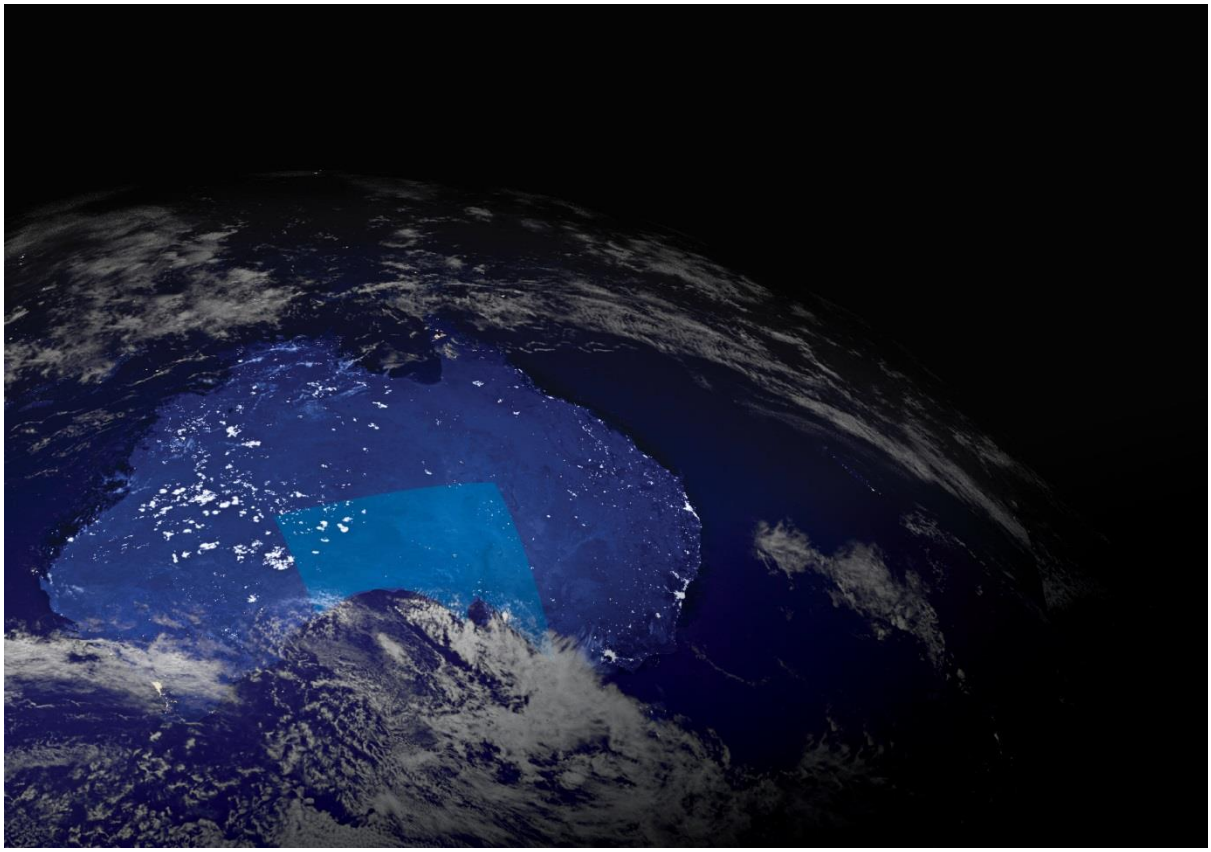
Societal and Economic Benefits of a Dedicated National Space Agency for Australia



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August 2017

'This report has been reviewed by Mr. Michael Davis (Space Industry Association of Australia) and Mr. Alan Smart (ACIL Allen Consulting).'

Acknowledgements

This report constitutes the conclusion of a three-month research activity carried out in Defence SA, and it has widely benefitted from the direct and indirect contribution of many people to whom I am beyond grateful.

Thanks to the whole Defence SA team for the joyful working environment created, for all the assistance provided and for giving me the opportunity to experience the kindness Australians are widely known for.

A special mention goes to Mr. Michael Davis, President of the Space Industry Association of Australia, for sharing his knowledge, for the extraordinary patience demonstrated during the revision of my drafts, and for his kind words of appreciation towards this report.

I would like to thank sincerely Mr. Alan Smart, Senior Associate with ACIL Allen Consulting, for his kind availability, his suggestions and his willingness to share his valuable expertise.

My sincerest gratitude to my supervisor, Mr. Nicola Sasanelli, for the trust he had in me throughout my whole stay and for being a source of invaluable advice and pearls of wisdom. The deepest thanks to him for having been the greatest mentor, close to me as an amazing person, more than incredible supervisor. "Nico', grazie di tutto".

I extend my gratitude to his family for the overwhelming hospitality and in particular to his wife Maria Lucia, whose cuisine is something special, and his daughters Letizia and Francesca, who have been the sincerest friends.

Lastly, my most heartfelt thanks to my parents, Marian and Paolo, and my brothers, Alexander and Thomas.

I will never be able to thank you all enough, for having been – each in its own special way – essential for the feeling I leave Adelaide with: honest gladness for a priceless experience that inspired me, both as a professional and as a person.

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EXECUTIVE SUMMARY

The global space sector is in a state of rapid change. The advent of **small, scalable technologies** have lowered the barriers to entry and have created an environment conducive to the participation of new entrants. The **global space economy was worth US$329 billion in 2016** and is of immense strategic importance throughout the world.

Use of space-derived data and systems is growing and applications of space technologies stretch far and wide. In most advanced economies space is seen as an enabler that improves lives and helps develop both economic and social spheres. Applications of space are embedded in virtually all sectors, and range from the universally recognised navigation, meteorological forecasting, and broadcast of live television and internet connectivity to lesser-known applications such as in precision agriculture, transport tracking, resource extraction and monitoring of utility networks. Additional applications exist in the realm of disaster monitoring and relief, insurance and military applications. Thus, **data coming from satellites is embedded in virtually all economic sectors** – making the world a better and safer place.

In most countries national space agencies are fundamental actors. Generally speaking, their mission is to coordinate national space activity under a unified vision for the nation's space ambitions.

Australia's performance in space activities is widely perceived as not reflecting its capabilities, opportunities and potentialities. Advocates argue for the development of a strong and globally competitive domestic sector that can participate more effectively in the global market. Capturing only a **0.8% share of the global space economy**, and deriving annually around **A$4 billion of revenues**, it is argued that Australia needs to carefully consider its priorities in order to secure the future of the Australian space industry, and safeguard access to global space-derived data and systems, as well as to maintain the capacity to exploit them. With the core aim of achieving long-term **cost-effective access to space capabilities** it is often argued that a **dedicated National space agency would be the most effective means of enabling Australia to exploit and maximize the potentialities open to it.**

International experience would suggest that space agencies deliver value by providing a central point for academia, industry, defence and foreign entities to collaborate among themselves and with government and to facilitate the flow of knowledge and capital. In space-faring countries the National space agency is a body responsible for all strategic decisions for its national civil space program, providing a clear single voice for national space ambitions. It also helps create the best context – domestically and internationally – for exploring and benefitting from space, allowing for central coordination and administration of all space-related activities, budgets, and plans.

The experience of the UK and Canada, analysed in this report, support the proposition that **a dedicated National space agency is an investment in the country's future development, a source of growth and a driver of innovation**. Australia and Canada present *natural geodemographic similarities* with small populations scattered on a vast territory. The *UK is a recent example of a country with a recently established National space agency* (in April 2010), and this occurred within a space economy and industry environment that was not dissimilar to Australia's.

The **UK precedent has been used in this report as a best-practice predictor of the consequences of the successful establishment of a National space agency in Australia**: the UK currently captures a **6.5%** share of the global space economy, and over the 8-years period between 2006-07 and 2014-15 experienced an *improvement* of: i) **£7.8 billion** in space-related **turnover**; ii) **£4.48 billion** of **total value-added**; and iii) **a total of 46,023 additional employment in the sector.** Every £1 spent by the UK Government generates an additional £0.97 in the supply chain and supporting sectors and the employment multiplier is **2.96**, meaning that the activity of 100 employees in the space sector supports the jobs of 196 additional workers among suppliers and in other economic sectors.

If Australia is able to replicate the performance of the UK space economy over the first eight years following the establishment of the UK Space Agency, it is possible to extrapolate that over a similar time frame, there would be an absolute improvement of about **A$5.3 billion** (132% increase on current figures) and an increase in direct employment in the sector of about **11,700 jobs** (102% increase on current figures). These calculations are based on conservative assumptions.

The overall organisation of the UK Space Agency shows the importance of having a *strong cooperative attitude and collaborative approach. It* represents the example of an *efficient, dynamic and well-organised body* capable of *efficiently allocating funding*, and *building a national and international network*.

The **longer experience of the Canadian Space Agency delivers Australia a second-mover-advantage in the space market**, suggesting a **cluster of useful practices and facts to learn from, both in terms of what is best practice and what should be avoided.** Canada currently captures **2%** of the global space economy, and experienced over the 15-year period between 2000 and 2015 an improvement of: i) **C$3.867 billion** of space **turnover** (corresponding to an additional 0.177% of GDP); and ii) **3,977 total space-related jobs** (corresponding to an additional 0.013% of total workforce). The multipliers achieved are **1.85** for the value-added, and **2.5** for employment.

Advocates for a permanent national space program in Australia argue that the **government's involvement in the space sector** should extend beyond providing finance for space-related research and development: it should also be involved in direct coordination of national research; and be at the forefront of formulating policies and laws that promote business innovation, space product and service development and sustainability. It should also be the institutional representative of the nation in government to government space cooperation, facilitating collaboration at an international level with other countries' institutions and programs.

Australia has developed over time a highly skilled and well-qualified workforce capable of growing the country's space sector. There are many potential players with capabilities developed in other industries. **The establishment of a properly funded space agency would help Australia tap further into the multi-billion-dollar international industry and maximize the socio-economic benefits outlined in this report.**

INTRODUCTION

The next industrial revolution is going to start in space.

The global space sector is rapidly evolving. Space activity is of immense strategic importance around the world and the global space economy is a multi-billion-dollar business. The world is currently witnessing the rise of a *new space era* defined by small, scalable technologies and agile mindsets, where new approaches to space have created an environment conducive to the participation of new entrants, especially from the private sector.

In parallel to our growing use of space-derived data and systems is our growing dependence on them[1]. We rely on data coming from satellites to make our world a better and safer place and to provide services that we all benefit from, including in telecommunications, health, transport, banking, security, and climate change monitoring. The list is long - the positive contribution to our quality of life is real.

In most advanced economies space is seen as of growing importance in everyday life. This has led most countries to realise the importance of having – at a national level – a coordinated space activity and a well-organised industry-government partnership.

In a sector that is undergoing increased global competition, Australia is at a crossroads. It is widely believed that Australia's performance is not reflecting its potentialities, capabilities, and opportunities. Access to space-derived data and systems, as well as capacity to exploit them, is an increasing requirement of both government and private sector. *The identification of appropriate niche areas to focus the Australian space industry will deliver the most benefit to Australia*[2]. It is argued that a dedicated National space agency could help Australia exploit and maximize the potentialities open to it.

The aim of this report is to analyse the *social and economic benefits of establishing a National space agency in Australia*. In pursuit of this objective, the *UK and Canadian experience* is analysed. The current performance of the space sector in Australia is comparable to the UK *before* the UK Space Agency was established. The longer experience of the Canadian Space Agency suggests a cluster of useful practices and facts to learn and take advantage from, both in terms of what is best practice and what errors should be avoided.

The analysis has been carried out partly through an in-depth study of the historical evolution and actual structure of the global space economy, with particular focus on the specifics of the countries of interest. The investigations made in this report present some interesting *food for thought* for Australian space policy planning.

[1] Australian Government, (2017). *Review of Australia's Space Industry Capability. Issues paper – August 2017*.
[2] Australian Government, (2017). *Review of Australia's Space Industry Capability. Issues paper – August 2017*.

Chapter 1 identifies the unique characteristics of the space ecosystem and the dynamic, fast-changing environment that is shaping the global space economy into a 'New Era'. This worldwide revolution is driving technological innovation, and converging the efforts of business, government, academia and research centers to deliver economic and social benefits through the creation of new space-derived products and services. The delivery of economic effects for virtually any sector of the society need to be estimated in order to understand the 'value' of the space activity within an economics-based setting. This template constitutes the background for the analysis carried out in the following chapters.

Chapter 2 depicts how Australia builds on its position in the space sector, ranging from its structural dependence on space-data, to its national priorities in the space sector, to the close alliances with space-faring countries that are essential for the provision of a sound basis to develop space industry capability. Central to supporting Australia's space capability is the role of the Government in supporting programs and initiatives., The chapter briefly outlines the Government's space-related expenditure and its impact in terms of jobs generation. A summary of the salient points of space activity in Australia since 1985 is given, leading to the conclusion that the Australian space sector needs to be renewed and the roles that a National space agency would have is outlined.

Chapter 3 examines the experience of UK, and recounts the successes that have been achieved since the establishment of the UK Space Agency in 2010. The socio-economic benefits that the UK space sector has been able to generate are then analysed. In the final section of this chapter the national socio-economic effects of its space sector 'before' the establishment of the UK Space Agency are compared with those realised 'after', in an effort to estimate the consequences of the establishment of the National space agency.

Chapter 4 focuses on the evolution, capabilities and size of the space sector in Canada, and on the activities of the Canadian Space Agency. Established in 1989, the Canadian Space Agency offers the opportunity to evaluate its longer-term impact. This is performed at different points in time in order to provide a more complete analysis, and a comparison is made between the UK and Canadian examples in order to suggest reasons for Canadas less impressive performance.

Chapter 5 discusses how the UK and Canadian experience can be related to Australia, in an effort to show that Australia can consider them as good examples to look at and learn from. The chapter aims to present some interesting food for thought as to how Australia can advance in space and boost its economy through the process of establishing a National space agency in an efficient and pragmatic way.

1. OVERVIEW OF SPACE ECONOMY

1.1. Background and context

"Creating a dedicated space agency could help Australia tap further into the multi-billion-dollar industry" one of Europe's most prominent space leaders says.[3]

The global space sector is a high-technology niche with a complex ecosystem, which employed at least 900,000 persons around the world in 2013[4], including public administration (space agencies, space departments in civil and defense-related organizations), the space manufacturing industry (building rockets, satellites, ground systems), direct suppliers to the industry (components), and the wider space services sector (mainly commercial satellite telecommunications). But these estimates do not take into account universities and research institutions, which also play a key role in R&D, as receivers of public contracts and initiators of much of space sector's innovation.

1.1.1. The *changing era*: the world context for space activities is changing

Space systems play an increasing role in the functioning of modern societies, their strategic organization, and their economic development due to the use of satellite technology in navigation, communications, meteorology and Earth observation. Space technologies are also involved in agriculture planning, disaster management, medicine, land monitoring, transportation and urban planning. Its multifarious fields of application make space a powerful engine of economic growth.

Globalization is affecting the space economy at different levels. In the 1980s, only a handful of countries had the capacity to build and launch a satellite. An increasing number of countries and corporate players across a wide range of industrial sectors are now engaged in space-related activities, a trend that is expected to strengthen in the coming years. Supply chains for the development and operation of space systems are also increasingly evolving at the international level, even if the space sector remains heavily influenced and shaped by strategic and security considerations. Many space technologies are dual use, meaning that they are employed for both civilian and military programs; this tends to constrain international trade in space products. Nevertheless, a recent OECD research on global value chains showed evidence for sustaining that product and service supply chains for space systems are internationalising at a rapid pace. While the mode of interaction between space actors may vary (e.g. in-kind co-operation among space agencies, contracting out to foreign suppliers, industrial offset programs), **the trend towards globalization is having an impact right across the space economy** – from R&D and design, to manufacturing and services.

In other words, the world context for space activities is changing: the international space sector is experiencing a profound revolution. Countries with historical leadership in space have been under

[3] Waldhunter L.. 'Australia's space industry entering a new era prompting calls for national agency', *ABC News*, [website], 12 April 2017, http://www.abc.net.au/news/2017-04-12/australia-space-industry-could-benefit-from-national-industry/8439070 (accessed June 2017).

[4] OECD, (2014). *The Space Economy at a Glance 2014*. OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264217294-en.

pressure as a result of a tough financial environment leading to the definition of their priorities. In the meantime, new leaders such as China and India have affirmed their ambitions in space through massive investments in the development of their capabilities, while a flourishing number of countries now invest in space, shaking up the international hierarchy. Changes are not less significant in the **market environment of the space industry** that **faces important evolution along its value chain, from upstream to downstream**. Worldwide space industry players are rethinking their business models and strategies as they experience disruptive innovations, a tougher competitive environment and new drivers impacting the manufacturing, launch and services businesses.

We can in fact talk about a new *space era*, in which more and more innovative applications of space data are developed, dependence on space-data in everyday life rises, and an increasing share of economic growth relies on the space market, both in terms of opportunity benefits and job creation.

Since the early days of the space age, Australia has been an active participant in space activities, and was one of the first countries to have telecommunications by satellite. One of the *practical* and *pragmatic* reasons for this is its geography and its demographics. Australian companies and institutions are active across all three primary areas of space-enabled services, namely *satellite communications* (Satcoms), *Earth observations* (EO), and *positioning, navigation and timing* (PNT)[5].

In recent years **the Australian Government has recognized space-related technologies as critical** in allowing a range of Australian industries to maintain ongoing operations, productivity and growth. Results outlined by Asia Pacific Aerospace Consultants (APAC) in 2010 and 2011 show that the 631 organizations involved in space activities in Australia generated collectively around A$2 billion revenue per annum – encompassing Australian space sector diverse functions incorporating both services and production[6].

1.1.2. Definition of space market & space industry

Before going through a deeper analysis about space activity and its impact on the growth of a nation and its social effects, it is necessary to define the object of analysis: it is fundamental to have a clear and correct idea in mind about *space capability*, *space activity* and the associated concept of *space economy* as well as their application.

When most people think about *space* it is usually the big Government space projects that first come to mind, such as the International Space Station (ISS), the Hubble Space Telescope, the NASA rovers on Mars, the New Horizons flyby of Pluto and the Rosetta Mission landing on a comet. However, this natural and understandable association of *space* with these big government exploration missions actually masks the transformation that has characterized the space industry over the last 50 years. Few people realise that the big space projects and missions supported by the Government are not expressive of the major focus, nor major activity related to space: the commercial activity taking place in the space industry has now overcome them by far. Things started to change around 15 years ago. Since this inflection point took place, the quiet evolution of the commercial space industry has turned

[5] Asian Pacific Aerospace Consultants Pty Ltd, (2015). *A Selective Review of Australian Space Capabilities: Growth Opportunities in Global Supply Chains and Space Enabled Services*.
[6] Department of Industry, Innovation and Science, (2015). *Final evaluation of the Australian Space Research Program.* Ernst & Young, Australia.

into a revolution with significant commercial growth that today is transforming the industry and has significant ramifications for Australia as well.

Thus, it is important to know what is meant by ***space capability*** in order to understand what space activities involve. Clearly, it may invoke different meanings depending on the background and space understanding of the audience. For some it recalls only those objects that physically go into outer space; others might include also those ground systems that communicate with space objects; for others the idea of space is comprehensive of all the services and goods that are part of our everyday life and whose functioning depends on some space-related technology, most commonly satellites. In order to unify the understanding about *space capability* among people, within the space community it is generally accepted that it includes the ability to: i) produce and operate everything from the spacecraft that flies in the space; ii) the launch vehicle and service that takes it to space; iii) the ground equipment that supports and communicates with it; iv) the products and the services that it enables[7]. A line must be drawn between space capability and the mere use of available services. To take a concrete example, the Global Navigation Satellite System (GNSS) provides the case of a service that fully relies on space activity, but whose mere use does not represent a proper space capability. In fact, it only is representative for the capability of using a service deriving from space. Nevertheless, it is generally accepted to consider companies that provide GNSS location services and devices as having space capability.

In order to clarify the **definition of *space capability*** with the objective of being **consistent with the definition used in major international studies**, a broader one will be used including:

- *the designing, building, testing, installation, deployment and operation of hardware, or systems developed*: i) to be located in space; ii) for the purpose of getting into or returning from space; iii) for the purpose of getting data or information to or from space.
- *the designing, building, testing, installation, deployment and use of applications that require the operation of hardware or systems* listed immediately above;
- *governance arrangements* (such as legal, management and advisory structures) *to support space hardware, systems or applications listed* in the two points above;
- *research* into the environment in which space hardware or systems listed in the first point above;
- *space-related activities* (consulting, financial services, education and training)[8].

This broad definition is wider than the strict *space sector* definition proffered by the OECD, interpreting it as inclusive of "all actors involved in the systematic application of engineering and scientific discipline to the exploration and utilization of outer space, an area which extends beyond the earth's atmosphere"[9].

The influence of space expands even beyond direct applications, as companies in non-space sectors benefit directly from space-enabled services, and indirectly via knowledge and technological spillovers. When talking about the companies involved in the space industry, historically the focus was

[7] Asian Pacific Aerospace Consultants Pty Ltd, (2015). *A Selective Review of Australian Space Capabilities: Growth Opportunities in Global Supply Chains and Space Enabled Services*, p 56.
[8] Asian Pacific Aerospace Consultants Pty Ltd, (2015). *A Selective Review of Australian Space Capabilities: Growth Opportunities in Global Supply Chains and Space Enabled Services*, pp 56-57.
[9] OECD, (2012). *OECD Handbook on Measuring the Space Economy*. OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264169166-en

on those that manufacture, launch and operate space assets (e.g. satellites). However, there is a further layer of companies that utilizes the signals and data supplied by these space assets to develop value-added applications. This latter group, even though clearly not part of the space industry, still make significant revenues thanks to the exploitation of its equipment and services, relying mainly on these. It is exactly this expanded group of companies that is recognized as being part of a wider term: the ***space economy***.

"The space economy is much wider than the space sector, and can be defined using different angles. It can be defined by its products (e.g. satellites, launchers…), by its services (e.g. broadcasting, imagery/data delivery), by its programmatic objectives (e.g. military, robotic space exploration, human spaceflight, Earth observation, telecommunications…), by its actors/value chains (from R&D actors to users), and by its impacts (e.g. direct and indirect benefits…). One drawback is that narrow definitions might ignore important aspects, such as the R&D actors (laboratories and universities), the role of the military (as investor in R&D budgets and customer for space services), or ignore scientific and space exploration programmes altogether".

OECD (2012, p.19) [10]

"The Space Economy is the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilising space. Hence, it includes ***all public and private actors involved in developing, providing and using space-related products and services****, ranging from* ***research and development, the manufacture and use of space infrastructure*** *(ground stations, launch vehicles and satellites)* ***to space-enabled applications*** *(navigation equipment, satellite phones, meteorological services, etc.)* ***and the scientific knowledge generated by such activities****. It follows that the Space Economy goes well beyond the space sector itself, since it also comprises the increasingly pervasive and continually changing* ***impacts (both quantitative and qualitative) of space-derived products, services and knowledge on economy and society.****"*

OECD (2012, p.20) [11]

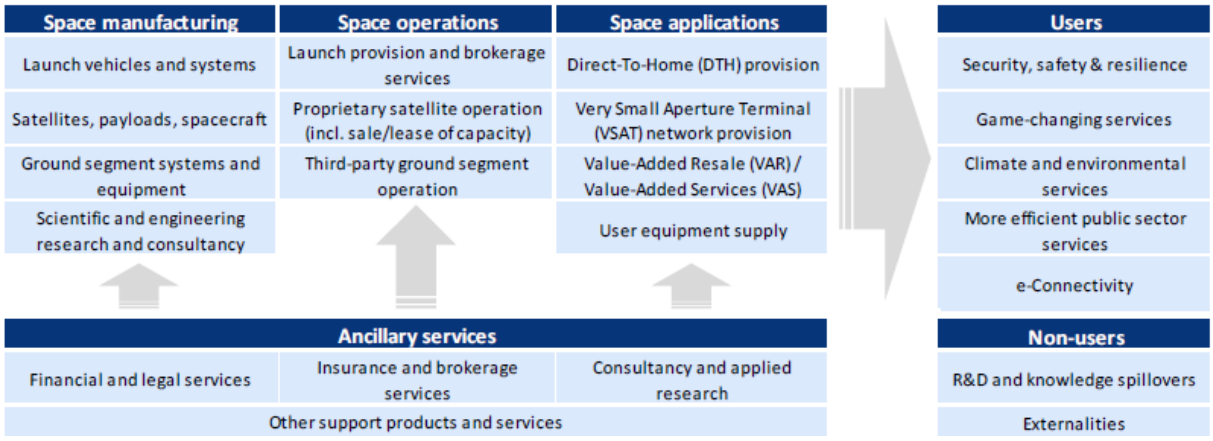

Figure 1. "Space Economy Value Chain". Source: London Economics – The Case for Space 2015.

Thus, more broadly ***space industry*** **can be identified as the companies involved in the space economy and providing goods and services related to space**. Space economy comprises a long value-added

[10,11] OECD, (2012). *OECD Handbook on Measuring the Space Economy*. OECD Publishing, Paris, p 19.

chaining, starting with research and development actors and manufacturers of space hardware and ending with the providers of space-enabled products and services to final users.

1.2. Relevance of space activity: daily lives, social and economic benefits.

Since ancient times humans have always been fascinated by the sky and the unknown. The eagerness to understand what's happening beyond what our eyes can observe has pushed us to get closer to that open space we were staring at. Today, in 2017, our eyes are not that blind anymore and space knowledge and understanding is developing at an impressive, increasing and revolutionary speed.

It is more than fifty years that humans have been exploring space from a closer perspective, more than fifty years of human activity in space that have produced societal benefits that improve the quality of life on Earth. The first satellites, designed to study the space environment and test initial capabilities in Earth orbit, contributed critical knowledge and capabilities for developing satellite telecommunications, global positioning, and advances in weather forecasting. Space exploration has led, year after year, to important socio-economic gains: it indeed initiated the economic development of space that today delivers high returns for invested funds in space. Although being a truly challenging domain, space exploration has led to **new scientific and technological knowledge of intrinsic value to humankind**, and consequently to better understanding of our Universe and the solar system in which we live. Knowledge, coupled with curiosity and eagerness to further discover the Universe, not only has introduced new perspectives on our individual and collective place in the Universe, but it also provides people around the globe with useful products and services as well as solutions.

Thus, there is no denying the fact that space activities have a **beneficial and valuable impact on everyday life and society**, helping people to understand that, despite the high costs of space activities, there is a tremendous return to the community in terms of technological know-how, scientific knowledge, jobs and space-related new companies. The knowledge delivered and the benefits of space technologies have been integrated so deeply in our modern society that life without these would now be quite difficult. One could not imagine daily life without GPS-based products and services or a world without the capacity to predict natural disasters, whose forecasts are also mainly relying on GPS

Medical and scientific development would suffer a huge slowdown as well. Weather, Environmental analyses, Telecommunications and National Security are only the most obvious examples underlying how far we depend on space activity. Education is also a fundamental aspect of the space-related action: the progress of human kind depends on the spread, dissemination and enhancement of space knowledge, representing the driving force and inspiration for further development in the most diverse fields on one hand, and an innovation and competitiveness factor consolidating the industrial capabilities on the other hand. Indeed, although space programmes might appear to be expensive, they have improved society by providing communication and education services in remote areas, bringing information and entertainment to the masses, creating new materials for stronger and more durable structures, providing meteorological data so ships can be safer on sea, monitoring the threat of pollution, enhancing medical instruments for better health-care, enabling hikers and skiers to be located when lost, and many more. Moreover, space-related technical discoveries have found many

relevant applications in the society: the camera in space developed to take pictures of far-distant galaxies is now used as a medical instrument to detect lymph-node cancer; the instruments on an orbiting spacecraft designed to discover more about planets can be packaged into a portable device for identifying the minerals in rocks on Earth; Sun's rays can be harnessed to provide cheap and abundant solar energy to warm and light houses.

The emphasised positive social aspects of space activity are just the most evident factors that have pushed both governments and the community to take care about it, realising its enormous potentials and its degree of integration in daily lives. No negative impact on space activities has been registered so far by the society and an endless list of positive aspects has been listed; this is a strong enough justification for looking at the space-related expenditure made by nations as investments, rather than waste of money.

Up to now, the focus has been on highlighting the *social* benefits of space activity. Nevertheless, there is a parallel listing that can be made for the more concrete, tangible and measurable *economic* effects of space exploration and exploitation, benefits that are often the first ones to be considered when supplying impact analysis and decisions around investments and funds distribution. During recent years, an increasing number of nations and organizations have paid attention to the contribution of the space sector to the national economy. The contribution and the impact may vary significantly across countries, but an overall OECD estimate calculates 'that the revenues generated by institutional investments have led over the last decade to a multiplier effect of between 4.5 and 6.2 when considering the value chain and indirect effect only, and between 8.5 and 9.7 including the societal effects, contributing considerably on growth, employment and competitiveness in many sectors of the economy'[12]. Moreover, it can be argued that the national multiplier effect representing the minimum estimate of the volume of direct and indirect effects to private sector would exceed 1 in the countries acceding ESA, making space investments desirable considering accompanying societal effects. Increased industrial activity, cost efficiencies and productivity gains are some of the economic returns on space investments, with several space applications reaching technical maturity and becoming the source of new commercial downstream activities. Research conducted by OECD and a technical report from ACIL Allen consulting company show that the economic impacts that have been analysed so far for the space sector can be categorized in several forms[13]:

- **Cost savings** in doing the same things more efficiently
- Delivery of **new products or services** producing greater value in the use of the resources required to deliver them (including indirect industrial effects from space industry contrasts, meaning new exports or new activities in diverse economic sectors)
- **Dynamic savings** within and across sectors of the economy, creating new value not previously possible i.e. productivity and efficiency gains in diverse economic sectors
- **Lower costs for governments and regulators** in managing environmental, health, and social services
- **Better environmental, health, and social outcomes** with the resources available

[12] Võõras et all., (2013). *Ex ante Assessment of Economic and Societal Effects induced by Space Investments in a Small Emerging Space Country*, p 1. http://www.spaceindustry.com.au/project/documents/IAC-13,E3,3,5,x16998.pdf
[13] Cohendet P., *Evaluating the Industrial Indirect effects of Technology Programmes: the Case of the European Space Agency (ESA) Programmes. B.E.T.A*, chapter 11. Université Louis Pasteur, Strasbourg, France; Smart A. and Bernknopf, (2014). *Evaluation Methods and Techniques- Position Paper, Workshop on valuing the Societal Benefit of Geospatial Information.* GeoValue, Paris.

- **Economic growth** regionally and nationally.

1.2.1. Measuring the relevance of the space activity: value, size, and economic contribution

Words like 'value', 'direct and indirect impacts', 'multiplier', 'economic and social effects' have already been mentioned several times in the report, and will be fundamental concepts over the whole analysis. Hence, an economic understanding of those concepts will be a key for appreciating the content and the results. The following paragraphs serve to shape their meaning and provide the appropriate, needed background of knowledge.

Measuring the ***economic and social impact***: Looking at the *approach* for measuring the impact of the space industry, there are many channels through which the latter contributes to the national economy and society, and there are some standard effects that are usually taken into account for those kind of assessments: *direct*, *indirect*, and *induced* impacts. Moreover, even though hardly representable through a number, there is also a series of additional economic catalytic impacts, named *spillover*s.

Building in the space sector, or in sub-segments of it, a national competitive advantage is one of those factors giving strength to the national space economy – so *the understanding of the national space-related strengths and capabilities, and thus of the specific areas holding real growth potentials, is the key for the sector's growth.* 'Upgrading in an economy is the movement toward more sophisticated **sources** of competitive advantage and toward position in higher productivity segments and industries'[14]. One source of progress in an economy is the achievement of '**higher-order competitive advantage** in existing industries and developing the capability to compete successfully in new, high-productivity segments'[15]; this is particularly true for the national space economy, which finds growing paths exactly in those space-sectors in which efforts, skills and capabilities are clustered and stronger. Indeed, the **mutual reinforcement of industries**, and the **capability of low-cost transfer of the space-enabled technologies to other industries and sectors** is one of the most important and characterising aspects that the space industry provides. This means that the impact of the space sector is not limited to the direct effects on the economy – where ***direct impact*** refers to the employment and activity in the national space industry itself, covering upstream (provision of technology) and downstream (exploitation of technology) companies[16]. Indirect and induced impacts are produced by the space sector as well and can be seen as equally important to the direct one. In particular, what is meant with ***indirect impact*** is the employment and activity supported down the supply chain to the national space industry, as a result of national space companies purchasing goods and services from domestic suppliers (e.g. suppliers, manufacturing, business services, etc.). The space-sector's ***induced impact*** is instead coming from the *capability of adapting technology and apply it to the needs of industry*[17]: it refers to the employment and activity supported by those directly or indirectly employed in the national space industry spending their incomes on goods and services in the wider domestic economy (e.g. retail, recreational, real estate, hotels and restaurants, transport, etc.). More precisely, related and supporting industries play a fundamental role in strengthening both the space industry itself and in general the whole national economy and society: the **capability of widening (horizontally) the**

[14] Porter M.E., (1990). *The Competitive Advantage of Nations*, p 543.
[15] Porter M.E., (1990). *The Competitive Advantage of Nations*, p 544.
[16] Oxford Economics, (2009). *The Case for Space: the impact of Space Derived Services and Dat.*, p 8.
[17] Porter M.E., (1990). *The Competitive Advantage of Nations*, chapter 9.

range of successful industries and of spawning entirely new clusters[18], **and of feeding the process of upgrading national space benefits** creates more potential for the spillovers and cross-ferilisation among industries that are so essential to the upgrading process[19].

Spillover impacts result from the benefits that government, consumers, society and other industries derive from the existence of the space industry, and they partly reflect the *wider use of technology and applications developed through the R&D undertaken by the space industry*. Another component of those spillovers is however represented by the fact that the use of space derived services and data facilitates the *development of a variety of products and services that would not be possible without the use of satellite technology*. Those products and services often assist a more efficient use of the economic infrastructure and resources as well, conducing to an enhanced productivity[20]. Indeed, space technologies (especially navigation, satellite communication and Earth observation) and skills enable spillover effects because they can be strongly argued to qualify as General Purpose Technologies (GPTs)[21], and thus as technologies and skills that **allow for wider applications and can be transferred to other sectors**. In other words, space-enabled applications promote externalities[22] such as[23]: i) application across multiple sectors (*spillover effects*); ii) possibility for step changes in more efficient production processes; iii) structural changes in industry and new business processes and organizational learning; iv) new applications, some of which cannot be foreseen at the time of the GPT invention; v) impacts in terms of inducing new methods of working, vi) *social impacts* arising from public acting in new ways because of available new technologies; and vii) GPTs show improvements as they age. Spillover effects may be categorized into two main groups[24]: 1) *end-user*[25] *benefits spillovers*, which is the value, defined in a wide sense (efficient gain, cost avoidance or reduction, new activities, products or services, etc.), that an end-user gains directly from using the product or service, and ideally measured above and beyond the price or cost of use; 2) *R&D and knowledge spillovers*, which is the generation of R&D activities and the resulting technological and scientific innovations in the space industry that generate widespread benefits that go beyond the returns made by the party undertaking the research. These indirect benefits that accrue to parties other than the innovating

[18] Paone M., (2016). *Aerospace Clusters. World's Best Practice and Future Perspectives. An Opportunity for South Australia*. Definition of *cluster*: 'a cluster can be summarised as a plural entity which embeds a global perspective in a local economic activity, carried out through a variety of interactions among a wide range of participants, which establish both vertical (supplier-manufacturer-dealer-customer) and horizontal links, fostered by geographical proximity and by the presence of a common infrastructure that allows knowledge to be shared. Competition through specialization results into a cooperative effort towards innovation that ultimately provides competitive advantage to the local system, thus generating widespread socioeconomic development'.

[19] Porter M.E., (1990). *The Competitive Advantage of Nations*, p 555.

[20] Oxford Economics, (2009). *The Case for Space: the impact of Space Derived Services and Dat.*

[21] Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency*. London Economics, p 63.

[22] Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency*. London Economics, p 69.
Definition of *externalities*: 'externalities are benefits that accrue to non-users services, but derive from users' change of behavior. For example, traffic-redistributing satnavs will reduce congestion for non-users when its users are directed to alternative routes. Another example is that more efficient air traffic control results in shorter flight times and less time spent in holding patterns, which benefits families of air passengers.

[23] Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency*. London Economics, p 63.

[24] Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency.* London Economics, p 67.

[25] Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency*. London Economics, p 70. Definition of *end-user*: 'an end-user is an individual or organisation at the end of the provision value-chain that actually uses the product or service'.

party are referred to as spillovers – which are distinguished in terms of drivers and diffusion channels as knowledge, market and network spillovers[26]. Lastly, as already stressed before the influence of space-enabled applications touches virtually every domain of a nation: communication, emergency services, energy, financial services, food, government, health, transport, and water among others[27].

A conclusive remark is to introduce the concept of ***multiplier effect***, as it will be often referred to in this report. Leaving for simplicity the spillover impact aside, it will be useful to isolate the direct effect rather than looking at the *total* impact on the economy comprehensive of all direct, indirect and induced impacts. Isolating the multiplier effect (indirect plus induced), it is possible to focus on the additional economic impact only. The multiplier is often the major element of focus, as it provides *evidence of how fruitful an investment is through looking at the amount of additional effect allowed and achieved by the investment itself*.

