS partners to encourage the creation of collaborations, implement policies for encouraging innovation and competition and protection of commercial property. Their "coordinating role", will include implementation of commercial policy, reducing regulation and withdrawal from ISS market development, as discussed in section 2.4.1.

creating a customer base. These conclusions contribute to answering research Question 3.

7.7.3 Driving Forces - Step 3

The driving forces for this scenario are derived from the oligopoly theories, from Appendix B, section B.2 and also from the analysis of the most important driving forces from section 5.3.1. In a non-cooperative oligopoly national business functions would be exposed to market and competitive driving forces. They would also be exposed to forces originating from the power of suppliers (i.e. ISS partners) and commercial customers. The national business functions could experience additional competition from new competitors. The national business functions would compete with each other on prices, product differentiation and will to bear the investments and risks of new ISS market development. National business functions will be exposed to market and competitive driving forces and these forces will influence the expected market developments in ISS commercialisation and thus, address research Question 5.

7.7.4 Market Trends - Step 4

As the markets enter the Frenzied stage of development and ISS partners' investments will reduce as discussed in section 2.4.1. A reduction of the ISS partners' investment will encourage the creation of a competitive environment and relaxed regulation. The national business functions would have various options to set their strategies under this scenario; because of the non-cooperative oligopoly in which they operate, the following strategies may arise:

- The creation of strategies for market penetration, based on the national business functions market strategies (Game Theory)
- The national business functions with most market power choose commercial strategies by setting prices. This leaves them in a situation that is inefficient both for them and for the competing national business functions (Prisoners Dilemma)[20]
- The Russian national business function could take advantage of lower labour costs, reduce their prices and the rest could follow. However, if it increased its ISS prices, the rest of the national business functions would probably not follow (Kinked Demand Theory)

Predictions cannot be made on which oligopoly theories (i.e. Game Theory, etc.) could be applicable for this scenario because the ISS markets are currently in an emerging stage

[20]For more information on the Game Theory, Prisoners Dilemma and the Kinked Demand Theory see Appendix B.

of development and so it is difficult to assess the market power of the different national business functions. All national business functions would have strong incentives to create ISS self-sustainable markets[21], resulting from their profit maximisation objectives. These conclusions contribute to answering research Question 5.

7.7.5 Business Function Creation - Step 5

In this scenario national business functions will market its ISS products and services and will compete with each other on the ISS markets. In this section the scenario is compared with the selected "minimum conditions" for the creation of a business function. The conditions of ISS partners *political approval and implementation of a competitive environment* will be met. The ISS partners would encourage the creation of a competitive environment for the development of ISS markets by implementing policies that encourage innovation and competition. In contrast to the cooperative oligopoly scenario, in which the ISS partners encourage collusion of the national business functions, the *risk and profit sharing* condition between the national collaborations and the ISS partners will be met. The national business functions could bear the business and economic risks while the ISS partners would bear the political and technological ones. By having profit maximisation the national business functions will have the opportunity to *attract private capital* and that they can invest in the development of new ISS markets. The national business functions would aim at developing ISS self-sustainable markets. Under the non-cooperative oligopoly, the minimum conditions for *attracting start-up capital and sharing investment by the national business functions would be met.* The market forces to which they are exposed could push them to be flexible and to meet market and customers needs. This scenario of a *non-cooperative oligopoly creates favourable conditions for the creation of national business functions.* This scenario is the desired one for the creation of a future business function, the strategic and market developments under this scenario address research Question 5. The ISS partners support the creation of a competitive environment for the ISS markets, thus encouraging competition between national business functions and thus also answering research Question 3.

7.8 Two-way ISS Access Scenario

This scenario is built on the assumption an ISS partner offers access to ISS products and services to commercial customers either directly or through a national business function.

[21]ISS Self-sustainable markets are markets that do not need the rely on public support for their development and supply and demand are dominating. Moreover, these markets, which will continue to develop after the end of the life-time of the ISS, will therefore be able to meet the needs of the future commercial customers for space-based technology, products and services.

This assumption results from the analysis of the Russian space collaboration strategy in section 4.4.3. The results from the analysis of this scenarios will contribute to answering research Questions 3, 5 and 6.

7.8.1 Major Assumptions - Step 1

In this scenario there is one hypothetical ISS partner, referred to as Agency C, offers direct access to ISS products and services for commercial customers. In parallel Agency C allocates commercial ISS products and services to a national business function for sale of ISS products and services to commercial customers, as presented in Figure 7.6.

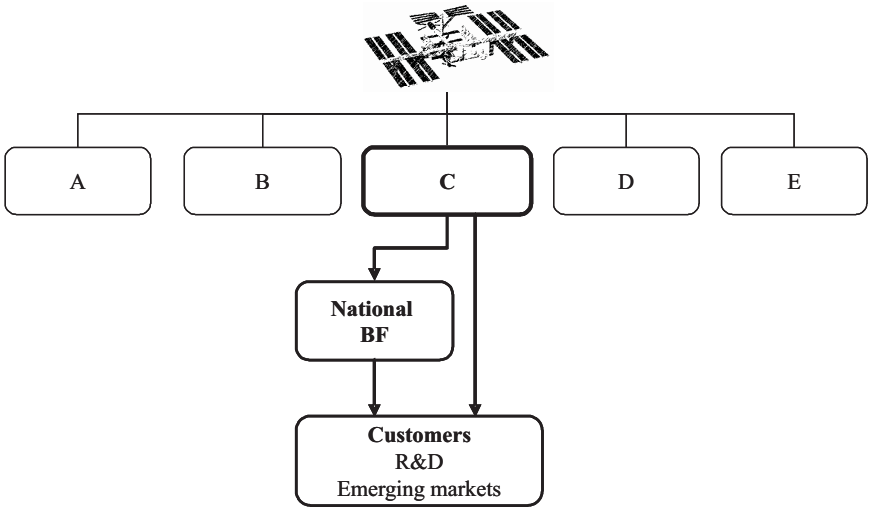

Figure 7.6: Two-way-ISS access Scenario

The Agency C agreement with a national business function would result in contracts "incompleteness" (see section 5.5.1). The national business function may be able to generate residual rights from the exploitation of ISS products and services.

7.8.2 ISS Partners' Roles, Interests and Power Positions - Step 2

Dual access to ISS products and services would influence Agency C and its relationship with the national business functions (see section 7.2, Figure 7.1).
Relationship 6: ISS Partners - the direct sales of ISS products and services to customers by Agency C prove to be controversial and an internal conflict of interest between its public and commercial activities could result. The business department of Agency C would be under constant pressure to generate sales and gain customers.

Relationship 1: ISS partners and Business Function - competition from Agency C means the national business function would have little incentive to develop ISS markets or to target customers for the ISS products and services specified in the contractual agreement. Potential commercial customers could be confused about accessing ISS products and services through Agency C or the business function.
Agency C will have a controversial role and national business function will have little incentive to develop ISS markets. Customers could be confused as to how to access ISS products and services. The role of Agency C here shows how ISS partners can discourage ISS commercialisation and addresses research Question 3, while the rest of the conclusions addresses research Question 5.

7.8.3 Driving Forces - Step 3

The risks and threats to which the agency would be exposed are similar to those observed in Competition scenario of section 7.7.3. Agency C will not only have to bear the political and strategic risks, but as Agency C would be to market ISS products and services directly to commercial customers it will therefore also be exposed to business and economic risks, such as incorrect market analysis, high prices, competition and inability to attract customers. The national business function would be exposed to competition from Agency C, as the ISS services and products they offer to commercial customers, could overlap with those of the national business functions. This competition between Agency C and the national business function could result in the failure of their agreement and endanger ISS commercialisation. Agency C could be exposed to different business risks, as a result of its direct dealings with customers.

7.8.4 Market Trends - Step 4

Competition between Agency C and the national business function may potentially result in conflict if Agency C targets the same markets as the national business functions. Agency C can be accused of using public money for generating revenue. Threats similar to those to which the ISS partners are exposed in the current ISS commercial environment as observed in section 5.3 would exist for Agency C if it undertakes direct commercialisation. A lack of clear roles and responsibilities between Agency C and the national business function could result in commercialisation failure.

7.8.5 Business Function Creation - Step 5

This scenario is compared with the selected "minimum conditions" for the creation of a business function. For Agency C, the conditions of *political approval and access provision*

to ISS products and services would be met. The *investment and risk sharing conditions* could be met among the founders of the national business functions. The condition of a *competitive environment* would not be met under this scenario, because this condition is only met when the ISS partners create conditions in which different national business functions could compete with each other and not with agencies. Agency C could provide the conditions for creating a business function, but the national business function can run into difficulties in *attracting investment* from investors who can find out that the national business function is in direct competition with a space agency. The national business function would have no incentive to *attract first-time customers* and create ISS self-sustainable markets. The national business function would be more capable of meeting market and customer needs than Agency C. However, direct competition from Agency C may not give the national business function the flexibility to fully develop the ISS markets. This scenario is likely to result in a hostile environment for the creation of a business function and the minimum conditions for creation of a business function under this scenario would not be met. This scenario describes an environment in which an ISS partner can discourage the successful development of ISS commercialisation and therefore, also answers research Question 3.
Two-way access for ISS products and services for customers will lead to underdevelopment of ISS commercialisation and the creation of a successful business function under this scenario is unlikely. The results of this scenario also describe market and strategic developments which will constrain ISS commercialisation and thus, address research Question 5.

7.9 ISS commercialisation and Regulation

In this section there is a discussion of the role of regulation in the future ISS commercial environment, therefore continuing to address Question 3:*How will ISS partners' commercial activities encourage or discourage ISS commercialisation?*. The analysis of the ISS market evolution in section 2.4.1, showed that the ISS partners will have a regulative role once the ISS markets develop. ISS partners' regulation will be relevant when the ISS markets develop under a cooperative oligopoly and various commercial projects are implemented by the ISS partners.
As analysed by [124] the securing of legal interests in both national and international law will be a precondition for companies' increased participation in commercialisation. ISS partners will be involved in the creation of their national regulation in various areas, such as proposed by [124]:

- liability for damage caused by space objects involving private entities
- space insurance law

- intellectual (i.e. right of invention) and industrial property law

The ISS partners as the owners of the space station and as those who decide what and how the ISS products and services will be allocated. Also they can become liable for the consequences of commercial projects to the public. In order to prevent becoming liable for this, the ISS partners could become involved in defining national regulations in these aspects. Furthermore, the aspects of space insurance law and the use of IPR rights for commercial customers will become important. Offering IPR rights to customers for commercial projects, such ESA IPR policy could lead to the ISS partners offering a competitive advantage to customer products and processes. The regulative role of ISS partners under a cooperative oligopoly will be to define national regulation in areas of liability of commercial projects, space insurance and IPR rights, the latter offering competitive advantage to customers. This shows how the ISS partners can encourage ISS commercialisation and addresses Question 3.

7.10 Results and Conclusion

The analysis of future ISS scenarios contributes to conclusions for future strategic and market developments and to to answering research Questions 3, 5 and 6. Research Question 3: *How will ISS partners' commercial activities encourage or discourage ISS commercialisation?* is addressed in the description of the ISS partners roles in Step 2 and through the hypotheses validation (H1, H2 and H3). The ISS partners' policies for encouraging competition, innovation and protection of commercial exploitation in the selected ISS future scenarios in section 7.6 of cooperative oligopoly in section 7.7, show ways the ISS partners can encourage ISS commercialisation. The regulative role of ISS partners under a cooperative oligopoly will be to participate in the definition of national regulations in the areas of liability of commercial projects, space insurance and IPR rights. Monopoly, direct competition or two-way access scenarios, show how the ISS partners can discourage ISS commercialisation. Research Question 5: *What are the expected future market and strategic developments in ISS commercialisation?* is addressed by the selected market structure for the future ISS commercial environment. Cooperative oligopoly is the expected market development in the future ISS commercial environment. Therefore, high market entry barriers, business function similar prices for their products and services and ISS partners encouraging collusion are some of the expected strategic and market developments. Price leadership theory is relevant for the future ISS commercial environment, as cartel creation will result in underdevelopment of ISS commercialisation. Business functions can become either price takers or price setters.
The answer of research Question 6: *Within what type of markets would a future collaboration model operate?* show that the market structure of the future ISS commercial environment

is an oligopoly market structure. As a result of the expected ISS partners technical, political and commercialisation interdependence cooperative oligopoly is the expected market under which a business function will operate in. However, the most favourable conditions for creation of a business function and most desirable is non-cooperative oligopoly.

Chapter 8

Business Function

8.1 Introduction

This Chapter presents a proposal for the development and implementation of a future business function. The findings in this Chapter will directly address research Question 7, from section 1.3:

- What are the necessary steps for the development and implementation of a future collaboration? - Question 7

The business function structure overview starts with the presentation of its objectives and activities, followed by an analysis of its targeted markets in section 8.3. The results of the market analysis will then be used for the identification of the business function's products and services in section 8.4. The business function will pass through two phases of development; preparation and implementation, as concluded from section 5.5.2. In this Chapter is also a description of the necessary resources and founders in section 8.6, necessary for achieving the business functions' activities. Finally an analysis is made of the potential risks to which a business function will be exposed in the future ISS commercial environment in section 8.8. The results of this Chapter will support the selection of a collaboration for a future business function under different market demand conditions in Chapter 9.

8.2 Objectives and Activities

This section presents the objectives and activities of a future business function. Initial recommendations for the business functions' objective definition was made in section 5.5.2:
To provide, through space, technology commercialisation and space research (knowledge), value-based products and services for ground-based industries
The above objective will permit the future business function to sell space-based products

and services, even after the end of the ISS. The main objective of the business functions can be extended to the following secondary objectives:

1. marketing and selling ISS products and services to non-space industries

2. attracting customers for the ISS markets

3. define and offer commercial customers a competitive advantage from their use of space-based technology and research

4. support customers in increasing their profits and expanding their own markets, through space-based technology and knowledge

5. support customers in the implementation of their ISS commercial projects

The above objectives are divided into marketing, sales, consulting, publishing, project and networking activities. The marketing and sales activities support the first two secondary objectives. The consulting activities will support the third secondary objective. The customer support activities will support both the third and the fourth secondary objectives and project management activities will support the fifth secondary objective of the future business function.

- The **marketing and sales activities** will require the business function to develop and access ISS markets (i.e. R&D and emerging markets). The business function should build awareness among potential customers to encourage the creation of market demand for ISS products and services and will have to perform business development activities, in order to attract customers. As recommended in section 2.3.4 the future business function will have to define and develop a flexible portfolio of ISS products and services, because of the current lack of an attractive ISS portfolio of products and services

- The **consulting activities** of the business function will support its customers in the identification of the benefits, such as property and marketing rights, that customers can derive from the use of ISS products and services. The consulting service could also include the provision of access to potential investors for projects that need financing

- The **customer support activities** aim at the creation of a user-friendly environment. As recommended in section 4.3.3, the business function will provide consulting support to potential customers for commercial proposals and business plan preparation. By integrating customer requirements, the business function could support

customers in improving the products and process in their own markets[1] by using space-based technology

- The **project and network activities** supports the development of projects in educational and space health programmes. The business function activities will include the creation of networks between space and non-space companies, industry associations and marketing and sales organisations

The business function will have a strong marketing, sales and business development role in ISS commercialisation.

8.3 Market Analysis

In this section is a market analysis of the future business function targeted markets. The result of this analysis will support the identification of the business function products and services. The targeted markets for the business function are divided into two main categories, **R&D** and **Emerging markets**, similar to the ESA targeted markets in section 4.3.4. The targeted markets presented in Figure 8.1 are complementary to ESA's markets, as recommended in section 4.3.4. The classification of the targeted markets is based on discussions with space experts[2] combined with the experience of the author in undertaking market analyses for ESA CPO on the R&D markets. Figure 8.1, presents an overview of primary and secondary R&D markets, emerging markets and industrial applications. The primary market segments describe the targeted industry sectors, while the secondary sectors present the specific markets under the industry sector that could benefit from research on board the ISS. The industrial applications present possible examples of utilisation of the ISS products and services by non-space industries. Figure 8.1 illustrates the future business function targeted markets.
The business function could target customers from industries (see section 4.3.4) in which technology innovation, IPR and industry growth are common features. In the **R&D markets**, the *biotechnology industry* customers come from the related food, chemical and pharmaceutical industries. The space environment can support biotech companies in the faster selection or rejection of drug candidates for new medicines or in the design of bioreactors

[1]Certain companies, such medical equipment producers could be interested in testing and improving their technology on board the ISS. Therefore, through technology demonstration on board the ISS they could be able not only to test, but also to improve the quality of their equipment and sell their products as "space-proven".

[2]ESA space experts are the Head of the Commercial Promotion Office (CPO) and engineers from the Cost engineering division, are top European scientists responsible for European multi-disciplinary teams, performing space research on board the ISS, under the Microgravity Application Programme (MAP). Also are the Head of Economic development for an European space industry association.

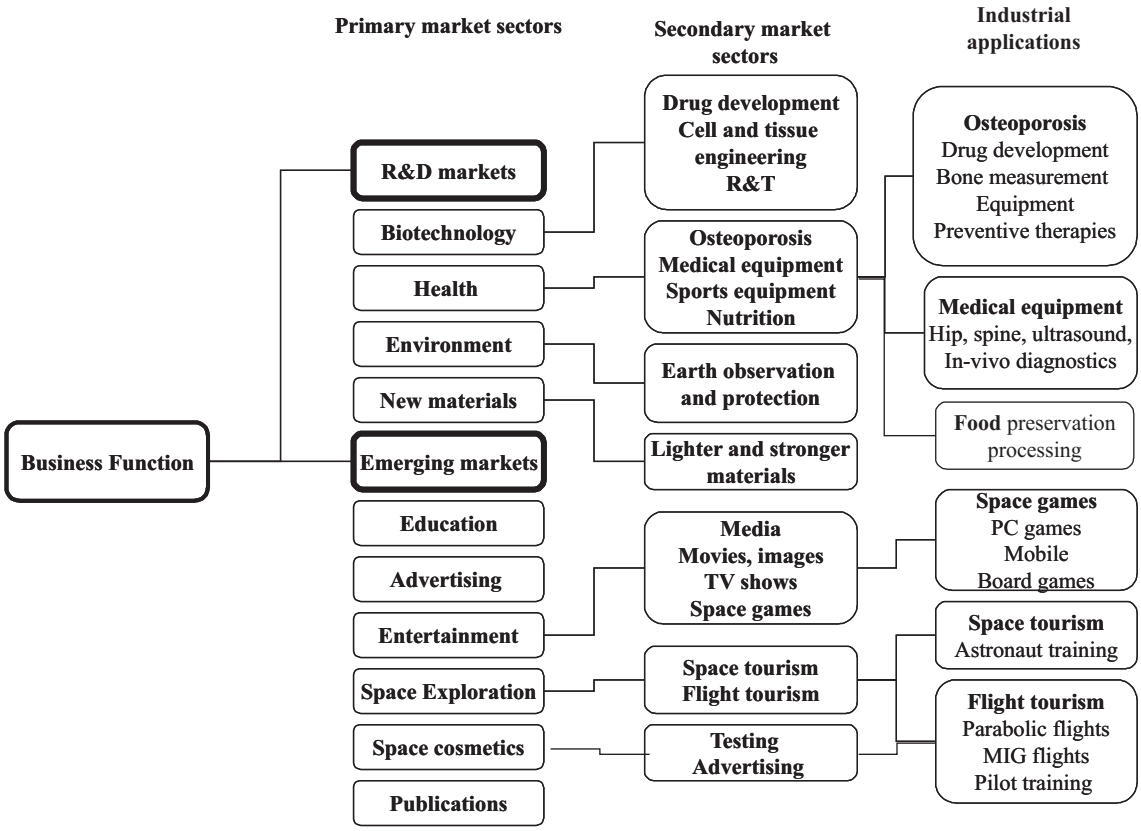

Figure 8.1: Business Function Targeted Markets

for tissue and cell engineering[3]. The drug development process takes on average 15 years with an investment of $800 million [25], but space environment can contribute to the faster selection of drug candidates in the initial phases of drug development. In the *food industry* the business function can aim at implementing a project for food processing, preservation and nutrition. As already discussed in section 4.3.4 the osteoporosis research and medical equipment (Figure 8.1) and be beneficial for pharmaceutical and nutrition companies. In the area of osteoporosis[4], biopharmaceutical companies might aim at drug development for osteoporosis and therapies for prevention, as this disease costs national EU treasuries over €4.8 billion annually in hospital care [48]. The European osteoporosis market was

[3]In the area of cell and tissue engineering these experiments could result in growth of organo-typical materials for artificial organs, and biotech companies can use space research for the design of bioreactors for mimicking organo-typical conditions, leading to the development of artificial organs [68].

