



European Space Policy Institute

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The Future of European Commercial Spacecraft Manufacturing

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Table of Contents

Executive Summary	5
Introduction – Research Question	7
1. The Global Satellite Manufacturing Landscape	9
1.1 Introduction	9
1.2 Satellites in Operation	9
1.3 Describing the Satellite Industry Market	10
1.4 The Satellite Industry Value Chain	12
1.4.1 Upstream Revenue by Segment	13
1.4.2 Downstream Revenue by Segment	14
1.5 The Different Actors	15
1.5.1 Government as the Prominent Space Actor	15
1.5.2 Commercial Actors in Space	16
1.6 The Satellite Manufacturing Supply Chain	17
1.6.1 European Consolidation of the Spacecraft Manufacturing Industry	18
1.7 The Satellite Manufacturing Industry	19
1.7.1 The Six Prime Contractors	21
1.7.2 The Smaller Commercial Prime Contractors	23
1.7.3 Asian National Prime Contractors in the Commercial Market	23
1.7.4 European Prime Contractors' Relative Position in the Global Industry	23
2. The Changing Landscape	24
2.1 Maintaining a Competitive Advantage	24
2.2 Intensity of Rivalry amongst Existing Competitors	26
2.2.1 Barriers to Entry	28
2.3 Threat of New Rivals	31
2.3.1 China	31
2.3.2 India	33
2.3.3 Smaller Emerging Geostationary Satellite Manufacturers	34
2.3.4 Russia	36
2.4 Bargaining Power of Suppliers	37
2.5 Bargaining Power of Buyers	38
2.6 The Availability of Substitutes	41
2.6.1 Non-Satellite Substitutes	41
2.6.2 Small Satellites	42
2.7 Sounding the Competitive Environment	45
3. Risks and Opportunities for European Manufacturers	46
3.1 Introduction	46
3.2 What Is the Strategic Value of Having a European Commercial Satellite Manufacturing Sector?	46
3.2.1 The Necessity of Commercial Business for the European Space Sector	46
3.2.2 The European Institutional Framework Supporting the Competitive Environment	47
3.3 Improving the Competitive Position of the European Satellite Integrators in the Global Satellite Market	48
3.3.1 Internal European Cooperation and Measures in Place to Collectively Improve the Competitive Position	48
3.4 External International Cooperation to Improve the Competitive Position of European Satellite Integrators	49
3.4.1 Broader Alliances/Cooperation with the Traditional Competitors	51
3.4.2 Broader Alliances/Cooperation with Emerging Low-Cost Satellite Manufacturers	54



3.5 What About Outsourcing or Offshoring the Low-End Technology to Low-Cost Countries?	60
3.5.1 Outsource or Offshore Subsystems and Equipment	61
3.5.2 Components	61
3.5.3 Outsourcing and Offshoring Lower-Tier Technology to Central and Eastern European Countries?	62
3.5.4 Lessons from the Automotive Manufacturing Industry in Outsourcing	64
3.5.5 Lessons from the Aircraft Manufacturing Industry in Outsourcing and Offshoring	65
3.6 Potential New Paradigms for Europe?	67
3.6.1 Small Satellites	67
3.7 Conclusion	67
4. Findings and Recommendations	69
<hr/>	
4.1 ESA Interest in Space Industrial Policy	71
4.2 EU Interest in Space Industrial Policy	71
4.3 Industrial Response to EU Interest in Space Industrial Policy	71
4.4 Applying a SWOT Analysis to Europe's Prime Contractors	72
4.5 Assessing Alternative Roadmaps for European Competitors: Trade-off Considerations on Forming Alliances and on Outsourcing / Offshoring	74
4.5.1 Alliance Building among European Competitors	75
4.5.2 Alliance Building with Traditional Rivals	75
4.5.3 Alliance Building with New Rivals	76
4.5.4 Outsourcing / Offshoring Low-End Technology to Low-Cost Countries	76
4.5.5 Outsourcing / Offshoring Low-End Technology to CEE	77
4.5.6 Summary	77
4.6 Recommendations	79
Annex	81
<hr/>	
A.1 COCOM, Wassenaar, and European Export Control	81
List of Acronyms	82
<hr/>	
Acknowledgements	86
<hr/>	
About the Author	86
<hr/>	

Executive Summary

This report assesses the future of European commercial spacecraft manufacturing of satellites that are bought through open competition in situations where European bidders are faced with non-European competition. This study aims to inform and provide recommendations to decision makers and actors within the European space sector, but is also meant to engage all persons interested in the industrial aspects of space.

European prime contractors are in a watershed period, faced with increasing competition from traditional U.S. competitors, while simultaneously being pressured by low cost manufacturers targeting emerging regions that seek less sophisticated technology at a discounted price. Moreover, competitors in the U.S. have the luxury of being able to draw on a giant well of domestic institutional investment when commercial demand ebbs; while new commercial competitors in China, India, and Russia are state-financed and thus to some extent cushioned from commercial pressures. European manufacturers must rely much more on commercial revenue, especially from export markets. Considering the scarcity of new contracts, the level of competition, and the marginal profits to be earned, maintaining a significant role in this domain will require new and forward-looking approaches.

Using Porter's Five Forces Model, an assessment of the competing forces and how governments impact these forces enables European competitor strengths and weaknesses to be identified. As traditional rivals fight for market share by developing new technologies, and new rivals increase the stakes thanks to their lower cost manufacturing base and strong government support, Europe's prime contractors will need to position themselves according to where they possess competitive advantage to remain successful within the global commercial satellite manufacturing industry. Moreover, they must be ready to take on other competing forces, such as the bargaining power both of their suppliers and of their buyers, which are likely to change in the future due to reduced export restrictions and further globalization within the industry. And they must also be ready to compete with substitute products that could one day become game changers.

Maintaining the competitiveness of Europe's prime contractors is essential to sustain the critical mass of European space industry as a precondition for Europe's space ambitions. Yet, remaining competitive might require a change in industrial strategy, with a focus on building stronger ties with Western manufacturers in addition to accessing their industrial markets. Similarly, competitiveness might benefit from allying with rapidly emerging nations with low cost manufacturing capabilities, or outsourcing or offshoring to these countries. A further consideration might be to foster low cost internal capability in Europe by seeking to relocate parts of the manufacturing chain to CEE countries - this having the dual advantage of providing highly skilled labour at a lower cost and greater geographical proximity. This last approach has the further benefit of being more likely to push forward Europe's goal of technological non-dependence in components and parts.

Uncertainty is the hallmark of predicting the future evolution of commercial spacecraft manufacturing, and in assessing how to remain competitive in an increasingly globalised society. While the competitive environment can be plotted from a historical perspective, and its current dynamics captured in the frame of Michael Porter's Five Force model, the picture is likely to change as time progresses. The risks and opportunities envisioned in this report attempt to provide an initial sample of the range of options that could be pursued by European prime contractors in response to changes in the competitive environment; however they are not exhaustive, are often complementary, and do not give a definitive answer to what is in the best interest of Europe's prime contractors, which also depends on the delicate compromise between commercial and government actors. Answers for individual companies must necessarily be found with reference to the specifics of each company and as part of an overall commercial strategy. Answers must thus also consider the specific risk appetite and financial buffers of the company. So even if binary answers are not available, this report has sought to be helpful by surveying the landscape and describing many of the tools available for European satellite manufacturers. Moreover, this report can hopefully be a useful tool for decision makers



to help them be better informed about the benefits and burdens before selecting the best strategies for their companies.

The analysis in this report leads to the identification of the following elements to be considered when formulating responses to the very substantial changes in the competitive environment of European satellite manufacturers:

On Alliance Building

- European prime contractors should decide whether to form alliances with traditional competitors and/or low-cost competitors to benefit from respective economies of scale, technology transfer, the spreading of risk among partners, and shaping the nature of competition in the industry.
- European prime contractors should also consider forming alliances with other European competitors which would provide the added benefits of 1) collectively enhancing European bargaining power in bidding for international contracts, 2) enabling specialization and standardized manufacturing processes, and 3) reducing geo-return requirement interference with competition, as participants would be able to gain access to a larger share of European institutional funding.
- Throughout the life-cycle of an alliance, prime contractors should monitor that the arrangement does not become competitively disadvantageous, i.e. the point at which the costs in terms of coordination, the erosion of competitive position, and the creation of an adverse bargaining position, disproportionately offset the benefits of the alliance.
- Regardless of the type of alliance, to preempt the creation of an adverse bargaining position, European prime contractors should aim to maintain an entire vertical supply chain within Europe to ensure that external alliance investments can be reversed.

On Outsourcing/Offshoring Subsystems, Equipment, and Components

- European competitors should seek to place more focus on the critical European capabilities, by outsourcing/offshoring non-essential technologies (e.g. low-end equipment and components) to low cost Central and Eastern European (CEE) countries (which will help to maintain the European industrial base), or outsourcing/offshoring those technologies to low cost non-European countries (which will

provide more immediate factor cost advantages). It should be noted, however, that both outsourcing and offshoring require strong and engaged management to be successful.

- Outsourcing/offshoring production of non-essential technologies will create greater price bargaining power with lower-tiered suppliers, but it will not eliminate Europe's dependence on foreign suppliers and locations, and this could be critical, unless multiple sourcing strategies are pursued.

On the European Non-Dependence Strategy and Competition

- To maintain European technological competitive advantage, and also reduce European prime contractors' vulnerability to U.S. ITAR restrictions, Europe's space industry should continue to indigenously develop key Electrical, Electronic, and Electromechanical (EEE) components under the European Components Initiative (ECI), along with technologies developed through ESA's ARTES programme and the EU's Horizon 2020 space research and development programme.
- As the timeline between investment and return on investment typically extends over 10 years, investors should expect to sacrifice some short-term returns for larger payoffs in the future.
- To remain at the forefront of competitiveness, European industry should seek to acquire technology from other leading competitors, and hire highly skilled labour trained outside of Europe to develop new synergies.
- To stimulate the growth of the entire European space sector, more institutional spending is needed to lower costs in the long run through further economies of scale, and bring Europe's industry closer to being on an equal footing with U.S. and low-cost competitors.
- To remain competitive with low cost countries selling in-orbit delivery packages using export credit mechanisms, Europe's industry should seek to adopt a similar approach when marketing satellites to emerging countries.

Introduction - Research Question

- » Does Europe have a future as a home of commercial spacecraft manufacturers, and, if so, what steps should Europe take to ensure or improve such a future?

Until fairly recently, the main threat to Europe's spacecraft manufacturers came from their United States counterparts as global competitors in the commercial satellite manufacturing industry. Now the growing relevance of low cost manufacturers, mostly from Asia, should give European manufacturers cause to reassess their relative position in the global industry. While the number of global competitors in the commercial satellite manufacturing industry is concentrated, with two 'prime contractors' in the EU and four in the U.S., pickings are slim for European manufacturers that do not have the luxury of courting the lion's share of the world institutional market that is concentrated in the U.S. and accessible only to U.S. companies. With one to two dozen commercial contracts for telecommunication satellites (and some Earth observation satellites) negotiated on a yearly basis, some being earmarked to replace heritage models, new contracts for satellites are scarce and in high demand by satellite makers, creating a vigorous level of competition in a market with marginal profits.

Emerging space nations are now expanding into the market, peddling low-cost alternatives (enabled by favourable factor endowments such as low-cost labour) to commercial operators who critically evaluate cost versus quality and reliability. European manufacturers must fight to remain at the cutting edge of this industry, producing state of the art technologies (such as electric propulsion systems, high throughput satellites, and greater functional flexibility), while also reducing manufacturing costs to compete with low-cost manufacturers in China, India and Russia that can cater to the needs of aspiring space-faring nations, such as Nigeria, Venezuela, Pakistan, Bolivia, as well as to the big operators eventually. In the past, European as well as U.S. spacecraft manufacturers had been fairly shielded from competition from low-cost manufacturers. There were several reasons for this; first, even common platform manufacturing for telecom satellites had not been fully commoditised, requiring significant inputs of specialised knowledge. Second, export control regulations made for a

very high market entry threshold. And third, Russia, surprisingly, did not develop a competitive satellite manufacturing industry, in contrast to its successful commercial launcher industry - and this despite great capability and more than twenty years having passed since the end of the Cold War.

The current threat for the European commercial spacecraft manufacturing industry has arisen because technologies have become more manageable and the low cost countries have had time to develop industrial capabilities. Whether this poses an existential risk must be determined in relation to a number of factors. One such factor, discussed in the first chapter, is whether the risk applies equally to the production of commercial telecommunication satellites and commercial Earth observation satellites. Following this introduction which presents the main research question, the first chapter provides an overview of the global satellite manufacturing landscape, distinguishing satellites according to markets and to the position in the upstream or downstream segments of the satellite industry value chain. The chapter then focuses on the different actors purchasing satellites, thereafter honing in on the satellite manufacturing supply chain and satellite manufacturing industry competitors.

Another factor underpinning the second chapter is whether the risk is posed only by low cost manufacturers in Asia or also by radical new approaches in the United States, such as those of SpaceX when it begins producing its own satellite constellation. Here, the second chapter looks at the changing competitive landscape of the satellite market in terms of maintaining competitive advantage. Michael E. Porter's Five Forces Competitive Model analysis is applied, focussing on the position of European Prime Contractors vis-à-vis the global industry. The model assesses the intensity of rivalry amongst current competitors in the U.S., the threat of new rivals from China, India, Russia, and select emerging countries, the bargaining power of lower-tiered suppliers, the bargaining power of buyers, and the availability of substitutes, in order to identify strengths and weaknesses and provide a vivid picture of the competitive environment.



The third chapter then addresses the risks and opportunities faced by European satellite manufacturers. Existential questions on the overall importance of the commercial satellite manufacturing sector and its necessity are considered first, including whether to continue as low margin prime contractors of commercial satellites or become high margin, niche providers of subsystems - and how that would impact Europe's space ambition in other domains, noting that other issues at stake are Europe's position as an innovation leader, and European space technology non-dependence. The chapter then identifies methods to improve the competitive position of European satellite integrators in the global satellite market. These methods look both to internal European cooperation and measures in place to collectively enhance Europe's competitive position, and to external international cooperation to improve the competitiveness of individual European prime contractors. The trade-offs between forming an alliance with traditional competitors or with the emerging low-cost satellite manufacturers are discussed – along with outsourcing or offshoring subsystems, equipment and components to manufacturing bases in low-cost and CEE countries. Furthermore some comparisons are made with the automotive and aircraft manufacturing industry that have also weathered many competitive challenges.

The final chapter describes the interests of the different European stakeholders (ESA, EU, and Industry) in terms of European commercial satellite manufacturing, and groups the strengths, weaknesses, opportunities and threats outlined in the previous chapters into a SWOT analysis matrix. It then compares the trade-offs in choosing one or several alternative roadmaps to remain competitive in the future, contrasting benefits to burdens over the near- and long-term. The chapter ends with a conclusion and a set of recommendations.

The central question in this report is solely the future of European commercial spacecraft manufacturing, by which is meant whether satellites are bought through open competition in situations where European bidders will be faced with non-European competition. The customer will normally be a commercial operator but, particularly in emerging economies, could also be an institutional buyer.

This study aims to inform and provide recommendations to decision makers and actors within the European space industry, but is also meant to engage all persons interested in the industrial aspects of the global space endeavour.

1. The Global Satellite Manufacturing Landscape

1.1 Introduction

The term *'satellite'* existed long before Russia's Sputnik was launched on 4 October 1957. Deriving from the Latin term *'satelles'* meaning 'attendant, companion, courtier, accomplice, assistant'¹, the term was used by German astronomer Johannes Kepler to describe Jupiter's four moons, which were first observed by fellow Italian astronomer Galileo Galilei on 7 January 1610.² In the centuries that followed, the term *'satellite'* expanded into the realm of geopolitics (i.e. satellite states)³ and also to biology (i.e. satellite virus).⁴ Yet arguably, the most common use of *'satellite'* is in reference to a natural celestial body (i.e. moons and planets) orbiting a larger body, or an artificial (machine) object launched into space to orbit a celestial body. The first definition of a theoretical artificial satellite was recorded in 1936, while the launch of Sputnik transformed that definition into a factual one in 1957.⁵ As the space industry developed - nurtured initially by military interests - artificial satellites were built for navigation, Earth observation, communication and scientific purposes. In this study the focus will be on commercial satellites (particularly telecommunication satellites, and to a lesser extent Earth observation commercial satellites). Telecommunication satellites are the primary issue, as this segment is the most mature and generates the majority of European satellite export revenue.

1.2 Satellites in Operation

As at 31 December 2015, the Earth was orbited by 1381 active satellites, positioned in different orbits according to their respective functions, and operated by actors from various countries.⁶ Of these operational satellites, 534 (38.7%) had been developed for commercial communications purposes, while 75 (5.4%) had been developed for commercial Earth observation.

Most telecommunications satellites operate in geostationary orbit (GEO); a fixed distance from Earth's equator (some 36,786 km), in the same angular velocity of rotation, which enables the satellite to maintain its position relative to the Earth's surface for ongoing signal transmission to satellite antennas that are pointed permanently toward the satellite. Due to the convenience of GEO positioning, slot positions in attractive orbit regions have become partially crowded. In part, this has contributed to the placement of some telecommunication satellites in lower orbits such as medium Earth orbit (MEO), or low Earth orbit (LEO). According to Kepler's laws, satellites closer to the surface of the Earth travel at progressively higher angular velocities to maintain orbit, so many satellites working in concert are needed to maintain coverage over the same location. The specific advantages associated with the different orbit regions will be further explained in the description of state-of-the-art technologies in the following chapter.

¹ "Satellite (n.)." Online Etymology Dictionary 20 Aug. 2014 <<http://www.etymonline.com/index.php?term=satellite>>.

² Baalke, Ron. "The Discovery of the Galilean Satellites." 24 Jan. 2011. NASA Solar System Exploration 20 Aug. 2014 <https://solarsystem.nasa.gov/scitech/display.cfm?ST_ID=2283>.

³ Satellite (n.)." Online Etymology Dictionary 20 Aug. 2014 <<http://www.etymonline.com/index.php?term=satellite>>.

⁴ "Satellite Virus." The Free Dictionary – Medical Dictionary 21 Aug. 2014 <[http://medical-dictionary.thefreedictionary.com/Satellite+\(biology\)](http://medical-dictionary.thefreedictionary.com/Satellite+(biology))>.

⁵ "Satellite (n.)." Online Etymology Dictionary 20 Aug. 2014 <<http://www.etymonline.com/index.php?term=satellite>>.

⁶ "UCS Satellite Database." 25 Feb. 2016. Union of Concerned Scientists 29 Apr. 2016 <<http://www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database>>.



Global Space Industry Revenue in 2014: \$322.7 billion

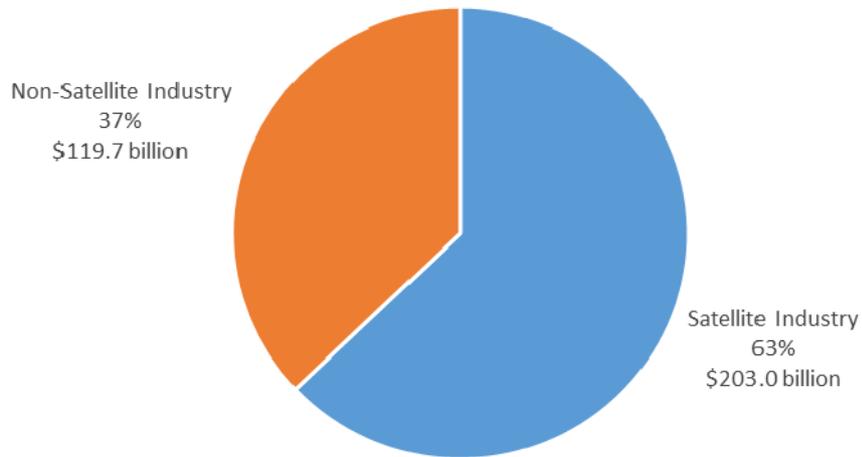


Figure 1.1. Global Space Industry in Context (Revenue in 2014, Source: SIA)

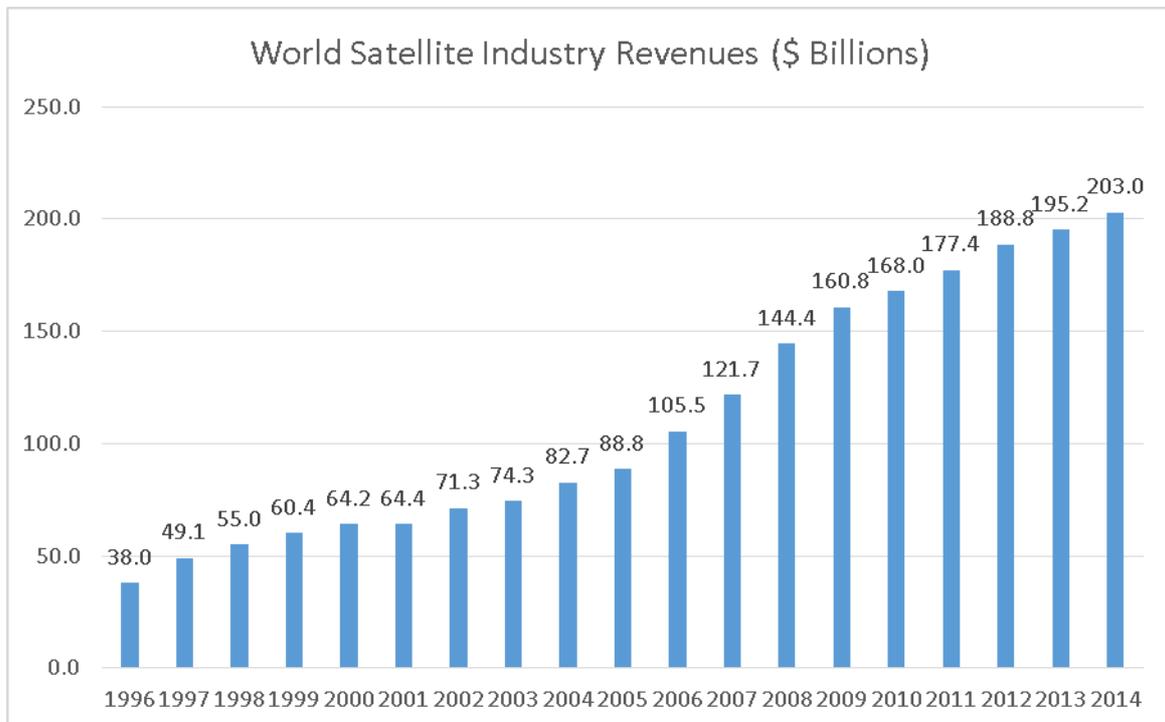


Figure 1.2. World Satellite Industry Revenue (\$ Billions, Source: SIA)

1.3 Describing the Satellite Industry Market

The Satellite Industry Association (SIA) has estimated that the total value of the global space industry was \$322.7 billion in 2014.⁷ In

⁷ "2015 State of the Satellite Industry Report." 15 Sept. 2015. Satellite Industry Association and The Tauri Group 23 Feb. 2016 <<http://www.sia.org/wp-content/uploads/2015/06/Mktg15-SSIR-2015-FINAL-Compressed.pdf>>.

the SIA's *State of the Satellite Industry Report*, the satellite industry is listed as a subset of the global space industry accounting for about 63% of the total revenue earned for that year. This subset groups commercial operator and institutional spending on upstream commercial space products and support industries (i.e. satellite manufacturing, launchers, and ground infrastructure), as well as downstream spending on commercial space products and services (i.e. ground equipment and satellite services). The remaining 37% of total revenue generated

came from non-satellite industry space spending, mainly from government space budgets relating to human spaceflight, space. In 2014, the satellite industry was estimated to have generated \$203.0 billion in revenue. The industry has grown considerably over the past decade, more than doubling the \$88.8 billion generated in 2005 and increasing over five-fold from the \$38.0 billion in industry revenue reached in 1996. This consistent growth trend does not show signs of slowing down (Figure 1.2).

Revenue in 2014 was derived from four main segments of the satellite industry, i.e. satellite manufacturing (7.8%), launch services (2.9%), ground equipment (28.7%), and satellite services (60.5%). However, the relative share of revenue generated in each segment reveals substantially higher growth in some segments over the years covered (Figure 1.3). Moreover revenue growth in the period 1996 to 2014 cannot be attributed solely to the business activity that was con-

observatories, non-orbital spacecraft etc. (Figure 1.1).

ducted within each reporting year. Rather, these revenues were generated by numerous satellite undertakings, each at a different stage of operational life, which continued to contribute to the revenue generated in each year.

However, revenues generated by the satellite manufacturing and launch industries are counted in the year that they are launched into space. Unlike with satellite services and ground equipment services, these gains are not compounded into subsequent years, as the activities from these segments do not directly benefit from increased satellite capacity already in orbit. Yet, while indicative of the overall growth of the satellite industry, viewing the segments separately reveals only a partial picture of how the entire value chain results in industry growth.

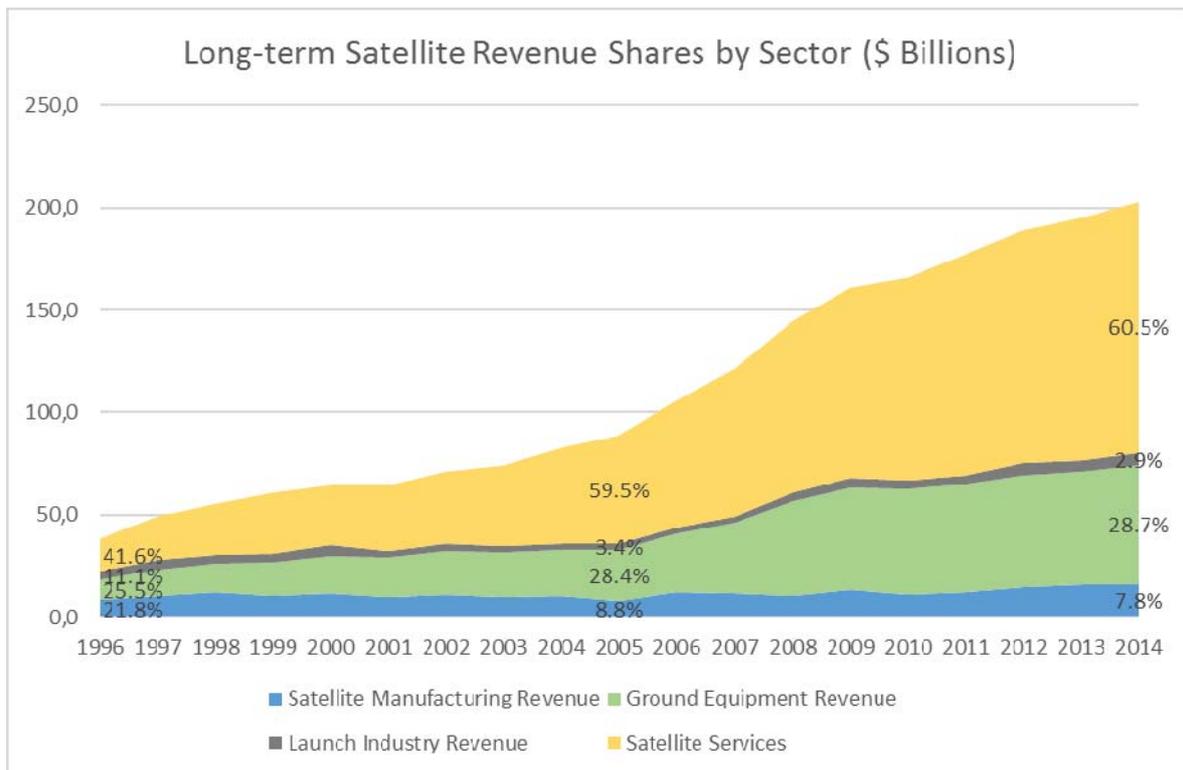


Figure 1.3. Satellite Revenue Share by Segment (\$ Billions, Source: SIA)



1.4 The Satellite Industry Value Chain

In the broader context of the satellite industry, the satellite value chain has the following sequence of interconnected segments where additional value is created through successive



Figure 1.4. The Value Chain of Commercial Telecom, Earth Observation, and Navigation Satellite Applications⁸

The first stage in the space value chain is the design and manufacture of the satellite. A satellite operator places an order for one or more satellites with a selected satellite manufacturer. Based on the requirements of the operator, the manufacturer designs and builds the satellite. Upon completion of assembly, integration and testing (AIT), the satellite is placed in its operating orbit by a launch service provider. Following the launch and early orbit phase (LEOP) of the satellite, where diagnostic activities are conducted to ensure the proper operation of subsystems and deployment of any appendages, control of the satellite is handed to the operator to begin direct use of the capacity or the lease/sale of that satellite capacity to organizations that market satellites services to the end consumers.

A hallmark characteristic of the value chain for space products is the long development and utilisation cycle. A typical communication satellite lifecycle lasts on average between 14 and 19 years. The period between the approval of the business case for a space infrastructure and the start of operation (Phases A – D) spans at least 2 to 4 years. During that time, the satellite undergoes a series of severe and challenging tests with the goal of an operational lifetime (Phase E) of between 12 and 15 years in orbit.⁹ When there is a business case for renewed or additional capacity, new capacity is purchased by the operators and this is how the value chain is sustained.¹⁰

rounds of inputs from contributors specific to each segment within the value chain (Figure 1.4). While simplified to serve as an overall outline, it should be noted that the internal composition of each segment depends on the intended function and purpose of the spacecraft being developed. The final outcome is a space infrastructure that delivers services to end customers.

The satellite industry value chain can be separated into an upstream and a downstream segment. The upstream segment is where space infrastructure is developed, involving the design, manufacture and launch of space elements, along with the production of necessary ground equipment to control the satellite from Earth. The downstream segment denominates the satellite services that are enabled through the space infrastructure as well as the ground equipment, essential for the end customer to receive the satellite's services. The lion's share, almost 90% of the revenue, is found in the downstream market. As will be described below, the largest portion of private commercial business lies in the downstream part of the satellite industry value chain as there is relatively more profit to be earned there than in the upstream segment.

Necessarily, the value chain for commercial Earth observation satellites differs from communication satellites. The upstream segment does not generate commercial revenue as governments fund most of the production of these satellites. However, there is much commercial revenue in the downstream segment, as value added services generate economic activity from users. Commercial downstream revenue generated by Earth Observation reached *\$1.6 billion in 2014*, whereas commercial downstream revenue generated by communication services (including voice & data transmission and broadcast services) was *\$104.2 billion*.¹¹

⁸ Regarding navigation satellites, the sale of capacity (or time) is currently not applicable. See further Ozgur Gurtana. *Fundamentals of Space Business and Economics*. SpringerBriefs in Space Development. 2013. p.12.

⁹ "Economics of Satellites." 7 Feb. 2012. The European Satellite Operators' Association (ESOA) 15 Sept. 2014 <http://www.esoa.net/Economics_of_satellites.htm>.

¹⁰ "Value Chain." iDirect 10 Sept. 2014 <<http://www.idirect.net/Company/Resource-Center/Satellite-Basics/Value-Chain.aspx>>.

¹¹ "2015 State of the Satellite Industry Report." 24 May 2015. Satellite Industry Association and The Tauri Group 27 Sept. 2015: 11 <http://www.space.taurigroup.com/reports/SIA_SSIR_2015.pdf>.

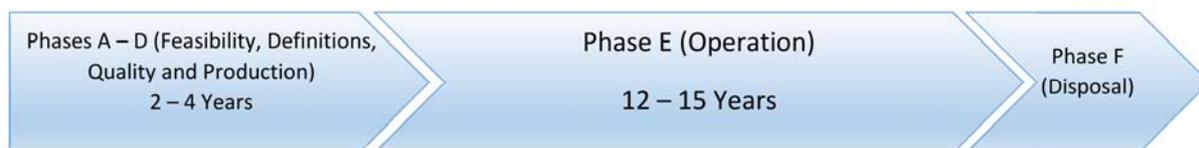


Figure 1.5. Satellite Development Lifecycle

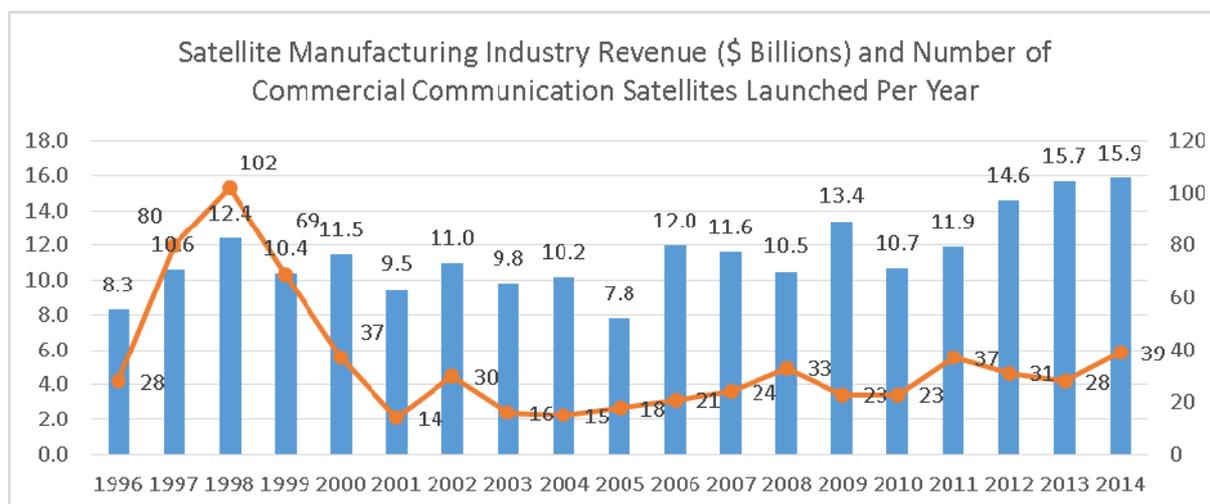


Figure 1.6. Satellite Manufacturing Industry Revenue (\$ Billions, Source: SIA) and Number of Commercial Communication Satellites Launched Per Year (Source: The Spacecraft Encyclopaedia)

1.4.1 Upstream Revenue by Segment

Satellite Manufacturing

The revenue realized from satellite manufacturing is modest when compared to the revenue earned from downstream satellite services. And in terms of profit margins, satellite manufacturers typically operate at below 10%, especially when their business is predominantly commercial, involving more stringent terms and conditions than for institutional customers, due partly to the intensity of competition for commercial contracts.¹²

Despite the burst of commercial communication satellites launched in the 1990s, rather than having a consistent increase in revenue, global satellite manufacturing revenue shows a cyclical growth trend with an upsurge in recent years. This surge is confirmed by the Euroconsult report, *Satellites to be Built & Launched by 2022*, which forecasts an increase in the global demand for satellites within the next decade. According to Euroconsult estimates, around 1,150 satellites will be launched between 2013 and 2022, which is a 26% growth in satellite manufacturing

revenue compared to the past ten years (2003-2012).¹³

These revenues, generated from both commercial and government customers, reflect the amounts earned only by prime contractors who integrate individual subsystem components into a complete satellite; payments to subcontractors are not directly reflected to avoid double counting.

Launch Industry

While the commercial launch industry generates the lowest revenue of the segments, it is of critical importance for the global space value chain as it is essential in deploying space infrastructure. Traditionally, this upstream segment has placed spacecraft into orbit with the use of expendable launch vehicles and related launch support. During the design and manufacturing phase of a satellite, the cost and capability of an intended launch service provider can have a substantial impact on the size and operational lifetime of a satellite.

With several launcher options available for any-sized satellite, the launch services indus-

¹² "Satellites to be Built & Launched by 2022." 2013. Euroconsult: 57.

¹³ Henry, Caleb. "New Euroconsult Report Forecasts Exciting Changes in the Satellite Industry." 8 Nov. 2013. Via Satellite 30 Oct. 2014. <<http://www.satellitetoday.com/telecom/2013/11/08/new-euroconsult-report-forecasts-exciting-changes-in-the-satellite-industry/>>.



try operates in a highly competitive environment. This competitive environment among established launch providers and new entrants such as SpaceX has resulted in mini-

mal revenue growth within this segment. Yet, as in satellite manufacturing, a similar cyclical growth trend is visible, as they go hand-in-hand.

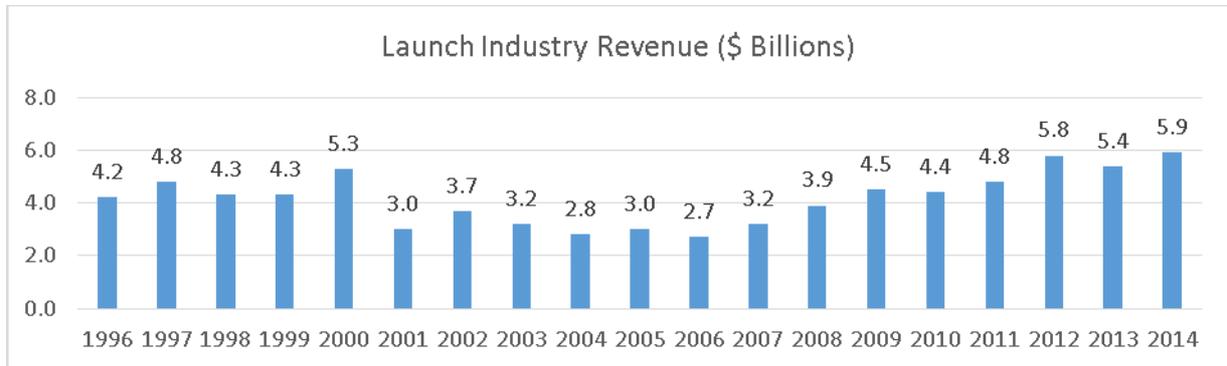


Figure 1.7. Launch Industry Revenue (\$ Billions, Source: SIA)

1.4.2 Downstream Revenue by Segment

Ground Equipment

Ground equipment, depending on its nature, can be considered as part of both the upstream and downstream segments in the space value chain. In the upstream component, ground equipment consists of network equipment, where the service providers/network operators lease bandwidth from the satellite operators and use the network equipment to set up a network in order to provide a full assortment of satellite services

to the end consumers. The downstream component of ground equipment is the consumer equipment used by satellite service customers to receive satellite TV, radio, broadband signals in homes, and mobile communication terminals, in addition to satellite navigation equipment (not including chipsets in smartphones whose primary use is not satellite navigation). As ground equipment functionality increases year-by-year, the revenue generated by ground equipment has been growing steadily in tandem with the increasing economic impact of satellite services.

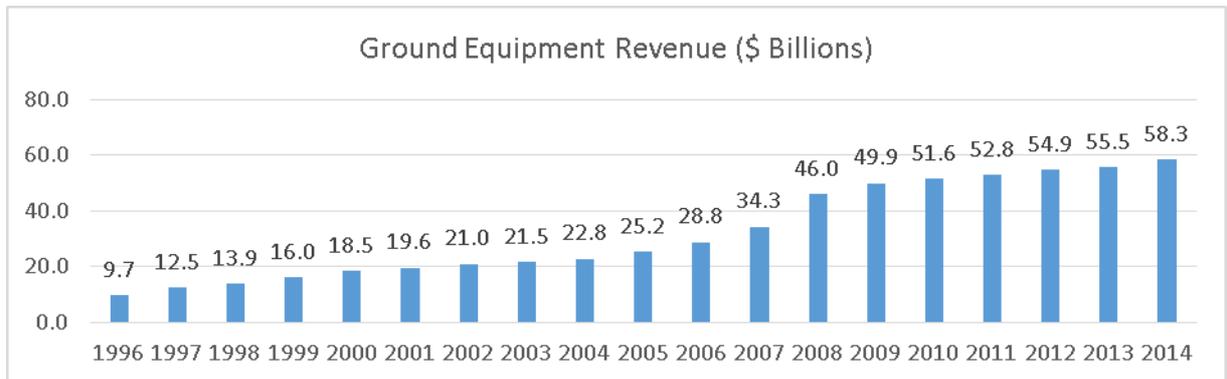


Figure 1.8. Ground Equipment Revenue (\$ Billions, Source: SIA)

Satellite Services

With the growth of satellite capacity over four decades, telecommunication services have become the leading commercial space market among the other services provided by commercial satellites, such as remote sensing. Figure 1.9 presents the SIA's estimate of revenue generated from commercial satellite services including Direct-to-Home (DTH) broadcasting (including satellite television, radio, and broadband services), fixed and

mobile satellite communication services (FSS & MSS), and remote sensing.¹⁴

Increased global demand for satellite services, particularly in emerging countries, has driven growth in this market.

¹⁴ "Satellites to be Built & Launched by 2022." 2013. Euroconsult: 30.

