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GLOBALISATION OF SPACE MANUFACTURING: RECENT TRENDS AND PUBLIC POLICY RESPONSE

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ABSTRACT

The growing international segmentation of the production of space products and services (e.g. components, subsystems, entire systems, distribution of services…) comes with new opportunities and risks for both traditional and new actors in the space industry. Globalisation allows for cost savings for a number of private operators, universities and entrepreneurs that can rapidly develop satellites and innovative activities, thanks to the growing capacity to shop around for the best value and off-the-shelf systems. But it also comes with growing risks as value chains stretch further around the globe and delivery of supplies vital to production suffer chances of interruption. The increased exposure of value-creating industries to industrial rationalisation and foreign outsourcing may also have impacts on future public innovation capabilities.

This paper summarises key findings from the Organisation for Economic Co-operation and Development (OECD), an intergovernmental economic organization, which is tracking globalisation trends and providing policy advice to its 34 member states. The OECD has been examining global value chains in the space sector, with preliminary results featured in the recent report “The space economy a glance 2014”. Results indicate that the space sector is increasingly subject to globalisation, mainly triggered by companies’ efforts to reduce production costs in a more competitive environment. The paper concludes that governments must establish better methods for tracking domestic industrial activity, as well as for supporting key scientific and industrial skills in the space sector.

GLOBALISATION OF SPACE MANUFACTURING: RECENT TRENDS AND PUBLIC POLICY RESPONSE

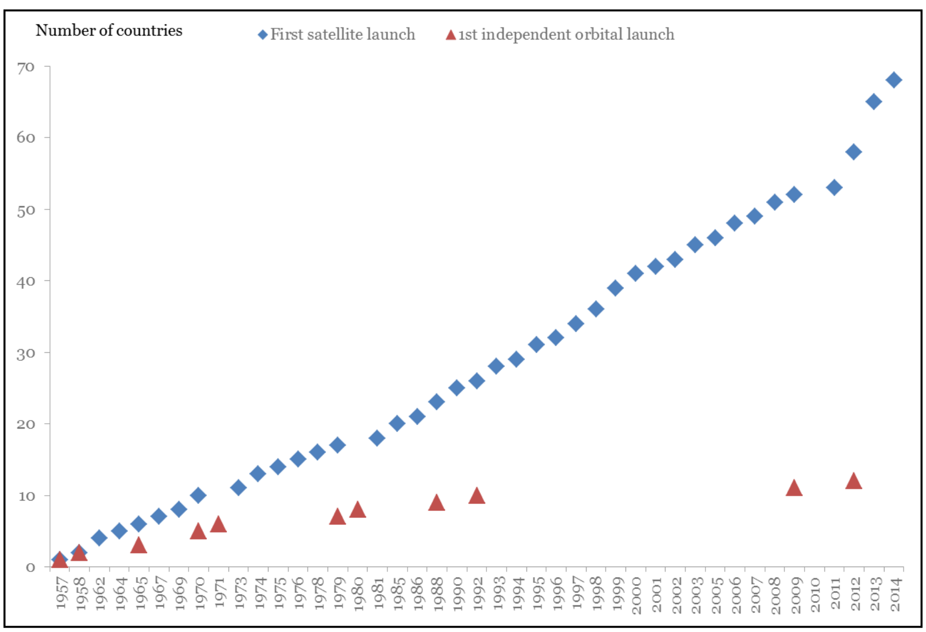
In our interconnected world, science and technology activities are major drivers of productivity and economic growth, and the space sector is one vector of this dynamic. This central role is comprehensively portrayed in the OECD report *The Space Economy at a Glance 2014*. This publication from the Organisation for Economic Co-operation and Development (OECD), draws on original data on the space industry to provide major findings, with a special focus on the space sector's evolving global value chains. This rapid globalisation takes many forms, brings innovation that may transform the sector, but also generates a host of policy issues for OECD countries. This paper summarises some of the key findings and suggests ways for governments to establish better methods for tracking domestic industrial activity, as well as for supporting key scientific and industrial skills in the space sector.[1]

The globalisation of the space sector is accelerating.

In the 1980s, only a handful of countries had the capacity to build and launch a satellite. Today, almost 70 countries have satellites into orbit. Supply chains for satellites and rockets have never been more developed or internationalised. As these global value chains develop, we see a rise in the mobility of people and ideas.