[4]By observing the physiological changes experienced on astronauts bodies as a result of microgravity. Microgravity affects various systems of human physiology: cardiovascular, respiratory, nervous systems, human sensory and balance systems, bone mass loss, muscle atrophy, metabolism, hormonal patterns and body posture [105].

valued at $1.09 billion in 2000, with a positive growth rate and expectation of reaching $1.86 billion in 2007 [46]. In this market, the future business function could also target medical equipment manufacturers for developing bone density measurement equipment or ultrasound measuring equipment for hip and spine. The medical device sales worldwide correspond to € 154 billion [45] and medical equipment producers could gain benefits from technology and process innovation during development, improvement and testing of their equipment on board the ISS.

In the *environmental sector*, the ISS could provide earth observation services for monitoring erosion, forests (e.g. deforestation), seas and even volcano eruptions, such as the eruption of Etna, documented by Frank de Winne during the Odissea Mission in 2001. The industrial applications of earth observation could support companies interested in urban mapping, crop control or providing harvest insurance.

For the *new material* markets, the space environment allows for more precise measurements of thermo-physical properties than are available on Earth. Particle reinforced composites and metal/matrix composites for reduced weight for cars and airframes, are possible, leading to the introduction of lighter, higher strength material offering a wide range of industrial applications of interest for automobile and aerospace industries [87].

The **Emerging markets** include space exploration, education, advertising, entertainment, cosmetics and publications. The *space exploration market* can be divided into space and flight tourism. Space tourism covers the section under which space tourists visit the ISS (see section 4.3.4) and when citizens undergo astronaut training. Companies, such as Space Adventures have been offering trips to the ISS or astronaut training for its customers. Space tourism is considered to be the market with the highest potential for development and it is predicted that space tourism will generate $100 billion a year by 2030 [90]. Therefore, the future business function could establish strong networks with companies such as Space Adventures and Virgin Galactic, to sell their on-board SpaceShipOne flights to European customers.

The *flight tourism* secondary market includes zero-g flights, MIG fighter flights and pilot training. Private companies already offer the zero-g flights and MIG flights, with prices ranging from $6,995 to $8,995 [3]. For the time being these prices are targeted at a small number of rich customers or space enthusiasts. The business function could explore the opportunity of reducing these prices by offering zero-g flights in small business jets at lower prices. For this purpose, the business function could establish networks with universities or flying schools that could provide these services.

In the *education market* the future business function can contribute to the preparation of education programmes, space books and interviews with astronauts on board the ISS.

In the area of *advertising* the business function can support the creation of advertisements of different products, relating them to space exploration and life on board the ISS. For example, the Givenchy perfume advert uses ESA astronaut suits.

The advertisment market could be related with the entertainment market and the business function could target movie companies and TV producers for the use of ISS images in movies and TV shows. The business function could also target the space games markets and and encourage the creation of space games, with the use of ISS images. Furthermore, the business function could also target telecom companies and the use of mobile phones receiving SMS messages from space. If there is strong market demand, the business function could also collaborate with companies creating ISS based board games. NASA experience in the creation of Lego prototypes of the space shuttle and Mars Landers (i.e. Spirit and Opportunity), may lead to an attractive market for the business function.
The *space cosmetics market* is seldom mentioned, but it will be targeted by the business function. The development of space cosmetics could be beneficial for the cosmetics companies, who can market their products as "space-proven". For example, the creation of cosmetic products for personal hygiene may be beneficial for the astronauts on board the space station. This market segment could be related to the Russian and US experience in developing an "integrated hygienic set" [109]. The cosmetic companies can test their products in space and research the properties of materials. Cosmetic companies are known for their huge investment in R&D treatments. A good example is L'Oreal's research in the European Synchrotron Radiation Facility (ESFR) on the use of X-ray beams for hair growth in vitro [32] to develop hair growth treatments[5]. Cosmetic companies can benefit from research on board the ISS and also from the use of ISS images or marketing rights in the case of having space-proven products[6].
The business function can pursue a marketing and sales strategy that focuses on different from the ISS partners markets, such as flight entertainment, space cosmetics and advertising ones. The business function can offer to its customers combined solutions from space research, ISS technology demonstration and ISS images and brand use. The description of business function targeted markets not only define its products and services and but also contribute to defining the necessary steps for its implementation and thus, address research Question 7.

8.4 Business Functions Products and Services

The business function objectives and activities from section 8.2, define its products and services and support the identification of the resources required for the implementation of the future business function. The definition of [94] will be used for the identification of the business function products and services. A business function products could be

[5]X-ray analysis can, for example, provide in-depth information about beauty creams, hair products and lipsticks [33]

[6]For example cosmetic companies could test a space mascara on a female astronaut and then market it as a space-proven product that is even able to work under microgravity conditions.

anything offered to the customers (i.e. R&D, emerging) for attention, acquisition, use or consumption (i.e. tangible), which will satisfy the demand of a commercial customer. The business functions' service is an activity or benefit offered to its commercial customers which is intangible and does not result in ownership. The classification of the business functions products and services, will be based on its activities from section 8.2. The business functions' products and services are classified as: marketing and sales, customer support, consulting, project and network, based on the business functions objectives and activities from section 8.2. Furthermore, for their classification the analysis of the ESA commercial projects selection in section 4.3.3 is taken as an example. As ESA has a transparent overview of the criteria for commercial project selection. The business function products and services will be divided in a similar way to those of ESA in **pre-mission, mission** and **post-mission**, as presented in Figure 8.2. This division is similar, because the business function will support customers in commercial proposals and business plans preparation (i.e. customer support activities), as already observed in section 8.2. For pre-mission services, the business function would support the customers in commercial proposals and businesses plan preparation and ensure that the commercial proposals meets ESA business, ethical and technical criteria. The services during mission would be the definition and evaluation of the necessary documentation for the successful implementation of commercial payloads. This would be followed by post-mission services, such as identifying the benefits for customers from IPR, marketing or sponsorship rights of their commercial payloads. Figure 8.2, shows the business function products and services in the context of the ESA Commercial projects implementation.

Marketing and sales services for selling ISS products and services to customers from the R&D and emerging markets. Furthermore, the business function could aim at developing space images, games and advertisements and support customers in the promotion of their commercial projects. Customers from the emerging markets could request the business function to arrange access to the ESA Erasmus User Centre to view a mock-up of the Columbus module. The future business function could sell space images and actively participate in the creation of space games for PC or board games.

For the *Customer support products and services* of the business function as products it can offer commercial proposals and business plans to its customers. As services[7] it can prepare the commercial proposals and business plans for commercial customers willing to qualify for ESA ISS promotion support (see section 4.3.3). The business function could verify whether the business plans will meet ESA selection criteria[8].

[7]For commercial proposal preparation information will be necessary for project description of background, objectives and structure. For business plan description the business function can support its customers in company description, financial status & organisation - structure, markets and businesses, customers and financial situation preparation.

[8]ESA's criteria for assessment of the commercial business plans are the following: competitive advantage

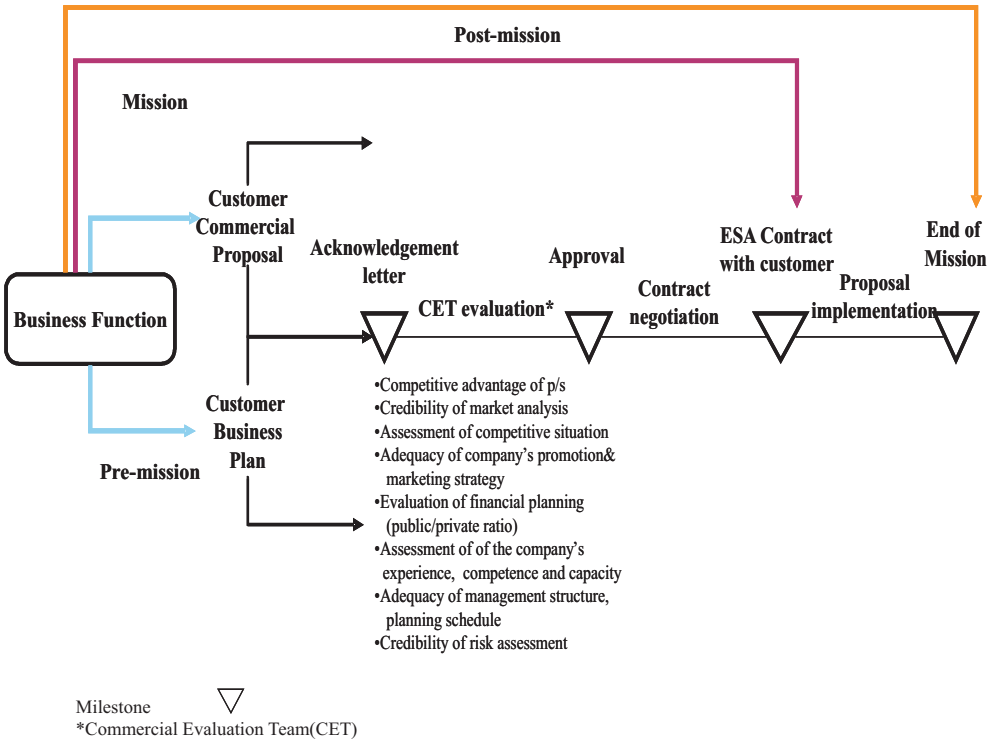

Figure 8.2: Business Function Products and Services and ESA Commercial Projects Implementation

In *customer support products and services* a business function could offer customers the opportunity to witness manned launches to the ISS and unmanned Ariane 5 launches, which could be combined with tours around the space centres, such as the French Guyana launch pad and offer opportunities for viewing launches.
In *Consulting services support* the business function will support its customers' in the description and provision of the necessary documents for the the preparation of their space payloads: payload mission statement (Phase 0/A), payload mission architecture (Phase B), detailed design (Phase C), testing and qualification (Phase D), utilisation (Phase E) and disposal (Phase F).
The mission and the post mission products and services will be quite different. Due to the few and very diverse projects[9] on emerging markets, common assumptions on the business

of products or services, credibility of the market analysis, assessment of competitive situation, adequacy of companies promotion & marketing strategy, evaluation of financial planning (public/private ratio, assessment of the companies experience, competence and capacity, adequacy of management structure, planning schedule and credibility of risk assessment [87].

[9]Until 2004, only RSA has had a few projects from the emerging market segment , such as placing a Pizza Hut logo on a Proton launcher and launching space tourists to the ISS. Meanwhile, ESA has implemented proposals for commercial payload projects, such as the Blood Measurement Instrument (BMI), Mediet

function products services could hardly be made. This is the reason for describing just a few products and services of the business function for these markets.
Commercial proposals and business plans preparation and consulting services for the technical documentation for customers' commercial payloads, are the core business functions' products and services.

8.5 Resources and Competencies

In this section is an initial identification of the required business function resources, based on the business function products and services identified in section 8.4. In order to be able to identify the business function resources and competencies will be classified in a similar way to those of ESA ISS products and services in section 4.3.5. As ESA presents a transparent overview of its ISS products and services. An estimate of the required resources for a business function is difficult, due to the emerging nature of the ISS markets and in the absence of information on the market demand for ISS products and services. It is however possible to present an overview of the basic resources and competencies[10] required for the creation of a future business function. The *technical resources and competencies* for the business function include the use of ISS facilities and can represent 30% of the European ISS products and services. The future business function could also offer access to short-term microgravity flights, such as drop towers, parabolic flights, sound rockets and Foton capsules. *Marketing and sales resources and competencies* include business development competencies, customer acquisition resources and marketing and sales competencies. The business function will need the resources to perform market analysis, target customers and develop a marketing mix[11]. The *customer support and management resources* will include those needed by the business function to support its customer in the preparation of commercial proposal and business plans (see section 4.3.3). The *management resources and competencies* will include funding resources, such as start-up capital[12], venture capital, private equity capital, loans and grants. This will be essential for the creation and implementation of a business function. The business function will need access to financial and project management resources and competencies in order to support its customers in setting up funding schemes of certain commercial projects. The business function will need resources for commercial project management that will successfully support the im-

and others.

[10]Competencies represent the knowledge and capabilities of the business function, such as marketing and sales competencies or business development ones.

[11]Marketing mix is a set of marketing tools,that supports a company in defining its products, prices, promotion and placement strategies. Companies use a marketing mix to pursue its marketing objectives in a targeted market.

[12]Start-up capital is one of the "minimum conditions", as earlier discussed in section 5.3.3.

plementation of customer projects. Consulting resources in the areas of business, technical, scientific and business strategy for non-space customers will also be required, but their allocation will depend on the market demand for the business function products and services. The overview of the necessary business function resources and competencies will facilitate the identification of potential business function founders and execution partners and directly contribute answer research Question 7.

8.6 Business Function Founders and Execution Partners

This section proposes potential founders and execution partners for a future business function. The results from this section directly contribute to answering research Question 7 and will also be considered in the selection of a collaboration for a business function in Chapter 9. Founders are the creators and the owners of the business function, while execution partners perform certain activities for the business function. Companies with marketing and sales experience have to be attracted as founders, in order to achieve the business function's objectives (see section 8.2). Section 5.5.1 provided initial recommendations on attracting founders and execution partners who will supply unique, but complementary resources and competencies to the ISS products and services. The founders and execution partners will have to be identified during the business function preparation phase (see section 8.7), but as the business function becomes operational, the initially selected execution partners will probably change depending on the market demand for certain types of ISS products and services. The founders will select the type of execution partners depending on market development of either the emerging or the R&D markets. Therefore, at present the description of the type of execution partners is not possible. The proposed future founders will allocate the necessary resources available for the business function's operations and the market demand for ISS products and services. Hereby, are initial recommendations on the profiles of these founders:

- ISS partners - the role of an ISS partner will be to provide access to ISS products and services and ground-based testing facilities
- Marketing and sales organisations - the role of these organisations will be to provide access to non-space customers from the targeted markets of biotechnology and health markets. These could also be advertising, media or consulting companies that will allocate marketing, sales and business development resources and competencies. Consulting companies could provide business plan and commercial proposal preparation competencies, while advertising and media companies could provide promotion and communication competencies for both the R&D and the emerging markets

- Industrial associations - will provide customer and network access. These associations could be from the biotechnology, health or food industries or in general from the business function R&D and Emerging markets (see section 8.3)

- Investors - their role will be to provide funding for the business function could be from venture capitalists, banks, corporate investors, insurance companies and non-financial corporations.

- Small Medium Enterprises (SME)- will provide scientific, technical and project management competencies to the commercial projects of the business function

- Non-profit organisations - roles will be to identify whether certain commercial projects could be beneficial to the public. These could be environmental or health organisations or foundations

The selection of certain business function founders and execution partners will be based on the needs of the future business function under the high, medium and low market demand for ISS products and services in Chapter 9. For example, in the case of high demand for ISS products and services in the R&D markets, the future founders will need to offer technical services to its commercial customers. In this scenario, the founders will be science and technology organisations, such as research institutes, universities or engineering companies. Each business function founder will have ownership rights in the business function in the form of shares, such as ordinary or preferential shares[13], thus providing strong incentives to participate in a future business function.
As the ISS markets develop, the founders will change depending on the market demand conditions.

8.7 Business Function Preparation

In this section is an overview of the aspects which the future business function founders and execution partners will need to address during the business functions' preparation and therefore, the results of this section will directly contribute to answering research Question 7, from section 1.3. Earlier analysis in section 5.5.2 proposed two phases of a business functions' development; **preparation** and **implementation**.
In the **preparation phase** the founders will have to identify the business case, as well as their needs, objectives, functions, activities, resource and investment allocation. During the business function **implementation phase** the founders will have to deal with negotiations,

[13]Shares could be preferential or ordinary shares. The owners of preferential shares have the right to receive their dividends first, but not to vote, while ordinary shares give the right to vote, but are last to receive dividends.

governance and management, as recommended in section 5.5.2. In the same section it was concluded that the implementation phase is not going to be considered in this analysis, because the business function is not yet established. The business function founders will have to address the following questions in the preparation phase:

- Objectives and activities - each founder of a business function will have to clearly identify the objectives and activities they would like to achieve through a potential business function, by answering the following questions: What are the strategic objectives to be achieved through a business function? What will be the business functions' range of activities? What are the reasons for becoming a business function founder? What is the business model of the business function? What is the collaboration (i.e. PPP, strategic alliances) that will be best for the business functions' activities?

- Identify the founders and execution partners - the choice of the right founders and execution partners is an essential prerequisite for the successful operations of a business function. The following questions can be considered by business function founders and execution partners: Who are the preferred founders or execution partners for the future business function? What will be the founders' and execution partners functions in the collaboration? Who will be the execution partners?

- Strategy identification, resources and business activities - each founder will have to identify the activities (see section 8.2) and resources (see section 8.5), to be allocated to a business function. To set up the business functions' strategy, the founders and execution partners will have to address following questions: What type of resources (i.e. financial, marketing, sales) will the potential founders and execution partners have to allocate? What ISS products and services will a space agency make available? What type of collaboration model for the business function will be most appropriate for achieving the business function objectives? Which business, marketing and competitive strategies will be implemented by the founders and execution partners to ensure success?

- The allocation of investments and ownership resources by the founders or execution partner is significant for the successful funding and operations of the business function. The following questions should be asked: How will the future business function be funded? What is the financial commitment of each founder? What are the funding approaches for a business function? What is the expected Rate of Return for a business function? What are the minimum requirements for business function capital investment, current financing and additional investments? What are the ownership rights in the business function for each founder? Under which legal form and legal

system will the business function be registered? What type of shares can the founders have in a business function?

Some of the planned present business functions, such as JAXA's ISS Business Forum from section 4.4.2 could use the above preparation question and address the above aspects in its actual implementation. The above issues will need to be carefully considered by potential business function founders and execution partners during the preparation phase.

8.8 Business Functions' Risks

The analysis of the current and future ISS commercial environment showed the existence of risks that will influence the successful development of the business function.

- Business Risks - faulty sales forecasts, poor marketing surveys and failure to anticipate competition can be hidden risks (see Appendix C, section C.3) that will need to be considered by the business function. More obvious risks include the ISS cost overruns, as this will probably lead to reduced ISS products and services and capabilities.
- Market Risks - the ISS markets are underdeveloped and there is high uncertainty associated with unknown markets, as observed in see section 2.4.1. The current lack of customer interest could be additional risks the business function will face in the process of acquiring new customers. The business function has to face high market entry barriers in a cooperative oligopoly and become a price taker as concluded in section 7.10.
- Economic Risks - global economy slowdown and the creation of a monopoly company in the future ISS commercial environment as observed in section 7.4 will influence the activities of a future business function.
- Technological and Resource Risks - risks of launch failure and loss of human life and payloads. ISS products and services cancelation and reduction will have a direct impact on the business functions' activities.
- Political Risks - the danger of break-up of the ISS partners international cooperation for the ISS due to ISS partners disagreements on cutbacks or competition, similar to the competition scenario in section 7.5, will influence the future business function.

In order to mitigate the above risks, the operational criteria from section 5.6 can be used by the future business function founder for monitoring the performance of the business function.
The future business function will have to perform a risk analysis and take into consideration the business, market, economic, technological, resource and political risks.

8.9 Results and Conclusions

The description of the future business function in this Chapter contributes to answering research Question 7, from section 1.3; *What are the necessary steps for the development and implementation of a future collaboration ?*. To answer this question the following elements were analysed: objectives, activities, markets, products, services resources, founders and risks. The prime objective for the future business function is to provide commercial, research, technical and value-based products and services through space commercialisation for ground-based technologies. The business function activities describe strong marketing, sales and business development activities and will change once it is operational. The business function can pursue a marketing and sales strategy that focuses on different activities from the ISS partners markets, such as flight entertainment, space cosmetics and advertising ones. Thus, it can offer its customers combined solutions from space research, ISS technology demonstration and ISS images use. Commercial proposal, business plans preparation and consulting services for the technical documentation for customers' commercial payloads, are some the business functions' products and services.
Ownership rights allocation by founders, as discussed in section 8.6 gives them an incentive to allocate resources to the business function and mitigate ownership and negotiation risks. Possible business function founders can be ISS partners, marketing and sales organisations, industrial associations, investors and non-profit organisations. The questions from section 8.7, can be considered by the potential business function founders and also the planned present business functions (i.e. NGI, JAXA ISS Business Forum). The future business function has to take into consideration the business, market, economic, technological, resource and political risks. This business function proposal addresses research Question 7 and supports the selection of a collaboration in Chapter 9.

Chapter 9

ISS Market Demand Scenarios and Future Business Function

9.1 Introduction

The successful development of ISS commercialisation will depend on the market demand for the ISS products and services, as concluded in earlier Chapters. The objective of this Chapter is to select a collaboration for a future business function and thus, contribute to achieving the first objective from section 1.3.

- What type of future collaboration could be proposed between space agencies and private companies? - Question 8

To answer this question, as already discussed in section 6.4 is an analysis of three market demand scenarios; high, medium and low. In each scenario, is a description of the market demand assumptions for ISS products and services. In the demand scenarios, the future business functions' objectives (see section 8.2) and founders (see section 8.6) under the three scenarios will be examined. In each scenario the driving forces and market trends which influence the business functions objectives and founders will be analysed. The validation of hypotheses (H4) and (H5) will support the selection of a collaboration for a future business function. The final selection of a collaboration for a business function will be made through the application the chosen "initial selection criteria" from section 5.6.