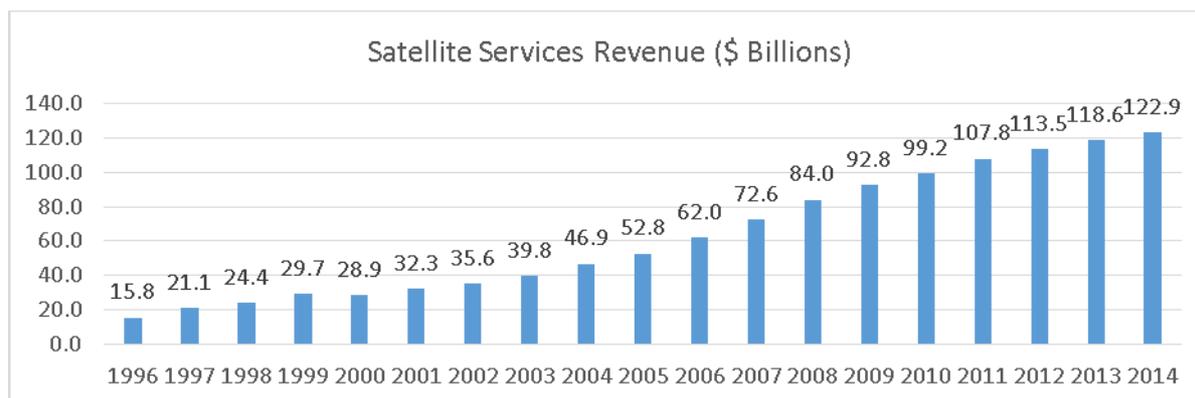


Figure 1.9. Satellite Services Revenue (\$ Billions, Source: SIA)

In the commercial space industry, satellite communications are clearly the most attractive and lucrative revenue-generating commercial space application. The sector is also the most mature of the space applications, as over the decades it has developed into a highly privatized and commercial market.¹⁵

Year	Satellite Manufacturing Revenue (\$ Billions)	Launch Industry Revenue (\$ Billions)	Ground Equipment Revenue (\$ Billions)	Satellite Services Revenue (\$ Billions)
1996	8.3	4.2	9.7	15.8
1997	10.6	4.8	12.5	21.1
1998	12.4	4.3	13.9	24.4
1999	10.4	4.3	16.0	29.7
2000	11.5	5.3	18.5	28.9
2001	9.5	3.0	19.6	32.3
2002	11.0	3.7	21.0	35.6
2003	9.8	3.2	21.5	39.8
2004	10.2	2.8	22.8	46.9
2005	7.8	3.0	25.2	52.8
2006	12.0	2.7	28.8	62.0
2007	11.6	3.2	34.3	72.6
2008	10.5	3.9	46.0	84.0
2009	13.4	4.5	49.9	92.8
2010	10.7	4.4	51.6	99.2
2011	11.9	4.8	52.8	107.8
2012	14.6	5.8	54.9	113.5
2013	15.7	5.4	55.5	118.6
2014	15.9	5.9	58.3	122.9

Table 1.1. Satellite Revenue Share by Segment (\$ Billions, Source: SIA)

Considering Downstream and Upstream Segments

Ground equipment and satellite services revenue have witnessed consistent growth in the past two decades, while the space infrastructure segments, i.e. the manufacturing and launch industries have been a more conservative market where revenues have remained relatively flat. This is likely because the market entry threshold is much higher due to the high initial investment needed for space infrastructure. Consequently large players dominate. Moreover, the extreme environmental conditions of space necessitate high quality technology and expertise, and long development and qualification cycles, while there is strong customer demand for on-time delivery and proven long term reliability. Nevertheless, a key element is that with the same investment in space infrastructure, a rapidly expanding service sector can be served. This is both because of the better use of data, and especially because the price per transponder/per bit has declined significantly to an average transponder price of \$1.62 million per year for 36 megahertz of capacity in August 2012, with further declines expected in the coming years as some markets soften with new satellites entering service.¹⁶

1.5 The Different Actors

1.5.1 Government as the Prominent Space Actor

A distinction can also be made between commercial and institutional spacecraft manufacturing. Different business models exist within the space value chain, distinguished by the interaction between govern-

¹⁵ "Economics of Satellites." The European Satellite Operators' Association (ESOA) 15 Sept. 2014 <http://www.esoa.net/Economics_of_satellites.htm>.

¹⁶ De Selding, Peter B. "Rising Transponder Prices Mask Regional Disparity." 23 Aug. 2012. SpaceNews 1 May 2016 <<http://spacenews.com/rising-transponder-prices-mask-regional-disparity/>>.



mental, industrial and scientific space actors. It should be noted that a variety of actors participate in the global space value chain nowadays. Yet historically, governments have been the driving actor in space activities. Beginning with the launch of Sputnik 1 in 1957, the space race between the United States and Soviet Union boosted the space capabilities of both nations since space was considered as a strategically important sector. The initial policy rationales for governmental involvement in space activities centred on national security, national prestige, scientific interests, and industrial policy objectives¹⁷; and these expanded in the following decades to include strategic interests in access to space, and overall increased national space capability.

In recent decades, the rationale for government activities in space has grown to include increased reliance on space assets that provide socio-economic benefits.

Socio-economic benefits have encouraged many emerging countries to own their own space assets so as to provide a domestic infrastructure for space services and enable better utilization of the country's resources. Space as a high-end technology sector has become acknowledged as an engine for economic growth, i.e. growth through investment in innovation and new technologies. By leveraging the benefits of space technology for socio-economic development, a nation can hasten its transformation into a knowledge-based economy.

1.5.2 Commercial Actors in Space

In recent decades there has been a paradigm shift in the space business, with space undergoing a process of privatization. Prior to the 1980s, governments were the only customers of private aerospace contractors and suppliers of space infrastructure. One very notable exception was, however, the licence granted by the United States to the terrestrial telecommunications giant AT&T, giving AT&T the right to develop and commercially use telecommunication satellites to complete their monopoly as a long-distance service provider.¹⁸ AT&T launched its two-satellite Telstar system in 1962.

In 1967, France and Germany began joint development of their own European telecommunications satellite system, Symphonie. However, as Europe still lacked a launcher capable of launching these satellites to GEO

orbit, the United States was asked to launch Symphonie. As United States policy at the time sought to limit foreign competition in satellite telecommunications, it agreed to launch the two satellites system as long as they were not used to provide commercial services. The United States eventually did launch Symphonie in 1974 as experimental satellites, however, the experience spurred Europe to develop its own Ariane launcher system to place European satellites in orbit.¹⁹

Commercial satellite manufacturing took a substantial step forward in the early 1980s, with the maturation of the space industry and the United States' policy shift toward economic deregulation of the domestic space manufacturing industry. During this period manufacturers that provided space equipment for domestic government customers began competing with independent offerings of space components and systems for the private sector. However, while the United States sought to expand its private sector involvement in space, commercial deregulation would not be at the expense of its national security.²⁰

By the late 1980s, the increasing space access capabilities of new entrants suggested a new playing field, yet U.S. concerns about undue technology transfer led to a strengthening of the International Traffic in Arms Regulations (ITAR). This strengthening conveniently also provided a high degree of protection for incumbent launch providers. ITAR also increased entry barriers for emerging space actors.

Against this backdrop of regulatory protection and the overall increase in global wealth, the Western commercial space industry flourished in the 1990s while ties to the military decreased.²¹ More recently, in the past decade governments have faced severe budget constraints, reducing institutional space spending, which had otherwise been on an upswing. Consequently, spacecraft manufacturers started to look more to commercial operators for growth.

Today there are at least 57 commercial companies providing satellite applications mostly in the field of satellite telecommunications.²²

¹⁷ Munsami, V. "South Africa's National Space Policy: The Dawn of a New Space Era." *Space Policy* 30 (2014): 115-120: p. 118.

¹⁸ *Ibid.*

¹⁹ Hertzfeld, Henry R. "Commercial Space and Spacepower." *Towards a Theory of Spacepower: Selected Essays*. Eds. Lutes, Charles D., Peter L. Hays et al. Washington D.C.: National Defense University Press, 2011: p. 230.

²⁰ *Ibid.* 225.

²¹ Brennan, Louis, and Alessandra Vecchi. *The Business of Space: The Next Frontier of International Competition*. Hampshire: Palgrave Macmillan, 2011: p. 18.

²² "Satellites to be Built & Launched By 2022." 2013. Euroconsult

The customer base of spacecraft manufacturers has thus expanded significantly.

The space domain has not only been commercialized and privatized, but has also opened up to international competition. Space companies now directly compete with many foreign entities in all the space value chain segments. The technological capability to build and operate sophisticated space infrastructure has spread from an initially U.S. and Russian competency to a globalised one.²³

1.6 The Satellite Manufacturing Supply Chain

The spacecraft manufacturing supply chain has a 'tiered' structure. This structure of tiers defines the commercial distance in the relationship between the system integrator and the supplier. It can be represented as a pyramid hierarchy, with system integrators at the top, whereas the remaining suppliers are organized in relatively larger numbers in other levels in the supply chain (Figure 1.10).

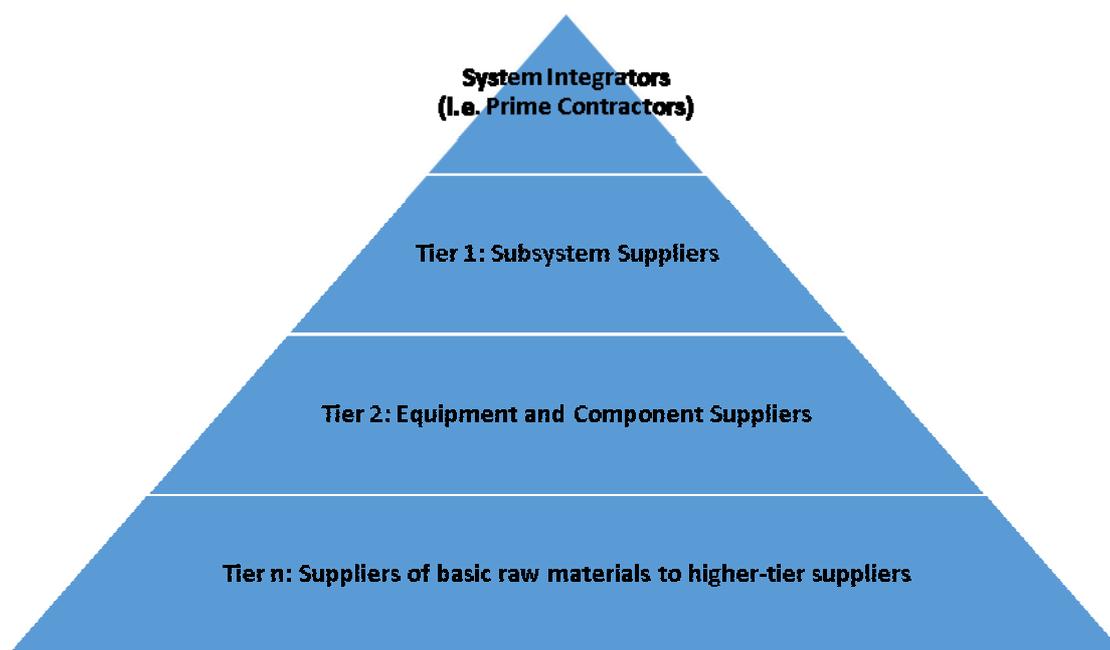


Figure 1.10. Pyramid Supply Chain from System Integrators to Tier n

System Integrators, known also as Prime Contractors, deliver either complete space systems or complete spacecraft to their customers. Within an overall system design, satellite integrators design a satellite according to the needs of the customer, followed by the selection of subsystems provided by suppliers in the first tier of the satellite manufacturing supply chain. These companies include large subsystem contractors, which design, manufacture and deliver the subsystems contracted for by the system integrator. Likewise, subsequent tiers of contractors and suppliers supply equipment and component parts to manufacturers in the upper tiers.

²³ Lutes, Charles D., Peter L. Hays et al., eds. *Towards a Theory of Spacepower: Selected Essays*. Washington D.C.: National Defense University Press, 2011: p. 215; see also, Blamont, Jacques. "Space Governance and Globalisation." *Yearbook on Space Policy 2014: The Governance of Space*. Eds. Cenan Al-Ekabi, Blandina Baranes, Peter Hulsroj, and Arne Lahcen. Vienna: SpringerWienNewYork, 2016. 167-85.

Following successful assembly, integration and testing (AIT) of the subsystems of both the platform/service module and payload(s), the satellite is delivered either on the ground or in-orbit to the customer.

Both horizontal and vertical integration is common within the satellite manufacturing supply chain in order to secure the supply of critical components, while also providing competitive advantage in terms of standardisation and the development of common platforms and technologies.²⁴ This notwithstanding, system integrators may also divest their interest in space subsidiaries that underperform.²⁵ A fundamental question is the make-or-buy dilemma, i.e. whether a product should be manufactured in-house or pur-

²⁴ "Study on the Internationalisation and Fragmentation of Value Chains and Security of Supply | Case Study on Space." 17 Feb. 2012. Danish Technological Institute 18 Sept. 2014: 38.

²⁵ "Satellites to be Built & Launched By 2022." 2013. Euroconsult. 51.



chased from an external supplier. Satellite integrators may also decide to combine forces in order to increase their competitive position in the market.

As in other manufacturing industries in the aerospace and automotive sectors, a satellite manufacturing supply chain will often be concentrated in regional clusters near a first tier system integrator.²⁶ This can reduce the time needed for the delivery of components to the satellite integrator, in addition to expediting the development of technologies. Although the preference in government procurement is for satellite integrators to procure subsystems, equipment and components domestically, commercial contracts usually have the added flexibility of being able to procure internationally.

Approximately 30 companies (including Europe's Airbus Defence & Space, Thales Alenia Space, OHB, and SSTL) in the global satellite manufacturing industry have the capability to assemble, integrate, and test complete satellite systems (excluding universities and their spinoffs, research laboratories and institutes that develop very small satellites for LEO). The 30 companies do not all compete directly since satellites have different capabilities, e.g. LEO vs. GEO satellites, and some companies may focus solely on government contracts while others on commercial contracts. Around 14 manufacturers have the capability to produce GEO satellites, of which 9 compete internationally.²⁷ There are more than 50 subsystem suppliers, while equipment and component suppliers number above 300 internationally.²⁸

1.6.1 European Consolidation of the Spacecraft Manufacturing Industry

An industry in a new market tends to be fragmented during initial formation, but will normally consolidate as the market matures.²⁹ This phenomenon can be seen also in the space industry, with consolidation having taken place in recent decades in both the upstream and the downstream segments.³⁰ This notwithstanding, the value chains for

commercial telecommunication satellites and Earth observation satellites are in different stages of consolidation (i.e. satellite communications is a much more mature sector than Earth observation).

Consolidation in the satellite industry is not a worldwide phenomenon. In the 1990s, it took place mainly in the United States and Europe, while countries such as Japan and China have not yet seen a significant change in the composition of their respective space industries.³¹ Bucking that trend, in 2013, the Russian government began consolidating its space industry into one single state-controlled corporation.³²

In Europe, companies went through a consolidative transformation through mergers and acquisitions in the 1990s, which led to two space company groups at the prime contractor level, Airbus Defence & Space and Thales Alenia Space.³³ When considered together, these two conglomerates employed 52.7% of all employees in the European space industry in 2014 (this also comprises employment in launcher manufacturing).³⁴ However, these two groups are complemented by OHB as another burgeoning system integrator; OHB being the result of strong internal growth and investment in space, particularly in the past two decades.

The challenge of consolidation is obviously that it may lead to ineffective competition as barely enough players are left to compete for new contracts.³⁵ Figure 1.11 provides the timeline of major consolidations within Europe's space industry.

²⁶ See *generally* Satellites to be Built & Launched By 2022." 2013. Euroconsult. 53, 59-64.

²⁷ *Ibid.* 52.

²⁸ Spagnulo, Marcello, et. al. Space Program Management – Methods and Tools. New York: Springer New York Heidelberg Dordrecht London, 2013: 48.

²⁹ Deans, Graeme K., Fritz Kroeger, and Stefan Zeisel. "The Consolidation Curve." Dec. 2002. Harvard Business Review 9 Oct. 2014 <<http://hbr.org/2002/12/the-consolidation-curve/ar/1>>.

³⁰ It should be noted that in the downstream segment, consolidation within industry has been uneven, consolidating in the communication sector, but expanding and fragmenting in other areas, including Earth observation.

³¹ Ozgur Gurtana. Fundamentals of Space Business and Economics. SpringerBriefs in Space Development. 2013. p. 49.

³² "Russian Space Industry to Be Consolidated Within Year – Rogozin." 4 Sept. 2013. RIANOVOSTI 4 Nov. 2014 <<http://en.ria.ru/russia/20130904/183163496/Russian-Space-Industry-to-Be-Consolidated-Within-Year--Rogozin.html>>.

³³ Ozgur Gurtana. Fundamentals of Space Business and Economics. SpringerBriefs in Space Development. 2013. p. 49.

³⁴ ASD-Eurospace. "Facts & figures – The European Space Industry in 2014." 19th edition. June 2015: 9.

³⁵ "Satellite Industry Consolidation: Why, When and Where?" 23 June 2003. Futron 25 Sept. 2014 <http://www1.futron.com/pdf/resource_center/articles/SpNws_IndCons.pdf>.

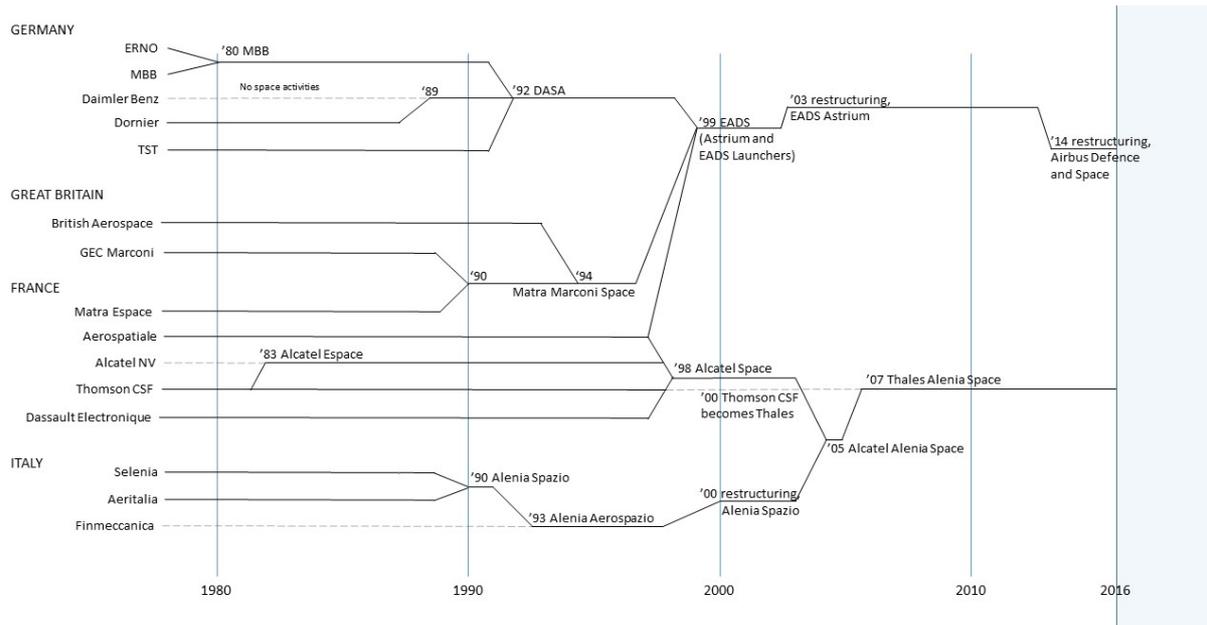


Figure 1.11. Consolidation in the European space industry³⁶

1.7 The Satellite Manufacturing Industry

The satellite manufacturing industry had a turn-over of \$15.9 billion in 2014 or 7.8% of total satellite industry revenue.

Euroconsult estimates that 74.3% of satellite manufacturing revenue originates from government contracts.³⁷ This notwithstanding, some segments have matured enough to stand on their own. Further, Euroconsult estimates satellite manufacturing revenue to grow by more than 25% in the next decade, while the share of institutional satellites is likely to remain roughly equivalent to previous years, at 75.7%. In 2012, more than half of government contract revenue for the year was concentrated in the U.S., with the remaining share divided between China (20%), Russia (14%) and Europe (13%).³⁸ U.S. satellite manufacturers have access to a large domestic market protected by *Buy American* regulations. European manufacturers are hard pressed to compete for satellites for use by non-European governmental, military or civil uses and have to take into account national preferences when competing for commercial non-European communication satellites.

³⁶ Updated diagram showing the evolution of Airbus Defence and Space and Thales Alenia Space adapted from the diagram found in Peeters, Walter. "Overview of the Space Sector." Presentation. Space Economy in the Multipolar World. Vilnius, Lithuania. 7 Oct. 2010.

³⁷ "Satellites to be Built & Launched by 2022." 2013. Euroconsult: p. 54.

³⁸ Ibid.

The space industry designs and manufactures satellite systems and launch vehicle systems for three main types of customers³⁹: domestic government agencies (civilian and military) in the home country of the industry; global or regional commercial satellite operators (mainly GEO communication satellite systems); and government agencies in newly emerging space countries that lack indigenous satellite manufacturing or launch capabilities and thus have to procure them from abroad.

A relevant statistic for gauging the number of spacecraft manufactured is to analyse the details of satellites launched per year. According to *The Annual Compendium of Commercial Space Transportation: 2016* (FAA Compendium), 86 launches took place in 2015, which delivered 116 satellites to orbit.⁴⁰ Of those satellites ranging from small to heavy in size, 49 satellites had a commercial payload, denoting a commercial function or operation by a commercial entity.⁴¹ The remaining 67 satellites were used for non-commercial civil, military, or non-profit purposes.

³⁹ Ibid. 47.

⁴⁰ This value does not include the 149 micro-satellites built mainly by governments, universities, non-profits, and commercial companies such as 'Planet Labs' that were also released into orbit in 2015.

⁴¹ "The Annual Compendium of Commercial Space Transportation: 2016." Feb. 2016. Federal Aviation Administration 1 May 2016 <https://www.faa.gov/about/office_org/headquarters_office/s/ast/media/2016_Compndium.pdf>.



Share of Commercial satellites launched by year

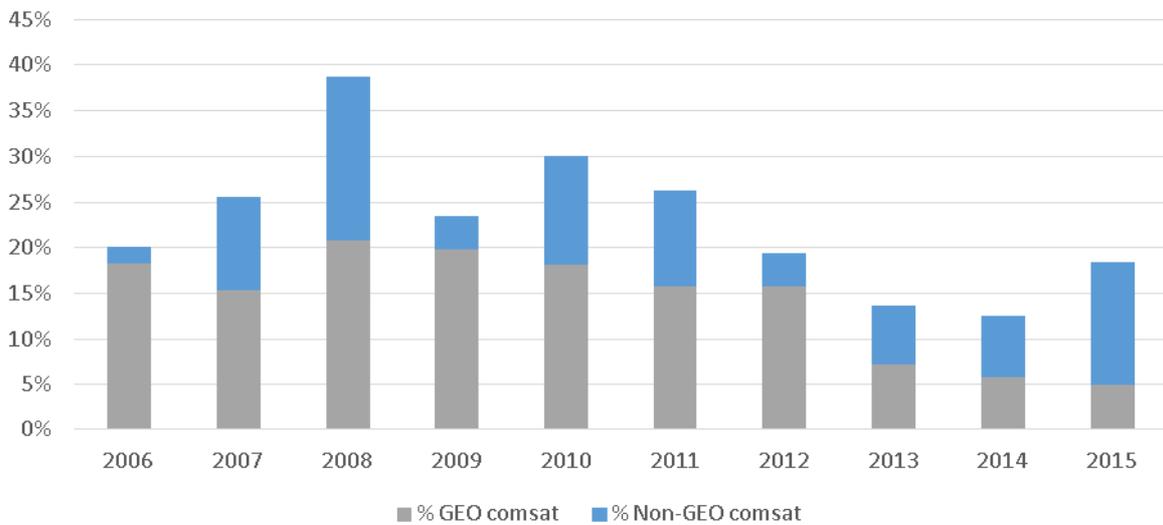


Figure 1.12. Percentage of Commercial Satellites Launched (Source: FAA)

From Figure 1.12 above, in the past decade an average of 22.8% of all satellites launched had a commercial purpose. This is in line with Euroconsult estimates that in 2012, 76.5% of satellite manufacturing revenue originated from government contracts.

The market for geostationary communications (GEOCOM) satellites is highly competitive, especially in the case of GEOCOM satellites that have a commercial payload. Over the past 15 years, an average of 21 GEOCOM satellites with a commercial payload have been ordered each year. Although these spacecraft command very substantial prices, profit margins for manufacturers are low because of the high level of competition.

In 2015, 32 of the 39 geostationary satellites that were launched were for communication

purposes, and 18 of those GEOCOM satellites had commercial payloads. The 188 GEOCOM satellites with a commercial payload that were launched in the past decade were designed and produced by 13 manufacturers, with 82% made by the six traditional prime contractors. Of these, four are U.S.-based, i.e. Space Systems/Loral, Orbital Sciences, Lockheed Martin and Boeing. Their market share was 51% of all commercial GEOCOM satellites launched in the past decade. This shows the scale of U.S. capabilities in the global satellite manufacturing industry. The two European manufacturers, Airbus Defence & Space and Thales Alenia Space were their main competitors and managed to acquire a market share of 31% of all GEOCOM satellites with a commercial payload.

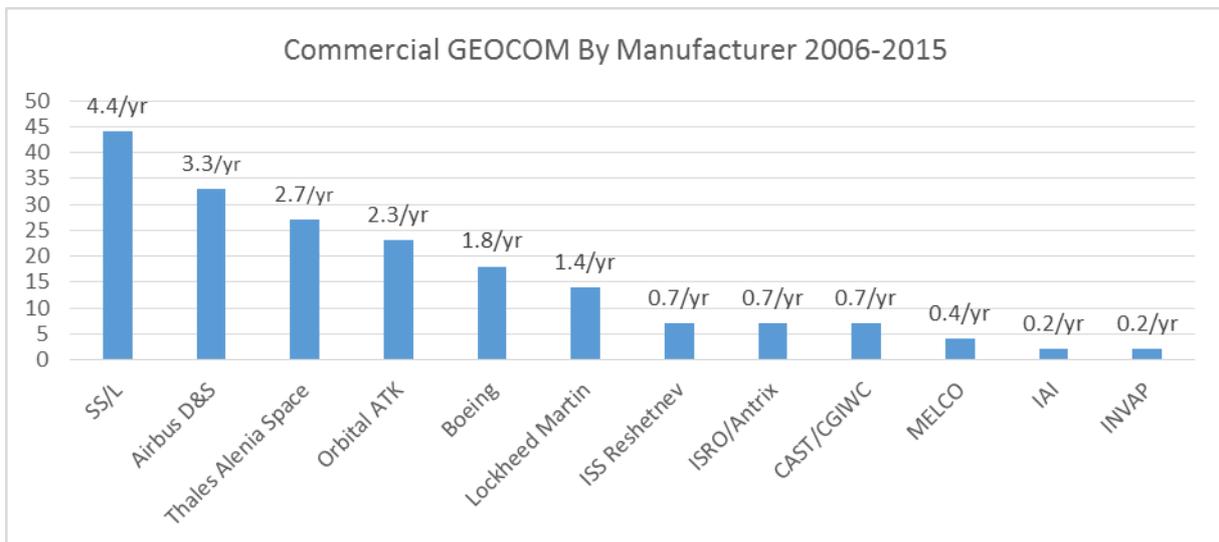


Figure 1.13. Commercial geostationary commercial satellites for the period 2006-2015 (Source: FAA)

In the past decade manufacturers from six other countries have competed for contracts with the American and European prime contractors. These include Russia (with ISS Reshetnev and Khrunichev) as well as Japan (with Mitsubishi Electric Corp. (MELCO)). China is a relatively new player in the market, with its first successful GEOCOM satellite launched in orbit in 2007 (Sinosat 3, now leased to Eutelsat). Also India is relatively new to the market, with its first GEOCOM launched in 2002. More recently, Israel and Argentina have also made a noticeable presence, with their respective Amos and Arsat communication satellites.

It is important to note here that the FAA Compendium identifies satellites with a commercial payload as spacecraft that serve a commercial function or are operated by a commercial entity. This does not mean they have been commercially procured. Although the communications satellite Insat 4G/GSAT-8 has a commercial payload and its services might be sold through its Antrix commercial arm, it is manufactured and operated by the Indian Space Research Organisation (ISRO) and is therefore not commercially procured.

There are therefore 9 manufacturers that compete internationally for commercial GEO comsats, these being Boeing, Lockheed Martin, Orbital ATK, SS/L, Airbus Defence & Space, Thales Alenia Space, MELCO, China Great Wall Industry Corporation (CGWIC), and ISS Reshetnev.

1.7.1 The Six Prime Contractors

The six largest commercial prime contractors in the commercial satellite manufacturing industry are Space/Systems Loral, Boeing, Lockheed Martin, Airbus Defence & Space, Thales Alenia Space, and Orbital ATK. Airbus Defence & Space and Thales Alenia Space are European, whereas the other largest prime contractors are from the United States. Reigning over a considerable market share, they also compete with a number of smaller commercial prime contractors, including MELCO, OHB, MDA, Turkish Aerospace Industries, and others. Competition has intensified with three national prime contractors entering into the commercial market, these being China (CAST→CGWIC), India (ISRO→Antrix) and Russia (ISS Reshetnev & Khrunichev State Research and Production Space Center).

Europe's Prime Contractors

- Airbus Defence & Space

Airbus Defence & Space (Airbus D&S), an amalgamation of several separate divi-

sions of EADS (Astrium, Cassidian, and Airbus Military), is a subsidiary of the Airbus Group and is headquartered in Toulouse, France. Its ownership is shared between France (12%), Germany (11%), and Spain (4%) as state holdings, with the remaining 73% of shares floated on the market.⁴² While the main operations are conducted in France and Germany, divisions are located in 9 countries, with 16 of its 18 sites and offices in Europe.⁴³ Airbus D&S generates revenue of approximately €14 billion per year, and has some 40,000 employees.⁴⁴ Prior to the reorganization of divisions, EADS Astrium generated a revenue of €5.8 billion in 2012, while having 18,000 employees, with 87% residing in France, Germany, or the UK.⁴⁵ Airbus D&S conducts AIT activities for its communications satellites at its Toulouse site, with most component parts arriving from sites in the UK, France, Germany and Spain.⁴⁶ Intespace, also headquartered in Toulouse, performs environmental testing of satellites, under shared ownership with Airbus D&S (87%) and Thales Alenia Space (13%).⁴⁷

- Thales Alenia Space

Thales Alenia Space is a French-Italian aerospace company headquartered in Cannes, France. A joint subsidiary of the Thales Group (67%) and Finmeccanica (33%), the company operates in the space industry in a space alliance with Telespazio, also parented by the Thales Group (33%) and Finmeccanica (67%).⁴⁸ Generating revenues of €2.0 billion in 2014, the company employs around

⁴² EADS (Airbus Group) Annual Review 2013. 26 Feb. 2014. Airbus Group 6 Nov. 2014: 27 <http://www.airbusgroup.com/dam/assets/airbusgroup/int/en/group-vision/business-suppliers/Airbus_Group_Annual_Review_2013.pdf>.

⁴³ "Worldwide space presence." 2016. Airbus Defence and Space 10 May 2016 <<http://www.space-airbusds.com/en/locations/>>.

⁴⁴ "The company." 2016. Airbus Defence and Space 10 May 2016 <<http://www.space-airbusds.com/en/who-is-airbus-defence-and-space/>>.

⁴⁵ "Imperial Space Laboratory Launch." 1 July 2013. Astrium 5 Dec. 2013 <<https://workspace.imperial.ac.uk/spacelab/Public/10.%20Astrium%20Presentation%20to%20ICL%20June%202013.pdf>>.

⁴⁶ "Satellite Assembly, Integration and Test." 24 Aug. 2011. Airbus Defence & Space 6 Nov. 2014 <<http://www.space-airbusds.com/en/news2/satellite-assembly-integration-and-tests-kqn.html>>.

⁴⁷ "History." 2013. Intespace 6 Dec. 2013 <<http://www.intespace.net/en/corporate-profile/history.html>>.

⁴⁸ "Annual Financial Report 2013." 19 Mar. 2014. Finmeccanica 7 Nov. 2014 <http://www.finmeccanica.com/documents/10437/2042705/5/body_AnnualReport2013_web_2.7.14_EN.pdf>.



7,500 employees within 14 industrial divisions located in France, Italy, Spain, Germany, Belgium, the United Kingdom, and the United States.⁴⁹

U.S. Prime Contractors

- Space/Systems Loral

Space/Systems Loral, wholly owned by Canadian MacDonald, Dettwiler and Associates Ltd. (MDA) through a holding company, is a U.S. company headquartered in Palo Alto, California. Prior to its acquisition in 2 November 2012, Space Systems/Loral reported \$1.1 billion in revenue for 2011, and employed about 3,200 employees.⁵⁰ At the time of its acquisition, it had 11 business locations in or near California, with 5 additional sites spread over parts of Europe, Japan, and Canada.⁵¹

- Boeing

Boeing Space & Intelligence Systems, a division of Boeing Defense, Space & Security, manufactures government and commercial satellite systems, with headquarters in El Segundo, California.⁵² Its parent, Boeing Defense, Space & Security, earned \$31 billion in 2014, and has around 50,000 employees. Boeing Space & Intelligence Systems (Boeing) generates 82% of its revenue from government customers⁵³, and is staffed by about 5,400 employees mostly based at its headquarters, but with several hundred staff in other offices throughout 22 business locations spread across 12 states of the United States.⁵⁴

- Lockheed Martin

Lockheed Martin's Space Systems (Lockheed Martin) has the headquarters of its Commercial Space division in Denver, Colorado.⁵⁵ The division has four related space system units with about 11 business locations spread across 9 states in the U.S., and has around 16,000 employees.⁵⁶ Lockheed Martin Space Systems generated sales of \$9.1 billion in 2015, which represents 19.7% of the parent company's total consolidated net sales (\$46.132 billion) for that year.⁵⁷

- Orbital ATK

The Space Systems division of Orbital ATK (formerly Orbital Sciences Corp.) is headquartered in Dulles, Virginia. One of three segments within Orbital ATK, the Satellites and Space Systems division has four facilities, of which two are satellite manufacturing facilities capable of performing AIT production processes.⁵⁸ The largest facility is located in Gilbert, Arizona, developing commercial Earth imaging, space science, and military technology demonstration satellites.⁵⁹ A smaller AIT facility, developing commercial GEO communications satellites and other types of satellites, is located near Orbital ATK headquarters in Dulles, Virginia.⁶⁰ Orbital ATK has over 12,000 employees, of which 2,700 work in its Space Systems Group in business locations spread across 8 states of the U.S.⁶¹ Approximately 25% of Orbital ATK's revenue of \$3.2 billion in 2015 came from commercial and foreign customers,

⁴⁹ "The Global standards in innovative space technologies." 29 Mar. 2016. Thales 10 May 2016 <<https://www.thalesgroup.com/en/worldwide/space/space>>

⁵⁰ Clark, Stephen. "Loral purchase gives Canadian firm a U.S. footprint." 27 June 2012. Spaceflight Now 13 Jan. 2014

<<http://www.spaceflightnow.com/news/n1206/27loral/>>.

⁵¹ "MDA Announces Transformational U.S. Acquisition." 27 June 2012. MDA Corporation 13 Jan. 2014 <http://spaceref.ca/news/MDA_Transformational%20US%20Acquisition-27-June-12.pdf>.

⁵² "Space & Intelligence Systems." Boeing 7 Nov. 2014 <http://www.boeing.com/assets/pdf/bds/mediakit/2014/satellite2014/bkgd_sis_0214.pdf>.

⁵³ De Selding, Peter. "New Boeing Unit Focused on Hosted Payload Market." 22 Feb. 2011. SpaceNews 7 Nov. 2014 <<http://www.spacenews.com/article/new-boeing-unit-focused-hosted-payload-market>>.

⁵⁴ "Network and Space Systems." Jan. 2014. Boeing 7 Nov. 2014 <http://www.boeing.com/assets/pdf/bds/mediakit/2014/navyleague/bkgd_nss_0114.pdf>.

⁵⁵ SpaceNews Staff. "Satellite Telecom | Lockheed Opens Commercial Satellite HQ in Denver." 1 Nov. 2014. SpaceNews 7 Nov. 2014

<<http://www.spacenews.com/article/satellite-telecom/42432satellite-telecom-lockheed-opens-commercial-satellite-hq-in-denver>>.

⁵⁶ "Lockheed Martin To Slash 1,200 Jobs At Space Systems Unit." 14 June 2011. RTT News 10 May 2016 <<http://www.rttnews.com/story.aspx?id=1646041>>.

⁵⁷ "Lockheed Martin Corporation. 2015 Annual Report." 31 Dec. 2015. Lockheed Martin 10 May 2016

<<http://www.lockheedmartin.com/content/dam/lockheed/dam/corporate/documents/2015-Annual-Report.pdf>>.

⁵⁸ "Facilities." 2012. Orbital Sciences Corporation 16 Jan. 2014

<<http://www.orbital.com/newsinfo/imagesmultimedia/images/Facilities/index.shtml>>.

⁵⁹ "Fact Sheet MSF – Arizona." 3 Dec. 2013. Orbital Sciences Corporation 16 Jan. 2014

<http://www.orbital.com/NewsInfo/Publications/SMF_Arizona.pdf>.

⁶⁰ "Fact Sheet MSF – Virginia." 11 Dec. 2013. Orbital Sciences Corporation 16 Jan. 2014

<http://www.orbital.com/NewsInfo/Publications/SMF_Fact.pdf>.

⁶¹ Wall, Mike. "Orbital ATK, Merger of Orbital Sciences and ATK, Begins Operations." 10 Feb. 2015. Space.com 10 May 2016 <<http://www.space.com/28515-orbital-atk-merger-private-spaceflight.html>>.

whereas the remaining 75% came from U.S. government customers.⁶²

1.7.2 The Smaller Commercial Prime Contractors

Other smaller commercial prime contractors compete within the industry, albeit on a diminished production scale compared to the six largest prime contractors. These companies include OHB (based in Germany), Mitsubishi Electric Corporation (Japan), MDA (Canada), Turkish Aerospace Industries (Turkey), and others. OHB is a smaller European commercial prime contractor that develops fully integrated satellites from its two locations in Bremen and Munich, Germany. The remaining prime contractors are each capable of developing fully integrated commercial satellites, however doing so in smaller quantities over the last decade.

1.7.3 Asian National Prime Contractors in the Commercial Market

Three notable national prime contractors, CASC through its CGWIC commercial arm of China, ISRO of India through its Antrix commercial arm, and ISS Reshetnev & Khrunichev State Research and Production Space Center of Russia, have begun entering the commercial market, carving out a niche market in low cost commercial satellites. Combined, these national prime contractors had captured a 16.4% share of the commercial satellite market by the end of 2015. In the coming years (further elaborated on in Chapter Four below) their share is expected to grow to 28% of the commercial satellite market. These state-owned companies benefit from factor endowments such as the low cost of labour, and favourable exchange rates. Moreover, their low-cost satellites with in-orbit delivery arrangements are attractive to emerging countries, which have fewer capability requirements.

1.7.4 European Prime Contractors' Relative Position in the Global Industry

European prime contractors are in a watershed period, faced with increasing competition from the traditional U.S. competitors, while simultaneously being pressured by low cost manufacturers catering to emerging regions that seek less sophisticated technology at a discounted price. Moreover, competitors in the U.S. have the luxury of catering to a giant well of domestic institutional investment when commercial demand dries up; and new commercial competitors in China, India, and Russia are state-financed and thus to some extent cushioned from commercial pressures. European manufacturers must rely much more on commercial revenue, especially from the export market. Considering the scarcity of new contracts, the level of competition, and the marginal profits to be earned, maintaining a significant role in this domain may require new and forward-looking approaches. Investigating these is the purpose of the following chapters.

⁶² "Orbital ATK, Inc. Fiscal Year 2015 Annual Report." 30 June 2015. Orbital ATK 10 May 2016 <<https://www.orbitalatk.com/news-room/docs/Annual%20Report%20Optimized.pdf>>.



2. The Changing Landscape

2.1 Maintaining a Competitive Advantage

The global market for commercial geostationary satellites is changing through the shifting dynamics of incumbent rivals, increasing competition from rising commercial spacecraft manufacturing nations and the availability of substitute products, including small satellites and non-satellite alternatives. This directly affects the competitive landscape of European satellite integrators and poses a risk to their competitive position. In order to assess the changing external environment for

European satellite integrators in the commercial satellite manufacturing industry, Porter's Five Forces Model will be adopted to serve as an underlying framework.⁶³ The model provides a qualitative evaluation tool to assess an industry's external environment and describes how profitability is determined by five forces that impact the level of competitiveness. The five forces include three "vertical" competitive forces that originate from established rivals, new entrants (i.e. growing commercial rivals), and substitute products; and two "horizontal" competitive forces that stem from the bargaining power of suppliers and the bargaining power of buyers (see Figure 2.1).

