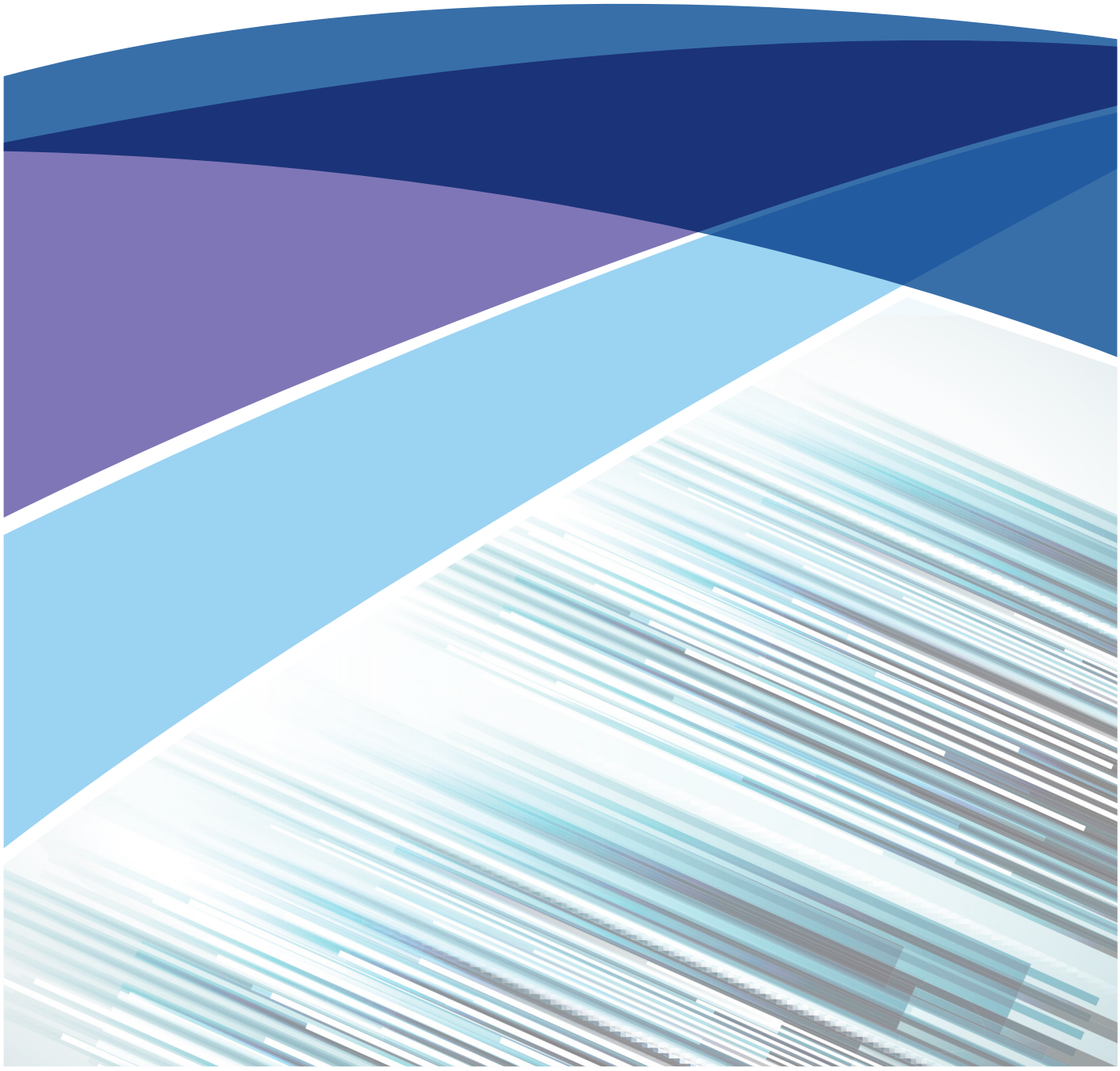
Intellectual Property Office

Eight Great Technologies

A summary of the series of patent landscape reports



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#8Great

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1 Introduction

The UK Government has identified ‘eight great technologies’ plus a further two which will propel the UK to future growth. These are:

- the big data revolution and energy-efficient computing;
- satellites and commercial applications of space;
- robotics and autonomous systems;
- life sciences, genomics and synthetic biology;
- regenerative medicine;
- agri-science;
- advanced materials and nanotechnology;
- energy and its storage;
- quantum technologies;
- the internet of things.