9.2 Market Demand Scenarios

In this section is a description of the approach used for building ISS market demand scenarios. Market demand influences the level of integration[1] between founders of the

[1]Business function founders could integrate their ownership rights, resources and activities at different levels, as discussed in section 5.4. Contractual level of integration is when companies integrate part of

future business function as discussed in section 5.4. Three market demand scenarios are developed for ESA ISS products and services and for each of them market demand is considered as an independent variable that will influence the objectives, functions, products and services, resources, founders and execution partners of the future business function. The approach used for scenario construction[2] is similar to the one used for the development of the ISS future scenarios in section 7.3. The difference is that there is only an analysis of the assumptions made and the driving forces of the founders' activities and not those of the ISS partners'. This alteration is necessary because market demand influences the driving forces and the roles of the founders under high, medium and low market demand conditions. Similar to the approach used in section 7.3, this approach is divided into 5 steps, as discussed below:

- Step 1 - presents the major assumptions for market demand scenario, which are derived from section 5.3.1
- Step 2 - presents the driving forces that result from the assumptions (step 1) of the selected future ISS scenarios of the expected cooperative oligopoly in section 7.10
- Step 3 - identifies the market trends that result from the driving forces from Step 2 and their influence on the level of integration between the business function founders and execution partners
- Step 4 - presents an analysis of the objectives, functions, products and services, resources, founders and execution partners of a future business function under the market demand conditions. Furthermore, in this step the high and medium market demand hypotheses (H4, H5) are validated
- Step 5 - presents the selection of a collaboration for a future business function. The future business function has to meet the "initial selection criteria" from section 5.6. These are: 1) value for money, 2) political transparency, 3) possession of complementary resources and 4) investment

The above steps will be applied for the high, medium and low market demand scenarios for ISS products and services. For market demand examples will be taken the demand for ESA

their activities and the integration is a non-equity based one. Companies aiming at joint production or R&D, which do not require ownership could form strategic alliance agreement or have licensing agreements. Collaborative level of integration is when founders integrate their ownership rights, resources (i.e. financial, marketing) and activities. This is an equity-based collaboration. Founders could allocate marketing, technical and sales resources to the future business function.

[2]The approach to scenario-planning proposed by Wharton University was selected in section 7.3 in preference to the Cross-impact method, Shell direct scenario building or Porter's industry scenarios because it supports the creation of scenarios for emerging markets such as the ISS ones (see Appendix F, section F).

ISS products and services, in order to be concrete when selecting a collaboration for the future business function. In the **high market demand scenario**, there is a demand for 50 to 100% of the 30% of ESA ISS products and services. In the **medium market demand scenario**, a demand of 10 to 50% of the 30% of ESA ISS products and services and in the **low market demand scenario** there will be demand for a maximum of 10% of the 30% of the ESA ISS products and services (see section 6.4). The development of three scenarios will permit the selection of a collaboration that will be adaptable to customer's market demand needs. The above approach for creating market demand scenarios also could be considered for commercialisation of earth observation, navigation or launch services. This approach could also be used by private companies that sell space and flight tourism services to customers.

9.3 High Market Demand Scenario

In this section is a description of the high market demand for ISS products and services. In this scenario the high market demand hypothesis (H4) from section 6.4 will be validated in section 9.3.8.

9.3.1 Major Assumptions - Step 1

The high demand scenario describes an environment in which the ISS markets are in the Frenzied stage of market development (see section 2.4.1) and could experience market demand fluctuation. In this stage of market development competition in the ISS markets will increase, profits will rise and the ISS markets will continue to expand. The above assumptions will influence the driving forces in section 9.3.2 and market trends in section 9.3.3.

9.3.2 Driving Forces - Step 2

This section presents the driving forces that will influence the business function under high market demand. These driving forces are derived from section 2.4.1 and the expected cooperative oligopoly in the future ISS commercial environment, as concluded in section 7.10. The driving forces will influence the business functions' objectives and activities in section 9.3.4. Hereby is an overview of the applicable driving forces from section 2.4.1:

- market demand and supply driving forces (i.e. market forces)
- increased competition between collaborations
- sustain market expansion and improving the market position of the future business function against competitors

- increased market entry barriers for the future business function as a result of competition

These driving forces will push the future business function to meet customer needs and to further develop the ISS markets. As a result of these forces, the future business function will need to develop and expand its portfolio of ISS products and services, sustain its markets and offer large scale of products and services to customers.
Under the **collusion scenario**, the American, European, Russian, Japanese and Canadian national business functions collude with each other. Dominant price leaders, as concluded in section 7.7.3 will define prices and the ISS prices will be set by American and Russian national business functions as they will have market power and the ISS products and services. The market strategy of the future business function will be strongly influenced by price setters, but due to high market demand the future business function can become a barometric price leader in the R&D markets. The above driving forces will have a direct influence on the market trends in section 9.3.3 and the future business functions objectives in section 9.3.4.

9.3.3 Market Trends - Step 3

This section describes the market trends that will influence the business function's development under high market demand. These market trends result from the influence of the above driving forces, the Frenzied stage of ISS market development from section 2.4.1 and the selection ISS future scenarios from Chapter 7. The market forces of increased demand for ISS products and services will create positive market trends. Like ISS markets expansion, increase of profits from the sales of ISS products and services and reduced regulation from the ISS partners, as observed in section 2.4.1. An increased level of integration between founders will facilitate the business function in sustaining and expanding its ISS markets and offer a wide range of products and services and securing fast access to ISS products and services.
Under the **collusion scenario** under high market demand for ISS products and services, the business function will be exposed to trends that will encourage an increased interdependence. The business function will be exposed to the negative market trend of becoming a 'price taker', as discussed in section 7.6.4. The future business function would need to sustain its ISS markets and withstand becoming a price taker. Furthermore, it would have to aim at gaining market power by increasing its share in the ISS markets and generating cost advantages, as earlier discussed in section 9.3.2. Becoming a price setter (i.e. barometric, see section 2.3.7), would require an increased level of integration and commitment by its founders.
Increased level of integration between business functions founders for securing access to

ISS products and services and increased capability to withstand becoming a price taker, will be beneficial.

9.3.4 Business Functions Objectives and Activities - Step 4

This section presents an overview of the relevant business functions objectives and activities under the high market demand scenario. Based on this analysis, it will be possible to identify the business functions' founders under the high market demand scenario, as considered in section 8.6. The objectives and activities are derived firstly from section 8.2 and then from the driving forces of this scenario from section 9.3.2. These business functions objectives will be the following:

- To meet customer demand, by providing products and services
- To sustain and expand its market share in the ISS markets (see section 9.3.2)
- To develop a portfolio of products and services that brings competitive benefits to the business function's customers
- To secure fast access to ISS products and services, via the acquisition of exclusivity rights for accessing ISS products and services
- To secure access to substitute space-based products and services, such as drop towers and parabolic flights
- To identify, select and prepare commercial projects and business plans of customers, which would meet ISS partners (i.e. ESA) criteria (e.g. technical, ethical and business criteria) for the implementation of commercial projects, as presented in section 4.3.3

The business functions' objectives will be categorised under the business function activities of marketing and sales, customer support activities, consulting and projects and network ones, as outlined in section 8.2. As a result of the high market demand for ISS products and services, the business functions' most important activities will be **marketing, sales and customer support**. Since the business function will have to market and sell the ISS products and services, it will need to have business development and network activities, in order to sustain its ISS markets.
To meet customers market demand, the business function will have to secure high priority access to ISS products and services and implement marketing and sales activities under the high market demand scenario.

9.3.5 Business Functions Products and Services - Step 4

The analysis of the business functions products and services in this section will support the identification of resources and competencies that the business function need to have for this scenario. These are derived from the previously identified business functions' products and services (see section 8.4). As concluded earlier in section 8.4 the business functions products and services are grouped in **pre-mission**, during **mission** and **post-mission**. The type of products and services necessary for the business function under this scenario is defined by its objectives and its activities from section 9.3.4. In the **pre-mission group** the following products and services are relevant:

- Marketing and sales services necessary for the preparation of a marketing strategy and portfolio of business function products and services
- Commercial proposal[3] and business plan preparation support (see section 8.4) to customers to ensure that their proposals meet ISS partners' technical, ethical and financial criteria in order to be flown to the ISS. Services related to the preparation of a business plan[4] for commercial customers willing to qualify for ESA ISS promotion support
- Consulting services, project management and network services including business strategy development and attracting investors for certain commercial projects. The project management services could include commercial proposal management during the pre-mission, during mission and post-mission phases

In the **mission phase** the business function could support the customers with the following services:

- Description and identification of the necessary documents requested from an ISS partners (i.e. ESA) for the commercial payload implementation and flight to the ISS

In the **post-mission phase** the business function could support its customers with the following services:

- Defining the benefits for customers from IPR or marketing rights, as a result of the flight of their commercial payloads to the ISS, as presented in section 8.4

[3]The commercial proposal will need to include the payload description, objectives and proposal for commercial payloads. For more information see section 4.3.3.

[4]Business plans preparation for customers will need to include the description of company, status, markets, customers, product description, targeted markets, competition and project financing, as presented in section 8.4.

The business function will offer most of its products and services to customers during the pre-mission phase. Customer demand for the business functions products and services will, over time, define whether the above products and services will change. Duplication of products and services with the ISS partners will need to be avoided, which could potentially cause confusion for future customers, as earlier observed in section 4.3.5.
The business function will offer most of its products and services to customers during the pre-mission phase, as its main services will be in commercial proposal and business plan preparation.

9.3.6 Business Functions Resources and Competencies - Step 4

This section presents the necessary resources the founders and execution partners will need to allocate in the future business function under high market demand. Initial recommendations for the business functions resources and competencies, was already made in section 8.5. These recommendations will be combined with the business functions objectives and activities in section 9.3.4 and the products and services in section 9.3.5; this will support the proposal of resources of the business function under the high market demand scenario. As already observed in section 9.3.4, the most important activities of the business function under this scenario will be marketing, sales and customer support. Marketing, sales and customer support resources and competencies will be most needed during the pre-mission of a commercial payload, with the consulting ones in the post-mission period. The customer support and network resources will be needed throughout the commercial proposal implementation (i.e. pre-mission, during mission and post-mission). The business function's resources and competencies are classified as marketing and sales, customer support, consulting and project and network ones. This classification is based on the business functions resources and competencies from section 8.5. The **technical resources and competencies** include access to the ISS facilities, transportation services (i.e. Soyuz, Proton) and astronaut services. The business function requires secure high priority access, for example of the the 30% of the available ESA ISS products and services. The business function will also have to secure back-up and offer access to to ISS products and services and offer access to short term micro-gravity flights, such as drop towers, parabolic flights, sounding rockets and Foton capsules. **Marketing and sales resources and competencies** include business development competencies, customer acquisition resources and marketing and sales competencies. The business function will need the resources to perform market analysis, target customers and develop a marketing mix. The **customer support competencies** should include expertise for the preparation of commercial proposals and business plans for commercial customers, as presented in section 8.5. The business function will, therefore need to have knowledge of ISS partners' commercial project requirements and ethical, financial and legal criteria. The **consulting competencies** will also encom-

pass project-financing, the business function could have funding resources, such as start-up capital, venture capital, private equity capital, loans and grants.

9.3.7 Business Functions Founders and Execution Partners - Step 4

In this section is an overview of the necessary founders and execution partners for the future business function. Early recommendations for the types of founders and execution partners were already made in section 8.6. The potential founders and execution partners will be selected based on the business functions objectives and activities from section 9.3.4 and resources from section 9.3.6. Furthermore, there will be a description of their profiles and of the resources they will allocate to the business function, followed by a proposal for the allocation of ownership rights for the business function in the high market demand scenario. As has been observed in section 8.6, the future business function needs to provide marketing and sales resources for commercial payload preparation and testing. From earlier analysis in section 8.6 the following founders and execution partners for the future business function are proposed:

- ISS partners - their roles will be to provide access to ISS products and services and ground-based testing facilities. As observed in section 9.3.4, the business function under high market demand will need to secure access to ISS products and services and therefore become a founder

- Marketing and sales companies - their roles will be to access non-space customers from the targeted markets of biotechnology, health, as observed in section 8.4. Marketing, sales and customer support competencies can be provided by these companies from the biotechnology, health and food industries

- Industrial associations - from the ISS targeted markets (i.e. biotech, food), their roles will be to offer information to the business function on industry trends and access to customer networks and associations

- Investors - these will be to be venture capitalists, banks, corporate investors, insurance companies and non-financial corporations. These founders could provide business function with consulting competencies and also financial advice for financing commercial projects and business plans preparation

- Small Medium Enterprises (SME) - their roles will be to provide scientific, technical and project management competencies to the commercial projects of the future business function

- Non-profit organisations - their roles will be to identify whether certain commercial projects could be beneficial to the public. These could be environmental or health organisations or foundations.

The type of founders may change in response to market demand for ISS products and services. The founders will select the execution partners in the future business function. As an incentive to sustain the ISS markets the execution partners would be allowed to become shareholders in the business function. The need for an increased and diverse amount of resources and competencies by the business function under the high market demand scenario will require a balanced ownership structure and higher levels of integration and commitment between the business function founders. In order to create a balance of power and to mitigate the ownership risks, as discussed in section 5.5.1 there should be balanced ownership of a business function. That is to say, ISS partner (33%), non-space companies (33%) and industrial and investors (33%) as founders. This ownership structure will provide a balance for both public and private partners and ownership rights and because of its composition no partner will be able to impose their will on future activities. Figure 9.1, presents the business function ownership structure under the high market demand scenario. The marketing, sales and industrial associations could also have ownership of 33% and the remaining percentage could be allocated to investors and technology and science organisations.

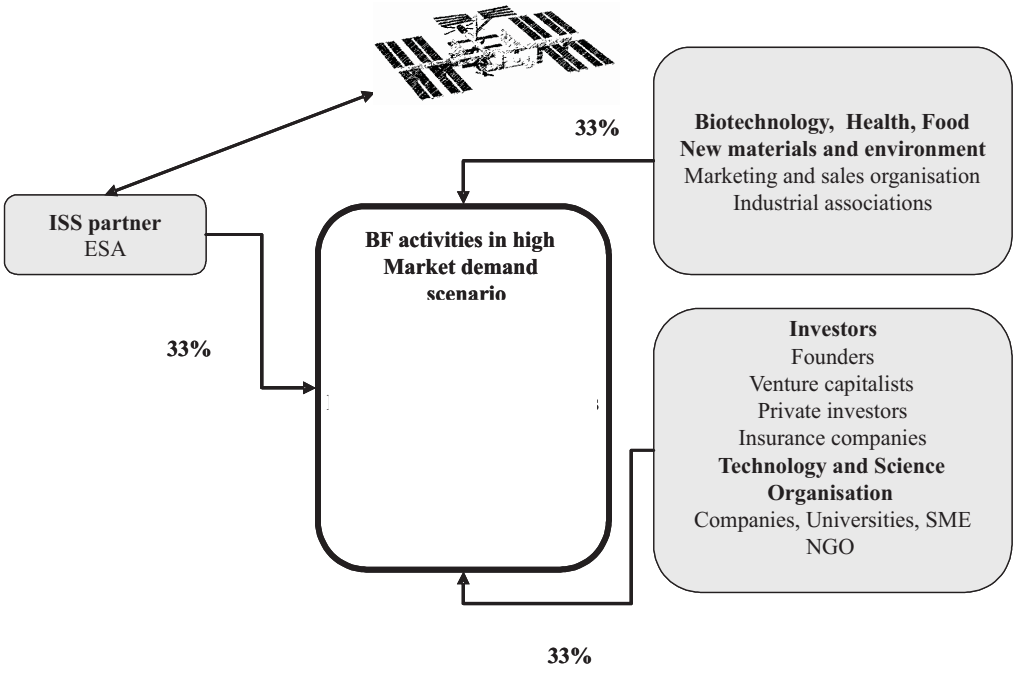

Figure 9.1: Business function ownership structure under the high market demand scenario

The business function under the increased level of integration will need to have diverse founders in order to meet high market demand for ISS products and services.

9.3.8 Validation of High Market Demand Hypothesis - Step 4

In this section the high market demand hypothesis (H4) from section 6.4 will be validated. Under high market demand for ISS products and services, the business function will have to offer increased access to ISS products and services and marketing and sales resources to its commercial customers. The present lack of information on the demand for ISS products and services creates a constraint in linking founders' level of integration with market demand. A high level of integration between founders with a view to meeting the customers' market demand for ISS products and services is considered for the following hypothesis:

H4: High market demand of 50% to 100% for ISS products and services, requires a collaborative level of integration between business functions' founders.

The hypothesis is verified through the following reasonings:
Reasoning 1: The driving forces from section 9.3.2 under the high market demand scenario mean that a business function must be able to have the capability to sustain and expand its markets, as observed in section 9.3.4. The future business function should have priority access to ISS products and services.
Reasoning 2: Market forces, such as an increased demand for ISS products and services require an increased level of integration between future founders, as discussed in section 9.3.3. This is necessary for the future business function to withstand high market entry barriers that result from the cooperative oligopoly, as observed in section 9.3.3.
Reasoning 3: Technological forces result in a need for fast and secure access to ESA ISS products and services. This is achieved through an increased level of integration between an ISS partner and the other business function founders, as observed in section 9.3.7.
Reasoning 4: The future business function needs to gaining market power, generating cost advantages, become a price setter in the cooperative oligopoly and withstand high market entry barriers. The accepted hypothesis shows once again this will require increased levels of integration and commitment by the founders of a business function, as discussed in section 9.3.4.
The above reasonings show that the collaborative level of integration for future business functions founders is most appropriate for a high market demand scenario for ISS products and services.

9.3.9 Collaboration Model Selection - Step 5

In this section, a collaboration for the future business function under the high market demand scenario will be selected. This selection will directly contribute to answering research Question 8, from section 1.3. The hypothesis validation in section 9.3.8 already showed that a collaborative level of integration between business function founders is required for the high market demand scenario. As presented in section 5.4, Figure 5.2 there are different possibilities for a collaborative level of integration for the future business function. These are joint ventures, public private partnerships (PPP), marketing and sales alliances or consortiums (see section 5.4). To select a collaboration model the "initial selection criteria" (see section 5.6) will be applied for the different types of collaboration models (i.e. joint ventures, consortium). These criteria are: 1) value for money, 2) political transparency, 3) possession of complementary resources and 4) risk and profit sharing.
The above criteria were not satisfied by the present business functions, as concluded in section 5.6 and it was recommended the future business function have to meet them. A literature review of various authors has been used for the description of the collaboration models characteristics, advantages and disadvantages as described in Appendix D, section D.2, Table D.3. The collaborations described below are those presented earlier in section 5.4, Figure 5.2:

- Public Private Partnership (PPP) - a partnership between a public and private organisation and is usually implemented for large scale projects, such as the PPP for the Galileo [118]
- Joint Venture - a distinct legal form is given to a partnership agreement usually involving private bodies forming an equity stake in a PPP [99]. Joint ventures are also implemented when there is a high degree of market uncertainty and high degree of asset specificity [4] and costly technological innovation is involved. A joint venture is usually created when activities develop in a distinct business [4]
- Collectively managed joint venture - two or more partners jointly manage the collaboration activities of the joint venture. Requires the founders to share complex and tacit knowledge for projects [125]
- Consortium - several companies work together and management is equally shared. Large company size is necessary for the firm to be credible for potential customers and specialists skills required are so wide and varied that they cannot be adequately provided by two firms. The consortium will require extensive geographic coverage to achieve strong market presence and it will need to spread and limit the financial risk to each partner [4]
- Corporation - is a legal entity that exists with or without any shareholders [19]

The above collaborations are compared against the "initial selection criteria" in a similar way as of the present business functions in section 5.6. The joint venture meets all criteria, followed by the consortium. A joint venture meets the criterion of value for money, if it is capable of generating cost advantages of its activities by encouraging cost-effective use of ISS products and services (see section 4.3.4), through the implementation of commercial projects that use ISS products and services. The criterion of political transparency is also met by this type of collaboration, because as a public founders, ISS partners will have to be transparent in their activities. The risk and profit sharing criteria and the possession of complementary assets from the business function founders are major characteristics of the joint venture. Furthermore, it will be able to market, sell and sustain its market share and become a price setter under the cooperative oligopoly from Chapter 7. The consortium is also an attractive model for the future business function, because it could provide wide market coverage and products and services to customers. In the case of a Frenzied market stage of development, however as discussed in section 9.3.1, there can be market demand fluctuations. A consortium could inefficiently offer too wide market coverage for market demand fluctuations for ISS products and services. Therefore, under cooperative oligopoly (see section 9.3.3) the consortium may not be able to sustain its ISS market share or expand its markets. The most attractive collaboration model for the high market demand scenario is a **Joint Venture**, because it meets all selection criteria. The joint venture as a collaboration for the business function has advantages and disadvantages. The joint venture's advantages are that it will probably increase the market power for the future business function in the ISS markets. This is an essential aspect of a business function operating either under cooperative oligopoly, as concluded in section 7.10. It is a collaboration in which the founders can share the costs and risks of new market development. The risk and profit sharing and capability to increase and sustain market power (see section 9.3.6), are important for meeting the needs of the future business function under the high market demand scenario and cooperative oligopoly. The joint venture's advantages will best meet the business functions objectives from section 9.3.4.