Overall, **advanced demand conditions** often provide the initial seed, the engine that puts in action this chain of economic impacts deriving from the space sector – and early advantages in the industry are fundamental to sustain demand and thus the strengthening itself of a competitive advantage in such sector. National advantage is often a reflection of a particular segment structure of *home demand*, and can strengthen in front of *international needs and demand* i.e. gaps in the global market which give potential opportunities to build a successful industry. The demand for space technologies, skills, capabilities, and services represent a concrete opportunity to play internationally and **gain international competitiveness**.

An understanding of ***value***: The above described impacts and underlying economic mechanisms represent the approach used in the report to capture both causation and consequences of the space industry in the social and economic spheres. What feeds those impacts is *value* i.e. what these measures capture is the *value of the industry*. However, valuing the contribution made by the space industry involves **various valuation techniques, which reflect as many different concepts of value**. While the size and economic impact of the space sector will be measured through space turnover (size), value-added, employment, labour productivity, and tax revenues (economic impact), society and daily life gain from the transfer and use of valuable technologies and applications from space. The underlying conceptualisation of value differs depending on the subject of analysis[28], and so the techniques for its estimate (it is on the basis of those different techniques for space industry evaluation that the *measurement approach* described above – direct, multiplier, and spillover impacts – will be applied).

Estimate of space ***turnover*** (or revenues): Evaluations of revenues are useful **indicators of the *size*** of an industry or sector, thus space related turnover can be used to estimate the size of the space sector. However, it has to be noted that they ignore the cost side of the equation, and thus are not a true indicator of economic value: revenues estimate the size of the transactions being generated by the industry sector but they do not indicate the full economic contribution of the industry.

[26] A more exhaustive explanation about those channels can be found in: Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency.* London Economics, pp 67-69.
[27] Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency*. London Economics, p 65.
[28] Smart A. and Bernknopf, (2014). *Evaluation Methods and Techniques- Position Paper, Workshop on valuing the Societal Benefit of Geospatial Information*. GeoValue, Paris.

Value-added approaches: Value-Added analysis incorporates the cost of inputs and, in turn, provides an **indication of the contribution of an activity to GDP**. Gross value added (GVA) across sectors of the economy makes up the bulk of the gross domestic product (GDP); thus, the report will often refer to GVA contribution as it will indicate the contribution of the specific sector of space. In addition to this, i) ***value-added analysis along a supply chain*** can be undertaken to enrich the analysis of the relative contributions from organisations and industries involved in the supply of and use of space data and technologies, and ii) ***value chain analysis*** can be useful to illustrate the linkages between the spatial data supply chain and related and supporting industries, in order to provide insight into where there are opportunities for adding value and generating further value and competitiveness. Those extend the estimate of the value-added beyond that immediately associated with the space sector alone, providing a more realistic estimate of the wider contribution of space activity to the supply chain (this is exactly the value captured by the indirect, induced and spillover impacts).

Overall, the extra value of space applications and technologies is essentially what is underlying the evaluation of the economic contribution of the space sector through its direct, indirect, induced and spillover effects. Thus, an indication of the space sector's *size* will be given by the space turnover, and an indication of the space sector's *contribution to* the national economy will be captured by the value-added of the space industry, employment, labour productivity and tax productivity – that will be measured through direct, indirect, induced and spillover impacts, based on the appropriate relative concept of value[29].

1.3. The general role of space agencies

"The fact that taking steps in advancing one goal does not always preclude progress against another goal does not mean a hierarchy of preferences is unnecessary." [30]

Given the many and diverse beneficial effects resulting from space technology and knowledge in relation to both social and economic sceneries, however different they may be across various countries, there is no doubt about the importance of having a well-organized national space activity. Governments have for many decades decided to have a direct, concrete and significant involvement in its coordination. In many cases this originated from an understanding that the private sector may not perform well due to the high costs, the long payback times and the high risks involved.

The ways in which support to space activity can be offered by the Government are multiple:

i) funds can be delivered in order to finance the research;
ii) setting up of internal researcher's groups allowing for a more direct and controlled coordination of the development of the tasks;
iii) introducing policies that provide the right conditions for entrepreneurs and businesses to innovate and capitalize on their space-related activities;
iv) establishing accommodating laws that allow space development and sustainability;

[29] See *Annex 1* for additional clarification on terminology and conceptual approaches used throughout the report.
[30] Sterner E.R., Pace S., Adkins W., Miller C. and Vedda J., (2013). *America's Space Futures: Defining Goals for Space Exploration*, 1 edition, Marshall Institute.

v) collaborating on an international setting with other countries' institutions and projects, building a strong and efficient industry-government relationship and cooperation relatively to the space economy;
vi) issuing contracts able to monitor development.

The way to achieve the above mentioned support has been recognized by most of the countries involved in space economy as through the creation of a *National space agency*, an organization set up to coordinate the national space programs. Thus, the government plays the role of a central administrative agency. This is indeed true for South Africa, the US, Japan, China, Canada, the UK, most of the other OECD countries, and many others.

Definition of Space Agency: There is no universal, official and established definition of 'space agency'. However, *understanding* space agencies is not a matter of definition, but of function.

A National space agency is a **body responsible for all strategic decisions on the national civil space programme, providing a clear single voice for national space ambitions**. It focuses on creating the best context for exploring and benefitting from space, allowing for a central coordination and administration of all the space related activities, budgets and scopes. Being responsible for ensuring the *development of strategic capability* in space-based systems, science, technologies and applications, a space agency aims to provide benefit to all citizens and to the national economy. It is the fundamental body that represents *guidance* for all space activities, partners and stakeholders, providing *leadership*, *technical expertise* able to foster the innovation that will serve future businesses, and *stabilizing space funding*. Thus, space agencies deliver value by providing a central point for academia, industry, defence and foreign entities to collaborate among themselves and with government and to facilitate the flow of knowledge and capital.

A Space Agency builds an *efficient network of collaboration both domestically and internationally,* creating a context of *well-organized industry-government partnership* and focusing on establishing the *ideal regulatory background* needed to accommodate space-related industry's needs as well as on encouraging the broad *space based research system*. Therefore, establishing a National space agency means being able to increase autonomy in space based fields and giving confidence to the economic actors involved in space activities, attracting more players and start-ups, and bringing the space-world closer to the national citizens and young potential field-related students and workers.

Together with a national space strategy, which is absolutely essential to the well-functioning of the above described space-machinery, a Space Agency sets main goals and intermediate objectives according to its national opportunities and major concerns. Those targets are always focused on: i) addressing the national priorities, creating jobs and driving industry growth; ii) developing policies, laws and international relations that are optimal for national space-stakeholders' rise and growth; iii) developing nationally STEM skills and space expertise, inspiring young people and including space-related topics in their educational path and university programs[31]. What lies always on the back of any statement, action and goal, is the care that this growth and space infrastructure is used effectively by all: the public, industry, academia and Government. Finally, the expertise of the body is ensured and proved by its composition itself, being a **concertation** between a number of ministers: Defence, Foreign Affairs, Economic Development, University and Research.

[31] Space Industry Association of Australia, (2017). *SIAA White Paper: Advancing Australia in Space*.

The **added-value of a National space agency for a country** is substantial and can be summarised in a better coordination amongst space stakeholders that allows to deliver important benefits for the development of the society and the growth of the economy. This means the added-value is:

- **Network of collaboration and coordination**: space stakeholders have the opportunity to be involved in a complex and expensive programme and research activities that gather the expertise of universities and research organizations, allowing for the establishment of agreements and joint programs with trans-national organisations and thus promoting international cooperation. Providing a clear leadership, guidance and a unified vision of the national space ambitions, it allows the establishment of a systematic collaborative approach between research organisations, academia and industry that facilitates an effective technological transfer and education (future skills to match the industry demand), as well as the strengthening of that technical expertise able to foster the innovation that will serve future businesses.
- **Optimal regulatory context**: together with a valuable stabilised funds-allocation, laws and regulations are provided with the attempt to facilitate the industry-government communication, converging the different interests to a single voice. This allows for the establishment of the ideal regulatory background both to accommodate space-related industry's needs (by elaborating and implementing the appropriate industrial policy) and to encourage the whole national research system and its development of a close relationship with the users of the knowledge achieved.
- **Beneficial effects on society and economy:** promoting industry and encouraging technical education, the development of satellite-based services and applicable technological innovation delivers significant improvement in the quality of everyday life as well as in the organisation and management of critical national situations. Self-owned satellite data allows for cheaper GPS installation (embedded in countless technological devices), connection and communication independently from distance, and environmental disasters prediction and prevention becomes effectively reliable, with a significant saving of lives and costs for recovery.

A distinction can be made between **National Space Agencies**, organizations covering only a specific national space market and priorities, and **Multinational Space Agencies,** which instead are bodies that gather together the space-related interests of a number of Member States. The European Space Agency (ESA) is the most straightforward example of the latter, while the Agenzia Spaziale Italiana (ASI), the Centre National d'études Spatiales (CNES), the UK Space Agency (UKSA), the Canadian Space Agency (CSA) and the Deutschen Zentrums für Luft- und Raumfahrt (DLR) are examples for national bodies. The activity of some of the most relevant ones is reported below in order to show how each body is different but sill similar in the way it sticks to the main characteristics defining a Space Agency.

European Space Agency (ESA): The European Space Agency (ESA) is an international organisation with 22 Member States, Europe's gateway to space. *Its mission is to provide and promote space, research and technology, and space applications for exclusively peaceful purposes. Its mission also involves to shape the development of Europe's space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world*. By coordinating the financial and intellectual resources of its members, it can undertake programmes and activities far beyond the scope of any single European country. ESA's programmes are designed to find out more about Earth, its immediate space environment, our Solar System and the Universe, as well as to develop satellite-based

technologies and services, and to promote European industries[32]. The way ESA realizes its purpose is: i) by elaborating and implementing a long-term European space policy, by recommending space objectives to the Member States, and by concerting the policies of the Member States with respect to other national and international organisations and institutions; ii) by elaborating and implementing activities and programmes in the space field; iii) by coordinating the European space programme and national programmes, and by integrating the latter progressively and as completely as possible into the European space programme, in particular as regards the development of applications satellites; iv) by elaborating and implementing the industrial policy appropriate to its programme and by recommending a coherent industrial policy to the Member States[33].

Agenzia Spaziale Italiana (ASI): *being founded in 1988, the Italian Space Agency's purpose was to coordinate all of Italy's efforts and investments in the space sector that had begun in the 1960's.* As one of the most significant players in space science, satellite technologies, and the development of mobile systems for exploring the universe, ASI has a key role at the European level, where Italy is the third contributor country to the ESA. It also is involved at the international level, as its close working relationship with NASA shows, leading ASI to its participation in many of the most interesting scientific missions of recent years. Thanks to ASI's efforts, the Italian scientific community has had unprecedented successes in recent years in astrophysics and cosmology, contributing, among other things, to reconstructing the first moments of life in the universe and making essential steps towards understanding the gamma ray bursts phenomenon. Furthermore, ASI has contributed significantly to space exploration by building scientific instruments used by NASA and ESA.

In addition to providing the means to study the universe, through to the work of ASI: i) Earth observation allows Italy to predict and prevent environmental disasters, to ensure quick intervention in crisis-stricken areas and to measure the effects of climate change (COSMO-SkyMed, the jewel in the crown of ASI programmes); ii) Italy pursues a tradition in the field of research in spatial propulsion (leadership in the European VEGA programme); iii) continuous expansion of the telecommunications and satellite navigation market is allowed; iv) with its experience in building and placing satellites into orbit, ASI operates in such a way that Italy will be ready to seize new opportunities[34].

UK Space Agency (UKSA): *being responsible for all strategic decisions on the UK civil space programme and providing a clear, single voice for UK space ambitions*[35], UKSA is at the center of space research in the UK. It collaborates with research councils, industry, academia and government bodies to successfully establish and exploit a wealth of research in the space sector. It acts as the UK's representative for international collaborations by managing the UK's relationship with space agencies and trans-national organisations across the world. The organisation also ensures that new technology and knowledge is successfully transferred to other sectors and into industry, advancing the development of areas crucial to today's society, from communications to environmental management[36]. UKSA works to: i) co-ordinate UK civil space activity; ii) encourage academic research; iii) support the UK space industry; iv) raise the profile of UK space activities at home and abroad; v) increase understanding of space science and its practical benefits; vi) inspire our next generation of

[32] http://m.esa.int/About_Us/Welcome_to_ESA
[33] http://m.esa.int/About_Us/Welcome_to_ESA/ESA_s_Purpose
[34] http://www.asi.it/en
[35] https://www.gov.uk/government/organisations/uk-space-agency
[36] http://www.stfc.ac.uk/innovation/useful-links/uk-space-agency/

UK scientists and engineers; vii) licence the launch and operation of UK spacecraft; viii) promote co-operation and participation in the European Space programme.[37]

Canadian Space Agency (CSA): *the mandate of the Canadian Space Agency is to promote the peaceful use and development of space, to advance the knowledge of space through science and to ensure that space science and technology provide social and economic benefits for Canadians*[38]. The Agency is responsible for numerous science and technology programs, including development of satellites, space robotic technology, the Canadian Astronaut Program and space sciences[39]. To achieve its main objective, the CSA co-operates with other nations' programs, and promotes an environment where all levels of the organization: i) pursue excellence collectively; ii) advocate a client-oriented attitude; iii) support employee-oriented practices and open communications; iv) commit itself to both empowerment and accountability; v) pledge to cooperate and work with partners to our mutual benefit.

1.4. Global Space Economy: growth and dimension

"Between 1998 and 2015, space-sector growth was about three times the annual growth rate of the world's GDP". [40]

Looking at the whole global space economy, there has been a **significant growth across the years**, especially in the last decade. It seems to be going through a period of reinvention – as evidenced by a variety of changes in the way it conducts operations: there is more efficient launch vehicles being designed and developed, which may help to bring launch costs down. The space industry is seeing rapid growth, as an increasing number of small satellites for Earth observation and telecommunication is being ordered and built as well as large satellites are taking advantage of more efficient propulsion systems that may help increase their usable lifespan. These are but a few examples of how the industry is making space more affordable and consequently more accessible to a broad swath of public agencies, industries, and individuals: space economy is growing and it is **expected to double its dimension within a decade.**

The global space economy in 2009 reached US$261.6 billion in government budgets and commercial revenue, and US$276.52 billion in 2010 that saw the largest contribution in direct-to-home television that relies on satellites to deliver a broad range of customized programming to costumers, and devices and chipsets that use the GPS satellites for navigation and logistics. Growing to US$289.77 billion in 2011, the global space economy reflected a surprisingly robust single-year expansion of 12.2 percent and five-year growth of 41 percent in a global economy that has been suppressed in many other

[37] https://www.gov.uk/government/organisations/uk-space-agency/about
[38] https://www.canada.ca/en/space-agency.html
[39] http://www.thecanadianencyclopedia.ca/en/article/canadian-space-agency/
[40] Defence SA, Space Industry and R&D collaborations, (2016). *Space Innovation and Growth Strategy (South Australia). Action Plan 2016-2020*.

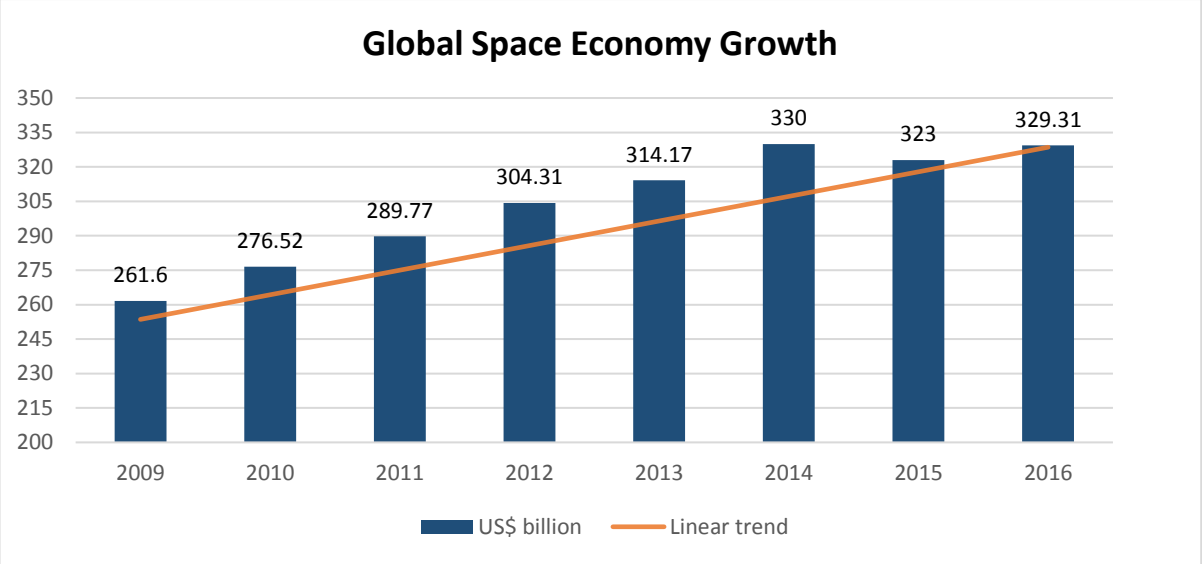

Figure 2. "Global Space Economy Growth". Source: The Space Report, [document of the years from 2010 to 2017].

sectors. Growth has been nearly 7% in 2012, reaching a new record of US$304.31 billion. As in previous years, the vast majority of this growth was in the commercial sector, establishing nearly three-quarters of the space economy, with government spending making up the rest. *The Space Economy at a Glance 2014*[41] estimates a conservative global space economy worth US$256.2 billion in 2013. However, that report excludes ancillary services and some value-added services such as fleet management or Earth Observation services. In 2013, a report commissioned by Google estimated that these 'geo-services' generated between US$150 and US$270 billion in global revenue in 2013 alone. *The Space Report 2014*[42] indeed values global space activity in 2013 at US$314.17 billion. In 2014, the global space economy accounted for US$330 billion, where the biggest growth occurred in the commercial infrastructure and support industries sector, which constitutes more than a third of the overall global space revenues. The last update for the value of interest is from 2016, where the global space economy grew to a total of US$329.31 billion worldwide[43], up from US$323 billion in 2015[44]. This includes[45]:

- 38 per cent commercial infrastructure and support industries (US$126,26 billion)
- 38 per cent commercial space products and services (US$126.62 billion)
- 14 per cent US government space budget (US$44.44 billion)
- 10 per cent non-US government space budgets (US$31.98 billion).

The massive transformation that has been taking place in the space sector has already been mentioned. Typically, the process of opening new domains to industrial development goes through three distinct phases: i) the Exploration Phase; ii) the Experimentation Phase; iii) the Exploitation phase. While the Exploration Phase clearly involves discovering the unknown, often with the use of

[41] OECD, (2014). *The Space Economy at a Glance 2014*. OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264217294-en.
[42] Space Foundation, (2014). *The Space Report 2014, The Authoritative Guide to Global Space Activity.*
[43] Space Foundation, (2016). *The Space Report 2016, The Authoritative Guide to Global Space Activity*; The Tauri Group 2015, (2015). *State of The Satellite Industry Repor*t. Satellite Industry Association (SIA).
[44] Space Foundation, (2017). *The Space Report 2017, The Authoritative Guide to Global Space Activity*; The Tauri Group 2015, (2015). *State of The Satellite Industry Repor*t. Satellite Industry Association (SIA).
[45] Space Foundation, (2017). *The Space Report 2017, The Authoritative Guide to Global Space Activity*.

unproven technology and therefore incorporating high costs and risks, the Experimentation Phase builds on the success of the above mentioned one, usually driven by the aim of understanding the new domain and learning to operate in the new environment. The activities of both phases are generally led by the Governments, even though the Experimentation Phase involves a major shift in the business paradigm for the new domain. At this point, when the technology has been understood in depth, it is time for the industry to start investing.

Since the "new era" has started, the global space economy and its total worldwide revenue have been growing immensely. Parallel to this global space economy growth, the governments' spending in the space sector has followed the same path, both globally and singularly in most of the countries. Total global government space budgets in 2016 was US$76.43 billion, of which more than half was in the United States (US$44.44 billion)[46]. In order to get a more accurate and global picture of the space spending sustained by the governments, the total space spending of the most relevant countries will be unpacked in its most relevant components, in terms of contributors and categories of spending[47].

United States. The United States had a budget of **US$44.44 billion** on space activities in 2016, representing a spending of **0.239% of GDP**. The *Department of Defence (DoD)* and *NASA* are the two major space agencies in the US, making up 92.9% of the total US government space spending. In addition to these, at least seven other agencies receive funding to conduct space activities. The DoD represents the major national security space budget, accounting for US$22.00 billion (49.5%); NASA received US$19.285 billion. *Major activities and programs*: in the US space activities are clearly divided among Civil Space Activities and National Security Space Activities. The *Civil* Space Budget was US$22.4 billion in 2015, up 6.7% from 2015, with NASA as largest contributor (US$19.29 billion), and NOAA as the second largest contributor (US$2.35 billion). The largest civil space categories of spending have been: Science (US$5.5841 million), with major support for Earth Science and Planetary Science; Space Operations (US$5.0323 million); Exploration, both in System Development and in R&D (US$3.9962 million); Safety, Security, and Mission Services (US$2,7724 million). The *National Security* Space Budget was of US$23.57 billion in 2015, up 1.8% from 2014, with the largest programs conducted by the military services, the National Reconnaissance Office (NRO), and the National Geospatial-Intelligence Agency (NGA). The major national security programs are: the Evolved Expendable Launch Vehicle (EELV) program (US$1.65 billion); Global Positioning System (GPS) program (US$837.7 million); the three largest military communications satellite programs (US$1.02 billion all together); the new radar system developed through Space Fence program (US$191.7 million).

Canada. Canada had a budget of C$406.4 million (**US$312.8 million**) on space activities in 2016, a decrease of 1.6% from 2015, representing a spending of **0.021% of GDP**. The space agency responsible for Canadian space activities directory is the *Canadian Space Agency (CSA). Major activities and programs*: in Canada the space activity is for Civil purposes. The main categories of space spending in 2016 have been: Space Data, Information and Services sector (C$209.2 million), which has seen the development of the RADARSAT Constellation Mission (RCM); Space Exploration (C$96.4 million); Future Canadian Space Capacity (C$61.8 million); Internal Services (C$45.4 million). The increased funding will also support Canadian participation in the Surface and Ocean Topography (SWOT)

[46] Space Foundation, (2017). *The Space Report 2017, The Authoritative Guide to Global Space Activity*.
[47] The following nation-specific figures all come from: Space Foundation, (2016). *The Space Report 2016, The Authoritative Guide to Global Space Activity*; Space Foundation, (2017). *The Space Report 2017, The Authoritative Guide to Global Space Activity*.

mission, in collaboration with NASA and CNES. *Collaboration with ESA*: Canada is a cooperating state in ESA, and contributed C$23.5 million (**US$18.1 million**) to the organization in 2016.

China. The budget of China is not made publicly available. However, given China's capabilities and numerous space projects, it is reasonable to assume that the nation spends at least as large a proportion of its GDP on space activities as other major spacefaring nations – excluding the United Nations and Russia (**0.039% of GDP** on average). Assuming this, as China's GDP was 74.5 trillion yuan in 2016, it would correspond to a budget of 28.7 billion yuan (**US$4.32 billion**). If China spent at a similar level as the United States and Russia, China's spending would be 269.1 billion yuan (US$40.5 billion). *Major activities and programs*: China is spending its space budget in many activities and programs, even though the precise budgets are not known for its total spending. A number of main activities can be outlined: China is one of the three nations, along with the United States and Russia, capable of launching humans to space and developing its own space station, which sees its first main step the launch of Tiangong 2 space laboratory.

Europe. Europe's government spending on space programs and activities has several sources, and is coordinated by a number of space agencies and organizations responsible for the space activities directory according to whether the budget is for Civil or National Defence programs. *Civil* government spending comes from four sources: activities directed by the *European Union (EU)* and executed by the *European Commission (EC)*, which are mostly implemented by the *European Space Agency (ESA)* acting as the procurement and development agency; activities implemented by ESA and founded by ESA members; activities directed by the *European Organism for the Exploration of Meteorological Satellites (EUMETSAT)*; activities carried out by European countries independent of the EU, EUMETSAT, and ESA. *National Security* government spending comes from the *European Defence Agency (EDA).*

Functioning of ESA: ESA is a multinational organization, operating with a budget of €5.250 billion (**US$5.82 billion**) in 2016, up 18% from 2015, whose largest contributors are EU and EUMETSAT. Besides those, each Member State contributes to ESA's budget every year with two different contribution schemes: a mandatory contribution, based on the national income (24% of total member state's contributions in 2016); optional contributions to various programs as determined by the interests of individual member states (76% of total member state's contributions in 2016). The majority of ESA's budget goes to: Earth Observation (€1,573.09 million); Launchers (€1,189.02 million); Navigation (€830.06 million); Scientific Programme (€507.90 million).

France. France had a budget of €2.120 billion (**US$2.348 billion**) on space activities in 2016, up 5.9% from 2015, representing a spending of **0.095% of GDP**. The space agency responsible for French space activities directory is the *Centre National d'Etudes Spatiales (CNES)*. *Major activities and programs*: in France the space activities are involving both Civil Space Activities and National Security Space Activities. Looking at the *Civil* Space Budget, in 2015 it spent its majority on: technologies to help the French industry to win more contracts, such as low Earth orbit broadband satellites (US$33.5 million) and high-resolution imagery satellites; developing the new generation of Infrared Atmospheric Sounding Interferometers (IASI-NG); developing the Merlin satellite together with Germany. Looking at the *National Security* Space Budget, in 2015 military space spending through CNES was €264.0 million (US$294.4 million), and it was mainly spent on: Earth-Observation satellites, the Pleiades satellites; the Multinational Space-Based Imaging System (MUSIS) observation system. *Collaboration*

with ESA: France is one of the major cooperating states in ESA, and contributed €844.6 million (**US$935.4 million**) to the organization in 2016, which is roughly 40% of France's spending.

Germany. Germany had a budget of €1.43 billion (**US$1.58 billion**) on space activities in 2016, essentially unchanged from 2015, representing a spending of **0.046% of GDP**. The space agency responsible for German space activities directory is the *Deutschen Zentrums für Luft- und Raumfahrt (DLR)*. *Major activities and programs*: in Germany the space activity is for Civil purposes. The main categories of spending in 2015 have been: the contribution of instruments to a variety of space missions (such as the German asteroid lander Mascot, carried by the Japanese Hayabusa-2); the contributions to the International Space Station (ISS), being Germany one of the main suppliers; research programs closer to Earth, such as the provision of eight out of the twelve experiments flown on the first parabolic flight campaign of the new ZERO-G aircraft; the support to the Stratospheric Observatory For Infrared Astronomy (SOFIA) in partnership with NASA. *Collaboration with ESA*: Germany is a cooperating state in ESA, and contributed €872.6 million (**US$966.5 million**) to the organization in 2016.

Italy. Italy has several space agencies responsible for its space activities directory, among which two play the most relevant role: the *Agenzia Spaziale Italiana (ASI)* and the *Ministry of Defence*. ASI is the most important agency: with a budget of €769.0 million (**US$851.8 million**) on space activities in 2016, up 28.9% from 2015, it represented a spending of **0.036% of GDP**. The Ministry of Defence has a minor impact: its budget amounted to €200 million (US$223 million) in 2015. *Major activities and programs*: in Italy the space activity is mainly for Civil purposes. The major categories of spending in 2015 have been: Exploration and Observation of the Universe (€169.6 million); COSMO-SkyMed (€167.157 million); Microgravity research (€122.31 million); launchers and space transportation (€102.74 million). *Collaboration with ESA*: Italy is the third largest cooperating state in ESA, and contributed €512.0 million (**US$567.1 million**) to the organization in 2016 (an increase of 55% from 2015). A significant focus is set on the Vega launch vehicle, which is manufactured in Italy.

United Kingdom. The United Kingdom had a budget of £370.98 million (**US$491.67 million**) on space activities in 2016, up 6% from 2015, representing a spending of **0.019% of GDP**. The space agency responsible for British space activities directory is the *UK Space Agency (UKSA). Major activities and programs*: in the UK the space activity is for Civil purposes. Following the National Space Policy released in December 2015, the main categories of spending and focus areas are: recognition of the strategic importance of space for public services, national security, science and innovation, and the economy; commitment to preserving the safety and security of the space environment; support for the growth of the commercial space sector and academic research; commitment to international cooperation to develop legal frameworks for the responsible use of space. Another relevant program has been the launch of Major Tim Peake astronaut. *Collaboration with ESA*: the UK is a cooperating state in ESA, and contributed £304.72 million (**US$403.85 million**) to the organization in 2016.

India. India had a budget of 75.09 billion rupees (**US$1.11 billion**) on space activities in 2016, up 16% from 2015, representing a spending of **0.049% of GDP**. The space agency responsible for Indian space activities directory is the *Indian Space Research Organization (ISRO). Major activities and programs*: in India the space activity is mainly for Civil purposes. The largest categories of space spending in 2016 have been: Space Technology, which largely supports launch vehicle development (US$775.44 million); the launch of the fourth of the seven satellite constellation necessary to the in-progress building of the Indian Regional Navigation Satellite System (IRNSS); communication and Earth

Observation satellites, producing high-resolution imagery; space and planetary science activities; the launch of its first astronomy satellite, Astrosat. Space applications account for overall US$153.20 million.

Japan. Japan had an overall budget of 332.3 billion yen (**US$3.24 billion**) on space activities in 2016, up 2.4% from 2015, representing a spending of **0.062% of GDP**. The main space agency responsible for Civil space activities is the *Japan Aerospace Exploration Agency (JAXA)* JAXA, which received 1.54 billion yen (US$1.50 billion). In addition to it, there are 11 other agencies giving their contribution, among which the largest space budget is spent by the *Education, Culture, Sports, Science and Technology (MEXT)*, accounting for 179.3 billion yen (US$1.746 billion) and responsible for the funding of the majority of JAXA space activity. *Major activities and programs*: in Japan the space activities have both Civil and Security purposes. The national space priorities and largest categories of spending in 2015 have been: the development of Japan's Quasi-Zenith regional navigation system (US$172 million); support for Intelligence Gathering Satellites (US$571 million); launch activities, such as i) the new flagship H-III launch vehicle (US$102 million), ii) the launch of a small satellite on its Epsilon launch vehicle (US$7.37 million), iii) the launch of the first commercial payload of Japan's H-IIA rocket; the development of an optical satellite capable of broad and high-resolution imagery (US$42 billion); the development of a data relay satellite for intelligence, surveillance, and reconnaissance; the development of an optical imaging satellite with a ballistic missile early-warning sensor; the development of a research program to develop satellites that can be built and deployed rapidly.

Russia. Russia had an expected budget of 104.5 billion rubles (**US$1.6 billion**) on space activities in 2016, representing a spending of **0.122% of GDP**. The space agency responsible for Russian space activities directory is *Roscosmos. Major activities and programs*: the organization of Russian space activities is evolving, and in January 2016 the Federal Space Agency Roscosmos was shut down and replaced with a state-run corporation by the same name. A 10 years' program has been set, in which the main area of space activity will be: communications and broadcasting satellites; completion of the assembly of the Russian segment of the International Space Station; building of the promised new launch-pad for the human-rated version of the Angara rocket in the Russian Far East; development of the new-generation spacecraft to replace the Soyuz capsule; development in its robotic lunar probes[48].

South Korea. South Korea had a budget of 746.4 billion won (**US$646.7 million**) on space activities in 2016, up 20.6% from 2015, representing a spending of **0.046% of GDP**. The space agency responsible for South Korean space activities directory is the *Korean Aerospace Research Institute (KARI). Major activities and programs*: the South Korean government announced plans to develop a major space power, focusing on space areas as: Launch Capability, through the i) development of Korean-made launch vehicle, ii) launch of the Korean Multipurpose Satellite 3A, which carries both optical and infrared sensors; strengthen national safety and public service; industrialize satellite information and applications technology, improving the country's ability to utilise information gathered by satellites as well; explore the moon through their own technology; develop environmentally-friendly and highly-efficient cutting-edge aircraft and core aerospace technology; developing Satellite Based Augmentation System (SBAS), a more accurate and safer position information[49].

[48] http://www.planetary.org/blogs/guest-blogs/2016/0323-russia-space-budget.html
[49] https://www.kari.re.kr/eng/sub01_01.do

Country	Governments' Total Budget		% of GDP	Space Agency (most relevant)	Budget contribution to ESA		Employees in Agency (units)
	local currency	US$			local currency	US$	
United States	US$ 44.44 B	**44.44 B**	0.239 %	National Aeronautics and Space Administration (NASA)	-	-	17,310
				Department of Defence (DoD)			-
Canada	C$ 406.4 M	**312.8 M**	0.021 %	Canadian Space Agency (CSA)	C$ 23.5 M	US$ 18.1 M	616
China*	yuan 28.7 B	**4.317 B**	0.039 %	-	-	-	-
France	€ 2.120 B	**2.348 B**	0.095 %	Centre National d'Etudes Spatiales (CNES)	€ 844.6 M	US$ 935.4 M	2,446
Germany	€ 1.430 B	**1.58 B**	0.046 %	Deutschen Zentrums für Luft- und Raumfahrt (DLR)	€ 872.6 M	US$ 966.5 M	8,000
Italy	€ 769 M	**851.8 M**	0.046 %	Agenzia Spaziale Italiana (ASI)	€ 512 M	US$ 567.1 M	**200
United Kingdom	£ 371 M	**491.67 M**	0.019 %	UK Space Agency	£ 304.72 M	US$ 403.85 M	70
India	rupees 75.091 B	**1.11 B**	0.049 %	Indian Space Research Organization (ISRO)	-	-	16,902
Japan	yen 332.3 B	**3.235 B**	0.062 %	Japan Aerospace Exploration (JAXA)	-	-	1,529
Russia	rubles 104.500 B	**1.6 B**	0.122 %	Roscosmos	-	-	-
South Korea	won 746.4 B	**646.7 B**	0.046 %	Korean Aerospace Research Institute (KARI)	-	-	**910
Europe (ESA)	€ 5.250 B	**4.82 B**	-	European Space Agency (ESA)	-	-	-
Australia	A$ 28.2 M	**21 M**	-	Commonwealth Scientific and Industrial Research Organisation (CSIRO)	-	-	-

Figure 3. Global overview about Government spending on Space. Source: The Space Report 2016-17.

*Figures are updated at 2016; *assuming that the nation spends at least as large a proportion of its GDP on space activities as other major spacefaring nations - excluding the US and Russia (on average); **relative to year 2015.*

2. THE SPACE ECONOMY IN AUSTRALIA

2.1. An overview of current Australian space economy

Australia with its talent, its universities, and its engineers that come out of the country has a real role to play in the space sector. The value of scientific assets, data and expertise we can generate will give Australia a concrete advantage.

While globally the space economy is estimated to be worth US$329.31 billion annually, Australia is well placed to leverage existing strengths and investments in space-related activities, and thus to benefit the national economy driving innovation. Evidence of the vibrant space sector ecosystem in Australia is the presence of an enormous number of organizations with space-related expertise, or the potential to apply their expertise to the space sector. Australia can boast significant achievements in the field of space-data application gains, and has credible growth potentials in space economy in terms of necessary assets, technologies and knowledge developed over the past 70 years of the state's involvement and interest in space. Despite the concentration of space industry and research expertise as well as the awareness of the importance of the space-related activity, the Government and the sector itself believe there is a need for a more organized and coordinated space strategy: a stronger national policy program and leadership would be definitely fundamental to fully leverage this opportunity, paving the path for the development of the critical mass necessary to gain a larger share of this important and rapidly growing industry.

The core duty for Australian space activity is to achieve an **on-going, cost-effective access to the space capabilities and potential areas of growth in which the nation relies on**, and will increasingly in the future. Space technologies and data are critical for a wider range of essential services, and space capabilities already enable Australian telecommunications emergency management, weather forecasting, banking, transport, agriculture, environmental management and national security applications[50]. Space capabilities means satellites in orbit (whether foreign or Australian) as well as the ground system and expertise to access satellite data and transform it into information that is useful for Australian users. While satellites make measurements and take images, send positioning signals and spread communications, ground-based systems not only include satellite dishes for data downlink, computing facilities for storing and interpreting data; they also represent domestic expertise to source, interpret and apply the data to meet Australia's national priorities. **Satellites and ground systems together deliver Australia the space information that is relied on**. As evidence of their importance, Satellite Communications (Satcoms), Earth Observation from Space (EOS) and Position, Navigation and Timing (PNT) have been identified by *Australia's Satellite Utilization Policy (2013)*[51] as the critical space-based technologies for the national economic, societal and strategic well-being, now representing 76% of global space expenditure[52]. It is however important to mention that, despite the acknowledgment of the relevance of those domains, the *Australia's Satellite Utilization*

[50,51] Australian Government, The Department of Industry, Innovation, Science, Research and Tertiary Education, (2013). *Australia's Satellite Utilisation Policy*.

[52] Space Industry Association of Australia, (2017). *SIAA White Paper: Advancing Australia in Space*.

Policy does not commit Australia to human spaceflight, domestic launch capabilities or to the exploration of other planets: those have not been identified as priorities in Australia. Instead, the policy safeguards interests closer to home, by recognizing that space capabilities enhance services Australians depend on, and seeks to protect access to those capabilities.