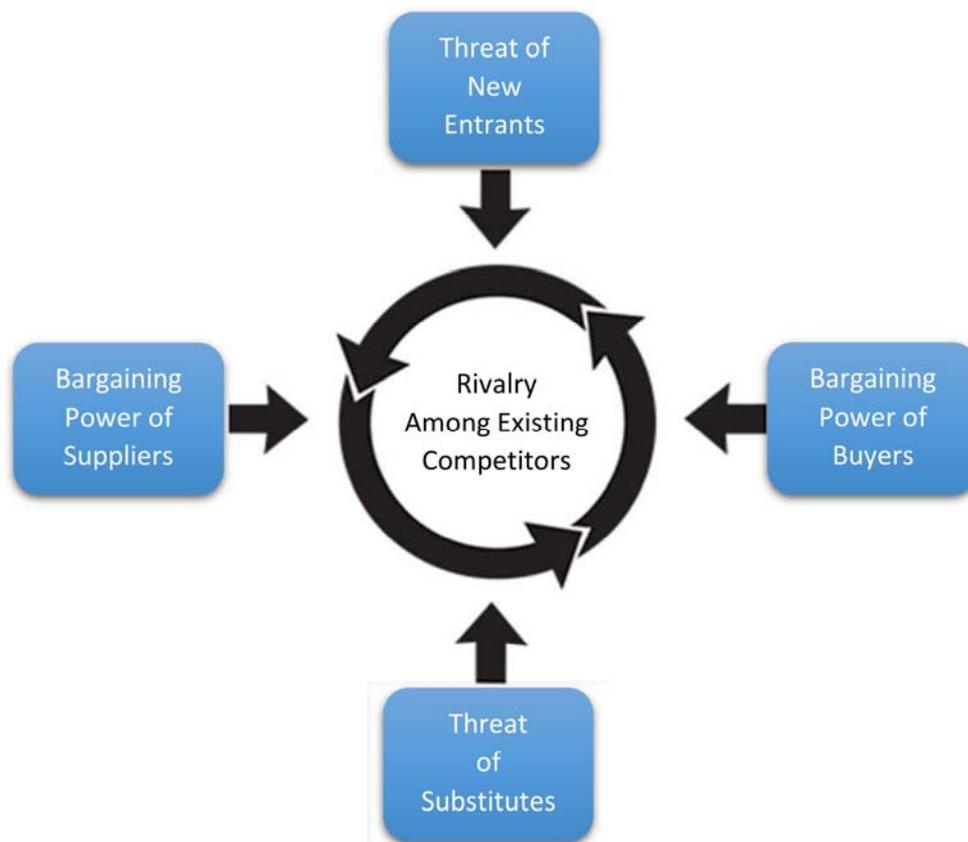


Figure 2.1. Diagram of Porter's Five Forces Model

⁶³ The Five Forces Model was developed by Michael E. Porter at the Harvard Business School in 1979 and further

developed since. See further Porter, Michael E. 1979. How competitive forces shape strategy. *Harvard Business Review*. March-April 1979, pp. 137-145.

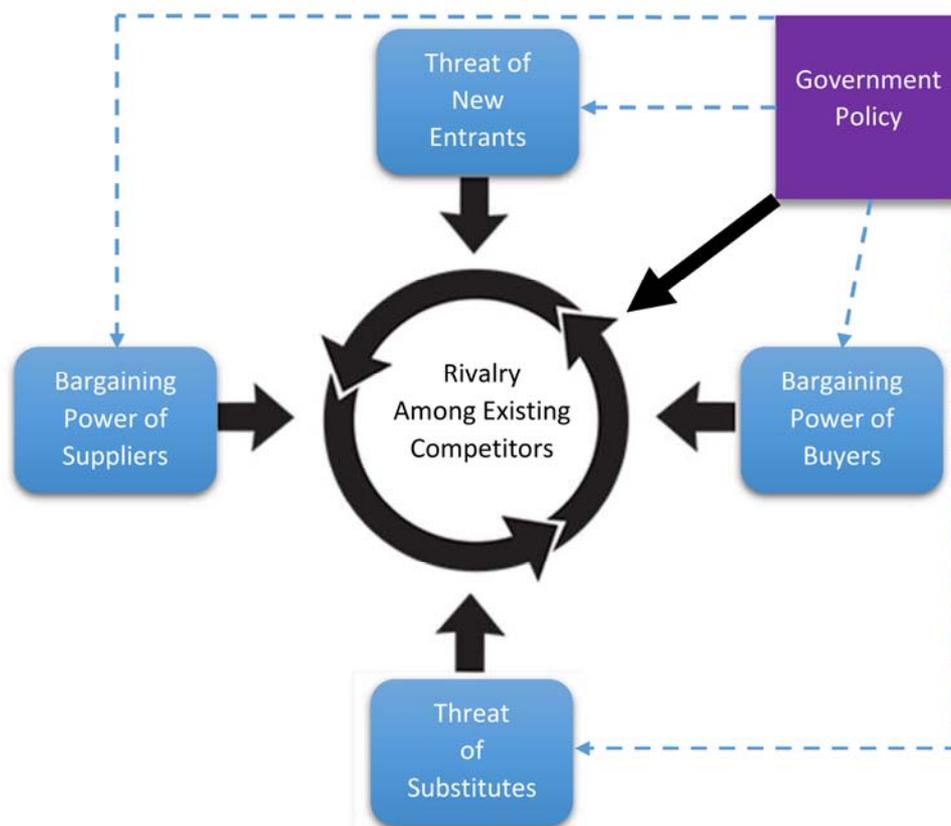


Figure 2.2. Diagram of the adapted Five Forces model⁶⁶

Porter's Five Forces Model however needs to be slightly adapted in order to be in line with the characteristics of the space industry. In the Model, the impact of government involvement is treated as a "factor" rather than a force.⁶⁴ While this might be the case for a number of industries, strict adherence to governments as a mere *factor* would understate their determining role in the global space sector. Historically, governments have been the driving actors in space activities and space has been considered as a highly strategic and political asset for reasons of national security, national prestige, and autonomy as well as for scientific interests and socio-economic development. It is only since the 1980s that a commercial space industry beyond the United States began to emerge, first in the satellite telecommunications market and later in other market segments such as Earth observation. But government policies still influence the landscape of the commercial space industry by shaping domestic industry to contribute to national and societal needs, resulting in an interdependence between the commercial space industry and

institutional actors where one would be operationally deficient without the activities of the other.⁶⁵ When applied to the space industry, the foundation of the model, which is solely the profitability of an industry, does not provide a complete picture. The government actor is therefore included in the Model as a sixth overarching force that impacts each of the five forces unidirectionally and will be addressed transversely as represented in Figure 2.2.

Secondly, Porter mainly focuses on the relative strengths of the respective forces that affect the level of competition and profitability of an industry, with each force having an impact on the economic and technical topog-

⁶⁴ McGinn, David. "Michael Porter's Five (and a Half) Forces." Harvard Business Review. 14 Mar. 2010. <<https://hbr.org/2010/05/michael-porters-five-and-a-half/>>.

⁶⁵ Fuller, Joseph Jr., Foust, Jeffrey, Frappier, Chad, Kaiser, Dustin, and David Vaccaro. "Chapter 6: The Commercial Space Industry: A Critical Spacepower Consideration." Towards a Theory of Spacepower Selected Essays. Eds. Charles D. Lutes and Peter L. Hays. Washington D.C.: Institute for National Strategic Studies National Defence University. 2011.

⁶⁶ Diagram adapted from: Li, Zhe, and Lu Sun. "The Impact of the Government Policy on the Chinese Electric Vehicle Industry and Business Strategy Management: Case of FAW." Student Thesis at the Linköpings University 30 May 2011 <http://www.iei.liu.se/fek/722a31/file-archive/1.273563/LiZhe_SunLu-TheimpactofthegovernmentpolicyontheChineseelectricvehicleindustryandbusinessstrategymanagement.pdf>.



raphy of the industry. The Model is therefore applied herein from the perspective of European satellite integrators to provide a portrait of the global competitive environment, i.e. the intensity of rivalry among established competitors, the threat of new commercial rivals, the bargaining power of suppliers, the bargaining power of buyers, and the threat of substitution. Following the identification of the relative strength of the different forces, Chapter 3 will consider the risks and opportunities associated with the strategies the European satellite integrators might choose to put forward to either maintain or improve their competitive position.

2.2 Intensity of Rivalry amongst Existing Competitors

As in most industries, the intensity of rivalry in the commercial space manufacturing sector stems from a number of interacting structural factors, i.e. not only the number and scale of competitors, and the industry's rate of growth (as described in Chapter 1) – but also fixed costs, product differentiation and associated switching costs, production capacity, competitor diversity, the strategic stakes involved, the scale of exit barriers, and market politics.⁶⁷ Until recently, major rivalry within the commercial satellite manufacturing industry centred mostly on the six main commercial prime contractors in Europe and the United States, each competing for market share. But, as noted above, an additional number of smaller commercial prime contractors also compete with these prime contractors, albeit on a diminished scale, providing smaller customised satellites.⁶⁸

While a limited number of commercial GEOCOM contracts are available to be won on the global market, an estimated five to ten satellite contracts (commercial or not) are needed per year (depending on the size, power, pricing and complexity of the satellite) to cover the fixed costs associated with each prime contractor's AIT processes and highly skilled labour⁶⁹. As a result, operations tend to be of a job-order nature, rather than an assembly line process. However, some prime contractors have sought to increase economies of scale through the consolidation of product lines or by streamlining activities to

reduce overhead costs, capital expenditure, facility space, and labour, and to reap R&D and production cost advantages as well as faster cycle times. Nevertheless, rivalry is further intensified by the uncertain demand for satellites, which can affect production capacity, notwithstanding production backlogs among prime contractors. For instance, following EADS's December 2013 reorganization to become the Airbus Group, Airbus D&S required its Astrium division to cut 2,470 positions from its pool of 18,000 employees as part of Astrium's streamlining effort⁷⁰; that number was reduced by 600 positions following the success of new product lines for EO and telecommunications satellites on the export market in 2014, however.⁷¹ Moreover, even prior to the November 2012 acquisition of Space Systems/Loral by Canada's MacDonald, Dettwiler and Associates Ltd. (MDA), Space Systems/Loral sought to streamline activities through standardization whenever possible, in addition to improving efficiency in its engineering and manufacturing programmes. And in ongoing government contracts, both Boeing and Lockheed Martin offered to trim manufacturing costs by decreasing government oversight, reducing reporting requirements, and conducting less testing on later edition satellites.⁷²

The diversity among prime contractors, the high strategic stakes involved, and the high exit barriers (i.e. the loss of technological capability) are also factors that sustain intense rivalry among prime contractors. Whereas prime contractors in the U.S. have the added support of an established domestic market for satellites, with government and military actors that prefer domestic manufacturers, Europe's market for military systems is relatively underdeveloped. In Europe, 24% of European space industry sales is generated from exports to commercial telecommunication satellite operators, including a small share generated from operators purchasing Earth observation satellites - combined, these customers accounted for 81% of total export revenue in 2014.⁷³ Moreover, sales generated

⁶⁷ See further, Porter, Michael E. *Competitive Strategy*. New York: The Free Press, 1980: 17-21.

⁶⁸ See Chapter 1 – 1.7.2 The Smaller Commercial Prime Contractors

⁶⁹ Cf. Space Systems / Loral Annual Reports 2008, 2009, 2010, 2011.

⁷⁰ De Selding, Peter. "EADS Restructuring To Eliminate Nearly 2,500 Astrium Jobs." 10 Dec. 2013. SpaceNews 19 May 2014

<<http://www.spacenews.com/article/financialreport/38588e-ads-restructuring-to-eliminate-nearly-2500-astrium-jobs/>>.

⁷¹ De Selding, Peter B. "Successes in 2014 Prompt Airbus To Reduce Space Layoffs." 20 Jan. 2015. SpaceNews 12 Mar. 2015 <<http://spacenews.com/successes-in-2014-prompt-airbus-to-reduce-planned-layoffs-in-space-business/>>.

⁷² Werner, Debra. "Satellite Manufacturers Look for Ways to Reduce Costs." 9 Apr. 2012. SpaceNews 20 Jan. 2015 <<http://spacenews.com/satellite-manufacturers-look-ways-reduce-costs/>>.

⁷³ ASD-Eurospace. "Facts & figures – The European Space Industry in 2014." 19th edition. June 2015: 10, 15.

by the commercial export of European telecommunication satellites and Earth observation satellites far exceed the value of Europe's domestic sales of similar systems.⁷⁴ And this does not take currency inflation into account, considering the relatively flat yearly revenue generated since 1996 compared with the diminishing value of the U.S. dollar.⁷⁵ So it is clear that commercial satellite contracts, especially geostationary satellites, are essential for the business of European satellite integrators.

Prime contractors historically have insulated their competitive positions by differentiating their products and by increasing switching costs in the form of ground equipment upgrades for their customers. That differentiation, developed with a focus on cost reduction and increased capabilities for customers, is robust among mature prime contractors whose customers (i.e. major commercial satellite operators) also compete for market share, expanding coverage into emerging regions, while also mindful of the bottom-line. The latest differentiated satellites marketed by the main competitors include cutting-edge technologies such as electric propulsion, high-throughput, and low-latency, among others, with each technology having the potential to change the game within the commercial space sector.

Electric Propulsion

Electric propulsion is not a new capability; dating as far back as the 1960s, experimental satellites launched by both the U.S. and Soviet Union demonstrated the concept of ion propulsion as a form of in-orbit station keeping.⁷⁶ This concept has now been expanded to allow orbit insertion by electric propulsion. The main benefit from the use of electric propulsion is the reduction in consumption of propellant, substantially lowering the total amount of propellant needed for the lifetime of the satellite, translating into either a lower launch cost of a satellite that has less mass, or increased capabilities derived from additional payload capacity. However, in contrast to chemical propulsion systems, the gradual thrust generated by the small flow of ejected propellant means satellites will take much longer, up to 6 months, to reach their intended orbital slots.⁷⁷

⁷⁴ Ibid. 11.

⁷⁵ See Figure 1.5. Satellite Manufacturing Industry Revenue (\$ Billions).

⁷⁶ Hoskins, W. Andrew, R. Joseph Cassady, et. al. "30 Years of Electric Propulsion Flight Experience at Aerojet Rocketdyne." Paper IEPC-2013-439, 33rd International Electric Propulsion Conference, Washington DC, October 2013 <<http://www.iepc2013.org/get?id=439>>

⁷⁷ Allen, Greg. "Satellite Electric Propulsion: Key Questions for Satellite Operators and their Suppliers." 21 Mar. 2013. Avascent 28 Nov. 2014

Following Boeing's contract for the production of four "all-electric" 702SP satellites in 2012, the remaining main manufacturers (i.e. Airbus D&S, et. al.) in addition to OHB, stated a current or upcoming capability to offer electric propulsion technology to their customers.⁷⁸

High Throughput Satellites

Whereas traditional geostationary communication satellites transmit data through a single beam to cover a broad regional footprint with a fixed signal capacity, high throughput satellites (HTS) are a type of communications satellite that uses multiple focussed spot beams, leveraged by frequency reuse, to increase both the available coverage and signal capacity.⁷⁹ With increased signal capacity, a satellite operator is able to be more competitive by offering customers either better throughput, in terms of bandwidth and efficiency at the price currently charged, or current level throughput at a lower cost per bit.⁸⁰ As the global demand for satellite bandwidth continues to increase, HTS satellites enable operators to provide services to emerging and remote regions, including maritime commercial routes. While the leading prime contractors delivered an aggregate total of 31 HTS between 2004 and 2013, Euroconsult predicts that an additional 33 HTS satellites will be manufactured and launched between 2014 and 2016.⁸¹

Low Latency Technology

While HTS satellites increase the amount of signal capacity available, providing higher throughput at a lower cost-per bit compared to traditional FSS satellites using the same amount of allocated frequency, signals that are transmitted from GEO orbit take longer to reach Earth than signals from satellites orbiting at lower altitudes. This latency time is most noticeable when comparing the +500 milliseconds needed to transmit a signal round trip from Earth to GEO orbit compared to substantially below 100 milliseconds for terrestrial internet connectivity via DSL, cable or optical

<<http://www.avascent.com/blog/2013/03/21/satellite-electric-propulsion-key-questions-for-satellite-operators-and-their-suppliers/>>.

⁷⁸ Federal Aviation Administration. 2013 Commercial Space Transportation Forecasts. Washington DC: FAA, May 2013: 11.

⁷⁹ "High Throughput Satellites (HTS)." Comtech EF Data 1 Dec. 2014

<<http://www.comtechefdata.com/applications/mobile-backhaul/hts>>.

⁸⁰ Neumann, Terry. "High-Throughput Satellites to cut maritime data costs." 10 Jul. 2012. iDirect 1 Dec. 2014 <http://www.idirect.net/~media/Files/Maritime_Campaign/Digital_Ship_Article_Aug12.ashx>.

⁸¹ Prokosh, Brent. "2014 Could be a Defining Year for High Throughput Satellites." Satellite Executive Briefing 7.1 (2014): 17-18 <<http://www.satellitemarkets.com/pdf2014/jan14.pdf>>.



fibre. For example, the HTS satellite ViaSat 1 was reported to have a measured latency of 638 milliseconds, approximately 20 times more than the terrestrial average in the U.S.⁸² To overcome this signal delay, constellations of communications satellites in Medium Earth Orbit (MEO), a distance ranging between 2,000 km to 35,786 km, are being developed to provide satellite broadband service with latency time much closer to terrestrial providers. The O3b satellite constellation built by Thales Alenia Space, and operated by O3b Networks, claims a round-trip data transmission time of less than 150 milliseconds⁸³, or just 4 times longer than the terrestrial average in the U.S. – resulting in a more fibre-like experience for its customers.

Other Advanced Technologies

In addition to the differentiated technologies listed above, several other technologies are currently being developed with the potential to disrupt current technologies within the commercial satellite manufacturing industry in the near-to-mid future. These technologies include: Earth observation satellites with full-motion satellite imaging capability (e.g. Terra Bella satellites (formerly Skybox Imaging) manufactured by Space Systems/Loral); the use of hosted payloads on commercial satellites to allow governments to test space-based technologies while lowering overall purchase cost of a satellite for an operator (e.g. the commercially hosted infrared payload (CHIRP) on the SES-2 satellite); and the development of less costly nanosatellite and microsatellite constellations for use in lower orbits (e.g. Planet Labs and Terra Bella microsatellite constellations). Another potentially disruptive technology being developed is the capability to refuel satellites while in orbit through the use of orbiting life extension vehicles (e.g. ESA's conceptual ConeXpress orbital life extension vehicle).⁸⁴

2.2.1 Barriers to Entry

Even with the relatively intense rivalry between prime contractors in Europe and the United States, high entry barriers that have hindered new actors have sheltered the com-

mercial satellite manufacturing industry. Once strong during the infancy of the commercial industry, these barriers have eroded in recent decades, increasingly shaped by globalization and international competition. The most relevant of these entry barriers specific to satellite manufacturing are economic and policy-based.

Economic Barriers Inherent to the Satellite Manufacturing Industry

In previous decades, economic barriers such as high capital requirements, the need for scale economies, and the research and development involved, kept new actors from entering the satellite manufacturing industry.

Space is inherently a capital-intensive industry due mainly to its harsh operating environment. Each component undergoes rigorous testing to ensure proper functioning of the satellite and its subsystems, including redundant systems in the case of a malfunction. Presently, a space infrastructure capable of building and servicing satellites while in orbit does not yet exist. This therefore necessitates not only a high level of knowledge capital (i.e. know-how, technical expertise) but also capital investment in high-tech production facilities to manufacture a spacecraft that meets the requirements defined by the customer and the space environment.

In the 1980s, during the Cold War, only a small number of countries were capable of building and launching a satellite. For instance, according to statistics available on the OECD Database, between 1976 and 2014 the vast majority of space-related patents (designated as B64G) filed under the European Patent Office (EPO), Patent Co-operation Treaty (PCT), and the United States Patent and Trademark Office (USPTO) came from the U.S., France, Germany, the UK, and Japan.⁸⁵ It was in this cold war period, when different parts of the world remained in isolation, that major scientific and technological advancements were made, backed by military interests and the need for industrial secrecy to preserve technological advantage. Following the end of the cold war, globalisation provided a window for researchers to increase the collaboration and dissemination of scientific advances, knowledge flows and dual-use technological transfers to other parts of the world.⁸⁶

⁸² "2013 Measuring Broadband America - February Report | A Report on Consumer Wireline Broadband Performance in the U.S." Feb. 2013. FCC 2 Dec. 2014: 11 <<http://transition.fcc.gov/cgb/measuringbroadbandreport/2013/Measuring-Broadband-America-feb-2013.pdf>>.

⁸³ "O3b advantage." 2014 O3b Networks 2 Dec. 2014 <<http://www.o3bnetworks.com/o3b-advantage>>.

⁸⁴ "Support to ESA Programmes." 7 May 2014. ESA 2 Dec. 2014 <[http://www.esa.int/Our_Activities/Space_Engineering/Automation_and_Robotics/Support_to_ESA_Programmes2/\(print\)](http://www.esa.int/Our_Activities/Space_Engineering/Automation_and_Robotics/Support_to_ESA_Programmes2/(print))>.

⁸⁵ OECD. The Space Economy at a Glance 2007. OECD Publishing, 2007: 56-58.

⁸⁶ OECD. The Space Economy at a Glance 2014. OECD Publishing, 2014: 22.

Breakdown of Space-related Patents (B64G) at EPO, PCT, and USPTO from 1976-2014, by Country of Applicant

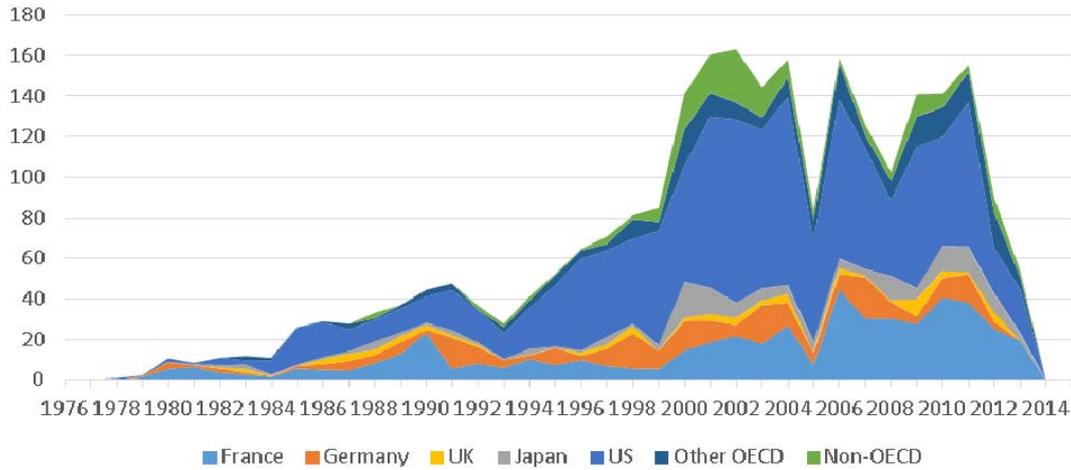


Figure 2.3. Breakdown of Space-related Patents (B64G) at EPO, PCT, and USPTO from 1976-2014, by Country of Applicant (Source: OECD Database⁸⁷).

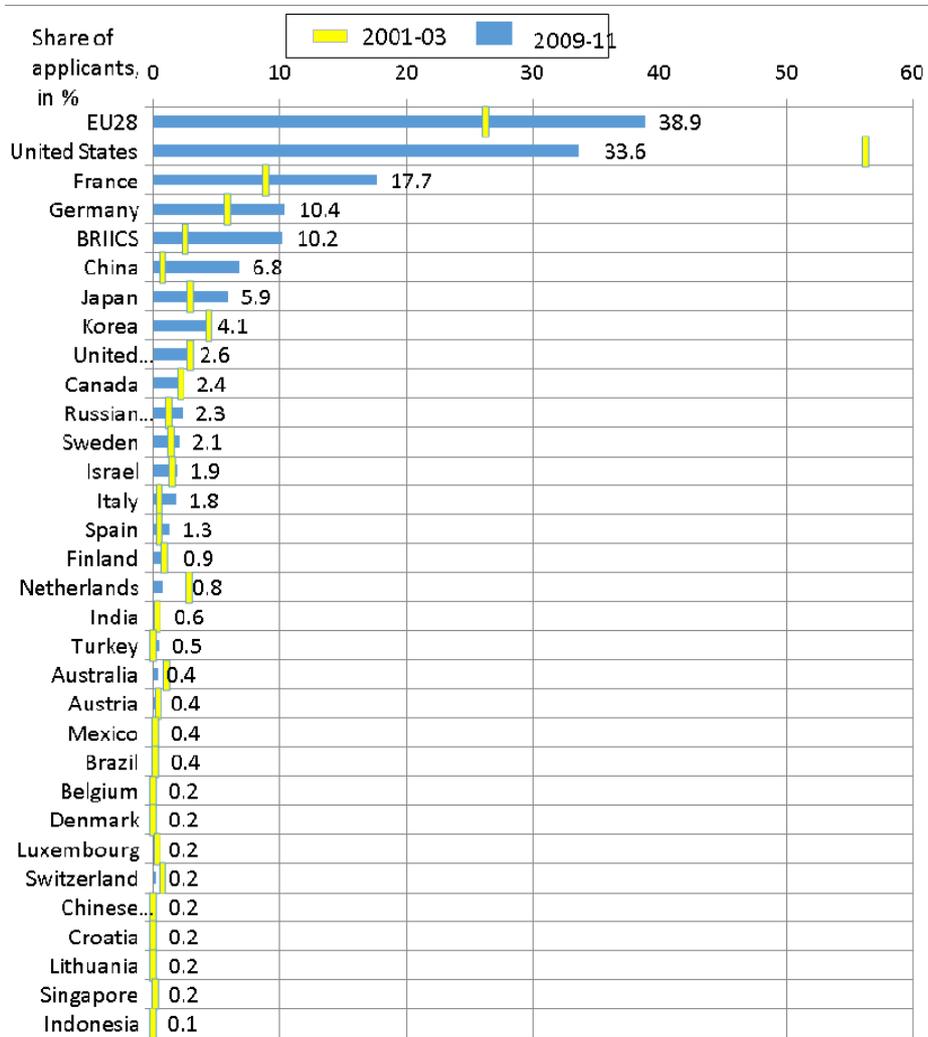


Figure 2.4. Breakdown of Space-related Patents filed under the PCT from 2001-03 and 2009-11 (Source: OECD 2014).

⁸⁷ "OECD.Stat." OECD 1 May 2016 <http://stats.oecd.org/Index.aspx?DatasetCode=PATS_IPC#>; please note the impact of the time lag on the last few years of data.



Today, the technological advantage in space related technologies, as reflected in the OECD 2014 edition of *Space Economy at a Glance*, shows a different picture. Taking a sample from filings submitted under the PCT, countries such as China and Russia have made significant strides in increasing their shares of space-related patents filed in 2009-2011 compared to 2001-2003.⁸⁸

Policy-based Barriers Inherent to the Satellite Manufacturing Industry

Policy-based barriers are government policy, and laws and regulations that are restrictive for new actors to enter the satellite manufacturing industry, of which export control regulations are the most significant obstacle.

Export restrictions are a highly relevant matter in the satellite manufacturing industry, particularly since satellite components sourced from the United States have the potential to keep a European prime contractor from selling satellite technology to export-restricted countries such as China, or to limit the available options for procuring cheaper launch services from other low-cost regions. Export restrictions prevent the export of technological goods and services that would make a significant contribution to the military potential of other states, thereby potentially harming the exporting state's national security. The U.S. International Traffic in Arms Regulations (ITAR), first introduced in the mid-1970s, are currently the most notable unilateral restrictions.

The U.S. ITAR export regulations, which grew more restrictive in regard to the transfer of satellite technology during the 1990s, had a tide shifting effect on technology transfer and the development of indigenous capabilities throughout the globe. The most notable of the ITAR regulations is the Arms Export Control Act (AECA) of 1976, which authorises the President of the United States to control the trade of defence articles and services as designated by the U.S. Munitions List (USML). The Export Administration Regulations (EAR) also govern the export of strategically significant commodities and technology that are not listed as a defence article or service, but may still have 'dual-use' civilian and military applications as designated under the U.S. Commerce Control List (CCL). While both export control regulations list specific countries or groups of countries that may be subject to specific control criteria and conditions, export to a country under the AECA requires the approval of the U.S. State Department, involving a large number of applications, long

processing times, and a detailed disclosure of the nature of the transaction, while also prohibiting the export or re-export of commodities to countries under U.S. embargo. By contrast, the export of commodities under the EAR is far less burdensome, needing the approval of the U.S. Commerce Department, which has fewer requirements and greater flexibility in its application process.⁸⁹

Finding an increased competitive environment stemming from the growth of indigenous capabilities in Europe and in Asia bypassing ITAR requirements, the U.S. government called for an assessment of the risks associated with removing satellites and related components from the USML under Section 1248 of the NDAA of 2010.⁹⁰ The Aerospace Industries Association (AIA) estimated that between 1999 and 2009, \$21 billion in commercial manufacturing revenue was lost for U.S. industry, which cost about 9,000 direct jobs annually.⁹¹ In April 2012, the U.S. Department of Defense (DoD) and State Department released their joint report to Congress concluding that communication satellites and remote sensing satellites, including their subsystems, parts, and components were more appropriately designated as dual-use items on the CCL, to be controlled under the EAR.⁹² So long as these satellites did not contain classified components, and had performance parameters below thresholds specified for items remaining on the USML, they were not critical to U.S. national security. In 2013, under Section 1261 of the NDAA of 2013⁹³, dual-use satellite technology was transferred back to the CCL, with final classification rules by the State Department taking effect on 10 November 2014.⁹⁴ However,

⁸⁹ Panahy, Dara, and Bijan Ganji. "ITAR Reform: A Work in Progress." *The Air & Space Lawyer* 26.3 (2013) 14 Nov. 2014

<<http://www.milbank.com/images/content/1/5/15123/ITAR-Reform-A-Work-In-Progress-December-2013.pdf>>.

⁹⁰ Section 1248(a) National Defense Authorization Act for Fiscal Year 2010, Pub. L. no 111-84, 123 Stat. 2546 (2009) <<http://www.gpo.gov/fdsys/pkg/PLAW-111publ84/pdf/PLAW-111publ84.pdf>>.

⁹¹ "AIA Supports Lifting of Export Restrictions on U.S. Space Systems." 13 May 2014. AIA 20 Nov. 2014

<http://www.aia-aero-space.org/news/aia_supports_lifting_of_export_restrictions_on_us_space_systems/>.

⁹² Departments of Defense and State. Final Report to Congress: Section 1248 of the National Defense Authorization Act for Fiscal Year 2010 (Public Law 111 - 84). 18 Apr. 2012. US DoD 20 Nov. 2014

<http://www.defense.gov/home/features/2011/0111_nsssdocs/1248_Report_Space_Export_Control.pdf>.

⁹³ Section 1261(a) National Defense Authorization Act for Fiscal Year 2013, Pub. L. no 112-239, 126 Stat. 2018 (2013)

<<http://www.dod.mil/dodgc/olc/docs/1999NDAA.pdf>>.

⁹⁴ US State Department. "Amendment to the International Traffic in Arms Regulations: Revision of U.S. Munitions List

⁸⁸ OECD. *The Space Economy at a Glance 2014*. OECD Publishing, 2014: 70.

certain restrictions remained on satellite exports to China, North Korea, and states that the U.S. considers to be sponsors of terrorism.⁹⁵ For further consideration of multilateral and European export control requirements, see 'ANNEX 1: CoCom, Wassenaar, and European Export Control'.

2.3 Threat of New Rivals

In Porter's Model, new entrants constitute a threat to established rivals because they have the potential to gain market share with new capacity and substantial resources. But in every industry there are barriers that impede the ascendance of new entrants. The height of these barriers determines the profitability of the established firms - the higher the barriers, the higher the profitability of established firms above the market level in the long-term.⁹⁶ In the commercial spacecraft manufacturing industry, barriers are high and the entry of new actors is difficult because spacecraft manufacturing is a highly technological industry that requires heavy financial investment. Although well protected by entry barriers, profitability is low, because the competition between incumbents is fierce.

This notwithstanding, in recent decades several emerging space nations have acquired the capacity to manufacture geostationary satellites domestically and thus have successfully transcended these barriers with the goal of establishing national space industries that are competitive in the global satellite manufacturing market. Most notably, China and India have shown incremental space advancements and technological breakthroughs that have allowed them to emulate the technological level of Western spacecraft manufacturers. While the focus of India's satellite manufacturing is still mainly the generation of domestic socio-economic benefits to address its enormous societal needs, China has started to explore the international satellite manufacturing market by competing for

commercial contracts, although so far only with governments of emerging space nations searching for low-cost alternatives. Yet, it seems that it is only a matter of time before China has the means to gain even more market share from the top satellite integrators. The quality of Chinese satellites, i.e. capacity, reliability, and lifetime, has significantly increased, while remaining low-cost due to the lower wages of skilled technicians and operators in the country and strong government support. As seen in the next section, with China having won several contracts from developing countries with its DFH-4 commercial GEOCOM satellite, it has become the main emerging competitor in the commercial satellite marketplace, with India as a potential competitor in the short to medium term. In addition to China and India, other emerging space nations are developing spacecraft manufacturing capabilities, including Turkey, Argentina and Brazil. These emerging manufacturers pose both threats and opportunities to European spacecraft integrators.

In addition to the high cost of entering the industry, government policy, even among long established space actors, can result in a barrier to entering the commercial market. During the Cold War, export restrictions such as COCOM operated as a uniform export regime among Western countries.⁹⁷ In that period, uniformity of approach worked to keep Western technology from reaching the Soviet Union. Stunted but not swayed, satellite manufacturers in the Soviet Union relied instead on their indigenous space industry to meet the needs of their domestic institutional market. Following the Soviet collapse in 1991, and COCOM's expiry in 1994, Russia rapidly began to commercialize with a focus on launchers, and subsequently on commercial satellites.⁹⁸ Hence Russia, in the context of commercial satellite manufacturing, can be seen as a 'quasi' new commercial rival bringing new capacity and substantial resources to the industry with the intention of gaining market share.

2.3.1 China

The China Aerospace Science and Technology Corporation (CASC) is a main prime contractor of the Chinese space program, which, nominally, is governed by the China National Space Administration (CNSA). The state-owned organization controls a cluster of sub-

Category XV." 13 May 2014. US Federal Register 24 Nov. 2014

<<https://www.federalregister.gov/articles/2014/05/13/2014-10806/amendment-to-the-international-traffic-in-arms-regulations-revision-of-us-munitions-list-category-xv>>.

⁹⁵ Section 1261(c)(2) National Defense Authorization Act for Fiscal Year 2013, Pub. L. no 112-239, 126 Stat. 2019 (2013)

<<http://www.dod.mil/dodgc/olc/docs/1999NDAA.pdf>>.

⁹⁶ Li, Zhe, and Lu Sun. "The Impact of the Government Policy on the Chinese Electric Vehicle Industry and Business Strategy Management: Case of FAW." Student Thesis at the Linköpings University 30 May 2011: 25

<http://www.iei.liu.se/fek/722a31/file-archive/1.273563/LiZhe_SunLu

TheimpactofthegovernmentpolicyontheChineseelectricvehicleindustryandbusinessstrategymanagement.pdf>.

⁹⁷ Members as of 1994: Australia, Belgium, Canada, Denmark, France, Germany, Greece, Italy, Japan, Luxembourg, the Netherlands, Norway, Portugal, Spain, Turkey, the United Kingdom, and the United States.

⁹⁸ See further Harvey, Brian. *Russia in Space: The Failed Frontier? Germany: Springer-Verlag Berlin Heidelberg New York / Praxis Publishing, 2001: 281-300.*



ordinate entities, at various tiers, which are primarily engaged in the research, design, manufacturing and launch of space systems, including satellites, launch vehicles and manned spaceships as well as strategic and tactical missiles.⁹⁹ The other main contractor of the Chinese space programme is the China Aerospace Science & Industry Corporation (CASIC) that focuses more on defence issues. Within CASC, its subordinate company China Academy of Space Technology (CAST) deals with space technology and products, engaging in such fields as the development and manufacturing of satellites, satellite applications and external exchange and cooperation in space technology.¹⁰⁰ In addition to a number of other smaller satellite programs, CAST has manufactured the spacecraft for the established satellite series Yoagan (reconnaissance satellites for presumably military purposes), Beidou (global dual-use satellite navigation satellite constellation), Shi Jian (scientific and technology demonstration minisatellites series) and Feng Yun (weather satellites). It has also manufactured communications satellites for commercial use for Hong Kong based operators Asiasat, Apstar, ABS, and for semi-commercial use for state-owned satellite operator Chinastar.¹⁰¹ Building on this rapidly growing expertise in satellite manufacturing, CAST has also started to export fully integrated satellites through the China Great Wall Industry Corporation (CGWIC), a specialized company of CASC, which is the sole commercial organization authorized by the Chinese government to sell Chinese satellite technology abroad.¹⁰²

As a result of increased export restrictions in the U.S. ITAR in 1999 (following the unauthorised release of technical information to the Chinese government about two commercial satellites that were destroyed during Chinese launch failures¹⁰³), and the ongoing embargo following the Tiananmen Square tragedy of 1992, satellite components from the U.S. cannot be used in Chinese satellites, which has compelled China to develop all satellite technologies indigenously leading to

the fully "ITAR-free" DFH-4 (Dong Fang Hong ("The East is Red")) satellite platform. DFH-4 was envisaged as doubling the capacity of its predecessor DFH-3 and equalling the capacity of Western small and medium size geostationary satellite platforms (with a satellite mass up to 5.2 metric tonnes and a payload power of 8 kW).

Introduced in 2006, the platform was developed by the DongFangHong Satellite Company Ltd. (DFH Satellite Co), a subsidiary of CAST, and was marketed domestically and internationally to private and governmental satellite operators as a low-cost alternative to the satellites offered by the United States, Europe, Russia and Japan.¹⁰⁴ CGWIC has made a business case of selling all-inclusive 'In Orbit Delivery Contracts' which include satellite manufacturing, insurance, and launch, typically on-board the Chinese Long March 3B rocket.¹⁰⁵ It also often includes the construction of ground segment facilities, the training of satellite operators, and financing in the form of a generous loan.¹⁰⁶ CGWIC has been successful in selling these inclusive satellite packages to fast-growing developing countries in Asia, Africa and South America, which see satellite technology as the next step in their country's socio-economic development and as a status symbol. Nigcomsat-1 was the first commercial in-orbit delivery contract won by CGWIC in 2004 in an international tender with 22 companies, including Western satellite integrators.¹⁰⁷ Since then, CGWIC has exported several DFH-4 GEOCOM satellites to the governments of emerging space nations, including Venezuela, Pakistan and Bolivia, and signed export contracts with the governments of Laos, Belarus, the Democratic Republic of the Congo, Nicaragua, and Sri Lanka.¹⁰⁸

⁹⁹ "Company Profile." 10 Jan. 2014. China Aerospace Science and Technology Corporation 6 Feb. 2014 <<http://english.spacechina.com/n16421/n17138/n17229/c127066/content.html>>.

¹⁰⁰ "A Brief of CAST." 2008. China Academy of Space Technology 24 Jan. 2014

<<http://www.cast.cn/CastEn/Class.asp?ClassID=70>>.

¹⁰¹ McDowell, Jonathan. "China Satellite Update – 2014." Jonathan's Space Report 18 June 2014

<<http://www.planet4589.org/space/papers/china2014.pdf>>.

¹⁰² "China Great Wall Industry Corporation (CGWIC)." 5 Oct. 2012. Nuclear Threat Initiative 6 Feb. 2014

<<http://www.nti.org/facilities/50/>>.

¹⁰³ Zelnio, Ryan. "A short history of export control policy." 9 Jan. 2006. The Space Review 1 May 2016

<<http://www.thespacereview.com/article/528/1>>.

¹⁰⁴ Although China mainly focuses on selling geostationary communication satellites in the global market, it has also started to export smaller Earth observation satellites, such as VRSS-1, the first Venezuelan remote sensing satellite, which was launched in 2012.

¹⁰⁵ Harvey, Brian. *China in Space. The Great Leap Forward*, Springer, New York, 2013.

¹⁰⁶ "Dongfanghong-4 (DFH-4) Satellite Platform." 10 Jan. 2014. SatLaunch 27 Jan. 2014 <<http://www.satlaunch.net/2012/11/dongfanghong-4-dfh-4-satellite-platform.html>>.

¹⁰⁷ "China's First Satellite for A Foreign Buyer Going on Smoothly As Scheduled." 12 July 2005. China National Space Administration 8 Jan 2015 <<http://www.cnsa.gov.cn/n615709/n620682/n639462/54413.html>>.

¹⁰⁸ These satellite contracts are often based on barter agreements with other clauses included in the contract. In the case of Nigeria, oil deals, political connections, influence in Africa and hard currency were influencing the agreement. Exporting satellites is therefore more than a money-maker; it is part of China's overall space diplomacy to improve space collaboration and deepen cooperation in all areas with developing countries in order to bring bilat-

Even though Chinese satellites have become a low-cost alternative to Western satellites, price and other contractual advantages are not the only factor that needs to be taken into consideration. Quality is a significant discriminator. Reliability, capacity, lifetime, and on-time delivery of the satellite are important features for any satellite project. In the past decade, Chinese-made satellites have faced several in-orbit failures. The satellite Sinosat 2 for China Satcom, the first DFH-4, was designed to operate for 15 years but had a total failure after 15 hours due to the non-deployment of its solar arrays and antennas, while the solar arrays of Nigcomsat-1 failed in 2008, the second year of its 15 year expected lifetime; in 2010 Sinosat 6 was hampered by a leak in its helium-pressurization system that resulted in a five year reduction of its 15 year expected operational life.¹⁰⁹ By the end of 2013, three DFH-4 satellites had been delivered to orbit for Chinese domestic customers, whereas CAST had contracted for the development of DFH-4 satellites for the governments of Nigeria, Venezuela, Pakistan, Laos, and Bolivia.¹¹⁰ China launched the replacement satellite Nigcomsat-1R for Nigeria on 20 December 2011.