The creation of a joint venture carries however, certain disadvantages. The future business function founders could incur significant bargaining and negotiation costs in the process of its creation (see Appendix D, Table D.3).

Implementation of similar joint ventures are possible for other ISS partners programmes, such as in earth observation, telecommunications, navigation, technology transfer and Moon and Mars interplanetary programs.

The joint venture will meet the high market demand for ISS products and services and also contribute to an increased market share, implementation of competitive strategies and the management of commercial projects by the business function. The selected joint venture for a future business function, directly contributes to answering research Question 8 and achieves the first objective of this thesis.

9.4 Medium Market Demand Scenario

In this scenario a collaboration for a future business function is selected under medium market demand for ESA ISS products and services. The analysis performed in this scenario will support the validation of hypothesis (H5) from section 6.4.

9.4.1 Major Assumptions - Step 1

The medium demand scenario is built on the assumption that there is market demand for 10 to 50% of the 30% of ESA ISS products and services.

- As a result of the lower demand for ISS products and services the business function will also have to target the ISS emerging markets (see section 8.4)
- The ISS markets will be in a Nascent stage, as presented in section 2.4.1. There will be few competitors to the business function in the ISS markets and the ISS markets will be similar to the current ISS commercial environment, as concluded in section 2.6

The above assumptions will influence the business functions objectives and activities under the medium market demand scenario.

9.4.2 Driving Forces - Step 2

The identification of the driving forces in this scenario will define the business function's objectives and activities. Similar to the high market demand scenario, first the driving forces as a result of the Nascent stage of market development from section 2.4.1 will be presented. Then there is an overview of the driving forces from the selected ISS future scenarios from Chapter 7, will be given. The relevant driving forces for this scenario are as follows:

- ISS market uncertainty and complexity (i.e. market forces) and unknown customers
- new ISS markets are being created
- lack of awareness by the non-space industry about ISS opportunities
- need for ISS market development
- ISS partners regulation

The above driving forces will push the business function to achieve market expansion through the development of the ISS markets and in particular target the emerging ones.
In the **collusion scenario**, the American, European, Russian, Japanese and Canadian

national business functions collude with each other. Dominant price leaders, as concluded in section 7.6.3 will define the prices for the national business functions, including the future business function for ISS products and services. In the R&D markets, the prices will be set by American and Russian national business functions as they will have market power and ISS products and services. The market strategy of the future business function will be strongly influenced by price setters. Due to the medium market demand for ISS products and services, the business function will become a price taker for the R&D markets, but has the potential to become a price setter for the emerging ones.
The influence of the driving forces described above will force the future business function to achieve market expansion in the ISS markets and will need to develop a competitive strategy based either on cost advantages or product differentiation. The future business function has the potential to become a price setter for the emerging markets.

9.4.3 Market Trends - Step 3

This section provides an overview of the market trends that will influence the business function's development under the medium market demand. These trends result from the driving forces from section 9.4.2 and the ISS markets of the Nascent stage in section 2.4.1. Furthermore, the driving forces from the collusion scenarios of the future ISS commercial environment (see section 7.10) will encourage the creation of market trends similar to those outlined in the high market demand scenario in section 9.3.3. In order to avoid repetition, a second description of the market trends like that of the high market demand scenario will be avoided. The Nascent stage of market development is similar to that currently witnessed in ISS market development, as concluded in section 2.4.1, but with the ISS market evolution the Frenzied stage can be most probable for the future ISS commercial environment. In emerging markets such as the ISS ones, a future business function could have a contractual level of integration between its future founders for the first 2-3 years of its operations, as recommended in section 5.4. Therefore, a contractual level of integration (see section 5.4), between the business function founders will support the creation of a collaboration that can operate under a Nascent and Frenzied stages of ISS market development.

9.4.4 Business Functions Objectives and Activities - Step 4

This section presents an overview of the business function's objectives and activities under the medium market demand scenario. Based on this overview it will be possible to identify the business function products and services. The business function's objectives under medium market demand are derived from the initially proposed objectives section 8.2 and are the following:

- To increase market share in R&D and emerging markets

- To meet customer demands
- To secure access to ISS products and services, brand and images
- To secure access to substitute microgravity resources, such as drop towers, parabolic flights
- To identify, select and prepare commercial proposals and business plans for customers for both the R&D and the Emerging markets
- To encourage the implementation of sponsorship, educational, advertising and branding projects

Under the medium market demand scenario, the business function will have to focus on developing and expanding the ISS emerging markets, to substitute a lower demand for ISS products and services. To achieve this, the business function will have to implement marketing campaigns to build awareness for ISS commercial opportunities and encourage market demand for ISS products and services. Under the marketing and sales activities the business function would be focused on increasing its market share for both ISS markets (e.g. R&D and emerging) in contrast to the high market demand scenario in which a business function's main priority would be to sustain its current markets. For the customer support activities, the business function would have to secure access not only to ISS products and services, but also to ISS images to enable the development of products and services for the emerging markets. The consulting activities of the business function are those of similar to the high market demand scenario in section 9.3.5. In this scenario the business function would have to focus on expanding its customer base.
A reduction in market demand for ISS products and services means that the business function would need to focus on developing both the R&D and emerging markets, thus, focusing its activities on customer acquisition.

9.4.5 Business Functions Products and Services - Step 4

This section presents an overview of the business functions' products and services under medium market demand. They are based on the identified business functions products and services from section 8.4. The results of this section identify the needed resources and competencies for the business function under medium market demand scenario. The products and services for the medium market demand scenario are defined in a similar way to those under the high demand scenario in section 9.3.5. The business function's products and services in this scenario are also classified into **pre-mission**, during **mission** and **post mission phase**. The types of products and services necessary for the business function under medium market demand are defined by its objectives and its functions

from section 9.4.4. The business function would offer the same products and services to its R&D customers, as for the high market demand scenario in section 9.3.5 for the pre-mission, during mission and post-mission. In contrast to the high market demand scenario, the business function for the medium demand scenario for the **pre-mission phase** would be focused on offering extra promotion services (i.e. price discounts) to its customers for commercial proposal and business plan preparation. During the **mission** and **post-mission phase** the business function would supports its customers in identifying benefits from IPR or marketing rights for their commercial projects. Due to the intangibility of the services in the emerging markets, predictions of the exact type of business functions products and services can hardly be made.
Under the medium market demand scenario, the business functions products and services for the R&D markets are the same as those under the high market demand scenario, but different for the emerging markets.

9.4.6 Business Functions Resources and Competencies - Step 4

This section presents the business functions' resources and competencies under medium market demand. The analysis of the business functions objectives and activities in section 9.4.4, products and services in section 9.4.5 and resources in section 8.5, resulted in the identification of the necessary resources for the business function under medium market demand. In the medium market demand scenario, due to lower market demand for ISS products and services, different resources would be required.
The **marketing and sales resources and competencies**, include business development resources, customer acquisition resources and marketing and sales competences. These are competencies for performing market analyses, targeting customers and expanding markets. Business development competencies will allow to the business function to achieve market expansion (see section 8.5). The **consulting competencies** of the business function will have to be capable of defining the business, technical, scientific and business strategy for non-space customers. Under this scenario, the collaboration would need to focus on sponsorship, educational and advertising resources in order to develop the emerging markets and provide a larger variety of products and services. To integrate the considerable variety of business functions resources required, founders of the business function could have a contractual level of integration.

9.4.7 Business Functions Founders and Execution Partners - Step 4

This section shows the business function's founders and execution partners under the medium market demand scenario. Preliminary recommendations for the types of busi-

ness function's founders and execution partners were already given in section 8.6. The potential founders and execution partners would be selected based on the business functions objectives and activities (see section 9.4.4) and required resources (see section 9.4.6) under the medium market demand scenario. The business function would have to intensively market and sell ISS products and services in order to stimulate market demand. The business function would be required to offer a wide portfolio of services in the ISS markets. As earlier concluded in section 9.4.6, the business function would need to develop the emerging markets and provide a larger variety of products and services, such as sponsorship, entertainment and flight tourism resources, that is to say it would need increased flexibility in the business function. To integrate the considerable variety of resources required, founders of the business function would need a looser level of integration. This is a result of the earlier analysis in section 8.6 and the necessity for the business function to perform its activities (see section 9.4.4).

- Marketing and sales organisations, industrial associations, investors and Small Medium Enterprises (SME) for the description of the potential founders discussed for the high market demand scenario in section 9.3.7.

In contrast to the high market demand scenario, the medium market demand scenario does not require an ISS partner or non-profit organisations as future founders or execution partners. There is not a vital necessity for the business function to gain priority access to ISS products and services, so therefore there is no need for an ISS partner to become a founder. As a result of the reduced market demand for ISS products and services there is a need for the business function's founders to have a strong presence in the emerging markets. The type of execution partners would depend on the market demand in the R&D and emerging markets for ISS products and services. The execution partners could be advertising and media marketing organisations and SMEs. Figure 9.2 presents the ownership structure of the future founders under the medium market demand scenario.
The above business function founders would be able to meet the needs of the business function under the medium market demand for ISS products and services. Marketing, sales, SMEs and industrial associations would support the business function in expanding its market share and the development of a wide portfolio of services for commercial customers.

9.4.8 Validation of Medium Market Demand Hypothesis - Step 4

The considerations for the medium market demand hypothesis results from the analysis of the driving forces in the current ISS commercial environment from section 5.3.1.
The most important driving forces for the development of the business function are the economic and market driving forces. However, reduced market demand encourages the

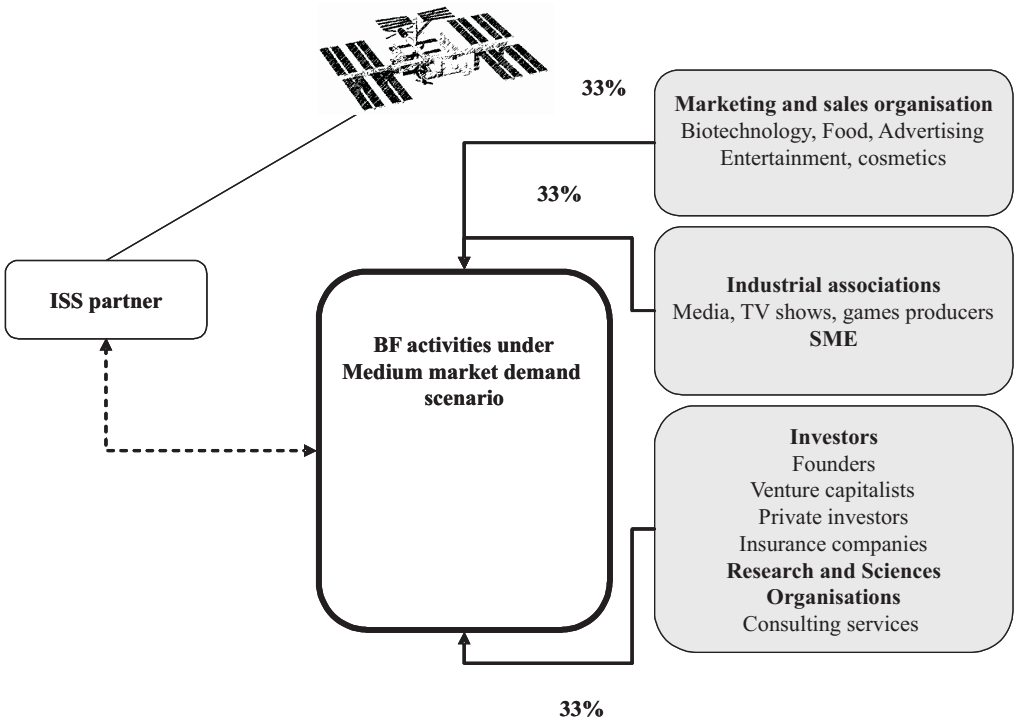

Figure 9.2: Business Functions ownership structure under the medium market demand scenario

future business function founders to have a contractual level of integration.

H5: Medium market demand of 10 to 50% for ISS products and services, requires a contractual level of integration between the business functions' founders and execution partners.

The hypothesis is validated from the earlier analysis in this scenario and from the example from the biotechnology industry from section 5.4.
Reasoning 1: In order to develop the emerging ISS markets and provide a larger variety of products and services the business function will need to have a contractual level of integration, as concluded in section 9.4.6.
Reasoning 2: The necessity of bringing together business function founders and execution partners who can offer market access, both in the emerging and the R&D markets, requires the business function to have a contractual level of integration (see section 9.4.7).
Reasoning 3: The overview of collaborations in the biotechnology industry from section 5.4, Figure 5.3 showed the existence of licensing and strategic collaborations. It was recommended that the potential contractual level of integration can be considered by the

business functions founders if the ISS markets are in Nascent and Frenzied stages.
Proofs 1, 2 and 3 accept the above hypothesis and confirm that in a medium market demand the most attractive level of integration between founders is the contractual level of integration in a medium market demand.

9.4.9 Collaboration Model Selection - Step 5

In this section a preferred collaboration for a business function under the medium market demand scenario is selected. This selection will answer directly research Question 8, from section 1.3. The hypothesis validation in section 9.4.8, showed that for the medium market demand, a contractual level of integration is considered. The collaborations under a contractual level of integration are: licensing, leasing, franchise or strategic alliance agreements, which were initially presented in section 5.4, Figure 5.2. The selection criteria of an appropriate collaboration model will be similar to the high market demand scenario. The initial recommendation for having a contractual level of integration for a business function in its first 2-3 years of operations from section 5.4. For the selection of a collaboration, the initial selection criteria[5] from section 5.6 will be applied. The collaborations that are considered are those from Figure 5.2 and are described in detail in Appendix D, section D.2, Table D.2.

- Licensing agreement - a government licenses facilities to a private firm under a licensing agreement and collects fees [31]. This type of collaboration is usually implemented when there is a product or service which needs to be introduced to new markets and for which lacks brand recognition [4]. It is also implemented when there is a need between future founders to share investment risks and a short term contractual agreement of 3 to 5 years

- Leasing agreement - a government-owned property can be used by private lease to engage in commercial activities and the duration of the agreement could span from 5 up to 10 years

- Franchise agreement - a government or private organisation awards a private organisation the right (often exclusive) to sell a service or product to the public [31]

- Concession - is applied when a private company uses public properties, for example airports, for commercial activities [31]. Under the concessions agreements ownership of the property remains governmental and is usually a long-term agreement from 10 up to 30 years

[5]The initial criteria are value-for-money, political transparency, complementary resources, and profit and risk sharing.

- Strategic Alliance - is an agreement between organisations [57] and this type of collaboration is usually implemented when founders are interested in joint technology development, production and R&D activities. A strategic alliance is usually implemented when there is a need for flexibility and high uncertainty over the tasks involved. Furthermore, a strategic alliance is not bonded by a specific business [4]. A strategic alliance could also be an individually managed alliance, in which each partner autonomously manages a definite set of activities and fulfils specific tasks. Division of labour among partners is established [126]

A **licensing agreement** would meet the criterion of value for money because the founders would have high incentives to generate profits from the ISS markets, through the implementation of commercial projects. This high incentive comes from the type of agreement that requires financing by a private company. The criterion of political transparency is also met, because the ISS partner would receive a fee for the ISS products and services, without carrying the burden of the business risks for market development. The founder could provide marketing and sales resources and competencies as described in section 9.4.6. Moreover, the business function founders share investment risks and profits.
The leasing agreement could also be an attractive option, but it does not offer risk and profit sharing to the future founders. It is a more long-term agreement of 5 to up to 10 years, but because of the medium market demand and the Nascent stage of market development, it will be difficult to predict an increase or reduction in the market demand for ISS products and services. Therefore, an agreement longer than 5 years between founders will not be appropriate for this scenario. The licensing agreement would meet all the four criteria for implementation of a business function.
The licensing agreement for the business function has a number of advantages and disadvantages. The advantages are that by creating a licensing agreement ISS products and services would remain publicly owned, but financing of the commercial activities would be carried out by the future business function. The licensing agreement provides opportunities for meeting the objectives from section 9.4.4 of the business function under the medium demand scenario. In the case of reduced market demand for ISS products and services, the business function founders can withdraw from the agreement and the ISS partner could also withdraw the licence in case of disagreements or low demand for ISS products and services. As discussed in section 9.4.2 the business function will become a price taker for the R&D markets, but has the potential to become a price setter in the emerging ones under the cooperative oligopoly. The implementation of a licensing agreement will also carry certain disadvantages, such as the danger of under-commitment to the agreement by the founders and execution partners. The ISS partner must be aware of the danger of over-licensing access to ISS products and services and of possibly creating a dilution of the ISS brand name. The licensing agreement presents an opportunity for an ISS partner to

collect fees, without carrying the risks. An ISS partner could issue a licence to the business function for the commercial exploitation of the ISS products and services. Furthermore, this agreement could be attractive for the other ISS partners, such as JAXA, that would still need to create a business function for selling ISS products and services. The selection of the holder of the licensing agreement could be done through competitive bidding and both the ISS partner and the business function, could withdraw from the agreement after 3 to 5 years, depending on changes in the market demand for ISS products and services. The Licensing agreement is the most attractive option for a business function under a medium market demand for ISS products and services. This agreement can already be applied by some ISS partners (i.e. JAXA) for their planned business functions. The results from this section directly answer research Question 8 and contribute to achieving the first objective of this thesis.

9.5 Low Market Demand Scenario

In this section is an analysis of the low market demand scenario. Under a low demand for ISS products and services, there is no need to establish a business function, as its creation will result in the inefficient use of ISS partner financial and management resources. For example a business department, such as the ESA Commercial Promotion Office (CPO) could handle the market demand for ISS products and services. The business departments' objectives under this scenario will be to:

- enter and develop targeted ISS markets (i.e. R&D and emerging markets)
- attract first-time customers
- create a customer-friendly environment
- create awareness of existing ISS opportunities

The business department will have to develop marketing and sales skills and undertake marketing, sales, customer support and project management activities. The business department will have a nurturing role, similar to the one of the ISS partners in the Nascent stage of ISS market evolution from section 2.4.1. The business department would be exposed to political, market and competitive forces, similar to those identified in the current ISS commercial environment in section 5.3. It would also be exposed to similar threats to those identified in section 5.3 from the direct ISS partners commercialisation activities. The business department would have to face the challenging task of developing the emerging ISS markets, and will bear the marketing risks and the ISS new market development risks. Furthermore, the business department would have to perform commercial activities (i.e. sell ISS products and services) under the hat of a non-profit organisation.

The resources and competencies required for meeting the business department's needs are primarily marketing and sales, such as business development competencies. For example the present ESA ISS products and services offered to commercial customers[6] would mostly be sufficient to meet a low market demand for ISS products and services. The low demand for ISS products and services would result in market conditions under which the cooperative oligopoly (i.e. ISS future scenarios) will not be relevant. Because of low demand for ISS products and services, there would be no need for the creation of a business function. As the market demand can be handled by the business department of an ISS partner.
The business department of an ISS partner would be able to meet the market demand for ISS products and services and the creation of a future business function would be unnecessary, due to low market demand.

9.6 Results and Conclusions

The results in this Chapter answer research Question 8; *What type of future collaboration could be proposed between space agencies and private companies?*. To answer this question there is a selection of collaborations under three market demand scenarios: high, medium and low. Joint venture for high market demand is relevant, as a collaborative level of integration between founders of a business function will be necessary, as concluded in section 9.3.8. Joint venture can meet the high market demand for ISS products and services, sustain its ISS market share and become indispensable partners to an ISS partner in the process of ISS commercialisation. A joint venture can become a price setter under a cooperative oligopoly.
A licensing agreement for medium market demand is relevant, as contractual level of integration between founders will be necessary, as observed in section 9.4.8. Under a licensing agreement as discussed in section 9.4.9 the business function can increase its ISS market expansion and become a price taker for the R&D markets, but has the potential to become a price setter in the emerging ones under the ISS future scenarios. As discussed in section 9.4.3 with the ISS market evolution the Frenzied stage can be most probable for the future ISS commercial environment and will resemble most the medium market demand scenario.
In a low demand scenario, there is no need for the creation of collaborations, because the business department of the ISS partner will be able to handle the market demand for ISS products and services. It will have a have a nurturing role, similar to the current one of

[6]ESA CPO offers: access to the ISS products and services (i.e. ISS facilities) commercial project evaluation, support and implementation, "end-to-end services", sponsorship services, ISS brand support and promotion opportunities. It also offers access provision to ISS products and services of other agencies, project financing and management, payload operations and management (management products & services) and IPR, marketing and sponsorship rights [87].

the ISS partners in the Nascent stage of ISS market evolution.
The market demand scenarios are relevant not only for the present business functions, but also for the future business function. The proposed joint venture and licensing agreement can also be applied for programmes such as Moon and Mars space exploration, navigation, earth observation and technology transfer programmes.