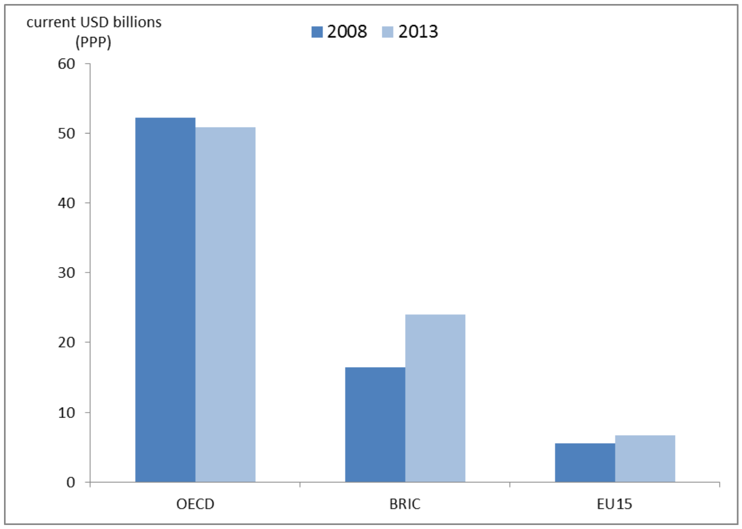
Globalisation is affecting the space economy at different levels. In the 1980s, only a handful of countries had the capacity to build and launch a satellite. Many more countries and corporate players across a wide range of industrial sectors are now engaged in space-related activities, a trend that is expected to strengthen in the coming years. More countries than ever before are pursuing activities in the space sector. More governments are investing in the space sector around the world, this represents around USD 76 billion in 2013 (in PPPs). While not trivial, even in the largest programme in the world – the United States -- space represents less than 0.3% of GDP; in France, it's less than 0.1% of GDP. The OECD recorded that 19 countries had an institutional space budget surpassing USD 100 million PPP (or purchasing power parities), with three non-OECD countries (China, Russia and India) among the top 5 in 2013. Purchasing power parities, which are routinely used in international comparisons, attempt to eliminate price differences between countries, and are particularly useful when comparing countries in different stages of economic development.

Exhibit 1: Number of countries with satellites (launched independently or via a third party)
Source: OECD, 2015.



When looking more closely at governmental space budgets, which remain the main customers of the space manufacturing industry in many countries, we see a reduction in budgets for OECD countries as a whole between 2008 and 2013, mainly due to spending cuts in the United States. Meanwhile, budgets in BRIC countries have increased (as a result of investments in Russia and China).

Exhibit 2: OECD, BRIC and EU15 space budgets, 2008 and 2013
Source: OECD, 2014.