Patent data can give a valuable insight into innovative activity, to the extent that it has been codified in patent applications, and the IPO Informatics team has produced a series of patent landscape reports looking at each of these technology spaces and the current level of UK patenting on the world stage. As an aid to help people understand the eight great technologies and to consider the direction of future funding, the IPO is offering a comprehensive overview of what is already patented in the each of these technologies. This information should not be taken as a direct measure of the level of innovation in the UK; it should be considered in conjunction with other sources of information to form a fuller picture.

This document provides a brief summary of each of the ten technology areas studied. Full versions of each patent landscape report can be downloaded from the gov.uk website. Each dataset used for analysis was based on patents published between 2004 and 2013 and was extracted from worldwide patent databases following detailed discussion and consultation with patent examiners from the Intellectual Property Office who are experts in the field and who, on a day-to-day basis, search, examine and grant patent applications relating to the technologies involved. Published patent application data was analysed rather than granted patent data. Published patent application data gives more information about technological activity than granted patent data because a number of factors determine whether an application ever proceeds to grant; these include the inherent lag in patent processing at national IP offices worldwide and the patenting strategies of applicants who may file more applications than they ever intend to pursue. Further details on the patent databases searched and the text mining and analytics software used can be found in each individual report.

2 The big data revolution and energy-efficient computing

This report analyses the worldwide patent landscape for technology directed towards big data and its energy-efficient processing. The term ‘big data’ relates to a specific type of data which has such magnitude (typically several petabytes per dataset), processing speed requirements and variety that it requires innovative new approaches to its handling and manipulation. Analysis of such data is typically performed via parallel computing using, for example, an inter-networked collection of computers arranged for cloud-based sharing of the processing; however, the emergence of this specific type of data has been largely fuelled by the recent explosion in social media data, open data and other forms of internet-based data for which a meaningful ten-year analysis would not be feasible. Consequently, this report was not narrowed to just one specific type of data but was directed towards patent applications involving the processing of any type of large dataset(s) for which intensive, distributed processing is required. As such, this report included consideration of patent applications relating to simulation, modelling and forecasting based upon all types of large datasets, of which ‘big data’ is just one example. It should be noted that in some countries patents are not granted in certain categories such as computer programs and mathematical methods; this is an issue for areas such as data structures, search algorithms and computer modelling which are prominent in the big data and energy-efficient computing technology area.

There were more than 22,000 published patent applications between 2004 and 2013 relating to big data and energy-efficient computing technologies, resulting in almost 10,000 patent families (inventions). Patenting activity in this field has grown steadily over the last decade and has seen its highest increases in annual patenting over the last two years analysed; the growth has continually been above the general worldwide increase in patenting with a maximum increase of 39% over worldwide patenting for 2012-2013.