Chapter 10

Conclusions

10.1 Introduction

The research in this thesis started in 2000, based on an ESA request for an academic investigation into ISS commercialisation and resulted in the following research objectives:

- **Objective 1:** To select, develop and propose a collaboration between space agencies and collaboration partners to be used to market ISS products and services to commercial customers

- **Objective 2:** To describe, analyse, judge and predict strategic and market developments (processes) for ISS commercialisation

To achieve these objectives eight research Questions in section 1.3 were identified and addressed in this thesis. The methodology used in this research is typically "case based", because the information provided by the ISS partners, ISS products and services is so limited that statistically sound analysis cannot be made. The research objectives from section 1.3, the availability of research data and literature and the research questions on ISS commercialisation pointed to the direction of the use of case based research. As the research focuses on the work of the researcher within the ESA Commercial Promotion Office (CPO), there are also elements of "action research" especially for the description and analysis of ESA ISS targeted markets, ISS products and services and pricing policies and commercialisation programs. For the above aspects of the research the ESA ISS commmercialsiation experience is taken as an example. The expected results for current ISS commercialisation allow a generalisation of certain conclusions on ISS partners pricing policies, targeted markets and ISS products and services. Due to the ISS partners interdependence certain recommendations on ESA commercialisation policies are also applicable for the rest of the ISS partners.

10.2 Research Results

What are the current market and strategic developments in ISS commercialisation? - Question 1
To answer the above question the supply and demand sides of the current ISS commercial environment were described in Chapter 2 and market trends in the space industry were analysed in Chapter 3.
The current market and strategic developments on the supply side of the current ISS commercial environment resemble a cooperative oligopoly. These developments result from the limited number of ISS players, ISS homogenous or differentiated products and services and high market entry barriers, as concluded in section 2.6. Cartel creation is unlikely in the current ISS commercial environment because of the ISS partners' freedom to sell their ISS products and services. Price leadership theory shows that NASA and RSA behave as price setters, while ESA, JAXA and CSA as price takers, as observed in section 2.3.7. On the demand side of the current ISS commercial environment the ISS markets are currently emerging. New ISS markets are being created, there is market uncertainty and customers are unknown. ISS partners and present business functions, operate under the Nascent stage.
From Chapter 3 reduced ISS products and services availability and the total dependence on Russia for regular ISS access, are strategic developments that constrain ISS commercialisation. Current market developments in space tourism and sponsorship will encourage ISS commercialisation. The current market and strategic developments in ISS commercialisation are those of a cooperative oligopoly, emerging ISS markets and dependence on Russia for regular ISS access.

Is there a need for a collaboration between space agencies and private companies to facilitate successful ISS commercialisation? - Question 2. This question was addressed in Chapters 2 and 5. The ISS partners' lack of clear definition of ISS products and services, complex and high market entry conditions, as observed in section 2.3.2, confirmed the need for a collaboration. Clearly the ISS partners have difficulties in creating attractive ISS portfolios, accessing and acquiring customers from the non-space industries. Exploitation of new ISS market opportunities, achieving partial ISS recovery and being first on the markets are some of the reasons put foward for the future founders to create a future business function, as observed in section 5.3.2. The analysis of the present business functions (i.e. NASA RPC, ESA Co-operation agreement, CA) showed that they do not meet the initial selection criteria[1]. Therefore, there is a need for a collaboration between

[1]The initial selection criteria were of value-for-money, political transparency, complementary resources, and profit and risk sharing. NASA's RPC does not meet the risk-profit sharing criterion, ESA Co-operation agreement does not meet the value-for money criterion and the Commercial Agent does not meet the risk

space agencies and private companies that will facilitate successful ISS commercialisation.

How will ISS partners' commercial activities encourage or discourage ISS commercialisation? - Question 3. This question is addressed for the current ISS commercial environment through the analyses performed in Chapters 2, 4 and 7. The analysis in section 2.3.7, showed NASA and RSA price dominance discourages ISS commercialisation development for the other ISS partners (i.e. ESA, JAXA, CSA) and present business functions. As the ISS partners with lesser quotas and the present business functions will experience uncompetitive prices, loss of customers and damage of their own image. As discussed in section 2.4.1 in the ISS emerging markets the ISS partners have a nurturing role, of setting up and implementing ISS access and pricing policies, that encourages ISS commercialisation. The regulative role of ISS partners in the future ISS commercial environment will be to participate in the definition of national regulations in the areas of liability of commercial projects, space insurance and IPR rights. Furthermore, the analysis in Chapter 4 showed that economic transition and budgetary constraints encourage ISS commercialisation. ISS partners need to create a user-friendly environment, with transparent, simple procedures and IPR rights for commercial projects to encourage ISS commercialisation development. However, their pricing approaches are different, complex and lack transparency. The ISS prices send a signal to the market that price changes can occur through political decisions, low market demand and ISS product and services availability. Therefore, these ISS prices discourage ISS commercialisation.
In the future ISS commercial environment the ISS partners should encourage competition, innovation and protection of commercial exploitation in the cooperative oligopoly selected in section 7.6. The discarded monopoly, direct competition or two-way access scenarios, show how the ISS partners can discourage ISS commercialisation development.

How are ISS products and services going to be marketed and sold? - Question 4. This question was addressed in Chapter 4, through the analysis of an example of an ESA commercial proposal selection, ISS targeted markets, products and services and present business functions. The ISS partners and present business functions market and sell ISS products and services. The ISS partners sell their ISS products and services to customers after they receive commercial proposals from them. Commercial proposal selection is a complex process, and for customers the preparation of a commercial proposal is difficult. The ISS partners currently market their ISS products and services by bundling them in a complex and difficult way to be used by non-space customers. Therefore, ISS partners for example can either simplify proposal requirements or introduce a step-by-step procedures for ISS products and services. These difficulties can be overcome by present

and profit sharing criterion. For RSA and JAXA collaborations there is little information available.

and future business functions offering certain services, such as technical and commercial support for commercial proposal preparation. ISS products and services are sold to customers from the R&D and emerging markets. Examples of R&D markets are medical drug development, preventive therapies for osteoporosis or development of lighter and stronger materials, while, the emerging ones are education, sponsorship and space tourism.
Three present business functions; ESA Co-operation agreement, Commercial Agent and NASA RPC also market and sell ISS products and services. They provide the easiest market and customer access to ISS products and services, except for RSA that directly markets and sells its ISS products and services.

What are the expected future market and strategic developments in ISS commercialisation? - Question 5. The answer to this question is a result of the analysis of market trends in the space industry in Chapter 3 and description of the future ISS commercial environment in Chapter 7. Reduced ISS products and services for commercial customers, increased ISS price and cooperation between Europe and RSA, are some of the expected future strategic developments. The expected growth of the space tourism, sponsorship markets and the creation of privately funded transportation vehicles (i.e. SpaceShipOne) are some of the expected market developments.
NASA and ESA future space exploration visions will have a negative influence on the successful development of ISS commercialisation. To prevent the end of ISS commercialisation and loss of potential customers and profits, the ISS partners will have to be careful not to repeat the mistake of the current ISS programme, in building a space station and in initiating the commercialisation process only in the final stages of its construction. The high costs for implementing space missions to the Moon and Mars and hence the potential necessity for attracting private funding is obvious. Other important reasons for considering commercialisation on board interplanetary space missions are the development of new markets and the creation of self-sustainable ISS markets. The early integration of customer needs in future missions is a strategic development. The lack of a long-term space laboratory result in the need for short-term investments in ISS markets by the present business functions.
A cooperative oligopoly is the expected market development in the future ISS commercial environment. High market entry barriers, business function charging similar prices for their products and services and ISS partners encouraging collusion are some of the expected strategic and market developments. Price leadership theory is relevant for the future ISS commercial environment, as cartel creation will result in underdevelopment of ISS commercialisation. Business functions can become either price takers or price setters. As discussed in section 9.4.3 the ISS market evolution in the Frenzied stage can be most probable for the future ISS commercial environment and will resemble most the medium market demand scenario.

Within what type of markets would a future collaboration operate? - Question 6. This question was answered in Chapter 7. The markets of the future ISS commercial environment will be under oligopoly market structure. As a result of the expected ISS partners technical, political and commercialisation interdependence cooperative oligopoly is the expected market under which a business function will operate in. However, the most favorable conditions for the creation of a business function and most desirable one is non-cooperative oligopoly.

What are the necessary steps for the development and implementation of a future collaboration? - Question 7. To answer this question analysis of the conditions, phases of development and initial selection criteria for collaborations was made in Chapter 5, followed by a step-by step proposal of a business function in Chapter 8. The main steps for the successful implementation of a collaboration are; checking whether it meets the conditions for its creation[2], undertaking the necessary phases[3] of development and meeting the initial selection criteria[4].
For the business function proposal in Chapter 8, the following elements were described; objectives, activities, market analysis, products, services resources, competencies, founders and risks definition. The primary objective for the future business function is to provide commercial, technical and value-based products and services through space commercialisation for ground-based technologies. The business function activities describe strong marketing, sales and business development activities and will change once it is operational. The business function can pursue a marketing and sales strategy that focuses on different areas from the ISS partners markets, such as flight entertainment, space cosmetics and advertising. Thus, can offer to its customers combined solutions from space research, ISS technology demonstration and ISS images use. Commercial proposal, business plans preparation and consulting services for the technical documentation for customers' commercial payloads, are some the business functions' products and services.
The allocation of ownership rights by founders, as discussed in section 8.6 gives them an incentive to allocate resources to the business function and mitigate ownership and nego-

[2]Political approval, access provision to ISS products and services and implementation of ISS commercial policies are minimum conditions identified in section 5.3.3 for the ISS partners to set up collaborations. Attracting start-up capital, first-time ISS customers and meeting customer needs are the conditions the business functions to meet.

[3]Two phases of collaboration model development were selected; preparation and implementation phases. Future founders of a collaboration first have to prepare and identify their needs, objectives, activities and roles (i.e. preparation phase) and then deal with negotiations, governance and management (i.e. implementation phase).

[4]Value-for-money, political transparency, complementary resources, profit and risk sharing are the criteria used against the present business functions.

tiation risks. Possible business function founders can be ISS partners, marketing and sales organisations, industrial associations, investors and non-profit organisations.

What type of future collaboration could be proposed between space agencies and private companies? - Question 8. In answer to this question there are a selection of collaborations under three market demand scenarios: high, medium and low in Chapter 9. A joint venture for high market demand and a licensing agreement for medium market demand are the proposed collaboration models between space agencies and private companies. Joint venture can meet the high market demand for ISS products and services, sustain its ISS market share and become indispensable partners to an ISS partner in the process of ISS commercialisation, thus, becoming a price setter under cooperative oligopoly.
Under the licensing agreement as discussed in section 9.4.9 the business function can increase its ISS market expansion and become a price taker for the R&D markets, but has the potential to become a price setter in the emerging ones under the ISS future scenarios. The medium market demand scenario can become relevant for the future ISS commercial environment, as it is for the current.
In the low demand scenario, there is no need for the creation of collaborations, because the business department of the ISS partner will be able to handle the market demand for ISS products and services.
The market demand scenarios are relevant not only for the present ISS products and services, but also for the commercial activities of the other ISS partners (i.e. JAXA, CSA) The proposed joint venture and licensing agreement can also be applied for programmes such as Moon and Mars space exploration, navigation, earth observation and technology transfer programmes.
The answers to the above research Questions contribute to the selection of a collaboration (Objective 1) and to the description and predictions of strategic and market developments in ISS commercialisation (Objective 2).

10.3 Reflection and Overall Conclusions

In this thesis there were aspects which addressed and met my personal motivation from section 1.2 and others which did not. The research objectives from section 1.3 set the direction of the research process and research questions, some of which resulted from direct observations on the European ISS commercialisation. Examples of such questions are "how are the ISS partners going to encourage or discourage ISS commercialisation" (Question 3) or "how are the ISS products and services going to be sold" (Question 4). The eight research questions raised considerations for the development of ISS commercialisation and the creation of collaborations, and became a basis for the hypotheses development in

Chapter 6. The research objectives, the availability of research data[5] and literature and the research questions on ISS commercialisation pointed to the direction of the use of case-based research. Descriptive research or statistical analysis were not considered due to data limitation. Working at the ESA Commercial Promotion Office (CPO) on ISS prices, R&D market analysis and ISS commercialisation from its beginning gave me the unique opportunity to analyse and research the opportunities and challenges in developing ISS commercialisation. However, had I not worked in ESA CPO I would not have chosen the case-based research process, due to the lack of actual case studies to research.
ISS commercialisation markets and developments are emerging; there is high market and strategic uncertainty, new players and unexploited market opportunities. The market and strategic uncertainty in ISS commercialisation will not diminish, but can be mitigated through better understanding of ISS commercialisation and ISS partners' commercialisation policies. ISS partners will have to simplify their requirements for commercial proposals and encourage the creation of a competitive environment for the sales of ISS products and services. The targeted audience of this thesis are non-space companies, potential investors (i.e. venture capitalists, banks, etc.) in commercial projects, national space agencies and institutes, aerospace companies, universities and industrial associations.
ISS commercialisation was initiated by the ISS partners and can be considered more as a technological push, than a market pull. Therefore, it is difficult to predict market developments in ISS markets or the products and services requested by customers, or whether the ISS products and services sales volume will partially recover the ISS partners' expected ISS cost of around $100 billion. Success or failure in ISS market development and customer acquisition of the present business functions will determine whether they will survive in the next few years. The continuation of the development of the space tourism market, the creation of SpaceShipOne and the expected development of the R&D and emerging markets, all showed market potential. Examples of R&D markets are drug development, preventive therapies for osteoporosis or development of lighter and stronger materials and the emerging ones can be defined as flight entertainment, space cosmetics and advertising markets. At present in the ISS markets the ISS partners have a nurturing role, due to the lower market demand, however with the ISS market evolution the Frenzied stage can be most probable for the future ISS commercial environment and will resemble most the medium market demand scenario.
The irregular space shuttle flights after 2003 left only one ISS partner to offer transporta-

[5]There is limited literature on ISS commercialisation and a lack of consistent information on national space budgets as a percentage of GDP of national economies. Furthermore there is a lack of a centralised European information portal for civil/military space expenditure, European space industry turnover, expected growth of space applications sales (i.e. launch services, navigation, etc.). Furthermore, certain research data shows overly optimistic projections for turnover from commercial and civil space applications.

tion access to the ISS and is considered a risk, the cost of which is paid by all the ISS partners. At present in 2006, ISS commercialisation is exposed to political risks. The introduction of the new US Moon and Mars space visions in the beginning of 2004 created consideration for an increase of the NASA space budget to finance the development of new technologies for this vision. According to [9] the US Senate approved a $16.4 billion space budget for 2006, showing a $200 million budget increase from the previous year. This expected budget increase is a positive trend for space companies, that will encourage the development of new space technology. In anticipation, US space companies (e.g. Boeing, Lockheed Martin, etc.) created in 2004 a Coalition of space exploration to lobby for the implementation of the US Moon and Mars space visions. The question that thus arises is whether NASA's request of $100 billion for the next 12 years [9] for a human Moon mission in 2018 will be sufficient to achieve its goal and whether cost overruns combined with political ignorance will constrain US Moon and Mars visions. The US initiative for the new vision of Moon and Mars space exploration is diverting public attention from the existing ISS commercial opportunities and is causing harm. This new Moon and Mars space exploration vision may only serve political objectives, without sufficient funding. The lack of a clear role of space commercialisation in this new space exploration vision could result in the end of commercialisation of space technology and the loss of potential customers and revenues. ISS commercialisation can be a basis for future commercialisation of other space technologies, for earth observation, navigation or technology transfer programmes. Today's ISS commercialisation can become the basis for tomorrow's partial commercial exploitation on human and robotic interplanetary space missions.

Chapter 11

Glossary

Acquisition is the outright purchase of one organisation by another and the whole transfer of the ownership thereof.
Barometric leader changes the price of a product or service, at the right time and in the right economic climate.
Break-even pricing is a pricing approach under which the price of a product or service is set at a level at which the relevance from the break-even volume of sales matches the variable and fixed costs.
Business cycles describe the changes in economic growth or slowdown, also referred to as trade cycles or economic cycles.
Business Function is an intermediary between a space agency and commercial customers.
Cartels are usually created between companies that agree to behave as if they were a monopolist in a specific market. They agree to have the same cartel price for the products or services, to divide the market among themselves and capture the benefits that usually exist for monopolists. These companies achieve this by reducing production while increasing artificially prices.
Collaborative integration is an equity-based collaboration, occurs when founders integrate their ownership rights, their resources (i.e. financial, marketing) and their activities.
Commercial customer is any customer, who buys ISS products and services and pays a certain price for using them.
Commercial Evaluation Team (CET) is an ESA based team that evaluates and selects commercial proposals.
Commercial payload is a payload operated by a private company. However, a commercial payload, can also be a payload funded by the government, but provides satellite services partially or totally through a private company. The second distinction is usually applied to certain telecommunication satellites whose transponders are partially or totally leased to a variety of organisations, some or all of which generate revenues [37].
Commercial space markets include satellite operators, launch services operators, and

sales of space technology.
Commercial proposal is an official document, in which a commercial customer submits his/her idea of a project to ESA. In this proposal she/he describes the project objectives, scenario and schedule. The commercial proposal needs to consist of information on the technical, ethical and financial aspects of the customer's project [87].
Commercialisation is the process in which public facilities or properties are used for the commercial activities of private companies, without transfer of public ownership.
Competitive environment is an environment in which companies compete for customers.
Concentration ratio in an industry is a measure of competition. It shows the degree by, which an industry is dominated by large companies. Or the percentage of industry sales (or assets, output, labor force, or some other factor) accounted for by x-number of companies in the industry [96]. Concentration Ratio (CR)=Four-firm Concentration Ratio(CR4)/CR4=% of industry sales accounted for by the largest companies [96].
Contractual integration is defined as companies integrate only part of their activities on a non-equity basis. Companies aiming at joint production or R&D which do not require ownership could form strategic alliance agreements or create licensing agreements.
Cost-based pricing is a pricing approach in which a company identifies its costs for production and sales and adds a mark-up to these costs.
Demand illustrates the willingness and ability of buyers to purchase different quantities of a good, at different prices, during a specific period of time. The law of demand states: the quantity of demand for a good for a period of time will fall as the price rises and rises as the price falls with other parameters being constant [55].
Dominant price leader is an organisation that determines prices for certain products or service and the other companies take this price as given.
Drop towers are ground-based research facilities with which up to 10 sec of weightlessness can be achieved [41].
Driving force is considered one that has a strong influence on the strategic and market developments in ISS commercialisation and makes ISS partners, present and future business functions to take certain policy or business decisions.
Duopoly is a when there are only two companies in a specific market and compete each other for customers.
Economic development is a qualitative change of an economy and restructuring of a country's economy in connection with technological and social progress. The main indicator of economic development is increasing GNP per capita (or GDP per capita), reflecting an increase in the productivity and average material wellbeing of a country's population [7].
ESA CPO is ESA's commercial promotion office esponsible for the marketing and sales of ESA ISS products and services.
ESA promotion support is granted by ESA upon acceptance of a submitted commercial proposal, with attached business plan, on the basis of a number of evaluation criteria and

in accordance with some restrictions stated in the policies of the Agency. Support may be in-cash or in-kind. In-cash promotion support includes direct funding, deferred payment and price reduction. In-kind promotion support includes among others on-ground payload related services and provision of test facilities and expertise [87].

Ethical constraint are criteria to reject any form of association with the following; alcohol, tobacco, religion, politics, intolerance, violence, firearms, pornography, obscenity, gambling and narcotic drugs [87]. Commercial projects under the above aspects will not be selected as commercial proposals.

Extravehicular activities (EVA) are cosmonaut/astronaut activities outside a spacecraft space stations.

Joint ISS Business Function (JIBF) is an ISS future scenario in which one company has exclusive rights to sell the ISS products and services for all the five ISS partners.

Founders are the creators of the future business function. They could be ISS partners or non-space companies willing to commit resources to a future business function.

Game Theory is when each company forms a strategy, which is a plan of action (i.e.price setting or quantity changes) and each company can use them in competition with the rest of the companies in the market.

Initial selection criteria are used for the assessment of present business function and for the selection of a collaboration model for the future business function. These criteria are; value-for money, political transparency, complementary resources and risk and profit sharing.

Institutional markets is the demand from institutional customers (i.e. space agencies, institutes), high market entry barriers and strong governmental regulation. The institutional markets include customers from space agencies, national civil programs and multi-lateral civil and military programs.

Intellectual Property Rights (IPR) are the rights which commercial customers, who finance 100% of their commercial experiments to the ISS, can recieve from ESA. While, the institutional users have to reveal their research results to the publicwithin a period of one year [87].

Internal environment of business functions cover aspects such as objectives, ownership allocation and level of integration between the potential founders.

External environment describes the driving forces that influence the current ISS commercial environment and present and future business functions' development.