Even though there is no comprehensive report evidencing the value of the overall space economy in Australia, there are many reports that in recent years have estimated that the downstream **benefit of space-derived data to the Australian economy is particularly significant.** This highlights once again the important opportunity for Australia to play a major role in the development and use of downstream applications, further enhance GDP, and access a larger share of the global space economy. Barriers to entry into the space market have already seen a decisive reduction, but a better coordination, lead and organization of the whole space strategy are a fundamental objective to help Australia tap further into the multi-billion-dollar industry.

2.1.1. Why should Australia be involved in space: space capabilities & benefits

There are numerous reasons why Australia should be involved in the space sector. First of all, Australia has proven space capabilities in many of its segments. Moreover, space activities allow for several valuable contributions: while some have already been mentioned in the report, a more detailed and concrete list follows in order to mature a comprehensive perception of their importance – both in daily lives and in terms of national economic growth. An expansion in Australia's involvement in space would thus enhance the following already-evidenced **space benefits**:

- *Overcome the challenging issue concerning the enduring access to the space-related knowledge and data*. The degree of reliance of Australia on space capabilities is significant, but a permanent access to the knowledge and information needed represents a challenging concern for the future due to the degree of dependence on other countries' space access: if in the past Australia's reliance upon other countries' data and goodwill was enough to grant the sustainability of space activity, this is not the case anymore and a more active and coordinated space engagement is fundamental to secure the nation's most important space capabilities. Indeed, the satellites in which Australia depends on are reaching the end of their life-spans, and there are no new satellites replacing them.
- *Increase the national economic growth*. Australia has improved space capabilities strengthening the coordination of domestic as well as international space-related players; as a consequence, appreciation has been expressed by an increased productivity and competitiveness of Australia's industry as well as a better capability to deal with the challenges that rely on the access of space data. Around A$4 billion of revenues, and 11,500 jobs are indeed annually derived from the space sector[53].
- *Advance efficiency of environment monitoring.* Fully relying on space capabilities, the Australia's environmental stewardship particularly benefits from the access to accurate space data: its responsibilities extended to areas of difficult access, and the information can only be provided cost-effectively by using satellites.
- *Improve Australia's safety and security.* An improved level of protection against threats and capability to manage disasters efficiently is gained thanks to the provision of real-time images,

[53] Asian Pacific Aerospace Consultants Pty Ltd, (2015). *A Selective Review of Australian Space Capabilities: Growth Opportunities in Global Supply Chains and Space Enabled Services*.

positioning and communications from space. As a result, lives are saved during natural disasters, while security, intelligence, law enforcement and border security are allowed to plan and conduct activities that maintain a safe and secure Australia.

- *Provide Australia with significant innovation opportunities*. Space applications allow to: faster, earlier bushfire detection, preventing loss of life and property; centimeter-level positioning accuracy, increasing productivity in many sectors; pinpoint diseased crops and measure water supplies, helping farmers to improve their production; adoption of unmanned vehicle, remote controlled and guided, therefor capable of navigating on their own (already in use in the US).
- *Ensure space capabilities in the future.* Assisting the writing of the 'rules of the road' for space, Australia helps protect the space environment and ensure the ongoing capability of sharing benefits of space. Specifically, norms and policies are needed to limit the proliferation of debris resulting from normal space operations, collision between artificial objects in space or deliberate acts, as half a million of those scattered pieces of rubbish are estimated to be large enough to damage a satellite.

Given the significant **space capabilities** and areas of strength that characterize the country, the above mentioned enhancements related to Australia's involvement in space are concrete and real. From a study conducted by the Asia Pacific Aerospace Consultants in 2015 on a representative sample of 46 Australian space-related industries, Australia is active in all of the broad segments of space capabilities: Space Systems, Launch Systems, Ground Systems, Space Enabled Services, Space Support Services; Space Research and Development, Space Education and Training. However, Australian capabilities tend to be confined to certain niche sub-categories[54].

Space Systems. One third of the companies has capabilities in Space Systems, representing a relatively small number. At one extreme, capabilities in sub-categories such as *System Engineering and Technical Support Services* for space systems, including environmental testing, are strong and owned by many companies. At the other extreme, there are small pockets of capability for supply of space components and subsystems.

Launch Systems. This is the segment in which Australia has the least representation of space capabilities. Although Australia has been a significant user of launch services, it has essentially no orbital or sub-orbital launch capability of its own even though it has some competences in this area, such as technical support services for launch activities.

Ground Systems. As Australia has a long history of building and operating ground stations for NASA, ESA and the satellite communications operators Intelsat and Inmarsat, Ground Systems represent one of the two longstanding strength areas for Australian space capabilities. In particular, these are concentrated in the *Systems Engineering*, *Systems Integration, Installation, Operation* and *Technical Support* areas. One of the growing areas of the Ground Systems segment is the installation and maintenance of GNSS reference stations.

Space Enabled Services. This is the largest sector of space industry, both worldwide and within Australia. Given the critical importance of Space Enabled Services to Australia as the result of its unique demographics and geography, it is not surprising to find that Australian companies have significant capabilities in this segment, with major involvement in three areas: Satellite

[54] Asian Pacific Aerospace Consultants Pty Ltd, (2015). *A Selective Review of Australian Space Capabilities: Growth Opportunities in Global Supply Chains and Space Enabled Services*.

Communications, Earth Observation, and PNT, as well as the technical support capabilities that serve them.

Space Support Services. This is an area where the Australian companies have considerable capabilities, being actually an important aspect of the space industry. The major focus in Australia is on a few sub-categories related to *Consultancy Services,* especially technical consulting in EO, satcoms and ground systems, as well as site inspection survey for dish location.

Space Research and Development. A significant majority of the companies see space R&D capabilities as an integral part of their commercial activities, and a key factor in driving their commercial success and obtaining a competitive edge in this industry. A particular focus is set on R&D in *Space Engineering* and in the *Development of Applications for Space Derived Data*.

Space Education and Training. A significant number of companies have capabilities in Space Education & Training, and use these as integral part of their commercial activities. Particularly strong is the focus on sub-categories such as *Professional Development Courses* and *Commercial Training Courses*.

Having a broad picture of the Australian Space Capabilities lead the country to a vast number of space based benefits, it is important that those competences map onto the **global supply chain** for space activity: this reaches from the owner/operator of a satellite down through to the companies that supply the spacecraft that flies into space, the launch service that launches it, the ground equipment that supports it, and the services that it enables. Ultimately there are the consumers or customers who utilize the space enabled services and applications. Overall, as shown by the APAC study, the Australian space industry has capabilities in most of the categories used in the supply chain for the key satellite domains of Satellite Communications, Earth Observation and PNT.

2.1.2. Australia's dependence on space

Australia's dependence on space-related data, technologies and activities is straightforward. However, Australia's dependence on other countries' space-related data and information is as obvious. Although the relationship between Australia's wellness and space technology is clear, the nation is among the lowest investors in publicly-funded space-related research and development[55] and among the most dependent nations on other countries' space data.

A noteworthy weakness of the Australian EO sector is that million-dollar Australian government programs and executing agencies are completely reliant on the health and continuity of the foreign-owned and operated space assets, which provide the necessary imaging, positioning and data relay services, as well as the vagaries of internal data-policies, and budgetary cycles of operation countries. **The flow of this critical data and its access depends on the bilateral or commercial agreements and on the others' goodwill**. Japan, Europe and the US have traditionally provided Australian Government with satellite data at very little cost[56], allowing the nation to exploit Earth Observation data to generate societal and economic benefits such as weather forecasting, onshore and offshore mining,

[55] Space Industry Association of Australia, (2016). *SIAA Green Paper: The 2016/17 Commonwealth Budget and the Civil Space Sector*. Figures, values and proportions reported below are meant to be indicative, as they refer to the results coming from interviewing 46 Australian space-related companies, not all the existing ones.
[56] Australian Government, Geoscience Australia, Bureau of Meteorology, (2016). *Australian Government Earth Observation Data Requirements to 2025;* Symbios, (2015). *Risks of Data Supply of Earth Observations from Space for Australia*. Report prepared for the cooperative Research Centre for Spatial Information.

mitigation and management of natural disasters, design and assessment of conservation areas, insurance assessment, land use planning and many others (listed already in paragraph 2.1.1.). It is straightforward that the country would face significant disadvantages and slowdowns in the scenery of a sudden lack of access to this critical infrastructure which enables our modern society to function. In fact, while the most common way in literature to look at the importance of this dependence focuses on *what can be achieved* thanks to a well-organised and efficient space activity, a different way of looking at the same issue reveals really how essential the space sector actually is: a **counterfactual for Australia if it had no space contribution** at all. Australians' life is nowadays undeniably dependent on space technologies, applications and knowledge, and any reality not comprehending these is virtually unconceivable. A missing space contribution would for Australia mean no satellites data, thus no broadcasting nor internet connection – resulting in a population that struggles communicating given its scattered distribution over the territory. A lack of satellite information and images would make weather forecast impossible, affect negatively the security and surveillance of the country, and reduce the agriculture production's capacity. In a world without space applications embedded in Australia's activities, even environment monitoring, fast bushfire detection, flood disasters' prevention, and distance healthcare would not be possible. Navigation and GPS would not be part of Australians' lives either – making it even harder for the continent to build relationships overseas with serious consequences for the Australian economy. In other words, **Australia with no space contribution represents a quite dramatic setting,** reinforcing the common believe that **the undergoing relationship of dependence that involves both private and public sector is of considerable risk for the national wellness and it increases national uncertainty**: having no independent autonomy in this regard exposes Australia to latent vulnerability. Hence, a key issue in the development of the national space policy may be the securing of long-term access to foreign owned space-segment capabilities, and preferably reducing the level of dependence.

2.1.3. The size of Australian space sector

The size of the space sector in Australia is today not accurately recorded as it is imperfectly understood. A recent estimate on the Australian space capabilities reports an **annual revenue of A$3-$4 billion**, together with an estimated **workforce of between 9,500 and 11,500** full time equivalents produced by the space sector in Australia[57]. The global space economy was estimated to be around US$323 billion in 2015[58] and the percentage of it captured by Australia was only reaching approximately **0.8%**. This – together with the facts that the share of the world's total economy captured by Australia is 1.8%, and that only 8% of Australia's space revenue is generated from exports – raises concerns about the performance of the Australian space activity.

It is not due to a lack of opportunities, nor a lack of demand that Australia seems to under-perform. In fact, it is not fulfilling its potential in the global space economy and it is vulnerable to sudden geo-political changes threatening national security. There are few countries that are better suited to the exploitation of spatial technologies, being Australia characterized by an exceptionally vast territory and small population. Key explanatory reason for the low performance is also the perception of Australia, both within the country and internationally, as fairly passive in terms of space data

[57] Asian Pacific Aerospace Consultants Pty Ltd, (2015). *A Selective Review of Australian Space Capabilities: Growth Opportunities in Global Supply Chains and Space Enabled Services*, pp 11, 40.
[58] Defence SA, Space Industry and R&D Collaborations, (2016). *Space Innovation and Growth Strategy (South Australia). Action Plan 2016-2020*.

generation, purchasing most satellite information from other countries (as already highlighted in previous paragraphs). This static approach leads the national industry to face a lack of credibility in international competitive fields. Hence, a greater overall Government support and leadership would most probably help to counter this view.

2.1.4. Australia's actual national leading goal in space

"Achieve on-going, cost-effective access to the space capabilities on which we rely"[59]. This is the national goal in space that Australia wishes to achieve. Having first been drawn and outlined in the *Australia's Satellite Utilization Policy*, approved by Federal Cabinet in 2013 it still represents the core guideline for the Australian Government in the related field. Its achievement would contribute in particular to five key benefits for Australia[60]:

1. *Improved Productivity*: space capabilities such as satellite imagery and high accuracy positioning deliver information that brings about greater efficiencies and encourages innovation.
2. *Better Environmental Management*: satellite information enables effective environmental management across Australia's extensive and often inaccessible land and ocean territory.
3. *A Safe and Secure Australia*: space capabilities are important contributors to national security, law enforcement and to the safety of all Australians in disasters.
4. *A Smarter Workforce*: space capabilities help transform existing industries and build new ones that provide quality jobs.
5. *Equity of Access to Information and Services*: satellite communications enable high-speed, universal access to TV broadcasting, internet and telephone services.

As Australia already proved through the achievement of substantial records in space activity related fields, the real challenge for the success of this objective is not of technical order. It is rather a matter of **building a series of complementary and sustainable space activities equipped with strong expertise** that can be both exploited domestically and carried internationally. The achievement of this goal would require a **distinct focus and concentration of efforts and funds specifically in those most beneficial space-related sectors, rather than being spread across many different activities**. A distinct leadership and the setting of relevant values may therefore be wished to guide this achievement, and a sustainable strategy with a strong concentration on the nation's more relevant strengths may need to be set: this would allow the delivery of those critical space capabilities.

Achieving Australia's space goal requires following a **sustainable strategy** that relies on seven nationally recognised principles[61], taking important steps towards developing a coordinated space policy too. However, the general impression that the Australian community is getting is that the mere setting of this principle-based strategy is not sufficient to achieve the widest and most fruitful exploitation of the opportunities Australia has. More precisely, the strategy captures exactly the needs

[59,60] Australian Government, The Department of Industry, Innovation, Science, Research and Tertiary Education, (2013). *Australia's Satellite Utilisation Policy*.

[61] See: Australian Government. *Australia's Satellite Utilization Policy,* Chapter 4. The seven Principles for a National Space Industry Policy are: 1) focus on space applications of national significance; 2) assure access to space capabilities; 3) strengthen and increase international cooperation; 4) contribute to a stable space environment; 5) improve domestic coordination; 6) support innovation, science and skills development; 7) enhance and protect national security and economic wellbeing.

of the Australian space economy, but the actual methods and behaviors followed to achieve it may not be the most efficient and convenient, leading to a waste of time, funds and resources, and widening the gap with the other nations' performance. The SIAA[62] already noted that the policy fails significantly in a number of areas among which: i) there is no clear, ambitious and measurable strategy for growing the industry, with a proportionate increase in economic activity and jobs; ii) national oversight and program management is not provided by any government agency; iii) there is no unified approach to a national strategy for capability development, including promoting STEM studies at school level and education, training and professional development at post-school levels; iv) there is no strategy or follow through to promote the commercialization of technology and knowledge gained from programs such as the Australian Space Research Program (ASRP)[63]. Hence, it is believed by the committee that "the Australian government should have a space policy and, like most other comparable countries, an agency to implement it".[64]

2.2. Australia's actual organization in space activities: role of Government

"The Australian Government places a high priority on achieving on-going and cost-effective access to space applications of national significance that underpin critical national capabilities. The government meets this objective through coordinated actions undertaken by agencies with interests in civil space." [65]

The Government recognizes Australia's reliance on satellite-delivered services, with **over 11 different departments or government agencies currently involved in an inter-departmental committee** that was intended to facilitate coordination of these activities. Thus, the Government's activities in civil space are grouped across **four broad themes of motion**, which are central to ensure that Australia has the space capabilities it requires, now and into the future: policy and regulation, space capability, national interest, international engagement.

There is rich supportive evidence highlighting the importance of strategic government engagement for the realization of crucial benefits and in securing the access to space-based systems and services – given that the efficacy of the space-market is constrained by public good characteristics, the potential for knowledge spillover and the complexity of the space sector itself.

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[62] Space Industry Association of Australia, (2017). *SIAA White Paper: Advancing Australia in Space*. These points are also supported by the findings of an industry wide survey conducted in 2016 that formed the basis of the five priorities identified in the Australian Earth Observation Community Plan – 2026.

[63] The Australian Space Research Program (ASRP) is a competitive merit-based grants program which provides grants to support space-related research, education and innovation activities. The ASRP's primary objective was to develop Australia's niche space capabilities by supporting space-related research, innovation and skills in areas of the 2009-10 Budget with A$40 million allocated across four rounds of founding between 2009 and 2013. Fourteen projects were funded through the ASRP across two streams: i) Space Education Development grants, ii) Space Science and Innovation Project grants.
https://industry.gov.au/industry/IndustrySectors/space/SpaceIndustryDevelopment/Pages/FinalEvaluationAustralianSpaceResearchProgram.aspx

[64] Australian Senate Economics Committee, (2008). *Lost in Space? Setting a new direction for Australia's Space Science and Industry Sector*.

[65] Australian Government, Department of Industry, Innovation and Science, (2016). *2016 State of Space Report. A Report by the Australian Government Space Coordination Committee.* space.gov.au

2.2.1. Australian Government responsibilities and activities in civil space

To support the nation's priorities, the Australian Government invests in a wide range of activities administered by a number of agencies. Those governmental responsibilities can be listed in: *Coordination*, *Earth Observation from space*, *Positioning*, *Satellite Communications*, *Space Science*, *Space Weather*, *Radiofrequency Spectrum*, *International Engagement.* In particular, the four broad themes of activity, which are key to ensuring that Australia has the Space Capabilities it requires, now and in the future, are[66]:

1. ***Policy and Regulation***: coordinated activities undertaken by government agencies to facilitate innovation in the space sector while ensuring Australia's space-related activities do not jeopardise national interests and Australia's international obligations in space. Specifically, the government sets space-specific policy frameworks and administers regulations that aim to create the ideal conditions for researchers, entrepreneurs and businesses to develop capabilities, innovate, and capitalize on their space-related activities.
2. ***Space Capability***: support for the provision of the physical infrastructure, research and development activity, and human capital required to leverage opportunities and benefits derived from space systems. Strengthening key space-related capabilities, the government aims to enhance its international partnership to secure the access to space systems and the information they provide, and to assist in areas such as research collaborations, skill and knowledge transfer and development, sharing resources and information, influencing capability development and encouraging the peaceful use of space.
3. ***National Interest***: addressing space-related issues that ensure Australia's national security, economic, and social objectives are appropriately achieved. In particular, the Government protects national interests by implementing a range of domestic and international arrangements, and undertaking activities that develop government-business partnership.[67]
4. ***International Engagement***: building on Australia's engagement as a global citizen by participating and collaborating in international space initiatives, agreements and international forums. The investments of the Government are finalized to strengthen national capabilities as well as continued access to critical space-based datasets.[68]

The Commonwealth responsibilities for space activities are developed through the activity of thirteen members of the Australian Government Space Coordination Committee, together with the support of The Department of Prime Minister and Cabinet, The Department of the Treasury, The Department of Environment and Energy, and The Department of Agriculture and Water Resources[69]:

Attorney-General's Department (AGD). AGD has two key areas of responsibilities around civil space:

[66] Australian Government, Department of Industry, Innovation and Science, (2016). *2016 State of Space Report. A Report by the Australian Government Space Coordination Committee.* space.gov.au Find here more specific and detailed information about any of the cooperating Department, Agency and Committee, together with an exhaustive list of their key and future activities and developments.
[67] Contributing to this, a major role is represented by the Department of Defence, AGO, DIIS, CSIG, the Bureau, DCA, etc.
[68] Facilities dealing with this objective: CDSCC, Department of Defence, Geoscience Australia, DFAT, ACMA, on one side, and GA, the Bureau and CSRIO on the other side, working closely with EOS operators i.e. NASA, ESA, etc.
[69] Australian Government, Department of Industry, Innovation and Science, (2016). *2016 State of Space Report. A Report by the Australian Government Space Coordination Committee.* space.gov.au

- Policy Function: critical infrastructure resilience (CIR) and national security. AGD leads policy development and implementation relating to Australia's critical infrastructure. AGD coordinates and actively contributes to the work within the Trusted Information Sharing Network (TISN) for Critical Infrastructure Resilience.
- Legal Function: international law. AGD's Office of International Law provides legal advice on international space law, to ensure Australia's engagement in the space domain is consistent with our international rights and obligations.

Australian Communications and Media Authority (ACMA). ACMA is Australia's regulator for broadcasting, radiocommunications, telecommunications and online content. With respect to civil space activities, listed below are some key responsibilities of ACMA, of which part of the work enables the use of, for example, fixed, broadcasting, mobile, scientific and radionavigation satellite services:

- managing domestic access to the radiofrequency spectrum through the development and maintenance of a regulatory framework for satellite services in Australia, including licensing;
- representing Australia's space spectrum management interests internationally, including the filing and coordination of Australian satellite systems with the ITU; and
- providing advice in areas of its responsibilities to the Minister for Communications.

Bureau of Meteorology. Being Australia's national weather, climate and water agency, the Bureau's expertise and services assist Australians in dealing with the realities of their natural environment, including drought, floods, fires, storms, tsunami and tropical cyclones. Through regular forecasts, warnings, monitoring and advice, spanning the Australian region and Antarctic territory, the Bureau provides one the most fundamental and widely used services of government. Its forecast, warnings, climate and water services are underpinned by meteorological, hydrological and oceanographic observations. Observations are also stored for future use as part of Australia's national climate record. For this reason, the Bureau invests a significant portion of its resources in taking and recording of observations, including observations from space.

Commonwealth Scientific and Industrial Research Organisation (CSIRO). CSIRO is an independent statutory authority and designates functions to:

- conduct scientific research to benefit Australian industry and the community, and to contribute to the achievement of national objectives;
- encourage and facilitate the application of the results of scientific research;
- manage and make available national facilities for scientific research;
- contribute to scientific collaboration between Australia and other countries; and
- contribute to training the next generation of Australian researchers.

Under the Science and Industry Research Act 1949, CSIRO is granted powers to undertake a broad range of activities consistent with performing the above functions. These include: arranging for scientific research to be undertaken on behalf of the organisation; forming partnerships, joint ventures and spin-off companies; and deriving income from intellectual property through licensing and royalty arrangements.

The organisation employs 350 staff involved in space activities, primarily focussed on using space-based systems and data streams to perform research and deliver nationally significant outcomes, where space provides the most effective and efficient means for delivering this impact. Consistent

with this strategy, CSIRO has developed extensive capability in space-related areas that include EO, navigation and communication, advanced aerospace technologies, spacecraft tracking and radioastronomy.

Department of Communications and the Arts. Being responsible for policy oversight on the licensing of spectrum used for space activities, the Department's key area of work consists in providing advice to the government, and information to the public, regarding NBN provision of satellite broadband services to regional, rural and remote Australia. The Department is also responsible for preparing advice to the Minister for Communications as a shareholder Minister of NBN. Part of this role includes monitoring NBN's broadband satellite program.

Department of Defence. As space is an important enabler for the Australian Defence Force as a modern, networked military, the Department of Defence uses both military and civil space-based systems for a range of applications, including: global positioning, navigation and timing; satellite communications; surveillance and reconnaissance; mapping; and weather forecasting. It also has an interest in maintaining assured access to space, as space plays a vital role in all ADF and coalition operations.

The Department of Defence responsibilities in space are:

- contributing to space situational awareness and help ensure the security of Australia's space-based assets. This includes working with the United States to locate and jointly operate space-monitoring infrastructure in Australia;
- engagement with international partners on military use of space through the Combined Space Operations initiative and bilateral partnerships and talks;
- managing radiofrequency spectrum access for its satellite networks;
- space-based geospatial intelligence collection in support of Australian government national security, foundation data and intelligence requirements; and
- contributing significantly to the development of Australia's space capabilities through a number of R&D programs in collaboration with international and domestic partners.

Department of Foreign Affairs and Trade (DFAT). Working with key international partners and participating to regional and international forums – including the United Nations and the Conference on Disarmament – the DFAT has responsibility for international security issues, including for space.

Geoscience Australia (GA). Applying geoscience to Australia's most important challenges, GA is the government's technical adviser on all aspects of geoscience, and custodian of the geographical and geological data and knowledge of the nation. It supports civil space activities through leadership and planning, operational service delivery, ongoing maintenance of infrastructure and data, strategic partnerships, and knowledge-transfer. These activities create value for stakeholders by supporting capability development and critical decision-making across the agency's strategic priorities.

GA is the lead agency for Positioning, Navigation and Timing (PNT) and non-meteorological operational use of Earth Observations from Space (EOS) in Australia. It provides geoscience infrastructure, knowledge and expertise that assures access to space capability, supports innovation, science skills and development, strengthens domestic and international coordination, and protects economic well-being. Moreover, the GA work program supports the work of other government agencies, state and territory governments, researchers, international partners, and industry.

Department of Industry, Innovation and Science (DIIS). DIIS has three key areas of responsibility around civil space are:

- Coordination Function: The Department is the central point of contact and coordination for the government's involvement in domestic and international civil space activities. The DIIS also chairs the Australian Government Space Coordination Committee (SCC), a forum for information sharing and coordinating the government's activities and priorities in civil space activities;
- Regulatory Function: administration of the Space Activities Act on behalf of the Minister. The Space Activities Act regulates rocket launches from Australia (or by Australians overseas) and the return of space objects to Australia; and
- Policy Function: advancement of Australia's space capabilities. The space sector is a driver of advanced technologies which have significant potential to generate technology spillovers that can flow into other sectors of the economy and advance Australia's positioning in global markets.

Department of Infrastructure and Regional Development (DIRD). DIRD is responsible for providing policy advice and targeted research, delivering administered items and regulation in respect of the government's infrastructure, transport and regional development policies and programs. It works to:

- promote, evaluate, plan and invest in infrastructure and regional development;
- foster an efficient, sustainable, competitive, safe and secure transport system;
- facilitate local partnerships between all levels of government and local communities; and
- provide good governance in the Australian territories.

DIRD's interests in civil space include the application of satellite-enabled services for road, rail, maritime and aviation sectors. These activities are carried out by DIRD and its portfolio agencies: **The Australian Maritime Safety Authority (AMSA)**, which provides a range of regulatory functions and services that significantly use satellite based technology; **The Civil Aviation Safety Authority (CASA)**, which develops, promulgates and oversees the implementation of appropriate aviation safety standards; **Airservices Australia**, which is the service provider responsible for Australia's airspace management, aeronautical information, aviation communications, radio navigation and aviation rescue firefighting services.

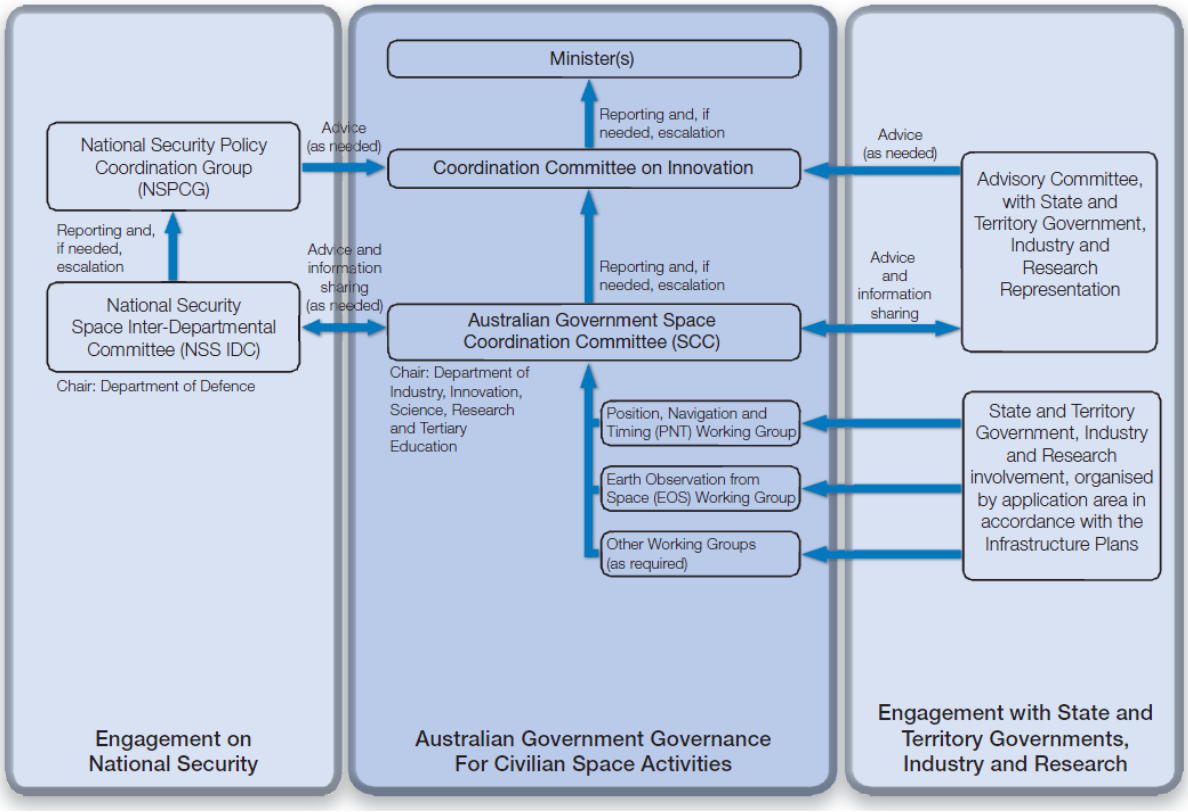

Figure 4. "Australian Government Coordination Framework for Civilian Space Activities". Source: Australia's Satellite Utilisation Policy, Australian Government (2013). See for more details pp 18-19.

2.2.2. Government spending on space. *Where does the money spent by the Government in the space sector go? How many jobs related to space are there in Australia?*

One of the main national Government's goals is the creation of more jobs within the country and it is with the purpose of accommodating this core objective that the Australian Government tries to allocate its funds efficiently. The attempt to meet this goal is shown by the trend of *overall* government spending in Australia, which has systematically increased over time. The same increasing trend has been followed by the *space-related* government expenditure, which is particularly critical for the creation of the kind of high-tech jobs Australia is aiming for.

2.2.2.1. Need for more high-tech space-related jobs

Australian space industry sector is estimated to produce an annual revenue of between A$3-4 billion, of which 92% comes from domestic activity and 8% from export. Employment in the sector is estimated to be between **9,500** and **11,500** full-time equivalent[70], and an increasing number of projects are launched and financed by the Government with the intention of supporting more workers – fitting the broader national goal of the Government of jobs creation. A recent example is the A$500 million investment announced on 18 June 2017 by the Turnbull Government[71] to improve Australia's

[70] Asian Pacific Aerospace Consultants Pty Ltd, (2015). *A Selective Review of Australian Space Capabilities: Growth Opportunities in Global Supply Chains and Space Enabled Services*.
[71] https://www.minister.defence.gov.au/minister/marise-payne/media-releases/500-million-enhanced-satellite-capability

space-based intelligence, surveillance and reconnaissance capabilities: this investment will create immediately 22 new jobs in Defence and Industry across Australia in direct support of the establishment and maintenance of the capability, with many others created in the supply chain as the project matures. Another supportive statement is the upcoming investment of A$100 million of the Australian Government, announcing in May 2017 that these funds will be invested to 'drive innovation in Australia's manufacturing sector to create jobs, grow businesses, improve productivity and be globally competitive'[72].

Jobs creation is a priority for Australia, and the space sector represents a great opportunity to support it: innovation and high-tech jobs are going to represent an increasing share. This is not only a need for the country, but also a 'must'. Holden announced its intention to leave Australia in 2017, leaving 2,900 unemployed[73]; Toyota will close its Altona plant in Melbourne in October, with the loss of more than 2,600 jobs[74]; Ford's closure in Campbellfield and Geelong has left 1,200 people without jobs[75]. The car workers' union, the Australian Manufacturing Workers Union (AMWU), stated that Australia had never before experienced such a rapid closure of an entire industry especially one as important as car manufacturing, and that between 40,000 and 200,000 jobs would be lost nationally[76]. Australia starts to be considered as a non-competitive country in those 'standard and traditional sectors' which historically have driven its economy. Hence, Australia needs to replace those jobs and gain competitiveness in segments in which it has a real opportunity. The space sector appears to represent exactly one of those: space-related jobs creation will and already are being created quickly, and there is evidence from other countries' experience that a more coordinated space sector will even significantly improve this high-tech jobs creation rate of growth.

2.2.2.2. Government space-related expenditure: locally and overseas

Focusing on the portion of the government budget spent on space-related activities, annual expenditure figures have trended significantly upward since 2005-06, with the Commonwealth Government estimated to spend over **A$1 billion per year on space services** and related activities[77]. This includes Satcoms, space science and technology research, EO, satellite broadcast and the use of GNSS. The main purposes of government space activity are national security (predominantly), national and international telecommunications and broadcasting, international development assistance, environmental monitoring, and space scientific and industrial research and development[78].

There is no shortage of evidence that government funding can play a critical role in space industry development: Australia is having the possibility to participate and conduce many programs thanks to the government's financial support. However, given Australia's dependence on other countries, the **government is obliged to spend its space-related budget not only internally but also overseas**: some of those funded projects involve *local* expenditure only – keeping cash within the country allowing directly for national revenues and for building and strengthening a space structure nationally; other

[72] http://www.spaceindustry.com.au/news.php
[73] https://www.theguardian.com/business/2013/dec/11/holden-confirms-leaving-australia-cars
[74] http://www.abc.net.au/news/2017-01-31/toyota-set-to-close-in-melbourne-in-october/8227698
[75] http://www.shanghaidaily.com/business/auto/Ford-leaves-Australia-as-nation-prepares-for-car-industry-closure/shdaily.shtml
[76] http://www.shanghaidaily.com/business/auto/Ford-leaves-Australia-as-nation-prepares-for-car-industry-closure/shdaily.shtml
[77] Space Industry Association of Australia, (2017). *SIAA White Paper: Advancing Australia in Space*.
[78] Australian Government, Space policy Unit, Department of Innovation, Industry, Science and Research, (2010). *Analysis of Australian Government Space Activities.*

projects require instead the space-related government expenditure going at least partially *overseas* – providing the country with critical data and technologies but at the same time bringing evidence of Australia's dependence on other countries' space access.

Among the numerous government funded projects, a few have gained particular interest, both for having led to specific benefits and for representing good opportunities for the Australian development in space. An example of a project which involved money spent within the country is the ASRP's A$40 million program, that run from 2010 to 2014 and achieved direct co-investment from industry of A$39.1 million[79]. Another significant project is the recent launch of Sky Muster II in October 2016, following Sky Muster I's launch in October 2015. Commissioned by the National Broadband Network, this series of satellites have been designed to provide access to fast and affordable broadband to 400,000 regional and remote Australians, helping bridge the digital divide between the country and the city[80]. NBN co-contracted Space Systems/Loral (SSL) to build and launch the two satellites as part of a total investment costing A$2 billion. In this case, not having the technologies within the country, most of the national money expenditure on the program has gone overseas.

The above listed are just a few examples of government areas of space dedicated expenses; in order to get a more precise understanding about the actual, concrete way the government organizes its space-related budget, it is of great interest to analyze more in detail the specific portfolios and what share is spent on acquiring commercial data from abroad rather than on local space activities.

Government organization of space-related expenditure & portfolios: very recent information about the subdivision of government's space-related spending is not available. However, there is some valuable data from 2010 and there are arguments supporting to deduce from this a similar trend for today' portfolios and expenses. There are different ways to represent and rank the expenditure of the government in space-related fields, each of which gains relevance according to the focus of interest. On a total annual expenditure of A$965 million on space activities: i) ranking of portfolios by reported space-related activity sees *Defence* as the most significant; ii) ranking of space-related activity classification shows *Satellite Telecommunications* to be the predominant category; iii) ranking on space-related activity purpose outlines *National Security* as primary scope (Figure 5).

[79] Department of Industry, Innovation and Science, (2015). *Final evaluation of the Australian Space Research Program.* Ernst & Young, Australia. Examples of lasting benefits include: i) The Space-based National Wireless Sensor Network Project; ii) The Automated Laser Tracking of Space Debris Project; iii) The Southern Hemisphere Summer Space Program (SHSSP). The ASRP was independently assessed by EY in 2015, concluding the program represented value for money, was delivered efficiently, and achieved its objectives.

[80] http://www.nbnco.com.au/blog/features/Sky-Muster-Launch.html

Ranking of Portfolio by reported space-related activity (A$m)		Ranking of space-related activity classification (A$m)		Ranking of space-related activity purpose (A$m)	
Defence	661	Satellite telecommunications	422	National security	668
Broadband, Communications and the Digital Economy	144	Human capital (policy, governance, liaison, regulatory, and/or diplomatic functions)	149	National and International telecommunications and broadcasting	144
Foreign Affairs and Trade	66	Space science and technology research (industry grants, Defence capability development)	135	International development assistance	55
Innovation, Industry, Science and Research	43	Earth Observations from space (and associated data processing)	105	Space scientific and industrial research and development	41.5
Infrastructure, Transport, Regional Development and Local Government	14	satellite broadcast (television)	79.3	Transport regulation	14
Climate Change of Energy Efficiency	10.5	Leases and licenses' (Defence)	52	International diplomacy	11.3
Environment, Water, Heritage and the Arts	10.2	GNSS/PNT	19	Environmental and climate change monitoring	10.9
Resources, Energy and Tourism	8.8	Space observations from Earth (non-astronomical)	4.6	Meteorology	9.8
Attorney General's	6.6			Mapping, geodesy and oceanography	9.3
Agriculture, Forestry and Fisheries	0.8			Spectrum management	1.1
				Natural resource exploitation and management	0.8
				Space exploration	0.2
tot.	**965**	**tot.**	**965**	**tot.**	**965**

Figure 5. "Government space-related expenditure, according to focus of interest". Source: Analysis of Australian Government Space Activities, May 2010, Department of Innovation Industry, Science and Research.