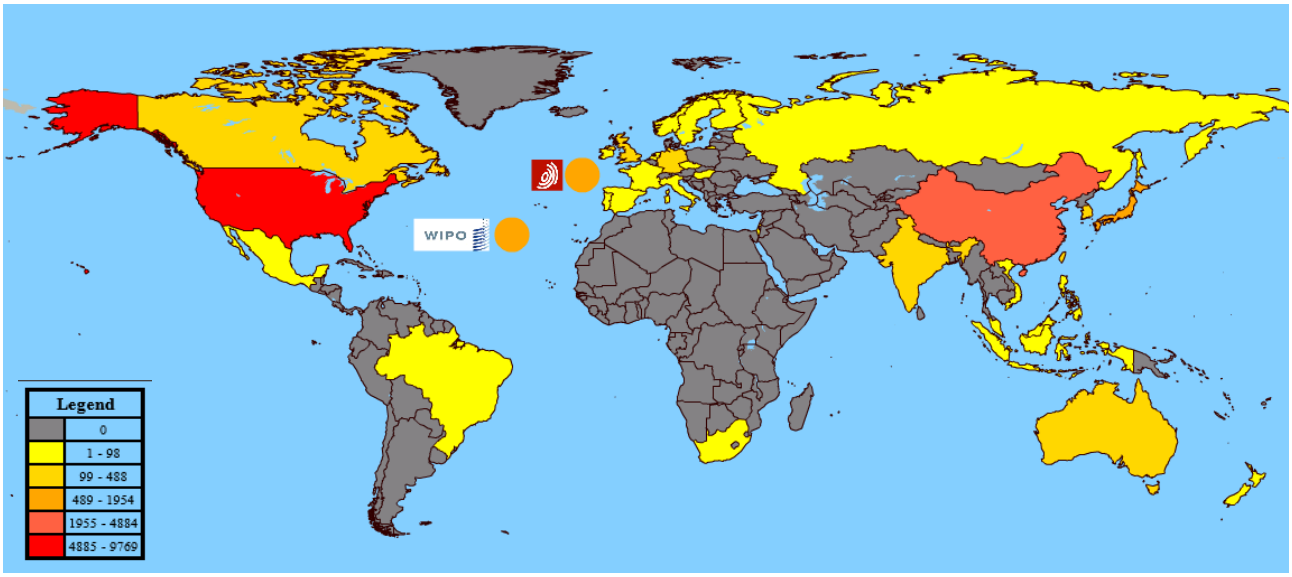

Figure 1: Patent coverage (publication country coverage) for the big data revolution and energy-efficient computing

IBM has the most patent families with more than double those of its nearest competitor, Microsoft. SAP (headquarters in Germany), with its acquisition of Business Objects (USA) and their patent portfolio, represents the highest-placed European applicant, whilst IBM also heads up the list of top UK applicants. IBM's prominence in the UK big data patent filings should come as no surprise since it has around 20,000 UK employees including around 3,000 at the IBM research and development lab in Winchester. BT has the second largest number of UK patent families.