International Space Station (ISS) is a space habitat and laboratory, positioned in an orbital altitude of 360-460km. The ISS construction started in 1998, with the launch of the Russian "Zarya" module. The ISS is designed to host 3 to 7 astronauts.

ISS commercial environment is the environment in which the ISS products and services are sold to commercial customers, by either the ISS partners directly or by present or future business functions.

ISS commercialisation is the process by which ISS products and services are sold to industry, based on market forces, in order to generate income to offset the incurred ISS marginal costs by the ISS partners. Ownership of the ISS products and services remains with the ISS partners.
ISS market failure this is a situation in which the ISS markets do not develop and commercial customers are not able to access and buy ISS products and services.
ISS partners are the five space agencies NASA, ESA, RSA, JAXA and CSA building and operating the International Space Station (ISS).
ISS self-sustainable markets are markets that do not need to rely on public investment for their development and dominated by the forces of supply and demand. These are markets which will continue to develop after the end of the life-time of the ISS, will be able to meet the needs of the future commercial customers for space-based products and services.
ISS Partners Direct Competition (IPDC) is an ISS future scenario in which all ISS partners sell their ISS products and services directly to commercial customers. The ISS partners are in direct competition for customers and there are no business functions.
Intravehicular Activity (IVA) are cosmonaut/astronaut activities inside a spacecraft (e.g. space stations, Soyuz).
Joint Venture is a distinct legal term given to an organisation usually involving public and private bodies assuming some equity or stake in the organisation.
Lease is when a government or an organisation owned property is used by a private company to engage in commercial enterprise.
Licensing agreement is when a company acquires a licence for the use of a specific technology.
Low-Cost leader has cost advantages to its rivals, therefore has market power in a certain market, could change prices and is a price setter. The rivals would be concerned for a price war and this is the reason rivals tend to see how the low-cost leader changes prices [70].
Market Power is the ability of a company to set prices above marginal cost and earn a positive profit.
Marketing Rights are rights involved in the act or process of promoting and selling products or services. Marketing rights are mainly copyrights and trademarks, that are subject to negotiation in sponsorship and advertising contracts. Should a customer wish to take pictures or videos on board the ISS, marketing rights will be a matter of negotiation [87].
Monopoly theory is a theory of market structure based on three assumptions; there is one seller, it sells a product or service for which no close substitutes exist and there are extremely high barriers to market entry.
National business functions are hypothetical business functions which are an intermediaries between ISS partners and customers for selling ISS products and services in the future ISS commercial environment.
Negative market trends are market trends that constraint ISS commercialisation of

space stations [117].
Operational assessment criteria are criteria to measure performance of a collaboration once it is implemented. Financial, strategic, managerial and founders compatibility are some of the examples for criteria.
Positive market trends are market trends which encourage the successful development of ISS commercialisation.
Price is the amount of money charged by an organisation or company for a product or service.
Price discrimination occurs when sellers in a certain market charge different prices for the product it sells, where the price differences don't reflect cost differences.
Price Leadership Theory is a theory under which a company is referred to as a dominant price leader in the industry, determines and sets the price of a certain product or service and all other firms in the industry/market take the price as given.
Price setter is a company which influences the market price of the rest of players in the market.
Price taker is a company that takes the price of a certain product and service from the price setter.
Prisoner's dilemma occurs when two companies independent from each other choose the best strategy for their competitive actions and end up in the worst position, than if they had cooperated together.
Privatisation is the transfer of ownership and control of state-owned enterprises, is a major trend in industrial countries, transitional economies and developing countries [8].
Products can be anything (i.e.tangible) offered to customers for attention, acquisition, use or consumption, which will satisfy a demand of a commercial customer [94].
Service is an activity or benefit offered to its commercial customers which is intangible and does not result in ownership.
Product differentiation exists when organisations upgrade and change existing products and services to make them different from the ones of the competitors.
R&D markets are the ISS targeted markets from either the ISS partners, present and future business functions. These are markets, such as biotechnology, health, environment and new materials.
Relevant scenario is an ISS future scenario in which the market conditions permit the creation of a future collaboration model between an ISS partner and private company.
Supply illustrates the willingness and ability of the sellers to produce and offer to sell different quantities of a good at different prices during a specific time of period.
Target-Return pricing is when the profit is calculated based on the financial investment required for the product or service, the return needed to attract that investment and the estimated sales volume.
Two-way access scenario is an ISS future scenario that describes customers access-

ing the ISS products and services, either through the space agency directly or through a national business function.

Appendix A

International Space Station Overview

A.1 International Space Station

In this appendix is a short description of the ISS, the ISS partners commercial objectives, sales conditions and ISS prices. This section supports the description of the current ISS commercial environment in Chapter 2 and ISS commercialisation. The ISS is currently the only space laboratory in orbit. In 1985 US president Reagan proposed the creation of the space station in response to US science needs in microgravity. In the early days of space station design the US was planning to build the station only together with ESA, Japan and Canada. The station became reality as a result of the international cooperation between the five ISS partners; NASA, ESA, RSA, JAXA and CSA. An Intergovernmental Agreement (IGA) signed on the 1998 sealed their partnership. Their roles and responsibilities were defined into four Memoranda of Understanding (MOU) between NASA and ESA, CSA, RSA, JAXA. The ISS assembly began in 1998, with the launch of the Russian built "Zarya" module, followed a month later by the US built "Unity" module. The ISS crew can be from 3 to 7 astronauts/cosmonauts, the orbital altitude of the ISS is between 360-460 km and its orbital velocity is of 28 000 km/h. The expected weight of the ISS will be around 450 tonnes and its expected lifetime longer than 15 years. Figure A.1 illustrates the ISS. The common objectives of the ISS partners for the ISS are: 1) to create a venue for space-based scientific research, 2) to create an infrastructure for the development of space-based commerce and 3) exploration among the people on Earth leading to demand for space-related education at all levels and countries and create a forum for international cooperation. The ISS partners also set commercialisation objectives, of which the more important ones are summarised below:

- Create new sustainable markets and encourage the use of free market principles in the servicing and operation of the ISS
- Position national industries for leadership and enhance their competitiveness

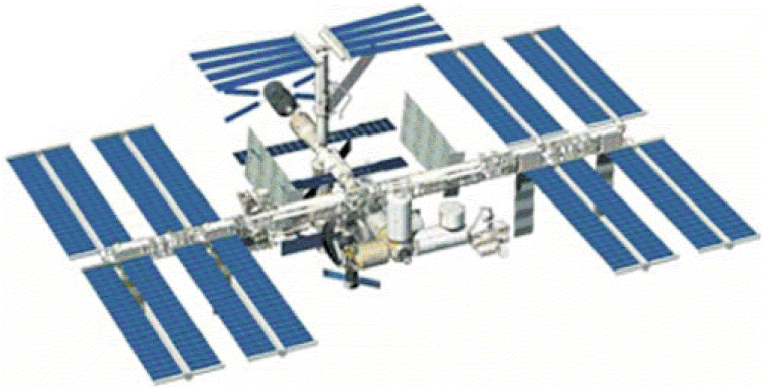

Figure A.1: International Space Station

- Exploring and exploiting innovative uses of the ISS
- Maximise value and positive image of the ISS
- Build partnerships

These objectives reveal strong motivation and openness the ISS partners towards the development of ISS commercialisation.

A.2 ISS Partners Transportation and Crew vehicles

In this section is an overview of the ISS partners transportation and crew vehicles. This overview in Figure A.2 contributes to a better understanding of the ISS partners products and services in section 2.3.4 and ISS prices in section 2.3.7.

A.3 ISS Partners' Sales

In this section is an overview of the conditions and ISS prices under which the ISS partners offer access to ISS products and services. Table A.1 shows the ISS partners sales conditions for ISS products and services sales. This table supports the identification of the market entry barriers in the current ISS commercial environment in section 2.3.2. Table A.1, summerises the sales conditions for commercial projects acceptance for each ISS partner. The conditions include timescale of a project and costs that customers have to pay. ESA customers can use promotional prices as a result of ESA geographical return rule and also can share the use of a facility, in contrast to NASA and RSA. NASA and RSA do not permit the re-sale customers rights for use of ISS products and services. Under the registration group all the NASA, ESA, RSA and CSA review the information on business&technical

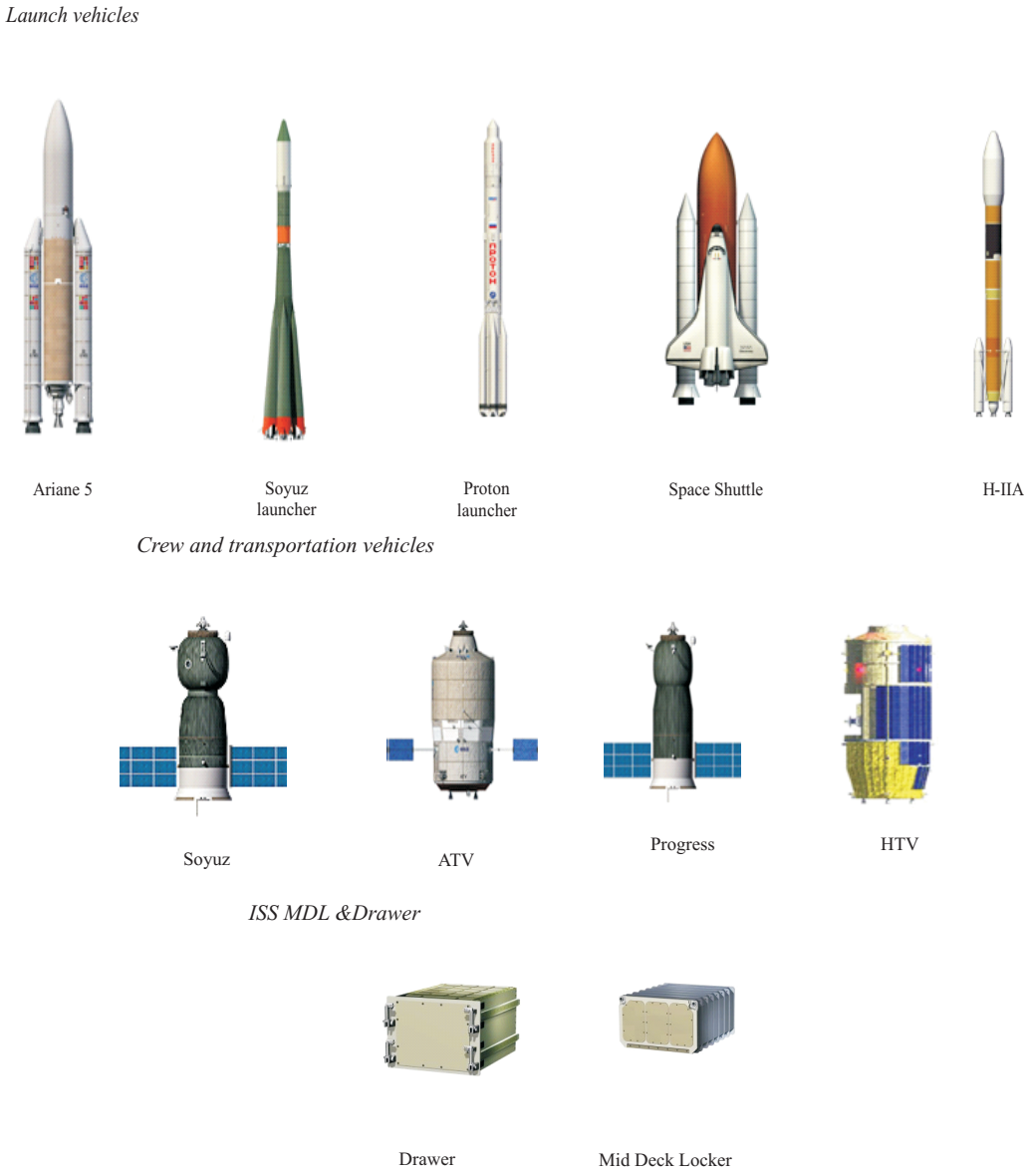

Figure A.2: ISS partners' transportation and crew vehicles. The MDL in the Figure are conventional lockers for Space Shuttle and ISPR, while the ISS drawers are ones typical for the Columbus Module [30]. Courtesy of ESA.

and legal issues. JAXA has an interview with customers. The offer description under commercial proposals includes also information on technical and company information, market analysis,strategy plan, financial plans and letters of intent. The ISS partners send regular information to the customers on the evaluation results and the status of the commercial project.

Conditions	NASA	ESA	RSA	JAXA	CSA
Timescale	1 year	negotiable	negotiable	n.a.	n.a.
Costs	integration	non-standard services	integration	n.a.	n.a.
Geog.rule	n.a.	deferred payments	n.a.	n.a.	n.a.
Facilities	re-sale forbidden	share 1 facility	re-sale forbidden	n.a.	n.a.
Com.proposals	offer descr.	offer descr.	offer descr.	offer descr.	offer
Review	registr.	registr.	registr.	registr.	registr.
Notification	letter	letter	letter	letter	letter

Table A.1: ISS partners sales conditions [80], [17], [101], [26]

Table A.1 shows that the ISS partners'sales conditions are very similar if not the same. This similarity is a demonstration for the ISS partners commercialisation interdependence, investigated in section 2.3.1.

A.4 ISS Prices

The information in Table A.2 is derived from the ISS partners' pricing information at the ISS Forum in Bremen in 2001. The bundled prices in Table A.2 for ISS products and services are ones sold together and include accommodation (i.e. locker, drawer, rack), crew hours and power. The unbundled prices for ISS products and services are sold separately to customers and include transportation, crew hours, accommodation and other services, as already presented in section 2.3.7, Figure 2.3. This overview is necessary for achieving a better understanding and judgement of the ISS partners pricing policies in section 4.3.2. The information presented in Table A.2 below is derived from the ISS partners price lists for 2001 [26]. At present in 2005, these ISS prices are still relevant for the ISS partners products and services.

ISS partners	Product/Service	Quantity	Price
ESA	EDR locker	1 locker for 3 months 3 crew hrs & 100 kWh	€830,000
	EDR drawer	1drawer for 3 months 4 crew hrs & 130 kWh	€1,050,000
	basic payload support	1 kg payload	€15,000
	data rate	1 min. TDRSS link	$100
	pressurised up/downmass	1 kg	$22,000
	upressurised up/down	1 kg	$26,500
	additional services	on demand	
	media & commercial	on demand	
NASA	ISPR rack (8 ISPR)	ISPR site per 1year 2880 kWh 86 crew hrs 2.0 terabits	$20,800,000
	external adapter (7 adapters)	1,800 kWh 32 crew hrs 2.6 terabits	$20,800,000
CSA	MDL locker	1 locker for 3 months 2.7 crew hrs. 90 kWh 30 gigabits space-to-ground	$650,000
	1 external pallet site (ExPA)	1 pallet site for 3 months 2.7 crew hrs 50 kWh 30 gigabits space-to-ground 1 min. TDRSS	$650,000
	data rate	1 min. TDRSS link	$100
	pressurised up/downmass	1 kg	$22,000
	upressurised up/down	1 kg	$26,500
	crew time	1 hrs	$15,000
	power	1 kWh	$2,000
RSA	up payload delivery	1 kg	$10,000-$20,000
	down payload	1 kg	$20,000-$30,000
	crew time	1 hrs.	$20,000-$40,000
	power	1 kWh	$1,300-$2,000
	pressurised volume	1 cub.m. per year	$800,000-$1,500,000
	EVA	1 exit	$2,000,000-$4,000,000
	space flight (guest mission)	1 person	over $10,000,000

Table A.2: ISS partners bundled and unbundled prices for ISS products and services [80], [17] , [101], [26]. The ISS partners prices for ISS products and services are from 2001. RSA ISS prices were later withdrawn and at present in 2005, RSA has no officialy published prices for its ISS products and services.

The ISS partners prices have already been analysed for the price leadership theory in the current ISS commercial environment in section 2.3.7 and the ISS partners pricing policies in section 4.3.2.

Appendix B

Monopoly and Oligopoly Theories

In this appendix is an overview of the monopoly and oligopoly theories. These theories are used in section 2.3 for the description of the supply side of the current ISS commercial environment. These theories are also used for the identification of predictions for the strategic developments (i.e. competition, collusion) in the future ISS commercial environment.

B.1 Monopoly Theory and ISS commercialisation

This section analyses the monopoly theory for the supply side of the current ISS commercial environment.The existence of monopolies has been observed in various industries[1] such as gas, water, electricity and others. The monopoly company sets prices to a certain product or service, meets its market demand and has no competitors. The monopolist company in an industry has the market power to set the prices for the product it sells and is therefore a price setter. Moreover, the monopolist generates monopoly profits. Therefore, the monopolist charges the highest price per unit to the customer. The profits a monopoly earns are sometimes referred to as 'monopoly rent seeking'. These are profits that aren't spent for production or new market development. The process of rent seeking refers to the actions of individuals and groups who spend resources to influence public policy, in the hope of transferring income to themselves [96]. For the monopolist this is possible because it has access to or owns unique resources. Historically, space exploration was reserved only for governments and they alone funded, developed and used space technology. With the end of the Cold War, military and civil space budgets were reduced and commercialisation of space technology was initiated by the space agencies in order to achieve partial cost recovery of their investment in building and operating the ISS. Until recently ISS partners were the only organisations with access to microgravity over extended periods of time,

[1]These are industries that require heavy infrastructure and extensive investment, which only governments can afford.

so they had and have access to unique resources similar to a monopolist company. The monopoly theory is built on three assumptions:

- there is only one seller
- the seller sells products or services, which have no close substitutes
- there are either extremely high market entry barriers in a certain market

Although rent seeking is considered a socially-wasteful activity, there are reasons against the existence of monopolies. Reasons against monopolies [96] are:

- the welfare cost of monopoly - the monopoly company produces a quantity of output that is "too small", compared to the quantity produced under perfect competition. The difference in quantity produced and results in welfare loss for society
- rent seeking is considered socially wasteful - companies competing for rent-seeking profits spend resources to influence public policies for their own purposes. These resources are not spent for the production of goods and services, but for transferring income
- X-inefficiency - is observed when there is an increase in the costs, as a result of organisational bureaucracy in a monopoly, due to a lack of competitive pressures to reduce costs

Some of the above reasons against the creation of a monopoly in the future ISS commercial environment are considered in section 7.4. Furthermore, a monopolist company can charge customers different prices for the same product or services and therefore, implement price discrimination. For the current ISS commercial environment, the overview of the ISS partner prices in section 2.3.7, Figure 2.3, resulted in considerations that RSA can become one. There are different types of price discrimination as presented below:

- perfect price discrimination is when the seller charges the highest price to each customer that is willing to pay for the product or service
- second-degree price discrimination occurs when the seller charges a uniform price per unit for a specific quantity and a lower price for additional quantities
- third-degree price discrimination occurs when the seller charge different prices for different markets

Public non-profit organisations the ISS partners have been exposed to political, rather than to market forces. Their political decisions to commercialise certain part of the ISS has led to giving commercial customers the choice to buy ISS products or services from

the five ISS partners (e.g. NASA, RSA, ESA, etc.). Moreover, they have developed and implemented independent ISS commercialisation policies and present business functions. Monopoly is not the current market structure on the supply side of the current ISS commercial environment, but as a result of the unique transportation capabilities of NASA and RSA, monopoly can exist in the future ISS commercial environment. Therefore, monopoly considerations arise for the future ISS commercial environment and will be further transformed into a monopoly hypothesis in section 6.2, the validation of which will contribute to strategic predictions for the future ISS commercial environment.

B.2 Oligopoly Theory and ISS commercialisation

In this section is an overview of the oligopoly theories for the analysis of the supply side of the current ISS commercial environment. The oligopoly theories are used in the analysis of the oligopoly in the future ISS commercial environment in sections 7.5 and 7.6. The overview of the oligopoly theories will contribute to addressing research Questions 1 and 7. In oligopoly a few companies occupy the market place and they have to take into consideration each other's actions. In oligopoly market structure:

- there are few sellers and many buyers
- companies produce and sell homogenous or differentiated products and services
- there are high market entry barriers limiting market entry for new companies

The existence of an oligopoly in a certain industry is measured by a concentration ratio[2]. In an oligopoly companies collude when they agree to limit competition among themselves, and compete when there is no such agreement. Economists have developed various theories and models under the oligopoly market structure, that describe the companies behaviour, decisions and prices under competition or collusion. In summary the theories are the following:

- cooperative oligopoly includes the cartel theory further described in section B.2.1 and the price leadership theory in section B.2.2
- non-cooperative oligopoly theories are the game theory in section B.2.3, prisoners dilemma in section B.2.4, Kinked Demand Theory in section B.2.5 and the Cournot model in section B.2.6

[2]Concentration ratio in an industry is a measure of competition. It shows the degree by, which an industry is dominated by large companies.

In the current ISS commercial environment, as concluded in section 2.3.6 the ISS partners are experiencing cost disclosure problems, market demand identification and negotiation lag problems. In the future ISS commercial environment as concluded in section 7.10 cartel creation can result in underdevelopment of ISS commercialisation.