Government spending in space-related R&D: non-military space Research and Development is a relevant portion of the *local* government's space-related expenditure. In 2016-17, the Australian Government is providing **A$10.1 billion in support of Research and Experimental Development overall** – figure that has increased by 52 per cent over 10 years[81]. This spending is spread between Australian Government research activities (19%), Higher Education sector (33.6%), Business Enterprise sector (33.1%), and Multisector (14.4%). The Australian civil space policy comes within the Industry, Innovation and Science portfolio (accounting for A$4,798.4 million of the total) – which consists of the

[81] Australian Government, Department of Industry, Innovation and Science (2016). *The Australian Government's 2016-17, Science, Research and Innovation Budget Tables, Minister for Industry, Innovation and Science's foreword.*

Department of Industry Innovation and Science and a number of statutory agencies. Following the path of the last couple of years, the estimated amount of government support for **non-military space R&D has decreased in 2015-16**, confirming Australia as one of the lowest among OECD countries in government investment in civil space. For this reason, the ambition of the government policy in relation to space funding is to encourage: 1) investment in innovative and entrepreneurial businesses; 2) collaboration between industry and researchers; 3) the development of STEM skills. A very relevant reason adding importance to it is that the government expenditure in space R&D, differently than other government expenses, adds value to the economy, providing services and other benefits for the country.

Government data acquisition: as overseas allocation of funding represents the source of riskiness and uncertainty related to space activity in Australia, it is relevant to identify the activities (and possibly the amount of money spent by the government on them) that need acquisition of other countries' satellite data. Earth Observation data represents one of the most relevant examples for Australia's overseas-data dependence.

When acquiring commercial EOS, the Commonwealth Government makes every effort to purchase data under arrangements that allow the widest possible use by Commonwealth, state and territory agencies[82]. However, this is not without a cost. Cost analysis and estimates of possible savings as a consequence of satellite and/or other instruments' building, have been delivered in recent years with regards to EOS data supply. EO represents, together with GNSS, one of the major utilizations of satellite, for which four main instrument types have been identified to be of greatest exploitation in the Australian case: low resolution optical, medium resolution optical, high resolution optical, and imaging radar (SAR). While for low resolution optical, data streams are generally available on a public good (free and open) basis, most of the other data supply arrangements are in place with key strategic partners like the U.S. and Japan. Some are indeed underpinned by the World Meteorological Organization's resolution 40, which assures the public good flow of data for weather-related observations; non-weather-related data supply is instead based on a mix of public good data streams, bi-lateral arrangements, and commercial purchases[83]. The *CEODA-Ops*[84] and *ACIL Tasman* reports found that EOS underpinned over 90 government programs, and for the relatively modest **annual expenditure of A$105 million**[85], EOS returned approximately $3.3 billion to the economy; a return of 30:1 on government investment in EOS. *ACIL Allen* (previously *ACIL Tasman*) revisited this analysis in 2015 and found significant growth in both the use of EOS and the contribution it makes to the Australian economy. The new report, titled *Value of Earth Observations from Space,* found that **EOS now returns approximately A$5.5 billion to the Australian economy** and the use of EOS-services has generated around 15,000 new jobs in 2015. The report predicts growth of up to A$8.8 billion, with more than 80,000 employed as a direct result of EOS services by 2025. It was estimated that the

[82] Symbios, (2015). *Risks of Data Supply of Earth Observations from Space for Australia*. Report prepared for the cooperative Research Centre for Spatial Information.

[83] Symbios, (2015). *Risks of Data Supply of Earth Observations from Space for Australia*. Report prepared for the cooperative Research Centre for Spatial Information. With regards to high resolution data, supply is almost exclusively commercial, with two principal providers dominating the market - Digital Globe and Airbus DS. Medium resolution data (particularly well suited to applications in Australia because of its broad areas) is mainly purchased as well, for which ETM+ and OLI (USGS) on Landsat represent the only current global workhorses, with an estimated economic benefit for 2011 of US$400 million for international users. With regards to SAR, the main heritage comes from Europe and Canada.

[84] CEODA-ops stands for *Continuity of Earth Observation Data for Australia.*

[85] This figure includes both purchases from satellite data archives, as well as the procurement of new commercial acquisitions.

combined impact of the use of EOS services resulted in employment in 2015 being around 9,293 higher than it would otherwise have been without EOS. This figure is expected to increase to 15,997 by 2025.

If on one side commercial data supply is strong, growing and diversifying, and thus producing increasing competition, on the other side acquisition costs will continue to control and deny access for Australian users who are not accustomed to having budgets for data purchase. The emergence of lower cost platforms based on development with commercial of the shelf components will result in significant cost reductions in securing access to space infrastructure. In the *Risks of Data Supply of Earth Observations from Space for Australia* report, a cost scenario for an autonomous build of optical instruments has been outlined, estimating substantial savings and showing the concrete opportunity for Australia to implement this construction[86].

Hence, there is currently a significant expenditure on local and overseas data purchases – despite the identification of the exact share that actually goes overseas unknown. However, there is a realistic opportunity of risks and costs reductions for the government by building optical instruments locally. If these platforms can reach a level of performance that makes them fit for purpose, they may potentially be disruptive[87].

2.3. Australia looking for a new, stronger space economy. A National space agency may help gaining it

"An Australian space agency would enable a strategy for a complex and currently fractured industry. It would unite our space goals with that of the world, foster collaboration between nations, and spur on innovation that will serve tomorrow's businesses – in addition to greater exploration and study of the universe".

The federal government is reviewing legislation to reform the Space Activities Act 1998. The reform aims to modernize Australian policy in order to ensure 'Australia's space regulation is appropriate to technology advancements and does not unnecessarily inhibit innovation in Australia's space capabilities'. One outcome of this reform is to develop a long-term plan to grow this important and exciting sector.

Many people believe that Australia is not performing according to its national potential and opportunities in the space sector and that it is not sufficiently and optimally contributing to the global space economy; it is not taking advantage of the chance to grow its national economy. The issue at stake is not funding. The commonly expressed concern is that there is an absence of a coherent strategy that promotes Australia's national goals. An Australian space agency would implement a strategy for a complex and currently fractured industry. It would unite the national space goals with that of the world, foster collaboration between nations, and spur on innovation that will serve tomorrow's businesses – in addition to greater exploration and study of the universe.

[86] For more details about costs: Symbios, (2015). *Risks of Data Supply of Earth Observations from Space for Australia*. Report prepared for the cooperative Research Centre for Spatial Information, p 79.
[87] Symbios, (2015). *Risks of Data Supply of Earth Observations from Space for Australia*. Report prepared for the cooperative Research Centre for Spatial Information.

Industry advocates argue that a strategic government engagement in space is fundamental to reach the sustained benefits, but – as will be outlined in the following paragraph – there are many reasons why the Australian Government should come up with a renewed vision and leadership in order to pave the path for an ongoing, growing national space activity. It is argued that a National space agency would ease and allow this transition in the most optimal and efficient way.

2.3.1. How Australia developed its involvement in space: 1985-2017

The idea that the government's support and leadership in space activities is of unique value for the country was highlighted first in 1985 in *The Madigan report*. The importance of having a centralized space agency has been stressed 'officially' in more occasions over the last three decades, however every time without being able to unify the thinking around it and succeed in its establishment. This is what the Australian Government space history states has been happening since 1985; and this is what newspapers releases, political speeches and space experts continue to tell us today in 2017.

A Space Policy for Australia (also called The Madigan report) represented the first extensive review of national space activities. This included a comparison with the space activities of other nations (particularly Canada), supported international collaboration on space projects and suggested an initial government commitment to spending A$100 million over five years toward suitable programs[88]. In response to the Madigan report, the *Australian Space Board (ASB)* was established in 1986 to oversee a *National Space Program (NSP)*. Being the ASB's role to act as an advisory and supervisory body in the formulation of a national space policy, its main goal was industry focused, aimed to encouraging greater involvement by Australian industry in space R&D activities to promote the development of commercially viable industries based on space technologies[89]. To assist the ASB, *The Australian Space Office (ASO)* was established the following year in order to conduct the daily activities necessary for the coordination and management of the National Space Program, and successive federal budgets provided around A$4 million per year in support of it[90]. In 1989 the *Space Science in Australia* (Cole) report **recommended consistent government support** for an active program of space science and urged a specific funding for the establishment of a space and astronomy data storage capability, education programs and spacecraft expertise[91]. The ASO sought to redress the perceived industry bias of the NSP by promulgating the *Balanced National Space Program* in 1991, which refocused the policy directions to include opportunities for public goods and services and national benefits from the use of space, while at the same time continuing to address the requirements of industry. However, given the failure in developing the space database that the Cole report had asked for, by 1992 astronomers were **calling for the creation of a completely independent and professional space agency**: this was the first time that a National space agency was mentioned and asked for in Australia. In the same year, the Australian Government commissioned an expert panel review (*the Curtis review*) of the NSP which resulted in the creation of a space council when the *Australian Space Council Act 1994* passed. Its mandate was to report on matters affecting the application of space-related science, and to recommend a new *Integrated National Space Program* to encourage applications of space-related science and technology by the public and private sector in Australia. The government ultimately

[88] Australian Academy of Technological Sciences, (1985). *A Space Policy for Australia (The Madigan report).* Space Science and Technology Working Party.
[89] Dougherty K. *Australia in Space*. Chapter 9.
[90] Dougherty K. *Australia in Space*. Chapter 9; Highlights of Australia's Space History 2013. www.space.gov.au
[91] Dougherty K. *Australia in Space*. Chapter 9.

accepted the Curtis Report's recommendations and the ASB was replaced with a statutory body, the *Australian Space Council (ASC)*. The suggested budget was not met though, leading the last developments to less success than expected: in fact, in 1996 the government abolished both ASO and ASB, terminated the NSP funding, while it established a new *Space Policy Unit* in 1998[92]. In the same year, the *Space Activities Act* was enacted with the scope of ensuring the creation of regulations governing matters related to the national space involvement, within the countries and overseas. Another step towards a collaborative approach and a better co-ordination amongst agencies involved in space was the establishment of the *Australian Government Space Forum* (2000), whose main added value was given by the exchange of information about policies, programs and activities it allowed. Given the urgency for a national plan for space activity, the *International Space Advisory Group* was established in 2001, facilitating the consultation with the scientific and research communities and with industry for the identification of opportunities and strategies for Australian involvement with the International Space Station (ISS). The *Policy Framework for Space Engagement* was a very important release, as it marked for the first time that defence and security-related matters had been formally incorporated into a national space policy. Still, the Minister's response to the Space Agency Advisory Group's recommendation for a renewed space policy and strategy (after the abolition of the NSP), was highlighting again the **government's belief that the current decentralised arrangement was appropriate** given the wild range of matters affected by space. In 2008, the Senate Economics Committee's Report *Lost in Space? Setting a New Direction for Australia's Space Science and Industry Sector* recognized that Australia was the only major nation in the OECD not to have a National space agency and therefore put forward **six recommendations for the gradual establishment of a national space policy and National space agency**[93]: 1) that government allocate resources to the existing Space Policy Unit to enable the establishment of an Australian government Space Information Website; 2) that immediate steps taken to coordinate Australian space activities and reduce over reliance on other countries in the area of space technology; 3) that the government establish a unit to coordinate Australian space activities, including those in the private sector, with a proper balance between industry and government involvement; 4) that the government initially establish a Space Industry Advisory Council comprising industry representatives, government agencies, defence and academics; 5) that the **Advisory Council, as a precursor to the establishment of the space agency**, undertake audits, assessments and analysis of any aspect related to Australian space involvement. The Council should also develop a draft strategic plan for the establishment of a space agency; 6) that any Australian Space Agency re-assess the case for Australia becoming more closely linked to an international space agency. In response to the Senate Economics Committee Report, the government established in 2009 both a *Space Policy Unite* in the Department of Innovation, Industry, Science and Research for Australia's national and international civil space activities, and the *Space Industry Innovation Council*. In 2010, the *Australian Space Research Program (ASRP)* was advanced with the objective of developing Australia's niche capabilities, through support for space-related research, innovation and skills: A$40 million were granted by the ASRP in two streams for a three-year project, as well as other 14 projects were supported over four rounds of funding. One of the last achievements was the approval by the Federal Cabinet of the *Australia's Satellite Utilisation Policy* (2013), which outlined seven principles upon which the national space industry policy would be based. The policy's stated goal was to achieve an 'on-going, cost-effective access to critical space capabilities while

[92] Dougherty K. *Australia in Space*. Chapter 9.

[93] Australian Senate Economics Committee, (2008). *Lost in Space? Setting a new direction for Australia's Space Science and Industry Sector*.

delivering the benefits of improved national productivity, better environmental management, national security and safety, a smarter workforce and equity access to information and services'[94]. At the same time, it specifically ruled out Australian participation in launch services, human spaceflight and planetary exploration. A final evaluation of the ASRP has been commissioned in 2015 by the Australian Government to Ernst & Young, concluding that 'the program had represented value of money, had been delivered efficiently, and had achieved its objectives whilst continuing to realise benefits to the space sector'[95]. However, there are more and more stakeholders claiming the need for a more centralised and coordinated space activity in Australia, which is the reason for the current processing of a review of the Space Activities Act and the release of the White Paper *Advancing Australia in Space*. This last document is of fundamental importance as it **stresses the need of a space strategy and agency** highlighting, for the first time, the benefits and the role that a space agency in Australia could have.

2.3.2. Need for renewed vision and leadership from the Australian Government

The relationship with Australia's national priorities and space activity is clear and yet, of all OECD countries, Australia is among the lowest investors in publicly-funded space-related research and development[96]. Despite the existing evidence supporting the importance of a strategic government engagement, the Australian Government's approach to the space sector needs a renewed vision and leadership. Among many, a few supporting arguments are i) the opportunities arising from the recent substantial inflow of venture capital in the space sector globally: more venture capital (US$1.8 billion) has been invested internationally in space ventures in 2015 than in all the previous 15 years cumulatively[97], and it will be primarily invested in start-up ventures trying to take advantage of the reducing cost of small satellite construction and operations; and ii) the way the government currently allocates funds to sustain space-related projects: based on analyzing the proposals of scientists, biologists, researchers and any other individuals or institutions interested in advancing and innovating the sector first, it then focusses on deciding whether the project is good enough to gain allowance to the government financial support. This way of proceeding has no established and stable guidance, nor a fixed dedicated fund. Results are a loss of money, efficiency and benefits.

Australia's approach to space activities is passive and regulatory, and the country does little to direct them in a way to take advantage of new opportunities. Two are the areas of the space sector in which Australia is failing[98]:

1. Strategic oversight and development of nationally important space services; and
2. Strategic investment to exploit a growing multi-billion-dollar space market.

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[94] Australian Government, The Department of Industry, Innovation, Science, Research and Tertiary Education, (2013). *Australia's Satellite Utilisation Policy*.

[95] Department of Industry, Innovation and Science, (2015). *Final evaluation of the Australian Space Research Program.* Ernst & Young, Australia.

[96] Space Industry Association of Australia, (2016). *SIAA Green Paper: The 2016/17 Commonwealth Budget and the Civil Space Sector*.

[97] Christensen C.B. Tauri Group, Armstrong K. Tauri Group and Perrino R. Tauri Group, (2016). *Start-Up Space: Rising Investment in Commercial Space Ventures,* AIAA Space. Long Beach, California. Read more at: https://arc.aiaa.org/doi/abs/10.2514/6.2016-5233

[98] Osborne B., Dempster A. and Aboutanios E., (2014). 'Investing in space: What the UK Space Agency can teach Australia", *The Conversation*, [website], 24 July 2014, http://theconversation.com/investing-in-space-what-the-uk-space-agency-can-teach-australia-28559 (accessed July 2017)

To support the first point, Australia needs a space agency; for the second it needs a space program. Those two broad areas of weakness come from many concrete, smaller gaps that, summed up, give rise to the bigger inefficiency Australia is known for. In other words, those gaps can be explained through a series of important *reasons* why Australia is argued to strongly need a renewed leadership from the government – most powerfully implemented through a National space agency able to set a unifying space program. Among many, a few of these reasons can be identified, with the aim to give concrete examples of what such a defined space strategy would provide in terms of added capabilities:

- *establishing how satellites can solve Australian's problems*, pulling together stakeholders and providers;
- *leading and allowing the development of satellite programs identified as useful*. For example, Australia has produced an implementation project showing how it could develop a specific satellite, but there is no body in the government that can take this idea and make it happen;
- *representing the government as a technically informed customer*. Professionals with whom to discuss matters need to overcome problems arising from failure of communication and lack of expertise;
- *providing leadership on technical space issues*, as often the problem now is a lack of people to ask to, rather than a lack of competence;
- *enabling Australia to communicate with international agencies at a technical level* without failing to meet the other countries' expectations from our potentials
- *enabling Australia to share international programs and projects*;
- *filling the gap in technical responsibilities in space*, as our space administration is missing important aspects – as the UK and Canada space structural organization shows;
- *stabilizing space funding*; and
- *ensuring the very best young engineers are not forced to go overseas* if they want to pursue their ambitions in space.

All those reasons are unified by a broader drive to develop the economy of the country, and an analysis of the economic benefits matched to them will follow later in the report.

2.3.3. Consequences of having a National space agency. *Why may Australia need a dedicated National space agency? What would be the additional benefits?*

The fact that Australia represents an exception among the OECD countries for not owning its dedicated National space agency is already an indication of the importance of being able to coordinate centrally all the space related activities, budgets and scopes. Establishing a National space agency means building and strengthening a government-industry partnership, increase autonomy in space based fields, giving confidence to the economic actors involved in space activities, attracting more players and start-ups, and bringing the space-world closer to Australian citizens and young potential field-related students and workers.

2.3.3.1. Roles of a dedicated Australian Space Agency

Establishing a permanent and sustainable, internationally recognized national space program for Australia is critical for any national strategy. The Australian Space Agency would enable a strategy for

a complex and currently fractured industry, establishing, as highlighted by the SIAA in its White Paper[99], three main goals and objectives:

1. Addressing Australian priorities and driving industry growth
2. Policy, Law and International Relations
3. Capability Development, STEM and Outreach

Addressing Australian priorities and driving industry growth. Industry development and jobs creation would be the main objective of the new program. It would be the National space agency's responsibility to formulate a detailed national strategy and setting growth targets as well as priorities. The plan would address technology development and innovation, earth observation, support for technology commercialization, niche capability development and enhancement, and export strategies. With the purpose of succeeding in these objectives, consultation with industry and space-sector coordination groups would be established[100], and projects and research government funding would be provided efficiently. It is important that the new body is technically competent and has international credibility, being able to participate in joint projects with international partners as well. In relation to the growth targets, the SIAA believes that in developing this strategy, the new agency should aim for i) doubling the size of our space industry sector within five years of its establishment, and ii) capturing 4% of the world market for Australian industry within 20 years.

Policy, Law and International Relations. The Agency would be responsible for developing and administering Australian civil space legislation and regulations, and for implementing the licensing of space activities covered by the legislation. Another concern coming with the implementation of the new space program would be giving advice to the government on domestic and international policy as well as on law and relations with international organizations and other governments. Among the others, the policy development would include: assuring secure access to space for Australia; coordinating and monitoring cross-agency civil space spending, aiming to save money and maximizing the national commercial opportunities in space industry sector; advancing reforms, changes and new regulations if required for a more efficient monitoring of the international regulation and government advice; guiding the country in following its obligations in relation to the key international treaties; playing an active role in shaping international space policy; ensuring equity of access to space-based services.

Capability Development, STEM and Outreach. Education plays an important role for the future development of a country. Hence, it would be an unforgivable error to not put enough effort in inspiring and guiding the young people to pursue studies that would eventually lead to a space-related field and, more in general, to careers in STEM. The way of pursuing this objective would mainly be based on the inclusion of space-related topics in school and university programs throughout Australia. In addition, providing people with a wider comprehension of the importance of space-related activities in our daily lives, together with the highlighting of the national space achievements, would both help push the interest and the enthusiasm in the topic, with the consequence of a potential sector growth, thus economic growth.

[99] Space Industry Association of Australia, (2017). *SIAA White Paper: Advancing Australia in Space*.
[100] See for example: The Australian Earth Observation Community Coordination Group, (2016). *Australian Earth Observation Community Plan 2026*.

While the last two are not very expensive in their realization, addressing the first goal means to be able to overcome various obstacles, put together a much bigger amount of financial resources and completely change the way funds are assigned to projects as well as the way the latter are selected for funding. Up to now, the process of projects selection for government financial support has happened on the basis of a comparison and analysis of the projects presented by the most diverse stakeholders (biologists, scientists, universities, companies, etc.). However, there is not a specific strategy that guides this process, nor a permanent program of dedicated funds for space, with a loss of opportunities and resources. The same happens for the industry-government relationship, which appears to be fragmented and inefficient for the exact same reason of lack of a unifying strategy. The previous paragraph lists a few examples that call, together with the need for a stronger international credibility and consideration in space economy, the valuable consequences of a dedicated National space agency: coordination around the government (CSIRO, Geoscience, Defence SA, etc.) of all space-related aspects would improve, and jobs creation would benefit as well.

Despite realising the first goal especially might be costly and hard at the beginning, the realisation of this program would lead the country to stop being prevalently a consumer of space services and to actively shape the future of its space sector, **playing a key role in innovation, inspiring and imagination, and thus advancing Australia into the new space age**. Examples of improved development and economic growth are provided by other countries' experience of creation of a National space agency: outcomes, trends and results are promising as will be outlined later in the report. Establishing a space agency does not necessitate investment in a sovereign launch capability; **space agencies deliver value by providing a central point for academia, industry, defence and foreign entities to collaborate among themselves and with government and to facilitate the flow of knowledge and capital**. Australia will indeed find it difficult to compete on the scale of private enterprises such as SpaceX and Arianespace or rising powers like China, if such a centralized organized program will miss to be established. Indeed, **without a space agency, Australia will simply have no unified goals, nor a national program thanks to which the Australian industry and research center can grow.**

2.3.3.2. Societal & Daily Benefits of space-based applications improve as consequence of a unified space activity

The establishment of a National space agency would deliver direct effects on the society as well, with the areas affected being the most diverse: the disruptive technologies on which the space industry relies on allow the development of new products and services, causing a real change in the daily habits. "*Space Innovation and Growth Strategy (South Australia). Action Plan 2016-2020*", a recent study developed by Defence SA, has highlighted the daily benefits of space-based applications. Experts assume that, given the homogeneity and the overall activities organization within the country, those beneficial consequences can be extended to the whole country. Those benefits – which would be significantly amplified the more space activities are guided efficiently and the more efforts converge towards a unifying strategy – are:

- *Increase efficiency in agriculture and fisheries*: satellite-enabled applications improve the mapping of cropland in need of irrigation, harvest forecasts, and fisheries control. This guarantees better food quality and security while safeguarding the environment.

- *Help regions access knowledge and information*: telecommunication satellites support telecommunication needs when Earth-based solutions are limited. This reduces regional imbalances by serving communities in remote areas without internet access.
- *Improve crisis response*: satellite services help shorten response times in emergencies. Swift damage images and assessment maps contribute to more efficient planning and relief efforts, and help guide rescue access.
- *Protect the environment and help tackle climate change*: environment monitoring provides crucial information on vegetation, ocean currents, water quality, natural resources, atmospheric pollutants, greenhouse gases, and the ozone layer.
- *Increase security:* satellite positioning, satellite communications, and Earth observation contribute to detecting illegal immigration, preventing cross-border organised crime, and combating piracy at sea.
- *Improve the health of our citizens*: space-based applications can significantly improve healthcare and the health education of patients through remote medical support. They also help to prevent or mitigate the outbreak of disease.
- *Optimise transport*: when combined with enhanced communication capabilities, highly accurate satellite positioning contributes to a modern and reliable transport sector for cars, planes, and ships. It optimises fleet management, vessel traceability, collision prevention, speed control, assistance for shipping manoeuvres, etc.

3. THE CASE OF THE UK SPACE ECONOMY

3.1. An overview of the UK space economy

" If ever there was a time to be bold with industrial strategy it is now. We should seize the opportunity to take a successful UK Space sector and transform it into a foundation stone of our future economy", Andy Green, Chairman (2010).

Soon after the UK Space Agency (UKSA) was created.

The UK is the best example of impressive national space economy growth in recent years. It also provides a precedent in current economic circumstances of the establishment of dedicated National space agency with proper funding of a national space program, that has allowed the UK to gain a significantly increased global share –thus contributing to significant growth in the national economy. The distinctive fact that the United Kingdom has things in common with Australia when it comes to language, culture, population size, economic features and governmental systems, allows meaningful comparisons among the two nations. Hence, it should be possible to predict trends, consequences and effects for the Australian country by analysing carefully the UK experience. **Therefore, it is possible to argue that Australia can learn from the UK experience best practice in the evolution and implementation of a new Australian space policy.**

3.1.1. The evolution of the space sector in the UK

The history of British aerospace can be tracked back to the end of the XVIII century, when the 'father of aviation' Sir George Cayley first set forth the concept of modern aircraft in 1799. In the first half of the 20th century the growth of the British aerospace sector was mainly driven by aeronautics through the massive public remunerations of the military division and of the British Air Ministry. However, UK's approach to the space sector started to change between the 50's and 60's towards a more pragmatic one, focusing the national strategy on the downstream segment of the industry – putting aside the upstream segment, which was highly attractive from a political perspective but economically unprofitable. Being one of the first countries supporting the growth of a space-related industry from a commercial perspective, it developed the perfect context to grow expertise in a broad set of fields. This way of approaching space activities, which evolved also in funding upstream R&D in order to support downstream businesses, led the UK to grow much faster than other countries in space industry. However, the British soon realized that they were missing out opportunities and not fully exploiting their potentialities. In fact, while prior to 2010 the UK space sector was managed through the British National Space Centre, in 2010 the UK Government and the British industry agreed on the necessity of a change: they were realizing that the absence of a structured coordination of the broad system of space related activities, as well as the lack of a strong vision guiding the space-related decisions were undermining the British participation in the global space industry. The acknowledged need for a stable dedicated fund and detailed, targeted space plan led to the publication of the Space Innovation Growth Strategy in February 2010. Since then, the UK has achieved incredible successes: the creation of both the Space Leadership Council and the Satellite Applications Catapult followed,

together with the transfer of the ESA's European Centre for Space Applications and Telecommunications (ECSAT) to the UK. The bounding component of all those great innovations was however the establishment of the **UK Space Agency** (**UKSA**) in April 2010, with the mission of being "*responsible for all strategic decisions on the UK civil space programme and provide a clear, single voice for UK space ambitions*"[101]. From this moment on, government, industry, business and academia have worked together to create major success for the industry and the UK economy.

As a result of the collective action that has allowed those achievements and that the new Strategy itself led to in the space sector, the UK now features much more strongly on the global space map, attracting start-ups and inward investment alike[102]. Through ESA, the UK has the opportunity to invest in exciting new commercial and scientific missions[103], and the government increased its contributions to European Space Agency in two steps from £220 million per annum in 2010 to £300 million in 2015, responding to the need to reach the European average level of investments (£400 million) by 2020[104]. Britain has also improved its competitiveness with a number of reforms to regulation, insurance tax and licensing, and both a Smart Government Programme (SSPG) – with the objective to improve public services and increase their productivity – and the National Space Security Policy (NSSP) – to ensure continued access to space-based service – have been set up lately.

The UK has made smart choices and its rising space sector has been recognized globally, evidence of which it is attracting inward investments. It is well positioned for future success as well, which makes it absolutely realistic to reach the future ambitious goals that have been set. The *Case for Space 2015*[105] is clearly showing that the UK is on track in the realization of the motivated target to increase its national share of the global space economy **from 6% to 10% by 2030**, estimated to reach £400 billion[106]. In order to reach this share, the Space IGS has set the ambitious target of leading the actual size of the UK space economy of **£13.7 billion** to reach **£40 billion** by 2030, with an interim goal of £19 billion turnover by 2020[107]. In order to achieve this, it will now be necessary to accelerate the progress, identifying and developing new high-tech markets, pursuing initiatives to substantially grow exports and working to increase the UK's returns from Europe: new programmes will need indeed to address both domestic and overseas users, with the aim of i) grow the domestic market from £7 billion to £15 billion over the period, ii) dramatically grow the export market from £2 billion to £25 billion. To sum up, the actual focus for the extension of the UK space economy is strategically concentrated on: identifying opportunities, improving public sector efficiency, reforming regulation, growing exports and export opportunities, improving skills.

3.1.2. The actual organization of UK space activities and UKSA

The space activities in which UK is involved are the most diverse, from upstream to downstream, built on the framework of an efficient network of collaboration both domestically and internationally: it sets in a context of a **well-organized industry-government partnership**, focusing on creating the ideal

[101] https://www.gov.uk/government/organisations/uk-space-agency/about
[102] Space IGS, (2013). *Space Innovation and Growth Strategy 2014-2030. Space Growth Action Plan.*
[103] Examples of it: the development of the new 'Quantum' small and flexible geostationary satellites; the development and testing of the rover for Europe's 2018 ExoMars mission.
[104] Space IGS, (2013). *Space Innovation and Growth Strategy 2014-2030. Space Growth Action Plan.*
[105] Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency.* London Economics.
[106] Space IGS, (2013). *Space Innovation and Growth Strategy 2014-2030. Space Growth Action Plan.*
[107] Space IGS, (2013). *Space Innovation and Growth Strategy 2014-2030. Space Growth Action Plan.*

regulatory background needed to accommodate space-related industry's needs as well as encourage the broad space based research system. As mentioned already, the possibility to coordinate this whole big machinery lies in the effective space strategy, *Space Innovation Growth Strategy,* combined with the National space agency, *UKSA.* A series of bodies sets and leads important space programs pointing the targets' achievement, and the participation to the European Space Agency (ESA) is a fundamental resource for UK as well.

Among those bodies, some are engaged in operating directly in the space-guidance, such as 'official' organizations and departments of the government. Their main focus is on leading space-related decisions as well as assisting the space agency and strategy to set guidelines and priorities. Moreover, they support the realization of the targets through **coordinating all the players involved in the space economy.** Next to this group of bodies, there is another one composed by important organizations and particular big companies whose objective is to sustain businesses in their growth, assisting them with their space-related expertize, technologies and knowledge – often gained also with the help of a self-developed research department. Those big organizations are very important to integrate the lead of space agency, strategy, government and official space bodies, as well as to bring their plans and priorities to action and realization. Among those, most of which were established right after the rise of the Space IGS and UKSA: Satellite Applications Catapult, Aerospace Defence Security Space, TechUK.

Space Innovation and Growth Strategy (IGS): the strategy brings together a partnership of industry, UK Space Agency, Satellite Applications Catapult, Innovate UK, Knowledge Transfer Network (KTN) and academia. This team is working together aiming to identify opportunities and remove barriers to growth for the UK space sector. The IGS team was established in 2009, short before the following important decision of creating a National space agency, which was perceived as a fundamental instrument to reach the ambitious target that the strategy set: to increase the UK share of global space economy from 6% to 10% by 2030, leading the actual size of the UK space economy of £13.7 billion to reach £40 billion by 2030[108]. This forward looking goal highlights the long-term vision of the strategy, making it of fundamental importance to be able to continue to create the conditions for growth. This requires close government and industry cooperation by all IGS stakeholders.

In general, what Space IGS body perceives is:

i) the necessity of supporting industry and academia to help drive forward the science and technology;
ii) the necessity of a partnership with entrepreneurs with new business models that challenge us to think beyond traditional approaches[109].

UK Space Agency (UKSA): first established in April 2010 as an executive agency sponsored by the Department for Business, Energy & Industrial Strategy (BIS), this body is *responsible for all strategic decisions on the UK civil space programme and provides a clear, single voice for UK space ambitions*[110]*.* At the heart of UK efforts to explore and benefit from space, UKSA is responsible for ensuring that the UK develops a strategic capability in space-based systems, science, technologies and applications, with the aim of providing benefit to all citizens and to the national economy. The plan is to capture 10% of the global market for space by 2030, as set out in the Space IGS. UKSA is the fundamental body that

[108] Space IGS, (2013). *Space Innovation and Growth Strategy 2014-2030. Space Growth Action Plan.*
[109] Space IGS, (2015). *UK Space Innovation and Growth Strategy: 2015 Update Report.*
[110] https://www.gov.uk/government/organisations/uk-space-agency

represents guidance for all space activities, partners and stakeholders, avoiding the inefficient use of dedicated funds and loss of money, providing the maximization of the results and being careful to take all the opportunities that UK may get. Moreover, it plays a fundamental role of communication on an international level, providing coordination among all the space-based bodies and players i.e. organizations, agencies, companies or governments.

A short list of *concrete tasks* in which the agency works on include: co-ordinate UK civil space activity, encourage academic research, support the UK space industry, raise the profile of UK space activities at home and abroad, increase understanding of space science and its practical benefits, inspire its next generation of UK scientists and engineers, license the launch and operation of UK spacecraft, promote co-operation and participation in the European Space programme. What lies on the back of any statement, action and goal, is the care that this growth and space infrastructure is used effectively by all: the public, industry, academia and government.

Space Leadership Council: it is *the forum through which the space sector engages with Government*[111] and it has been a significant contributor to the success of the UK space policy since it was first established in 2010. The commitments of this body are mainly two: i) to assist ministers that have responsibility for space in developing their strategic policy; ii) to support actions by providing expert inputs to set alongside advice from officials. Assisting the government in creating the conditions needed for the space sector to grow, the council acts as a knowledge exchange forum and offers clear and strategic advice to Ministers related to, and aiming at, the integrated action of all the space involved bodies in terms of collaboration, investment decisions and policy setting.

Innovate UK: representing the UK's Innovation agency, it represents an executive non-departmental public body, sponsored by the Department for Business, Energy & Industrial Strategy. People, companies and partner organizations are the subjects the agency works with, driven by the guiding aim to find the science and technology innovations that will grow the UK economy. Their characteristic is to have a strong business focus, driving growth by working with companies to de-risk, enable and support innovation. However, they work in a strong relationship with Satellite Applications Catapult, which shows how often Innovate UK deals with the space industry.

UK's involvement in ESA: ESA, Europe's gateway to space with the mission of shaping the development of Europe's space capability and ensure that investments in space continue to deliver benefits to the citizens, was formed in 1975 from the merge of the European Launch Development Organisation (ELDO) and the European Space Research Organisation (ESRP)[112]. Ten nations were involved with its conception, and the United Kingdom was one of those. Since then, the benefits conceived by the UK through being involved in the ESA have been substantial, with a turnover of £243 million in 2012-13[113]. This explains the recent commitment to increase funding to the European Space Agency. ESA operates on the basis of geographical return, meaning it invests in each Member State, through industrial contracts for space programmes, an amount more or less equivalent to each country's contribution. Particularly, ESA's funding works in a precise structured way: each Member State needs to provide a mandatory amount of money, which will be spent on general space programs

[111] https://www.gov.uk/government/groups/space-leadership-council
[112] http://m.esa.int/About_Us/Welcome_to_ESA/What_is_ESA
[113] Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency.* London Economics.

and activities with the aim of benefitting the whole space economy; each Member State then also provides a second amount of money, whose entity is of national choice, that instead will be invested by ESA in the country of provenience itself, through industrial contracts for space programmes, and thus with direct benefits to the specific country. The UK's funding of ESA's optional programmes allows UK companies to bid for involvement in ESA's missions and UK companies exploit this option. UK companies have been very successful in winning contracts since it joined the organization in 1978, and the annual report of 2013 from ESA shows that the UK has a return coefficient of 0.99, meaning UK companies win contracts worth 99p for each £1 that is paid to ESA. The remaining penny is expended to come back to the individual companies through the knowledge acquired in the process and potential for further commercialization[114].

This system based on the division of funds in a mandatory part spent on the space economy as a whole, and a facultative part invested directly in the Member State's industry has proved to be very successful for a multi-national body with independent Members like ESA. In fact, space experts have exposed their conviction that this structure of space agency would be particularly beneficial for Australia, especially given its federal composition. It may be a potential proposal to suggest the rise of an Australian Space Agency with this kind of structure and functioning.

Government: one of the factors and acknowledgments that led to the described organization of the space activities is the awareness of the important role that the government plays in the sector. Without its support, most of what has been gained and achieved would not have been possible. Like many other governments, much of the UK's Government involvement in the space economy is based on the undertaking of scientific research and the procurement of services, of which remote sensing, defence and forecasting are just the most straightforward examples. The main and broader role for the government in the UK is to ensure that UK citizens and companies can access the benefits of space. In addition, the government has the unique capability of sustaining significant investments and massive funding for the enhancement of the space economy, which is often lacking among privates. An important section of those expenses is the funding of the ESA – whose size has increased and will increase further given the tangible and concrete benefits it allows for – and significant investments are also in R&D and defence.

Satellite Applications Catapult: this is a unique technology and innovation industry that focusses on helping organizations that realize the potentials of the space technology to fulfil their aspirations. Established three years later the Strategy was launched, the Catapult boosts UK's productivity by helping organizations harness the power of satellite based services. Results are new services brought on market and a stronger connection between industry and academia, allowing for new research on the ground more quickly. The Catapult's projects have global reach, focusing on what the end user needs to achieve: it applies its expertise to create new programs combining space-based information with its personal resources, and providing partners with powerful new tools and data platforms that are easy to access. Given the actual size of the UK space economy of £13.7 billion and the aim of reaching £40 billion by 2030, the Catapult targets to help generating 5 billion from that total. Collaboration, innovation and support to market's growth are the means by which the Catapult will bring its help for reaching the broader goal.