To correct this quality deficiency, CAST is developing a next-generation geostationary satellite platform. The DFH-5 platform will offer increased performance and reliability compared, making the platform more competitive on the international satellite manufacturing market, which might enable Chinese satellites to break into the high-end market dominated by Western manufacturers. In order to broaden its product offer, CAST is also developing several variants of its current DFH-4 satellite platform, i.e. DFH-4S (Small and Smart Bus), a lighter design to be launched on the smaller, less-expensive Long March 3C, and the DFH-4E (Enhanced Bus) which offers more capacity, in addition to offering stand-alone satellites without insurance and launch on board a Chinese rocket, which might be a good strategy since Chinese launchers are losing some of their competitive advantage due the emergence of other

eral ties to a higher level. See further "China's Space Diplomacy." 24 Dec. 2013. *The Diplomat* 6 Feb. 2014 <<http://thediplomat.com/2013/12/chinas-space-diplomacy/>>.

¹⁰⁹ "Sinosat 6 [Chinasat 6A, Xinnuo 6]." 18 Sept. 2010. *Satellite News Digest* 6 Feb. 2014 <<http://sat-nd.com/failures/index.html?http://sat-nd.com/failures/timeline.html>>.

¹¹⁰ Federal Aviation Administration. *Semi-Annual Launch Report: October 2010*. Washington DC: FAA, Oct. 2010: 15 <https://www.faa.gov/about/office_org/headquarters_office/s/ast/media/2010-2%20Semi-Annual%20Layout%20Final.pdf>.

low-cost launch alternatives, such as SpaceX.¹¹¹

In sum, China is on the verge of becoming a stronger competitor to European satellite integrators, which signals a threat but also several opportunities. For instance, Europe's Thales Group has seen China as a key growth area in the aerospace sector for several decades; it has gained a solid foothold in China's air transport market, and its subsidiary Thales Alenia Space is also the only foreign supplier of satellites to China.¹¹² The implications of the risks and opportunities emerging from China's commercial space sector will be explained in Chapter 3.

2.3.2 India

The Indian Space Research Organisation (ISRO), founded in 1969, is the main contractor for India's space programme, set up by the Indian Space Commission and administered by the Department of Space (DOS).¹¹³ ISRO has established two major space systems, the INSAT and IRS satellite series. The Indian National Satellite System (INSAT) series has enabled India to focus on its national economic and social development. It is considered as one of the largest domestic communication systems in the world, currently consisting of 11 multi-purpose geostationary satellites that provide operational services in many areas ranging from telecommunication, television broadcasting, and meteorology, to societal applications, such as telemedicine, tele-education, tele-advisories and similar such services.¹¹⁴ The second major Indian space system is the Indian Remote Sensing (IRS) satellite system which is the largest civilian remote sensing satellite constellation in the world providing remote sensing services with applications for agriculture, water resources, urban development, mineral prospecting, environment, forestry, drought and flood forecasting, ocean resources and disaster management.¹¹⁵ The constellation

¹¹¹ "China Plans 2013 Release for 2 New Telecom Satellite Options." 5 Oct. 2012. *SpaceNews* 6 Feb. 2014 <<http://www.spacenews.com/article/china-plans-2013-release-2-new-telecom-satellite-options>>.

¹¹² "China." 1 Oct. 2008. Thales 7 Oct. 2015 <<https://www.thalesgroup.com/en/careers/china>>.

¹¹³ "Annual Report 2012-2013." 2013. Government of India Department of Space 14 Dec. 2015 <<http://dos.gov.in/rep2013/index.htm>>.

¹¹⁴ NB: The satellites part of the INSAT constellation are: INSAT-3A, INSAT-3C, INSAT-3E, INSAT-4A, INSAT-4B, INSAT-4CR, GSAT-8, GSAT-10, GSAT-12, GSAT-14, and GSAT-16; see further "Manoranjan Rao, P.V. "No Ambiguity of Purpose. The Indian Space Programme." 50 Years of Space A Global Perspective. Eds. P.V. Manoranjan Rao. Himayatnagar: Universities Press (India), 2007. 203-263.

¹¹⁵ "Satellites." Government of India Department of Space 13 Jan. 2015 <<http://dos.gov.in/satellites.aspx>>.



currently has 11 satellites in sun-synchronous orbits.¹¹⁶

ISRO has mainly focussed its resources on developing satellite technology to cater to India's domestic needs but it has been seeking to become more active in the international satellite market and thereby expand its communications satellite production capabilities to capture a share of the commercial market.¹¹⁷ Antrix Corporation, established by ISRO as its commercial arm, has been marketing Indian space products and services in the global market.¹¹⁸ Antrix has access to ISRO's satellite design, manufacturing and launch facilities and offers products ranging from complete satellite programs to function-specific components, as well AIT services and launch services.¹¹⁹ In 2001 Antrix initiated talks with Boeing to cooperate in the manufacture of small geostationary communication satellites. Due to management changes at Boeing and ITAR export controls, an alliance proved impossible. Antrix then turned to European satellite integrator Airbus D&S.¹²⁰ As a result, in 2005, Airbus became the principal foreign partner of ISRO and Antrix in the market for smaller geostationary communication satellites (with a satellite mass of between two and three tons and a payload power of 4 kW).¹²¹ In the Memorandum of Understanding it was stipulated that Airbus would provide the communication payload that would then be integrated by Antrix on an Indian satellite bus (an I-2K satellite platform).¹²² Antrix would lead the bids as prime contractor for customers originating from most of South Asia while Airbus would be the leading actor for satellites sold in the rest of

the world.¹²³ This agreement has enabled Airbus to have a presence in the small geostationary satellite market without having to invest in a light version of its larger Eurostar satellite platform. While it is estimated that two or three satellites would be manufactured each year, only two spacecraft were ordered, however – for the European satellite operators Eutelsat (W2M) and Avanti (Hylas-1).¹²⁴ The industrial partnership encompassing overarching cooperation on launchers and satellites was renewed in 2010 for five years, and by December 2015, that relationship appeared poised to continue for an additional five years.¹²⁵ Another key long-term agreement between Airbus and Antrix was signed in 2008 on the use of the Indian PSLV launcher that enabled Airbus to offer attractive launch solutions in the international market for the in-orbit delivery of its Earth observation satellites.¹²⁶ This had led to the successful launch of two Earth observation satellites, Spot 6 in 2012 and Spot 7 in 2014. The decade-long alliance between the partners has allowed Airbus to establish itself as the premier foreign industrial partner of ISRO and the Indian space industry.¹²⁷

2.3.3 Smaller Emerging Geostationary Satellite Manufacturers

Global access to space technology has dramatically increased over the years and has enabled several emerging space industries to very quickly catch up technologically, rather than develop indigenous technologies organically.¹²⁸ This has enabled several small space nations, besides the large emerging space

¹¹⁶ The satellites part of the IRS constellation are: IRS P6, IRS P5, Cartosat 2 (IRS P7), Cartosat 2A, IMS 1, Oceansat-2, Oceansat-2B, Resourcesat-2, Megha-Tropiques, RISAT-1, and SARAL/AltiKa.

¹¹⁷ Chesebro, Jonathan. "Country Studies: India." 13 Aug. 2012. International Trade Administration 26 Jan. 2015 <http://trade.gov/mas/manufacturing/OAAL/build/groups/public/@tg_oaai/documents/webcontent/tg_oaai_003958.pdf>.

¹¹⁸ "Creating Value from Space." 2007. Antrix Corporation Ltd. 22 Nov. 2013 <http://www.antrix.gov.in/Antrix-one_source.pdf>.

¹¹⁹ Ibid.

¹²⁰ Gopinath, C. and Surendra, L. "Antrix Corporation Limited: A Strategy for the Global Market." 2009. <<http://www.cgopinath.com/media/f23d337e3c458d7ffff8314a00140f.pdf>>.

¹²¹ "EADS Astrium-ISRO alliance sealed. First contract with Eutelsat for W2M satellite." 20 Feb. 2006. Indian Space Research Organisation 21 Nov. 2013 <http://www.isro.org/pressrelease/scripts/pressreleasein.aspx?Feb20_2006>.

¹²² Gopinath, C. and Surendra, L. "Antrix Corporation Limited: A Strategy for the Global Market." 2009. <<http://www.cgopinath.com/media/f23d337e3c458d7ffff8314a00140f.pdf>>.

¹²³ De Selding, Peter B. "Strong Market for Smaller Satellites Spurs New Competition." 6 Feb. 2006. SpaceNews 21 Nov. 2013 <<http://www.spacenews.com/article/strong-market-smaller-satellites-spurs-new-competition>>.

¹²⁴ The W2M satellite suffered from a major anomaly that affected the satellite's power subsystem but is still in operation in 2015, and has been leased to the Afghan government and rebranded as AFGHANGSAT 1.

¹²⁵ "Airbus targets \$2 billion sourcing from India in five years." 30 Nov. 2015. Business Standard 15 Dec. 2015 <http://www.business-standard.com/article/news-ians/airbus-targets-2-billion-sourcing-from-india-in-five-years-115113000659_1.html>.

¹²⁶ "Airbus Defence and Space and Antrix/ISRO Strengthen Their Tie-Ups." 30 Sept. 2008. Airbus Defence & Space 13 Jan. 2015 <http://www.space-airbusds.com/en/press_centre/airbus-defence-and-space-and-antrixisro-strengthen-their-tie-ups-.html>.

¹²⁷ "The EADS Group in India." 12 Nov. 2013. Diplomacy & Foreign Affairs 13 Jan. 2015 <<http://diplomacyandforeignaffairs.com/the-eads-group-in-india/>>.

¹²⁸ Foy, Hubert. "EIAST: The United Arab Emirates Space Program." National Space Programs Space Safety Magazine 13 Oct. 2014 <<http://www.spacesafetymagazine.com/space-on-earth/national-space-programs/eiast-uae-space-program/>>.

powers China and India, to develop geostationary satellite manufacturing capabilities. These nations have seen rapid economic growth in recent decades and have started to address their socio-economic needs by using satellite technology for the benefit of their populations, various industry sectors, education and research. Some of them have shown interest in becoming commercially active in the global satellite market and are therefore a potential threat in the long term, but equally an opportunity for European satellite integrators. Nevertheless, these countries are only beginning to enhance their technological capability, with a very long timescale for development, and do not present the same level of threat as China, India, or Russia.

Brazil

In 2013 a contract was signed between Thales Alenia Space and the Brazilian government for the delivery of a dual-use geostationary satellite named the Geostationary Defence and Strategic Communications Satellite (SGDC). The agreement included a large technology-transfer package in line with the Brazilian government's objective to establish a national satellite prime contractor that is competitive in the commercial satellite manufacturing market.¹²⁹ The outcome of the bidding competition – Thales Alenia Space was selected from seven bids – was in part decided by how much technology a bidder was willing and able to transfer to Brazil's space programme.¹³⁰ Although U.S. industry officials claimed that U.S. export regulations no longer posed limitations on U.S. participation in international competition and related technology transfer, they most likely played a factor in the decision process. This again demonstrates the liberal setting European manufacturers have over their U.S. counterparts in selling satellites to emerging space nations that expect a sizable technology transfer. Notwithstanding the recent change in ITAR regulations, European satellite integrators have gained considerably more experience in technology transfers than their U.S. counterparts, making them more attractive partners. Nevertheless, whether such fluidity in transferring technology can be said to be a European competitive advantage still remains to be seen, as it brings with it the risk of intensifying competition in the future.

¹²⁹ "Brazilian Competition Proving Irresistible to Satellite Builders." 12 Apr. 2013. SpaceNews 15 Jan. 2015 <<http://spacenews.com/34822brazilian-competition-proving-irresistible-to-satellite-builders/>>.

¹³⁰ "Thales Alenia Space Wins Hotly Contested Brazilian Satellite Contract." 13 Aug. 2013. SpaceNews 10 Jan. 2014 <<http://www.spacenews.com/article/satellite-telecom/36761thales-alenia-space-wins-hotly-contested-brazilian-satellite-contract>>.

Argentina

With the launch in 2014 of the geostationary communications satellite ARSAT-1, Argentina became the first Latin American country to operate an indigenously integrated geostationary satellite. Even though most of the satellite subsystem and components were supplied by foreign manufacturers, the full design, integration, and testing was done by the Argentinian satellite manufacturer INVAP. A Thales Alenia Space payload and several Airbus D&S satellite components were integrated on an indigenously developed ARSAT 3K satellite bus. ARSAT-1 is the first of three satellites of the ambitious ARSAT program which has the objective of not only achieving 100% satellite coverage of the Argentine territory but also of developing an indigenous industrial and technological capability for the manufacturing of GEOCOM satellites. Thales Alenia Space also supplied the payload, and Airbus D&S supplied several components for the Arsat-2, proving their role as leading equipment suppliers in the ARSAT program.

Initially the program envisaged procuring several communication satellites and launch services from the Chinese government. A cooperation agreement was signed but nothing more came of it after the United States lobbied against the partnership. It was therefore decided to develop indigenous GEO satellite manufacturing capabilities, resulting in the cooperation with European satellite manufacturers, indicating that the political neutrality of Europe as a cooperating partner promotes European manufacturers for current and emerging space nations.¹³¹

Turkey

In 2009, Thales Alenia Space and the Turkish Defence Ministry signed the Göktürk contract, an industrial agreement for the manufacturing of Göktürk-1, a high-resolution optical Earth imaging satellite system to be launched in 2016. In addition to the satellite, the contract included a substantial technology transfer program, i.e. the construction of the Göktürk ground infrastructure and a satellite Assembly, Integration and Test Centre (AIT) near Ankara.¹³² The AIT centre was completed in 2014 and is Turkey's first facility for the integration of low-Earth and geostationary orbit satellites up to 5 metric tons for

¹³¹ Belluscio, Alejandro G. "ArSat-1: Argentina to Communicate Its Heightened Space Ambitions." NASA Spaceflight 6 Oct. 2014

<<http://www.nasaspacespaceflight.com/2014/10/arsat-1-argentina-communicate-heightened-space-ambitions/>>.

¹³² "Thales Alenia Begins Work on Turkish Sat." 7 Sept. 2010. SpaceNews 14 Jan. 2015 <<http://www.spacenews.com/article/thales-alenia-begins-work-turkish-sat-0>>.



military and civil purposes. It serves as a critical infrastructure for the development of Turkey's national space program and provides Turkey with the capability to become a satellite designer and integrator for small GEO communication satellites.¹³³ Final assembly of the Göktürk-1 will be in the facility, followed by Türksat 5A, a communication satellite based on a DS-2000 satellite bus provided by the Japanese company Mitsubishi Electric (MELCO). Türksat 5A is slated for launch in 2017 and will be the first geostationary communications satellite to be assembled and integrated in Turkey, with 25% of the satellite technology manufactured domestically.¹³⁴ By 2020, Turkish Aerospace Industries (TAI) aims to produce Türksat 6A, which is labelled as Turkey's first domestically manufactured satellite but will likely include substantial foreign components, with Airbus's subsidiary Surrey Satellite Technology Ltd. (SSTL) expected to provide a Ku-band payload. After the qualification based on the processing of Göktürk-1, TAI hopes to commercially use the facility to assemble, integrate and test satellites for other nations.¹³⁵

The long-term objective of the Turkish government is to develop an indigenous capability to manufacture a complete satellite, shifting Turkey from a satellite purchaser to a satellite manufacturer. In order to reach this ambitious goal, Turkey will need to continue to cooperate with foreign suppliers to support the development of its spacecraft manufacturing infrastructure in the near-to-medium term.¹³⁶

2.3.4 Russia

The space program of the former Soviet Union was the first to put a man-made object in an orbit around Earth in 1957 and evolved into one of the biggest space programs in the world. Russian space commerce is mostly identified with its launchers with which it has had many successes in the export market

(e.g. TsSKB-Progress' Soyuz launcher commercialised by Starsem and now also launched from Kourou, Kruchinev's Proton launcher commercialised by ILS, NPO Energomash's RD-180 engine on Altas 5, and KBkhM Isaev's KDVD1 engine on the Indian GSLV¹³⁷). However, in the more recent past Russia's space sector has jeopardised its market situation because of lack of productivity and lack of oversight, resulting in a string of launch and spacecraft failures amounting to billions of roubles in losses.¹³⁸

By 2005, the Russian Federation had already begun taking measures to resuscitate its industry by signing Resolution No. 635, approving the Federal Space Program for 2006-2015, worth 305 billion roubles (~\$10.6 billion in 2005 prices).¹³⁹ The resolution's main goal was 'to satisfy the increasing needs of the state governmental institutes, regions and the citizens of the country, by providing them space technologies and services'. In a two stage process, to be completed by 2010 and 2015 respectively, it set ambitious objectives to be achieved in all space-related fields: i.e. telecommunications, Earth observation, launchers and space ports, fundamental space research and technology, and space applications; and was expected to result in a total economic impact of about 500 billion roubles by the end of the period.¹⁴⁰ Much of the resolution was dedicated to communications satellite manufacturing, where in addition to developing, augmenting and maintaining satellite constellations, the government sought to maintain the expected operational lifetime at 15 years and reduce its dependence on imported subsystems and component parts to as little as 10%; therefore requiring Russian-built components capable of competing globally.¹⁴¹ In that pursuit, the resolution also set objectives for the evolution of Russia's satellite manufacturing capacity, which would result in 'an increase in the volume of external trade turnover and improve the quality of Russian involvement in the international trading processes' by utilizing the com-

¹³³ "Turkey's Satellite Test Center Ready for Launch." 28 Nov. 2014. YeniSafak 14 Jan. 2015 <<http://english.yenisafak.com/technology/turkeys-satellite-test-center-ready-for-launch-2031843>>.

¹³⁴ "TAI Türksat 5A Project is Going to Cooperate with the Japanese MELCO (in Turkish)." Jan. 2013. Uyduda Ne Var? 17 Dec. 2013 <<http://www.uydudanevar.com/2013/01/tusas-turksat-5a-projesinde-japon-melco.html>>.

¹³⁵ "Turkey's Gokturk-1 Imaging Satellite in Limbo at Thales Alenia Space." 5 Feb. 2015. SpaceNews 4 Mar. 2015 <<http://spacenews.com/turkeys-gokturk-1-imaging-satellite-in-limbo-at-thales-alenia-space/>>.

¹³⁶ Stein, Aaron. "Turkey's Space Policy." May 2014. Centre for Economics and Foreign Policy Studies <http://www.edam.org.tr/Media/Files/1156/Turkey_Space_Policy.pdf>.

¹³⁷ Bènilan, Ivan. Supporting Russian Satellite Equipment Suppliers to Export. Strasbourg: ISU, 2010.

¹³⁸ "Russian Prime Minister Inks Asset Merger for New Space Corporation." 4 Feb. 2014. Astrowatch 4 Mar. 2014 <<http://www.astrowatch.net/2014/02/russian-prime-minister-inks-asset.html>>.

¹³⁹ "Major Provisions of the Russian Federal Space Program for 2006-2015." 22 Oct. 2005. Infoespacial 18 Feb. 2014 <<http://www.infoespacial.com/wp-content/uploads/Major-provisions-of-the-Russian-Federal-Space-Program-for-2006-2015.pdf>>.

¹⁴⁰ At the 2005 cost level.

¹⁴¹ "Major Provisions of the Russian Federal Space Program for 2006-2015." 22 Oct. 2005. Infoespacial 18 Feb. 2014 <<http://www.infoespacial.com/wp-content/uploads/Major-provisions-of-the-Russian-Federal-Space-Program-for-2006-2015.pdf>>.

petitive advantages its industry has in the export of knowledge-intensive products.¹⁴² However, Russia's space industry continued to lose its capability to produce many satellite components and thus by the end of 2013 up to 80% of the equipment on new Russian satellites was imported from Thales Alenia Space and MDA.¹⁴³

In 2010, the inferior quality of electronic components sourced by the Russian space industry was addressed at the collegiate council of the Russian space agency. Continued reliance on those components increased the number of failures both at the AIT stage and in the operational use of satellites and other space technology. The problem seemed to be a lack of ground testing and too much reliance on calculations instead of full-scale testing. Another more systemic cause seemed associated with the increased obsolescence of the entire infrastructure of the Russian space agency, Roscosmos.¹⁴⁴

This problem was acknowledged in a report by the Russian Audit Chamber, which declared Russia's Federal Space Program as "ineffective", caused by poor management of space activities and the budget funds allocated for space projects.¹⁴⁵ This resulted in Russian President Vladimir Putin signing a December 2013 decree that started a fundamental reform of the country's space industry, with the objective of streamlining production and the operation of spacecraft and cutting down on the misuse of funds.¹⁴⁶ The reform first split the Federal Space Agency Roscosmos into two, a demand and supply side, where Roscosmos was intended to act as a customer, responsible for space policy, research and ground infrastructure (e.g. the Baikonur Cosmodrome)¹⁴⁷, while the supply side consisted of a holding company consolidating most of the sector's companies that developed and manufactured spacecraft into the United Rocket and Space Corporation

(URSC).¹⁴⁸ In a change of course, on 21 January 2015, President Putin then approved the merging of Roscosmos's duties with the URSC, providing a single entity 'Roscosmos State Corporation' (RSC) at the helm of Russia's space industry.¹⁴⁹

By consolidating the industry, in addition to eliminating excess manufacturing capacity (prior to the declaration, manufacturers operated at 40% of their capacity), RSC should streamline the procurement of foreign electronic components with increased purchasing power to negotiate volume-based discounts.¹⁵⁰ In addition to industry reform, Russia plans to spend an estimated 2.1 trillion roubles (around \$63 billion) including extrabudgetary sources, for the development of its national space activities in 2013-2020.¹⁵¹

Russia is also looking to increase cooperation with emerging entrants. A series of consultations is expected to take place between the Indian and Russian space agencies to engage Indian partners in the plans and projects to be undertaken by RSC.¹⁵²

2.4 Bargaining Power of Suppliers

When prime contractors procure subsystems, equipment and component parts from lower-tier suppliers for final integration into a satellite, the bargaining power of those suppliers can affect the overall profitability of the prime contractor. Using the Porter model as a basis, the strength of this segment in the manufacturing sector depends on its own interacting structural factors, such as the number of suppliers, availability of substitutes, the importance of the prime contractors as the customer of the suppliers, the switching costs involved in resorting to other suppliers, the

¹⁴² Ibid.

¹⁴³ "Russia Bets on Sweeping Reform to Revive Ailing Space Industry." 26 Dec. 2013. Reuters 4 Mar. 2014 <<http://www.reuters.com/article/2013/12/26/us-russia-space-idUSBRE9BP02S20131226>>.

¹⁴⁴ "The Russian Space Industry at the Turn of the 21 Century." 26 Nov. 2012. Russian Space Web 5 Mar. 2014 <http://www.russianspaceweb.com/centers_industry_2000_s.html>.

¹⁴⁵ "Russia's Space Program Is Ineffective – Audit Chamber." 4 July 2013. RIANOVOSTI 4 Mar. 2014 <<http://en.ria.ru/russia/20130704/182063035.html>>.

¹⁴⁶ "Russian Prime Minister Inks Asset Merger for New Space Corporation." 4 Feb. 2014. Astrowatch 4 Mar. 2014 <<http://www.astrowatch.net/2014/02/russian-prime-minister-inks-asset.html>>.

¹⁴⁷ "Russia Bets on Sweeping Reform to Revive Ailing Space Industry." 26 Dec. 2013. Reuters 4 Mar. 2014 <<http://www.reuters.com/article/2013/12/26/us-russia-space-idUSBRE9BP02S20131226>>.

¹⁴⁸ "Overhaul pending in Russian space sector." 3 Dec. 2014. ITAR-TASS News Agency 4 Mar. 2014 <<http://en.itar-tass.com/russia/763105>>.

¹⁴⁹ Bodner, Matthew. "Putin Approves Roscosmos Merger with Conglomerate." 23 Jan. 2015. SpaceNews 13 Nov. 2015 <<http://spacenews.com/putin-approves-roskosmos-merger-with-conglomerate/>>.

¹⁵⁰ "Putin Signs Legal Decree Consolidating Russian Industry." 9 Dec. 2013. SpaceNews 30 Apr. 2014 <<http://www.spacenews.com/article/civil-space/38551putin-signs-legal-decree-consolidating-russian-industry>>.

¹⁵¹ "Russia Launches \$70 Bln Space Program for 2013-2020." 27 Dec. 2012. RIA NOVOSTI 30 Apr. 2014 <http://en.ria.ru/science/20121227/178432916/russia_launches.html>.

¹⁵² "Russia, India to discuss space cooperation." 3 Mar. 2014. Space Daily 4 Mar. 2014 <http://www.spacedaily.com/reports/Russia_India_to_discuss_space_cooperation_999.html>.



importance of the supplier's subsystems to the prime contractor's business, differentiated products, and whether suppliers pose a credible threat of forward integration.

As reflected in Chapter 1, the concentration of suppliers appears to increase almost exponentially as the sophistication of components and parts decrease. One estimate lists the number of large prime contractors to be around 10, whereas sub-system suppliers number between 40-50, equipment suppliers' number over 300, and so on.¹⁵³ As the number of suppliers increases per tier, the technology they provide becomes increasingly widely offered. Moreover, through globalization, the technological capabilities that previously had been difficult to source in the global market have become widely available from manufacturers throughout the world. However, large integrators have also reduced the potential for forward integration by sub-system suppliers by absorbing them as subsidiaries, and competing alongside other lower tier competitors in the industrial pyramid. The consolidation with key subsystem suppliers has allowed prime contractors to exert greater control over parts of the supply chain that are strategic for their core business and has removed the risk of acquisition by competitors.¹⁵⁴

Government policy has also resulted in a shift in the strength of the bargaining power of higher tier subsystem and component buyers geographically. The prime example of this is ITAR, which hinders export of some components.

Government action can also support suppliers in an industry, as shown by the EU and ESA's push for Electrical, Electronic, and Electromechanical (EEE) components to be sourced less from U.S. components suppliers through its 'European Components Initiative'. Whereas in 2006 a European satellite had an average U.S. electronic content of 75%, by 2013 this had reduced to 60%, edging closer to the 2020 goal of having European satellites composed of 50% European electronics

While suppliers in the lower tiers can have an impact on the competitive environment in commercial satellite manufacturing, their influence depends largely on the technology they offer, and the environment in which they operate. When compared to the remaining competitive forces in the global satellite

manufacturing industry in previous decades, that influence can be described as having been eclipsed. Among North American and European suppliers, this is in part attributable to the effect of U.S. export restrictions that apply to strategic or dual use subsystems, equipment and component parts, which have limited their respective abilities to compete globally. Key lower tiered suppliers are also at risk of being targeted for acquisition by higher tiered competitors; as consolidation is another recurrent activity among competitors in higher tiers.¹⁵⁵ Similarly, in state-owned industries such as in China and Russia, suppliers are controlled as subordinate entities within the vertical supply chain. Moreover, the size of the industry is another factor limiting the bargaining power of suppliers, as there is an abundance of suppliers further down the tiers in the supply chain, i.e. lower tiered less-strategic equipment and component suppliers number over 300 globally, and must compete with subsidiaries of higher tiered manufacturers.¹⁵⁶ Through globalization, the technological capabilities that previously had been difficult to source by prime contractors in the global market are now ubiquitously available from manufacturers throughout the world.

2.5 Bargaining Power of Buyers

The buyers of satellites, be they institutional or commercial, have a strong impact on prime contractor competitiveness, with the potential to influence the price, quality, and competitive environment for prime contractors. The strength of buyer bargaining power depends on its own set of market characteristics, (as for suppliers). Here, customer power depends on factors such as the number of buyers, the volume purchased, product knowledge, product differentiation and associated switching costs, the threat of backward integration (i.e. the ability of a customer to build its own satellites¹⁵⁷), and the importance of the prime contractor's satellites to the quality of the buyers' business. Additionally, government policy can also play a role in influencing the bargaining power of buyers.

¹⁵⁵ "Satellite Industry Consolidation: Why, When and Where?" 23 June 2003. Futron 25 Sept. 2014: 3 <http://www1.futron.com/pdf/resource_center/articles/SpNws_IndCons.pdf>.

¹⁵⁶ Spagnulo, Marcello, et. al. *Space Program Management – Methods and Tools*. New York: Springer New York Heidelberg Dordrecht London, 2013: 48.

¹⁵⁷ For instance, the Earth imaging company Planet Labs designs and manufactures its own constellation of Flock-1 cubesats that are released into orbit; Planet Labs also owns Blackbridge and its RapidEye constellation.

¹⁵³ Spagnulo, Marcello, et. al. *Space Program Management – Methods and Tools*. New York: Springer New York Heidelberg Dordrecht London, 2013: 48.

¹⁵⁴ "Study on the Internationalisation and Fragmentation of Value Chains and Security of Supply | Case Study on Space." 17 Feb. 2012. Danish Technological Institute 18 Sept. 2014: 38.

	Airbus Defence & Space	Thales Alenia Space	Space / Systems Loral	Boeing	Lockheed Martin	Orbital ATK	China	India	Russia
Platform	Eurostar series, E.g. Eurostar 3000	Spacebus series, E.g. Spacebus 4000	LS 1300 series	BSS-## series, E.g. BSS-702 (redesigned)	A2100A series	GeoStar series, E.g. GeoStar 2	DFH-# series, E.g. DFH-4	I-#K series, E.g. I-3K	Express series, E.g. Express-1000, Express-2000
First launch	2004	2005	1989	2003	2004	2003	2006	2003	2011, 2013
Number of transponders	Wide-ranging (Between ~10 and ~200, mode 64, average 59); Inmarsat-4F1, Inmarsat-4F2, Arabsat 4A → 228 Narrow Spots, 19 Wide Spots and 1 Global Beam	Between 20 and 72, mode 56, average 42; AMC 12 with 72 transponders	Between 9 and 124, mode 32, average 53; SES 4 with 124 transponders	Between 24 and 152, mode 60, average 86; SkyTerra 1 with 152 transponders	Between 12 and 54, mode 24, average 32; Astra 4A with 54 transponders	Between 20 and 52, mode 24, average 31; Intelsat 28 with 52 transponders	Between 22 and 46, mode 28, average 32; ChinaSat 10 with 46 transponders	Between 24 and 32, mode 24, average 27; Eutelsat W2M with 32 transponders	Between 16 and 84, average 42; Telkom 3 with 42 transponders, Express-AM 5 with 84 transponders
Operating Life (Years)	~ 15	~ 15	~ 15	~ 15	~ 15	~ 15	~ 15	~ 12 - 15	~ 13, ~ 15
Payload power (at BOL in kW)		~ 16		~ 12 - 18	~ 15	~ 5.6	~ 10.5	~ 4 - 6.4	~ 3-5.6, 14
Mass (BOL, kg)	2,460 - 6,150	3,050 - 5,915	3,400 - 6,910	4,700 - 6,200	1,950 - 4,530	1,730 - 3,330	5,000 - 5,400	3,025 - 3,460	1,150 - 1,975, 3,150 - 3,360
Total # produced by 2014	~ 29 Eurostar 3000	~ 22 Spacebus 4000	Over 100 LS 1300, since 1989	~ 17 BSS-702 (redesigned)	~ 21 A2100A	~ 29 GeoStar 2	~ 9 DFH-4	~ 5 I-3K	~ 9 Express-1000, ~ 3 Express-2000

Table 2.1. Comparing select satellite capabilities between top commercial prime contractors and national integrators.



From a historical perspective, the limited number of both institutional customers (i.e. Russia, U.S., China, Japan, India, ESA and its largest members), and commercial operators (i.e. Intelsat, SES, Eutelsat, etc.), has helped increase their bargaining leverage due to the dependence of prime contractors on their business. Obviously, the number of satellites purchased also has an impact on that power. The reliability of a satellite is another determining factor of bargaining power, as buyers might be less price sensitive on satellites with flight heritage, rather than risk the consequences of an operational failure on a previously untested satellite.

While the exact cost and content details of satellite contracts are not widely disclosed, bargaining power can be assessed with the help of the experience and knowledge of the numerous consultancy groups in the U.S. and in Europe. Table 2.1 provides a sample comparison of the commercial satellites offered by top commercial prime contractors, in addition to lower low-cost satellites offered by (quasi-)new commercial rivals (i.e. China, India, and Russia). While in no way a complete representation of the differentiated satellites offered by each market participant, it lists some of the technical capabilities of commercial satellites, in addition to listing some of the factors buyers might consider in selecting a satellite.

Customer bargaining power can shift according to both the nature of the buyer (private or institutional) and the contract (satellite purchase contract or a supply of service contract). For instance, commercial contracts with private satellite operators will likely call for the cost-effective procurement of materials supplied domestically or internationally, whereas institutional contracts may require that prime contractors procure certain less cost-effective subsystems, equipment and components domestically. Another term might specify that the satellite be delivered to an unaffiliated launch service provider; or it might require an "in-orbit" delivery that would include the successful launch and in-orbit testing of the satellite by the prime contractor.¹⁵⁸ In a commercial satellite purchase contract, standardised satellite platforms are increasingly produced with the use of standardised assembly processes to accelerate and simplify the manufacturing process.¹⁵⁹ Yet, the buyer and prime contractor might

instead enter a contract for the supply of services, typically in a hands-off mode.¹⁶⁰

Export restrictions such as the U.S. ITAR in the last decade restricted the use of cheap launch services to reduce costs. In the mid-2000s, European prime contractor Thales Alenia Space developed an ITAR-free version of its Spacebus 4000 product line to overcome the export burdens of satellites built with export-controlled U.S. subsystems or components. Between 2005 and 2012, a total of seven ITAR-free Spacebus 4000 GEO telecommunications satellites were ordered by Chinese companies Chinasat and APT Satellite Company, and launched on Chinese Long March launchers.¹⁶¹ Eutelsat was the only western operator to order the ITAR-free Spacebus 4000 satellites, W3B and W3C, and while both satellites were intended for launch on Chinese launchers, W3B was switched to an Ariane 5 launcher due to a temporary shortage of non-ITAR controlled components. However, following a successful launch separation from the Ariane 5 on 28 October 2010, the W3B failed due to a propellant tank leak.¹⁶² The W3C was successfully launched on a Chinese Long March launcher on 7 October 2011; the first launch of a Western satellite on a Chinese launcher in over a decade following the 1999 changes to ITAR.¹⁶³ However, the ITAR-free version of the Spacebus 4000 platform was discontinued in August 2013, following a U.S. State Department investigation that determined that improper labelling by a U.S. component supplier allowed export-controlled defence articles to be integrated into the series¹⁶⁴; thus reducing available launcher options available to Western buyers. On the other hand, the emerging commercial operator Apstar Inc. was able to reduce its manufacturing and launch costs by bypassing U.S. export restrictions, having purchased ITAR free satellites developed by China.

¹⁶⁰ Ibid.

¹⁶¹ Federal Aviation Administration. Semi-Annual Launch Report: October 2010. Washington DC: FAA, Oct. 2010: 15

<https://www.faa.gov/about/office_org/headquarters_office/sast/media/2010-2%20Semi-Annual%20Layout%20Final.pdf>.

¹⁶² De Selding, Peter. "Eutelsat W3B Declared Total Loss; Plans Under Way To Deorbit Craft." 29 Oct. 2010. SpaceNews 17 Nov. 2014

<<http://www.spacenews.com/article/eutelsat-w3b-declared-total-loss-plans-under-way-deorbit-craft>>.

¹⁶³ De Selding, Peter. "Chinese Rocket Launches Eutelsat's W3C Satellite." 7 Oct. 2011. SpaceNews 17 Nov. 2014 <<http://www.spacenews.com/article/chinese-rocket-launches-eutelsats-w3c-satellite>>.

¹⁶⁴ Svitak, Amy. "U.S. Electronics Firm Fined \$8 Million For Export Violations." 16 Sept. 2013. Aviation Week 17 Nov. 2014 <<http://aviationweek.com/awin/us-electronics-firm-fined-8-million-export-violations>>.

¹⁵⁸ See generally Ravillon, Laurence. "Typology of Contracts in the Space Sector." Contracting for Space | Contract Practice in the European Sector. Eds. Leslie Jane Smith and Ingo Baumann. Farnham: Ashgate Publishing Limited, 2011: 162.

¹⁵⁹ Ibid. 163.

2.6 The Availability of Substitutes

A company in a certain industry is restrained in pricing because consumers might turn to a competitor that offers an identical or nearly similar product. This was a topic of discussion in the first two vertical forces of the Five Forces Model - established rivals and new entrants. But the lowest price of a good or service within an industry cannot exceed the price of suitable substitute goods.¹⁶⁵ Substitutes for geostationary satellites can be categorized into non-satellite and small satellite substitutes that pose a threat to the profitability and revenue of European satellite integrators.

2.6.1 Non-Satellite Substitutes

Many communications satellites reside in GEO orbit above the Earth's equator and are able to broadcast signals over a large geographical area.¹⁶⁶ Where terrestrial communication systems are deficient or lacking, satellites can provide a more economical alternative to providing access for remote regions because the cost and speed of deployment of satellite communications is independent of distance. Satellite communications also offer flexibility in terms of user mobility (e.g. aviation, maritime, land mobile) and in situations when more bandwidth is required for emergency connectivity or network redundancy.¹⁶⁷ But satellites also bring a number of disadvantages. The high-altitude orbit of geostationary satellites causes path loss and propagation delay, which is problematic for services that are sensitive to latency such as voice communication. Moreover, geostationary satellites are much more complex to develop and currently significantly more expensive to deploy than other competing non-satellite technologies, resulting in a higher cost per bit.¹⁶⁸ In addition, to receive the satellite signal the user requires a specialised terminal that is often quite costly and can be used with only one operator.

¹⁶⁵ Porter also states that consumers are price sensitive if a close substitute is existent and price insensitive if a close substitute is absent. See further Porter, Michael E. 1979. How competitive forces shape strategy. *Harvard Business Review*. March-April 1979, pp. 137-145.

¹⁶⁶ See further Chapter 1 Section 1.2 Satellites in Operation.

¹⁶⁷ See further Chapter 2 Section 2.1.

¹⁶⁸ "Satellite Communications Basics Tutorial." Radio-Electronics 20 Jan. 2015 <http://www.radio-electronics.com/info/satellite/communications_satellite/satellite-communications-basics-tutorial.php>.

Terrestrial fibre optics and cellular networks also require significant capital investment but can often be offered at lower cost, making them a direct competitor to satellite communications - for example, satellite fleet operators are facing increased competition from terrestrial communication systems in Africa as undersea cables have reached the continent. However, terrestrial systems also have disadvantages; they require manual construction of physical terrestrial infrastructures which not only makes them vulnerable to instability on the ground, such as theft, looting, war, and natural disasters, but they are also economically unattractive and impractical in rural and remote areas with a low population density, and time-consuming to lay down. The customer of communication services takes both alternatives into consideration and makes an informed decision as to which option serves its needs the best based on price, quality and availability. The upshot is that terrestrial communication services are a direct competitor of satellite communications, especially in urban areas, resulting in a smaller demand for communication satellites and therefore indirectly impacting the revenue and profitability of European satellite integrators. However, it also appears relatively clear that the global communication needs in the future will require a combination of terrestrial and space based communication as neither system on its own will be able to fill demand. This is a considerable safeguard for satellite manufacturers.

A factor that influences the choice of the customer is government policy, often in the form of subsidies. The Digital Agenda for Europe, one of the seven flagship initiatives under Europe 2020, aims to boost Europe's economy through digital technologies. One of the objectives is to make fast broadband of more than 30 Mbps available for every European citizen by 2020. The European Commission has stated that this is not feasible without the use of satellites for those who live in remote and rural areas. Europe 2020 stimulates the use of satellite systems in the European Union by subsidizing the satellite dish and modem that are required for satellite broadband.¹⁶⁹ Government policy therefore also influences the number of satellites ordered.

Besides the traditional terrestrial communication systems, disruptive technologies are emerging that rely on high-altitude balloons and Unmanned Aerial Vehicles (UAV, also called drones) to deliver communication services to the user. These systems are currently under development, mainly by Internet

¹⁶⁹ "Broadband for all via Satellite." European Commission 29 Jan. 2015 <<http://ec.europa.eu/digital-agenda/en/broadband-all-satellite>>.



giants Facebook and Google, which aim to provide Internet connectivity to the two-thirds of the world population that does not have Internet access today. Facebook, under its Internet.org partnership with other companies, non-profits, and governments, plans to offer worldwide Internet access, especially to rural and remote areas that are separated from major population centres by long distances or rugged terrain, by using a combination of terrestrial networks, drones, and LEO and/or GEO communication satellites based on the different population densities served. Dense urban areas would be served through terrestrial networks, medium density areas through drones and low-density areas through communication satellites.¹⁷⁰ Similarly, Google's Project Loon aims to create an aerial wireless network using solar-powered high-altitude balloons, with a long-term plan to replace the balloons with drones for high-capacity services in smaller areas.¹⁷¹ In addition to balloons and drones, Project Loon will rely on low-Earth orbit satellites to complement the drones by offering broader coverage in sparsely populated areas.¹⁷² These initiatives can potentially bring an end to the digital divide the world is facing today and, less altruistically, bring new customers and revenue to both companies. It seems that both Google and Facebook have turned these projects into a key priority and the reciprocal competition could result in a race to be the first to offer low-cost global Internet connectivity, strengthening and accelerating deployment. Also satellite manufacturer Thales Alenia Space has recognized the potential of airborne systems. It is developing an autonomous long-endurance airship, a combination of a drone and a satellite called the StratoBus project, which could be deployed for a wide range of applications, including observation, communications and navigation.¹⁷³

Balloons and drones could become a competitive substitute for geostationary communication satellites as a more efficient and cost

effective alternative in medium density areas. Drones, unlike satellites, do not burn up in the atmosphere and can be returned to Earth for refurbishment and easily redeployed afterwards. They cause almost no propagation delay, which makes them a very good alternative for broadband communications such as voice and Internet. Even though Google and Facebook are predominantly targeting a new market of consumers in demand of low cost Internet access, they might also take away business from the large satellite operators that also offer broadband services, thus making balloons and drones an indirect threat to the European satellite manufacturers. Nevertheless, geostationary satellites will remain essential in operating and coordinating the drones, making drones more of a complementary product than a substitute for geostationary satellites - the more drones are deployed, the more demand there will be for control through GEOCOM satellites. Moreover, a large number of small satellites are needed in the Facebook and Google projects to provide Internet access to low density areas where it is uneconomical and impractical to deploy drones or balloons.