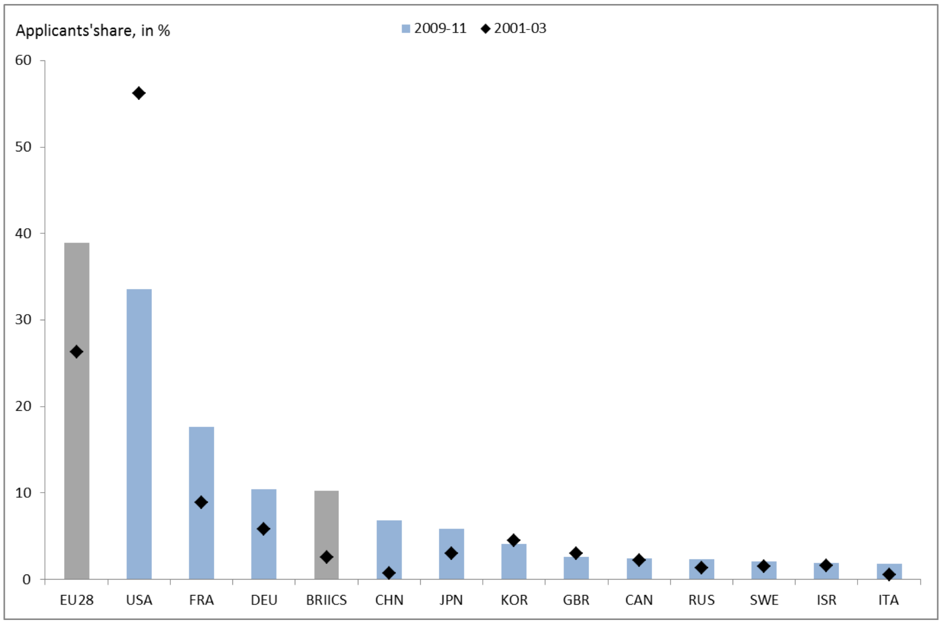


There is also a greater international distribution of scientific activity in the space sector. Patenting in the space sector is not as common as in other sectors, as commercial discretion and institutional confidentiality are often still priorities for some space systems. There are only a few hundreds patents a year. Still, the number of space-related patents has almost quadrupled in 20 years and has diversified internationally, as revealed by the applications filed under the Patent Co-operation Treaty (PCT) (see exhibit 3). When comparing patent applications for space-related technologies per country over 2001-03 and 2009-11, the United States still leads but its share has shrunk. Other countries have seen their shares of worldwide patents grow in relative terms, noticeably France, Germany, China, Japan and Italy. In terms of revealed technological advantage, eight countries demonstrate a level of specialisation in space technologies. The Russian Federation, France, Israel, Turkey, Chinese Taipei, Canada, Spain, Brazil and the United States show a relatively large amount of patenting in space activities, compared to other economic sectors.

Industrial supply chains in the space sector are becoming ever-more international

Industrial supply chains for the development and operation of space systems are 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, i.e. employed for both civilian and military programmes, which tends to constrain international trade in space products. Nonetheless, as evidenced by recent OECD research on global value chains, 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 programmes), the trend towards globalisation is having an impact right across the space economy – from R&D and design, to manufacturing and services.

Exhibit 3: Patent applications for space-related technologies per country
Patent applications filed under the PCT, by priority date and inventor's residence, using fractional counts
Source: OECD, 2014.



Where is my satellite coming from? More than a hundred satellites were launched in 2013, mostly for institutional missions. Some 29% of these satellites were launched for commercial telecommunications, representing around USD 2 billion in revenues for manufacturers (FAA, 2014). The open market for satellites remains therefore quite small, and the dominant position of just a few companies in space manufacturing markets has been weakening.

In a major 2012-13 survey of the US space industrial base by the Department of Commerce, 78% of the US organisations surveyed considered they were not the sole manufacturer or distributor of a given space product, based on the total number of product areas identified. Respondents identified critical suppliers from 56 countries (DoC, 2014). The most prominent non-U.S. suppliers were located in Japan, Germany, Canada, France, and the United Kingdom, providing materials, structures, mechanical systems, electronic equipment, and communications systems. Russian hardware is also often procured by US manufacturers, particularly propulsion systems integrated on US rockets and satellites.

So when private operators buy large telecommunications satellites today, they have a much larger choice in terms of manufacturers internationally, with their main criteria being costs, time-to-market and reliability; rarely do they need to care about the provenance of the satellite and its parts, except if it affects relations with their customers. As of end-2013, American satellite builders have built around 60 commercial telecommunications satellites in the past five years, while European manufacturers have sold around 50. And in that context, although the bulk of commercial satellites are still produced in North America and Europe, more actors from emerging economies are entering the already competitive market as commercial satellite manufacturers, i.e. the Russian Federation, China and India. They accounted in the 2000-10 timeframe for only 13% of the insured telecommunications satellites launched into geostationary orbit. In 2013, the Russian and Asian builders' share of the market rose to 27%, demonstrating in only three years an inclination of private satellite operators to now go to manufacturers they would not have gone to previously.

When examining a standard commercial telecommunications satellite built in the United States or Europe for geostationary orbits (16-20 commercial satellites launched per year), the main subsystems and equipment are all manufactured in different locations before being assembled by the space manufacturing prime. And these subsystems and equipment include themselves components produced in the United States, Europe and increasingly Japan. Although this provides only rough orders of magnitude, according to different industry sources: around 95% of a standard Loral telecom satellite is built in the United States; around 75% of a Thales Alenia Space's telecom satellite is built in France (with some sub-systems coming from its subsidiary in Italy); and around 25% of an Airbus standard telecom satellite is built in France, with most of the other equipment manufactured in European subsidiaries (Germany, Spain).