[114] ESA, (2013). *ESA Annual Report 2013.*

Aerospace Defence Security Space (ADS): as premier trade organization for companies in the UK Aerospace, Defence, Security and Space sectors, the ADS membership is made up of over 1,000 British registered businesses. Its set of key focus areas is comprehensive of supporting business development opportunities, which may often be linked to the space sector: this means ADS encourages investments in technology and innovation, influencing the policy debates of most importance to UK industries. The essential roles ADS plays are bringing industry and government together, and providing the industry with expertise, knowledge and development support.

UKspace: UKspace is the trade association of the UK space industry and focusses on representing the interests of its Members supporting them in growing and developing their businesses. The way the businesses are assisted is by being offered a wide range of information, advice, support and expertise from the UK space industry. UKspace aims to promote space providing, jointly with ADS and TechUK, a primary forum for industry dialogue with the UK government and with other national and international stakeholders. Moreover, acting as a leading voice of the UK space industry, it aims to actively contribute to the realization of the UK's target of growing the share of the global space market by promoting the best commercial, political and public environment for the UK space industry. UKspace also supports the space SME community and aims to stimulate greater awareness in government, media, public and other key stakeholders of the wide-ranging benefits achievable from one of the UK's most innovative, high skilled and value-adding sectors.

TechUK: with more than 950 Member companies generating all together approximately half of all the tech sector jobs in the United Kingdom, TechUK represents the companies and technologies that are *defining today the world that we will live in tomorrow*[115]. Its commitment is helping its members to grow by developing markets, relationships and networks, and by reducing business costs and risks. As the space sector needs ongoing new technologies and innovation, it represents one of their areas of expertise and focus – the direction in which they push companies' innovation.

With the purpose of outlying an extensive, non-exhaustive, list of the bodies and organizations that allow the success of UK's space economy, it is clear how important coordination, collaboration and a common leading goal are. Bringing all those bodies together generates a powerful flow of information and expertise, which has been possible especially thanks to the existence of a National space agency and Strategy. This, together with the support of the government, fuels the whole space machinery and explains its achievement of impressive results in few years. A common strategy, a central leading agency, and a system that allows exchange and sharing of expertise and knowledge are the key to success in the space economy.

3.1.3. The UK Space Agency: overall achievements & 2016-17 goals

Having a deeper look at the UK Space Agency, it is interesting to examine UKSA's establishment and its evolution. In particular, this chapter aims to outline: the goals set since the beginning and their evolution in time; the achievements since 2010; the future ambitions of UKSA. This is with the purpose of showing how the National space agency established and evolved, what has been possible to achieve and what will be, and how it organises itself in order to foster the growing UK space sector, delivering benefits to public services, science and innovation, national security and the wider economy.

[115] http://www.techuk.org/

Review of the space evolutionary path since UKSA: The transformation of the UK space activity started in 2010 with the rise of the Space Innovation and Growth Strategy. Shortly after, the UK Space Agency was established with the ambitious target to improve the national space revenues from 6% of the global volume to 10% by 2030. For this purpose, the Space Leadership Council and the Satellite Applications Catapult were formed as well, and the UK Space Gateway's development set in Harwell. Those decisions were intended to help the growth of innovation and its stimulation. The government increased its contributions to ESA up to £300 million in 2015, responding to the IGS call to reach the European average level of investment of £400 million by 2020. Through ESA programmes, the UK is investing in a range of exciting new commercial and scientific missions such as 'Quantum' and ExoMars. Actions resulting from IGS have improved UK competitiveness, with a number of reforms to licensing, insurance tax and regulation. Within the government, the Space for Smarter Government Programme (SSGP) was set up with the aim of improving the public services and their productivity. To ensure continued access to space-based services and make the UK more resilient to the risks of operating in space, the implementation of the National Space Security Policy (NSSP) has taken place. The IGS has identified lately new priority areas to capture fresh domestic as well as export markets, while it is vital to stimulate a vibrant SME environment and grow skills for all space related businesses. Looking at the future, the target to reach a £40 billion value space industry by 2030 is expected to be achieved thanks to the identification and development of new high-growth markets, pursuing initiatives to substantially grow exports.

UKSA's Corporate Plan 2016-2017: the UK Space Agency Corporate Plan 2016-2017 is the expression of the current *hot topics* in space and of what the UK space sector perceives as beneficial and worth investing in. In 2016 a National Space Policy (NSP) has been developed, and the Agency's portfolio of work for this year conveys the following themes in order to reach the ambitious major target set by the Space IGS[116]:

1. *Set out the priorities for the UK space sector addressing the need for continued economic growth, increased exports and industrial sustainability*. The 2016-2020 Civil Space Strategy will translate the National Space Policy into a plan of action for the civil space sector within the 5-year time frame.
2. *Run a National Spaceflight Programme to deliver a stepwise approach to establishing a commercial small satellite launch capability in the UK as set out in the National Space Policy. Initial capability will build on the operation of sub-orbital science spaceflights from a UK spaceport*. It is a governmental ambition for the UK to become the European hub for commercial spaceflight. We will start with sub-orbital operations which are a crucial stepping stone to establishing launch capability for small satellites from the UK.
3. *Set out and achieve the UK programme priorities for investment at the European Space Agency's Council of Ministers in December 2016*. The 2016 European Space Agency Ministerial (CMin 16) will be the most significant ESA ministerial meeting of this spending review period and the key opportunity to make substantive decisions that reflect government and industry priorities.

[116] UK Space Agency, an executive agency of the Department for Business Innovation and Skills, (2016). *UK Space Agency Corporate Plan 2016-2017.* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/515049/16_17_UKSA_Corp_Plan_Final.pdf

4. *Fund and monitor the progress of the development and delivery of the Agency's agreed national and international space programmes*. The Agency delivers a range of programmes and projects to benefit UK industry, academia and society, working at the local, national, European and global level.
5. *Through the Space for Smarter Government Programme (SSGP), facilitate the public sector in using satellite enabled services for smarter, more efficient operations, in addition to stimulating economic growth*. The SSGP enables the public sector to save money, innovate and make more effective policy decisions by using space technology and data.

As discussed in the National Space Policy (NSP), published in early 2016, government[117]: i) recognises that space is of strategic importance to the UK because of the value that space programmes deliver back to public services, national security, science and innovation and the economy; ii) commits to preserving and promoting the safety and security of the unique space operating environment, free from interference; iii) supports the growth of a robust and competitive commercial space sector, underpinned by excellent academic research; iv) commits to cooperating internationally to create the legal frameworks for the responsible use of space and for collaborating with other nations to deliver maximum benefit from UK investment in space.

UKSA's mission, vision and structure: In order to achieve its **mission** (Figure 6), the UK Space Agency will be investing in many projects over the next year which are meant and thought with the purpose to advance the UK space economy, built facilities in the UK and support UK scientists and industry to supply instruments and technology on space missions. In 2016-2017 these highlights will include[118]: an expected NovaSAR spacecraft launch; expansion of the Space for Smarter Government Programme; continuation of the International Partnership Programme (IPP); delivery of the UK flight instruments to ExoMars Rover and Solar Orbiter; the first science survey results and first data will be received.

[117] UK Space Agency, an executive agency of the Department for Business Innovation and Skills, (2016). *UK Space Agency Corporate Plan 2016-2017.*

[118] UK Space Agency, an executive agency of the Department for Business Innovation and Skills, (2016). *UK Space Agency Corporate Plan 2016-2017.*

UK Space Agency	
Vision 'the what'	A £40 billion a year space economy by 2030
Mission 'the how'	Deliver an excellent space programme with the maximum economic, scientific and policy benefit for the UK
Outcomes 'the what'	1. We will have clear and established space policies and policy positions 2. UK space policies and policy positions will be effectively represented at a national and international level 3. The UK will maintain and grow its national capability in space 4. UK investment in civil space will be effective, targeted and will deliver tangible economic or scientific benefit 5. The criticality and utility of the space sector to science, enterprise and economic growth will be increasingly understood by policy makers, commerce and the general public 6. The UK Space Agency will have the operational capability, capacity and culture to deliver the Civil Space Strategy
Pathways 'the how'	1. Growth through new opportunities 2. Growth from export 3. Innovation supporting growth 4. Science to underpin growth 5. Education for growth 6. Growth through smarter government
KPIs 'the measures of success'	1. Set out the priorities for the UK Space Sector for the UK space sector addressing the need for continued economic growth, increased exports and industrial sustainability 2. Run a National Spaceflight Programme to deliver a stepwise approach to establishing a commercial small satellite launch capability in the UK as set out in the National Space Policy. Initial capability will build on the operation of sub-orbital science spaceflights from a UK spaceport 3. set out and achieve the UK programme priorities for investment at the European Space Agency's Council of Ministers in December 2016 4. Fund and monitor the progress of the development and delivery of the Agency's agreed national and international space programmes 5. Through the Space for Smarter Government Programme, facilitate the public sector in using satellite enabled services for smarter, more efficient operations, in addition to stimulating economic growth

Figure 6. "UK Space Agency overall organization with vision, mission, outcomes, pathways and measures of success". Source: UK Space Agency Corporate Plan 2016-2017.

In order to achieve its **vision** (Figure 6), the UK Space Agency is focusing on making the most efficient use of investments, regulation, national programmes, education and communication, and its bilateral and multi-lateral arrangements and partnerships – for example with ESA and the EU[119].

- *Investments*. targeting areas that have the greatest potential, investments lead to: i) provide **coherence between investment in long-term basic research and near term-applications** in order to harness the skills of universities, national facilities and industry to create a strong national capacity; ii) build **links between industry and the research community**, and **between government users and those who deliver space capability**[120]; iii) **sell UK capability abroad** and **attract inward investments** by promoting the UK as a leading business-friendly location for starting and growing a space company as well as a centre of innovation for products and services that exploit space systems.
- *Regulation*. With the aim of creating a regulatory environment that supports the space sector while meeting international obligations and ensuring that the UK is a trusted space-faring

[119] UK Space Agency, an executive agency of the Department for Business Innovation and Skills, (2016). *UK Space Agency Corporate Plan 2016-2017*, pp 10-12.
[120] These include industry, academia, Innovate UK and the Research Councils.

nation, the agency is: i) undertaking a suite **regulatory reform**; ii) building on **insurance premium tax exemption** for UK space operators; iii) considering a regulatory framework for high resolution satellite data, a revised fee structure for the UK Outer Space Act (OSA) applicants and options for satellite constellation.

- *National programmes*. Providing the link between UK industry and the mission partner, the UK Space Agency co-founds projects with organizations such as ESA, NASA, DfT, UK industry and international governments.
- *Education and communication.* Communication and education programmes are structured in a way to increase the general public understanding of space, its practical benefits and grow the next generation of the UK scientists and engineers. An example is represented by **Team Peake's six-month mission** to the ISS, which clearly is a source of inspiration for the population.
- *European Space Agency.* **Attending to approximately 60 formal ESA meetings every year and many more informal meetings and technical workshops**, the UK Space Agency channels roughly three quarts of its investment budget through ESA to allow the UK industry and academia to work in collaboration with Europe and develop world leading technologies, services and missions.
- *European Union.* The total **funding allocated to EU space activities** is increasing (currently around £11 billion), and the UK Space Agency supports programs like: EU's satellite navigation program 'Galileo' and 'European Geostationary Navigation Overlay Service'; the Earth Observation programme 'Copernicus'; 'Horizon 2020' programme.

When analysing the **structure** of the UK Space Agency, the breadth of its agenda, its specialist nature and its size (it currently employs approximately 80 full-time equivalents staff[121]) require skilled staff working across multiple work-streams. The team includes secondees from other organizations and industries with a vast range of expertise and knowledge. The organization of UKSA is based on four directorates: Policy, Growth, Programmes and Operations. Within this structure[122]:

- *Advice and governance for the CEO and Agency*: the CEO receives advice and guidance from the Agency Steering Board as well as risk control and assurance from the Agency Audit Committee; the Minister receives high level policy and strategic advice from the Space Leadership Council; the Executive Board is advised through a suite of subject-matter-expert advisory committees.
- *The Business and Science Group*: within the BIS Department, it acts as the Agency's sponsor and the Agency is accountable to the sponsor team for the success of its objectives. BIS determines the framework within which the Agency's objectives and targets are set. The Agency is however responsible for its own policy development, working closely with its BIS partners to ensure consistency and coherence with BIS policies.
- *Space Leadership Council*: reformed in January 2016, the new council membership will focus their activity around growth (which is a main IGS recommendation), and the government activity is required to support sector growth.

[121] UK Space Agency, an executive agency of the Department for Business Innovation and Skills, (2016). *UK Space Agency Corporate Plan 2016-2017*, p 9.

[122] UK Space Agency, an executive agency of the Department for Business Innovation and Skills, (2016). *UK Space Agency Corporate Plan 2016-2017*, pp 6-7. See more about the UKSA Advice and Governance for the CEO and Agency at: *UK Space Agency Corporate Plan 2016-2017*, p 7 Table.

The UK Space Agency has also an administration allocation which is part of the overall BIS administration budget. This budget includes all the costs of providing policy, funding and regulation functions as well as all back-office costs.

3.1.4. The actual size of UK space economy

The UK, as one of the leaders in space thanks to its consistent growth over time, has reached international recognition and gained a relevant share within the world's picture of the space economy. Its actual size is behind only few other countries of its dimension, being estimated in *The Case for Space 2015* to be worth US$256.2 billion in 2013, equivalent to £155 billion. This is the OECD estimate that is outlined in *The Space Economy at a Glance 2014*. Besides this one, another leading measure of the space economy is available in the Space Foundation's *The Space Report 2014*, that values global space activity in 2013 at $314.17 billion, equivalent to £190 billion. The difference between estimates underlines the problems associated with estimating the size of the space economy: the OECD excludes ancillary services and some value-added services such as fleet management or Earth observation services. So, depending on which measure is used, the UK captures between 6.3% and 7.7% of the global space economy market.

Turnover: the space-related turnover is a good indication of the size of the space economy, therefore commonly used in many studies and reports. The UK space economy was valued at an aggregate turnover of **£13.7 billion** in 2014-15, of which the upstream segment accounted for £1.7 billion, while the downstream segment was £12 billion (88% of total industry). This represents a rate of growth of 6.5%, which however has significantly slowed down after reaching an average of 8.5% in 2012-13. Taking a longer perspective, the UK space economy has more than trembled in real terms since the turn of the millennium, growing at an average rate of 8.1% per annum since 1999-2000.

Analysing the space economy turnover by segment reveals substantial differences in size. At £10.1 billion, space applications is by far the largest segment, accounting for 73.7% of the turnover – dominated by Direct-To-Home (DTH) satellite television provision (52% of total space income). Space Operations is the second largest segment (15.1%) with space manufacturing (8.4%) at third and ancillary services accounting for only 2.9%[123].

Size of Space Economy								
Turnover								
Turnover (£ billion)			Turnover by segment (% of tot.)				Turnover Growth Rate (%)	Share of Global Space Economy
Total	Upstream	Downstream	Space Applications	Space Operations	Space Manufacturing	Ancillary Services		
£13.7	£1.7	£12	73.30%	15.10%	8.40%	2.90%	6.50%	6.3% -7.7%

Export intensity: the UK space economy has a strong home market focus, but it has enjoyed success in exports and was generating 31% of turnover abroad (**£3.6 billion**) in 2012-13. Thus, the majority of the UK space-related sales continues to happen in the home market, but it is interesting to notice that

[123] Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency.* London Economics; Sadlier G. et all., (2016). *Summary Report: The Size and Health of the UK Space Industry*. London Economics for UK Space Agency.

– as BSKYB dominates UK space turnover but has only small exports to Ireland – excluding BSKYB the UK space economy reached an export share of 62.3% in 2012-13. The main market outside Europe is clearly represented by the rest of Europe, valued at £1.5 billion[124].

R&D investment: being **£454 million** in 2012-13[125], the total UK space economy expenditure on R&D represented 4.1% of the total space turnover, of which the space manufacturing and ancillary services segments capture the majority. Looking at R&D investments in terms of share of GVA, it captures 9.8% of the total[126].

3.2. Effects of the UK space activity: daily, societal and economic benefits

"Space is an extraordinary and exciting business. It impacts virtually all aspects of our lives, in an unobtrusive but crucial way. It is a key enabler that is critical for our national economy and government departments understand that space delivers secure and efficient outcomes for UK citizens."[127]

UK has achieved a significant involvement in the space economy through its government active support, the convergence of its efforts towards a sole vision, the international collaboration it experiences, and the highly qualified expertise it has developed. A multilateral collaboration among all the space stakeholders, these being universities, research organisations, industries and government, has lead the UK space activity to gain truly significant benefits. Figures and numbers speak for themselves in all of the economic, social and daily lives domains, and will be outlined in this chapter with the intention to highlight how strong and influential the space activity has grown in the UK.

3.2.1. Actual economic benefits of the UK space activity

In order to measure the national economic contributions of UK's space sector, a number of indicators will be analysed in depth as regarded to be good pointers of the economic effects. Measurements acknowledged to be appropriate are value-added, employment, and labor productivity – which will be studied in their direct, indirect, and induced impacts, with particular attention on the multiplier effect.

Value-added: contribution to national GDP. The value-added represents a good indication of the economic impact of an industry through its contribution to the national GDP (approximated by Gross Value Added (GVA)). The direct value-added accounted for £5.1 billion in 2014-15 (0.27% of total UK GVA),[128] equivalent to 43.4% of turnover. The value-added multiplier was estimated to be **1.97**,

[124] Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency.* London Economics.
[125] Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency.* London Economics, p 28 Table 18.
[126] Figures relative to 2012-13, from: *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency.* London Economics.
[127] Space IGS, (2015). *UK Space Innovation and Growth Strategy: 2015 Update Report.*
[128,129] Sadlier G. et all., (2016). *The Size and Health of the UK Space Industry.* UK Space Agency, London Economics – December 2016; Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency.* London Economics.

meaning that for every 1 pound spent in the space industry it generates an additional £0.97 worth in the supply chain and supporting sectors. Being the direct impact of industries on GDP £5.1 billion, the additional multiplier impact was £5 billion (2.5 from indirect impact, 2.5 from induced impact). Thus, **total** industry's value-added contribution to GVA accounted for **£10.1 billion**.

Having a closer look into how the £5.1 billion of direct value-added is allocated across segments, as for turnover, the majority (71.26%) of UK space GVA was generated in the space applications segment, slightly less than the 73.3% of income accounted for by the segment. With 12.7% space operations account for the second largest segment, while space manufacturing is the third one (5.5% of GVA). Ancillary services instead contribute only 2.9%[129].

Economic Impact of Space Economy										
Value-Added										
Direct Value-Added		Direct Value-Added by Segment (% of tot.)				Value-Added Multiplier	Additional **Multiplier** Impact			**Total** Value Added (direct + multiplier)
£ billion	% of total UK GVA	Space Applications	Space Operations	Space Manufactur.	Ancillary Services		Indirect	induced	Total (Indirect + Induced)	
£5.1	0.27%	71.26%	12.7%	5.5%	2.9%	1.97	£2.5	£2.5	**£5**	**£10.1**

Employment: contribution to job creation. Employment represents another good indication of the economic impact of an industry through the number of people employed by the space sector. The direct employment accounted for 38,522 jobs in 2014-15 (0.12% of total UK workforce). The employment multiplier was estimated being **2.96**, meaning that the activity of 100 employees in the space industry supports 196 additional employees among suppliers and in other economic sectors. Being the direct employment in the space industry supporting 38,522 jobs, the multiplier impact supported 75,344 additional UK jobs (40,296 from indirect, 35,048 through induced). Thus, total UK-based employment supported by the activities of the UK space industry was **113,866 employees**[130].

The direct employment breaks down to 8,575 jobs supported in the upstream segment and 29,947 jobs supported downstream in 2014-15, while the UKSA currently employs 80 full-time equivalent (FTE) staff[131]. Unsurprisingly, analysing the space industry employment by segment reveals that the space application segment dominates again, accounting for 69.3% of total space industry employment. Space manufacturing (17.8%) employs a greater staff than space operations (8.4%), with ancillary services making up a small but important workforce (4.5%)[132].

[130] Sadlier G. et all., (2016). *The Size and Health of the UK Space Industry.* UK Space Agency, London Economics – December 2016; Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency.* London Economics.

[131] UK Space Agency, an executive agency of the Department for Business Innovation and Skills, (2016). *UK Space Agency Corporate Plan 2016 -2017*, p 6.

[132] Sadlier G. et all., (2016). *The Size and Health of the UK Space Industry.* UK Space Agency, London Economics – December 2016; Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency.* London Economics.

Economic Impact of Space Economy										
Employment										
Direct Employment		Direct Employment by Segment (% of tot.)				Employm. Multiplier	Additional **Multiplier** Impact			**Total** Employm. (direct + multiplier)
jobs	% of total UK Workforce	Space Applications	Space Operations	Space Manufactur.	Ancillary Services		Indirect	induced	Total (Indirect + Induced)	
38,522	0.12%	69.3%	8.4%	17.8%	4.5%	2.96	40,296	35,048	**75,344**	**113,866**

Labor Productivity: contribution to total productivity. Labor productivity represents one more good indication of the economic impact calculated as average GVA per employees. The labor productivity was standing at **£133,233** in 2014-15[133]. However, whilst a useful and informative metric, labor productivity does not tell the whole story. Activities that rely on a large capital stock to deliver goods and services may present large labor productivity estimates as fewer employees are required. Similarly, some activities such as applied research and policymaking, regulation and oversight enable creation of value elsewhere in the value chain. Indirect and induced effects are therefore not numerically representable, but those impacts are certainly of great significance.

Labor productivity varies across value chain activities again. Space operations in 2014-15 had the greatest GVA per employee (£199,424), followed by space services (£163,482) and space applications (£137,832). The segment in which labor productivity was lowest was space manufacturing, accounting for a generation of £75,950 per employee[134].

Economic Impact of Space Economy										
Labour Productivity										
Direct Productivity		Labor Productivity by Segment (£)				Product. Multiplier	Additional **Multiplier** Impact			**Total** Product. (direct + multiplier)
GVA per employee	% of tot. UK Prod.	Space Applications	Space Operations	Space Manufactur.	Ancillary Services		Indirect	induced	Total (Indirect +Induced)	
£133,233	NA	£137,832	£199,424	£75,950	£163,482	NS*	NS	NS	NS	NS

**NS = not significative.*

Being value-added, jobs creation and productivity just a few measures helping to capture the economic significance of UK's space activity, what results is an undeniable contribution of the space sector to the national economy. Leaving aside those measures and moving towards a more practical and concrete vision, **increased industrial activity**, **cost efficiencies** and **productivity gains** are some of the economic returns on space investments, with several space applications reaching technical maturity and becoming the source of new commercial downstream activities. A research conducted by OECD has shown that the economic impacts that have been analysed so far can be categorized in four different segments[135]:

[133] Sadlier G. et all., (2016). *The Size and Health of the UK Space Industry.* UK Space Agency, London Economics – December 2016.

[134] Sadlier G. et all., (2016). *The Size and Health of the UK Space Industry.* UK Space Agency, London Economics – December 2016; Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency.* London Economics.

[135] Cohendet P. *Evaluating the Industrial Indirect effects of Technology Programmes: the Case of the European Space Agency (ESA) Programmes. B.E.T.A*, chapter 11. Université Louis Pasteur, Strasbourg, France.

- Creation of **new commercial products and services** (including indirect industrial effects from space industry contrasts, meaning new exports or new activities in diverse economic sectors).
- **Productivity/efficiency gains** in diverse economic sectors.
- **Economic growth** regionally and nationally.
- **Cost avoidance**.

3.2.2. Actual societal & daily benefits of the UK space activity

When talking about the effects of the UK space economy, it is not just the economic contribution that should be thought of – even though this provides a very concrete picture. 'Space technologies are everywhere, and their applications stretch far and wide. Applications of space range from the universally recognised navigation, meteorological forecasting, and broadcast of live television to the less-known applications in agriculture and a whole host of professional transport applications through to uses of space services for track maintenance, oil & gas extraction and synchronization of utility network. Additional applications in the realm of policy-making, and disaster monitoring and relief are discussed alongside insurance and finance applications where space services serve as vital inputs, and military applications of space services'[136]. In the UK, the ***span of influence*** of space-enabled applications, and thus of space knowledge and satellite services can be summarised in a series of areas[137]:

- *Communications*: digital telecommunications, live broadcasts, and broadband to aircraft and ships allow for **postal services**, **Internet-of-things** (IoT), **Machine-to-Machine** (M2M), and **seamless personal communication** – as alternative to the previous less efficient fixed broadband provision solution.
- *Emergency services*: maritime search and rescue, and persistent surveillance allow for **ambulances**, **fire and rescue services**, and **disaster emergency response** – as alternative to mere post police intervention.
- *Transport*: polar infrastructure, maritime surveillance, driverless cars, Location-Based Services (LBS), and Unmanned Aerial Systems (UAS) allow for **aviation, maritime and land transport**, **professional and leisure navigation** (road, water, air, pedestrian), and **traffic management** – as alternative to warehousing & storage.
- *Health*: weather forecasting (pollen and other health warnings) and new medical technological devices allow for **prevention and mitigation of the outbreak of disease**, and **remote medical support** – as alternative to the previous linear health & social care.
- *Government*: secure satellite communications and Galileo PRS allow for **Central Government** (including Defence), **environmental policy**, and **smart cities** – as alternative to the previous regional and local government.
- *Financial services*: carbon monitoring allows for payment clearing & settlement services, markets & exchanges, and insurance – as alternative to previous public finance.
- *Water*: weather forecasting (early flood and drought warning) allows for **flood risk modelling** – as alternative to the previous time and resource consuming solutions such as portable water supply and wastewater services.
- *Food*: climate services and precise agriculture allow for **food production and security weather forecasting** – as alternative to previous simple distribution and retail.

[136] Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency*. London Economics, p 63.
[137] Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency.* London Economics. p 65.

- *Energy*: weather forecasting (demand modelling), power from space, and off-shore oil & gas exploration allow for **electricity, gas and fuel infrastructure**.

This list of areas of influence of the space technologies highpoints their capability to produce an **incredibly valuable series of social and daily effects that actually have revolutionised our life**. Naming them all would mean going through almost all the services of the society, and pretending to write a never-ending list as well. What is worth highlighting is that those space technologies, which can be considered General Purpose Technologies, influence those areas of the national society through a vast range of ***spillover*** (or catalytic) effects, which can be distinguished between end-user benefits, and R&D and Knowledge spillovers (as described in the first chapter). As the range of applications and users of space enabled services are wide and diverse, following London Economics (2015) structure the **end-user spillovers** can be categorised according to the markets they influence. Instead, the **R&D and Knowledge spillovers** can be considered as a broad intellectual value that spreads widely across every sector and market. The wider effects coming from spillovers determined by the space industry are thus identifiable, or at least comprehensive, of a countless list of societal benefits, as well as improvements affecting everyday activities, daily life and its quality.

In order to scale the significance of different space technologies and applications and their contribution to society and everyday life, an overview of most of the national benefitting sectors has been summarised by the London Economics in terms of turnover, value-added and employment[138].

[138] Sadlier G. et all., (2015). *The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency.* London Economics, p. 66. '*Valuation of sectors supported by space-enabled services'* refers to all sectors covered by the ONS Annual Business Survey and other sources.

Valuation of *sectors* supported by space-enabled services*				**Typology of *spillover* effects**	
Sector	Turnover (£ million)	Value-Added (£ million)	Employment ('000)	*End-user* spillovers (division per markets)	
Agriculture, forestry and fishing	4,443	1,804	41	market	user categories
Mining and quarrying	51,623	25,064	66	Security, safety and resilience	Maritime geospatial services, Secure satellite communications, Galileo PRS, Polar infrastructure for shipping & exploration, Polar infrastructure for shipping & exploration, Disaster & emergency response, Space robustness services.
Manufacturing	522,106	156,975	2,483		
Electricity, gas, steam and air conditioning supply	111,254	24,731	129		
Water supply, sewerage, waste management, and remediation activities	33,713	16,808	165		
Construction	204,282	79,900	1,301	Game changing services	Low-cost access to space, Persistent surveillance, Power from space, Driverless vehicles.
Wholesale and retail trade; repair of motor vehicles and motorcycles	1,487,353	153,384	4,803		
Transport and storage	156,850	70,728	1,205	Climate and environmental services	Insurance and finance, Agriculture and food security, Environmental services, Weather forecasting.
Accommodation and food service activities	76,412	38,096	1,973		
Information and communication	198,895	99,656	1,118	More efficient public sector services	Transport management, Smart cities/urban services for local government, Energy (and other critical) infrastructure services.
Finance	-	124,500	-		
Real estate activities	54,250	36,789	540		
Professional, scientific and technical activities	228,944	129,404	2,055	E-connectivity	Direct-To-Home TV, Fixed broadband, Broadband to ships and aircraft, Ubiquitous m2m, Location based services, Managing unmanned vehicles and hosted payloads, Seamless personal communications.
Administrative and support service activities	188,084	95,356	2,272		
Public Administration and Defence; compulsory social security	-	87,094	-		
Education	34,899	15,777	1,106		
Human health and social work activities	47,629	30,152	1,686	*R&D and Knowledge* spillovers	
Arts, entertainment and recreation	120,222	22,518	661		
Other service activities	31,192	15,437	547	On the one hand, space activities import basic technologies that have previously been developed in other sectors such as defence or aeronautics. On the other hand, space applications and space-born technologies spillover to other sectors.	
Activities of households	-	-	-		
Total	**3,552,151**	**1,224,173**	**22,151**		

Figure 7. "Qualitative and quantitative evaluation of the social & daily benefits of the UK Space Agency". Source: The Case for Space 2015. The impact of space on the UK economy. A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency. London Economics (2015).

3.2.3. The relevance of the Government engagement in the space economy

One of the factors that led UK to its actual efficient organization of the space activities is the awareness of the important role that the government plays in the sector. Without its support, most of what has been achieved would not have been possible. Like many other governments, much of the UK's government involvement in the space economy is based on the procurement of services (of which defence, remote sensing, and forecasting are just the most straightforward examples), the undertaking of scientific research, and the investments made in the sector.
Classical economic theory tells that the underlying rationale for public space investment is founded in market failure, which refers to where the market has not and cannot of itself be expected to deliver an efficient outcome, and the intervention that is contemplated will seek to redress this[139]. The foremost rationale for public space investment, and thus the key identified market failures underpinning the need of the government's intervention to influence supply and demand for space-enabled applications may be summarised by the following arguments:[140]

- Space is a largely externality-inducing industry, and governments or regulatory authorities are therefore needed to manage these **externalities** to a socially optimum outcome.
- Enable the provision of space services, which can be considered to be a **public good**.
- Manage the risk of **under-investment** in the infrastructure-forming, yet R&D-intensive, upstream segment of space economy value chain that enables the downstream applications.
- Facilitate **long and costly development** programmes, and manage high-risk programmes, for which finance and/or insurance might not be provided by the private market.
- Support **R&D** programmes, which can generate more spillover benefits, so often do not provide an appropriate incentive for private investors.

Unlike many other sectors, space may be a special case of science and innovation. Factors supporting this view relate to the unique and distinctive aspects of the space industry, the wider space economy and space science and technology, and the knowledge created[141]. However, the cutting edge technology and knowledge come at the cost of Research & Development funding, with both developmental and technical skills. Despite space investments tend to have a distinctive high-risk high-reward profile, attracting appropriate levels of investment can be a problem for businesses in the space sector, and space typically requires large amounts of invested capital to make an investment worthwhile, resulting in financial gap[142].

As a category as a whole, investments have one basic rule: give back a satisfactory return. This is the sufficient and necessary condition on the basis of which investments are made. This is also true for public investments. In fact, the government funds space activities only when estimated to give a high enough rate of return, which can be defined as 'the social net benefit/cost from the investment of public funds, measured as the impact on aggregate domestic economic output (GVA, producer

[139] HM Treasury, (2003). *The Green Book: Appraisal and evaluation in Central Government Treasury Guidance*, p 11.
[140] Sadlier G. et all., (2015). *Return from Public Space Investments. An initial analysis of evidence of the returns from public space investments.* London Economics, p v.
[141] A list of those distinctive aspects, wider space economy and knowledge created can be found in the: Sadlier G. et all., (2015). *Return from Public Space Investments. An initial analysis of evidence of the returns from public space investments.* London Economics, p 16-18. A few examples are: being a highly research intensive industry, employing highly skilled individuals, being a very high growth sector – also thanks to its export-oriented aptitude.
[142] Sadlier G. et all., (2015). *Return from Public Space Investments. An initial analysis of evidence of the returns from public space investments.* London Economics, p 18.

surplus) and wider benefits (knowledge spillovers, consumer surplus, environment, health, safety, etc.) net of deadweight and displacement effects relative to the quantum of public investment' [143]. In other words, the **public rate of return** can be seen as the *multiplier* of an investment, and can be split (as for previously analysed measures) in *direct* and *spillover* effects – with spillover returns from public investment in science and innovation being particularly significant, **typically 2 or 3 times larger than direct returns**. UK's public investments in space can be categorised in two main 'streams', both evidencing the uncommonly substantial impact of government's space-related funding[144]: 1) ESA membership, which presents a direct rate of return of £3-£4, plus a spillover rate of return of £6-£12 per £1 of public investment; 2) space science and innovation investments, whose impact is affected by a higher degree of variation depending on the space applications itself: Earth Observation presents a direct rate of return of £2-£4, plus a spillover rate of return of £4-£12 per £1 of public investment; Telecoms presents a direct rate of return of £6-£7, plus a spillover rate of return of £6-£14 per £1 of public investment; Navigation presents a direct rate of return of £4-£5[145], plus a spillover rate of return of £4-£10 per £1 of public investment.

Impact of Government Investment in the Space Economy			
Public Rate of return			
		Direct impact	**Spillover** impact
ESA membership		£3-£4	£6-£12
Space Science and Innovation	Earth Observation	£2-£4	£4-£12
	Telecoms	£6-£7	£6-£14
	Navigation	£4-£5	£4-£10

These values compare well with a study that has been developed by the OECD, that found 'that revenues generated by institutional investments in space over a decade have led to a multiplier effect of between 4.5 and 6.2 when considering the value chain and indirect effects only, and between 8.5 and 9.7 including the societal effects'[146]. Overall, those figures are the **proof of the contribution of public spending on space** and support the significance of government's intervention by allowing for concrete social and substantial economic benefits.

3.3. Comparison before-after UK Space Agency's establishment

The influence of the UK Space Agency's establishment is recognized in the theoretical domain; it is experienced in the everyday lives; it is appreciated by businesses and the economy as a whole gains from it. Values simply serve as evidence of this truth.

[143] Sadlier G. et all., (2015). *Return from Public Space Investments. An initial analysis of evidence of the returns from public space investments.* London Economics, p 4.
[144] Sadlier G. et all., (2015). *Return from Public Space Investments. An initial analysis of evidence of the returns from public space investments.* London Economics.
[145] Navigation: the values £4-£5 are direct plus partial spillover impact. It has not been possible to perfectly separate and disaggregate the spillover rate of return from the direct one.
[146] Võõras M. et all., (2013). *Ex ante Assessment of Economic and Societal Effects induced by Space Investments in a Small Emerging Space Country*, p 1.

The decisions taken across the years regarding the UK's involvement in space have each contributed to the successful position the UK space economy has now reached.

Although the entire stream of choices made has led to the noteworthy success of UK's space economy, specific individual decisions can be identified and highlighted in terms of their decisive impact: the establishment of the UK Space Agency, together with a national unified space strategy, between 2009 and 2010 is *undoubtedly* one of these – *probably* the most relevant. The whole space economy accelerated from that moment on, and growth rates increased. This resulted in greater confidence, and businesses and the government became more willing to invest and increase their involvement in the sector. Together with everything else the rise of the National space agency in the UK implied (as discussed in precedent chapters), by increasing its space activity and exploiting the available opportunities, the country developed new capabilities and found innovative ways to use space technology.

In the following section of this report these improvements will be evaluated, comparing the situation 'before' the establishment of the National space agency, and the same picture 'after'. This **before-after comparison** will contrast the *size* and the *economic impact* of the UK's space economy shortly 'before' the existence of UKSA (2006-07) and five years 'after' UKSA was established (2014-15). In particular, the same *measures*, that capture the size and economic impact that have been used in the previous chapter will be used, allowing for a **direct assessment of the economic impact of the UK Space Agency**. Thus, the measure used to evaluate the size of the space economy is space-*related turnover*; the measures used to evaluate the economic impact of the space economy are the *value-added* (as a contribution to national GVA), *employment* (as a contribution to jobs creation) and *labor productivity* (average GVA per employee). A deeper analysis of the improvements that the UKSA has contributed to will be provided through the estimation of growth rates over the period, and the numerical differences between two points in time. In order to ease the reading and comprehension, the 'situation before UK Space Agency (2006-07)' will be referred to as 'before', and the 'situation after UK Space Agency (2014-15)' will be referred to as 'after' from now on.

Size of the space economy. In order to efficiently make an impact assessment of the UK Space Agency on the *size* of UK's space economy, the *turnover* of the space industry is measured for the two points in time: 2006-07, as reference point for 'before' UKSA's establishment; 2014-15, as reference point for 'after'.

Before UK Space Agency (2006-07): the UK space economy was valued at a 'before' aggregate turnover of **£5.9 billion**, of which the upstream segment accounted for £0.83 billion, while the downstream segment accounted for £5.08 billion[147].