2.6.2 Small Satellites

The past decade has seen a significant growth of small satellites for a range of applications, including communications, Earth observation and remote sensing, science, exploration, technology demonstration, etc. Since European satellite integrators are mainly commercially active in the market of geostationary communication satellites, it is appropriate to assess the threat from the emergence of small satellites that provide communication services. Small satellites, as an alternative to much larger traditional GEO satellite systems, might therefore also challenge GEOCOM revenue. Yet, small satellites also offer opportunities for the European satellite integrators to improve their competitiveness. This will be discussed in the following sections.

Small Satellites for Communication Applications

The emergence of small satellites poses a viable alternative to large conventional satellites. Massive improvements in technology and the miniaturization of electronics and other satellite components, following Moore's Law of exponential technological improvement, together with the growth of secondary payload opportunities (e.g. NASA's CubeSat Launch Initiative, NanoRacks, etc.) and the increasing demand for commercial satellite data, have resulted in the proliferation of small satellites or "smallsats". They are based

¹⁷⁰ "Connecting the World from the Sky." 28 Mar. 2014. Internet.org 29 Jan. 2015 <<https://internet.org/press/connecting-the-world-from-the-sky>>.

¹⁷¹ Drones are a better alternative than balloons; unlike balloons they can be precisely manoeuvred and have more endurance because they can remain aloft for months and even years, much longer than balloons.

¹⁷² "The Internet Space Race is On: Google Loon vs. Facebook Drones vs. SpaceX Satellites." 19 Jan. 2015. Pocket Lint 29 Jan. 2015 <<http://www.pocket-lint.com/news/131699-the-internet-space-race-is-on-google-loon-vs-facebook-drones-vs-spacex-satellites>>.

¹⁷³ "StratoBus - Halfway Between a Drone and a Satellite." 10 Mar. 2014. Thales Alenia Space 2 Feb. 2015 <<https://www.thalesgroup.com/en/worldwide/space/case-study/stratobus-halfway-between-drone-and-satellite>>.

on standardized low-cost designs that use off-the-shelf components, require less complex manufacturing infrastructure for their production, have shorter production cycles, and are less expensive to operate. Moreover, because of their shorter intended lifetimes, they necessitate less redundancy and testing, furthering their low-cost character. Since they are lighter and smaller, they can be launched in multiples or as a secondary payload (piggyback), using excess launch capacity on a rocket at a significantly lower cost.¹⁷⁴ Smallsats not only offer significant cost reductions, they also bring technical advantages, such as shorter propagation delays and smaller chances of path loss since they are mostly launched in lower Earth orbits. However, a constellation of satellites is needed to achieve global coverage, hence requiring a multitude of satellites. A constellation of small satellites can provide great functionality while still remaining low-cost – importantly, a constellation is resilient to failure of an individual satellite because a replacement satellite (possibly from a stock of spares) can be launched much faster, and new technologies can be deployed and tested more swiftly. Another benefit of satellite constellations is scalability; if the market responds well to a business plan more satellites can be launched in order to enhance the capabilities of the constellation. Manufacturing a large number of small satellites enhances the potential of economies of scale through mass production, lowering the price per unit even more.

Small satellites usually weigh less than 1,000 kg although their mass can vary significantly. Table 2.2 gives an overview of the common categorization of the small and large satellite mass classes.¹⁷⁵

Class Name	Kilograms (kg)	Example
Pico	<= 1	AMSAT Fox-1 (LEO)
Nano (Cube-Sats)	1.1 – 10	ExactView 9 (LEO)
Micro	11 – 200	ORBCOMM-2 F2 (LEO)
Mini	201 – 600	DMC-3 A, B, C (LEO)
Small	601 – 1,200	Galileo FOC-3 (MEO)

¹⁷⁴ Though they are limited to the orbit of the primary payload.

¹⁷⁵ Petroni, Giorgio, and Stefano Santini. "Innovation and Change? The Evolution of Europe's Small Satellite Manufacturers." Space Policy 28.1 (2012): 25-32.

Medium	1,201 – 2,500	ABS 3A (GEO)
Intermediate	2,501 – 4,200	Intelsat 34 (GEO)
Large	4,201 – 5,400	Türksat 4B (GEO)
Heavy	5,400 – 7,000	Inmarsat-5 F3 (GEO)
Extra Heavy	>= 7,001	

Table 2.2. Satellite Mass Class Categorization (Source: FAA Compendium)¹⁷⁶

As small satellites can be very cost effective, this has stimulated the emergence of small satellite businesses for the provision of global communication services. The first generation of commercial small satellite ventures materialized in the 1990s with satellite operators Iridium, Globalstar, ICO Global Communications, Teledesic, and Orbcomm aiming to provide worldwide communication services (voice and low-bandwidth data with handheld satellite phones and other receivers) by deploying a constellation of small satellites in low and medium-Earth orbit. Contracts for the manufacture of these satellites were awarded to the traditional large satellite manufacturers, i.e. Lockheed Martin (72 LEO satellites for Iridium), Space Systems Loral and Thales Alenia Space (52 LEO satellites for Globalstar), Boeing (12 MEO satellites for ICO Global Communications), and Orbital ATK (36 LEO satellites for Orbcomm). However, all filed for bankruptcy because cheaper terrestrial alternatives such as cellular services had already come into service by the time the constellations achieved full operational capability. But several companies re-emerged after bankruptcy and were able to generate a profit, resulting in contracts for second generation satellites for Iridium (Iridium NEXT) and Globalstar-2, which were both awarded to Thales Alenia Space for 66 and 48 satellites, respectively. Also Orbcomm ordered several next-generation satellites with OHB (6) and afterwards with Sierra Nevada Corp (18).

The significant rise in demand for broadband services all over the world has made the business outlook for global satellite communication networks a lot better than two decades ago. This has stimulated the emergence of several private businesses using small satellites to provide low-cost satellite broadband services. O3b Network was founded with the goal of providing broadband internet to the "Other 3 billion" of the world popula-

¹⁷⁶ "The Annual Compendium of Commercial Space Transportation: 2016." Feb. 2016. Federal Aviation Administration 1 May 2016: 56 <https://www.faa.gov/about/office_org/headquarters_office/s/ast/media/2016_Compendium.pdf>.



tion that do not have reliable high-speed Internet connectivity.¹⁷⁷ Thales Alenia Space was contracted to manufacture twelve first-generation satellites for placement in medium-Earth orbit. At an average per-satellite cost of \$22 million, the whole O3b satellite constellation costs about as much as a large geostationary satellite and is able to provide nearly global Internet connectivity (full coverage within 45 degrees of latitude north and south of the equator) at a lower cost per bit, lower latency and a higher throughput (equals fibre quality), which demonstrates that small satellites are a competitive substitute for geostationary communication satellites.¹⁷⁸ More recently, SpaceX revealed plans to deploy an extremely large satellite constellation of 4000 satellites with the objective of setting up a global Internet connection network.¹⁷⁹ It intends to build the satellites in a new satellite production facility, which, moreover, is part of its objective of revolutionising the satellite manufacturing industry as it is attempting with the commercial launch industry.¹⁸⁰ Google has invested \$900 million in the SpaceX satellite system.¹⁸¹ Similarly

OneWeb Ltd., previously operating under the name WorldVu Satellites Ltd., announced plans to set up a constellation of around 700 satellites to provide high speed Internet and telephony all over the world. Both the Virgin Group and Qualcomm have made undisclosed investments in the company.¹⁸² By using small low-Earth satellites, the SpaceX and OneWeb systems will be able to offer an even lower latency delay than the O3b medium-Earth satellite constellation. The trade-off is that these systems require a multitude of satellites to be able to provide global coverage. It therefore remains to be seen whether they are economically feasible, but the interest shown by SpaceX, Google, Virgin Group, Qualcomm *et al.* clearly testifies to the business potential of deploying a huge constellation of small satellites to deliver worldwide Internet services.

However, satellite broadband services constituted only 1.5% or \$1.8 billion of total satellite services revenue in 2014. Even though this is likely to increase with Google, Facebook, OneWeb, SpaceX, O3b *et al.* opening new markets and reaching a large number of potential customers, 80.7% of total satellite services revenue originates from satellite broadcasting, i.e. satellite television and to a lesser extent satellite radio, which is provided by the large geostationary satellites.¹⁸³ Since propagation delay is less of a problem for broadcasting than for voice and broadband services, there is less business opportunity for small satellite businesses. Moreover, because of natural physical constraints, small satellites face natural limitations in complexity and mass of the payload module they can carry as well as limitations in attitude control and thrust essential for pointing accuracy.¹⁸⁴ And while the market value of future small satellites is estimated to reach \$7.4 billion in 2020 (at 2014 dollar values), that growth will remain eclipsed by an order of magnitude by GEOCOM satellite services.¹⁸⁵ Thus, geosta-

¹⁷⁷ The major shareholder of O3b is now one of the world's largest satellite fleet operators SES.

<<http://commercialspace.pbworks.com/w/file/attach/55473763/Adil%20Jafry%20Paper%20DIT%20for%20Small%20Sats.pdf>>.

¹⁷⁸ O3b has future plans to order a new series of second-generation satellites that will allow the company to grow its broadband communication capacity ten-fold. Even though O3b could benefit from economies of scale by awarding the contract to Thales, it is not certain whether this will be the case after the failure of the first four satellites' power systems which might possibly lead to a reduction of the spacecraft's operational lifetime. See further "O3b Networks Plans Satellite Fleet." 29 Dec. 2014. SpaceflightNow 2 Feb. 2015 <<http://spaceflightnow.com/2014/12/29/o3b-networks-plans-satellite-fleet-expansion/>>; see also, Jafry, Adil R. "Disruptive Competitive Dynamics Created By the Advent of Small Satellite Manufacturers and Operators." 2010.

<<http://commercialspace.pbworks.com/w/file/attach/55473763/Adil%20Jafry%20Paper%20DIT%20for%20Small%20Sats.pdf>>.

¹⁷⁹ The venture would allegedly serve as a money-maker to fund the long-term goal to colonize Mars since more profit is to be gained in the satellite manufacturing industry than in the launch industry.

¹⁸⁰ SpaceX is clearly betting on a positive outcome of its attempt to achieve reusability because putting such an extremely large constellation in orbit would only then be economically viable. See further "Musk Questions Integrity of U.S. Air Force Certification Process, Draws Rebuke from ULA." 13 Jan. 2015. SpaceNews 22 Jan. 2015 <<http://spacenews.com/musk-cites-cozy-u-s-air-force-ula-relationship-in-falcon-9-certification-delay/>>; see also, "Musk Questions Integrity of U.S. Air Force Certification Process, Draws Rebuke from ULA." 13 Jan. 2015. SpaceNews 22 Jan. 2015 <<http://spacenews.com/musk-cites-cozy-u-s-air-force-ula-relationship-in-falcon-9-certification-delay/>>.

¹⁸¹ "Google SpaceX Investment is \$900 Million." 10 Feb. 2015. SpaceNews 24 Feb. 2015 <<http://spacenews.com/google-spacex-investment-is-900-million/>>.

¹⁸² "Virgin and Qualcomm Back OneWeb's Satellite Venture." 15 Jan. 2015. NBC News 10 Mar. 2015 <<http://www.nbcnews.com/storyline/virgin-voyage/virgin-qualcomm-back-onewebs-satellite-venture-n287051>>.

¹⁸³ "2015 State of the Satellite Industry Report." 24 May 2015. Satellite Industry Association and The Tauri Group 27 Sept. 2015 <http://www.space.taurigroup.com/reports/SIA_SSIR_2015.pdf>.

¹⁸⁴ Jafry, Adil R. "Disruptive Competitive Dynamics Created By the Advent of Small Satellite Manufacturers and Operators." 2010.

<<http://commercialspace.pbworks.com/w/file/attach/55473763/Adil%20Jafry%20Paper%20DIT%20for%20Small%20Sats.pdf>>.

¹⁸⁵ C.f. Van Wagenen, Juliet. "Euroconsult SmallSat Report Sees Steady Increase Across the Market." 5 Mar. 2015 Satellite Today 26 Feb. 2016 <<http://www.satellitetoday.com/technology/2015/03/05/eur>>.

tionary satellites will remain central in providing broadcasting services, which is still the largest market for satellite operators, and smallsats currently do not appear to pose a fundamental direct threat to the demand for large geostationary communication satellites and the core business of European satellite integrators.

2.7 Sounding the Competitive Environment

By now it should be apparent that there is a growing risk for European satellite integrators in the commercial satellite manufacturing market due to increased competition from outside Europe, i.e. the traditional competitors, mainly in the U.S., and new market players, especially China, due to their lower cost manufacturing base and strong government support. Should European satellite integrators stovepipe and remain status quo, these developments will most likely result in the blunting of Europe's competitive edge and in a decline of market share in the global commercial satellite manufacturing industry.

To remain successful within the global commercial satellite manufacturing industry, Europe's prime contractors need to position themselves according to where they possess competitive advantage. In this pursuit, it should be noted that two basic types of competitive advantage exist: differentiation and lower cost.¹⁸⁶ Differentiation is the ability to provide unique and superior value to the buyer in terms of product quality, special features, or after-sales service. In commercial satellite manufacturing, this differentiation among the top prime contractors has led to a wide array of satellite capability meant to meet the different needs of customers (see *cutting-edge satellites above*). Lower cost is defined as the ability of a firm to design, produce, and market a comparable product more efficiently or with a lower factor cost than its competitors.¹⁸⁷

The emergence of China and India, and the re-emergence of Russia on the commercial market, gives pause. While they are increasingly becoming a threat to European satellite integrators they also provide opportunities for them to improve their competitive position by taking advantage of the low-cost labour and low-cost technology available in these countries. But smaller nations with satellite manu-

facturing capabilities are also emerging viz. Brazil, Argentina, and Turkey. Not only do these smaller space powers create a new revenue stream for European satellite integrators through satellite contracts and technology transfer programmes, they also offer the potential of future mutually advantageous relationships.

Both the bargaining power of suppliers and the bargaining power of buyers are likely to change in the future, enabled by reduced export restrictions and further globalization within the industry. In addition to the classic space pursuits of national prestige and national security, emerging space nations have shown increased interest in space applications and the socio-economic benefits stemming from Earth observation, satellite communications, science, and other space technologies. The development of a space infrastructure including dedicated organisations/agencies that execute national space programmes, can also be an enabler for the start of a domestic space industry, which is often part of a wider national strategy for science and technology aimed at high-tech industries, innovation and science worldwide. Again, this provides both opportunity and risk.

The largest share of commercial revenue in communication is, as mentioned, generated by geostationary communication satellites. While small satellites have recently emerged as a substitute product for conventional large satellites, they are not a direct threat to European satellite integrators since geostationary satellites will remain central in providing broadcasting services, the lion's share of total satellite services revenue. This is in contrast with the market for Earth observation and remote sensing satellite applications where small satellites seem to be a more potent substitute product.

oconsult-smallsat-report-sees-steady-increase-across-the-market/>.

¹⁸⁶ Porter, Michael E. *The Competitive Advantage of Nations*. New York: The Free Press, 1990: 37.

¹⁸⁷ Ibid.



3. Risks and Opportunities for European Manufacturers

3.1 Introduction

Based on the five forces competitive environment identified in Chapter 2 above, several strategies can be suggested for European prime contractors to maintain and enhance their level of competitiveness. The mooted strategies can be divided into two categories, the strategies that influence the internal dynamics of the European space sector, i.e. intra-European strategies, and those that rely on actors outside Europe, i.e. extra-European strategies.

3.2 What Is the Strategic Value of Having a European Commercial Satellite Manufacturing Sector?

With shifting dynamics increasingly challenging the commercial revenue of the European spacecraft manufacturers, some existential questions can be raised prior to assessing the risks and opportunities available to European competitors, along the lines of whether re-

maintaining active in the commercial satellite market as prime contractors is necessary for Europe's overall space industry; and whether the European institutional framework is sufficiently supporting the competitive environment. Such fundamental queries help to identify the beneficial interests of European prime contractors, and the European space industry overall.

3.2.1 The Necessity of Commercial Business for the European Space Sector

The first question is whether it is a precondition for Europe's space ambition that companies remain active in the commercial satellite market as prime contractors. The companies Airbus D&S, Thales Alenia Space, and more recently OHB, cater also to European institutional demand for space infrastructure, i.e. science and exploration satellite systems for ESA, Earth observation and navigation satellites for the EU, meteorological satellites for Eumetsat, and a number of civil and military satellites for the national space programmes of European nations. Hence it could be argued that without involvement in commercial spacecraft manufacturing, these companies will not be effective in institutional markets.

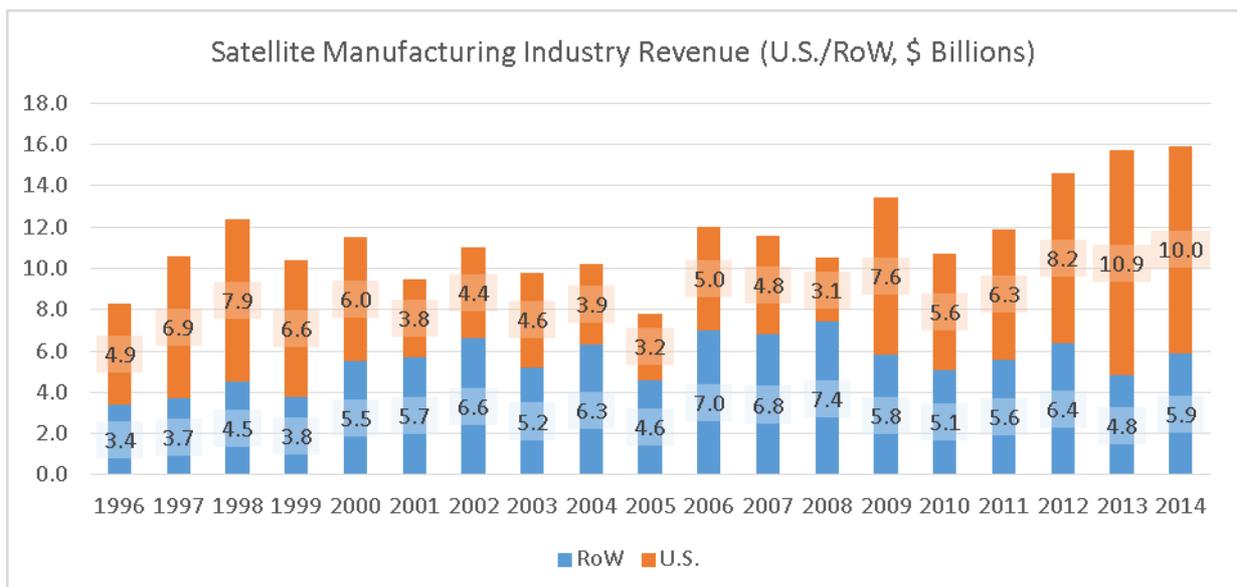


Figure 3.1. Satellite Manufacturing Industry Revenue (U.S./RoW (mostly European-generated), \$ Billions)

This seems likely since abandoning commercial activities would negatively affect prices and the level of innovation required for institutional uses of space. Commercial actors search for the best price/quality product, which stimulates European satellite integrators into taking more risks in order to offer cost-efficient and cutting edge satellite solutions and be more competitive in the global satellite market. The absence of commercial contracts would reduce the beneficial effect of economies of scale as the high fixed costs could no longer be spread over a larger number of satellites manufactured, triggering increases in cost. Moreover, because commercial revenue makes up more than half of European satellite integrators' business, European institutional demand might not be sufficient to retain the current critical mass of the European space industry. The existence of three prime satellite contractors in Europe might no longer be sustainable for the number and value of available institutional contracts, either leading to a bankruptcy of one of the satellite contractors or a further consolidation of Europe's industrial base.

A decrease of competition within the European space industry would consequently impair the cost effective and innovative capabilities of European integrators. Abandoning commercial activities would also affect the European level of autonomy in space technology. This could in the long term jeopardize the capability of the European space industry to be an enabler of economic and social benefits for the whole of European industry and a driver for growth and innovation that supports many industries outside the space industry.¹⁸⁸ Relinquishing commercial activities would therefore have far-reaching implications for Europe's space ambitions; similar to the large share of U.S. civil and military satellite contracts that sustain the U.S. satellite manufacturing base, it is essential for Europe's space ambitions that European satellite manufacturers maintain their activities on the commercial market in order to remain cost-efficient and cutting edge technology providers of space systems to fulfil institutional space infrastructure demand, as well as to preserve a healthy, competitive space industry that can cross-fertilize the whole European manufacturing base.

It may well be argued that the more profitable part of the value chain is the provision of subsystems and components. Hence, why bother with prime contractor activities? One

¹⁸⁸ The space industry is a driver for growth and innovation through spin-offs of cutting edge technologies and the sustainment of a knowledge economy by nurturing the growth of local talent in the highly innovative fields of technology and aerospace.

answer is the one just given, namely that prime contractors for commercial spacecraft manufacturing are necessary in order to retain prime contractor capabilities outside commercial space. But another is that European prime contractors are enablers of manufacturing of lower tier products. In markets that are not yet fully globalised and where conglomerates tend to favour their own products, champions in the form of prime contractors are needed to build and retain market share for subsystems and components.

3.2.2 The European Institutional Framework Supporting the Competitive Environment

Improving competitiveness in global markets is clearly a key priority for European satellite manufacturers but to a large extent it is dependent on the institutional framework in place, which is difficult for them to shape to their benefit. Although space is considered a highly strategic sector, the development of a national space industry is in some countries supported by substantial institutional spending and favourable policies, which directly affect the level of competition in the global market. Other countries support less.

The European institutional budget for civil and military space activities – in terms of R&D financing programmes and the institutional purchase of space products and services – is only a fraction of the U.S. government budget.¹⁸⁹ European space industry as

¹⁸⁹ Civil government spending in Europe originates from four distinct sources: activities by ESA that are funded by the ESA member states; activities of Eumetsat; activities directed by the EU and executed by the EC; and activities carried out by European countries independent of the EU, Eumetsat, and ESA, mainly in France, Germany, Italy, Spain and the United Kingdom. ESA has since its foundation been the facilitator of technology development in Europe with one of the key objectives to make the European space industry competitive on a global scale by stimulating innovation through R&D funding. ESA has also assumed the role of procurement and development agency for the Eumetsat and EU orbital infrastructure. The latter has become the single biggest customer and contributor to ESA's budget, primarily for its two flagship satellite programmes focused on navigation and Earth observation, i.e. Galileo and EGNOS, and Copernicus respectively. The EU to a lesser extent also supports R&D and innovation programmes for the European space sector through its 7-year framework programme Horizon 2020, of which the non-dependence for critical components is one of the key topics. In addition to the civil governmental activities in space, there is also a relatively small share of military government spending in several national military satellite programmes – mostly in France, Germany, Italy, Spain and the United Kingdom – as well as the military space activities of the European Defence Agency (EDA). See further "Europe's Space Industry – Competing Globally in a Complex Sector." 28 Feb. 2013. European Commission 17 Feb. 2015 <http://europa.eu/rapid/press-release_MEMO-13-146_en.htm>.



a consequence relies more on commercial sales, a more volatile and hence less secure market than the large U.S. institutional market. Also the synergies between civil and defence sectors in Europe are far less developed compared to some of the international counterparts.¹⁹⁰ This directly affects the competitive position of European satellite integrators on the global market and can therefore be considered as a clear competitive disadvantage.

European industry in general is supported by the geographical return principle of ESA, however. And this is also true for satellite prime contractors as. At first glance one may argue that geographical return (the principle according to which the value of contracts awarded to a given country should be commensurate with the amount the country has paid into ESA) diminishes competition and therefore encourages complacency. And although there is an element of truth in this, the reality is that funding for space would decrease very significantly if the geographical return principle did not apply. A main motivation for Member States of ESA to assign funds to ESA programmes is that there will be geographical return. Hence geographical return is a method for collecting funds in the multilateral framework of ESA, and all participants in the space endeavour benefit from the effectiveness of this funding mechanism. Yet, notwithstanding the geographical return principle, ESA's procurement system is based extensively on open competition.

The EU follows a different approach when it funds space activities. When community funds are involved, straight best-value-for-money competition takes place also for space investments. With EU funding becoming a significant factor in space, Europe thus has a co-existence of procurement principles: the industrial policy of ESA seeks to attract funding from Member States by ensuring that there is strong technological capability in Europe. And by this, it is creating a broad industrial base. The EU procurement system is based on traditional procurement principles and therefore will not necessarily advance the distribution of capabilities, but will serve the sharpness and competitiveness of the actors involved. Although these objectives may appear contradictory, the interplay of ESA and EU policies tends to reinforce the European space sector and ensure not only the creation of a broad industrial base in Europe, but also the keenness and competitiveness of European industry and its prime contractors.

¹⁹⁰ "Europe's Space Industry – Competing Globally in a Complex Sector." 28 Feb. 2013. European Commission 17 Feb. 2015 <http://europa.eu/rapid/press-release_MEMO-13-146_en.htm>.

3.3 Improving the Competitive Position of the European Satellite Integrators in the Global Satellite Market

It has been established that European satellite integrators need to remain active and competitive in the commercial market for large satellites at the satellite integrator level in order to assure Europe's future in space. But due to the changing forces in the external environment that challenge the commercial revenue of European satellite integrators in the global satellite manufacturing market, they cannot remain idle and proactivity is needed to preserve and improve their competitive position.

3.3.1 Internal European Cooperation and Measures in Place to Collectively Improve the Competitive Position

A fundamental factor in determining the competitiveness and effectiveness of a company or industry is technological competence. The European space industry is one of the most innovative, cutting edge space industries in the world and European satellite integrators and their subsystem and component suppliers offer highly reliable and state-of-the-art satellite technologies, such as electric propulsion, high-throughput satellites, small geostationary platforms, software-defined payloads, etc. This world-class capability to develop core satellite technologies has allowed European manufacturers, in addition to catering to the needs of the European institutional actors, to gain a fairly large market share in the global commercial satellite market. Although these highly innovative technologies have contributed to the competitiveness of European satellite integrators, they cannot be considered as disruptive technologies since they are also marketed by their U.S. counterparts on satellites with similar levels of reliability, and also the new market entrants, mainly China and India, are closing the technological gap. These cutting edge technologies are not a unique capability that allows European system integrators to significantly differentiate themselves from their competitors, but it is nevertheless essential that European satellite integrators uphold their level and rate of innovation in order to preserve competitive position.

Due to the emergence of low-cost manufacturers, the principal challenge to European satellite integrators is, firstly, to drive down costs and shorten development cycles while

keeping the rate of technological progress and satellite reliability constant. Therefore, innovative production technologies to reduce costs and production time are being constantly researched, designed and implemented by European manufacturers, such as standardization of components, additive manufacturing (i.e. 3D-printing), modular satellite platforms, etc. Also company restructuring and broad cost reduction efforts have been realized. In 2014, Airbus D&S was created from three previous standalone Airbus divisions, Cassidian, Astrium and Airbus Military. The military and space business lines were consolidated into one single entity to benefit from synergies and thereby cut costs, increase competitiveness and improve profitability.¹⁹¹ Also Thales Alenia Space rolled out a 10-year competitiveness improvement plan, called Ambition 10, with the goal of reducing costs across all its business lines and improving competitiveness. One of the objectives is to cut the costs of its telecommunications satellites by 30% and, as a consequence, win more satellite contracts in the global market. Two years into the programme this has already resulted in a sharp increase in the number of geostationary communication satellites orders - from 3 orders between 2011 and 2013 to 5 in 2014.¹⁹² Although production process innovations and corporate restructurings have a direct bottom line effect that lead to more competitive offers on the commercial market, costs reductions and shorter development cycles are a key priority of every internationally competing satellite integrator and will not *per se* create a competitive edge.

One of the strengths of European satellite integrators is cooperation, which they have used to their benefit. Even though they are direct competitors, they have repeatedly sought closer cooperation amongst themselves to form one united front against the rising competition from outside Europe. Thus Airbus D&S and Thales Alenia Space have occasionally collaborated in order to increase their chances of winning satellite contracts in

the global satellite market. One example of such successful cooperation has been vis-a-vis Arabsat – with the partners repeatedly winning the bidding for the latest eight geostationary communication satellites, with Airbus D&S as prime contractor while Thales Alenia Space supplies the communication payloads.¹⁹³ They have also jointly competed for Earth observation satellites, such as two Falcon Eye satellites for the United Arab Emirates (UAE) Armed Forces, with Airbus D&S again as the prime contractor and Thales Alenia Space supplying several sub-systems and components. In fact, this specific contract was politically influenced since the French Defence Minister persuaded Airbus D&S and Thales Alenia Space to pitch a cooperative offer so there was just one European offer, thereby increasing the chance of winning.¹⁹⁴ This form of collaboration between Europe's two largest prime contractors is rather unique in the global satellite market and is partially the outcome of their close collaboration for institutional contracts, such as for the manufacturing of the first two satellites for the EU Copernicus programme.¹⁹⁵ Yet, for a number of satellite bids they still compete independently. More frequent cooperation in bidding for satellite contracts might conceivably improve their competitive position.

3.4 External International Cooperation to Improve the Competitive Position of European Satellite Integrators

With closer cooperation between the two main European prime contractors not always being feasible, are broader alliances with traditional competitors another alternative? Perhaps the collective competitive advantage of international participants can be increased if they display complementary strengths and goals. In this case, in addition to potentially increasing economies of scale and sharing risk, a broader alliance might assist technol-

¹⁹¹ This was EADS' reaction to the steep reduction in European defence spending and the non-profitability of its space hardware and services division Astrium, mainly its launcher segment but also the satellite manufacturing segment. See further "EADS Restructuring To Eliminate Nearly 2,500 Astrium." 10 Dec. 2013. SpaceNews 17 Feb. 2015 <<http://spacenews.com/38588eads-restructuring-to-eliminate-nearly-2500-astrium-jobs/>>.

¹⁹² "Thales Alenia Steps up Efforts to Sell Earth-observation Satellites Abroad." 19 Sept. 2014. SpaceNews 18 Feb. 2015 <<http://spacenews.com/41921thales-alenia-steps-up-efforts-to-sell-earth-observation-satellites/>>; see also "Thales Alenia Space to Cut 300 Jobs in France." 30 Jan. 2014. Reuters 18 Feb. 2015 <<http://www.reuters.com/article/2014/01/30/thales-jobs-idUSL5N0L40X320140130>>.

¹⁹³ I.e. Arabsat-4A (Badr-1), Arabsat-4B (Badr-4), Arabsat-4AR (Badr-6), Arabsat-5A, Arabsat-5B (Badr-5), Arabsat-5C, and Arabsat-6B (Badr-7).

¹⁹⁴ "Airbus and Thales to Build Observatory Satellites for UAE Armed Forces." 11 Dec. 2014. Aerospace Technology 16 Feb. 2015 <<http://www.aerospace-technology.com/news/newsairbus-and-thales-to-build-observatory-satellites-for-uae-armed-forces-4465253>>.

¹⁹⁵ The contract was awarded to a consortium of around 60 companies led by Thales and Airbus, with Thales as prime contractor and Airbus to provide the radar instrument.

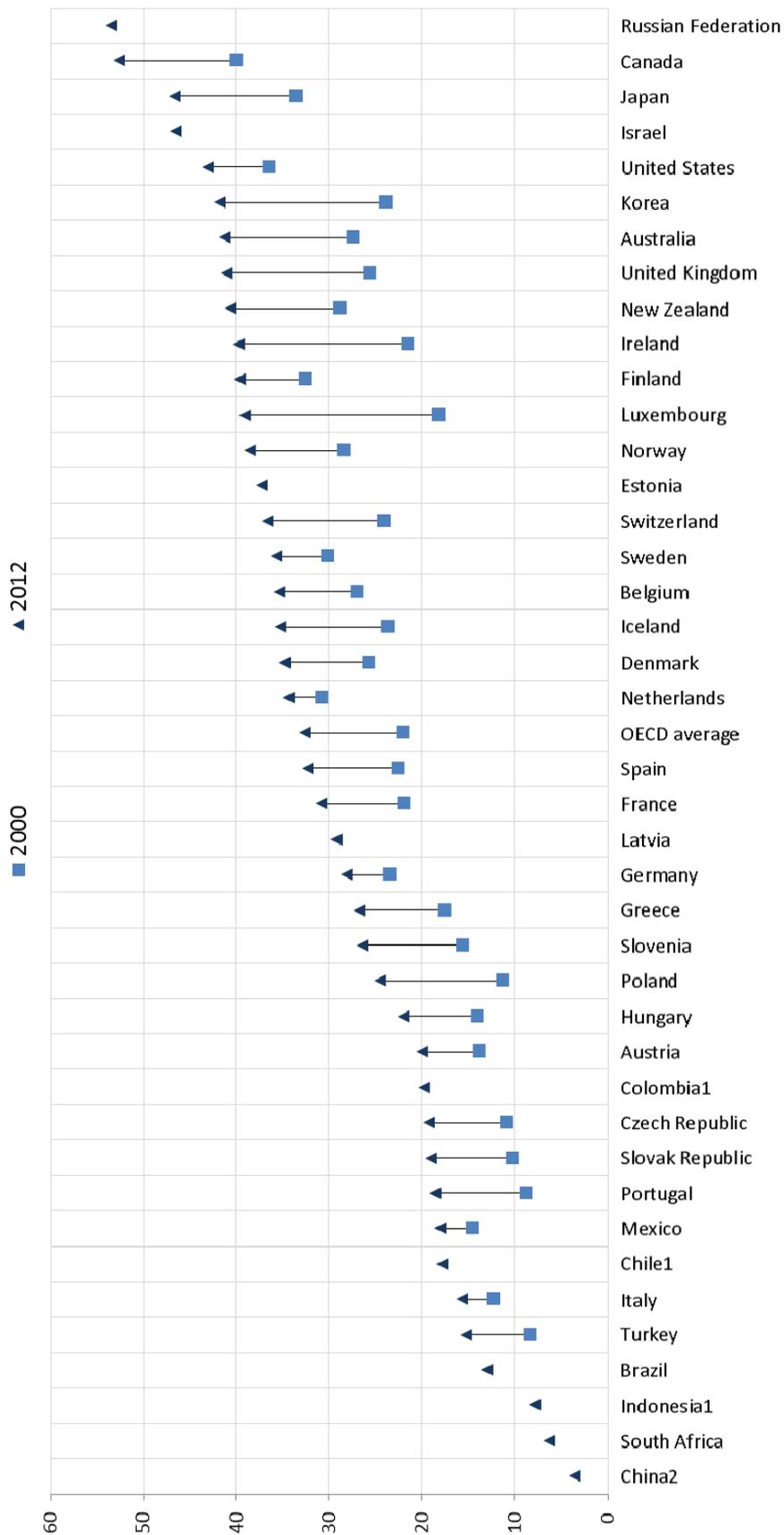


Figure 3.2. Percentage of tertiary-educated adults in 2000 and 2012 (25-64 year-olds) (Source: Education at a Glance 2014 – © OECD 2014).

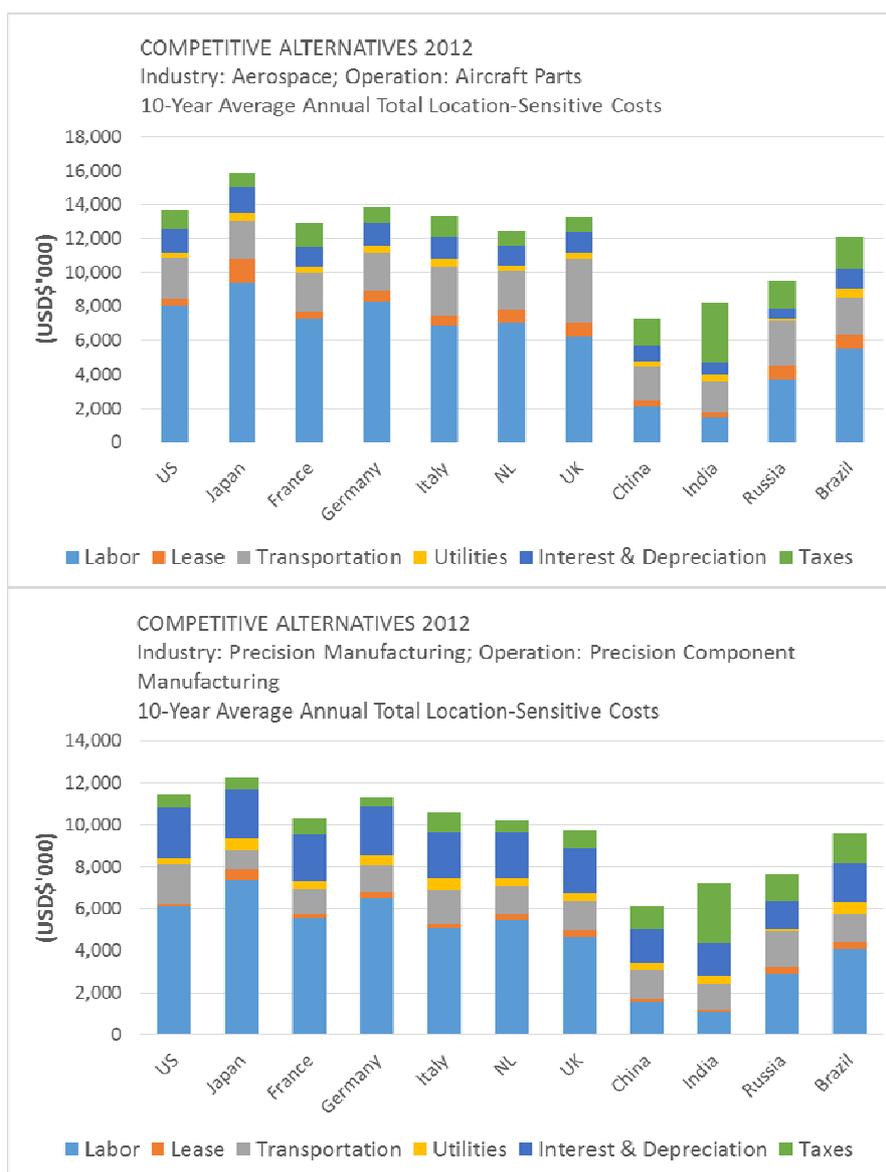


Figure 3.3. 10-Year Average Annual Total Location-Sensitive Costs for Aerospace and Precision Manufacturing Industries (Source: KPMG Competitive Alternatives 2012).

ogy transfer, cost reduction, and access to markets.

By way of background, the following figures show the demographics of labour skill levels and business costs for the mature and high growth markets. Figure 3.2 lists the percentage of tertiary-educated adults in 2000 and 2012, from the OECD's Education at a Glance 2014.¹⁹⁶ Figure 3.3 displays the cost factors in aerospace and precision manufacturing for mature and high growth markets from KPMG's Competitive Alternatives 2012 Edition¹⁹⁷, which might be representative also

¹⁹⁶ OECD. Education at a Glance 2014: OECD Indicators. OECD Publishing, 2014: 30 <<http://www.oecd.org/edu/Education-at-a-Glance-2014.pdf>>.

¹⁹⁷ KPMG. Competitive Alternatives: KPMG's Guide to International Business Location Costs – 2012 Edition.

for the satellite manufacturing sector, as there is a shared typology of workforce.

3.4.1 Broader Alliances/Cooperation with the Traditional Competitors

There are several incentive criteria that could be used in selecting an alliance partner, such as the possession of a desired source of competitive advantage, e.g. scale, technology, cost, or market access. There is also a need for complementarity, calling for a balanced contribution from the firms, as a disproportionate power balance in an alliance may result in instability, and undue enrichment by a partner. Also, partners might seek partners

KPMG LLP., 2012: 13, 33 <http://www.competitivealternatives.com/reports/2012_compalt_report_vol1_en.pdf>.



with complementary international strategies. And there is a greater incentive to maintain a long term alliance with a partner when continued benefit from investment and aligned goals and strategy can be had. An alliance can also have pre-emptive value if it can keep the partner from becoming a competitor itself, or providing a major source of competitive advantage to another rival. Lastly, the organizational style and norms of a partner might be similar enough to allow ongoing collaboration.¹⁹⁸

An initial step for European prime contractors could be to look at alliances with competitors from mature commercial space industries, including current rivals in the U.S., and the smaller scale system integrators of Japan.

Potential Alliances with Top Prime Contractors in the U.S.

The potential for future alliances with current competitors in the U.S. has become interesting with the possibility of the EU-U.S. Transatlantic Trade and Investment Partnership (TTIP) being put in place.¹⁹⁹ The TTIP might cover issues of dual-use technology, which could benefit Europe's commercial space industry with fewer tariff barriers between the two regions.²⁰⁰ However, the TTIP will likely require the EU and U.S. to align their dual-use technology export control policy, which could affect the EU's ability to act in other markets where its companies are currently active.