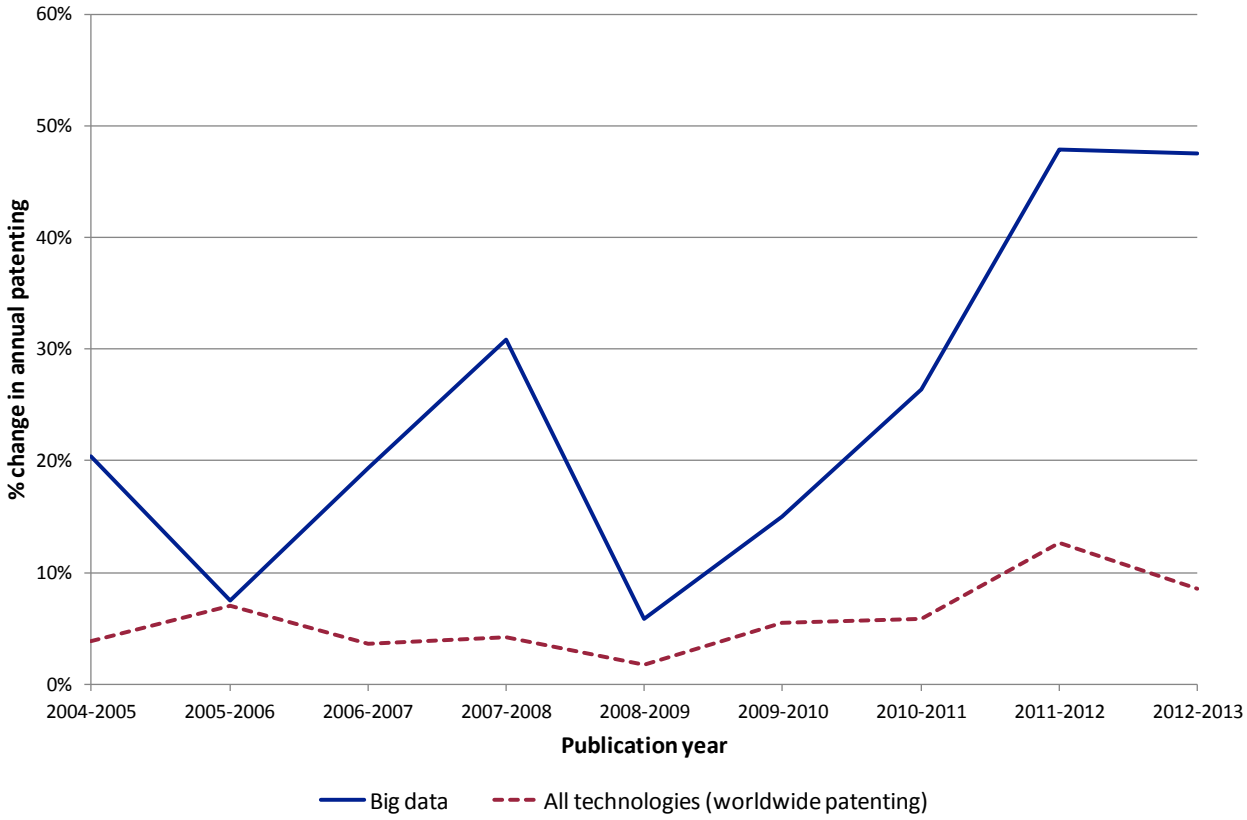

Figure 2: Year-on-year change in the big data revolution and energy-efficient computing patenting compared to worldwide patenting across all technologies

80% of all big data and energy-efficient computing patent families are filed by US and Chinese applicants. UK applicants account for just 1.2% of the dataset and file slightly fewer big data and energy-efficient computing patents than expected given the overall level of patenting activity from UK applicants across all areas of technology. Against this, however, it should be borne in mind that many of the potential improvements in data processing, particularly with regard to pure business methods and computer software routines, are not necessarily protectable by patents and were therefore not captured in this report. UK patenting activity in big data and energy-efficient computing has, on the whole, increased over recent years and the year-on-year changes are comparable to the growth seen in Germany, France and Japan.

3 Satellites and commercial applications of space

This report analyses the worldwide patent landscape for satellite technologies. In addition to patents for actual satellite hardware in space, the dataset analysed also included patents relating to GPS-based technologies, both space-based and earth-based (receiver-side) technologies.

There were almost 85,000 published patent applications between 2004 and 2013 relating to all satellite technologies, resulting in over 22,000 patent families (inventions). Patenting activity in this field has grown steadily over the last decade but it has not shown any significant increases above the general rise in patent applications seen worldwide across all technologies (an average 3.5% year-on-year growth above the annual increase in global patenting activity).

The American corporation Qualcomm have the most patent families (inventions) with the pan-European Airbus Group (consisting of published patents in the name of Airbus, EADS, Astrium or Cassidian, and having a large UK input) ranked in the top five applicants worldwide according to patent family size. Other UK companies active in satellite technologies include Inmarsat, BAE Systems, CSR, and QinetiQ.