Deconstructing these commercial satellites further, their subsystems often consist of a large share of US components, still not manufactured elsewhere (e.g. selected oscillators, radio-frequency passive devices, some fuses). Originally many of these components were based on heavy-duty military standards (MIL) developed by US manufacturers, which are still used extensively in the space sector. The global market for space qualified components is difficult to estimate, although there is an important competition in some segments between American and European components manufacturers, particularly on capacitors and resistors. Other actors are getting involved and exporting components, like Japan, South Korea, Turkey and Israel. The European components market is largely divided equally between American and European manufacturers in 2013 (ESCIES, 2013). In the case of Japan, the market for space–qualified components represented roughly YEN 3 billion in 2012 (around EUR 23 million), with 52% of parts coming from the US, 36% from Japan and 12% from Europe (ESCCON, 2013).

In general the electronic, electrical and electromechanical (EEE) components' suppliers with some activity in the space sector are either small specialised firms with unique know-how, or divisions in large multinational groups dealing with many other sectors (e.g. automotive, aeronautics, defence). Very few EEE parts, ranging from cables to electrical switches, up to semiconductors, are designed specifically for space applications, due to the relatively low volume and sporadic manufacturing requirements. Some unique characteristics are required of space quality parts (i.e. high resistance to low temperature and high heat; extremely long reliability; high vibration capability, extremely low defect levels, etc.). The issue of "space qualification" is therefore an inherent cost driver, as it takes time to qualify selected components before they are deemed to be integrated in equipment which eventually will fly to orbit (two to four years, or much longer in some cases). As many companies seek to limit as much as possible the non-recurring engineering (NRE) costs, which represent the one-time cost to research and develop components and equipment, relatively few invest in non-profitable R&D. For example, out of around 25 commercial manufacturers of Static Random Access Memory (SRAM) components, used in almost every industrial sector, internationally there are only six manufacturers of SRAM specifically designed for use in space. Still, EEE parts represent 40% to 70% of the value (and also quantity in average) of a space equipment (ESCCON, 2013). The space manufacturer Loral estimates, for example, that around 50 000 EEE parts are to be found in recent communications satellites. As another example, the centralised procurement for the ESA Automated Transfer Vehicle (an unmanned and expendable module bringing cargo to the International Space Station) covered for seven flight sets, 45 major equipment composed of over a million EEE parts.

The long-standing reliance on American satellite components and equipment, subject to strict technology transfers and re-export restrictions from the United States (i.e. the US International Traffic in Arms Regulations regime, ITAR), has been a key reason for European, Israeli and Japanese industries' moves to develop home-base alternatives. ESA's European Components Initiative (ECI) also had the objective within a few years to turn Europe from a net importer of components into a net exporter, as well as to secure access to strategic components. The ECI entered recently its fourth Phase (2013-16), focussing on strengthening the European supply chain, with already around 40 qualified manufacturers registered. In Japan, some 27 qualified manufacturers are registered and supported by the Japanese space agency. Manufacturing commercial "ITAR-free" satellites (i.e. satellites with components not subject to US government authorisation for export and re-exports) have been a selling-point of several manufacturers for a decade now with some effects on the US industry. The impacts of the ITAR regime affected the US industry with lost sales opportunities of between approximately USD 988 million and USD 2 billion from 2009 to 2012 according to a recent US Department of Commerce survey (DoC, 2014).

Where is my rocket made? At first glance, the rocket business may not seem very impacted by globalisation. Satellite launchers are related to missile technology, and are therefore kept under tight government control worldwide. The open market to launch commercial satellites remains relatively narrow, about USD 2 billion in revenues in 2013 with six companies able to compete internationally (See 7. Space launch activities). However, access to space remains an important source of income and jobs for domestic ecosystems of companies and public organisations, as the requirement to launch many institutional satellites for civilian and military missions offer de facto captive national markets in many countries (e.g. earth observation, military satellites…). Governmental satellites are typically launched domestically in the United States, China, India, and the Russian Federation. In Europe, there is no policy imposing the utilisation of the European Ariane launcher for ESA Member States' institutional satellites.

Despite these captive domestic markets and tight regulations on missile technology transfers, globalisation has permeated the industry. Korea joined recently the small club of countries with space launch capabilities, thanks to initial active international co-operation in the 1990s. In the case of Europe, the different Ariane launchers were conceived from the start as complex international systems, bringing together parts and equipment manufactured all over Europe, so as to involve as many countries as possible in the funding and development of a sustainable independent European access to space. With current European negotiations about the future of the Ariane family of launchers and its long-term economic viability, the current supply chains spanning many countries are being challenged.