An alliance between EU and U.S. competitors could increase Europe's access to the large U.S. institutional market, as governmental actors have a preference for domestic manufacturers, currently enshrined in the U.S. in the Buy American Act. An illustration of this is MDA's 2012 acquisition of prime contractor Space Systems/Loral. The Canadian parent company can now bid as a prime contractor on U.S. government contracts through its SS/L subsidiary.²⁰¹ Similarly, if European competitors wish to access the U.S. government market, they might be required to base

a significant part of operations in the U.S., and share work with U.S. contractors.

European contractors have been able to tap the U.S. government market in the past. For instance, the Airbus Group has a growing presence in the U.S. providing hardware, software, services and support to customers in the commercial, homeland security, aerospace and defence markets, and, its subsidiary Airbus D&S has been selected in key competitions for military aircraft and systems, starting in 2002.²⁰² Moreover, Thales Group has a U.S. subsidiary known as Thales USA, Inc., which focuses on naval, land forces, commercial aviation, military aviation, security, transportation, and space domains, and earned \$2.1 billion in U.S. generated revenue in 2015.²⁰³

Furthermore, Thales Alenia Space has had a joint venture with U.S. defence contractor Raytheon Co since 2001; however, the operation of this joint venture is focused on sales outside the U.S. and EU. About 10% of Thales Alenia Space's overall annual revenues come from the U.S., with the Pentagon and other government customers accounting for nearly \$1.3 billion in sales. While Thales Alenia Space has won many contracts from the Pentagon for specialized communications and military equipment, until recently it has rarely been the leader in Pentagon related projects. Yet, in June 2010, Thales Alenia Space won a satellite-production contract for nine satellites for the Iridium low-Earth communication network, requiring at least 40% of the work to be done in the U.S., with Boeing being one of the subcontractors. Although Iridium is a commercial operator, the Pentagon is a major customer for Iridium voice and data services, and thus this satellite award gave a significant boost to Thales Alenia Space in terms of expanding both its U.S. commercial and defence businesses.²⁰⁴ On 6 January 2015, in a collaboration between CNES and NASA, Thales Alenia Space was also awarded the first contract to develop and integrate the Surface Water and Ocean Topography (SWOT) platform which will provide enhanced capacity and coverage over the current series of Jason ocean-altimetry satellites, with NASA financing about two thirds of SWOT's overall budget, and CNES contributing the remaining share;

¹⁹⁸ Porter, Michael E., and Mark B. Fuller. "Coalitions and Global Strategy." *Competition in Global Industries*. Ed. Michael E. Porter. Boston: Harvard Business School Press, 1986. 315-343.

¹⁹⁹ See further "The Transatlantic Trade Investment Partnership: Making trade work for you." 10 Feb. 2015. European Commission 11 Feb. 2015 <<http://ec.europa.eu/trade/policy/in-focus/ttip/>>.

²⁰⁰ "Security exception for TTIP?" 26 May 2014. Stopwapenhandel.org 11 Feb. 2015 <<http://www.stopwapenhandel.org/TTIP/>>.

²⁰¹ De Selding, Peter B. "Gunning for U.S. Government Business, Canada's MDA Retools Calif. Satellite Factory." 9 May 2013. SpaceNews 12 Feb. 2015 <<http://spacenews.com/35240gunning-for-us-government-business-canadas-mda-retools-calif/>>.

²⁰² "Airbus Group in the United States." 2016. AirbusGroup 2 May 2016 <<http://www.airbusgroup.com/int/en/group-division/global-presence/united-states.html>>.

²⁰³ "United States." 2016. Thales 2 May 2016 <<https://www.thalesgroup.com/en/UnitedStates>>.

²⁰⁴ Pasztor, Andy and Daniel Michaels. "Thales Team Beats Lockheed for Satellite Job." 1 June 2010. The Wall Street Journal 26 Mar. 2015 <<http://www.wsj.com/articles/SB10001424052748704875604575280923067286504>>.

the two governments will invest some \$1.1 billion and expect a launch in 2020.²⁰⁵

While an alliance between competitors in the EU and U.S. could result in increased knowledge transfer and access to a pool of highly skilled employees, it is unlikely to reduce labour expenses. Nevertheless, with an alliance similar to MDA's acquisition of SS/L, European manufacturers could benefit substantially from the access to the very large U.S. domestic institutional market.

Potential Alliances with Japanese Competitors

The smaller but mature space industry of Japan is another prospect where alliances might be sought. However, Japan's industry has been effectively 'captured' by U.S. industry, with Boeing having particular dominance, having managed to create a relationship with Japanese firms where moving up the value chain is difficult.²⁰⁶ Nevertheless, there is a renewed emphasis on developing Japan's aerospace sector.

Japan's top satellite prime contractors are Mitsubishi Electric Company (Melco), and Nippon Electric Company (NEC), along with industrial suppliers Toshiba and Kawasaki Heavy Industries Ltd. that also have substantial in-house R&D experience in satellite manufacturing.²⁰⁷ Melco began as a satellite prime contractor in 1983, when it was selected to construct Japan's CS-3 communications satellite²⁰⁸; it entered the commercial market in 2000 with a winning bid for the Optus C1 satellite contract in collaboration with Space Systems Loral.²⁰⁹ While Melco is Japan's main commercial satellite prime contractor, its commercial production scale is dwarfed by the six largest prime contractors;

²⁰⁵ De Selding, Peter B. "Thales Alenia Space Nabs \$94 Million Contract for U.S.-French Ocean Topography Satellite." 6 Jan. 2015. SpaceNews 26 Mar. 2015 <<http://spacenews.com/thales-alenia-space-nabs-94-million-contract-for-u-s-french-ocean-topography-satellite/>>.

²⁰⁶ McGuire, Steven. "The United States, Japan and aerospace industry: from capture to competitor?" *The Pacific Review*, Volume 20, Issue 3, 2007, 329-350.

²⁰⁷ Harvey, Brian, Henk Smid, and Theo Pirard. *Emerging Space Powers: The New Space Programs of Asia, the Middle East, and South America*. Germany: Springer Berlin Heidelberg New York / Praxis Publishing, 2010: 139.

²⁰⁸ "Global – Mitsubishi Electric in Brief: 1980s." Mitsubishi Electric 12 Feb. 2015 <<http://www.mitsubishielectric.com/brief/sp/history/1980s/index.html>>.

²⁰⁹ C.f. "Communications: OPTUS C1." Mitsubishi Electric 13 Feb. 2015 <http://www.mitsubishielectric.com/bu/space/satellite/communication/optus_c1.html>; "Loral and Mitsubishi Electric Complete In-Orbit Testing of Optus C1." 21 Aug. 2003. Loral Space & Communications 13 Feb. 2015 <http://lor.client.shareholder.com/releasedetail.cfm?sh_print=yes&releaseid=183854>.

though in recent years Melco has been winning a number of satellite contract awards. Since the 1970s, NEC has mainly been a satellite prime contractor strictly for the Japanese government²¹⁰, though it is an active component supplier on the international market. In 2014, NEC entered the commercial market as a prime contractor with the sale of two low cost small EO satellites to Vietnam.²¹¹ NEC intends to market its low cost platforms to emerging countries, with package deals including communications, ground support, and geospatial products or services. The first Advanced Satellite with New System Architecture for Observation (ASNARO-1) was launched aboard a Russian Dnepr rocket on 6 November 2014.

At a time when the Japanese government has decided to increase investment in space, both Melco and NEC appear to be eager to expand their share in the commercial space market. Yet with Japan's highly skilled workforce, ranked third in terms of the percentage of adults with a tertiary degree²¹², and its comparatively high labour costs, the outcome of an alliance with competitors in this industry seems likely to have the same outcome as with competitors in the U.S. – that is, increased technology exchange, and access to a pool of highly skilled employees, but relatively little change in labour costs. However, even if European competitors can access Japan's domestic institutional market, access to that market is less beneficial than access to the substantially larger U.S. domestic institutional market, even if a footprint in Asia in general might become easier.

Japanese companies tend to be more focused on regional alliances, with sights on India. To respond to the growth of China, Japan has increased economic ties with India, strengthening the relationship with the establishment of the "Global Partnership between Japan and India" in 2000. The two countries later signed the Japan-India Comprehensive Economic Partnership Agreement (CEPA) that took effect in August 2011, and will eliminate about 94% of the tariffs between Japan and India in the next decade.²¹³ A recent summit

²¹⁰ "Space Systems." NEC 13 Feb. 2015

<<http://www.nec.com/en/global/solutions/space/>>.

²¹¹ Kallender-Umezumi, Paul. "Japan's NEC Looks To Expand Commercial Market Footprint." 24 Nov. 2014. SpaceNews 10 Feb. 2015

<<http://spacenews.com/42644japans-nec-looks-to-expand-commercial-market-footprint/>>.

²¹² OECD. *Education at a Glance 2014: OECD Indicators*.

OECD Publishing, 2014: 30 <<http://www.oecd.org/edu/Education-at-a-Glance-2014.pdf>>.

²¹³ "Japan-India Relations (Basic Data)." 30 Jan. 2015.

Ministry of Foreign Affairs of Japan 16 Feb. 2015 <<http://www.mofa.go.jp/region/asia-paci/india/data.html>>.



between the leaders of the two countries has further cemented the relationship.

Assessing the Merits of Seeking Technological Leadership Advantage through Cooperation

Allying with a mature industry is more likely to reinforce the technological competitive advantage collectively held by top rivals in the industry over new entrants, than to offset factor cost disadvantages in doing business.

However, such alliances could impede the global strategy of European prime contractors overall, as independent partners might have conflicting interests and objectives that could impact collaboration from the outset. For example, the U.S. ITAR restricts the sale of dual-use technologies to China, whereas Japan is in the midst of negotiating economic partnerships with China and other countries in the region.²¹⁴ However, if European competitors wish to access emerging countries with costs comparable to the state-run industries in low cost countries, and increase overall competitive advantage with the industry, focus must be placed on developing an internal capability to lower costs, similar to how SpaceX has lowered costs in the U.S. domestic launch industry.

Next, the higher costs of Western commercial satellites will continue to result in a seepage of market share to low cost countries whose technology competencies are converging to the global standard. Moreover, access to either the U.S. or Japanese domestic institutional market does not guarantee that institutional customers will veer away from preferring domestic contractors. Hence, if low cost labour is unavailable to reduce factor costs, perhaps automated assembly-line manufacturing – i.e. using robots instead of human labour, or the use of additive manufacturing (3-D printing) are other ways to drive costs down.²¹⁵ Assembly-line manufacturing has already begun to emerge among U.S. manufacturers such as Ball Aerospace, SpaceX, and Planet Labs in the production of small to large constellations of low Earth orbit (LEO) small-to-micro sized satellites.²¹⁶ Additionally, Space Systems/Loral and Lockheed Mar-

tin are beginning to equip satellites with metal parts made from 3-D printers, with the latter aiming to print an entire satellite bus by 2019.²¹⁷ Automating the assembly-line process and placing reliance on 3-D printed parts may initially contravene the interests of Europe's space industry labour force, as some staff would be supplanted by machines; but it will also work to plug the loss of market share that low cost countries have managed to capitalize on with their own labour cost advantage. Hence limited job losses of today might avert much larger job losses in the future.

3.4.2 Broader Alliances/Cooperation with Emerging Low-Cost Satellite Manufacturers

The trade-offs associated with alliance building change when focussing on emerging low-cost commercial satellite manufacturers, such as China, India, Russia, and to a lesser extent Brazil, Argentina, and Turkey et al. Yet, such alliances must also be contemplated.

Potential Alliances with Chinese Competitors

As described in Chapter 2 above, China's space industry has shown remarkable commercial growth in recent decades. The state-owned industry has made considerable strides in marketing low-cost satellites to institutional emerging markets in the past decade through CGWIC and CAST. Targeting emerging countries in Asia, Africa and South America, China's commercial space segment has made inroads by providing an 'all-inclusive' low-cost package including satellite design and construction; launch services, in addition to building ground segment facilities; training local personnel; and financing programme costs in the form of loans.²¹⁸

CASC through its 130 subsidiary organizations employs around 170,000 technicians and operators in total²¹⁹; of which 59% of employees in leadership positions in the subsidiary organizations hold advanced tertiary degrees.²²⁰ Of the countries listed in Figure 3.2, while China ranks lowest in terms of

²¹⁴ Tiezzi, Shannon. "China-Japan-South Korea Hold FTA Talks Despite Political Tension." 5 Mar. 2014. *The Diplomat* 19 Feb. 2015 <<http://thediplomat.com/2014/03/china-japan-south-korea-hold-fta-talks-despite-political-tension/>>.

²¹⁵ Watt, Ewen Cameron. "Why innovation really should matter to policy makers – and investors." 5 Nov. 2014. *Financial Times* 27 Feb. 2015 <<http://www.ft.com/cms/s/0/e2a7adfa-4fba-11e4-a0a4-00144feab7de.html>>.

²¹⁶ Rakow, John. "Op-ed | The Competitive Challenge Facing Satellite Manufacturers." 6 Mar. 2015. *SpaceNews* 15 Oct. 2015 <<http://spacenews.com/op-ed-the-competitive-challenge-facing-satellite-manufacturers/>>.

²¹⁷ Werner, Debra. "Reimagining satellite construction." 1 Mar. 2015. *Aerospace America* 16 Dec. 2015 <http://www.aerospaceamerica.org/Documents/Aerospace%20America%20PDFs%202015/March%202015/AA_Marc h2015_Feature1.pdf>.

²¹⁸ "Snubbed by U.S., China Finds New Space Partners." 24 May 2007. *New York Times* 27 Jan. 2014 <<http://www.nytimes.com/2007/05/24/world/asia/24satellite.html>>.

²¹⁹ "Company Profile." CASC 19 Feb. 2015 <<http://english.spacechina.com/n16421/n17138/n17229/c127066/content.html>>.

²²⁰ "Talented Personnel." CASC 19 Feb. 2015 <<http://english.spacechina.com/n16421/n17221/index.html>>.

population percentage of adults with tertiary degrees; it aims to increase that percentage to 20% (i.e. 195 million people) by 2020.²²¹

As can be seen from Figure 3.3 China's labour cost is only undercut by India, and China's total location-sensitive costs (including labour costs, facility costs, utility costs, costs related to capital, and taxes) remain the lowest. Yet, it should be noted that China's low-cost competitive advantage is diminishing, as wages have increased annually by 14.3% and 18.3% in the public and private sector, respectively, since 2004.²²² Thus, China's wage level is expected to have converged substantially with developed economies by 2030, and is in the process of being surpassed as a low-cost production hub by India and by other Southeast Asian countries.²²³

In the near term, an alliance with China's state-run industry could be ideal in pursuing a cost leadership competitive advantage, where European manufacturers trade market access for low-cost labour. Whilst intellectual property protection is a considerable issue, an alliance might enable European competitors to further access China's domestic institutional market. Moreover, European competitors may be able to cherry-pick higher skilled employees by offering comparatively more attractive wages.

Thales Alenia Space has been cooperating with CAST for several decades, providing key satellite components - such as the power supply of the "Simon Bolivar" satellite that was launched in 2008 - for the improvement of the quality of Chinese satellites.²²⁴ Thales Alenia Space has benefited as well from the close relationship with CAST in other respects, such as the launch of the Thales-built geostationary communication satellites Palapa-D and Eutelsat-W3C on the cheaper Chinese Long March rocket, which increased the competitiveness of the Thales Alenia Space offer on the international market. This was possible because the satellites were free of strategic U.S. components and thus did not fall under the U.S. ITAR regulations. However, as previously mentioned, the "ITAR-free" platform of Thales Alenia Space was

discontinued in August 2013.²²⁵ As a consequence, Turkmentsat-1, a third satellite built by Thales that was originally scheduled for launch on a Chinese rocket, was transferred to a SpaceX launcher. But the existence of the U.S. ITAR regulations still provide European satellite integrators with a comparative advantage because U.S. manufacturers are prohibited from exchanging technologies with Chinese manufacturers, such as the collaboration between Thales Alenia Space and CAST. This will remain so in the near future since there is still strong resistance in the U.S. to bilateral cooperation between the U.S. and China.²²⁶ The European satellite integrators can be uncontested in potentially benefiting from China's low-cost labour, and in utilising low-cost Chinese satellite components and subsystems, which could result in a lower price for European satellites.

However in the long term, the benefit of an alliance with China's low cost industry is likely to decline, as labour costs are expected to converge with Western levels faster than India and other Southeast Asian countries. In that time, depending on the level of technology exchanged, China might also gain a disproportionate benefit from the know-how provided by European competitors, allowing the state subsidised industry to enhance its own market position at Europe's expense. For instance, in developing its DFH-4 platform, CAST selectively brought in external expertise in order to match the highest worldwide standards. Of the four companies that submitted proposals, Thales Alenia Space was chosen because of its previous cooperation with China.²²⁷ This cooperation allowed CAST to reduce the need for further outside expertise and after the launch of the first DFH-4 satellite - Sinosat 2 - it was ready to sell fully indigenously built satellites on the global market.²²⁸ Moreover, in transferring satellite technology, European prime contractors might want to consider whether the U.S. might respond to that action and enforce its embargo on China extraterritorially through coercively punishing European manufacturers that transfer technology with China by prohibiting them from serving as contractors for

²²¹ "Education Indicators in Focus." May 2012. OECD 19 Feb. 2015: 3 <<http://www.oecd.org/edu/50495363.pdf>>.

²²² "China 360 | China's labor force: What happens when China's workers retire?" July 2013 KPMG 20 Feb. 2015: 2 <<http://www.kpmg.com/DE/de/Documents/China-360-Issue10-201307-labor-force.pdf>>.

²²³ "Global wage projections to 2030." Sept. 2013. PwC 20 Feb. 2015 <[http://www.pwc.com/hu/en/humaneroforras_tanacsadas/assets/Global_wage_projections_Sept2013.pdf_\(web_version\).pdf](http://www.pwc.com/hu/en/humaneroforras_tanacsadas/assets/Global_wage_projections_Sept2013.pdf_(web_version).pdf)>.

²²⁴ Harvey, Brian. *China in Space. The Great Leap Forward*, Springer, New York, 2013: p.164.

²²⁵ Svitak, Amy. "U.S. Electronics Firm Fined \$8 Million For Export Violations." 16 Sept. 2013. *Aviation Week* 17 Nov. 2014 <<http://aviationweek.com/awin/us-electronics-firm-fined-8-million-export-violations>>.

²²⁶ "NASA Spending Panel Chairman Keeps Focus on China." 25 Feb. 2015. *SpaceNews* 4 Mar. 2015 <<http://spacenews.com/nasa-spending-panel-chairman-keeps-focus-on-china/>>.

²²⁷ Harvey, Brian. *China in Space. The Great Leap Forward*, Springer, New York, 2013: p.164.

²²⁸ "China Looks To Boost Satellite Manufacturing With DFH-4 Line." 29 June 2004. *SpaceNews* 4 Feb. 2014 <<http://spacenews.com/china-looks-boost-satellite-manufacturing-dfh-4-line/>>.



U.S. institutional contracts²²⁹, i.e. putting at risk Thales Alenia Space's ongoing activities with the Pentagon and other U.S. government customers, which account for nearly \$1.3 billion in annual sales.²³⁰ In the above mentioned investigation of the "ITAR-free" platform of Thales Alenia Space, the U.S. State Department warned Thales Alenia Space that its U.S. suppliers might be denied export licenses absent greater cooperation in that investigation.²³¹

The reasoning for such a response arises from section 1233 of the U.S. Duncan Hunter National Defense Authorization Act of 2009.²³² Section 1233 mandated a Review of Security Risks of Participation by Defense Contractors in Certain Space Activities of the People's Republic of China, where satellite prime contractors of the DoD (including their subcontractors at any tier) that are in any way associated with China's space industry would be identified as a security risk by the DoD in a report provided to Congress, which could affect their ability to bid on future contracts as prime contractors or suppliers to the DoD. While this amendment was partly tailored to focus on Thales Alenia Space's mid-2000 commercial activities with China, with respect to the development or manufacture of satellites by Western manufacturers for launch from China, this mechanism could theoretically be extended to other U.S. institutional contracts.²³³ However, the likelihood of this is presumably very low as this route could risk severe retaliatory trade measures, and might run counter to WTO rules. In the converse configuration, a discriminatory action in 2014 by China in charging U.S. manufacturers three times the amount it charges its own domestic industry for rare Earth minerals was already seen as a violation of WTO rules, as they were designed to achieve in-

dustrial policy goals rather than conservation.²³⁴

Potential Alliances with Indian Competitors

India shares many of the qualities exhibited by China, including its rapidly developing space capability, its low cost access to space, and its wealth of low cost skilled labour. India's ISRO, itself a subdivision of the government's Department of Space (DOS), provides commercial products and services through its commercial arm, Antrix Corporation. With access to ISRO's satellite design, testing and manufacturing facilities, Antrix offers products ranging from complete satellite programs to function-specific components, as well AIT services.²³⁵

The DOS has a total of 18,561 employees of whom 12,850 work in scientific and technical capacities, while another 5,711 jobs are more administrative in nature.²³⁶ India's percentage of tertiary educated adults is estimated to be lower than that of China; for instance, India had an estimated 9.1 million adults between 25-34 with a tertiary degree while China had around 15.5 million in the year 2000 – in 2010, India's tertiary educated youth grew to around 14.2 million, while China's reached around 23.2 million.²³⁷ India's labour cost is lower than that of China, but the cost saving is offset by India's substantial taxation. Yet, even with high taxation, India is undercut only by China in terms of total location-sensitive costs. Moreover, unlike the anticipated growth of China's wage levels, India labour wage levels are expected to remain low until at least 2030, thus maintaining its appeal for low cost manufacturing (as long as the right institutional environment, transportation, and energy infrastructure is maintained).

Similar to developing an alliance with China's state-run industry, an alliance with India's industry is another possibility in pursuing cost leadership. Importantly, an alliance with India's industry will not be hindered by the same level of export control as with China. For now, Airbus is the principal foreign partner of ISRO and Antrix,, with Airbus and Antrix collaborating under a formal cooperation

²²⁹ Mineiro, Michael C. "An inconvenient regulatory truth: Divergence in the US and EU satellite export control policies on China." *Space Policy* 27 (2011): 213-221, 219.

²³⁰ Pasztor, Andy and Daniel Michaels. "Thales Team Beats Lockheed for Satellite Job." 1 June 2010. *The Wall Street Journal* 26 March 2015 <<http://www.wsj.com/articles/SB10001424052748704875604575280923067286504>>.

²³¹ Wolf, Jim. "Exclusive: U.S. squeezes French-led satellite maker over China." 10 Feb. 2012. *Reuters* 9 Oct. 2015 <<http://www.reuters.com/article/2012/02/10/us-usa-france-china-satellite-idUSTRE8181F020120210>>.

²³² Section 1233 Duncan Hunter National Defense Authorization Act of 2009, Pub. L. no 110-417, 122 Stat. 4639 (14 October 2008) <http://www.dod.gov/dodgc/olc/docs/2009NDAA_PL110-417.pdf>.

²³³ See further Mineiro, Michael. *Space Technology Export Controls and International Cooperation in Outer Space*. Springer Netherlands, 2012: 138.

²³⁴ "China's rare earth trade limits break global rules: WTO." 26 Mar. 2014. *SpaceDaily* 26 Feb. 2016

<http://www.spacedaily.com/reports/Chinas_rare_earth_trade_limits_break_global_rules_WTO_999.html>.

²³⁵ "Creating Value from Space." 2007. Antrix Corporation Ltd. 22 Nov. 2013 <http://www.antrix.gov.in/Antrix-one_source.pdf>.

²³⁶ "Annual Report 2012-2013." 2013. Government of India Department of Space 20 Jan. 2014 <<http://www.isro.org/rep2013/index.htm>>.

²³⁷ "Education Indicators in Focus." May 2012. OECD 19 Feb. 2015: 2 <<http://www.oecd.org/edu/50495363.pdf>>.

agreement to address the commercial market for smaller communications satellites, as explained above.²³⁸

The decade-long alliance between both partners has allowed Airbus to establish itself as the premier foreign industrial partner of ISRO and the Indian space industry.²³⁹ The industrial partnership is advantageous for Airbus because it increases its level of competition in the global commercial market by pooling skilled low-cost labour from India, resulting in lower-cost satellites. This is a competitive advantage that Airbus has over its American counterparts who, at the moment, do not have comparable cooperation agreements with India.

ITAR does not restrict U.S. competitors from building alliances with India's space industry. Here, the competitive edge the European satellite integrators have over their U.S. counterparts might be challenged due to the gradual increase in cooperation between India and the United States as a result of the loosening of U.S. government regulations on collaboration with that country. In 2008, the U.S. government eased sanctions on industrial cooperation by U.S. companies with India in the field of space and missile technology, sanctions that were originally put into force after Indian underground nuclear tests.²⁴⁰ ITAR regulations formed a second barrier that made it impossible for U.S. manufacturers to export U.S. satellite components and fully manufactured satellites to India, which impeded them from entering into industrial cooperation with ISRO/Antrix similar to the Airbus cooperation. Because of the 2014 changes in the ITAR regulations this barrier has been lifted. The access advantage European satellite integrators had is therefore reduced but no U.S. satellite integrator has so far established any form of cooperation agreement with ISRO or Antrix.

Although India is seen as less threatening than China in intellectual property terms, and attracting exceptionally skilled employees with better wages might also be feasible,

over time India's space industry might also gain a considerable benefit from the know-how provided by European competitors, allowing the state subsidised industry to enhance its own market position at Europe's expense. However, this is an issue that is relevant for all international cooperation scenarios to a varying degree.

Potential Alliances with Russian Competitors

Russia's space industry has a vast amount of experience in space, having been a leader in the first years of space exploration and exploitation and continuing to be a major space-faring nation. Thus, Russia remains a strong force in the spheres of human space-flight and satellite navigation systems, *inter alia*. Prior to the recent reorganization of Russia's space sector into one state-owned entity, it included over 100 companies that employed a workforce of about 250,000 highly skilled personnel.²⁴¹ Yet, with Russia cooperation it is not so much a question of innovation dynamics, but more that there could be a significant cost advantage, although this advantage is to a large extent offset by a current lack of capabilities to create high quality products.

Russia ranks the highest in terms of population percentage of adults with tertiary degrees, ahead of the U.S. and Japan, while labour wages are much lower than Western counterparts. Yet in its application to the space sector, Russia needs to make a substantial investment in its industry to revive an obsolete industrial base and renew its aging workforce (of which 46 years is the median age).²⁴² In this respect low wages are a disincentive to attracting young highly skilled engineers and scientists into the space industry, as a single Russian space industry employee generates an average 1.6 million roubles (\$32,000) in revenue for an employer, while the employee receives an average salary of 534,000 roubles (~\$10,000).²⁴³ By way of illustration, the average salary of an employee in the U.S. aerospace industry is over \$117,000, and the average age of an employee working at SpaceX is between 26 and 30 years. To revive its industry, Russia aims to recruit over 100,000 young engineers by doubling wages and implementing incen-

²³⁸ "EADS Astrium-ISRO alliance sealed. First contract with Eutelsat for W2M satellite." 20 Feb. 2006. Indian Space Research Organisation 21 Nov. 2013 <http://www.isro.org/pressrelease/scripts/pressreleasein.aspx?Feb20_2006>.

²³⁹ "The EADS Group in India." 12 Nov. 2013. Diplomacy & Foreign Affairs 13 Jan. 2015 <<http://diplomacyandforeignaffairs.com/the-eads-group-in-india/>>

²⁴⁰ "Semi-Annual Launch Report: Second Half of 2010 | Special Report: "ITAR-Free" Satellites and Their Impact on the U.S. Launch Industry." Oct. 2010. Federal Aviation Administration 13 Jan. 2015 <https://www.faa.gov/about/office_org/headquarters_office/s/ast/media/2010-2%20Semi-Annual%20Layout%20Final.pdf>.

²⁴¹ Ionin, Andrey. "Russia's Space Program in 2006: Some Progress but No Clear Direction." Moscow Defense Brief 2 (2007): 9-10.

²⁴² Ibid.

²⁴³ Bodner, Matthew. "Russia Plans Massive Productivity and Wage Hike for Space Industry Workforce." 28 Nov. 2014. The Moscow Times 9 Oct. 2015 <<http://www.themoscowtimes.com/business/article/russia-plans-massive-productivity-and-wage-hike-for-space-industry-workforce/512043.html>>.



tive systems to increase the sector's efficiency by 2025.²⁴⁴

Even if labour costs are higher than in China and India, Russia's total location-sensitive costs tend to be only slightly higher than India's. Hence competitive advantage on cost could still be pursued, with access to a pool of highly skilled employees, while European competitors might also benefit from a two-way technology transfer resulting from Europe's and Russia's experience in space, and their complementary scientific and industrial actors. Cooperation between Europe and Russia in the aerospace sector has been ongoing for more than two decades in the aviation, helicopter, and space sectors²⁴⁵, and with Roscosmos and ESA also agreeing to launch the Russian Soyuz-ST from the European Kourou space center in French Guiana.

Moreover, following the collapse of the Soviet Union in 1991, and the 'privatization' of the Russian space industry, numerous joint ventures and partnerships emerged with Western companies in the fields of launchers, rocket engines, and satellite and module manufacturing.²⁴⁶ For example, in the past two decades, ISS Reshetnev (Russia's leading communications, navigation and geodesy satellite manufacturer) and Thales Alenia Space have in cooperation built about 20 telecommunications satellites together, both for the Russian market and, to a lesser extent, for export customers. That cooperation increased further in August 2013, following the creation of 'Universum Space Technologies', a joint venture between ISS-Reshetnev (60%²⁴⁷) and Thales Alenia Space (the remaining 40%), to strengthen their ability mainly to win both Russian and international telecommunications satellite contracts.²⁴⁸ Initially, the company will focus on developing equipment on par with the most demanding international standards for use on Russian telecommunications satellites. Thereafter, new products for satel-

lites will be developed, enabling it to more completely address the future requirements of both Russian and international markets.²⁴⁹ The joint venture had its initial success with the 14 September 2015 launch of the Express AM8 satellite, for which Thales Alenia Space had supplied a payload, while ISS Reshetnev provided the bus, and assembled, integrated, and tested the satellite in its facility.²⁵⁰

Both Thales Alenia Space and Airbus D&S have other joint ventures with Russian competitors. Thus, Thales Alenia Space and ISS Reshetnev are developing the joint Russian-European satellite platform, Express 4000.²⁵¹ And, Airbus D&S and RSC Energia have a joint venture, Energia SAT, meant to build on the success of the Yamal and Eurostar E3000 platforms to construct the Express-AM4R and Express-AM7 communications satellites.²⁵² Russia's cooperation with both prime contractors extends to other aerospace sectors as well; yet, Russia has also had joint ventures with Japanese and U.S. competitors.²⁵³

With the change in the political climate (including mounting EU and U.S. sanctions on the Russian government) following Russia's annexation of Crimea in Ukraine in early 2014, a European prime contractor might be restricted in exporting technology to Russia for either ITAR or domestic reasons. For instance, in mid-April 2014, Germany deferred a decision on granting Russian export licenses to Airbus D&S, indefinitely putting on hold the sale of satellite technology worth up to €700 million (\$973 million).²⁵⁴ As political tension between Europe and Russia's governments continues, more restrictions in building commercial alliances might emerge. This is true also for Russia-Japanese alliances, and, *a fortiori*, for Russia-U.S. cooperation. However, from a strategy viewpoint the question is whether Russia will be perma-

²⁴⁴ "Russia's Space Industry Needs Over 100,000 Young Engineers by 2025." 24 June 2015. The Moscow Times 9 Oct. 2015

<<http://www.themoscowtimes.com/business/article/russias-space-industry-needs-over-100000-young-engineers-by-2025/524346.html>>.

²⁴⁵ Vasiliev, Vladimir. "Russia's Relations with Europe in Aerospace, Shipbuilding and Defense Industries." Moscow Defense Brief 1 (2007): 2-3.

²⁴⁶ Harvey, Brian. *Russia in Space: The Failed Frontier?* Germany: Springer-Verlag Berlin Heidelberg New York / Praxis Publishing, 2001: 292.

²⁴⁷ "МАКС-2013. День второй." (MAKS-2013. Second day – Google translation) 30 Aug. 2013. Topwar 18 Feb. 2014 <<http://topwar.ru/32641-maks-2013-den-vtoroy.html>>.

²⁴⁸ "ISS-Reshetnev and Thales Alenia Space Launch Joint Venture." 28 Feb. 2013. SpaceNews 18 Feb. 2014 <<http://www.spacenews.com/article/satellite-telecom/33903iss-reshetnev-and-thales-alenia-launch-joint-venture>>.

²⁴⁹ "Thales Alenia Space and ISS Reshetnev Create Joint Venture in Russia." 28 Feb. 2013. Thales Group 18 Feb.

2014 <<https://www.thalesgroup.com/en/content/thales-alenia-space-and-iss-reshetnev-create-joint-venture-russia>>.

²⁵⁰ "Express AM8 in Orbit!" 15 Sept. 2015. Thales 9 Oct. 2015

<<https://www.thalesgroup.com/en/worldwide/space/magazine/express-am8-orbit>>.

²⁵¹ "New platforms, new high-power satellites." 19 Nov. 2008. Reshetnev Company 26 Feb. 2015 <<http://www.iss-reshetnev.com/?cid=publications&pid=4>>.

²⁵² Konik, Leonid. "Competition and Collaboration." 1 Jan. 2014. The Standard 27 Feb. 2015 <<http://www.satellite-russia.ru/executive-view>>.

²⁵³ Harvey, Brian. *Russia in Space: The Failed Frontier?* Germany: Springer-Verlag Berlin Heidelberg New York / Praxis Publishing, 2001: 292.

²⁵⁴ Parkin, Bryan. "Merkel Said to Defer Airbus Satellite Export on Ukraine." 11 Apr. 2014. Bloomberg Business 26 Feb. 2015 <<http://www.bloomberg.com/news/articles/2014-04-11/merkel-said-to-defer-airbus-satellite-export-on-ukraine>>.

nently estranged and hence unattractive as a cooperation partner in space, or whether the tide will change and benefits will be reaped by those who are well placed to step up involvement.

Potential Alliances with Brazil, Argentina, Turkey et al

As described in Chapter 2 above, there are smaller space nations including Brazil, Argentina and Turkey, which may grow to be new rivals in the longer term, and are hence worth mentioning. Since data for the two latter countries is not completely available, their industries can be only partially contrasted in terms of skilled labour and wage levels. However, looking at Brazil, its space industry has an aging labour force of 3000 people and the percentage of the population with tertiary education is relatively low. This notwithstanding, Brazil plans to triple its space budget in the coming years, in addition to streamlining management, and educating more aerospace workers, and hence its labour force is likely to expand.²⁵⁵ In addition to the small size of its industry, another factor that places Brazil at a disadvantage is its location sensitive costs, which are greater than the above-described low cost countries, and nearly on par with the levels currently prevailing in Europe. While Brazil has developed technological competencies in liquid propellants, and is seeking access to space with its indigenous VLS-1 launch vehicle, the many drawbacks make Brazil a challenging cooperation partner.

In 2013, Thales Alenia Space won a contract to deliver a dual-use geostationary satellite, named the Geostationary Defence and Strategic Communications Satellite (SGDC), to the Brazilian government. The outcome of the tender was in part decided by how much technology a bidder was willing and able to transfer to Brazil's space programme.²⁵⁶ Thales Alenia Space was likely seen as the prime contractor in a better position than U.S. competitors to transfer technology with fewer export restrictions. The SGDC contract has created several opportunities for European satellite integrators because it has established an entry point into Brazil's ambitious national space program that could evolve into broader mutually beneficial cooperation.

²⁵⁵ Messier, Douglas. "Will a new space power rise along the Atlantic?" 15 Aug. 2011. *The Space Review* 27 Feb. 2015 <<http://www.thespacereview.com/article/1904/1>>.

²⁵⁶ "Thales Alenia Space Wins Hotly Contested Brazilian Satellite Contract." 13 Aug. 2013. *SpaceNews* 10 Jan. 2014 <<http://www.spacenews.com/article/satellite-telecom/36761thales-alenia-space-wins-hotly-contested-brazilian-satellite-contract>>.

Argentina and Turkey are still in the process of gaining their own footholds in the industry while also dealing with issues of scale. It should be noted, however, that both countries are determined and that particularly Turkey has favourable demographics and many well-educated youth. Turkey's proximity to Europe and its strategic importance are also important factors in assessing the suitability of its nascent space industry as a partner.

The long-term objective of the Turkish government is to develop an indigenous capability to domestically manufacture a complete satellite, shifting Turkey from a satellite purchaser to a satellite manufacturer. In order to reach this ambitious goal, Turkey will need to continue to cooperate with foreign suppliers to support the development of its spacecraft manufacturing infrastructure in the near-to-medium term.²⁵⁷ This creates an opportunity for European space industry to extend its involvement in the Turkish space program. European manufacturers possess valuable skills and know-how that would allow Turkish industry to further develop the infrastructure required to indigenously manufacture a complete geostationary satellite, in addition to supplying satellite components and subsystems for the Türksat 6A and other satellite projects. This kind of technology transfer would provide a supplementary revenue stream for European satellite integrators. Moreover, they could benefit from the low-cost Turkish satellite components and subsystems, manufactured with lower-cost labour than European wage standards. Continued cooperation would therefore positively influence the competitive position of European satellite integrators and potentially open new markets.

In 2014, Argentina became the first country to operate an indigenously integrated geostationary satellite, ARSAT-1, containing a Thales Alenia Space payload and several Airbus D&S satellite components on Argentina's ARSAT 3K satellite bus. The two European prime contractors reprised those roles as leading equipment suppliers in the ARSAT program with the follow-on Arsat-2. This is again a great opportunity for both system integrators to deepen their strategic relations and industrial cooperation with the Argentine satellite manufacturer INVAP.²⁵⁸

²⁵⁷ Stein, Aaron. "Turkey's Space Policy." May 2014. Centre for Economics and Foreign Policy Studies <http://www.edam.org.tr/Media/Files/1156/Turkey_Space_Policy.pdf>.

²⁵⁸ Belluscio, Alejandro G. "ArSat-1: Argentina to Communicate Its Heightened Space Ambitions." *NASA Spaceflight* 6 Oct. 2014



Assessing the Merits of Seeking Cost Leadership Advantage through Cooperation

If a European competitor were to pursue cost leadership by allying with a low cost manufacturing company abroad, the resulting labour cost benefits might have limited shelf-life if production remains in a single region. By 2020, China and India will make up 40% of the 200 million 25-34 year olds with higher education degrees across OECD and G20 countries, whereas the U.S. and Europe are expected to account for just over 25% of the total.²⁵⁹ As the percentage of the population with tertiary education in traditional low cost countries increases, in principle the cost of such labour will go down unless demand exceeds the increase in skilled work force supply, or the general wealth of a country means that labour rates generally go up. The latter is typically the case. For instance, China's average manufacturing sector wages now exceed comparable levels in South and Southeast Asia by as much as six times.²⁶⁰ By comparison, the average factory worker in China earns \$27.50 per day, while the wage is \$8.60 per day in Indonesia, and \$6.70 per day in Vietnam followed by even lower wages in the Philippines.²⁶¹ Relatedly, those Southeast Asian countries (along with Malaysia and Thailand) have also made important investments in space technologies and space sciences for decades to forecast and manage natural disasters and severe weather phenomena, with most investments in the region in the area of space based communication facilities, highlighting the potential for future alliances in the long term.²⁶²

While the labour cost benefit from low cost countries is likely to diminish over time, the capabilities transferred by European competitors cannot be taken back. It is more likely that those low cost manufacturers - now with higher educated talent pools - will increase productivity and adopt enhanced technical

capabilities that could chip away at Europe's own industrial base that cannot compete at the same margins. As technological prowess seeps to the low cost manufacturer, perhaps the best way to maintain a benefit in the arrangement is through continuous innovation on the European side. Should cooperation extend to the long-term, these low-cost countries could become repositories of previous innovation, allowing Europe's industrial base to put greater focus on critical new technologies that are central to the demands of Europe's space industry.

When considering market access, the U.S. institutional market can be seen as the prize in the near term. Yet, as the U.S. government adopts a disaggregation approach to defence spending - which will distribute functionalities and risks onto several small satellites working collaboratively rather than on costlier large satellites - in addition to the use of hosted payloads on commercial satellites, the U.S. institutional market might be seen as less of a bonanza in the long term.

In contrast, institutional markets are expected to boom in countries such as China and India. With such projected change in the economic landscape, the question becomes whether the technology and market access European companies can provide will outweigh protectionist instincts in partner countries.

3.5 What About Outsourcing or Offshoring the Low-End Technology to Low-Cost Countries?

In some instances, outsourcing or offshoring beyond the European area can provide substantial cost benefit, in addition to lowering production time and increasing economies of scale. The European space sector has long sourced main parts of its supply from the U.S., whose suppliers provide subsystems, equipment, and low-end components. In the face of increasing competition and globalisation, this section considers whether European prime contractors should look to increasingly source from, and outsource to, low-cost countries, and whether they should offshore (relocate) their own production to low-cost countries to maintain profitability and remain competitive in both the near and long term.

<<http://www.nasaspaceflight.com/2014/10/arsat-1-argentina-communicate-heightened-space-ambitions/>>.

²⁵⁹ "Education Indicators in Focus." May 2012. OECD 19 Feb. 2015: 2 <<http://www.oecd.org/edu/50495363.pdf>>.