After UK Space Agency (2014-15): the UK space economy was valued at an 'after' aggregate turnover of **£13.7 billion**, of which the upstream segment accounted for £1.7 billion, while the downstream segment accounted for £12 billion.

[147] Oxford Economics, (2009). *The Case for Space: the impact of Space Derived Services and Dat*, pp 7,9,11.

Those values show that between 2006-07 and 2014-15 there has been a gain in total space-related turnover of £7.8 billion, which can be identified with a cumulative average growth rate (CARG[148]) of 11.10% over the eight-year period.

Size of Space Economy: before-after comparison			
Turnover	**Total** (£ billion)	Upstream (£ billion)	Downstream (£ billion)
'Before' UK Space Agency (2006-07)	£5.9	£0.83	£5.08
'After' UK Space Agency (2014-15)	£13.7	£1.7	£12
Difference	**£7.8**	£0.87	£6.92
CAGR (Cumulative Average Growth Rate) over the 8 years	**11.10%**	9.38%	11.34%

'Before' % of UK GDP (2007) - Turnover[149]	UK GDP (US$ billion)	3,063	UK GDP (£ billion*)	2,347.98	**% of GDP**	**0.251%**
'After' % of UK GDP (2015) - Turnover	UK GDP (US$ billion)	2,861	UK GDP (£ billion)	2,193.12	**% of GDP**	**0.625%**

**Exchange rate 07/08/2017*

Economic impact of the space economy. In order to efficiently make an evaluation of the *economic impact* of the UK Space Agency on UK's space economy, the *value-added*, the *employment* and the *labour productivity* are measured in two points of time: 2006-07, as reference point for 'before' UKSA's establishment; 2014-15, as reference point for 'after'.

Value-Added: contribution to national GDP. Representing a good indication of the economic impact of an industry through its contribution to the national GDP (approximated by GVA), the space-related value-added is used for the purpose of making an assessment of the UK Space Agency's impact on the national space economy.

Before UK Space Agency (2006-07): the direct value-added accounted for a 'before' contribution to UK's GVA was **£2.76 billion**. The additional multiplier impact on GVA was £2.86 billion, of which £1.735 was produced by indirect impact and £1.125 from induced impact. Hence, the total 'before' value-added was **£5.62 billion**.

After UK Space Agency (2014-15): the direct value-added accounted for an 'after' contribution to UK's GVA was **£5.1 billion**. The additional multiplier impact on GVA was £5 billion, of which £2.5 was produced by the indirect impact and £2.5 from induced impact. Hence, the total 'after' value-added was **£10.1 billion**.

[148] CAGR is the Cumulative Average Growth Rate. It calculates the average growth rate over a specified period of time. The formula is: *{[(final value/initial value) ^1/8] -1}* where 'final value' is in this report equivalent to 'After', and 'initial value' to 'Before'.

[149] GDP data from The World Bank website database: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=GB

Those values show that between 2006-07 and 2014-15 there was a direct **gain in UK's GVA of £2.34 billion**, which translates to a cumulative average growth rate (CARG) of 11.21% over the eight-year period. The additional multiplier impact was about the same amount (£2.14 billion), leading to a total value-added improvement of £4.48 billion and an overall CAGR of 20.62% over the eight years.

Economic Impact of Space Economy: before-after comparison					
Value -Added	**Direct** Value-Added (£ billion)	Additional **Multiplier** Impact (£ billion)			**Total** Value Added (direct + multiplier)
		Indirect	induced	Total (Indirect + Induced)	
'**Before**' UK Space Agency (2006-07)	£2.76	£1.735	£1.125	£2.86	£5.62
'**After**' UK Space Agency (2014-15)	£5.1	£2.5	£2.5	£5	£10.1
Difference	**£2.34**	£0.765	£1.375	**£2.14**	**£4.48**
CAGR (Cumulative Average Growth Rate) over the 8 years	**11.21%**	-3.29%	4.06%	**9.98%**	**20.62%**

'Before' % of UK GDP (2007) - Value-Added (Tot.)	UK GDP (US$ billion)	3,063	UK GDP (£ billion)	2,347.98	**% of GDP**	**0.239%**
'After' % of UK GDP (2015) - Value-Added (Tot.)	UK GDP (US$ billion)	2,861	UK GDP (£ billion)	2,193.12	**% of GDP**	**0.461%**

**Exchange rate 07/08/2017*

Employment: contribution to job creation. Representing a good indication of the economic impact of an industry through the number of people employed by the space sector, the space-related employment is another valuable measure for the purpose of making an assessment of the impact on the national space economy.

Before UK Space Agency (2006-07): direct employment accounted for **19,097** jobs. The additional multiplier impact on employment was 48,746 jobs, of which 35,180 were produced through the indirect impact and 13,566 through the induced impact. Hence, the total 'before' UK-based employment supported by the activities of the UK space sector accounted for 67,843 employees[150].

After UK Space Agency (2014-15): direct employment accounted for **38,522** jobs. The additional multiplier impact on employment was 75,344 jobs, of which 40,296 were produced through the indirect impact and 35,048 through the induced impact. Hence, the total 'after' UK-based employment supported by the activities of the UK space sector accounted for 113,866 employees.

Those values show that between 2006-07 and 2014-15 there has been a direct space-related employment gain of 19,425 new jobs, which can be identified with a cumulative average growth rate (CAGR) of 44.89% over the eight-year period. The additional multiplier impact has grown by an even larger amount (26,598 additional jobs), leading to a total employment enhancement of 46,023 and an impressive overall CAGR of 61.39% over the eight years. The UKSA itself employs approximately 80 people currently.

[150] Oxford Economics, (2009). *The Case for Space: the impact of Space Derived Services and Dat*.

Economic Impact of Space Economy: before-after comparison					
Employment	**Direct** Employment (jobs)	Additional **Multiplier** Impact (jobs)			**Total** Employment (direct + multiplier)
		Indirect	induced	Total (Indirect + Induced)	
'**Before**' UK Space Agency (2006-07)	19,097	35,180	13,566	48,746	67,843
'**After**' UK Space Agency (2014-15)	38,522	40,296	35,048	75,344	113,866
Difference	**19,425**	5,116	21,482	**26,598**	**46,023**
CAGR (Cumulative Average Growth Rate) over the 8 years	**44.89%**	22.64%	46.73%	**50.70%**	**61.39%**

'Before' % of UK Tot. Workforce (2007) - Employment (Tot.)[151]	UK Tot. Workforce	31,321,803	**% of Tot. Workforce**	**0.217%**
'After' % of UK Tot. Workforce (2015) - Employment (Tot.)	UK Tot. Workforce	33,568,446	**% of Tot. Workforce**	**0.339%**

***Labor Productivity: contribution to total productivity*.** Representing a good indication of the economic impact of an industry calculated as average GVA per employee, *space-related labor productivity* represents a third valuable measure for the purpose of making an assessment of the UK Space Agency's impact on the national space economy.

Before UK Space Agency (2006-07): 'before' labour productivity was standing at **£145,500**, meaning that an average GVA of this amount was generated per employee. No additional information, nor available data could be found regarding the disaggregated values of the total productivity impact into direct and multiplier effects[152].

After UK Space Agency (2014-15): 'after' labour productivity was standing at **£133,123**, meaning that that an average GVA of this amount was generated per employee. Again, no additional information, nor available data could be found regarding the disaggregated values of the total productivity impact into direct and multiplier effects.

As the only exception among the analysed measures, those values show that between 2006-07 and 2014-15 there has been a direct space-related labour productivity loss of £12,267, which can be identified with a negative cumulative average growth rate (CAGR) of -1.09% over the eight-year period.

[151] Employment data from The World Bank website database: https://data.worldbank.org/indicator/SL.TLF.TOTL.IN?locations=GB

[152] Oxford Economics, (2009). *The Case for Space: the impact of Space Derived Services and Dat*.

Economic Impact of Space Economy: before-after comparison					
Labour Productivity	**Direct** Productivity (GVA contrib. per employee)	Additional **Multiplier** Impact (GVA contrib. per employee)			**Total** Productivity (direct + multiplier)
		Indirect	induced	Total (Indirect + Induced)	
'Before' UK Space Agency (2006-07)	£145,500	NA	NA	NA	NA
'After' UK Space Agency (2014-15)	£133,233	NA	NA	NA	NA
Difference	**£-12,267**	NA	NA	NA	NA
CAGR (Cumulative Average Growth Rate) over the 8 years	**-1.09%**	NA	NA	NA	NA

'Before' % of UK GDP (2007) - Labour Productivity	UK GDP (US$ billion)	3,063	UK GDP (£ billion*)	2,347.98	**% of GDP**	**0.0062%**
'After' % of UK GDP (2015) - Labour Productivity	UK GDP (US$ billion)	2,861	UK GDP (£ billion)	2,193.12	**% of GDP**	**0.0061%**

**Exchange rate 07/08/2017*

What this before-after UKSA evaluation shows is an overall substantial rapid growth of the space economy over the period considered, both in terms of size and economic impact. The space economy has experienced a growth in size of 11.10%, generating a space-related turnover of £7.8 billion. When analyzing the economic effects on the space economy, the outcome is a significant total (direct, indirect and induced) contribution to national GVA growth of 20.62% over the period, with a gain of £4.48 billion. The impact on space-related jobs generation represents the most significant and impressive economic effect, with an average cumulative growth rate of 61.39% that has been able to support a totality of 46,023 new jobs spread in the whole economy. Among all those noteworthy improvements, the only exception is represented by labour productivity. This measure has proven a slight slowdown (-1.09%), with a small reduction of £12,267 in GVA generation per employee. However, as the 'before' and 'after' values are very large (respectively £145,500 and £133,233), the drop is not very significant and might be due to the fact that in 2006-07 the UK's space-related labour productivity was extraordinarily high.

Overall, the main result of this impact-evaluation assessment of the UK Space Agency is the existence of effective, tangible and substantial economic improvements, that have also contributed to numerous social and daily benefits. Without the establishment of the UK Space Agency, these improvements would not have occurred. This analysis does not pretend to relate the totality of those improvements *only* to UKSA; yet, there is no doubt that its establishment and what it has allowed for across the years have significantly contributed to it, facilitating an overall space sector modernization. **Furthermore, the national space economy's growth exceeded (or almost exceeded) in 2015 the expectations and targets set in 2006-07 to be reached by 2020.** The Oxford Economics' (2009) study developed three different growth scenarios for 2020, a high, medium and low performance picture[153] on the basis of prospects at that time. While: i) direct space industry *turnover* was anticipated to reach £14.820 billion in the best scenario (£11.374 and £8.684 billion respectively in the medium and low

[153] Oxford Economics, (2009). *The Case for Space: the impact of Space Derived Services and Dat.,* p 41.

scenarios); and ii) direct space-related employment was anticipated to support 29,993 jobs (in the high scenario) by 2020, those figures were almost reached (or even exceeded) in 2015 – when direct turnover accounted for £13.7 billion, and 38,522 space-related jobs were supported. Thus, this sustains the argument that the establishment of a dedicated space agency allows the setting of even higher, sustainable targets.

4. THE CASE OF CANADA'S SPACE ECONOMY

4.1. An overview of Canada's space economy

"Canada has an enviable record of innovation in space science and technology, as well as in reaching the marketplace with new developments in niche areas." [154]

The Canadian space economy is characterised by a long history of successes and achievements, significant growth and worldwide partnerships. The presence of a dedicated National space agency in Canada, together with a specific strategy and program, and the effective strong collaboration between industry, government and academia has directed the country to a long sequence of substantial innovation improvements in the space sector, building exceptional scientific instrumentation, and leading the development of new knowledge and cutting-edge technologies. The smart and cooperative organisation of its space industry, supported by a series of successful decisions taken in terms of priorities and agenda setting have led Canada to become home to the fourth largest fixed satellite service provider worldwide, provider of technologies used in over 80% of all commercial communications satellites launched internationally, leader in robotics engineering and innovation thanks to its contribution to the International Space Station[155]. Canada offers the example of a country that has developed a big part of its space economy with the lead and the guidance of a National space agency, which combined with the exceptional similarities it has with Australia – for instance in terms of territory extension, population[156] and its low density – makes it a very appropriate country to put in contrast with the latter when it comes to the whole space domain. While the UK represents an exceptional forecaster for the short-term consequences of establishing a dedicated National space agency and program, **the Canadian case is particularly suitable to be brought as example for the Australian space evolution to forecast: on one side, how a country with similar characteristics has been able to develop in the longer term with the support of an organised space activity, inclusive of an efficient National space agency** supporting the proposition that 'creating a culture of innovation is more important than ever in driving economic growth'[157]; **on the other side, it also demonstrates how its performance has at times waned due to a series of criticalities it has experienced**. In other words, Canada represents another useful illustration of the importance of *establishing* in a *smart way* a dedicated National space agency, program and strategy – even in the long term.

4.1.1. The evolution of the space sector in Canada

Canada has been intensely involved in space from the early years of space activity, and the primary reason that has originally led to invest in space was the need to connect and reduce the distance gap

[154] Government of Canada. *Canada's Space Sector*. Produced in collaboration with: Canadian Space Agency, Industry Canada, Foreign Affairs and International Trade Canada, and Canadian Commercial Corporation.
[155] Government of Canada. *Canada's Space Sector*. Produced in collaboration with: Canadian Space Agency, Industry Canada, Foreign Affairs and International Trade Canada, and Canadian Commercial Corporation.
[156] Canada has a population of 36 million, while Australia has a population of 24 million.
[157] The Honourable Navdeep Bains, P.C., M.P., Minister of Innovation, Science and Economic Development. *Canadian Space Agency 2016-17, Report on Plans and Priorities*, p 1.

among the population scattered around the vast and dispersed country, making space essential to the operations of a national government and a modern economy. In 1962, only five years after the Sputnik was launched, Canada became the fourth nation in space with the launch of Alouette-I (after USSR, USA and UK), looking at this new technology as a powerful tool for connecting the population in its large territory. After Alouette-I, Canada launched Alouette-II, ISIS-I and ISIS-II satellites, focusing its efforts on the design and assembly of scientific satellites: the knowledge gained during this first scientific-led stage allowed Canada to develop the capabilities needed to build satellites tailored to meet its needs[158]. Thus, since those early bold investments in Canada's national priorities, the Canadian industry has endured at the forefront of global satellite communications technologies. In 1972 Canada launched Anik A1, built in order to connect the remote northern part of the country for the first time and in 1976 launched Hermes, the most powerful communication satellite at the time[159]. 'The initial focus on linking Canadians together through satellite communications was soon eclipsed by the realisation that space-based Earth Observation could further enhance the Canadian economic growth by contributing to a multitude of national needs, most notably: ice monitoring, resource management, environmental monitoring and stewardship, coastal and maritime situation awareness, surveillance and security and forestry and agricultural management, among many others'[160].

Canada has collaborated with the USA since 1960 and with Europe since the 1970's and currently has the status of 'Associate Member' with the European Space Agency, persisting in playing an ongoing active role in major international space programs. **Canada has traditionally managed its space interests through a government-wide planning framework** called Long Term Space Plan (LTSP). After LTSP I invested in RADARSAT-1 Mobile Communications Satellite (MSAT) and the ISS[161] in 1986, a very significant choice was made in **1989[162]**: the establishment of the **Canadian Space Agency (CSA)** with the mandate "*to promote the peaceful use and development of space, to advance the knowledge of space through science and to ensure space science and technology provide social and economic benefits for Canadians*"[163]. In 1994, LTSP II supported the RADARSAT-2, an advanced satellite communication platform and confirmed the ISS partnership: with Canada's RADARSAT family of satellites the country defined its unending worldwide EO leadership and its ongoing contribution to Canada's economy and economic growth and global scientific knowledge. From this moment on, the CSA became one of the most relevant national actors and has been working hard to achieve these goals as well as to help building an internationally-spread positive perception of a strong Canadian space activity.

However, one of the weakest and critical aspects of the CSA and its capacity to lead the whole space activity in Canada has been a **lack of the necessary funding**[164] to support a prosperous development in the sector: in 1999 an annual base of C$300 million was recognized for the agency – an amount that was already noted at the time to be able to maintain Canada's core program requirements, but would

[158,159] Lania G., (2016). *An International Comparison of Space History, Policy and Industrial Capability*. http://www.spaceindustry.com.au/Documents/Paper%20FINAL-5.pdf

[160] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*, p 3. Aerospace Industries Association of Canada (AIAC) – September 2016.

[161] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*, p 3. Aerospace Industries Association of Canada (AIAC) – September 2016.

[162] The Honourable Navdeep Bains, P.C., M.P., Minister of Innovation, Science and Economic Development. *Canadian Space Agency 2017-18, Report on Plans and Priorities*, p 1.

[163] *Canadian Space Agency. Mission and Mandate*. http://www.asc-csa.gc.ca/eng/about/mission.asp

[164] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*, p 1. Aerospace Industries Association of Canada (AIAC) – September 2016.

not accommodate any incremental investment in major projects[165]. Indeed, after the CSA and the Canadian industry started working on the development of LTSP III in 2001, budget in 2002 was cancelled and only in 2005 the government approved a reduced LTSP III and gave policy approval for a hyper-spectral mission, but allocated no capital. 'Since 2005, new investments and the future of Canada's Space Program has not been considered at the Cabinet level: space has been on the agenda, but mainly for the purposes of the on-going requirements of existing major crown programs, RCM and ISS. Over the life of the last government, in order to meet the demands of these two programs while coping with a steadily decreasing A-base (that is not tied to inflation), the CSA was forced to reduce spending in many areas of activity, including space science, space technology development and demonstration, astronomy, education and outreach, and international cooperation'[166]. The motivation for this retreatment from any involvement in the sector has been the estimation of the commercial sector as mature. Having been this an inaccurate assessment, Canada's space sector has seen essentially no government investment in new space initiatives for over a decade from 2001, nor a renewed vision for the government's long-term needs and spending in space. However, although without additional funds to the CSA, in 2015 the Canadian government announced the extension of Canada's participation in the ISS from 2020 to 2024, and in 2016 its allocation of C$379 million[167] over the next 8 years in it – an excellent first step. The main programs currently funded and implemented by the agency are aimed to enhance downstream activities in the form of investments on space data, information and communication, with one main project being to launch a new RADARSAT constellation before 2018.

Government has historically been an essential ally for the industry, with clear guidance and investments aimed to support both large companies and SMEs. However, it has been noted that **Canadian businesses depend strongly on government contracts**[168], and with the increasing commercialisation and internationalisation of the space economy, this **excessive reliance could lead to competitive disadvantage**. In fact, when public involvement decreased during the last decade (as already highlighted, the CSA budget suffered a 48% reduction between 2001-02 and 2013-14) the number of SME within the Canadian space economy decreased too[169]. Moreover, there is a widespread feeling that the Canadian legacy of excellence is in danger of being taken for granted and that the industry-government partnership – that was instrumental to the development of Canada's space industry – has been allowed to atrophy, and must now be reinvigorated with diligence and purpose if the Canadian space capability is to survive and prosper. There must be a focus on core aspects of the Canadian space capability, including robotics, optics radar satellite communications, space science and technology development and applications[170].

[165,167] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*, p 4. Aerospace Industries Association of Canada (AIAC) – September 2016.
[166] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*, p 3. Aerospace Industries Association of Canada (AIAC) – September 2016.
[168] Aerospace Review, Mandate by the Government of Canada, (2012). *Reaching Higher: Canada's interests and future in Space*. www.aerospacerevie.ca.
[169] Lansdowne, (2012). *A Report on the Development of a National Space Infrastructure to support the Global Competitiveness of the Canadian Space Industry*. Lansdowne technologies Inc. Publishing.
[170] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*, p 5. Aerospace Industries Association of Canada (AIAC) – September 2016.

4.1.2. The actual organization of Canadian space activities and CSA

Although the Canadian Space Agency is a fundamental element for the whole space economy functioning, it could not manage to succeed in guiding the space activity and representing the point of contact for government, academy and industry if it were not collaborating with a vast number of other organisations, departments and agencies. Ambitious programs like that of the CSA need strong organisational capabilities and cooperation with all of the stakeholders involved in space.

Historically, space-related activity has essentially been led by the government and its pervasive presence has been a particular feature of progress in space. On one side, this is due to the acknowledged inseparability of space from national security and geopolitical influence. On the other side, this also reflects the realism that space is a “long game” with significant risks and need for patient money[171]. Where the market economies exist, governments have established partnerships with businesses that have received contracts to design and manufacture space assets for public as well as private. If government is fundamental through its collaboration and funding, it is not the only actor alongside the CSA in establishing the direction of the space economy. A number of organisations are influential as well, especially for their capability of establishing industry-led working groups, which are able to bring together representatives of industry, academia and research institutions, and unions, as well as federal government officials. Moreover, a number of roundtables, meetings, and site visits in Canada and major space nations have been realised over the years to strengthen the collaboration among stakeholders and bring up the major needs in front of the space policy makers, the government and the CSA.

In other words, an efficient network of collaboration, both nationally and internationally has been developed, setting the context for a well-organised industry-government partnership. Among the countless bodies, agencies and departments actively creating this efficient network for the Canadian space sector, some of the most important working in close relationship with CSA are: the Government of Canada and a few federal bodies like the Innovation, Science and Economic Development Canada (ISED), and the Aerospace, Defence and Marine Branch (ADMB) of ISED; the Space Advisory Group; some associations such as the Aerospace Industries Association of Canada (AIAC), the Canadian Aeronautics and Space Institute (CASI) and the Canadian Space Commerce Association (CSCA); a number of public research institutions as the National Research Council (NRC) and Defence Research and Development Canada (DRDC); the Air Cadet League of Canada (ACLC). Moreover, of great relevance is Canada’s involvement in ESA – as well as in other world leading space agency (i.e. NASA).

Canadian Space Agency (CSA): as the national major player in the space sector, the Canadian Space Agency was established in 1989 to coordinate all civil, space-related policies and programmes on behalf of the Government of Canada[172]. With the mandate "*to promote the peaceful use and development of space, to advance the knowledge of space through science and to ensure that space science and technology provide social and economic benefits for Canadians*"[173], the CSA concentrates efforts in its achievement implementing the Canadian Space Program (CSP) in cooperation with other government departments and agencies, industries, and universities, as well as international partners.

[171] Aerospace Review – Mandate by the Government of Canada, (2012). *Reaching Higher: Canada’s Interests and Future in Space*, p 3.
[172] *The Canadian Space Agency. 2007-2008 Estimates. Report on Plans and Priorities*. http://www.tbs-sct.gc.ca/rpp/2007-2008/csa-asc/csa-asc-eng.pdf
[173] *The Canadian Space Agency. 2007-2008 Estimates. Report on Plans and Priorities*.

In addition to delivering its own programs, the CSA is responsible for coordinating all federal civil space-related policies and programs pertaining to science and technology research, industrial development, and international co-operation.

There are four key segments of strength in relation to the Canadian space capabilities, therefore areas of major focus for the CSA activity and its space program and strategy formation guidance: Earth observation, space science and exploration, satellite communications, and space awareness and learning[174]. The CSA communicates and works closely to the above listed stakeholders to conduce its activities through three key business lines: space utilisation (serving the needs of the Government Departments), space exploration (positioning Canadian science and technology to advantage in future international space exploration missions), and space science and technology (which drives synergy and builds capacity in academia, industry and government to respond to the current and future needs of Canada's space programme)[175]. Moreover, by leveraging international cooperation, the CSA generates world-class scientific research and industrial development for humanity's benefit.

Government: as the government departments that are major users of space include National Defence, Environment, Natural Resources, Agriculture and Agri-Food, Fisheries and Oceans, and Aboriginal Affairs and Northern Development – the pervasive presence of the government in supporting Canadian space industry has always been a particular feature of the country's space economy. *Besides the many departments and governmental agencies involved in the space domain, the government has always led the space-related activity, especially through providing significant funding and investments.* However, 'new opportunities to become a "costumer" for space activities rather than the owner or operator of space assets are emerging rapidly and may change the role of the Government of Canada in space innovation and the way that the government engages with the space commercial sector'[176].

Innovation, Science and Economic Development Canada (ISED): ISED is the federal institution that leads the Innovation, Science and Economic Development portfolio[177] and 'works with Canadians in all areas of the economy and in all parts of the country to *improve conditions for investment, enhance Canada's innovation performance, increase Canada's share of global trade and build a fair, efficient and competitive marketplace'*[178]. As it does so for all areas of the economy, this holds in particular for the space sector – being the latter one of the most innovation-driven and economic-growth-enabler these days. Its support is therefore fundamental for the success of the space activity and the government-industry communication and harmonization.

Aerospace, Defence and Marine Branch (ADMB) of ISED: this branch of the ISED '*promotes the development of an internationally competitive and sustainable space sector'*[179]. Its aim is to endorse research and development opportunities that will result in new advancements for the space capabilities of Canada, and in order to do so the ADMB works closely with the CSA and other government departments. Thus, the Branch has the privilege to participate in the development of space strategies and policies, as well as to ensure that the needs and critical aspects of the sector and

174,175 http://m.esa.int/About_Us/Welcome_to_ESA/ESA_and_Canada_renew_partnership_in_space_science_and_technology

176 *Consultation Paper for the Space Advisory Board: Driving Canada's Future in Space – April 2017*.

177,178 https://www.canada.ca/en/innovation-science-economic-development.html

179 http://www.ic.gc.ca/eic/site/ad-ad.nsf/eng/ad03864.html

the government are taken in consideration. This means the ADMB provides secretarial support to the Space Advisory Board.

Space Advisory Group: with the new mandate of providing '*advice to the Government of Canada on the Canadian space program to ensure a growing and sustainable space sector in the long-term'*[180], the Space Advisory Group has been led to renewal since 2016 by the Government of Canada with the objective to improve the whole space management and modernise its guidance role. The Advisory Group is playing a role of consultation among the space stakeholders to define key elements that would be included in the new in-progress strategy and plan for the Canadian space activity – again, reflecting the need for a strong cooperation within the growing sector.

Aerospace Industries Association of Canada (AIAC): as a member-driven, not-for-profit, national organisation that promotes and facilitates the competitiveness of Canada in the global aerospace industry[181], AIAC has worked for over fifty year with its members to develop what today is the fifth-largest national space industry in the world*. AIAC helps the industry to invest, innovate and develop best-in-class capabilities in the civil, defence and space sectors by collaborating with industry and with governance to develop products, services, programs and policies that enhance Canadian aerospace companies*[182]. In particular, AIAC works closely with Industry Canada, the CSA and government leadership towards the 'twin goals of re-invigorating Canada's short-term technology development funding commitments and developing a long-term plan for Canada's future in space that supports strong domestic space capacity and continued robust Canadian participation in the international space community'[183]. Its strength is to be able to respond quickly and effectively to capitalise on sector opportunities.

Canadian Aeronautics and Space Institute (CASI): having been established through a two-stage fusion among four space-related institutions (the first one in 1954, and the second one in 1962), CASI is today a not-for-profit scientific and technical organisation devoted to the *advancement of the art, science engineering and applications relating to aeronauts, aeronautics, and associated technologies and their applications*[184]. With the result of a strong cooperation among space-related bodies, the institute works closely with its Corporate Partners, organisations with an interest in the goals and mission[185] of CASI and a willingness to provide financial assistance. Moreover, many people make up for a Council, where important decisions need to be taken concerning CASI[186]. Various privileges and benefits come in a partnership with the Institute, among which the recognition in the scientific journals as well as other publications produced by the institute, and an elevated profile at all conferences hosted by CASI with the aim to strengthen the space network and exchange space-related ideas and knowledge.

Canadian Space Commerce Association (CSCA): as a federally-incorporated not-for-profit organization operating in Canada, the CSCA is Canada's national space industry association, representing industry, academia, professionals, young entrepreneurs and students.[187] In 2015, five

[180] http://www.ic.gc.ca/eic/site/ad-ad.nsf/eng/h_ad03983.html
[181] AIAC, (2009). *Appendix Specific Undertaking between the Air Cadet League of Canada (CLC) and AIAC.* http://aircadetleague.com/wp-content/uploads/2014/08/AIAC-Appendix-G.pdf
[182] http://aiac.ca/who-we-are/
[183] http://aiac.ca/
[184] http://www.casi.ca/about-us/history/
[185] http://www.casi.ca/about-us/vision-and-mission/
[186] http://www.casi.ca/about-us/members-for-council/
[187] https://spacecommerce.ca/about/governance/

new corporate members joined the association: Euroconsult Canada, Western University's Centre for Planetary Science and Exploration (CPSX), MacDonald, Dettwiler and Associates Ltd. (MDA), Space Strategies Consulting Ltd. (SSCL) and the Institute for Space Science, Exploration and Technology at the University of Alberta[188]. This gives an idea of what kind of actors and expertise the CSCA is able to gather, aiming to build a more efficient cooperation, collaboration and networking around the space domain. Moreover, '*it reflects the ongoing need of such an organisation in the country, able to work with all the stakeholders to promote importance and benefits of a growing space sector*', said CSCA Executive Director, Marc Boucher. The overall purpose is thus to support the competitive, legal, strategic, academic and educational interests of the Canadian commercial space and defense sectors[189].

National Research Council (NRC): as the Government of Canada's premier research organisation *supporting industrial innovation, the advancement of knowledge and technology development, and fulfilling government mandates*[190], the NRC works with clients and partners providing exactly what industry needs: infrastructure, personnel, equipment, experience and networking capabilities. Indeed, its focus is on offering 'access to leading technology equipment, research and training programs as well as on providing industry with a lower-risk way to develop innovative ideas, reduce start-up costs, and shorten time to market'[191]. While the benefits of working with the NRC can be enumerated in a long list – the development of highly skilled workforce, the bridging of the innovation gap between university-based discovery and industrial commercialisation, and the provision of technical and commercialisation services to industry are among the most relevant[192].

Defence Research and Development Canada (DRDC): with the 'mission to provide a strategic knowledge and technological advantage'[193], *the DRDC supports defence and security operations both at home and abroad with the support of knowledge and technology*. The public research institution provides Security Science and Technology (S&T) to forecast, cost and deliver future readiness levels to meet operational requirements as well as generates knowledge and technology for a robust connected and multi-jurisdictional security and intelligence environment. In order to do so, space is a fundamental tool. Therefore, DRDC leverages other organizations' expertise, knowledge and resources so that diverse collaborations with partners create a more networked environment[194].

Air Cadet League of Canada (ACLC): it is an organisation committed to *promoting ongoing education, citizens' skills and developing leadership with the objective of encouraging a practical interest in aeronautics amongst young people and assisting those intending to pursue a career in the field of aviation*[195]. As young talents and expertise are fundamental to develop in order to push further the space capabilities, ACLC partners with the Department of National Defence (DND) in the development,

[188] https://spacecommerce.ca/the-canadian-space-commerce-association-welcomes-five-new-corporate-members/
[189] CSCA, (2017). *Canadian Space Policy Symposium 2016. Consultation Report - March 2017.* https://spacecommerce.ca/wp-content/uploads/2015/02/2017-Canadian-Space-Policy-Consultation-Report.pdf
[190] http://www.nrc-cnrc.gc.ca/eng/
[191,192] http://www.nrc-cnrc.gc.ca/eng/solutions/index.html
[193] http://www.drdc-rddc.gc.ca/en/about/mission-impact.page
[194] https://www.space.com/22534-canadian-space-agency.html
[195] AIAC, (2009). *Appendix Specific Undertaking between the Air Cadet League of Canada (CLC) and AIAC.* http://aircadetleague.com/wp-content/uploads/2014/08/AIAC-Appendix-G.pdf

deployment and conduct of the Air Cadet Programs[196] and agrees to create a link between the young generation and the infinite space career opportunities.

Canada's involvement in ESA: international relationship with abroad organisations has always been a major interest for Canada. This is proven by the over 40 years of partnership enjoyed by ESA and Canada (since the 1970s), which has led to *many successful space projects through their joint forces in telecommunications, Earth observation, navigation, and related technologies*[197]. Not only the relationship between the two space agencies is beneficial for their cooperation, but also the European and Canadian companies have the opportunity to forge strong alliances, creating teaming arrangements and opportunities for new markets. Canada's major objective in making agreements with ESA lies in the leverage of its scientific and technological knowledge to further advance space-based expertise and strengthen its relations in support of mutual interests and priorities of the CSA[198].

With the purpose of outlying an extensive, non-exhaustive, list of bodies and organisations that participate in the development of Canadian space economy, it is once again clear how important cooperation and network-building are. Bringing all those bodies together allows to converge all the knowledge, expertise and stakeholders around the same interests of gaining from space, both in economic and in societal terms – and the CSA is the fundamental player in this whole coordination machine, moving on the binaries of the space program and strategy.

4.1.3. The Canadian Space Agency: overall achievements & 2017-18 goals

Focusing with major detail on the Canadian Space Agency, it is interesting to analyse its evolutionary path, its achievements and its weaknesses. CAS's past has been significantly more eventful than the UKSA's one, having led to a broader space for action. However, the CSA's success has not been linear throughout its existence, as it has faced periods of inefficiency and rose again with successful projects. It is thus interesting to have a deeper look into the reasons of those fluctuations, with the aim of making the misleading decisions as well as the positive moves that have been taken evident. An outline of the mission and the vision, the future plans and the structure of the CSA will provide an additional background knowledge about the agency's underlying rationality and functioning.

Review of the space evolutionary path since CSA: Over the course of more than 50 years the space ecosystem of Canada experienced a strong development thanks to the talent, hard work, and creativity of Canadians. Indeed, in the history of our modern world, few events rival those of the field of space in terms of its ability to induce entrepreneurial drive, spur scientific discovery, and generate national pride. Thus, established by the Canadian Space Agency Act – which received Royal Assent on May 10, 1990 – the **Canadian Space Agency (CSA)** reports to the federal Minister of Innovation Science, and Economic Development and is responsible for coordinating all government-funded space activities in Canada. The CSA also cooperates with the European Space Agency since 1970s and has several formal and informal partnerships and collaborative programs with space agencies in other countries, such as NASA, ISRO, JAXA and SNSB. Thanks to this extended space-related activity of the CSA, great improvement has been achieved in the Canadian nation in terms of social and economic development, representing a meaningful example of the immense opportunities that a space agency

[196] http://aircadetleague.com/about-us/mission/
[197,198] http://m.esa.int/About_Us/Welcome_to_ESA/ESA_and_Canada_renew_partnership_in_space_science_and_technology

brings to a country. With around 1.5 times the Australian's population, Canada has captured approximately **2% of the global space market**, while the Canadian space sector contributes around **24,300** jobs to the economy and has delivered over C$750 million in tax revenue. Moreover, it achieved a 5-year compound growth rate of **3.6%** in 2015, which was twice that of the general economy, and has a high proportion (53%) of personnel who have tertiary qualifications and delivers six times the national job growth rate[199].

The establishment of the CSA has performed a noticeable improvement in all aspects of the space sector, which branded Canada as a trusted international partner and as a nation of innovation. These improvements have however reached a significant slowdown, when domestically 'the combined forces of *reduced funding* and *lack of investment certainty* started depriving the space innovation engine of the fuel that it needs to respond to this dynamic environment and live up to its full potential'[200]: underlying the past success has been a clear vision for the Canadian space program, a long-term updated strategy, and sufficient government funding to the CSA for programs. However, all of these ingredients are missing in the current environment. First, the *long-term plan for Canada's space program has expired*, while not been renewed. Second, there is *currently no guidance* available to companies and institutions attempting to make long range plans for their Canadian operations. Third, the *annual budget of the CSA has declined* to the point where there is little funding for new initiatives[201]. In this setting, Canadian 'subsidiaries of larger multinational corporations find it increasingly difficult to attract corporate resources to Canada, and firms that have the option to invest in other jurisdictions are pursuing other opportunities'[202]. In conclusion, AIAC – in its report *The Future of Canada's Space Sector, September 2016* – is suggesting that two things are needed soon to allow Canada to retain its position at the forefront of innovation: i) a *renewed long-term vision*, crucial for the Canadian Space Program to be developed efficiently, and ii) a *new, modest, investment* of the government in the sector, while plans for the long term are being laid.

CSA's mission and vision: With the **mandate** *to 'promote the peaceful use and development of space, to advance the knowledge of space through science and to ensure that space science and technology provide social and economic benefits for Canadians[203]'* in mind, the Canadian Space Agency aims to reinvigorate the space economy. The mandate draws the broad lines in which the Agency pursues its **mission** of '*leading the development and application of space knowledge for the benefit of Canadians and humanity*'[204]. This commitment is aimed to be achieved by the CSA promoting an environment where all levels of the organisation: i) pursue excellence collectively; ii) advocate a client-oriented attitude; iii) support employee-oriented practices and open communications; iv) commit itself to both empowerment and accountability; v) pledge to cooperate and work with partners for mutual benefit.