This co-dependence on launcher development can be found in other countries also for political and economic reasons. As soon as the cold war ended, contractual arrangements for commercial technology transfers were set up between the Russian industry and many national space industries, contributing to not only sustain the Russian sector, but also offering its Western and Asian customers the possibility to benefit from long-proven technologies. China and the Russian Federation have had for instance a very fruitful co-operation on space technologies transfers, which assisted the Chinese space administration in developing the first elements of its human spaceflight programme. The US space sector has also developed industrial co-operation, by acquiring Russian engines for several US rockets. The joint-venture United Launch Alliance (ULA), which merged in 2006 Lockheed Martin's and Boeing's US government space launch services, has been using a Russian engine, the RD-180 for more than a decade on its Atlas heavy-lift rocket, which is dedicated to US governmental launches. Similarly, the satellite and rocket builder Orbital Sciences Corporation is using a Russian-sourced first stage engine for its Antares medium lift launcher. This AJ-26 engine is built in the Russian Federation and refurbished by Aerojet Rocketdyne, another US company.

In parallel, the US-Japanese industrial co-operation in terms of rocket engines is also indicative of close bilateral technological co-operation. The collaboration started back in the late 1970s, with the Delta N rocket which was a licensed version of the US Delta rocket, built in Japan but using both US and Japanese components. More recent industrial co-operation concerns the Japanese H-IIA and American Delta IV launchers, which share the same second-stage propellant tanks' configuration. In exchange for Mitsubishi Heavy Industry's LH2 (liquid hydrogen) fuel tanks, ULA gets LOX (liquid oxygen) fuel tanks to fly on its rocket. In addition, Mitsubishi exports to the US several components (e.g. valves, heat exchangers) and propellant tanks for Delta IV's RS- 68 engine. More joint engine development is currently underway, as both companies work on new upper stage engines for future launchers. For instance, the MB-XX engine under development since 1999 targets both the Japanese and US markets. Each company will be the prime contractor for the use in each country. On a more commercial launch services' level, Mitsubishi Heavy Industry has recently signed a memorandum of understanding with the European launch provider Arianespace to investigate possibilities for joint business opportunities.

Based on these illustrations, starting with limited exchanges, the situation has evolved so much that almost no launchers in activity today are composed solely of indigenous parts and equipment. Aside from developing bilateral co-operation axis, one of the main drivers for this international fragmentation of produced parts comes from evident cost-savings (i.e. no need to develop a multi-billion dollar engine for a rocket, when you can buy one off-the-shelf) and the possibility of accessing technologies already developed elsewhere to improve your own launcher. According to industry sources, propulsion systems can, for example, account for up to 40% of a launcher cost. These exchanges between companies and joint R&D projects are some of the opportunities available to the sector to reduce the cost of production.

So although restrictions in space technology transfers are still important in most parts of the world, including Europe, Japan, the United States and the Russian Federation, competition in major niche markets may soon intensify further at all levels of the space manufacturing supply chain. The US Department of Commerce published in May 2014 new regulations that will facilitate the US exports and re-exports of commercial, scientific, and civil satellites and their parts and components, by moving many items from the strictly controlled State Department's US Munitions List (USML) back to the Commerce Control List. The items moving to Commerce jurisdiction include communications satellites that do not contain US classified components, selected remote sensing satellites, as well as spacecraft parts, components, equipment, systems, and all radiation-hardened microelectronic microcircuits, that are essential for space systems. This will probably bear further on the trade in components, equipment and subsystems around the world.

What are the impacts of these trends for policy-makers?

Globalisation is ongoing in the space sector and can benefit a large number of countries and their industries in terms of economic development and innovation capabilities, but this will increasingly come with more challenges for incumbents and newcomers alike. The more countries invest in space programmes, the more the overall market should be stimulated and the global value chains strengthened, although many nations will keep strict control over sovereign interests and sub-sectors (e.g. defence space programmes). The key drivers for more globalisation will therefore include sustained institutional support from new sources worldwide, double sourcing guaranteed on the open markets offering new commercial opportunities, and a wider global addressable market size for all actors.

In order to take advantage of these trends, two avenues could be pursued by policy makers: better tracking of who is doing what, and sustaining value-creating industries.