²⁶⁰ Wong, Chun Han. "As China's Economy Slows, So Too Does Growth in Workers' Wages." 17 Dec. 2014. The Wall Street Journal 13 Oct. 2015

<<http://blogs.wsj.com/chinarealtime/2014/12/17/as-chinas-economy-slows-so-too-does-growth-in-workers-wages/>>.

²⁶¹ "A tightening grip | Rising Chinese wages will only strengthen Asia's hold on manufacturing." 14 Mar. 2015. The Economist 13 Oct. 2015

<<http://www.economist.com/news/briefing/21646180-rising-chinese-wages-will-only-strengthen-asias-hold-manufacturing-tightening-grip>>.

²⁶² Lele, Ajey. "India and Other Maturing Asian Space Enthusiasts." Yearbook on Space Policy 2012/2013: Space in a Changing World. Eds. Cenan Al-Ekabi, Blandina Baranes, Peter Hulsroj, and Arne Lahcen. Vienna: SpringerWienNewYork, 2015. 271-285.

3.5.1 Outsource or Offshore Subsystems and Equipment

Instead of entirely developing commercial satellites in-house, top prime contractors often outsource the production of subsystems and equipment to lower-tiered suppliers to reduce costs, and focus on core activities. Depending on the criticality of a specific technology, they may, however, also acquire a supplier to ensure that their supply chain is protected.

Emerging space faring nations are not as tethered to the U.S. for critical subsystems and equipment as is Europe; in fact, in the case of China and Russia, procuring strategic U.S. technology is not an option. Instead, they either source critical technologies from other regions or develop these technologies within their own industrial bases, at a lower cost possibly, but then without a track record. As a subsystem is only as good as its component parts, European prime contractors may find that the quality of their satellites may drop in line with the cost of the satellite in extensive outsourcing cases, although it has to be said that many Asian countries have outstanding records in manufacturing, particularly in the field of electronics.

An alternative to procuring subsystems and equipment from low-cost countries is to offshore European production to low cost countries to benefit from low-cost labour. Both the Thales Group and the Airbus Group have many joint ventures (one type of offshoring) with state-owned partners within the aerospace sector of low-cost countries. For instance, the Thales Group has created several joint ventures with partners in China in a wide range of domains including air traffic management, IFE, avionics, transportation and space²⁶³; Thales Group also has a strong industrial footprint in India's aerospace defence sector through partnerships with local industry.²⁶⁴ Similarly, Airbus Group has joint ventures with partners in China's aerospace sector, which cover training and support, engineering, final assembly and composite manufacturing of aircraft, in addition to a number of cooperation projects²⁶⁵; and it

²⁶³ "Thales celebrates 50 years of diplomatic relations between China and France." 30 Jan. 2014. Thales 19 Oct. 2015

<<https://www.thalesgroup.com/en/worldwide/group/event/thales-celebrates-50-years-diplomatic-relations-between-china-and-france>>.

²⁶⁴ "What We Do | Thales India Locations." 16 Oct. 2015. Thales 19 Oct. 2015

<<https://www.thalesgroup.com/en/india/what-we-do>>.

²⁶⁵ "Airbus celebrates 200th aircraft assembled in Tianjin." 3 Dec. 2014. Airbus 19 Oct. 2015

<<http://www.airbus.com/presscentre/pressreleases/press-release-detail/detail/airbus-celebrates-200th-aircraft-assembled-in-tianjin/>>.

recently formed a joint venture with India's Mahindra Defence company to set up assembly lines and establish supply chain and related infrastructure for military transport planes and helicopters in India.²⁶⁶ Offshoring production is also regularly done in the automotive industry, where it is common to see vehicles entirely assembled in a foreign country; for instance, besides manufacturing cars in Europe, both Mercedes-Benz and BMW manufacture or assemble vehicles in the Americas and Asia.

Unlike in the aerospace and automotive sectors, the limited production number of satellite subsystems and equipment makes offshoring production to low-cost countries trickier, and this may be wedded to intellectual property concerns (more pronouncedly in outsourcing than in pure offshoring). Yet, there may be no alternative, if European industry is to remain competitive in commercial markets. This may be a lesson from the automotive industry, as will be explained below.

3.5.2 Components

While the European space industrial base is adept at developing most parts of its supply chain, it is dependent on non-European suppliers at the lower levels of production, such as with Electrical, Electronic and Electromechanical (EEE) components and with advanced materials. While most high-tech components are imported from the U.S., microelectronics and semi-conductors are imported from Japan and other parts of Asia; and most of the world's rare earths are supplied by China.²⁶⁷ Currently, an average European manufactured satellite has about 60% U.S.-made electronic components and 5% Japanese-made components. As European space industry already procures most of its low-end components and non-critical technology from outside Europe, sourcing low-end components from low-cost countries should have the least harmful immediate impact on Europe's supplier base. The question remains whether the reliability of low-cost components can be ensured, although the Asian record on electronics is outstanding, as mentioned.

Should European prime contractors begin to outsource components to alternative suppliers in low-cost countries, another matter to

²⁶⁶ Sanjai, P. R. "Mahindra, Airbus Helicopters sign pact for chopper venture." 3 July 2015. Live Mint 19 Oct. 2015 <<http://www.livemint.com/Companies/RzKMUJxRwUGbbrBrFKSSTM/Airbus-Helicopters-teams-up-with-Indias-Mahindra-Group.html>>.

²⁶⁷ European Technological Non-Dependence in Space, Letizia Caito, ESPI Report 51, September 2015.



consider is whether Europe will remain in a vulnerable position, as it will still have some level of dependence on foreign suppliers, thereby making the industry susceptible to political changes including additional export controls or natural disasters.²⁶⁸ To limit this vulnerability to foreign produced low-end components, a European non-dependence strategy began to crystalize in the last decade through the initiatives of ESA, the EU, and the EDA. To reduce the European space sector's dependence on non-European EEE-components from single source suppliers or suppliers that might be subject to export restrictions, ESA developed the European Components Initiative (ECI). Under the ECI, the goal of several European governments is to reduce the share of U.S. supplied electronic components to 45% by 2020, with 50% of electronic components built in Europe, and the remaining 5% in Japan, and to avoid single source dependencies when components are sourced from outside Europe.²⁶⁹ The question is whether higher reliance can be placed on low cost manufacturers both by sourcing more from these and by offshoring some of the nominally European supply to low cost countries.

Another concern that has recently begun to emerge is in terms of technology integrity (i.e. concerns over cyber security). Two parallel classified studies conducted by ESA, in collaboration with GMV of Spain and the Thales Group, have determined that spacecraft hardware, firmware and software can be maliciously modified in a manner that can go undetected. Here, regardless of whether subsystems, equipment, or components are sourced from North America or from low cost countries, they carry the risk of being embedded with spyware or logic bombs that can be triggered at a later time by other cooperating components or by environmental factors.²⁷⁰ As the globalization of manufacturing capabilities and increased reliance on commodity software and hardware expands the opportunities for malicious modification in a manner that could compromise critical functionality, European competitors may want to place increased emphasis on procuring sensitive technologies directly in Europe.

²⁶⁸ Ibid.

²⁶⁹ De Selding, Peter B. "European Satellite Makers Shedding U.S.-made Content." 5 Feb. 2013. SpaceNews 23 Feb. 2015 <<http://spacenews.com/33509european-satellite-makers-shedding-us-made-content/>>.

²⁷⁰ Del Monte, Luca. "Cybersecurity for a Sustainable, Secure and Safe Space Environment." Presentation. EISC Workshop 2016: Space and Security. Sinaia, Romania. 18 April 2016.

3.5.3 Outsourcing and Offshoring Lower-Tier Technology to Central and Eastern European Countries?

Rather than outsourcing or offshoring the production of subsystems or components outside of Europe, an alternative low cost option exists within the Central and Eastern European (CEE) region. Here, CEE countries can offer a labour cost incentive similar to that of China, India, and Russia, without presenting as great a risk to Europe's current space industrial base. Some underlying knowhow already exists in CEE countries that were previously involved in Soviet-era space programmes. Moreover most CEE countries wish to join ESA as full members, and are working with ESA to raise their space related-industrial and scientific capabilities to ESA standards, and could therefore be strongly motivated.

Several CEE countries are already full ESA members, including the Czech Republic (having acceded to the ESA Convention in Nov. 2008), Romania (Dec. 2011), Poland (Nov. 2012), Estonia (Feb. 2015), and Hungary (Feb. 2015), entitling them to geographic return on their investment in ESA. Other CEE countries such as Bulgaria, Latvia, Lithuania, Malta, Slovakia, and Slovenia are in different stages of transition towards becoming full ESA members.

ESA enlargement could enable European prime contractors to benefit from both lower production costs, and the availability of skilled and highly motivated engineers within the CEE. As can be seen from Figure 3.4, the labour cost of most CEE countries is roughly around 33% of the labour cost in larger ESA member states. And when looking at Figure 3.2, there is a relatively higher percentage of tertiary educated adults within all CEE countries than in China and India.

As the industry and scientific communities within these CEE countries converge with ESA requirements, their increased capabilities could provide favourable conditions for specialisation as lower-cost subsystems and components suppliers for European prime contractors. Moreover, their experience in the automotive and aerospace manufacturing sectors might also be transferable to the space industry. The Research and Innovation performance in the EU – 2014 report, produced by the European Commission's Research and Innovation DG, provides some insight on how European states have at the national level developed their scientific and technological specializations.

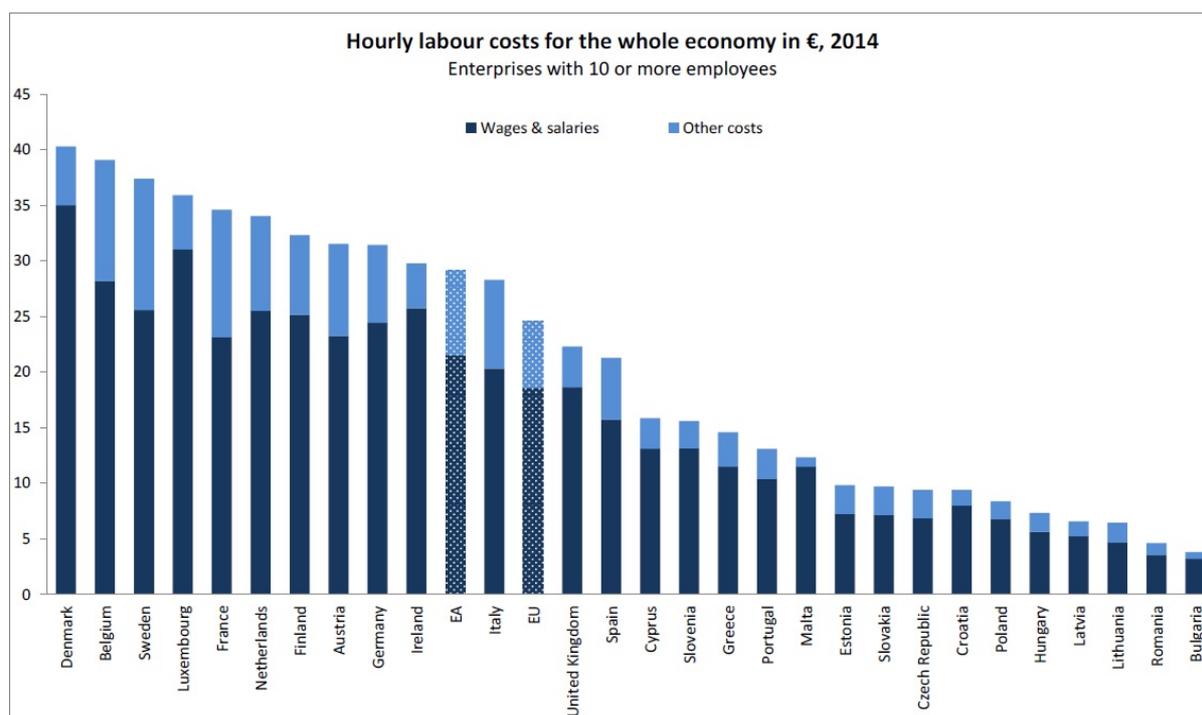


Figure 3.4. Hourly labour costs for the whole [European] economy in €, 2014 (not including agriculture and public administration). (Source: Eurostat news release: Labour costs in the EU).

For instance, the Czech Republic stands out for its scientific and technological specialization in aeronautics and space, which seems to rely on a narrow but high-impact science base that could benefit from greater prioritization.²⁷¹ It is worth noting that the country also stands out for its automobile sector that performs well in medium-high/high-tech goods exports, thanks to several Asian and European owned production facilities located in the region; yet scientific production is both relatively low in quality and scientific impact.²⁷² By comparison, Slovakia’s aeronautics and space sector has a lesser impact at the world level, but is better known for being the highest per-capita car producer in Europe and Slovakia’s medium-high/high-tech goods exports are above the EU average.²⁷³ Hungary is also notable for its high level of scientific excellence in aeronautics, while also being a host country for car manufacturers who, however, tend to do their research and patenting in the country of origin.²⁷⁴ This limited sampling does not exclude other lower cost regions within the CEE that might also have

the right environment to host production facilities.²⁷⁵

Clearly, CEE countries can then be attractive as outsourcing or offshoring hubs, but how this plays out depends not only on the prime contractors or on the receiving industry, but crucially on the plans of governments for integration within ESA and on ESA’s plans in this respect. ESA’s industrial policy dictates a spreading of work across all member states, so it would seem sensible to leverage the cost advantages of new member states in domains where this would bring relatively quick benefits. Lower-tier manufacturing might be a good solution in this respect, and even if cost advantages slowly disappear as a result of general economic progress, the systemic advantage, and the advantage for the prime contractors, will be that the system of geographical return will underpin the outsourcing or offshoring even when cost benefits decrease.

Obviously, from the perspective of new ESA Member States this cannot be the whole story, however. The ambition will naturally be to move up through the manufacturing tiers, and even if this does not extend to becoming system integrators, new member states would not be happy to be involved in lower tier work only. However, the point is that

²⁷¹ Research and Innovation performance in the EU: Innovation Union progress at country level 2014. 24 Nov. 2014. European Commission 27 Feb. 2015: 75 <http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2014/iuc_progress_report_2014.pdf>

²⁷² Ibid. 77.

²⁷³ Ibid. 253, 255.

²⁷⁴ Ibid. 145.

²⁷⁵ Additional details on the national space strategies and investments in space activities of CEE countries can be found in Chapter 2.2 of ESA Enlargement, Erich Klock and Marco Aliberti, ESPI Report 47, Jan. 2014.



lower tier manufacturing might be the best starting point for upwards expansion.

3.5.4 Lessons from the Automotive Manufacturing Industry in Outsourcing

The automotive industry first emerged in France, England, Austria, and in North America in the dawn of the 20th century. Like a precursor to the satellite manufacturing industry, the early custom-made vehicles were large and expensive, and their high price resulted in small markets and production volumes. Henry Ford's Model T assembly line greatly increased the availability of vehicles, allowing Ford to rapidly increase its market share and reach new customers.²⁷⁶ Car manufacturers in the U.S. and smaller European rivals then began to offshore entire production facilities throughout Europe, Latin America, Africa, and the rest of the globe to avoid transportation cost and trade tariffs; dominating the market for nearly three quarters of a century. Yet, by the mid-1970s, Japanese manufacturers were able to penetrate the U.S. and European domestic markets with low-cost vehicles that were highly competitive in quality, durability, and fuel efficiency.

Japanese manufacturers achieved competitive advantages by adopting lean-production techniques that were pioneered by Toyota. A progenitor of modern-day global outsourcing in subsystems and component parts – Toyota made its vehicle production more efficient by developing a lean production model and spinning-off its in-house supply operations into quasi-independent first-tier supplier companies (while Toyota still retained some equity); it then relied on a small number of suppliers that had proven their ability to deliver on time, maintain quality, control cost, and continue to innovate.²⁷⁷

With globalisation picking up momentum in the 1980s and onward, this outsourcing model was adopted by rival competitors and other industries, including the aerospace sector. Europe's automotive supply system is somewhat closer to the Toyota lean supply model than the U.S. mass supply industry, partly because European assemblers tend to be smaller in scale and greater in number.

²⁷⁶ Sturgeon, Timothy and Richard Florida. "Globalization and Jobs in the Automotive Industry." Mar. 2000. Industrial Performance Center – MIT 6 Mar. 2015: 22 <<http://ipc.mit.edu/sites/default/files/documents/00-012.pdf>>.

²⁷⁷ Levick, Richard. "Spotlight on Outsourcing: Boeing Scrambles as Toyota Triumphs." 30 Jan. 2013. Forbes 6 Mar. 2015 <<http://www.forbes.com/sites/richardlevick/2013/01/30/spotlight-on-outsourcing-boeing-scrambles-as-toyota-triumphs/>>.

Europe has benefitted from a number of major suppliers, including Bosch GmbH, Continental AG, and ZF Friedrichshafen AG, which have a technical lead in certain component areas, and can build complete subassemblies and components for assemblers. Moreover, European suppliers tend to be clustered near their home-country assemblers, both physically and in terms of long-term relationships, which meant that assemblers could choose from proven suppliers. However, a significant departure from the lean supply system in Europe is the large number of lower-tiered suppliers to each assembler – i.e. between 1,000 and 2,000, which complicates the supply system.²⁷⁸

In the following decades, carmakers began outsourcing research and development to their suppliers, which left them more dependent on the lower echelons of the supply chain. As competitors pushed into new and emerging markets, they concomitantly needed their suppliers to follow them. This forced suppliers to develop the capability to coordinate and deploy component manufacturing on a global scale, a task only within reach of the largest and cash-richest component makers. It also resulted in suppliers' development of more modularised component designs that catered to the needs of multiple automakers.

Today, while there are 16 major automakers that sell more than 1 million vehicles per year, those vehicles are built from parts supplied by only 10 major component suppliers, which have considerable bargaining power due to their ability to control the supply and price of critical vehicle components. Collectively, the top 10 first tier suppliers have the ability to build 85% of the parts found in mainstream cars.²⁷⁹ Moreover, in contrast to the commercial space sector, these components are not restricted by export controls that could impact their marketability to automakers.

In the automotive market, the battle for technological competitive advantage is also fought by the major suppliers within the industry, which spend heavily on developing new technologies. For instance Bosch – the world's largest automotive supplier by revenue – invested 10% of its 2013 revenue in research and development to maintain its

²⁷⁸ "The Machine that Changed the World – Summary." Univerzita Karlova 6 Mar. 2015: 8 <http://dl1.cuni.cz/pluginfile.php/218097/mod_resource/content/0/womack_the_machine_that_changed_the_world.PDF>.

²⁷⁹ Foy, Henry. "Age of megasupplier heralds danger for carmakers." 18 May 2014. Financial Times 6 Nov. 2015 <<http://www.ft.com/intl/cms/s/0/50c272c4-dce9-11e3-ba13-00144feabdc0.html>>.

position as an innovation leader. The investment is driven by the fact that rival suppliers have the ability to build components that are similar enough to be used interchangeably.

And while most of the top automakers generate more revenue per year than their major suppliers, the operating margins of the 10 largest automakers are on average 4 percentage points lower than the 10 largest suppliers. Moreover, suppliers are better able to respond quickly to the changing demands of automakers by making small adjustments to components, whereas carmakers need to commit greater amounts in new designs to meet customer demands and tastes.²⁸⁰

The automotive sector seems to depart from business theory, which expects profit margins to increase from initial supplier to final product. Here, it appears to be more profitable to be a large subsystem supplier than it is to be a carmaker. A parallel can thus be drawn with the European space industrial base, and the question can be asked whether it would be more advantageous to be a subsystem supplier than a system integrator. However, a major divergence between the industries is the scale production of commercial automotive vehicles on the market (numbering several million cars sold every year), and the scale effects of suppliers producing components that are in use in nearly all automotive vehicles. In contrast, in the case of commercial satellite manufacturing, the number of commercial satellite contracts available is around 25 per year, and the scale of production of subsystems and components used to construct a satellite is several magnitudes of order smaller than within the automotive industry. However, ultimately the result may be the same. Where only a few contracts can be won every year the commercial pressure on the satellite manufacturer will be intense, whereas at the subsystem level the pressure might be slightly less, depending on the niche status obtained. Take for instance the recent dynamic changes needed in OHB's structure following its branching out as a prime contractor, whereas subsystem supplier RUAG has steadily grown its portfolio in recent years.²⁸¹ The slower product renewal cycles in the satellite industry may also mean that niche status can be retained longer.

The fundamental lesson that can be learned from the outsourcing strategies of the automotive industry is, however, that it is possible to outsource very significantly without sacrificing quality, particularly if the geographical distance is limited. In the commer-

cial space business the degree of vertical integration may often have been driven by the desire of integrators to hang on to the most valuable parts of the supply chain, that is, the supply of subsystems and components, however, with the advent of stronger competition from low-cost manufacturers it is questionable whether this is a sustainable situation. The institutional space market has shown that buy-in approaches are perfectly possible²⁸², and although prime contractors have argued that this is not always cost effective, in the commercial field the conclusion must be that spacecraft manufacturers must adopt this approach whenever it drives down cost, as it will more frequently do with the increasing strength and capability of low-cost manufacturers. Paradoxically, the role of European satellite manufacturers may only be safeguarded in the longer term by allowing European subsystem and component suppliers to be increasingly exposed to the ever-harsher climate of worldwide competition.

3.5.5 Lessons from the Aircraft Manufacturing Industry in Outsourcing and Offshoring

The satellite manufacturing and aircraft manufacturing industries share a similar history, in that until the mid-1990s entry barriers and export controls protected the aircraft manufacturing industry in the U.S. and in Europe. Indeed, in addition to being two of the top commercial satellite prime contractors, Airbus and Boeing are the top prime contractors in manufacturing aircraft. And whereas in previous decades most value chain activities were conducted in the home market²⁸³, these manufacturers began to shift non-core capabilities to lower-cost countries seeking to maximize cost efficiencies, share risk, and minimize supplier management challenges in the process.²⁸⁴ While system integration usually takes place in home countries, partly for cultural reasons, lower-tiered suppliers have begun to offshore production of both minor components and major subassemblies to take advantage of low-cost labour and gain access to locally available technology.²⁸⁵ Moreover, complete system

²⁸² Because ESA insists on supplier competition at the lower tiers through its 'Best Practices' procurement system.

²⁸³ Michaels, Kevin. "Aerospace Globalization: The Next Wave." 17 Oct. 2013. ICF International 4 Mar. 2015 <<http://worldwide.erau.edu/caal/aaaims/Kevin-Michaels.pdf>>.

²⁸⁴ Bamber, Penny and Gary Gereffi. "Costa Rica in the Aerospace Global Value Chain: Opportunities for Entry & Upgrading." 20 Aug. 2013 Duke University 4 Mar. 2015: 7 <http://www.cgsc.duke.edu/pdfs/2013_08_20_Ch4_Aerospace.pdf>.

²⁸⁵ Ibid. 16.

²⁸⁰ Ibid.

²⁸¹ Space Policies, Issues and Trends 2014-2015, Cenani Al-Ekabi, ESPI Report 54, November 2015: 37.



integration is beginning to take place in low cost countries as well, close to where they are being marketed, such as the final assembly line for the Airbus A320 aircraft, and soon its A330 aircraft, in Tianjin, China.²⁸⁶

In fact, to lower costs and accelerate production, over half the Airbus fleet in service worldwide has parts produced by Chinese companies.²⁸⁷ Airbus also has partners and suppliers in India and Russia, and its major tier 1 suppliers are encouraged to partner with organizations in those countries to expand reach and capacity. Boeing is not much different, being responsible for the final assembly, marketing, sales and overall design of an aircraft, while outsourcing large elements of responsibility for the design and production of subsystems, equipment, and components to a small number of risk-sharing partners.²⁸⁸

As in satellite manufacturing in low cost countries, the main concern related to outsourcing or offshoring in other aerospace sectors stems from the risk of loss of intellectual property and technology to the nationalized industries of China, India and Russia, which could adopt that technology for their domestic aerospace industries.²⁸⁹ Moreover, aircraft manufacturers must balance the benefits of lower labour costs, access to a broader pool of suppliers and resources, and market access, against the detriments of export restrictions, the loss of intellectual property, and the political backlash toward globalization, outsourcing and offshoring.²⁹⁰

In light of the lower costs and accelerated development expected from outsourcing regionally and internationally, it should be noted that the poor implementation of an outsourcing model might bring the opposite result. Here, it is beneficial to return to Toyota's lean production and outsourcing example mentioned above, and expand on the methods that made it effective. In addition to spinning-off its in-house supply operations

into quasi-independent first-tier supplier companies and relying on a small group of suppliers, Toyota's lean production model focussed on maintaining lower inventories, just-in-time parts deliveries, high performance work organization, and continued improvement programmes for quality and productivity.²⁹¹ Moreover, problems of language and physical distance were overcome through face-to-face contractor and subcontractor communications. And rather than penalising suppliers for delays, they were motivated by rewards for timely deliveries.²⁹² When implemented properly, this model enables manufacturers to outsource and offshore production regionally and internationally at lower costs and with accelerated development.

However, Boeing's experience in outsourcing the development of its 787 aircraft in China provides an example of a project that was several billion dollars over budget and three years behind schedule due to poor implementation. While the 787's problem resulted from outsourced lithium-ion batteries that overheated, Boeing's approach to producing that aircraft had some systemic deficiencies in mitigating risks, i.e. in coordination, innovation, communications, labour relations, management, and disengaged leadership.²⁹³ For instance, onsite expertise and support to suppliers was not provided, resulting in poor coordination in ensuring that components would fit together during aircraft assembly. The lack of expertise also resulted in inefficient responses to unexpected problems that arose from new technologies. And lacking personnel onsite meant that the prime contractor was unable to overcome cultural and language differences and physical distances. Moreover, the employees were not involved in the decision making process on outsourcing, which could have helped to maintain labour relations and prevent potential costly strikes. In applying the outsourcing model, an engaged leadership team with a proven record in supply chain management and risk management was necessary, but not put in place.

²⁸⁶ "Airbus in China." Airbus 4 Mar. 2015 <<http://www.airbus.com/company/worldwide-presence/airbus-in-china/>>.

²⁸⁷ Ibid.

²⁸⁸ Morrison, Murdo. "Murdo Morrison: outsourcing and aerospace." 23 Aug. 2013. The Scotsman 15 May 2015 <<http://www.scotsman.com/news/murdo-morrison-outsourcing-and-aerospace-1-3059172>>.

²⁸⁹ "Brazil, Russia, India and China Governments' Aerospace Strategies and National Policies: Implications to Canada's Aerospace Industry." 11 Jul. 2012. Aerospace Review 4 Mar. 2015 <[http://aerospacereview.ca/eic/site/060.nsf/vwapj/Pravco_-_paper_on_BRICs.pdf/\\$FILE/Pravco_-_paper_on_BRICs.pdf](http://aerospacereview.ca/eic/site/060.nsf/vwapj/Pravco_-_paper_on_BRICs.pdf/$FILE/Pravco_-_paper_on_BRICs.pdf)>.

²⁹⁰ Michaels, Kevin. "Aerospace Globalization: The Next Wave." 17 Oct. 2013. ICF International 4 Mar. 2015 <<http://worldwide.erau.edu/caal/aaaims/Kevin-Michaels.pdf>>.

²⁹¹ Sturgeon, Timothy and Richard Florida. "Globalization and Jobs in the Automotive Industry." Mar. 2000. Industrial Performance Center – MIT 6 Mar. 2015: 36 <<http://ipc.mit.edu/sites/default/files/documents/00-012.pdf>>.

²⁹² Levick, Richard. "Spotlight on Outsourcing: Boeing Scrambles as Toyota Triumphs." 30 Jan. 2013. Forbes 6 Mar. 2015

<<http://www.forbes.com/sites/richardlevick/2013/01/30/spotlight-on-outsourcing-boeing-scrambles-as-toyota-triumphs/>>.

²⁹³ Denning, Steve. "What Went Wrong At Boeing?" 21 Jan. 2013. Forbes 5 Mar. 2015 <<http://www.forbes.com/sites/stevedenning/2013/01/21/wh-at-went-wrong-at-boeing/>>.

As with the lessons from the automotive industry, the aircraft manufacturing industry also shows that outsourcing and offshoring is necessary, but that it entails risks that mean that proper and stringent risk mitigation structures must be put in place. The greater the geographical and cultural distance, the more the risk increases, as does the need for risk mitigation measures.

3.6 Potential New Paradigms for Europe?

3.6.1 Small Satellites

The above scenario assumes a static outlook for the global space sector where the large conventional satellites for telecommunications, Earth observation, science, exploration, technology demonstration and other applications will remain central in a mainly government funded space sector with only a small share of private space ventures. But only recently a rise in small satellites businesses has taken place, triggered on the supply side by massive improvements in technology and the miniaturization of electronics and other satellite components, as well as a growth in secondary payload opportunities, and on the demand side by a surge in governmental and private demand for satellite data, e.g. geospatial satellite imagery, communications, etc.

The large satellite integrators have recognized the increased demand for small satellites and have broadened their customer range by developing or sustaining an in-house small satellite product line next to their large satellite integration business - Thales Alenia Space has recently sold small satellites to Iridium, Globalstar, and O3b, while SSL signed a contract for 13 small satellites with Terra Bella. And in June 2015, Airbus D&S was selected to design and build the first 10 of OneWeb's 648 small satellite constellation.²⁹⁴

The emergence of small satellite ventures has also stimulated the emergence of specialised small satellite manufacturers all over the world that offer end-to-end small satellite solutions on the commercial market. These manufacturers are disruptive innovators of the satellite manufacturing process by using commercial off-the-shelf components and streamlining the production process, enabling

them to manufacture satellites cheaper and faster. For example, Sierra Nevada has streamlined its production process by moving all testing and assembly in-house which has allowed it to reduce the production cycle by a factor of four, from two years to build a satellite to four to five months, at a fraction of the cost.²⁹⁵

This has stimulated several European system integrators into acquiring a specialised small satellite manufacturer. European system integrators thereby obtain the technological and production process innovations pioneered by the small satellite manufacturers to streamline their production cycle, reducing their manufacturing costs and increase their competitive position in the commercial market for large satellites. In 2009 Airbus became the principal shareholder of SSTL, a spin-off company of the University of Surrey that designs and manufactures subsystems and small satellites for Earth observation and remote sensing, science, navigation, telecommunications and technology demonstration purposes.²⁹⁶ Also OHB, which developed its small satellite technology in-house, purchased several specialized companies, i.e. OHB CGS, KaiserTrede and Swedish Space Corporation, to improve its small and large satellite manufacturing capabilities. As interest in small satellites grows, and launch costs continue to decrease, European manufacturers could bring their reliability paradigm to small satellite production, which would make them more competitive in this growing segment.

3.7 Conclusion

The competitiveness of European integrators for large satellites will remain essential to sustain the critical mass of the European space industry as a precondition for Europe's space ambitions. Remaining competitive may require a change in industrial strategy, with a

²⁹⁴ De Selding, Peter B. "OneWeb Taps Airbus To Build 900 Internet Smallsats." 15 June 2015. SpaceNews 13 May 2016 <<http://spacenews.com/airbus-wins-oneweb-contract/>>.

²⁹⁵ "Sierra Nevada Cuts Costs With In-House Satellite Assembly, Testing." 6 Jan. 2014. The Denver Post 3 Dec. 2014

<http://www.denverpost.com/business/ci_25870264/sierra-nevada-cuts-costs-house-satellite-assembly-testing/>.

²⁹⁶ SSTL is considered as one of the pioneers in the small satellites manufacturing market and has been stimulating the utility and application of small satellite solutions since the early 1980s. It is interesting to note that Airbus decided not to integrate SSTL in its core organizational structure but to keep it as a standalone business – a clear sign that it believes in the commercial growth potential of the company's business model – while allowing Airbus to remain focused on the high-end large satellite market. See further, Jafry, Adil R. "Disruptive Competitive Dynamics Created By the Advent of Small Satellite Manufacturers and Operators." 2010; "About SSTL." SSTL 1 Dec. 2014 <<http://www.sssl.co.uk/About-SSTL/>>.



focus on building stronger ties with Western manufacturers in addition to accessing their industrial markets. Similarly, it could benefit from allying with rapidly emerging nations with low cost manufacturing capabilities or outsourcing or offshoring to these countries. A further option is to foster low cost internal capability in Europe by seeking to relocate

parts of manufacturing to CEE countries, this having the dual advantage of having highly skill labour at a lower cost and greater geographical proximity. This last approach has the added advantage of being more likely to push forward Europe's goal for technological non-dependence in components and parts.

4. Findings and Recommendations

As presented in Chapters 1, 2, and 3 of this report, changes in the spacecraft manufacturing sector show that the intensity of competition is increasing, with aggressive commercial policies from other space faring nations, both old and new. Moreover, the course of business is also changing, as high-end technologies continue to develop at a rapid pace, while low-cost options from countries such as

China, India, and Russia are becoming more attractive, especially to emerging space markets. Furthermore, the capabilities of the different space actors are converging, through both technology transfer and organic growth, resulting in a more level playing field and potentially a smaller share of the pie to be won. The following three illustrations demonstrate the evolving situation.

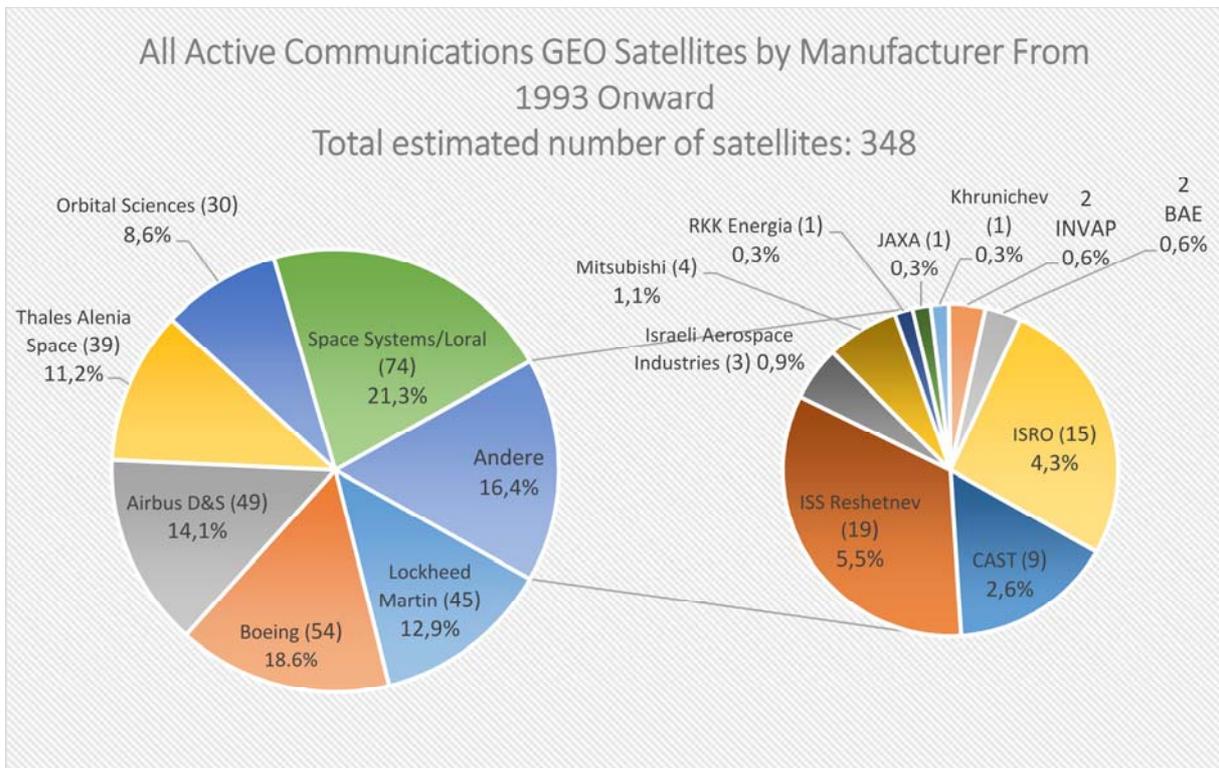


Figure 4.1. Active Commercial Communications GEO Satellites by Manufacturer from 1993 Onward (Source: SatBeams).

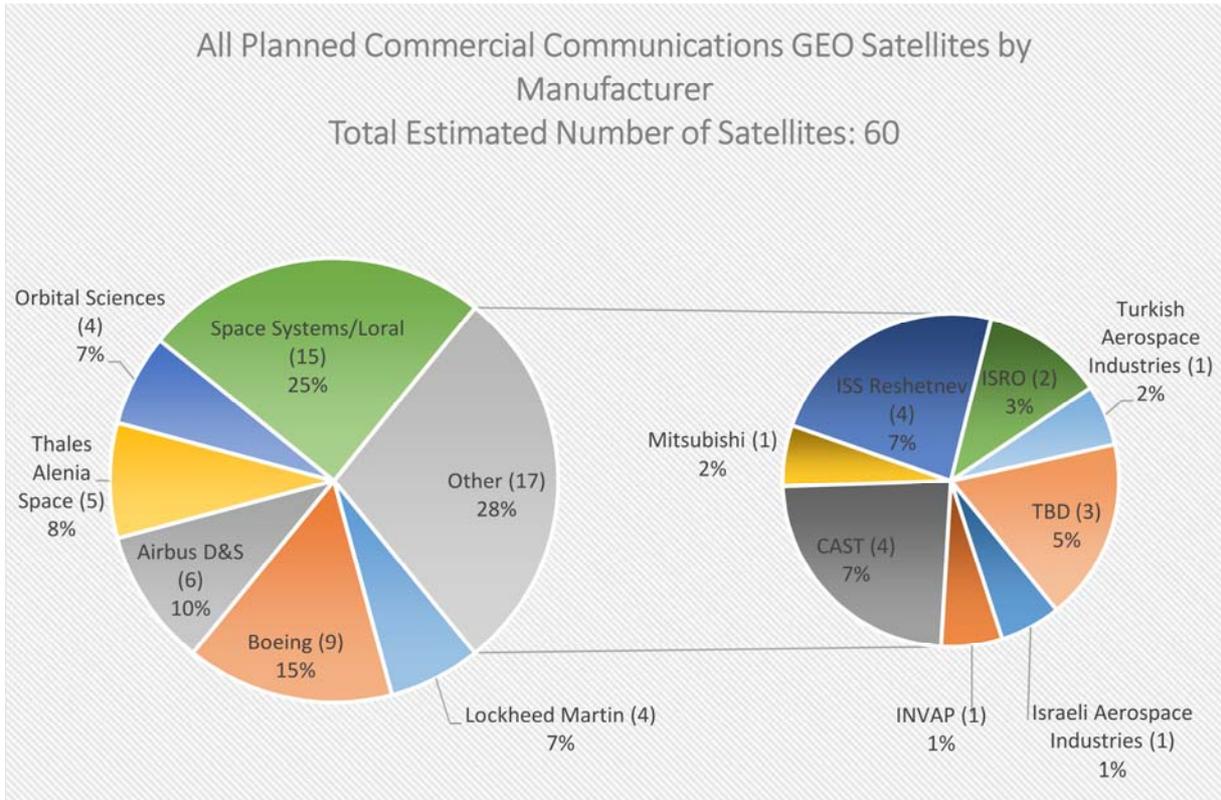


Figure 4.2. Planned Commercial Communications GEO Satellites by Manufacturer (Source: SatBeams).

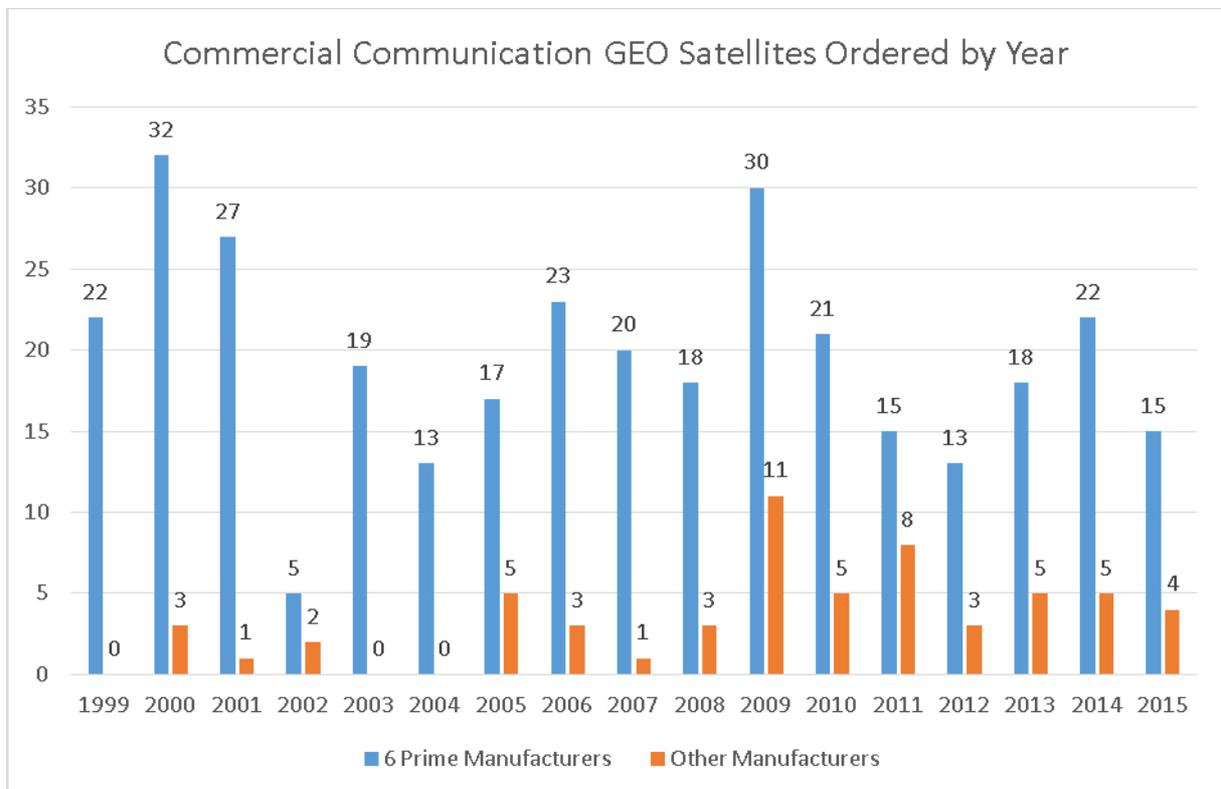


Figure 4.3. Comparison of All Prime Contractors (Source: Futron Manufacturing Report).