[199] Euroconsult, (2015). *Comprehensive Socio-Economic Impact Assessment of the Canadian Space Sector*, p vii.
[200] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*, p 1. Aerospace Industries Association of Canada (AIAC) – September 2016. http://aiac.ca/wp-content/uploads/2016/11/AIAC-Space-Submission-Sept-2016.pdf
[201] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*, p 21. Aerospace Industries Association of Canada (AIAC) – September 2016.
[202] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*, p 5. Aerospace Industries Association of Canada (AIAC) – September 2016.
[203] http://www.asc-csa.gc.ca/eng/about/mission.asp
[204] http://www.asc-csa.gc.ca/eng/about/mission.asp

The space activity of Canada is currently guided by five core principles that have been set out under Canada's Space Policy Framework (2014)[205]. Canada's future priorities for space will develop on the basis of these principles, while the Space Strategy will set out directions and priorities for Canada's space program, plan and long-term vision – that are now at a point of urgent need. While the priority areas will align with Canada's Innovation and Skills Plan to ensure Canada will be able to generate the most skilled workforce and potentially engage in new investment opportunities, the Space Strategy will also take into account Canada's current and future use of space technologies. Overall, the key areas that have been recognised to be essential focus points for the **new plan and long-term Vision**, and goals to be reached, are essentially two[206]:

i) Canada will consider *how best to use space to drive broader economic growth* by ensuring the space sector is positioned for success, is a deep source of innovation, an engine for partnerships and a source of inspiration for the next generation of scientists, innovators and explorers.
ii) Canada will consider *how to leverage space for the benefit of Canadians* by applying its special knowledge and expertise to address global challenges, by increasing the integration of space technologies into everyday life, and by continuing to use space to support key government mandates.

CSA's Plan 2017-2018: While the above are the key areas of focus on which everything else should be built on, the long term plan is based on aggressive targets for growth and performance. Experts believe that the space sector of Canada should aim to increase Canadian space sector revenues by over C$8 billion over 10 years (by 2026), increase its contribution to Canada's GDP (value-added) by over C$3.6 billion and increase employment by over 30,000 person-years over the same time[207]. Achieving these goals will require that both Canada's civil and defence requirements are addressed by a bold 'whole of government' plan supporting a robust program of space technology development, a balanced program of affordable space missions, and a flagship space program that continues Canada's leadership in space.[208] In particular, the short-term **CSA's plan for 2017-2018** has fixed a number of key objectives and hot topics[209]:

1. *Provide space-based data and services for the benefit of Canadians*. Space-based solutions provision is essential to the safety, security and well-being of Canadians, and this extends from disaster response to precision farming and from tracking vessels in Canada's waters to climate change monitoring.
2. *Provide innovative technologies and scientific instruments for space exploration*. The leverage of international partnership to support fundamental research for new knowledge as well as attracting highly qualified expertise will be fundamental to identify and provide innovative technologies and scientific instruments that will eventually enable space exploration.
3. *Secure Canada's future in space*. CSA's space science and technology development initiatives and activities will support the development of leading-edge capabilities, enhance its export

[205] The five principles of the Space Policy Framework are: 1) Canadian interests first; 2) positioning the private sector at the forefront of space activities; 3) progress through partnership; 4) excellence in key capabilities; and 5) inspiring Canadians.
[206] *Consultation Paper for the Space Advisory Board: Driving Canada's Future in Space – April 2017*.
[207,208] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*, p 1. Aerospace Industries Association of Canada (AIAC) – September 2016.
[209] The Honourable Navdeep Bains, P.C., M.P., Minister of Innovation, Science and Economic Development. *Canadian Space Agency 2017-18, Report on Plans and Priorities*, p 3.

growth, and create high-paying middle-class jobs. This will contribute to the Innovation Agenda[210] as well, with the aim of attracting and encouraging Canadians to develop the STEM skills that are essential to prepare the jobs for tomorrow.

4. *Continuous Improvement Agenda*. It is essential that the CSA puts effort in building a modern workforce and a culture of continuous improvements, aiming at providing a work environment that promotes health, psychological safety and working conditions conducive to wellness and vitality, key in achieving a productive workforce.

Analysing the **structure** of the Canadian Space Agency – currently employing around 670 employees[211] – its programs and activities are directed by the President and Chief Executive Officer through the Executive Committee, gathering senior officers responsible for core and corporate functions. The global environment is reflected by the organisational structure of the Agency, where many space activities are becoming more service-oriented and thus focusing on the needs of end-users and on the integration of the technology in terrestrial applications. When looking at the **functions** of the CSA, these can be listed in four main tasks[212]:

- Assist the Minister to coordinate the space policies and programs of the Government of Canada.
- Plan, direct, manage and implement programs and projects relating to scientific or industrial space research and development and the application of space technology.
- Promote the transfer and diffusion of space technology to and throughout Canadian industry.
- Encourage commercial exploitation of space capabilities, technologies, facilities and systems.

4.1.4. The actual size of Canada's space economy

Canada has always been considered an important player within the space economy, providing data and satellite services that have been and still are essential for the other countries' needs as well. Canada has developed expertise, knowledge and skills that have been able to lead the country's space sector to growth. However, as already mentioned in previous paragraphs, the growth of the Canadian space economy has slowed down due to a lack of stable guidance, efficient long-term vision, and investments. This results into a national space economy characterised by over 225 organisations (75% private companies and 25% research institutions[213]) involved at different levels of the space value

[210] In addition to the socio-economic benefits that fly from the Canadian space sector, it is also meaningful to view the sector through the lens of the Innovation Agenda. Given the long history of the Canadian Space Agency and its program, innovation has been acknowledged to be a key factor for the space economy and therefore it has been developed as goal and objective in the agenda itself. The nature of the problem of getting to, and operating in, space requires a wide variety of specialised expertise. This need has generated a whole space community or ecosystem in Canada, gathering together the raw material of innovation: talent, inspiration, investment, and expertise and turning it into scientific discovery, technological breakthroughs and economic prosperity. This then recycles to begin the process again, giving rise to a true "innovation engine" based on and promulgating many of the values upon which the Innovation Agenda is based. Showing how Innovation is really a priority area for Canada's space sector, this innovation ecosystem operates through a series of well-defined areas of action: i) entrepreneurial and creative society; ii) global scientific excellence; iii) world-leading clusters and partnerships; iv) grow companies and accelerate clean growth; v) compete in digital world. [Source: Aerospace Industries Association of Canada (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*, p 9. Aerospace Industries Association of Canada (AIAC) – September 2016.]

[211] http://www.asc-csa.gc.ca/eng/about/csa_organization.asp

[212] The Honourable Navdeep Bains, P.C., M.P., Minister of Innovation, Science and Economic Development. *Canadian Space Agency 2017-18, Report on Plans and Priorities*, p 5.

[213] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*. Aerospace Industries Association of Canada (AIAC) – September 2016.

chain, currently estimated to capture 2% of the global space economy market. This is a good performance when considering that Canada accounts for less than 1% of the world's total funding for civil space activities[214].

Turnover: the Canadian space economy was valued at an aggregate space-related turnover of **C$5.37 billion** in 2013[215] when taking into account satellite broadcasting, and C$3.7 billion[216] when excluding these activities. The cumulative revenues can be split into the upstream segment, which accounted for C$1.1 billion, and the downstream segment, which was C$4.3 billion. This represents an average cumulative growth rate of 5.9%[217] over 10 years (CAGR between 2004 and 2013).

Analysing the space economy turnover by segment reveals substantial differences in size. Attributing no revenues to launch services as no satellite launch activities take place within Canada, the largest segment is by far the satellite services and applications, accounting for 52% of the total turnover by generating C$2.82 billion from 48 companies (90% of those revenue come from satellite broadcasting activities). Satellite Operations is the second largest segment (21%) generating C$1.1 billion from 4 companies. At the third place space manufacturing captures 8.4% of the total turnover through the generation of C$825 million, followed by the ground segment (10%) and finally by research and engineering services, that generate C$96 million from 58 companies[218].

Size of Space Economy									
Turnover									
Turnover (C$ billion)			Turnover by segment (% of tot.)					Turnover Growth Rate (%)*	Share of Global Space Economy
Total	Upstream	Downstream	Engineering &Consulting Services	Space Manufactur.	Ground segment	Satellite Operations	Value-Added Service & Applications		
C$5.37	C$1.1	C$4.3	2%	15%	10%	21%	52%	5.90%	**2%**

**CAGR between 2004-2013. Annual growth: 3.7%.*

Export intensity: Canada's space sector is highly focused on export and commercial markets from which respectively 64% and 86% of its turnover was generated in 2013 when excluding broadcast services. These proportions have seen to be overall very stable in time[219], but also quite different depending on companies' positioning in the value chain.

R&D investment: with the total Canadian space industry expenditure on R&D of **C$180 million** in 2013[220], the space sector fosters the creation and the diffusion of knowledge and innovation in the Canadian industry, research and scientific communities. This expenditure represented an R&D intensity of 11% of the sector's GDP impact, and 3.3% of its revenues, which is much higher than any other major national industry. Another indication of the size of space R&D is the number of Canadian publications issued in space-related disciplines, which were 2,507 in 2013 (6.9% of the world's total, meaning Canada is part of globe's best performance)[221].

[214] Euroconsult, (2015). *Comprehensive Socio-Economic Impact Assessment of the Canadian Space Sector*, p II.
[215] Euroconsult, (2015). *Comprehensive Socio-Economic Impact Assessment of the Canadian Space Sector*, p 22.
[216] Aerospace Industries Association of Canada (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*. Aerospace Industries Association of Canada (AIAC) – September 2016.
[217] Euroconsult, (2015). *Comprehensive Socio-Economic Impact Assessment of the Canadian Space Sector*, p 27.
[218] Euroconsult, (2015). *Comprehensive Socio-Economic Impact Assessment of the Canadian Space Sector*, p 23.
[219] Euroconsult, (2015). *Comprehensive Socio-Economic Impact Assessment of the Canadian Space Sector*, p 25.
[220,221] Euroconsult, (2015). *Comprehensive Socio-Economic Impact Assessment of the Canadian Space Sector*, p III.

4.2. Effects of Canada's space activity: daily, societal and economic benefits

"Space is now ubiquitous and deeply integrated into the daily lives of Canadians. It is a rapidly growing global sector, enabling economic growth, driving science and technology forward while also creating important benefits for Canadians." [222]

Canada's long involvement in space has led to the formation of strong networks of cooperating bodies, which have been essential to develop the strong expertise that is today allowing Canada to benefit from economic space-related gains. The positive effects of Canadian space involvement do not end with an improved growth of the national economy, but go further and enter deeper in Canadians' lives, improving the standards and modernising the most diverse societal domains. The socio-economic benefits are embedded in the Canadian Space Agency's mandate, and their upgrading is the central focus of any space-related decision, being it the establishment of a new space strategy, program, or a plan of space-related investments allocation. Figures for the above mentioned effects will be the central topic of this chapter, with the aim of highlighting the additional value that the space sector brings to Canada in all dimensions.

4.2.1. Actual economic benefits of Canada's space activity

In order to measure the economic impact of the space economy in Canada, a number of indicators will be analysed in depth as regarded to be good pointers of the economic effects. As for the UK, these will be value-added, employment, and labor productivity, complemented by a fourth measure that is tax revenues, which is particularly relevant and representative for the impact on the Canadian economy. Again, they will all be analysed through their direct and multiplier effects.

Value-added: contribution to national GDP. The direct value-added accounted for C$1.565 billion in 2013 (0.097% of total Canadian GDP). The value-added multiplier was estimated to be **1.85**, meaning that every 1 dollar spent in space industry generates an additional C$0.85 worth in the supply chain and supporting sectors. In consequence, the additional multiplier impact was C$1.315 billion (0.71 from indirect impact, 0.605 from induced impact). Thus, **total** industry's value-added contribution to GDP was **C$2.88 billion**[223].

Looking more in detail into how the C$1.565 billion of direct value-added is allocated across segments, the majority (60%) of Canada's space GDP was generated (as for the UK) in the space applications segment (corresponding to C$940 million of direct contribution). With 28.12% space manufacturing accounts for a contribution of C$440 million and positions as second largest segment, while engineering and consulting services contributed C$95 million (6.07%). Satellite operations instead contributed only 5.75% of space economy GDP, which corresponds to C$90 million[224].

[222] *Consultation Paper for the Space Advisory Board: Driving Canada's Future in Space – April 2017*, p 2.
[223] Euroconsult, (2015). *Socio-Economic Impact of the Canadian Space Sector*, p 32. Euroconsult for the Canadian Space Agency.
[224] Self-calculation of % from figures taken from: Euroconsult (2015). *Socio-Economic Impact of the Canadian Space Sector*, p32. Euroconsult for the Canadian Space Agency. Engineering & Consulting Services: C$95 million is 6.07%; Manufacturing: C$440 million is 28.12%; Satellite Operations: C$90 million is 5.75%; Value-Added & Applications: C$940 million is 60.06%.

Economic Impact of Space Economy										
Value-Added										
Direct Value-Added		Direct Value-Added by Segment (% of tot.)				Value-Added Multiplier	Additional **Multiplier** Impact			**Total** Value Added (direct + multiplier)
C$ billion	% of total Canadian GDP[225]	Engineering & Consulting Services	Space Manufactur.	Satellite Operations	Value-Added Service & Applications		Indirect	induced	Total (Indirect + Induced)	
C$1.565	0.097%	6.07%	28.12%	5.75%	60.06%	1.85	C$0.71	C$0.605	**C$1.315**	**C$2.88**

Employment: contribution to job creation. The direct employment accounted for 9,784 jobs in 2013. The employment multiplier was estimated to be **2.5**, meaning that the activity of 100 employees in the space industry supports 150 additional employees among suppliers and in other economic sectors. As the direct employment in the space industry supported 9,784 jobs, the additional multiplier impact generated 14,570 additional Canadian jobs (7,895 indirect, 6,675 induced). Thus, the activities of Canada's space industry support the jobs of **24,354 employees** in **total**[226].

While the CSA is currently employing around 670 workers[227], analysing the space industry employment by segment reveals that the overall direct space-related occupation breaks down into segments of different size. The space services and applications segment dominated in 2013, accounting for 45% of total space industry employment, or 4,443 jobs. Space manufacturing (35%) employed a greater staff than space engineering and consulting services (14%), with respectively the generation of 3,376 and 1,333 jobs. Satellite operations made up a small workforce of 632 employees, which corresponds to only 6% of the total direct employment[228].

Economic Impact of Space Economy										
Employment										
Direct Employment		Direct Employment by Segment (% of tot.)				Employm. Multiplier	Additional **Multiplier** Impact			**Total** Employm. (direct + multiplier)
jobs	% of total Canadian Workforce	Engineering &Consulting Services	Space Manufactur.	Satellite Operations	Value-Added Service & Applications		Indirect	induced	Total (Indirect + Induced)	
9,784	0.05%	14%	35%	6%	45%	2.5	7,895	6,675	**14,570**	**24,354**

Labor Productivity: contribution to total productivity. Labor productivity was amounted to **C$160,000** in 2013[229]. However, as already outlined for the UK, whilst a useful and informative metric, labor productivity does not tell the whole story. Activities that rely on a large capital stock to deliver goods and services may present large labor productivity estimates as fewer employees are required. Similarly, some activities such as fundamental and applied research and policymaking, regulation and

[225] Self-calculation: *2.9 : 0.18% = 1.565 : x%,* where x% is the % of total Canadian DGP.

[226] Euroconsult, (2015). *Socio-Economic Impact of the Canadian Space Sector*, p 36. Euroconsult for the Canadian Space Agency.

[227] http://www.asc-csa.gc.ca/eng/about/csa_organization.asp

[228] Euroconsult, (2015). *Socio-Economic Impact of the Canadian Space Sector*, pp 37-38. Euroconsult for the Canadian Space Agency.

[229,230,231] Euroconsult, (2015). *Socio-Economic Impact of the Canadian Space Sector*, p 37. Euroconsult for the Canadian Space Agency.

oversight enable creation of value elsewhere in the value chain. Indirect and induced effects are therefore not numerically representable, but those impacts are surely of great significance.

Labor productivity varies across value chain activities again. With a GDP per worker of roughly C$130,500 in 2013, space manufacturing firms had higher productivity levels than several notable manufacturing sector peers including computers and electronics, pharmaceutical and automotive manufacturing firms. This higher productivity of space manufacturers is partially attributable to the fact that space firms generally manufacture goods in smaller, less standardised batches than their aerospace peers[230].

Economic Impact of Space Economy										
Labour Productivity										
Direct Productivity		Labor Productivity by Segment (C$)				Product. Multiplier	Additional **Multiplier** Impact			**Total** Product. (direct + multiplier)
GDP per employee	% of tot. Canada Prod.	Engineering &Consulting Services	Space Manufactur.	Satellite Operations	Value-Added Service & Applications		Indirect	induced	Total (Indirect +Induced)	
C$160,000	NA*	NA	C$130,500	NA	NA	NS	NS	NS	NS	NS

**NA = not available*

Tax Revenues: contribution to government revenues. Tax revenues represent a fourth good indication of the economic impact of an industry through its contribution to government revenues, being these federal, provincial and municipal coffers. The direct tax revenues generated in 2013 by the Canadian space sector were estimated to be over C$487 million across all levels of government. These taxes include direct corporate taxation of profits and income taxes on the wages of the nearly 10,000 space sector employees. A variety of indirect taxes, not tied to productive activity, are included as well such as local property taxes, sales taxes, fuel taxes and import duties paid by space sector firms or from the purchase made with incomes of direct employees[231]. The multiplier impact (indirect plus induced) in terms of contribution to government revenues amounted to C$263 million. Thus, the **total** space-related tax revenues contribution in 2013 was of **C$750 million**[232].

Economic Impact of Space Economy										
Tax Revenues										
Direct Tax Revenues[233]		Tax Revenues by Segment (C$ billion)				Tax Revenues Multiplier	Additional **Multiplier** Impact			**Total** Tax. Revenues (direct + multiplier)
C$ billion	% of tot. Canadian Prod.	Engineering &Consulting Services	Space Manufactur.	Satellite Operations	Value-Added Service & Applications		Indirect	induced	Total (Indirect +Induced)	
C$0.487	NA	NA	NA	NA	NA	NA	NA	NA	**C$0.263**	**C$0.750**

Value-added, jobs creation, labour productivity and tax revenues are just a few measures that help to capture the economic impact of the Canadian space activity, showing a quite straightforward contribution of the space sector to the national economy. Leaving aside those measures and moving

[232] Euroconsult, (2015). *Socio-Economic Impact of the Canadian Space Sector*, pp 37-38. Euroconsult for the Canadian Space Agency.

[233] It is not pure direct tax revenues, as a variety of indirect taxes, not tied to productive activity, are included as well such as local property taxes, sales taxes, fuel taxes and import duties paid by space sector firms or from the purchase made with incomes of direct employees.

towards a more practical and concrete vision, space technology has become a key enabler for a growing number of business operations – classifying as *benefits to private sector users*; in addition, there is a *range of services producing economic gains to end users,* as well as *benefits to government users*. **Efficiency gains** and **cost savings** are concrete and noteworthy. More precisely[234]:

- Range of services producing economic gains to **end users**: Satellite service serves over 1,000 Canadian private and public organisations active in multiple sectors such as natural resources, infrastructure, transportation, defence, utilities, science, health, public safety, financial services, media, telecommunications, engineering and others. Satellite services providers supply three main categories of services: imagery, communications, and navigation and positioning. These are exploited by end users through the most diverse applications, of which only a few examples (among the many) are environment monitoring, agriculture, and resource management operations.
- Benefits to **government users**: The Canadian space program has been tailored to meet the government's strategic priorities including, but not limited to, ensuring national sovereignty and security, linking communities, monitoring natural disasters, managing Canada's natural resources, protecting the environment.
- Benefits to **private sector users**: The Canadian private sector is a well-established user of satellite-based products and services due to Canada's specific geography and the profile of its business activities. A few of the many benefits from satellite services directly related to business operations include the monitoring of remote and inaccessible regions in order to improve their business efficiencies or acquire key information for their decision making, ensuring communication during their activities, and collecting real-time information to guarantee safety and improve productivity.

4.2.2. Actual societal & daily benefits of the Canadian space activity

As for the UK, 'the impact of space spending is found in virtually every sector of the Canadian economy, from aerospace and defence, to structures, composites, life sciences, health care, propulsion, biotech, energy and many others'[235]. Thus, besides pointing out the economic impacts it is important to highlight with the same emphasis the societal benefits as well as the way daily life is influenced.

The impacts of the Canadian space activity enumerated at the end of the previous paragraph (categorised under end, government, and private sector users) are definitely benefitting the economic sphere through cost reduction and gains in efficiency and productivity. However, this vast range of applications of space – and thus of direct consequences of the Canadian space development – can be linked back to **spillover impacts**. The wider contributions coming from spillovers are identifiable and comprehensive of an **incredibly valuable series of social and daily revolutionary effects**. Again, their overall estimation is virtually impossible, but what is relevant is their clear presence and noticeability, their concrete and substantial impact, and especially the fact itself that the Canadian space economy

[234] Euroconsult, (2015). *Socio-Economic Impact of the Canadian Space Sector*, pp 39-48. Euroconsult for the Canadian Space Agency.
[235] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*. Aerospace Industries Association of Canada (AIAC) – September 2016.

is allowing for these. Canadian experts summarise the wider impacts over four broader benefitting dimensions[236]:

- *Support of the national security and sovereignty*: space is key enabler for the Canadian defence and the whole security community is the most mature and operational user of space-based solutions across government agencies. Satellite imagery, satellite communications, GNSS space-based AIS, space surveillance allow for **improved maritime domain awareness**, **supporting Arctic sovereignty**, **enabling military operations abroad** – which would not be possible without the above mentioned space-based capabilities.
- *Part of Canadians' everyday lives*: the space sector has visibly grown to be increasingly prevalent in the everyday lives of Canadians, from ensuring their personal safety to improving their quality of life and being a source of inspiration. In relation to improving the quality of life, the domains benefitting from space-enabled services are **weather services**, **travel and transportation**, **entertainment**, and **broadcast connectivity**. Looking at the improvements in population safety, space-technologies allow for enhanced personal-safety and disaster management among the others. Finally, space inspires Canadian citizens, allowing for the rise of more and better initiatives to engage the public and social media.
- *Protect and manage Canada's environment:* space solutions provide advantages that are unique for both **natural resource management** and **climate change monitoring**, helping the government and private enterprise to protect and manage the national environment. Important information provided by satellite data is essential to several economic sectors such as agriculture, forestry, energy, water, and oil & gas.
- *Foster international collaboration*: the collaboration with international partners that Canada has been able to build over time brings multiple benefits to the nation, including to participate to programs it could not afford otherwise, undertake its programs in a more cost-efficient way, deliver on international commitments, promote relations between governments, and improve outcomes for Canadian industry abroad. This international cooperation allows for societal benefits such as **leverage data access**, **meet international commitments**, **exchange services**, **support Canadian industry's participation in foreign missions**, and **opening up Canadian industry market opportunities**.

4.2.3. The relevance of the Government engagement in the space economy

A robust governance and management framework as well as smart public procurements are what is needed, alongside a focus for developing technological and commercial capacity, to keep Canada among the global leaders in space. Besides relying substantially on space delivered services (the National Defence, the Canadian Armed Forces, and a much longer list of other federal departments depend on space in their capability of contributing to the nations' safety and development), the **Government of Canada has historically largely led space-related activities**: motivated partly by the desire to support provision of public services, partly by prestige, and partly by curiosity, governments have tolerated much of the cost of space exploration and activity[237].

[236] Euroconsult, (2015). *Socio-Economic Impact of the Canadian Space Sector*, pp 61-85. Euroconsult for the Canadian Space Agency.

[237] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*. Aerospace Industries Association of Canada (AIAC) – September 2016.

As **establishing partnership with companies** – through the delivery of contracts to design and manufacture space assets for public as well as private use – is common practice for most of the governments that are interested in developing a space economy, Canada is characterised by a particularly strong industry-government relationship, in which **industry virtually depends on the government support**. In Canada, the pervasive presence of government has proved to be a particular feature of progress in space, in part due to the near inseparability of space from national security and geopolitical influence, in part due to the reality that space involves significant risks and the need for patient money. Thus, as for the UK, where the market fails the government intervenes.

Overall, if on the one side space-based infrastructure impacts the 'whole of government' operations, future space sector requirements are best managed as a 'whole of government' undertaking: government investments and costs support are necessary for the development of the sector, and need to be apportioned appropriately with a focus on the national space capabilities, opportunities and needs. However, as the government has been literally fundamental enabler of the Canadian space development up to now, this strong dependence on its funding might result in a weakness. This feeling is supported by the significant suffer (CSA budget suffered a reduction of 48%, and so its activity and the number of SME within the national space economy[238]) of the Canadian space sector when government's funding in space activities reduced between 2001 and 2014. This results in the awareness that **government's leadership and support are fundamental, but the industry and sector's strength would improve when the dependence on government's funding is not that absolute**. In order to balance the two opposite needs, the role of the government in Canada has been supported and carefully delimited at the same time, concentrating in a number of key areas[239]:

- Supporting **R&D** that might take years to produce marketable results but has the potential to generate substantial benefit to the public good, in part through risk sharing.
- Improving the functioning of markets and business performance by **facilitating communication** between firms whose needs and capacities may be complementary, and between industry and academia and research institutions.
- **Making procurement decisions** that strengthen domestic industries, and therefore the national economy, while respecting international trade rules and acquiring the best product for the reasonable cost.
- Protecting the public and the industry by **ensuring that Canadian products are safe and that sensitive technologies do not fall into the hands of hostile states or interests**.
- Improving labour market efficiency by **supporting vibrant academic institutions** that understand the needs of industry and by **facilitating recruitment of talent** from abroad where serious domestic skills shortage exists.
- Levelling the global playing field for Canadian companies by **negotiating equitable rules** of the game, ensuring that these rules are respected in practice, and **providing companies with information** about foreign markets.

[238] Lansdowne, (2012). *A Report on the Development of a National Space Infrastructure to support the Global Competitiveness of the Canadian Space Industry*. Lansdowne technologies Inc. Publishing.
[239] Aerospace Review, Mandate by the Government of Canada, (2012). *Reaching Higher: Canada's interests and future in Space*, p 12. www.aerospacerevie.ca.

- **Providing financing** to support the purchase of Canadian products, as long as the terms of such financing produce a benefit to taxpayers and the economy, and fall within the bounds of international agreements.

While availability for exact figures highlighting the public rate of return in terms of direct and spillover impact is missing, these effects are undoubtedly existing and originate from the above mentioned beneficial activities the government's involvement allows for.

4.3. Canadian Space Agency - evaluation of long-term impact

After twenty-eight years, the long-term-effects of the Canadian Space Agency on the national space economy are observable and quantifiable. Size and economic impact have improved substantially – and are ready to grow further under a renewed plan.

Since its establishment in 1989, the Canadian Space Agency (CSA) has been the most important national space organisation, taking advantage of the government's support for the realisation of high profile achievements in the space sector. Without its involvement the figures achieved would undoubtedly be significantly reduced. The added value of a dedicated National space agency has been demonstrated in many countries, for example in the UK, as outlined in the previous chapter. Comparisons can be made between the UK and Canada, due to a number of similarities between the two countries.

In the case of the CSA, the establishment in 1989 is too far back in time to allow for a before-after impact evaluation (due to the lack of relevant data prior to 1989); and, even assuming they were available, they would not relevant for a useful evaluation of the effects of the establishment of a dedicated National space agency (as the space economy has completely changed in the meanwhile and entered a "new era"); this section will provide an evaluation of the longer-term effects of the establishment of the CSA . In other words, the report will follow with a **long-term impact evaluation** outlining the improvements that the National space agency has produced over time – as well as the immediate impacts that were achieved shortly after its establishment.

It is relevant to note that the CSA has suffered a reduction in funding for over a decade. It can be shown that this has affected negatively its performance and the impact it has had on the Canadian space economy. Thus, the value of the *size* and *economic impact* on the Canadian space economy that will be outlined here, should be read as a **lower-bound of the CSA's potentialities –** which may instead be fully exploited in the upcoming years given the recent positive inputs from the Government of Canada and the intention to renew the whole space sector with an updated strategy, plan and long-term vision.

The long-term impact evaluation of the CSA on the Canadian space economy will be based on an assessment of both its size, measured by the total space sector *turnover* (or revenues), and its economic effects, which will be captured through the measure of space-related *employment*. Both measures will be considered only in their *direct* impact, and their figures will be presented for a series of points in time with the intention to provide a more complete and detailed picture of the long-term effects, with a multiple-length-term impact evaluation and a trend. The moments in time that have been chosen are in four-year intervals starting from 2003 up to 2015. Besides allowing for an extended

picture of the economic effects (of course to be considered in close synergy with other bodies), this choice of dates also allows a measurement of an 8-year impact over the same period as the before-after UKSA comparison (2006-07 to 2014-15), which can be the starting point for a direct comparison among the two.

Size of the space economy. In order to efficiently make a multi-temporal, long-term evaluation of the impact of the CSA on the size on the Canadian Space Economy, the *turnover* of the space industry is measured for four points in time on a 4-year basis: 2003, 2007, 2011, 2015. Besides showing absolute space-related turnover each year in Canada, the assessment takes into consideration four indexes: the first two measures show the *difference* between each estimate in absolute value (C$ billion), and the *cumulative average growth rate* on the same basis of intervals (i.e. at every measurement, on a four-year basis); the second two indexes are represented by the 4 yearly *cumulative difference* expressed in absolute values (C$ billion), meaning the improvement that has been achieved from 2003 (the first measurement pointed out) to the last one considered, and the *cumulative average growth rate over 4, 8, and 12 years*, using 2003 as starting year.

The measurements on a 4-years basis are a good way to depict the trend of the Canadian space economy's size. This has been clearly growing since 2003 with an increasing growth rate, going from C$1.999 billion to C$5.298 billion of total revenues in 2015. Over 12 years total space-sector turnover has increased by approximately **C$3.3 billion**, with an average growth rate of **8.46%** over the whole period. It is also interesting to note the significant improvement of the growth rate over time (from 4.37% at the first evaluation in 2007, up to **11.06%** at the last in 2011-2015).

Size of Space Economy: after-CSA long-term impact					
Turnover	**Total**[240] (C$ billion)	**Difference** on 4 years basis	**CAGR** (Cum. Average Growth Rate) on 4 years basis	**Cumulative Difference** from 2003	**CAGR** (Cum. Average Growth Rate) from 2003
2003 After-CSA impact	C$1,999	-	-	-	-
2007 After-CSA impact	C$2,372	C$0.373	4,37%	C$0.373	4,37%
2011 After-CSA impact	C$3,483	C$1.111	10,08%	C$1.484	7,19%
2015 After-CSA impact	C$5,298	C$1.815	**11,06%**	**C$3.299**	**8,46%**

2003 % of Canada's GDP - Turnover [241]	Canada GDP (US$ billion)	892.381	Canada GDP (C$ billion*)	1,130.22	**% of GDP**	**0.177%**
2007 % of Canada's GDP - Turnover	Canada GDP (US$ billion)	1,465	Canada GDP (C$ billion)	1,855.45	**% of GDP**	**0.128%**
2011 % of Canada's GDP - Turnover	Canada GDP (US$ billion)	1,789	Canada GDP (C$ billion)	2,265.64	**% of GDP**	**0.154%**
2015 % of Canada's GDP - Turnover	Canada GDP (US$ billion)	1,553	Canada GDP (C$ billion)	1,966.76	**% of GDP**	**0.269%**

**Exchange rate 07/08/2017*[242]

Economic impact of the space economy. In order to efficiently make a multi-temporal, long-term evaluation of the economic impact of the CSA on the Canadian space economy, space-related *employment* is measured again for four points in time on a 4-years basis: 2003, 2007, 2011, 2015. Besides showing absolute space employment size that has been reached each year in Canada, the assessment takes into consideration the same four indexes analysed for the evaluation of the size of the Canadian space economy: the *difference* and the *CAGR* on a 4-years basis, and the same measures on a cumulative basis starting from 2003.

The measurements on a 4-year basis are a good way to depict the trend of the effects that the activity of the CSA has helped the Canadian space economy to achieve. The latter has been clearly growing since 2003 in terms of space employment with a particular jump between 2011 and 2015, when the four-year average growth rate was **7.35%**, with the number of jobs supported by the space economy peaking at 9,927, from the lower value of 7,474. The overall gain of newly generated space jobs over the 12 years was **3,805**, reflecting an overall CAGR of **4.11%.** When compared to the improvements in

[240] Canadian Space Agency, (2009). *The State of the Canadian Space Sector 2009. Policy and External Relations;* Same document for each year up to 2015.
[241] Data from The World Bank website database: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=CA
[242] Exchange rate site used: http://www.xe.com/it/currencyconverter/convert/?Amount=742%2C293&From=USD&To=CAD

the Canadian space economy's size (turnover) employment growth seems to have been smaller over time. However, the growth is substantial, and recently there has been a particularly steep acceleration (2,453 new space workers have been added between 2011 and 2015).

Economic Impact of Space Economy: after-CSA long-term impact					
Employment	**Total**[243] (jobs)	**Difference** on 4 years basis	**CAGR** (Cum. Average Growth Rate) on 4 years basis	**Cumulative Difference** from 2003	**CAGR** (Cum. Average Growth Rate) from 2003
2003 After-CSA impact	6,122	-	-	-	-
2007 After-CSA impact	6,481	359	1,43%	359	1,43%
2011 After-CSA impact	7,474	993	3,63%	1,352	2,53%
2015 After-CSA impact	9,927	2,453	**7,35%**	**3,805**	**4,11%**

2003 % of Canada's Tot. Workforce - Employment[244]	Canada Tot. Workforce	17,361,722	**% of Tot. Workforce**	**0.035%**
2007 % of Canada's Tot. Workforce - Employment	Canada Tot. Workforce	18,279,619	**% of Tot. Workforce**	**0.035%**
2011 % of Canada's Tot. Workforce - Employment	Canada Tot. Workforce	19,066,058	**% of Tot. Workforce**	**0.039%**
2015 % of Canada's Tot. Workforce - Employment	Canada Tot. Workforce	19,748,539	**% of Tot. Workforce**	**0.050%**

Overall, the Canadian space economy has seen significant positive growth over the last fifteen years, especially in terms of turnover gains and especially more recently: the last 4 years has seen the biggest overall growth, both in terms of size and economic impact.

What is interesting is to **make a comparison between the improvements gained with the UKSA and with the CSA** over the same period of time (eight years) and over the same years as well – as this would allow the two countries to be evaluated and the same technologies and knowledge available, and with the same underlying worldwide circumstances and criticalities.

[243] Canadian Space Agency, (2009). *The State of the Canadian Space Sector 2009. Policy and External Relations;* Same document for each year up to 2015.
[244] Data from The World Bank website database: http://data.worldbank.org/indicator/SL.TLF.TOTL.IN?locations=CA

CSA: on 8 year basis: 2007-2015					**turnover**
Difference	national currency (C$ billion)	C$ 2.926	common currency (US$ billion)*	**US$ 2.11**	
CAGR		10.57%		**10.57%**	
UKSA: on 8 year basis: 2006/07-2014/15					
Difference	national currency (£ billion)	£ 7.8	common currency (US$ billion)*	**US$ 11.56**	
CAGR		11.10%		**11.10%**	

**31-01-2015 exchange rate.*

Comparing the improvements that the UK and Canada have achieved over the years 2007-2015 in terms of space-related **turnover**, and thus in terms of the evolution of the size of their national space economies, the difference among the two countries is quite substantial in absolute value, but very close in growth rate (a reason for the difference may be that the things being measured are not exactly the same). The **growth rate** over the 8-year period has been **similar**, meaning that both countries are active in the encouragement of the space sector and that the stakeholders understand the importance of space activities and the opportunities that can arise. Conversely, the **difference** in **absolute value** of the revenues coming from the space industry is **significant**, with Canada performing at particularly low values. However, this is not a surprising finding for a number of reasons which have already been mentioned before in this report. The *first* explanation for this low performance for Canada might be linked to the reduction in funding from the government of approximately 48% that the CSA has experienced domestically between 2001 and 2014. This substantially affected its capacity given the effective and acknowledged dependence that space stakeholders (agencies and industry) have in Canada on government funding. Considering that it is evaluated that every 1 dollar spent by the CSA in business contracts has a **multiplier of C$1.2 billion**[245] (**spillover effect of CSA contracts**: e.g. for C$387 million invested by the CSA, the Canadian space industry generated an additional C$408 million for the Canadian economy), ***if the funding to CSA had not been reduced by half in than ten years and the SME turnover would not have reduced in turn, the turnover would potentially be much higher and comparable to the UK's one.*** A *second* explanation for the difference in turnover's absolute values of the two nations is found in the fact that the **Canadian space sector is much more mature**, having seen the establishment of the CSA almost 30 years ago. Instead, in the UK the establishment of the UKSA is more recent and it has literally shocked the space economy of the country. Overall, it is clear that, ***if the space activity is guided properly*** and with an appropriate program, strategy, and stable spending plan, **the guidance of a dedicated National space agency is crucial for** the success and the **fast development** of a strong national space economy - **both in short and in long time.**

[245] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*, p 6. Aerospace Industries Association of Canada (AIAC) – September 2016.

CSA: on 8 year basis: 2007-2015			**employment**
Difference	jobs	**3,446**	
CAGR		**5.47%**	
UKSA: on 8 year basis: 2006/07-2014/15			
Difference	jobs	**19,425**	
CAGR		**9.17%**	

Comparing the improvements that the UK and Canada have achieved over the years 2007-2015 in terms of space-related **employment**, and thus in terms of one (among the many) measures that are helpful in understanding the economic impact of the activity of a National space agency, the **growth rate** seems to be characterised by a **more robust difference** (of about **3.70%** extra growth for the UK) than what has been noticed in relation to turnover. This suggests that a more vibrant, modern and exciting space activity (such as the one of the UK has been able to capture) that satisfies the interest of a wider number of young professionals, is important. Thus a key of success for a country lies in being able to find the best way to **keep the interest in the sector alive – even in the long term**. Again, ***if the Canadian government had provided more stable and substantial funding –*** *instead of adopting the strategy of maximising the results with the minimum investment*[246] **–** most probably **the economic impact in Canada would have been more significant in the long term**. Moreover, due to a **lack of data**, it has not been possible to look into the same detail **for other measures of the economic impact of the Canadian Space Agency**, which might provide a more comprehensive vision and show a better performance. Finally, the analysis of the difference between Canada and UK in terms of turnover holds for employment as well: decreasing CSA funding has also been relevant in this context.