B.2.1 Cartel Theory

Cartel Theory for the current ISS commercial environment was already discussed in section 2.3.6 and was concluded that cartel doesn't exist in the current ISS commercial environment. The Cartel Theory is based on the assumption that the oligopolists behave as if they are the only company in the industry; like a monopolist. The cartel companies aim at collecting joint profit by reducing production and increasing prices. Companies agree to set prices and quantities, so they collude and form a cartel.
An example of a joint profit-maximising cartel is the Organisation of Petroleum Exporting Countries (OPEC). Five major oil exporters, Iraq, Iran, Kuwait, Saudi Arabia and Venezuela, which quickly rose to 13 member countries, formed it in 1960. In terms of activity and standing in the International Community, OPEC was most prominent in the 1970s. Saudi Arabia is a dominant member of the cartel, with the ability to set prices. Other members of the Cartel are therefore price takers, unable on their own to affect the market price. It is clear that when price falls, Saudi Arabia has increased output in the period beforehand. Cartels aim at capturing the benefits that usually exist for a monopolist. In cartels companies usually reduce quantity produced and increase price. Cartels impose price levels of their production at which they can earn a profit. Cartel profits are the incentive for companies to form a cartel, but a cartel also brings various problems. The ISS partners in the current ISS commercial environment have already experienced some of the problems below, as concluded in section 2.3.6. These problems as identified by [70] are the following:

- cost disclosure and accuracy problems - members have an incentive to understate their levels of costs, where the bargaining process may affect price and where members divide profits in a cost-differential way
- market demand identification - a cartel might find difficulty in accurately calculating market demand
- negotiation lag - the time it takes to organise even a few companies to gain agreement about appropriate price levels, quotas and other aspects, which can make binding agreements difficult to achieve
- free-riding - where organisations have higher cost bases than their fellow members, but gain from the profit-sharing nature of the cartel; they are considered as free-riders

- market entry by other companies - the high profits generated by the cartel are an incentive for other companies to enter the market and the cartel may break up
- cheating in cartels - a cartel creates an incentive for members to cheat. Cartel members can produce and sell additional units to the agreed volume, thereby generating more profits than other cartel members

In the current ISS commercial environment, as concluded in section 2.3.6 the ISS partners are experiencing cost disclosure problems, market demand identification and negotiation lag problems. In the future ISS commercial environment as concluded in section 7.10 cartel creation can result in underdevelopment of ISS commercialisation.

B.2.2 Price Leadership Theory

The analysis in section 2.3.7 showed that for the supply sides of the current ISS commercial environment this is the relevant theory. In the Price Leadership Theory a company, referred to as a dominant price leader (i.e. price setter) in a certain industry, determines the price of a certain product or services and all other firms in the industry take the price as given [96], so they are price takers. The dominant price leader thereby forces the other companies on the market to adopt their prices of their products and services to the leader's levels. However, the dominant firm takes a risk in changing prices, as the other firms might not follow suit. The dominant firm will use average costs as a basis for price setting for its product or services and the price is set at a level at which the dominant price leader achieves a target level of operating profits. There are generally three types of price leaders under the price leadership theory, as identified by [70]:

- Barometric Leader - changes prices at the right time and relevant economic climate
- Low-cost Leader - has cost advantages over the other companies in the market. Therefore, the cost leader could change prices and become a price setter. The rivals would be concerned for a price war and this is the reason rivals tend to see how the low-cost leader changes prices. In case of a price war the rivals will lose more [70]
- Dominant Firm - is a large company which sets its price based on price information it has of other companies in the industry [96]. The dominant firm then achieves profit-maximisation at a price level for which the other companies in the market will not achieve profit maximisation

The analysis from section 2.3.7 showed that NASA and RSA are price setters and NASA could behave as a dominant price leader while RSA could behave as a low-cost leader. ESA, CSA and JAXA are price takers due to their increased dependency on NASA and RSA for transportation services to the ISS and their smaller quota of ISS products and

services. The process through which the price leader sets its prices in a certain industry is based on information he has for the rest of the companies. Certain ISS partners, like NASA and RSA as concluded in section 2.6 are price setters, while others, such as ESA, JAXA and CSA are price takers in the current ISS commercial environment.

B.2.3 Game Theory

In this section is a short description of the Game Theory as a theory of the non-cooperative oligopoly. This theory is taken under consideration in the analysis of the future ISS commercial environment in section 7.5 and section 7.7. The Game theory as presented by [54] describes the theory in which companies form a strategy as a plan of action in which they either change the quantity companies sell or the price of the products or services. In this case each firm is interested in achieving the highest profit. To describe Game Theory, an example from [54] of two companies in a certain market, is presented (i.e. duopoly). Two airlines, American Airlines and United Airlines, compete for customers on flights between Chicago and Los Angeles. The total number of passengers flown by these two companies is Q, with the number of passengers flown by American Airlines (qA), and passengers flown by United Airlines(qU), as presented in Figure B.1. It is assumed that the airlines could pick-up a certain number of passengers; therefore an airline could pick up 64 units (one unit being a thousand passengers) per quarter or a smaller quantity of 48 units per quarter.

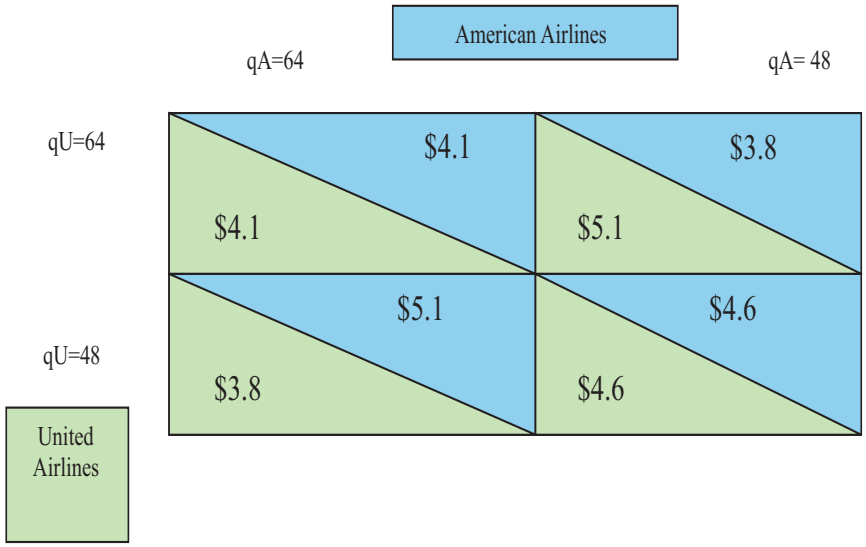

Figure B.1: Game Theory Example [54]

In the example from Figure B.1 both companies choose their strategies simultaneously; each firm selecting a strategy that maximises their profit, given what it believes the other

firm will do. The choice of the most appropriate strategy depends on what the company considers a dominant strategy and American Airlines can determine the dominant strategy, based on the following reasoning:

- if United Airlines chooses a high-output strategy (qU=64), then American Airlines makes a profit $3.8 million and therefore, better off using a high-output strategy if United uses a high-output strategy
- if United Airlines chooses a low-outputs strategy (qU=48), the high-output strategy of American Airlines(qA=64) is profit maximizing

Thus, the high-output strategy is American Airlines dominant strategy. American Airlines profit will be higher than of its high-output strategy. The high-output strategy is a dominant strategy for both firms qA=qU=64, this is called a Nash Equilibrium. In the future ISS commercial environment in the competition scenario in section 7.5 it is possible that NASA and RSA find themselves in a situation similar to the Game theory, as discussed in section 7.5.

B.2.4 Prisoner's Dilemma

The prisoners dilemma theory appears when two or more companies, independent from each other, choose the best strategy for whatever the other is likely to do and end up in a worse position than if they had cooperated. This is the case if the two companies United Airlines and American Airlines, as presented in Figure B.1, will produce the same quantity (Q) of 64. Therefore, both will earn a profit of $4.1 million, which is less than the potential profit of $4.6 million. They are therefore tempted to reduce prices at the same time and will end up with lower profits than if they had charged the higher price. Therefore, collusion between the two companies, rather than a price war, would have benefited both. Under the ISS Partners Direct Competition (IPCD) Scenario, from section 7.5, it is possible that NASA and RSA do find themselves in a prisoners dilemma.

B.2.5 Kinked Demand Theory

The Kinked Demand Theory is another non-collusive oligopoly theory that aims at explaining how, despite of no collusion between the oligopolists, the price of certain products and services can remain stable. The theory is based on two assumptions:

- if an oligopolist cuts prices, rivals feel forced to follow suit and cut theirs, to prevent losing customers to the first firm
- if an oligopolist raises price however, rivals will not follow suit, as by keeping their prices the same, they will gain customers from the first firm [70]

In the Kinked Demand Curve Theory the main assumption is that if a single firm lowers its price, other firms will do likewise, but if a single firm raises its price, the other firms will not follow suit. This theory can be relevant in the future ISS commercial environment, once the ISS markets develop and the competition scenario becomes actual as presented in section 7.7.

B.2.6 Cournot Model

In this section is an overview of the Cournot model under which companies can choose to sell at the output level they wish. The Cournot model can be observed when the following features exist in a market:

- there are two firms and no one can enter the market
- the two firms sell identical products or services
- the companies compete in a market in which the product and services they sell cannot be stored or sold later

The companies have to choose a strategy to maximise profits, by taking into account beliefs about the output competitors will sell. The Cournot Equilibrium: a set of quantities sold by companies where holding the quantities of all other firms constant, no other firm can obtain higher profit by choosing a different quantity [54]. The strategy chosen by each firm depends on the demand curve it faces and the marginal cost, because companies maximise profits by operating where marginal costs equal marginal revenues.
The game theory, the prisoner's dilemma, the kinked demand theory and Cournot model, are non-collusive oligopoly theories. These may become relevant in the future ISS commercial environment in Chapter 7.

Appendix C

Space Industry

In this appendix is an overview of the American and European civil space budgets and percentage of institutional and commercial customers in the European space industry. These overviews are directly linked to the analysis of world space budgets in section 3.3. In this section is an overview of the global sponsorship spending in section C.2, the overview of which will be considered in the analysis of the emerging markets in section 3.5 and ESA ISS targeted markets in section 4.3.4.

C.1 American and European Space Budgets

The analysis of the world space budgets and civil and military space budgets in sections 3.3, supported the identification of market and strategic development that influence ISS commercialisation. Therefore, in this appendix is a comparison of the US and European space budgets in Table E.1 and an overview of US space budget from 1997-2004 in Table E.2. In Table E.1 the European civil space budget is the sum of ESA budgets, the national space budgets and European contributions to Eumetsat. The US civil budget includes NASA and the National Oceanic and Atmospheric Administration (NOAA).
NASA highest public investments for 2003 are in human space flight and space science. In contrast to Europe, that has invested most of its budgets in launch development, earth observations and human space flight. The above percentages of allocated space budgets in human spaceflight for 2003, illustrates that NASA and ESA are on two different ways towards ISS commercialisation. Europe's space budgets show that it aims at implementing a wide spectrum of programs for different space applications. ESA will have to encourage the development of ISS commercialisation in the case of budget constraints, as discussed in section 3.3.
Table E.2, presents and overview of the US space budget from 1997 to 2004. The US space budget includes NASA and the Department of Defence (DOD) budgets and others.

Activity	USA	Europe
Human Space Flight	32.8%	13.3%
Space Science	24.3%	11.5%
Launch services	0.7%	17.0%
Earth Observation	8.2%	17.2%
Meteorology	4.7%	5.8%
Telecommunications	0.6%	6.9%
Navigation	0.0%	7.2%
Technology	17.4%	5.7%
Microgravity	2.2%	2.9%
General budget	9.1%	12.5%

Table C.1: US and European civil space budgets for 2003 [21]

Year	NASA	DOD	Others	Total
1997	€10,594	€11,602	€1,856	€24,053
1998	€11,333	€12,500	€2,000	€25,833
1999	€13,665	€15,000	€2,500	€31,165
2000	€14,315	€15,789	€2,631	€32,736
2001	€15,777	€16,666	€3,444	€35,888
2002	€17,011	€17,241	€3,448	€37,701
2003	€15,470	€15,000	€3,000	€33,470
2004	€15,600	€15,000	€3,000	€33,600

Table C.2: US space budget from 1997-2004 in million euros [76]

Until 2003 DoD received slightly higher budgets than NASA. Table E.2 shows that the ISS development is not a priority for the current US administration, compared to military space expenditures.

C.2 Sponsorship spending

The overview of sponsorship spending is necessary for a better understanding of the expected market trends from the development of this emerging market in section 3.5. Figure C.1, shows global sponsorship spending worldwide for 2001.

The information from Figure C.1 will also be used for the analysis of the ESA ISS targeted markets in section 4.3.4.

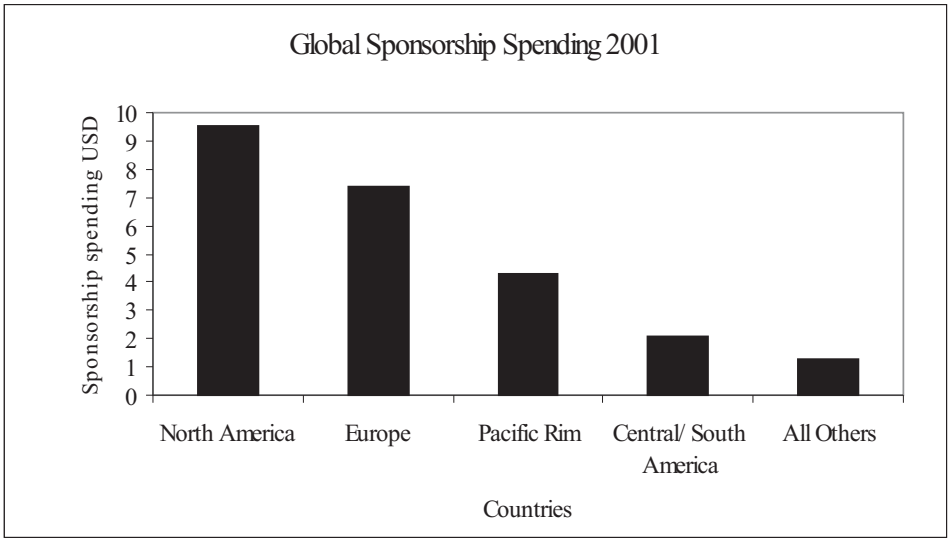

Figure C.1: Global Sponsorship Spending for 2001 [47]

C.3 Risks in Space Industry

In this section there will be an overview of the risks from space industry that could have an influence on the current and future ISS commercial environment.The space industry is accompanied by technical risks that can lead to loss of human life and spacecraft. In this section is a summary of the business, economic and political risks for the space industry. The results from this section will address research Questions 1 and 5, from section 1.3.

C.3.1 Business and Economic Risks

Space ventures have to deal with high technical risk and costs, which are inevitably part of space projects. The risks cannot be eliminated but need to be taken into account and defined measured and managed [23].
Tudge [23] describes business risks for space industry to cover faulty sales forecasts, poor marketing surveys and the failure to anticipate competition. These are hidden risks and may lead to the bankruptcy of companies. The Iridium case is a clear example of how business risks can lead to bankruptcy. To illustrate the danger of overpricing products and discarding ground-based competition the example of Iridium will be presented. The company failed to assess that "commercial users found a $7 billion, 66 satellite Iridium system too clumsy and too expensive to use" [107]. Too high expectations from sales forecasts and the advance of ground based mobile technology failed to take into account a pessimistic scenario, which later became a reality for Motorola and other companies. The low number of sales, reduced demand, high costs and high prices were major problems

Iridium had to face. The high prices for users were extremely discouraging; not only for the handset but also for the telephone calls "Initial phone cost upwards of 3,000 Dollars and were about the size of a brick" [107]. A user of the Iridium system had to pay $7 per minute, considered an extremely high price having in mind that, in 1998, probably the highest price a user had to pay on a cellular mobile was $1 per minute. Competition from cellular phones, and a decline in prices for their services, also put pressure on Globalstar, another mobile satellite phone company. Increased military space expenditure, and ISS partners' cost overruns are some of the economic and budgetary aspects affecting the space industry. The high military space budgets may constrain the successful development of ISS commercialisation. Political rather than market forces could become dominant in ISS commercialisation. Leading to a reduction of ISS products and services, constraining the R&D market development and increasing prices for ISS products and services, thus influencing ISS prices and present business functions. The US withdrawal of funding for a space station is possible on projects and resources that do not support the long-term Moon and Mars journeys. International cooperation and the successful development of ISS commercialisation can be endangered because of ISS partners' disagreement over such cutbacks. The economic and budgetary risks from space industry on ISS commercialsiation, will need to be taken into account by the ISS partners and present business functions when formulating a risk management strategy for mitigating risks in ISS commercialisation.

C.3.2 Political and Environmental Risks

The space industry is exposed to strong political and environmental forces, which will be illustrated with some examples. The war against terrorism has already started influencing the space industry. The loss of the Columbia Space Shuttle in 2003, and the life of seven astronauts, showed the dangerous nature of space exploration. This led to the grounding of the space shuttle, until 2005 and leaving Russia as the only ISS partner with access to the ISS. The delays in the space shuttle flights put the launch of the European Columbus module on hold, leading to Europe currently having to pay the cost of maintaining the module. ISS commercialisation will be negatively influenced and result in loss of customers, revenues and reluctance for long-term investment from present business function into the development of R&D markets. Business, economic and political risks must be carefully considered by the ISS partners and collaborations in the current ISS commercialisation.

Appendix D

Collaborations

In this appendix is a SWOT analysis of the ISS partners present business functions. The results of which are summarised in in section 4.4. Followed by a description of the strengths and weaknesses of the collaborations and summerised in section 5.4.

D.1 SWOT Analysis of Present Business Functions

The SWOT analysis of the present business functions in Table D.1, supports the present business functions analysis in section 4.4. Table D.1, shows an analysis of NASA RPC, JAXA ISS Business Forum, RSA, ESA Co-operation agreement and ESA Commercial Agent. At present in 2006, CSA has no plans for having a present business function.
The above SWOT analysis contributes in section 4.4 to the identification of opportunities and threats for the strategic development of present business functions. The information from Table D.1shows how the ISS partners market their ISS products and services.

D.2 Description of Collaborations

In this section is a description of the major characteristics of the various collaborations considered in section 5.4. These collaborations are considered for a future business function selection in section 9.3.9. Licensing agreement is signed when a government licenses a facility to a private company [31] and is a short term agreement of 3 to 5 years. While for the leasing agreement the duration is from 5 to 10 years. For the franchise agreement usually a government or private organisation awards the exclusive right to a company to sell a product or service. In contrast to the concession under which a private company uses public property (i.e. airports) for commercial activities and is usually a long-term agreement from 10 to up to 30 years [31]. The strategic alliance is an agreement between organisations [57] for joint technology development, production and R&D activities. Table D.2 presents an

Present Business Functions	Strengths	Weaknesses
NASA RPC	new centers	product development 2-3 years
	industry driven	needs of companies
		non-profit
JAXA ISS Bus.Forum	operated by private companies	non-profit
	business with ISS, Space Shuttle	public funding
RSA	direct negotiation	short-term
ESA Co-op.agreement	promotion of ISS opportunities	not active players
	wide range of technical services	functions not to aerospace
	wide market coverage	withdraw from the agreement
		no definition of p/s
		no ownership rights
ESA Commercial Agent	non-space founders	ESA defines its functions
	wide market coverage	undefined ISS portfolio
	Opportunities	Threats
NASA RPC	wide network between players	low industrial investment
	commercial centers creation	conflict of interest
		long period to the market
JAXA ISS Bus.Forum	integration of users requirements	public funding of com.projects
		reduced public investment
RSA	customer needs integrated	no transparant prices
	develop unexpected markets	price discrimination
	awareness of ISS opportunities	market power
ESA Co-op.agreement	wide market coverage	dual role &low incentive
		request for funding
ESA Commercial Agent	market&customer access	dependance on ESA
	profit oriented	
	freedom to develop ISS markets	

Table D.1: SWOT analysis of the present business functions

overview of the advantages and disadvantages of collaborations with contractual level of integration.

	Advantages	Disadvantages
Contractual integration		
Licensing agreement	public ownership [31]	danger of over licensing [4]
	financing from company	under-commitment
	ops & maintenance by company	
	management	
	risk carried by company	
Leasing agreement	5 to 10 years the agreement	no risk& profit sharing
Franchise	company sells a service to the public	
Concession	capital financing is by company	lack of ownership rights
	ops & maintenance by company	low incentive to invest
	management	
	risk carried by company [31]	
Strategic alliance	wide and flexible range of activities [4]	lack of ownership rights
	each company maintains its legal entity	low incentive to invest
	non-equity	alliance easily dissolved
		commitment is low

Table D.2: Description of contractual level of collaborations

The above information is used in the selection of a collaboration for a business function under the medium market demand scenario in section 9.4.9.
Public Private Partnership (PPP), joint venture, consortium and corporations are collaborations considered for the selection of a collaboration for the future business function under the high market demand scenario in section 9.3.9. PPP are collaborations between public and private organisations, while joint ventures are usually created when the collaborations activities develop in a distinct business [4]. Consortiums are collaborations created when several companies work together and management is equally shared, while a corporation is a legal entity that exists with or without any shareholders [19]. Table D.3 presents the major characteristics of collaborations under collaborative level of integration.