Clearly, the next steps to be taken by Europe's top competitors in maintaining their position in the industry will require careful deliberation by all stakeholders, as they are likely to have a lasting effect on Europe's space capability overall. In identifying the best course of action to be taken by European prime contractors, it is helpful to analyse the interests of all space industry stakeholders, i.e. ESA, the EU, and the European industrial base. Such an approach enables the identification of common avenues where interests are aligned, and where they diverge.

4.1 ESA Interest in Space Industrial Policy

At first glance, ESA might appear to be in the best position from the technological standpoint to address the new challenges, as the intergovernmental agency has shaped and developed initiatives in all space sectors, and has been Europe's key player for space activities. Indeed, it is a successful model in terms of coordination of national space policies, activities, and resources, and its core focus has been toward fostering innovative new technologies and space science. Yet, even with space commercialisation programmes such as BICs and ARTES, ESA is not a political actor and it lacks some of the tools to improve the overall competitive environment and create a level playing field for the European space industry at the international level, even though ESA has been instrumental in strengthening Europe's satellite manufacturing industry, in fostering innovation and in the consolidation of European industry over the last decades.

4.2 EU Interest in Space Industrial Policy

The emergence of new space powers, and the increasingly competitive global environment, has awakened in the EU to the need to provide increased support to the maintenance of a healthy industrial base. Driven by societal, economic, and strategic imperatives to benefit citizens' wellbeing, stimulate innovation, and broaden the EU's projection as a global actor, the EU is developing its own strategic space policy that will allow it to capitalize on investments it has already made in the space sector and maximize space innovation potential.²⁹⁷ Following the establishment of the

²⁹⁷ European Commission. Communication from the Commission to the European Parliament, the Council, the

EU's legal basis in space policy in Article 189 of its Treaty on the Functioning of the European Union (TFEU), a series of communications between the European Commission, the European Parliament, the Council, and various other institutional bodies have outlined the priorities that need to be followed in establishing a European space strategy.

Against this background, the EU's space industrial policy has centred on five specific objectives: 1) establish a coherent and stable regulatory framework; 2) further develop a competitive, solid, efficient and balanced industrial base in Europe and support the participation of SME [small and medium-sized enterprises]; 3) support the global competitiveness of the EU space industry by encouraging the sector to become more cost-efficient along the value chain; 4) develop markets for space applications and services; and 5) ensure technological non-dependence and an independent access to space.²⁹⁸ Moreover, EU support for research and innovation in space comes from the Horizon 2020 budget, which has allocated €1.4 billion for this over the course of 2014 to 2020. The objectives of Horizon 2020 are to: enable European competitiveness in space, with a focus on ensuring non-dependence on critical technologies and fostering innovation; enable advances in space technologies; and stimulate the full exploitation of space data and the development of innovative applications. On the technological level, Horizon 2020 is thus an important complement to the activities of ESA.

4.3 Industrial Response to EU Interest in Space Industrial Policy

ASD-Eurospace has also offered an industrial perspective in response to the changes occurring in the EU's initiatives in space industrial policy. The organization's satellite telecommunications working group has provided position papers on the competitive challenges that affect Europe's industrial space base, and has made its own recommendations for

European Economic and Social Committee and the Committee of the Regions. An Integrated Industrial Policy for the Globalisation Era Putting Competitiveness and Sustainability at Centre Stage. COM (2010) 614 final of 28 Oct. 2010. Brussels: European Union: 24.

²⁹⁸ European Commission. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. EU Space Industrial Policy: Releasing the Potential for Economic Growth in the Space Sector. COM (2013) 108 final of 28 Oct. 2013. Brussels: European Union: 5.



consideration by European decision makers with regard to the satellite communications industry. Those recommendations support the initiatives of the European Commission, which comes as no surprise as both share an interest in maintaining a strong industrial base in Europe. For instance, with regard to satellite manufacturing, it calls for an increase in public support for research and development activities, with a focus on enhancing performance and attractiveness while minimising price to align with market trends. Next, it recommends that the EU's industrial policy addresses the technology dependence issue and implements an efficient mechanism to promote and share the results of actions performed in this area. It also highlights the need for an appropriate framework to enable the deployment of innovative satellite communications infrastructures to serve the EU agenda through a new financial scheme involving public support; market demand-aggregation; pan-European harmonisation of satellite communication systems through standardisation and regulations; and the creation of government markets. And lastly, it goes further in its call for action to bring the European satellite industry on a level playing field with its non-EU competitors in the field of competition, competitiveness, and the development of bilateral and multilateral agreements to support the export market.²⁹⁹

4.4 Applying a SWOT Analysis to Europe's Prime Contractors

In considering the interests and initiatives of European stakeholders, it is beneficial to distil the relevant factors of Europe's commercial space industry in a Strength, Weakness, Opportunity and Threat (SWOT) analysis based on the findings in earlier chapters.

Drawing on the material provided in earlier chapters, a summary of the overall position of Europe's competitive sector can be described in an interrelated fashion, wherein the distinction between a strength and a weakness, and an opportunity and threat, can be seen as mirroring one another.

Europe's commercial space industry is endowed with a number of competitive strengths. Having overcome the barriers of entry into the industry during the Cold War,

its prime contractors Airbus D&S, Thales Alenia Space and, to a lesser extent, OHB Space Systems, are market leaders in commercial satellite manufacturing. With many decades of experience, they tend to a captive market for several space systems, building on their substantial space infrastructure. With their high technological capability, they market a wide assortment of reliable differentiated space systems according to the commercial needs of their customers. And because of the impediment of U.S. ITAR controls on the sale of commercial satellites containing U.S. dual-use and strategic components, the commercial business of U.S. competitors was harmed, whilst European industry was strengthened, even if this ban meant that possibility of exporting complete satellites to ITAR banned countries became impossible also for European manufacturers, since they rely on US components too.

Europe boasts a labour force of nearly 38,000 employees distributed according to the respective industry clusters within the member states, 88% of whom are highly-skilled, with qualifications ranging from high-vocational training (21%) to extended university backgrounds (67%), providing a strong setting for European manufacturers.³⁰⁰

A European prime contractor weakness, and perhaps a weakness inherently experienced throughout the global industry, is the increasing commercial rivalry between top contractors. In a Darwinian fashion, rivals must innovatively adapt their capabilities, and compete for the few available contracts, despite the low profitability of the industry, and the costly price tag of Western technology – weakening the demand from states that are beginning to enter the space sector. Unlike the U.S., China, and India, whose institutional market makes up a substantial proportion of domestic business that sustains contractors in times of low commercial demand, Europe lacks a comparable institutional safety net; rather, it is dependent on the revenue generated from exports to the rest of the world. In comparison to the domestic commercial industry, the commercial export of European telecommunication satellites and Earth observation satellites far exceeds the value of Europe's domestic sales for similar systems.³⁰¹ Moreover, currently, 60% of an average European-built satellite uses U.S.

²⁹⁹ "Space Telecommunications | A key sector for Europe: achievements and perspectives." 2013 ASD-EUROSPACE 23 Apr. 2015: 3
<<http://eurospace.org/Data/Sites/1/pdf/positionpapers/spacetelecomsreferencedocument2013.pdf>>.

³⁰⁰ ASD-Eurospace. "Facts & figures – The European Space Industry in 2014." 19th edition. June 2015: 8.

³⁰¹ Ibid. at 10-11, 16.

Strengths	Weaknesses
<ul style="list-style-type: none"> • Market leaders in commercial satellite manufacturing • Captive market for some commercial space systems • Substantial existing space infrastructure • High-technological capability • Wide assortment of proven differentiated technologies on the market • Less restricted by ITAR export regulations than U.S. competitors • Highly skilled labour • Large industry labour force 	<ul style="list-style-type: none"> • Intense rivalry among top competitors • Few contracts available to go around • Low profitability • General high cost of large satellites • Lack of institutional safety net for periods of low commercial sales • Large dependency on U.S. for strategic and dual-use components • Subject to foreign export control • High labour wages • Procurement inefficiencies / geo-return requirements potentially interfering with competition
Opportunities	Threats
<ul style="list-style-type: none"> • Growing international commercial markets • New potential customers in emerging countries • Access to non-European institutional markets through alliance building • Enhance competitiveness by generating economies of scale • Increase high technological capability and differentiated technology • Enhance competitiveness by lowering labour costs through outsourcing or offshoring • Circumvent/avoid potential export restrictions • Small satellite constellations and the changing technological landscape 	<ul style="list-style-type: none"> • New commercial rivals China, India, and Russia • Low-cost satellites • Alliances among external rivals • Unidirectional technology transfer • Increased dependency on non-European sources • Possible assembly-line production by current rivals in the U.S. for large satellites • Unfair price competition through national subsidies and price dumping • Uncertain export controls • Possible extraterritorial coercive measures on European industry • Rival low-cost small satellite constellations

Table 4.1 SWOT analysis of the European Prime Contractor Industry.

electronic content – highlighting Europe's continued dependence on U.S. industry for strategic and dual use components, and the impact U.S. export control policy has on Europe's competitive industry. Next, low cost countries such as China, India, and Russia have the comparative advantage of low cost labour, and often attractive exchange rates, enabling them to gain a substantial profit from low cost commercial satellite contracts, whereas the labour costs in Europe are significantly higher. Finally, ESA's geo-return requirements, whilst a strong fund raising tool, leads to industrial fragmentation that is not always helpful for the commercial positioning of European prime contractors; following the latest Ministerial Council meeting of December 2014, the requirement of geographic return for ESA institutional contracts was loosened only for Europe's launcher sector.³⁰²

Of course, the line between an opportunity and a threat is drawn by the perspective of

the reader. In this study some interconnected opportunities and threats can be established based on the evolution of the industry. In the case of opportunities, the international commercial market is expected to continue to grow with increased demand from commercial operators seeking to replace existing fleets with cutting-edge satellites. Moreover, with the anticipated creation of new agencies in Africa, Latin America, Eastern Europe, Central Asia, and Southeast Asia, the corresponding number of customers in emerging countries is expected to increase.³⁰³ And with substantial funds available to U.S. competitors through domestic institutional investment, and the state-financed markets of China, India, and Russia, European prime contractors could try to increase their access to these non-European institutional markets through alliance building. European prime contractors could also try to enhance competitiveness by generating further economies of scale by concentrating activities within one

³⁰² Rumpf, Clemens. "Op-ed | Increased Competition Will Challenge ESA's Space Authority." 16 Feb. 2015. SpaceNews 20 Apr. 2015 <<http://spacenews.com/op-ed-increased-competition-will-challenge-esas-space-authority/>>.

³⁰³ Lahcen, Arne. "The Globalisation of Space Activities: The Implications for Europe and Possible Strategies to Pursue." Yearbook on Space Policy 2012/2013: Space in a Changing World. Eds. Cenan Al-Ekabi, Blandina Baranes, Peter Hulsroj, and Arne Lahcen. Vienna: SpringerWien-NewYork, 2015. 287-332.



entity to serve both parties. European competitors could try to enhance their competitiveness by focussing on developing high technological capability and differentiated technology. Yet another way to enhance competitiveness could be by lowering labour costs through outsourcing or offshoring; doing so could also enable European prime contractors to circumvent or avoid potential export restrictions that are normally attached to components procured from the United States. Moreover, small satellite constellations and the changing technological landscape present a new opportunity for prime contractors to build and rapidly deploy an armada of satellites that do not require the quality/durability of typical satellite systems due to their low orbit and limited operating life, and these capabilities may cross-fertilise with the production of large satellites.

The threats that face European prime contractors in the medium-to-long term are potentially existential. Whereas in previous times, European prime contractors competed in the market through product differentiation and cutting-edge technology, the emergence of China, India, and Russia as new commercial rivals opens another front-line by way of cost leadership. Here, the European commercial space industry is not alone in seeking to mitigate the changing competitive environment; rather, cooperative activities have already begun among other traditional rivals, and, indeed, among some of the new entrants. Moreover, outsourcing or offshoring production to low cost countries would likely result in technology transferred out of Europe; and it also serves to increase European prime contractors' dependency on non-European sources. Next, sustained by substantial institutional investment by U.S. government actors, traditional rivals in the U.S. have begun to adopt assembly line and 3-D printing production methods in satellite construction to become more cost efficient. This makes it urgent that European satellite manufacturers strongly follow suit.

Unfair price competition through national subsidies and price dumping can also have the effect of distorting competition across the whole industry, just as export controls and market access controls in the US provide a tool for potential extraterritorial coercive responses, both by limiting the export of critical US technology as a competitive tool and by even further limiting the access of European competitors to the US institutional market.³⁰⁴

³⁰⁴ Mineiro, Michael C. "An inconvenient regulatory truth: Divergence in the US and EU satellite export control policies on China." *Space Policy* 27 (2011): 213-221, 219.

Finally, the rise of small satellite constellations, with ever increasing capability, is a clear threat to the manufacturers of large satellites, although this also constitutes an opportunity, because involvement in both domains will enable potentially highly beneficial cross-fertilisation.

4.5 Assessing Alternative Roadmaps for European Competitors: Trade-off Considerations on Forming Alliances and on Outsourcing / Offshoring

In order to chart potential routes for European Prime Contractors to remain competitive, it is useful to assess the trade-offs in forming an alliance to reap the best balance between the opportunities and threats in the global market. The strategic benefits of alliances include economies of scale, technology transfer, risk reduction (through the spreading of risk among partners), and shaping the nature of competition in an industry,³⁰⁵ it being noted that the benefit of an alliance exists so long as the strategic contributions of both participants remain complementary or critical mass relevant.

However alliances can also come with costs that could increasingly accrue over the life-cycle of such partnerships. Identifying when the cost of an alliance offsets its benefit can help to determine when an alliance becomes a competitive disadvantage.³⁰⁶ Ongoing coordination is required between participants, which can be complicated by divergent interests in configuring activity worldwide, in differing forms of ownership and production. The level of technology transferred could result in the dissipation of sources of European competitive advantage and create a new competitor or make an existing competitor even more formidable, thus undermining Europe's own industry structure. Furthermore, in an alliance where benefits are divided between participants, European prime contractors might find themselves in an adverse bargaining position if another partner is able to capture a disproportionate share of the value created by the alliance by making

³⁰⁵ Porter, Michael E., and Mark B. Fuller. "Coalitions and Global Strategy." *Competition in Global Industries*. Ed. Michael E. Porter. Boston: Harvard Business School Press, 1986. 315-343.

³⁰⁶ *Ibid.*

irreversible investments that make its contribution integral to the venture.³⁰⁷

4.5.1 Alliance Building among European Competitors

Benefits	Burdens
<ul style="list-style-type: none"> • Enhances bargaining power of European Prime Contractors in bidding for international contracts • Enables economies of scale between competitors • Standardized manufacturing of components and equipment for Telecom, EO and Navigation satellites • Less impacted by procurement inefficiencies /and geo-return requirements • Less dependence on U.S. built components • Coordination requirements limited to within Europe 	<ul style="list-style-type: none"> • Nominal technology transfer from outside Europe (need to attract high-skilled labour, and technology from abroad) • Need to find other ways to lower cost of doing business without affecting labour cost • Possible job losses • Potential acquisition of a participant by another competitor • Need to avoid becoming anti-competitive within the European Union.

Table 4.2 Trade-offs on Alliance Building among European Competitors.

An alliance between European prime contractors would enhance their collective bargaining power in bidding for international contracts, e.g. as when Thales Alenia Space and Airbus D&S cooperated to provide the payload and components to Argentinian satellite manufacturer INVAP for its ARSAT 3K satellite bus. With each participant benefiting from complementary economies of scale, repeating such an arrangement would enable prime contractors to specialize in key areas and facilitate standardized manufacturing processes encompassing components and equipment for European telecommunications, Earth observation, and navigation satellites. In Europe, procurement inefficiencies due to geographic return requirements would decrease, as participants could access a larger share of institutional funding. Reliance on US components could be reduced when European participants are better capable of designing similar components to those restricted in the US. Moreover, the coordination of activities between European participants could be aligned easier according to European strategic interests, while there would be less po-

³⁰⁷ Ibid.

tential for the erosion of Europe’s overall competitive position, and less chance of the creation of an adverse bargaining position as both participants would have direct access to the same European industrial supplier base.

Over time, technological capability within Europe’s industrial base would converge through standardisation. So to remain at the forefront of the competitive arena, European industry should seek to acquire technology from other leading competitors, and hire highly-skilled labour trained outside of Europe to develop new synergies. Yet, increased cooperation among European competitors is unlikely to reduce labour costs, so in manufacturing lower-cost satellites, manufacturers will need to lower costs in other ways, i.e. through assembly line production and automation, in addition to further rationalisation of divisions (e.g. Airbus’ rationalisation following its reorganization from EADS). Continued rationalisation could also evolve into a merger between the participants, or the potential takeover of one of the participants, which brings into question the need to protect Europe’s competitive industry from abuse of market position.

4.5.2 Alliance Building with Traditional Rivals

Benefits	Burdens
<ul style="list-style-type: none"> • Economies of scale • Reciprocal technology transfer • Access to potentially large institutional markets • Maintain high technological capability and differentiated technology • Access to highly skilled labour force 	<ul style="list-style-type: none"> • Aligned export control policy potentially further impeding European prime contractor global strategy • Unlikely to reduce cost of labour – need to find other ways of lowering cost (efficiency) • Continued dependency on U.S. for strategic and dual-use components • Less competitive among emerging countries

Table 4.3 Trade-offs on Alliance Building with Traditional Rivals.

In terms of alliance building with traditional rivals, a notable distinction from an alliance with new rivals is the mutual transfer of technology and know-how, in addition to reducing the risk for European competitors through access to other institutional markets, such as the U.S. institutional market. Next the technology involved would remain concentrated among traditional rivals, developed by a highly skilled labour force.



However, coordination is likely to be the biggest issue in the case of an alliance with traditional rivals, as export control interests will require alignment – which could impact Europe’s ability to sell a satellite to a country such as China; yet the trade-off may come from better access to the lucrative U.S. institutional market. Moreover, as labour costs would be unlikely to diminish, other forms of cost reduction through standardization and assembly-line manufacturing will be needed to lower the cost of a commercial satellite. It is likely that Europe will continue to depend on components sourced from the U.S. based on existing economies of scale; yet, to overcome export restraints, Europe would need to further develop its own capability in strategic and dual-use components. Next, as the reduction of any cost in an average satellite is unlikely to completely offset the price advantages of new rival low-cost countries, subsidisation methods similar to those of new rivals should be investigated and applied barring potential conflict with WTO trade rules.

4.5.3 Alliance Building with New Rivals

Benefits	Burdens
<ul style="list-style-type: none"> • Lower overall labour cost • More competitive among emerging countries • Less impeded by export restrictions • Outsourcing/offshoring potential for non-critical technologies 	<ul style="list-style-type: none"> • Unidirectional technology transfer (potential erosion of European industrial base) • Benefits of low labour wages diminishing over time • Continued state subsidisation of state industry while adopting new technology (will need to subsidise European industry to compete) • Potential coercive extraterritorial response by U.S.

Table 4.4 Trade-offs on Alliance Building with New Rivals.

The strategic benefit in allying with new rivals mainly comes from the lower overall labour cost, which could translate to greater economies of scale and the reduced cost of satellites. Lowering the price of a satellite will help European competitors to be more competitive among traditional rivals both in existing markets and when competing for customers in developing and emerging countries. Moreover, such an alliance could result in the replacement of dual-use and strategic U.S. satellite components, with components sourced from new rival competitors. And this activity provides an avenue for European competitors to outsource non-essential tech-

nologies, to place more focus on more critical European capabilities.

Yet, the erosion of Europe’s competitive position is the central concern about an alliance with new rivals, as European prime contractors may find a unidirectional technology transfer that could undermine Europe’s industrial supply base. Moreover, as the cost of labour in e.g. China converges with developed countries, relocation to other low-cost countries will be needed for Europe to continue benefiting from low cost labour. And while European prime contractors could potentially tap the state-subsidised institutional contracts of low cost countries, domestic industry is keen to adopt new technologies in separate institutional contracts. Depending on the alliance that is formed, it might affect commercial options with other competitive markets.

4.5.4 Outsourcing / Offshoring Low-End Technology to Low-Cost Countries

Benefits	Burdens
<ul style="list-style-type: none"> • Lower overall labour cost • Many untapped pools of low cost labour • Economies of scale • Avoidance of additional export restrictions • Low cost electronics manufacturing industries already established. • More competitive among traditional customers and emerging countries 	<ul style="list-style-type: none"> • European space industrial base may transition facilities to low cost countries as part of continued rationalisation of divisions. • Risk of moving technological capabilities away from Europe • Component reliability concerns (outsourced to manufacturers without a track record) • Additional concerns about Intellectual property and technology integrity (cyber security) • At risk of changes in the political climate. • Continued dependence on external suppliers as parts of supply chain would remain outside Europe

Table 4.5 Trade-offs on Outsourcing / Offshoring Low-End Technology to Low Cost Countries.

Outsourcing and offshoring the development of subsystems, equipment, or components to low cost countries is another option to cut the cost of satellite development. Here, China and India provide the greatest savings in terms of labour costs, along with other location-sensitive costs. However, as their labour cost benefit diminishes over time, nearby countries in South-East Asia are likely to provide additional low cost labour alternatives.

Lowering the cost of production will enable greater economies of scale, while also reducing the impact of U.S. ITAR export restrictions. And as most electronics manufacturers already outsource production to low cost countries in Asia, an infrastructure already exists to produce low cost components that European manufacturers could use to lower the cost of their satellites in the near term.

Yet, outsourcing or offshoring to low cost countries comes with a number of disincentives as well. It may affect Europe's space industrial base by moving facilities to low cost countries as part of continued rationalisation of divisions, or it could result in the movement of technological capabilities away from Europe. Moreover, the reliability of outsourced components is uncertain as they may be developed without a track record. There is also a risk that offshoring development of components to low cost countries might result in the adoption of that technology by domestic competitors. And slightly more concerning is the potential for outsourced components embedded with spyware, logic bombs, or other embedded malicious modifications (however, this is also a concern that could extend to traditional suppliers in the U.S.). Lastly, as in the case of Russia, there is also a chance that the political climate changes in the country where components are procured, which highlights the fact that European manufacturers would still be dependent on external suppliers as parts of the supply chain would remain outside of Europe.

4.5.5 Outsourcing / Offshoring Low-End Technology to CEE

Benefits	Burdens
<ul style="list-style-type: none"> • Lower overall labour cost • Economies of scale • Preservation of technological capabilities in Europe • Avoidance of additional export restrictions • More competitive among traditional customers and emerging countries • Solves geographical return issue in ESA 	<ul style="list-style-type: none"> • Job losses in existing manufacturing facilities • Requires ongoing financial commitment to see returns on industrial space investment (timeline typically 10 years)

Table 4.6 Trade-offs on Outsourcing / Offshoring Low-End Technology to CEE.

Another opportunity comes from the untapped capability of CEE countries, which could also be useful for outsourcing/offshoring subsystems, equipment, or component development. CEE countries provide their own labour cost advantage compared to Western European wages, though they are still higher than labour costs in countries such as China and India. However, this approach facilitates economies of scale by becoming more competitive in the global market at the component/equipment level while at the same time avoiding export restrictions because the activity remains within the European region. The resulting lower cost in production will enable European manufacturers to be more competitive among traditional customers while also allowing them to better compete in emerging countries.

But outsourcing or offshoring the development of subsystems, equipment, or components to CEE countries brings its own concerns, as it is likely to affect the current European space industrial base by pulling in a greater number facilities to cluster in CEE regions as part of the continued rationalisation of divisions. Moreover, outsourcing or offshoring any type of production to CEE countries is a long-term process, requiring ongoing financial commitment to see returns on industrial space investment.

Finally, it should be noted that outsourcing to CEE countries that are members of ESA would allow some of the investment required to be covered by institutional funds as a result of geographical return rules, since capacity would tend to be shared between commercial spacecraft manufacturing and institutional spacecraft manufacturing.

4.5.6 Summary

In order to evaluate the various alliance options, they were matched according to incentive criteria that could be used in selecting an alliance partner, as outlined in Chapter 3.4.1. The overall performance of each alliance option is presented in Table 4.7. A second assessment on the incentives for outsourcing or offshoring low-end technology was made to assess the trade-offs in outsourcing to CEE countries, or Asia, and is presented in Table 4.8.



Commercial Factors	EU Rivals	Traditional Rivals	New Rivals
Develop Economies of Scale	✓	✓	✓
Reciprocal Technology Transfer	✓	✓	
Lower Labour Costs			✓
High Skilled Labour (Increased Productivity)	✓	✓	
Access to New Markets		✓	✓
Fewer Export Restrictions	✓		✓
Increased Differentiated Technologies	✓	✓	
Significantly Lower Cost Satellites			✓
Complementarity between International Strategies	✓	✓	
Enduring Benefit of Maintaining Alliance	✓	✓	
Similar Organizational Styles	✓		
	8	7	5

Table 4.7 Trade-off Assessment of Alliance Options

Based on the number of criteria that are met in Table 4.7, it appears that the development of an alliance among European rivals would be the most feasible, which is not surprising as it essentially concentrates the already working formula, and could enhance their

collective bargaining power for international contracts. However, the other two alliance options present key incentives that are not present in the case of an alliance among European competitors and are also relatively feasible.

Outsourcing/Offshoring	CEE Countries	Asia
Lower Cost Components	✓	✓
Component Reliability	✓	
Established Infrastructure		✓
Lower Labour Costs	✓	✓
Fewer Export Restrictions	✓	✓
Intellectual Property Protection	✓	
Reinforce the Europe's Industrial Base	✓	
Fewer Procurement and Geo-Return Requirements		✓
Technology Integrity (Cyber Security)	✓	
Enhance Europe's Non-Dependence Strategy	✓	✓
	8	6

Table 4.8 Trade-off Assessment of Alternative Alliance Options

In Table 4.8, CEE countries present the most commercial and political incentives for outsourcing and offshoring production of low-end technology. Yet here too, there are key incentives for outsourcing to Asia that are not present in the CEE. Outsourcing or offshoring to low cost countries in Asia would likely substantially reduce labour costs, though reliabil-

ity and intellectual property issues might offset that advantage to some extent. Alternatively, outsourcing or offshoring production to CEE countries presents its own advantages, as it could be a hybrid middle ground in the pursuit of technological leadership and low-cost labour.

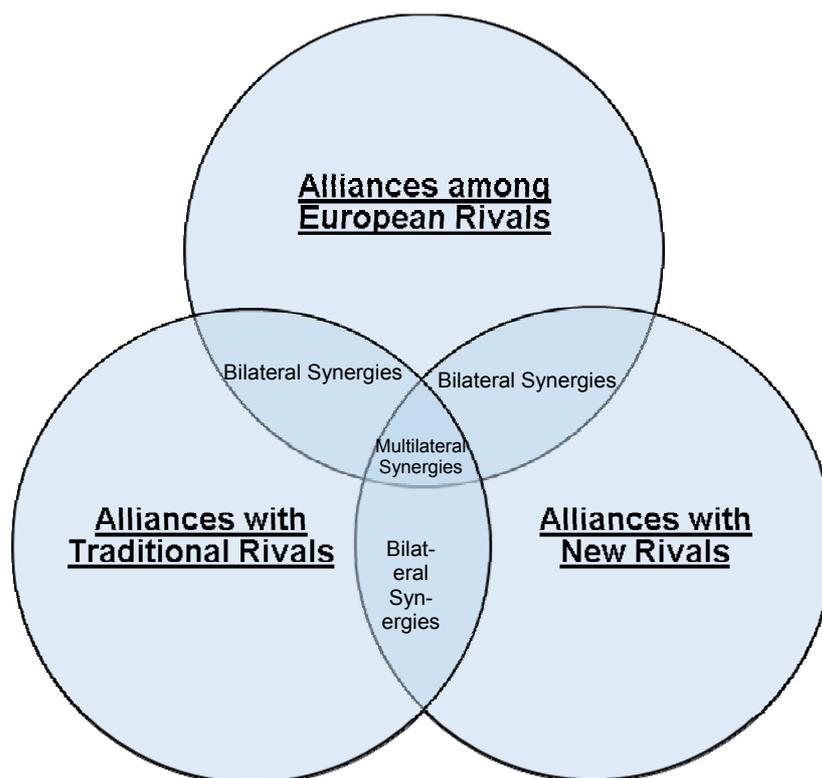


Figure 4.4. Alliance Building Scenarios.

Potential Scenarios

The route to becoming more competitive can be envisioned in a number of scenarios (Figure 4.4). Moreover, the choice of one route would not necessarily preclude a European competitor from forming relationships with competitors in other spheres. A European competitor could build an alliance with another European competitor, while also forming alliances with other traditional rivals or new ones, in various tiers. For instance, one can visualize the benefit of an alliance with China's low cost industry to develop technologies that are ubiquitous enough to not create a dependency, and then use that technology to develop a lower cost satellite meant for the U.S. market through another alliance with U.S. competitors. That ability to be a bridge could enable European competitors to capitalise on an ability that is not available to U.S. rivals. Other configurations could allow European competitors to place a greater focus on maintaining their own technological capability, by offshoring their production only to traditional rivals, whilst introducing lower-technology satellites to go up against new rivals in competing for business in emerging countries. Moreover, these various forms of alliances might enable a European competitor to negotiate lower prices from current suppliers as a result of bulk. Likewise, an alliance with traditional rivals could help to keep satellite prices at levels

where those prime contractors are able to achieve a proper return on their investment.

4.6 Recommendations

Uncertainty is the hallmark of predicting the future evolution of commercial spacecraft manufacturing, and in assessing how to remain competitive in an increasingly globalised society. While the competitive environment can be plotted from a historical context, and its current dynamics captured in the frame of Michael Porter's Five Force model, the picture is likely to change as time progresses. The risks and opportunities envisioned in this report attempt to provide an initial sample of the range of options that could be pursued by European prime contractors in response to changes in the competitive environment; however they are not exhaustive, are often complementary, and do not give a definitive answer to what is in the best interest of Europe's prime contractors, which also depends on the delicate compromise between commercial and government actors. Answers for individual companies must necessarily be found with reference to the specifics of each company and as part of an overall commercial strategy. Answers must thus also consider the specific risk appetite and financial buffers of the company. So even if binary answers are not available, this report has



sought to be helpful by surveying the landscape and describing many of the tools available for European satellite manufacturers. Moreover, this report can hopefully be a useful tool for decision makers to help them be better informed about the benefits and burdens before selecting the best strategies for their companies.

The analysis of this report leads to the identification of the following elements to be considered when formulating responses to the very substantial changes in the competitive environment of European satellite manufacturers:

On Alliance Building

- European prime contractors should decide whether to form alliances with traditional competitors and/or low-cost competitors to benefit from respective economies of scale, technology transfer, the spreading of risk among partners, and shaping the nature of competition in the industry.
- European prime contractors should also consider forming limited alliances with European competitors, which would provide the added benefits of 1) collectively enhancing European bargaining power in bidding for international contracts, 2) enabling specialization and standardized manufacturing processes, and 3) reducing geo-return requirement interference with competition, as participants would be able to gain access to a larger share of European institutional funding.
- Throughout the life cycle of an alliance, prime contractors should monitor when the arrangement becomes competitively disadvantageous, i.e. when the costs in terms of coordination, erosion of competitive position, and creation of an adverse bargaining position disproportionately offset the benefits of the alliance.
- Regardless of the type of alliance, to preempt the creation of an adverse bargaining position, European prime contractors should aim to maintain an entire vertical supply chain within Europe, to ensure that external alliance investments can be reversed.

On Outsourcing/Offshoring Subsystems, Equipment, and Components

- European competitors could seek to place focus on the more critical European capabilities, by outsourcing/offshoring non-essential technologies (e.g. low-end

equipment and components) to low cost Central and Eastern European (CEE) countries (which will help to maintain the European industrial base), or outsourcing/offshoring those technologies to low cost non-European countries (which will provide more immediate factor cost advantages). It should be noted, however, that both outsourcing and offshoring require strong and engaged management to be successful.

- Outsourcing/offshoring production of non-essential technologies will create greater price bargaining power with lower-tiered suppliers, but it will not eliminate Europe's dependence on foreign suppliers and locations, and this could be critical, unless multiple sourcing strategies are pursued.

On the European Non-Dependence Strategy and Competition

- To maintain European technological competitive advantage, and also reduce European prime contractors' vulnerability to U.S. ITAR restrictions, Europe's space industry should continue to indigenously develop key Electrical, Electronic, and Electromechanical (EEE) components under the European Components Initiative (ECI), along with technologies developed through ESA's ARTES programme and the EU's Horizon 2020 space research and development programme.
- As the timeline between investment and return on investment typically extends over 10 years, investors should expect to sacrifice some short-term returns of today for larger payoffs in the future.
- To remain at the forefront of competitiveness, European industry should seek to acquire technology from other leading competitors, and hire highly skilled labour trained outside of Europe to develop new synergies.
- To stimulate the growth of the entire European space sector, more institutional spending is needed to lower costs in the long run through further economies of scale, and bring Europe's industry closer to being on an equal footing with U.S. and low-cost competitors.
- To remain competitive with low cost countries selling in-orbit delivery packages using export credit mechanisms, Europe's industry should seek to adopt a similar approach when marketing satellites to emerging countries.

Annex

A.1 COCOM, Wassenaar, and European Export Control

While the U.S. International Traffic in Arms Regulations (ITAR) are the most notable unilateral export restrictions, export control in the EU is governed by international regimes (e.g. the international Coordinating Committee on Multilateral Export Controls (COCOM), the Wassenaar Arrangement, etc.), EU law, and the national law of EU Member States. COCOM came into existence shortly after the end of WWII (i.e. in 1949), and was one of the main multilateral arrangements governing export controls of sensitive technology (including satellite technology) among Western states. COCOM was succeeded by the more liberal Wassenaar Arrangement³⁰⁸ established in 1996.

Unlike the time of COCOM, under the Wassenaar Arrangement European export control does not require coordination with the United States. In the mid-2000s, EU export control for dual-use items was governed by Regulation 1334/2000 of 22 June 2000³⁰⁹ which was based on Article 133 of the Treaty establishing the European Community (as amended by the Treaty of Amsterdam)³¹⁰ relating to Title IX: Common Commercial Policy.³¹¹ In August 2009, Regulation 1334/2000 was reissued as Council Regulation (EC) No 428/2009, which sets out the scope, authorisations (including brokering), control measures, customs procedures and other measures concerning the control of Dual-Use goods across the EU.³¹²

³⁰⁸ Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies (the Wassenaar Arrangement) of 12 July 1996. Wassenaar.org 12 Mar. 2015 <<http://www.wassenaar.org/guidelines/index.html>>.

³⁰⁹ Later replaced by Council Regulation 428/2009 of 5 May 2009, providing exclusive authority over all dual-use items to the European Union, see Art. 4(2) Reg. 1334/2000, and Art. 4(2) Reg. 428/2009.

³¹⁰ Now Article 207 of the Treaty on the Functioning of the European Union (TFEU).

³¹¹ Bini, Antonella. "Export control of space items: Preserving Europe's advantage." *Space Policy* 23.2 (2007): 70-72.

³¹² Council Regulation 428/2009 of 5 May 2009 on setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items (Recast), 2009 O.J. L 134/1 <[http://eur-](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:134:0001:0269:en:PDF)

lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:134:0001:0269:en:PDF>.

In May 2012, Council Regulation (EC) No 428/2009 was amended by Council Regulation (EU) No 388/2012, which updated the EU Dual-Use List of controlled items.³¹³ Additionally, Council Regulation 1231/2011 of December 2011 amended Annex II of Council Regulation (EC) No 428/2009, expanding the types of Community General Export Authorisation (CGEA) licences that could be used to export certain specified Dual-Use Items to named non-EU destinations.³¹⁴

These legal acts provide for a common EU export control regime, with a common EU control list and harmonised policies for implementation, to remove barriers to the free movement of dual-use goods within the EU, and improve international competitiveness in the global industry. While the export of dual-use technologies under the EU control list still requires a licence from the state from where it is being exported, its authorization is based on a set of guidelines with common criteria for the authorising state to consider, and a common list of destinations where simplified formalities are applicable. Nevertheless, while this approach provides greater flexibility in EU export policy through harmonisation, EU Member States still reserve the right for themselves to make decisions on national security at the national level.

lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:134:0001:0269:en:PDF>.

³¹³ Regulation (EU) No 388/2012 of the European Parliament and of the Council of 19 April 2012 on amending Council Regulation (EC) No 428/2009 setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items, 2012 O.J. L 129/12 <[http://eur-](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:129:0012:0280:EN:PDF)

lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:129:0012:0280:EN:PDF>.

³¹⁴ Regulation (EU) No 1232/2011 of the European Parliament and of the Council of 16 November 2011 on amending Council Regulation (EC) No 428/2009 setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items, 2011 O.J. L 326/26 <[http://eur-](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:326:0026:0044:EN:PDF)



List of Acronyms

Acronym	Explanation
A	
ABS	Asia Broadcast Satellite
AECA	Arms Export Control Act
AIA	Aerospace Industries Association
Airbus D&S	Airbus Defence and Space
AIT	Assembly, Integration and Testing
ARTES	Advanced Research in Telecommunications Systems
ASNARO	Advanced Satellite with New System Architecture for Observation
B	
B64G	Space-related Patents
BIC	Business Incubation Centres
C	
CASC	China Aerospace Science and Technology Corporation
CASIC	China Aerospace Science & Industry Corporation
CAST	China Academy of Space Technology
CCL	Commercial Control List
CEE	Central and Eastern European
CEPA	Japan-India Comprehensive Economic Partnership Agreement
CGEA	Community General Export Authorisation
CGWIC	China Great Wall Industry Corporation
CHIRP	Commercially Hosted Infrared Payload
CNES	Centre National d'Études Spatiales (French Space Agency)
CNSA	China National Space Administration
COCOM	Coordinating Committee on Multilateral Export Controls
D	
DFH	Dong Fang Hong
DFH Satellite Co	DongFangHong Satellite Company Ltd.
DoD	Department of Defense
DOS	Department of Space
DTH	Direct-to-Home

Acronym	Explanation
E	
EADS	European Aeronautic Defence and Space Company NV
EAR	Export Administration Regulations
ECI	European Components Initiative
EDA	European Defence Agency
EEE	Electrical, Electronic, and Electromechanical
EO	Earth Observation
EPO	European Patent Office
ESA	European Space Agency
ESOA	European Satellite Operators' Association
EU	European Union
F	
FAA	Federal Aviation Administration
FAA Compendium	The Annual Compendium of Commercial Space Transportation: 2016
FSS	Fixed Satellite Services
G	
GEO	Geostationary Earth Orbit
GEOCOM	Geostationary Communications Satellites
H	
HTS	High Throughput Satellites
I	
INSAT	Indian National Satellite System
IRS	Indian Remote Sensing
ISRO	Indian Space Research Organisation
ITAR	International Traffic in Arms Regulations
L	
LEO	Low Earth Orbit
LEOP	Launch and Early Orbit Phase
M	
Mbps	Megabits per second
MDA	MacDonald, Dettwiler and Associates Ltd.
MELCO	Mitsubishi Electric Co.
MEO	Medium Earth Orbit



Acronym	Explanation
MSS	Mobile Satellite Service
N	
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organisation
NDAA	National Defense Authorization Act
NEC	Nippon Electric Company
O	
OECD	Organisation for Economic Co-operation and Development
OHB	Orbitale Hochtechnologie Bremen
P	
PCT	Patent Co-operation Treaty
R	
R&D	Research and Development
RoW	Rest of World
RSC	Roscosmos State Corporation
S	
SGDC	Geostationary Defence and Strategic Communications Satellite
SIA	Satellite Industry Association
SpaceX	Space Exploration Technologies
SS/L	Space Systems/Loral
SSTL	Surrey Satellite Technology Ltd.
SWOT	Surface Water and Ocean Topography
SWOT analysis	Strength, Weakness, Opportunity and Threat analysis
T	
TAI	Turkish Aerospace Industries
TBD	To be determined
TFEU	Treaty on the Functioning of the European Union
TTIP	EU-U.S. Transatlantic Trade and Investment Partnership
U	
UAE	United Arab Emirates
UAV	Unmanned Aerial Vehicles
URSC	United Rocket and Space Corporation

Acronym	Explanation
U.S.	United States of America
USML	U.S. Munitions List
USPTO	United States Patent and Trademark Office
W	
WTO	World Trade Organisation
WWII	World War II



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