Tracking who is doing what – A major challenge faced by national administrations, which are often customers of many space products and services, and their industrial primes concerns the need to have an overview of the complete supply chain, to allow a better visibility of procurement and handling of subsystems and equipment throughout the chain. There is a difference in the globalisation aspects of upstream and downstream segments in the space sector. The upstream segment is still influenced by R&D policy decisions of national governments, a situation that is likely to remain. Meanwhile, the downstream segment is increasingly addressing global markets. However, the segments are interdependent. The more lucrative applications of the downstream segment cannot exist without the infrastructure provided by the upstream segment, although the funding mechanisms and revenue generation between upstream and downstream are increasingly disconnected.

Europe is in a particular situation. As more countries join ESA, more national centres of space expertise can be expected to develop. ESA's geo-return policies, whereby a country's institutional funding provided to ESA programmes leads to contracts to the space industry on its territory, have historically contributed to the creation and support of several national hubs of expertise in space research and development throughout Europe. Many European countries would not have invested in space if it were not for the principle of geo-return. This industrial policy is at the core of many of the successful scientific, institutional and commercial space programmes developed in Europe. With an enlarged ESA, the system could successfully endure without detrimental effects on incumbents, only if the European budget grows with sustained national budgets from both old and new members, to recoup enough industrial contracts on a national basis and keep a level of expertise in selected space fields. Otherwise, like in any other sector, know-how and capabilities could inevitably move where new national funding becomes available. This will need to be taken into account by policy-makers, if they wish to support a dynamic space industry and workforce on their territory, especially as the European Commission, an increasingly important player in the European space sector, defends a different set of contractual rules based on open competition.

To better track who is doing what in the space industry, a number of initiatives can be taken by national administrations. In addition to working with industry associations, promoting and conducting regular industry surveys, other information sources in governmental agencies could be better exploited to provide a better picture of the actors involved in space-related activities (e.g. analyzing administrative data on firms, information on contracts). This would be conducive to improving the quality of national industrial policy evaluations, with detailed information on the structure, positioning along the value chain and competitiveness of the space industry and other actors involved in the larger space economy.

Sustaining value-creating industries - Many producers of space products and services are still regulated by national regimes that limit foreign ownership of their activities. However there are a number of recent instances where entire firms and activities have been bought out by competitors, with international technology transfers taking place. Multinational groups have also been moving low-key activities from one subsidiary to another, with impacts on local employment. These practices can be expected to continue, in a more competitive world for the space industry, on regional and global scales. However, a major difference for the space sector as a whole, as compared to other high-tech sectors, still lies in the important role of national agencies, laboratories and universities in fundamental research and development. This is, for example, the case for the United States, with several NASA and Department of Defense research centres, for France with CNES, ONERA and DGA centres, and India with major ISRO centres distributed throughout the country. These R&D capacities under governmental control have still important impacts on employment and future public innovation capabilities for the space sector that should not be underestimated.

So as economies get more interdependent and interconnected, all countries and all firms have the opportunity to participate and benefit from global value chains in the space sector. However, this situation puts new competitive pressures on governments to adopt reforms that enable their producers to find or to try retaining niches in which they may make the most of their capabilities. There is a need for complementary policies, such as those that boost education and skills, as well as ensuring long-term investments in research and development capabilities, leading to future innovation (OECD, 2014).

Conclusions

Space is still not a "business like others", despite the many globalisation patterns it follows. The more countries are investing in space, the more the global market will be stimulated, and global value chains will be strengthened. Even if companies involved in space activities seem to be freer than ever to pursue growth strategies internationally, many countries will unsurprisingly keep a level of control over sovereign interests and strategic technologies. In order to benefit from global value chains, countries will increasingly have to balance their strategic and industrial interests with further growth. Economies willing to develop and sustain an active national space programme in a more competitive world will need to remain key driving forces, as reliable customers and R&D enablers of their national space industries, as well as be promoters of more open markets for the industry as a whole.

[1] Original work on the space sector is taking place in the Organisation for Economic Co-operation and Development (OECD), an intergovernmental economic organisation, which is tracking globalisation trends and providing policy advice to its 34 member states. The OECD Space Forum was established to assist governments, space-related administrations and the private sector to better identify the statistical contours of the space sector, while investigating the space infrastructure's economic significance, innovation role and potential impacts for the larger economy. In April 2015, the Space Forum's Steering Group includes ten members, nine national space agencies / official bodies in charge of space activities from OECD economies (NASA, CSA, CNES, DLR, ASI, KARI, UKSA, NSC, SSO) and the European Space Agency (http://oe.cd/spaceforum). See the full report: OECD (2014), *The space economy at a glance 2014*, OECD Publishing, Paris.