	Advantages	Disadvantages
Collaborative integration		
Public Private Partnership (PPP)	risk & profit sharing	large scale of resources
		lacks robustness
		long negotiation processes
Joint Venture (JV)	risk & profit sharing	fragile structures
	increase size & market power	negotiations costs
	gain competence	IPR problems
	lead business to competitive edge	risk transfer [99]
	reduce competition	limitation of contracts [4]
	cost & risk sharing [4]	large scale of resources
	high level of commitment & resource	
	synergy of resources [4]	
Collectively Managed (JV)	partners allocate resources	
	new company creation aim	
Consortium	wide market coverage	lack of enough robustness
	wide range of p/s	reduced market demand
	combination of unique resources	
	ability to meet high demand	
Corporation	raise a large sum of money	separation of ownership

Table D.3: Description of collaborative level of collaborations

The above information is used in the selection of a collaborations for a future business function under the high market demand scenario in section 9.3.9.

Appendix E

Driving forces

In this annex is a SWOT analysis of the driving forces on the supply and demand sides of the current ISS commercial environment. The results of this analysis are summarised in section 5.3. The driving forces presented in the SWOT analysis are derived from the analysis performed in Chapters 2, 3 and 4.

E.1 SWOT Analysis of the Driving Forces

In this section there is a SWOT analysis of the driving forces from the supply and demand sides of the current ISS commercial environment. Table E.1, illustrates the opportunities and threats from the driving forces on the supply side of the current ISS commercial environment. The ISS partners are exposed to more threats than opportunities from the supply side of the current ISS commercial environment, as already summerised in section 5.3. Based on this SWOT analysis it will be possible to the reasons (see section 5.3.2) and minimum conditions (see section 5.3.3) for the creation of a future business.
Table E.2, illustrates opportunities and threats from the driving forces on the demand side of the current ISS commercial environment. On the demand side of the ISS commercial environment, business functions and customers can gain more opportunities from ISS commercialisation. The results for the SWOT analysis on the demand side of the current ISS commercial environment are presented in section 5.3. The above driving forces will influence the reasons for creation and minimum conditions required a future business function

Driving Forces	Strengths	Weaknesses
Political&strategic	ISS partners encourage ISS com.	non-profit organisations
	international cooperation	interdependence in ISS (section 2.3.1)
	awareness on ISS opportunities	power change of NASA&RSA
	present business functions access	
	customers (section 4.4)	
Economic&budgetary	lower space civil budgets (section 3.3)	NASA cost overruns in 2001
	space companies lower profits	freeze of ESA ISS budgets in 2001
	partial ISS cost recovery	military space expenditure
	ISS prices&com. policies (section 4.3)	prices are cost based
		standardised (section 4.3.2)
Market&commercialisation	ISS emerging markets	ISS p/s lack of definition (section 2.3.4)
	ISS markets are interrelated (section 4.3.4)	NASA &RSA prices setters(section 2.3.7)
	space tourism (section 3.5)	ISS customers unknown
		ISS markets uncertainty
		ISS market demand unknown
Resource&space industry	parabolic flights, drop towers	STS no regular ISS flights
	European companies develop	
	ISS com.(section 3.3)	Columbus not launched
		RSA provides regular ISS access
	Opportunities	Threats
Political&strategic	winning political support (section 2.5)	NASA&RSA forces
	new ISS cost-effective utilisation	high negotiations costs for ISS access
	user-friendly environment (section 4.2)	complex requirements for
		com.prop.(section 4.3.3)
		ISS partners nurturing role
Economic&budgetary	econ. slowdown encourage com.	ISS cost overruns
	market-based approaches	
	ISS price promotions	ISS prices increase(section 4.3.2)
	partial ISS cost recovery	
Market&commercialisation	encourage ISS markets dev. (section 2.4.1)	price setters increase ISS prices
	n.a	ISS market failure & wrong market
		analysis(section C.3.1)
	n.a	
Resource&space industry	international collaborations(section 3.6.1)	ISS assembly changes
	loss of investment in ISS markets	cancel. of com.payloads due to lack ISS p/s
		Columbus not launched

Table E.1: SWOT analysis of the driving forces on the supply side of the current ISS commercial environment.

Driving Forces	Strengths	Weaknesses
Political&strategic	ISS partners invest in ISS markets (section 2.4.1)	political forces
	ISS partners credibility	ISS opport.unknown
		to non-space sec.(section 2.4)
	ISS portfolio (section 4.3.5)	strong regulation(section 2.4.1)
	present business functions	
Economic&budgetary	economic growth	fear of recession
	n.a.	n.a.
	n.a.	n.a.
	ISS promotional policy	high ISS prices (section 4.3.2)
Market&commercialisation	market opport.	unknown customers
	increase sales	investments in ISS markets
	IPR, marketing rights, brand(section 4.3)	high costs
		visibility
		n.a.
Resource&space industry	parabolic flights, drop towers	RSA ISS access
	no Moon&Mars comm.	no future space stations(section 3.7)
	n.a.	n.a.
	Opportunities	Threats
Political&strategic	new ISS markets	lack ISS awareness
	n.a.	ISS prices increase
	n.a.	n.a
		n.a.
Economic&budgetary	econ. slowdown encourage com.	ISS prices cost-based (section 4.3.2)
	ISS prom.prices	high costs for use
		of space technology(section 3.7.4)
	property&marketing rights	
Market&commercialisation	first to be on market(section 2.4.1)	unknown customers
		and demand(section 2.4.1)
	competitive env.(section 4.2.2)	complex ISS com.prop. (section 4.3.3)
	comm.proposal prep. (section 4.3.3)	
Resource&space industry	investment from US space companies	reduced ISS p/s
	n.a.	customers&profit losses (section 3.7.5)
		short-term ISS market invest.

Table E.2: SWOT analysis of the driving forces on the demand side of the current ISS commercial environment

Appendix F

Research Approaches

In this appendix is an overview of the different research approaches considered for analysis of the current ISS commercial environment in section 5.3 and future ISS commercial environment in section 7.3. First there is an overview in Table F.2 of the research approaches considered for the current ISS commercial environment. These approaches are considered for the analysis of the driving forces in the current SIS commercial environment in section 5.3. Followed by an overview of the scenario planning approaches in Table F.2 for the future ISS commercial environment, which are considered for the ISS future scenarios in Chapter 7 and market demand scenarios in Chapter 9.
For the McKinsey/GE Matrix and the Boston Consulting Matrix, the SBU is a company unit, that has separate objectives and can be a company division, product line or brand. For the McKinsey/GE Matrix approach, the measuring if market attractiveness, covers aspects such as market size, growth, profitability and others. The Boston consulting product positioning is of products referred to dogs (i.e. low market share), cash cows (i.e. high market share, low growth market), problem children (i.e. low share, high growth market) and stars (i.e. high market share in high growth market). The above research approaches are considered in the selection of a research approach for the analysis of the driving forces on the supply and demand sides of the current ISS commercial environment in section 5.3. Predictions for the strategic and market developments in the future ISS commercial environment were made, as a result of the development of ISS future scenarios in Chapter 7 and market demand scenarios in Chapter 9. Table F.2, summarizes the various scenario building approaches.

Research Approach	Description
McKinsey/GE Matrix	analyse business portfolio
	develop growth strategies
	Strategic Business Unit (SBU)
	measures market attractiveness
	competitive strength of a company
Boston Consulting Matrix	analyse business portfolio
	develop growth strategies
	Strategic Business Unit (SBU)
	measures market share & growth
	positioning products (dogs, cash cows, children, stars)
PEST analysis	political, economic, sociocultural &technological forces
	forces transformed in factors
	political,economic,tech. factors
SWOT analysis	auditing companies environment
	strengths & weakness are factors of the internal environment
	opportunities & threats are in the external environment
Porters' five forces analysis	approach for analysing the competitive environment of a company
	threat of market entry, economies of scale, cost of market entry
	cost advantages
	power of buyers
	power of suppliers
	threat of substitute products
	competitive rivalry

Table F.1: Research approaches [70], [72] [65].

The use of the above approaches for the analysis of the future ISS commercial environment is analysed in section 7.3. From that analysis it becomes clear that the direct Scenario building approach of Wharton University is considered as most relevant one, because it supports the creation of scenarios in emerging markets. It will contribute to the description of players' behaviour, driving forces and trends in the ISS markets.

Scenario Approach	Description
Cross-impact method	define events & trends
(Helmer&Fowles)	define the planning intervals
	develop cross-impact matrices
	define the interdependence
	occurrence of events
	estimate the initial occurrence
	probabilities of each event & scene
	estimate the value of each trend
	perform calibration run
	define the policies, actions or sensitivity test
	perform cross-impact calculations
	evaluate results
Shell Scenario	analyse strategic concerns
(Shell)	identify key decisions factors
	analyse the key environmental forces
	define scenario logics (typically 2 issues)
	elaborate on two descriptive scenarios
	draw implications of strategic concerns & decision needs
	recommendations
Constructing industry scenarios	identify the uncertainties that affect industry structure
(M. Porter)	determine causal factors driving them
	make plausible assumptions for each causal factor
	combine assumptions for the factors into internally consistent scenarios
	analyse the industry structure
	determine the sources of competitive advantage
Direct Scenario Building Approach	define issues (time frame, scope, decision variable)
(Wharton university)	identify major actors(roles, interests and power positions)
	major forces shaping the future issues
	trends
	key uncertainties
	select two most important uncertainties
	assess the scenarios consistency
	key actors behaviour
	influence diagram
	uncertainty ranges

Table F.2: Description of various scenario building approaches [18], [98]

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Summary

Space exploration has captured the imagination and dreams of many scientists, engineers and visionaries. It has become a symbol of human ability to break the boundaries of science and technology; and now business boundaries. Yuri Gagarin's launch into space in 1961, Apollo 11 landings on the Moon in 1969 and the creation of the International Space Station (ISS) opened a new era of exciting scientific, technological and industrial achievements. The ISS has been built by five ISS partners: the National Aeronautics and Space Administration (NASA), the Russian Aviation and Space Agency (RSA), the European Space Agency (ESA), the Canadian Space Agency (CSA) and the Japanese Aerospace Exploration Agency (JAXA). The space station offers opportunities for long-duration human space-flight and provides a unique microgravity environment for scientific research and technology demonstrations. Commercialisation of space technology will bring benefits to society in the areas of, environmental protection (e.g. climate change), disease prevention (e.g. osteoporosis) and technological innovation. ISS commercialisation will allow private companies to develop and test their products. Commercialisation is the process by which ISS products and services are sold to private companies, without transferring ISS ownership .

This thesis will investigate the opportunities for the development, selection and implementation of collaborations between space agencies and commercial partners to market ISS products and services and will describe and predict strategic and market developments for ISS commercialisation. To achieve these objectives, eight research questions were identified and addressed in each of the chapters. The analysis of the research questions raised considerations for the strategic and market developments in ISS commercialisation and became a basis for the hypotheses of this thesis. The hypotheses' validation contributed to the selection of collaborations between space agencies and commercial partners under different market demand conditions (i.e. high, medium and low) for ISS products and services. The methodology used in this research is typically case-based, because the information provided by the ISS partners, ISS products and services is so limited that sound statistical analysis cannot be made. As the research is related to the professional work of the author, there are also elements of action research for the analysis of the ISS targeted markets, ISS products and services, pricing policies and commercialisation programs. Collaboration

creation is chosen as a major research subject for this thesis. A hypothetical collaboration (i.e. business function) is used between the ISS partners and the commercial customers and the description of its relationships with the various stakeholders permit the analysis of the strategic and market developments in ISS commercialisation and proposal of appropriate collaborations depending on the market demand for ISS products and services.
The current market and strategic developments in ISS commercialisation are characterised by a cooperative oligopoly: emerging ISS markets and dependence on Russia for regular ISS access. NASA and RSA are the dominant price leaders, while ESA, JAXA and CSA are price takers. NASA and RSA price dominance discourages ISS commercialisation development for the other ISS partners (i.e. ESA, JAXA, CSA) and present business functions. The expected growth of the space tourism, sponsorship markets and the creation of privately funded transportation vehicles (i.e. SpaceShipOne) are some of the current market developments. A cooperative oligopoly is the expected market structure for the future ISS commercial environment, characterised by high market entry barriers, similar prices for ISS products and services and ISS partners encouraging collusion. However the most favourable conditions for the creation of a business function (i.e. collaboration model) and most desirable is a non-cooperative oligopoly. The ISS partners' lack of clear definition of its ISS products and services, complex and high market entry conditions, confirmed the need for a collaboration model, with the primary objective to provide commercial, research, technical and value-based products and services through space commercialisation for ground-based technologies. A joint venture for high market demand and a licensing agreement for medium market demand are the proposed collaborations between space agencies and commercial partners. The proposed joint venture and licensing agreement can also be applied for programmes such as Moon and Mars space-exploration, navigation, earth observation and technology transfer programmes. The lack of a clear role of space commercialisation in the new Moon and Mars space exploration could result in the end of commercialisation of space technology and the loss of potential customers and income. Today's ISS commercialisation can become the basis for tomorrow's partial commercial exploitation on interplanetary space missions.

Samenvatting

De exploratie van de ruimte spreekt tot de verbeelding van vele wetenschappers, ingenieurs en visionairs. Het is het symbool geworden v oor de menselijke daadkracht om de grenzen van wetenschap en techniek te doorbreken; en nu de commercile grenzen. Met Yuri Gagarin's ruimtereis in 1961, de Apollo 11 landingen op de Maan in 1969 en de bouw van het International Space Station (ISS) ontstond een nieuwe tijd van spannende wetenschappelijke, technische en industrile prestaties. Het ISS is gebouwd door 5 ISS partners; de National Aeronautics and Space Administration (NASA), de Russian Aviation Space Agency (RSA), de European Space Agency (ESA), de Canadian Space Agency (CSA) de Japanese Aerospace Exploration Agency (JAXA). Het ruimtestation maakt bemande ruimtevaart reizen van lange duur mogelijk en biedt een unieke microgravitatie omgeving voor wetenschappelijk onderzoek en technologie demonstraties. De mensheid zal profiteren van de commercialisering van de ruimtevaarttechniek op het gebied van milieubescherming (denk aan klimaatverandering), ziektepreventie (b.v. osteoporosis) en technische innovatie. ISS commercialisering biedt bedrijven de mogelijkheid om hun producten en productie processen in de ruimte te ontwikkelen en te testen. Dit is het proces waarbij ISS producten en diensten verkocht worden aan bedrijven zonder dat er sprake is van eigendomsoverdracht van het ISS. Dit proefschrift zal de mogelijkheid onderzoeken van de ontwikkeling, selectie en implementatie van geschikte samenwerkingsmodellen tussen de ruimtevaartorganisaties en afnemers van ISS producten en diensten. Het zal strategische en marktontwikkelingen beschrijven en voorspellen voor ISS commercialisering. Om deze doelstellingen te bereiken zijn acht onderzoeksvragen geformuleerd en besproken in elk hoofdstuk. De analyse van deze onderzoeksvragen geeft inzicht in de strategische en marktontwikkelingen in de ISS commercialisering en vormt de basis van de hypotheses v oor dit proefschrift. De validatie van de geformuleerde hypothesesn, draagt bij aan de selectie van geschikte samenwerkingsmodellen tussen ruimtevaartorganisaties en afnemers, onder verschillende marktcondities van de vraag naar ISS producten en diensten. De methodologie die is gebruikt in dit onderzoek is case-based analyse, omdat de beschikbare informatie over de ISS partners erg beperkt is, waardoor een goede statistisch onderbouwde analyse niet mogelijk is. Omdat het onderzoek mede gerelateerd is aan dagelijkse beroepspraktijk van de auteur, zijn ook resultaten van de analyses van ISS markten, ISS producten en diensten, prijs-politiek

en commercialiseringsprogramma's opgenomen. Ontwikkeling van samenwerking tussen ruimtevaartorganisaties en samenwerkingspartners voor het commercialiseren van ISS producten en diensten is gekozen als het onderzoeksonderwerp voor dit proefschrift. Een hypothetische samenwerkingspartner (commercile functie) is gebruikt voor de beschrijving van de relaties met de verschillende samenwerkingspartners. Dit maakt tevens analyses van strategische en marktontwikkelingen in ISS commercialisering en de ontwikkeling van voorstellen voor samenwerkingsmodellen mogelijk. De huidige markt en strategische ontwikkelingen in ISS commercialisering kunnen worden gekarakteriseerd als een coperatieve oligopoly: ontluikende ISS markten en de afhankelijkheid van Rusland voor regelmatige toegang tot het ISS. NASA en RSA zijn de dominante prijsleiders, terwijl ESA, JAXA en CSA de prijs niet wezenlijk benvloeden. De NASA en RSA prijs dominantie ontmoedigt de ontwikkeling van de commercialisering van ISS voor de andere ISS partners (ESA, JAXA, CSA) en huidige commercile functies. De groei van ruimtetoerisme, sponsormarkten en het creeren van privaat gefinancierde transportvoertuigen (b.v. SpaceShipOne) zijn enkele voorbeelden van de verwachte commercile marktontwikkelingen. Een coperative oligopoly is de verwachte marktstructuur voor de toekomstige ISS commercile omgeving, gekarakteriseerd door hoge barrires voor toetreding tot de markt, uniforme prijzen voor ISS producten en diensten en ISS partners die "collusion" aanmoedigen. Maar de beste condities voor de ontwikkeling voor een wenselijke commercile functie (en samenwerkingsmodel) is een niet-coperatieve of competitieve oligopoly. De ISS partners hebben geen duidelijke definities van de ISS producten en diensten, en er is sprake van complexe en hoge markt toegangscondities. Dit onderschrijft de noodzaak voor een competitief samenwerkingsmodel, met als primaire doel om te voorzien in commercile, onderzoek, technologische en value-based producten en diensten door commercialisering van de ruimtevaart. Een joint venture bij een hoge en een licentie overeenkomst bij een gematigde marktvraag zijn de voorgestelde samenwerkingsmodellen tussen ruimtevaart organisaties en commercile partners. De voorgestelde joint venture en licentie overeenkomsten kunnen ook toegepast worden voor programma's zoals Maan en Mars ruimte-exploratie, navigatie, aardobservatie en technologietransfer programma's. Het gebrek aan een duidelijke visie over de rol van commercile ruimtevaart bij de nieuwe. Maan en Mars ruimte exploratie programma's, kan resulteren in de ondergang van commercialisering van ruimtetechnologie en het verlies van potientile klanten en inkomsten. De huidige ISS commercialisering kan een basis vormen voor toekomstige partile commercile exploratie van bemande en gerobotiseerde interplanetaire ruimtemissies.

Publications

Publication in a journal

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Biography

Stella Tkatchova was born on the 16th December 1973, in Sofia, Bulgaria. After graduating from her secondary school, the St.Cyril and Methodius and their five Disciples No7, in 1991, she enrolled as a student in the University for National and World Economy in Sofia. She undertook a bachelor and master degree in International Economic Relations and discovered the world of Economics. After graduating in 1996 she worked in various positions, but the most significant ones for her PhD research were her job as a reporter on privatisation for the Capital weekly and an expert on the secondary market for T-bonds in the Bulgarian National Bank (BNB). Her interest in the commercialisation of space technology led her to the International Space University in Strasbourg and in September 1998, she was accepted as a student there. From February until May 1999 she was an intern in the Cost Analysis Division at European Space and Technology Centre (ESTEC). During her internship she performed a market analysis on the expected revenues from the geomatic applications of the European Global Navigation Satellite System (GNSS-2). In July 1999 she was awarded a Master of Science (M.Sc.) in Space Studies. During her studies in Strasbourg, the team project of MSS 98/99 was on the commercialisation of the International Space Station (ISS). Captured by the subject in March 2000 she started her PhD research in the Faculty of Aerospace Engineering in the former group Industrial Engineering and Management under the supervision of Prof.ir.K.Smit. This research opportunity was given to her by Bob Chesson and Maurizio Belingheri, who became her industrial supervisors. From March 2000 until the finalisation of her PhD research, she worked for ESA Commercial Promotion Office (CPO) on ISS pricing policy, R&D market analysis (e.g. biotechnology, health, etc.) and ISS products and services. Meanwhile, Stella has developed a strong interest in researching the commercialisation of future technologies and potential markets for space-based technology for the future Moon and Mars human space missions.

A personal note

Ancient history has its magical ways to influence our daily lives and to impact our future. Khan Kubrat, the father of Khan Asparuh, the founder of the Bulgarian state in 681 AD, had bequeathed to his sons the motto "Power resides in unity". I myself have drawn strength from these words to continue and complete my work on this Ph.D research. Coming from the distant past, these words will continue to guide generations of young people to have the courage not only to study the planets in the Universe, but to travel and conquer them.