[246] Aerospace Industries Association of Canada, (2016). *The Future of Canada's Space Sector. An Engine of Innovation for Over Fifty Years*, p 6. Aerospace Industries Association of Canada (AIAC) – September 2016.

5. MODELLING THE NATIONAL SPACE AGENCY'S SOCIO-ECONOMIC EFFECTS

5.1. UK & Canada as predictors for Australia

Australia is one step behind UK and Canada, but many steps ahead – and it has now the unmissable opportunity to learn from those countries that are so significantly alike.

A National space agency is an unquestionable source of growth, an investment in the country's future *development, and a continuing innovation driver.*

The reason why the space economies of UK and Canada have been analysed with great detail is partly linked to the similarity that those two countries have with Australia: in particular, Canada is tied closely to the Australian case for the dimension of its population – 24.13 million for Australia, 36.29 million for Canada – and the characteristics of their territory – population scattered on vast territories with remote areas, Australia counting 7,686,850 km2, Canada 9,984,671 km2. The analysis of the UK space economy is instead mostly motivated by the fact that the UK Space Agency was established only recently, offering a good case to analyse, with data-availability, and happened in a space environment that is reasonably similar to the actual one. *Given that the scope of this report is the comprehension of Australian space activity, its potentialities, and its opportunities of growth and evolution,* ***the similarities with the UK and Canada allow Australia to study them as first-movers in the sphere of the space economy, and they are good examples to look at and learn from***. In other words, the two countries' experience and evolution in space represent a unique opportunity for Australia to emulate and hopefully to benefit from the lessons learned in each country.

Most countries have decided that national space agencies are fundamental actors for the growth of their space sectors. Australia – together with Iceland – are the only OECD countries not to have established one. This is why *it is of great interest for Australia to be aware that a National space agency may be a good solution for the perceived country's need for a renewed approach to the space sector's organisation and management*. This is exactly the scope of this chapter: to provide some ***evidence and arguments supporting the potentialities of a dedicated National space agency for the Australian space economy and more broadly its citizens' quality of life, security and health***. In attempting this objective, the UK and Canadian's experience will be used as examples that sustain this proposition.

The UK Space Agency and the Canadian Space Agency playing an important role in advancing the objective of developing a strong national space sector as well as in creating international synergies that result in improved global space activity and expertise.

5.1.1. UK as a potential best-practice predictor for Australia

The UK decided in 2010 it was time to establish a dedicated National space agency. A long list of achievements followed, including the accelerated growth of the sector, the rise of organisations focused on making space activities more efficiently and cooperative, which resulted in global

recognition of its impressive performance. The analysis in this paper of the 'before-after UK Space Agency's establishment' highlights:

i) the *fundamental improvements that a National space agency allows for*, in a range of daily, social, and economic spheres;
ii) the *areas of focus of the agency, perceived as key enablers and supporters of ongoing space innovation;* and
iii) *the importance of having a strong, vast and international as well as domestic cooperative attitude and collaborative approach*.

A summary of UKSA's effects on the *size* of the UK space economy, and of UKSA's *economic, social and daily* impacts, are provided in the table (Figure 7).

The following additional analysis aims to sustain further the claim that the UK and Australia are similar, and thus reasonably comparable: the purpose is to show **how similar the situation of the UK 'before' the establishment of UKSA and the current situation of Australia – which can be seen as its 'before' state – actually are.** The comparison will be made on the basis of two relevant measures: *space turnover* as indicator of the *size* of the national space economy, and *direct employment* in the space sector as indicator for the *economic impact*. These will be put in proportion to the *total workforce* of each country, as the resulting ratio is a more significant measure than the absolute values.

While the UK had a 'before' ratio of space turnover over total workforce of **0.0369%**[247], Australia had a 'before' ratio of **0.02275%**. What emerges is that the two ratios for the 'before' state are for Australia and UK reasonably close, with a *slightly lower value for Australia*. Looking then at the space employment, its 'before' impact on the UK total workforce accounted for a share of **0.0610%**, while in Australia space employment 'before' was **0.0869%** of its total workforce. This second set of 'before' National space agency ratios shows a *higher share for Australia*, meaning that in proportion to the total workforce of each country, Australia offers a higher presence of space related jobs.

[247] If the *inflated value* from for UK's turnover would be used to take account of the difference between 2006 and 2016, and thus see what the UK 2006 numbers would be in 2016 (inflated value of 'before' turnover: £7.83 billion, equivalent to US$15,338.20 million) the ratio would be of 0.04897%. Bank of England Inflation Calculator at the website: http://www.bankofengland.co.uk/education/Pages/resources/inflationtools/calculator/default.aspx

A *comparison of UK and Australia 'before'* the establishment of a National space agency		'Before' space-turnover ratio (%)	'Before' space-employment ratio (%)
Australia 'before' (2016)		**0.02275%**	**0.08690%**
Tot. Workforce	12,660,295		
Space-turnover (absolute value)	A$4 billion (US$ 2,880.6 million)		
Space-employment (absolute value)	11,000		
UK 'before' (2006)		**0.03690%**	**0.06100%**
Tot. Workforce	31,321,803		
Space-turnover (absolute value)	£5.9 billion (US$ 11,557.52 million)*		
Space-employment (absolute value)	19,097		

Figure 8. "A comparison of UK and Australia 'before' the establishment of a National space agency".
** If the inflated value from for UK's turnover would be used to take account of the difference between 2006 and 2016, and thus see what the UK 2006 numbers would be in 2016, the ratio would be of 0.04897%. (The inflated value of UK's Space-turnover in absolute value 'before' is £7.83 billion, equivalent to US$15,338.20 million in 2016).*

Analysing space employment and turnover figures in relation to appropriate national records allows for a more significant comparison among the countries, and results in a relevant observation: **Australia today is not performing very differently than what the UK was before the establishment of its National space agency.** This means that the 'before' National space agency state of Australia i.e. its actual status, is fairly similar to the 'before' state of the UK.

The *comparability* of the two countries arising from their proven similarities, and the *recent* establishment of UKSA **allows us to take the UK as a best-practice predictor of the consequences of the establishment of a National space agency in Australia**. In particular, the last analysis supports with additional confidence this inference, and it may be argued that an eventual Australian Space Agency could take inspiration from the general *organisation* and *structure* of UKSA, given the fact that such an agency can be planned afresh. Hence, the improvements that the UK has achieved with the establishment of its space agency may be considered as **indicative of the consequences that a National space agency's establishment in Australia would eventually lead to**: the dimension of its economic impacts may be expected to be in line with the ones presented for the UK Space Agency case.

Having observed this close association between the UK and Australia, the report will provide – on the basis of the British experience – a **simulation of the economic effects** that the establishment **of the Australian Space Agency** would eventually support. Assuming that:

i) a dedicated National space agency will be established in Australia;
ii) Australia currently accounts for a space turnover of A$4 billion and 11,500 jobs generated directly in the space sector (that is a conservative estimation for 2017);

iii) given the supportive arguments outlined beforehand, it is accepted that Australia will have a space sector's evolution analogous to the one experienced by the UK – once the National space agency established;

iv) the global space economy will continue growing at the same, constant rate (the compound annual growth rate was evaluated approximately 9.5% from 1998 to 2015[248]);

v) the projection is made over the same time span of 8 years i.e. the period over which the improvements for the UK case are evaluated – meaning the simulation will reflect Australia's situation in 2025.

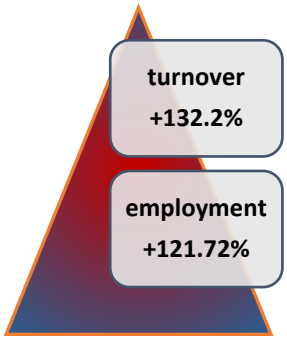

Figure 9. "UK-based Economic Effects – with the establishment of a National space agency, over 8 years".

On the basis of the economic effects modelled from the UK case, the establishment of a dedicated National space agency in Australia today will sustain the national economy with a **space turnover of A$9.29 billion** and **19,301 *direct* additional jobs in 2025** – a noteworthy improvement from the current estimated A$4 billion revenues and 11,500 employees[249] (figure 9; figure 10).

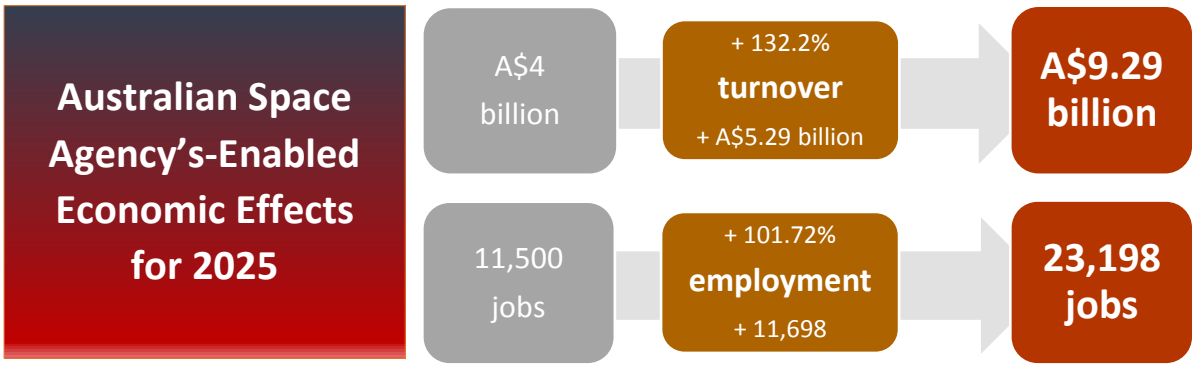

Figure 10. "Australian Space Agency's-Enabled Economic Effects for 2025 – UK-based Simulation".

Lastly, the **share of global space economy** captured by Australia is estimated to reach **1.52% in 2025,** and **4% in 20 years**[250].

5.1.2. Canada allows Australia for second-mover-advantages

The 'long-term impact evaluation of the CSA' is important to the understanding of the relevance of the activity of a National space agency in a country's development in the space sector. It also represents the best example of the need for constant coordination and collaboration among the different stakeholders involved: a National space agency by itself is not able to accomplish its tasks without the support of the government and its funding, and without a long-term constantly updated

[248] Defence SA, Space Industry and R&D collaborations, (2016). *Space Innovation and Growth Strategy (South Australia). Action Plan 2016-2020*, p 2.
[249] See *Annex 2* for detailed calculation and explanation.
[250] The estimation for the share of global space economy captured in 20 years (4%) can be found in the SIAA White Paper: Space Industry Association of Australia (2017). *SIAA White Paper: Advancing Australia in Space*, p 2. The estimation for the same measure that will be reached in 2025 (1.52%) is based on the SIAA's figure.

vision and strategic plan, and an efficient program of activities. The analysis of CSA's establishment, performance, and evolution path highlights:

i) its importance and *fundamental impact*, as well as the necessity of *efficient and coordinated communication with the other space-involved bodies* – these being academia, government departments and agencies, and industry;
ii) the *need to maintain ongoing attention, perseverance and constant renewal*; and
iii) the need for *new focus areas* for the future.

The impact of the CSA in the long term – in terms of *size* of the national space economy, and *daily*, *social*, and *economic effects* – is summarised in the table (Figure 8). Overall, the performance is less impressive than the UK. One natural and structural reason for this is the fact that the space sector has reached in Canada a more mature stage and it is natural that the initial explosion of growth (which the UK is now witnessing) tends to decline over time when the source of the 'new shock' stabilises. However, there are some other important factors that should be pointed out as being partly responsible for the differences. Besides the already-mentioned *change in funding* from the government to the CSA (the reduction of 48% of funding over approximately 10 years), and the *greater government-industry dependence* which seems to have led to less willingness on the part of businesses to commit to innovation-development and investment, in addition the CSA's *plan and strategy had not been updated and modernised* for many years; If those factors had not influenced the space activity of Canada over the last fifteen years, the impact of the CSA and the other national bodies' activity would have probably been measurably greater. A last relevant factor to mention is that the CSA has a much greater number of staff than the UK, suggesting that more of the science and engineering is done in-house rather than out-sourcing to the private sector.

These features of the Canadian space economy are for Australia though-worthy, representing aspects that could be analysed with deeper care when drawing up a path of action. The fact of having this **second-mover-advantage** in a market sector that has been explored previously by a close first-mover as Canada may suggest an interesting **cluster of useful practices and facts to learn and take advantage from, both in terms of what is best practice and what should be avoided**.

In addition, Australia can take inspiration from:

i) *the way Canada is approaching this changes* – in terms of program-setting and concrete action (direct communication with the various stakeholders to perceive their needs, provision of roundtables and discussing-forums, group-works creation to enable the exchange of ideas around the topic, etc.);
ii) *the areas on which it focuses* mostly its ambitions, as these will be perceived to be growth-enablers;
iii) *the extent to which the CSA collaborates and communicates with the other space-involved bodies* in the search of an optimal balance that survives in the long-term.

Overall, Australia is looking for a change and an improvement in the evolution of its space economy, and besides the fact that virtually all the OCED countries have moved in the same direction of establishing a National space agency, UK and Canada are two examples that are particularly close and significant for Australia, given the similarities among the countries. The suggestions in terms of looking

at, and taking inspiration from what has happened in those nations is not a scientific, exact forecast. It highlights the broad benefits and gives an idea of their potential scope (especially, looking at the UK as best-practice), as well as highlighting some critical aspects to handle with care (in particular, looking at the case of Canada).

The analysis made in this chapter is intended to present some interesting **food for thought** for Australia to advance in space and boost its economy, through the process of establishing a National space agency, sustained in an efficient and supportive way.

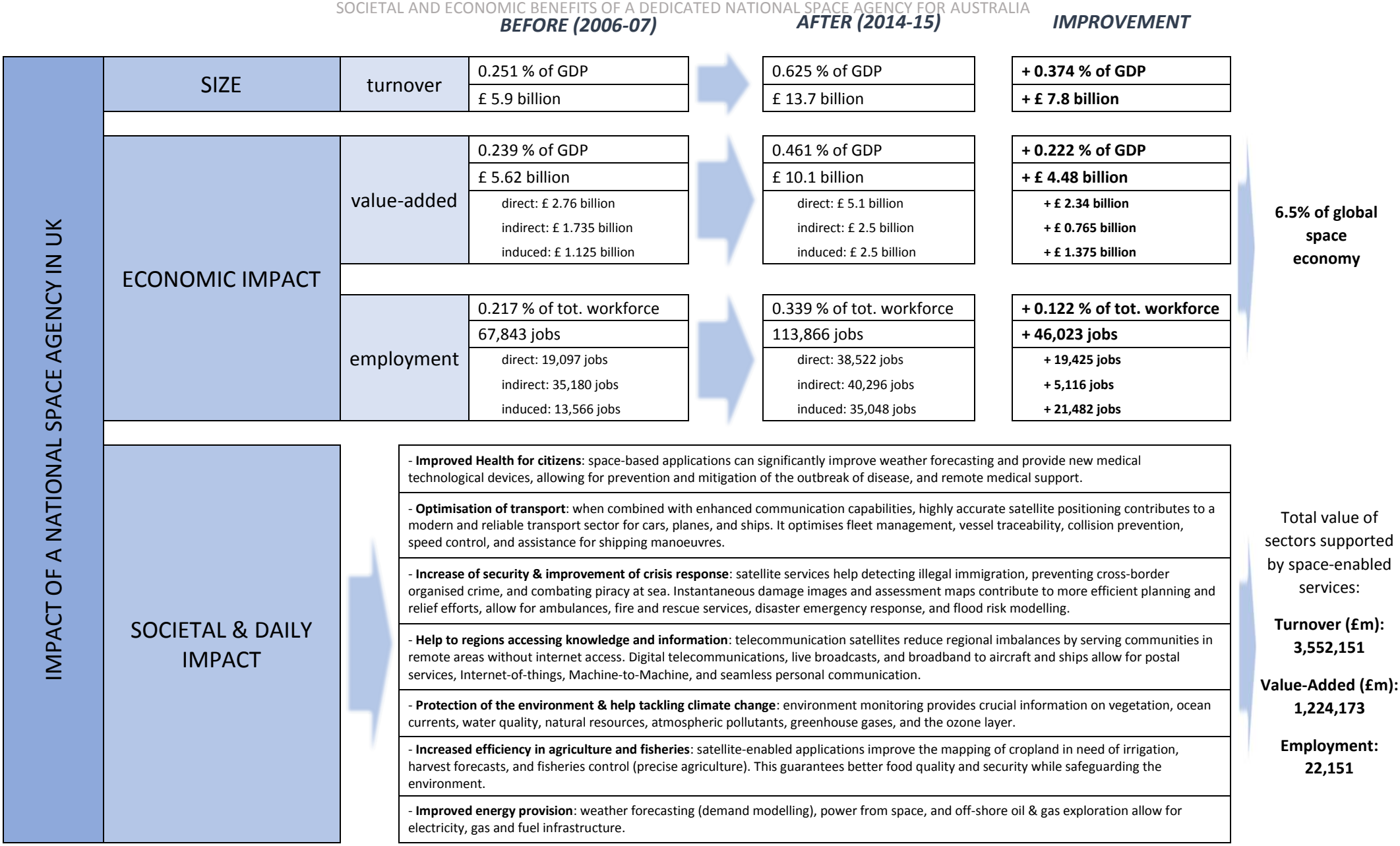

Figure 11. "Impact of a National space agency in UK – Size, Economic Impact, and Societal & Daily Impact".

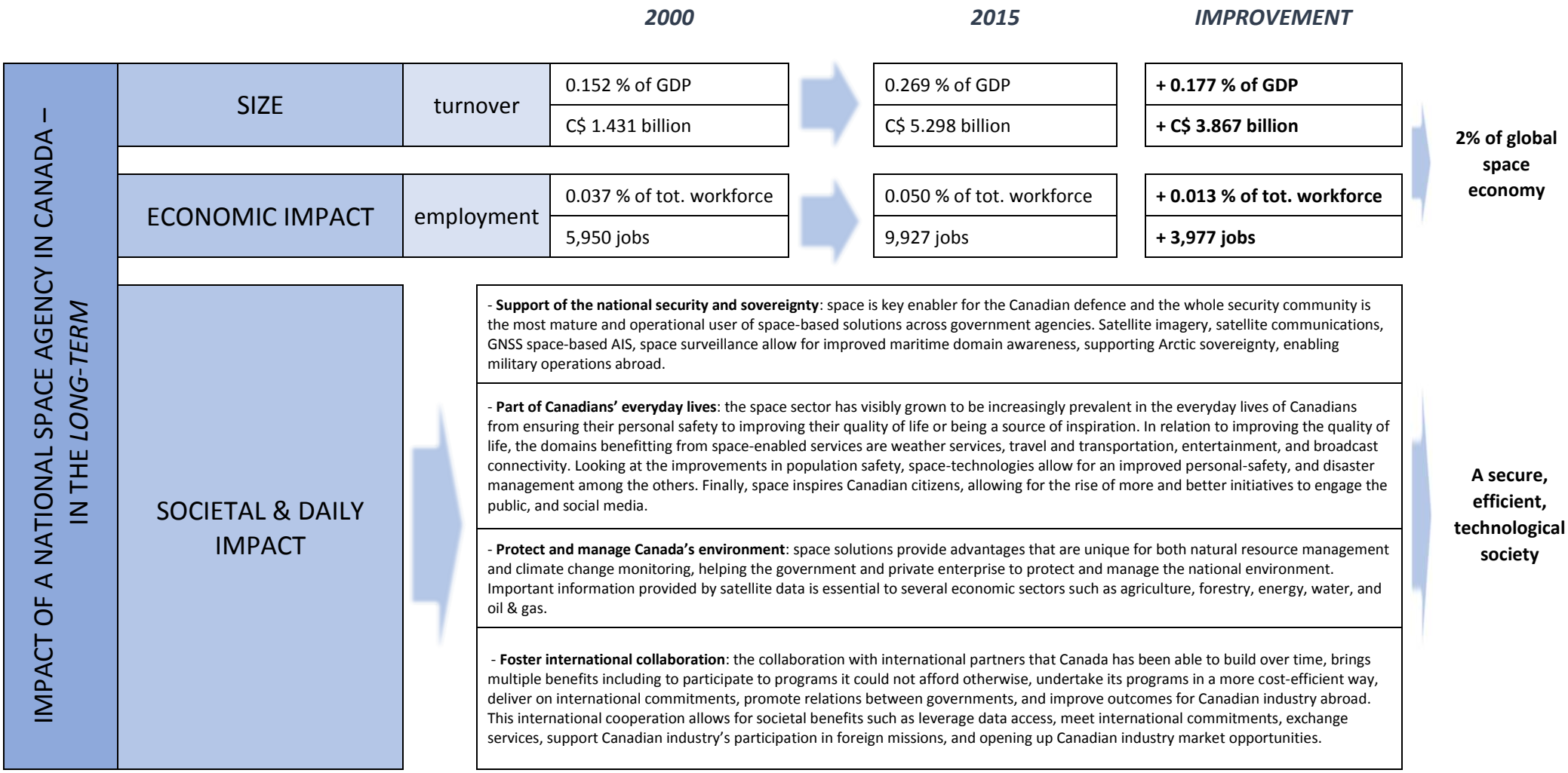

Figure 12. "Impact of a National space agency in Canada in the long-term – Size, Economic Impact, and Societal & Daily Impact".

CONCLUSIONS

A **National space agency** is a body responsible for all strategic decisions of the national civil space programme, providing a clear single voice for national space ambitions. Its added-value for a country is in better collaboration amongst space stakeholders through the creation of the best context – domestically and internationally – for exploring and benefitting from space, allowing for the central coordination and administration of all space-related activities, budgets, and plans.

The experience of the UK and Canada support the argument that **a dedicated National space agency is an unquestionable source of growth, an investment in the country's future development, and a continuing driver of innovation**. Indeed, figures for measures of *size* and *economic impact* of their national space activity show that an active, supportive role of the National space agency allows for a significant improvement in all the space-driven spheres of activity:

The **UK** currently captures a share of **6.5%** of the global space economy, and experienced over the 8-years period between 2006-07 and 2014-15 an *improvement* of: i) **£7.8 billion** of space ***turnover*** (corresponding to an additional **0.374% of GDP**) – that is a good indication of the *size* of its space economy; ii) **£4.48 billion** of ***total value-added*** (corresponding to an additional **0.222% of GDP**), split in additional direct impact of £2.34 billion, indirect impact of £0.765 billion, and induced impact of £1.375 billion – that is a measure for the *economic impact* of the space sector on the national economy; and iii) **46,023 *total space-related jobs*** (corresponding to an additional **0.122% of total workforce**), split in 19,425 direct newly generated jobs, 5,116 indirect, and 21,482 induced. The *multipliers* achieved are: **1.97** for the ***value-added***, meaning that every £1 spent in the space sector generates an additional £0.97 worth in the supply chain and supporting sectors; **2.96** for the *employment*, meaning that the activity of 100 employees in the space industry supports 196 additional workers among suppliers and in other economic sectors. The return to public space-related investment, which is the *multiplier of the Government's spending*, is typically **2 or 3 times larger than direct returns**, representing the **proof of the contribution of public spending on space**. In terms of *social and daily benefits*, represented partly by the induced, indirect and spillover effects, the main achievements allowed by space-derived applications and space-driven technological transfer have happened in health, transport, security, crisis response, knowledge and information access, environment protection, agriculture and fishing, and energy provision among the others.

The *dynamic structure* and *efficient internal organisation* of the ***UK Space Agency***, in addition to its capacity to *coordinate and cooperate* with all the stakeholders and government bodies involved in the space sector, *efficiently allocate space funds*, and *build a national and international network* have proved to be among the leading sources of UK's success in space.

Canada currently captures **2%** of the global space economy, and experienced over the 15-years period between 2000 and 2015 an improvement of: i) **C$3.867 billion** of *space* ***turnover*** (corresponding to an additional **0.177% of GDP**); and ii) **3,977 *total space-related jobs*** (corresponding to an additional **0.013% of total workforce**). The *multipliers* achieved are: **1.85** for the ***value-added***, meaning that every 1 dollar spent in space industry generates an additional C$0.85 worth in the supply chain and supporting sectors; **2.5** for the *employment*, meaning that the activity of 100 employees in the space

industry supports 150 additional workers among suppliers and in other economic sectors. In terms of *social and daily benefits,* major benefits were in the domains of security and sovereignty, in various aspects of Canadians' everyday life, in the protection of the environment and in fostering international collaboration.

Some factors explaining the **less impressive performance of Canada** with respect to the UK include that: the space sector in Canada has reached a *much mature stage* and it is natural that the initial explosion of growth (which the UK is now witnessing) tends to decline over time when the source of the 'new shock' stabilises; the *change in funding* from the government to the CSA (a reduction of 48% over approximately 10 years); the *greater government-industry dependence* which seems to have led to less willingness on the part of businesses to commit to innovation-development and investment; and the fact that the *CSA's plan and strategy had not been updated and modernised* for many years.

Given the following facts: i) the ***natural geodemographic similarities between Australia and Canada*** in having a small population scattered on a vast territory (24.13 million covering 7,686,850 km2 for Australia, and 36.26 million covering 9,984,671 km2 for Canada); ii) the ***UK represents a very recent, fresh case of a dedicated National space agency being established*** (in April 2010), and thus occurred within a space economy and environment that is not too dissimilar to the actual one; in addition to iii) arguments sustaining that ***Australia is not performing very differently from how the UK was performing 'before' the establishment of its National space agency*** in terms of space jobs and turnover i.e. UK had a slightly smaller 'before' share of space related jobs on total national workforce than Australia has now (0.0610% versus 0.0869%), and a slightly larger 'before' ratio of space turnover over total national workforce (0.0369% versus 0.02275%).

Given its proven comparability with **UK and Canada**, the two can be seen by Australia as **first-movers in the sphere of the space economy, and good examples to look at and learn from**: their experience represent an unmissable opportunity for Australia to take advantage of.

I) The ***UK represents a best-practice predictor of the consequences of the establishment of a National space agency in Australia***: ***Australia can expect a contribution from the establishment of an Australian Space Agency that is similar (in both economic and social impacts) to the one experienced by the UK***. Moreover: i) the UK Space Agency represents the example of an efficient, dynamic and well-organised body; ii) the areas of focus of the agency are perceived as key enablers and supporters of ongoing space innovation; iii) the UK space activity's overall organisation shows the importance of strong international relations as well as a domestic cooperative attitude and collaborative approach. Lastly, i**f Australia is able to replicate the performance of the UK space economy** over the first eight years following the establishment of the UK Space Agency, it is possible to extrapolate that over a similar time frame, there would be an absolute improvement of about **A$5.3 billion** (132% increase on current figures) and an increase in direct employment in the sector of about **11,700 jobs** (102% increase on current figures). These calculations are based on conservative assumptions.

II) The ***longer experience of the Canadian Space Agency delivers Australia a second-mover-advantage in the space market***, suggesting a ***cluster of useful practices and facts to learn and take advantage from, both in terms of what is best practice and what should be avoided*****.** Moreover: i) the Canadian Space Agency's experience highlights the importance of efficient and coordinated communication with all the space-involved bodies – these being academia,

government departments and agencies, and industry; ii) the National space activity's experience shows the need to maintain ongoing attention, perseverance and constant renewal; iii) the Canadian Space Agency needs new areas of focus for the future. *These features may encourage Australia to eventually define a National space agency that is best integrated in an efficient space system and environment*. *Australia may be inspired also by the evolutionary and changing approaches Canada is adopting to modernize its space activity*, including: discussing-forums and group-works creation to facilitate the exchange of ideas; the areas where ambitions are most focused, as perceived to be growth-enablers; the extent to which the Canadian Space Agency collaborates and communicates with the other national and international space-related bodies in the search of the optimal balance that survives in the long-term.

Australia is only one step behind UK and Canada, but many steps ahead at the same time. Australia has developed over time a highly skilled and qualified expertise and is privileged by the awareness from all the space stakeholders and government of the importance of the space industry for the socio-economic growth of the nation. *Its potentialities and future opportunities to develop new space-capabilities are real and **just need a lead***. The new industries willing to enter the space sector are countless and the research network, having already proven great expertise, is eager to open further its collaboration overseas to pull skills and knowledge together for greater results. *Australia is an exciting hub of knowledge, innovative ideas, expertise and space-stakeholders ready to be pushed further to turn any opportunity into a success.*

The establishment of an Australian Space Agency, sustained in an efficient and supportive way, would help Australia tap further into the multi-billion-dollar industry and maximize the space-driven socio-economic benefits, exploiting the opportunities open to it. The result will be – as UK and Canada show – a faster growing turnover and a consequent greater share of the global space economy, the generation of a significant number of jobs, and an ongoing modernization of Australian society.

Annexes

ANNEX 1: Clarification of terminology and concepts.

Clarification note on *social impacts*: whenever in this report it is talked about "social benefits" or "social impact", the idea is to capture purely the *social dimension*, leaving on a side the economic interpretation of it. In fact, what is meant are the practical benefits provided by wider applications of space derived data and space derived technologies, meaning the concrete way these affect daily lives and find applications in different domains. Hence, this note is to clarify that, despite induced and indirect impacts are comprehensive of social benefits, the choice has been to include them within the "economic effects*",* and to embrace only the above described practical and daily lives improvements in the "social impacts". Examples of the *social effects* the way this report identifies them are the benefits on health (e.g. distance-care enabled by space technologies), environment (e.g. climate change monitoring) and transport (e.g. collision prevention and speed control) among many.

Clarification note on the use of the expression *economic impact*: There are three different approaches by which it is possible to analyse a specific event in an economic perspective; hence, three different approaches can be used to measure the economic effects of the space industry in a country:

1. The *economic size* – which can be indicated by the revenues.
2. The *economic contribution* – which can be measured by value-added, jobs creation, spillovers, etc.
3. The *economic impact* – which can be measured by the economic outcomes with and without the space industry sector (or by changes in the output of the sector) and the consequential direct and indirect effects that result. In particular, this approach is based on comparing a reference case with a counterfactual.

A first note needs to be outlined with regards to the *approaches used in this report*: the focus is mainly on the first two i.e. the use of turnover to evaluate the size of the economy, and the use of value-added, employment, tax contribution, and labour productivity (among others) to identify the economic contribution of the space sector.

A second note is to clarify the *use of the word "impact"*. The report will often refer to "economic impacts". However, the meaning of this is not in terms of approach (3) above, but in terms of the *contribution* made by the space sector to the economy as outlined in approach (2).

A third and last note will describe more in detail what *economic contribution* is – being this the major focus when looking at the economic dimension in this report. The estimated economic contribution of the space industry includes the direct contribution made by the industry to the country's economy (including GDP, incomes and employment) along with the indirect contribution embodied in the space industry's supply chain as well as the economic contribution made by the workers throughout the

space industry's supply chain spending their after tax incomes on other goods and services. In essence, the economic contribution is a measure of the total amount of economic activity that is touched by the space industry in some manner (and therefore could be affected in some way if there was a shock to the industry)[251].

[251] Direct contribution from Alan Smart, Principal and Marketing Director in ACIL Allen Consulting – Sydney.

ANNEX 2: Australian Space Agency's-Enabled Economic Effects – UK-based Simulation.

UK		Initial Value (2006-07)	Final Value (2014-15)	Improvement (absolute value)	**Improvement (%)**	
Size	Turnover	£5.9 billion	£13.7 billion	+ £7.8 billion	**+ 132.2%**	*Establishing the **UK Space Agency** (span time of **8 years**)*
Economic Impact	Value-Added (total)	£5.62 billion	£10.1 billion	+ £4.48 billion	+ 79.72%	
	direct	£2.76 billion	£5.1 billion	+ £2.34 billion	+ 84.78%	
	indirect	£1.735 billion	£2.5 billion	+ £0.765 billion	+ 44.09%	
	induced	£1.125 billion	£2.5 billion	+ £1.375 billion	+ 122.22%	
	Employment (total)	67,843	113,866	+ 46,023	+ 79.72%	
	direct	19,097	38,522	+ 19,425	**+ 101.72%**	
	indirect	35,180	40,296	+ 5,116	+ 14.54%	
	induced	13,566	35,048	+ 21,482	+ 158.35%	

Figure 12. Observed Economic Effects on the national economy – over 8 years (from 2006-07 to 2014-15), with the Establishment of the UK Space Agency.

Australia		Initial Value (2017)	Final Value (2025)	Improvement (absolute value)	**Improvement (%)**	
Size	Turnover	A$4 billion	A$9.29 billion	+ A$5.29 billion	**+ 132.2%**	*Establishing the **Australian Space Agency** (span time of **8 years**)*
Economic Impact	Value-Added (total)	-	-	-	+ 79.72%	
	direct	-	-	-	+ 84.78%	
	indirect	-	-	-	+ 44.09%	
	induced	-	-	-	+ 122.22%	
	Employment (total)	-	-	-	+ 79.72%	
	direct	11,500	23,198	+ 11,698	**+ 101.72%**	
	indirect	-	-	-	+ 14.54%	
	induced	-	-	-	+ 158.35%	

Figure 13. Simulation of the Economic Effects on the national economy – over 8 years (from 2017 to 2025), with the Establishment of the Australian Space Agency.

The simulation for the economic effects of the establishment of the Australian Space Agency on the basis of the UK experience reflects projections for the space turnover and the direct employment only. This is because there it has not been possible to find figures for the other measurements in the case of Australia – while they exist for UK.

The improvement in percentage [*Improvement (%)*] has been derived from the UK case by executing the simple growth rate formula between the final and initial values.

List of abbreviations

ACLC	Air Cadet League of Canada
ACMA	Australian Communications and Media Authority
ADMB	Aerospace, Defence and Marine Branch
AGD	Attorney-General's Department
AMSA	Australian Maritime Safety Authority
ASB	Australian Space Board
ASI	Agenzia Spaziale Italiana
ASO `	Australian Space Office
ASRP	Australian Space Research Program
BIS	Business, Energy & Industrial Strategy
CAGR	cumulative average growth rate
CASA	Civil Aviation Safety Authority
CASI	Canadian Aeronautics and Space Institute
CIR	critical infrastructure resilience
CNES	Centre National d'études Spatiales
CPSX	Centre for Planetary Science and Exploration
CSA	Canadian Space Agency
CSCA	Canadian Space Commerce Association
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSP	Canadian Space Program
DFAT	Department of Foreign Affairs and Trade
DIIS	Department of Industry, Innovation and Science
DIRD	Department of Infrastructure and Regional Development
DLR	Deutschen Zentrums für Luft- und Raumfahrt
DND	Department of National Defence
DoD	Department of Defence
DRDC	Defence Research and Development Canada
DTH	Direct-To-Home

EC	European Commission
ECSAT	European Centre for Space Applications and Telecommunications
EDA	European Defence Agency
EELV	Evolved Expendable Launch Vehicle
ELDO	European Launch Development Organisation
EO	Earth Observation
ESA	European Space Agency
ESRP	European Space Research Organisation
EU	European Union
EUMETSAT	European Organism for the Exploration of Meteorological Satellites
FTE	full-time equivalents
GA	Geoscience Australia
GDP	Gross Domestic Product
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GPTs	General Purpose Technologies
GVA	Gross Value Added
IASI-NG	Infrared Atmospheric Sounding Interferometers
IGS	Space Innovation and Growth Strategy
IoT	Internet-of-things
IPP	International Partnership Programme
IRNSS	Indian Regional Navigation Satellite System
ISED	Innovation, Science and Economic Development
ISRO	Indian Space Research Organization
ISS	International Space Station
JAXA	Japan Aerospace Exploration Agency
KARI	Korean Aerospace Research Institute
KTN	Knowledge Transfer Network
LTSP	Long Term Space Plan
M2M	Machine-to-Machine
MDA	MacDonald, Dettwiler and Associates Ltd.

MEXT	Education, Culture, Sports, Science and Technology
MSAT	Mobile Communications Satellite
MUSIS	Multinational Space-Based Imaging System
NASA	National Aeronautics and Space Administration
NBN	National Broadband Network
NGA	National Geospatial-Intelligence Agency
NRC	National Research Council
NRO	National Reconnaissance Office
NSP	National Space Program
NSSP	National Space Security Policy
OECD	Organisation for Economic Co-operation and Development
OSA	Outer Space Act
PNT	Positioning, Navigation and Timing
SAR	Synthetic-aperture radar
SATCOM	Satellite Communications
SBAS	Satellite Based Augmentation System
SCC	Space Coordination Committee
SIAA	Space Industry Association of Australia
SME	Small and Medium-Sized Enterprise
SOFIA	Stratospheric Observatory For Infrared Astronomy
SSCL	Space Strategies Consulting Ltd.
SSGP	Space for Smarter Government Programme
SSL	Space Systems/Loral
STEM	Stems Engineering, Systems Integration, Installation, Operation and Technical Support
SWOT	Surface and Ocean Topography
TISN	Trusted Information Sharing Network
UAS	Unmanned Aerial Systems
UKSA	UK Space Agency

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