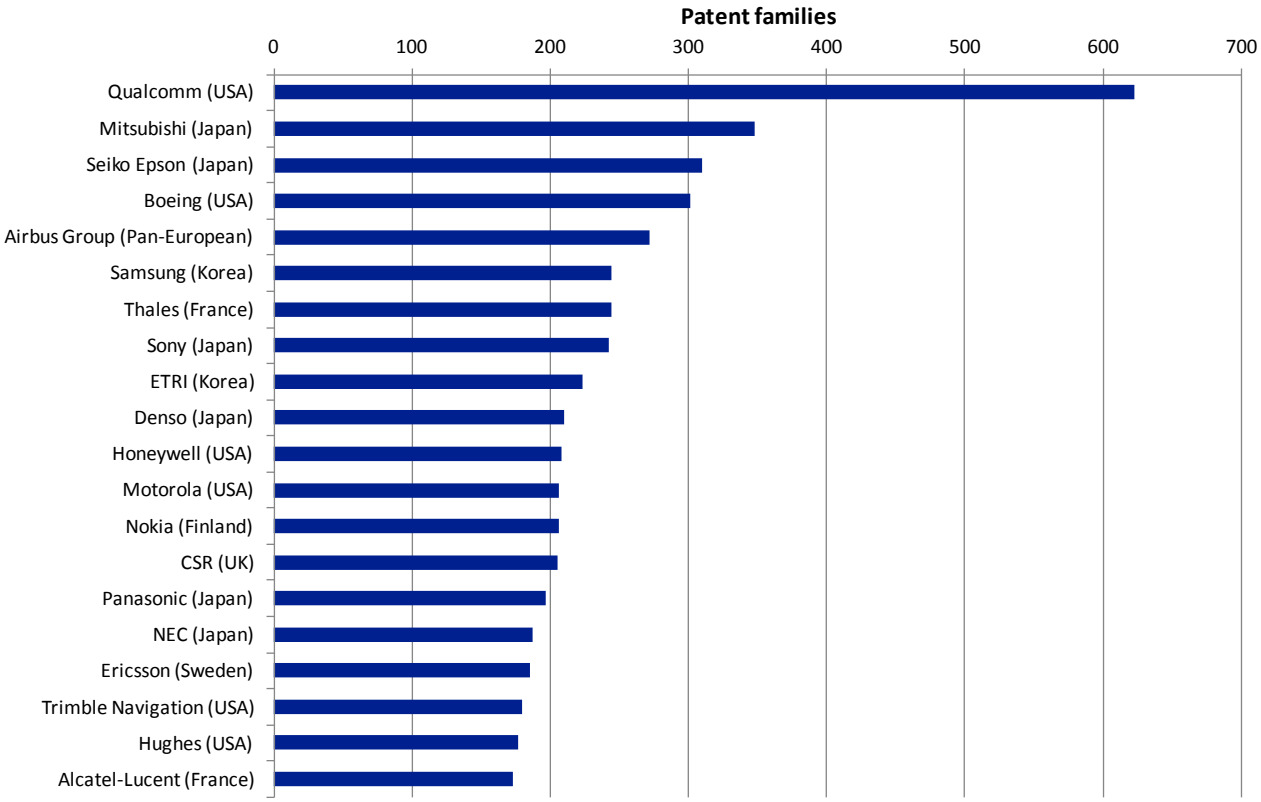

Figure 3: Top applicants worldwide in the patenting of satellites and commercial applications of space

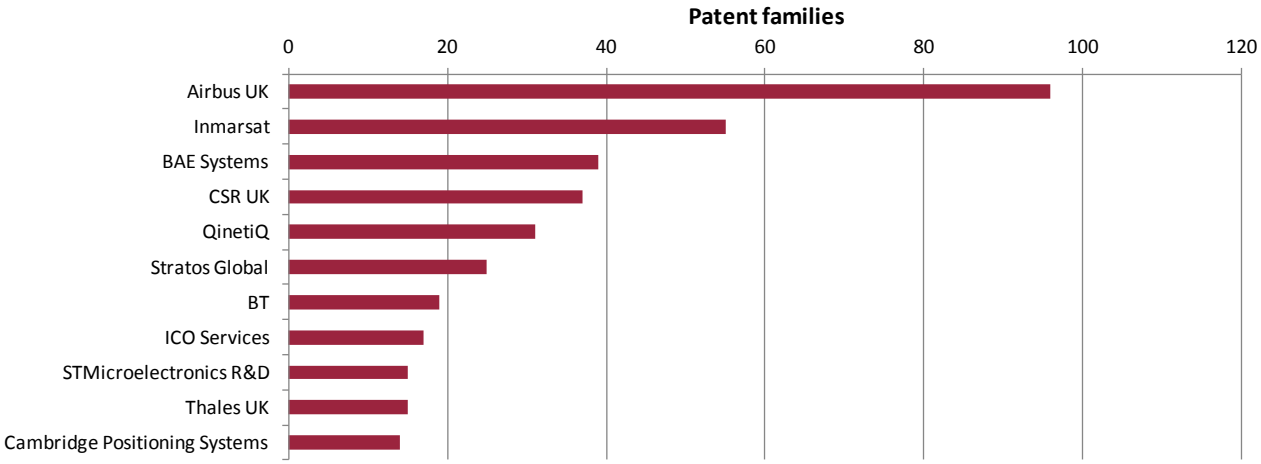

Figure 4: Top UK applicants in the patenting of satellites and commercial applications of space

Over 70% of all satellite patent families are filed by Chinese, US or Japanese applicants with UK applicants accounting for just 2% of the dataset and filing slightly fewer satellite patents than expected given the overall level of patenting activity from UK applicants across all areas of technology. UK patenting activity in satellite technologies has shown a modest average year-on-year increase of 6.5% over the past decade. This is a long way behind the rapid annual increases seen from patenting activity stemming from China (80%) and Korea (22%), but UK patenting activity is above the average year-on-year increase seen in Japan (3%) and the USA (4%) and similar to the level seen in Germany (9%).

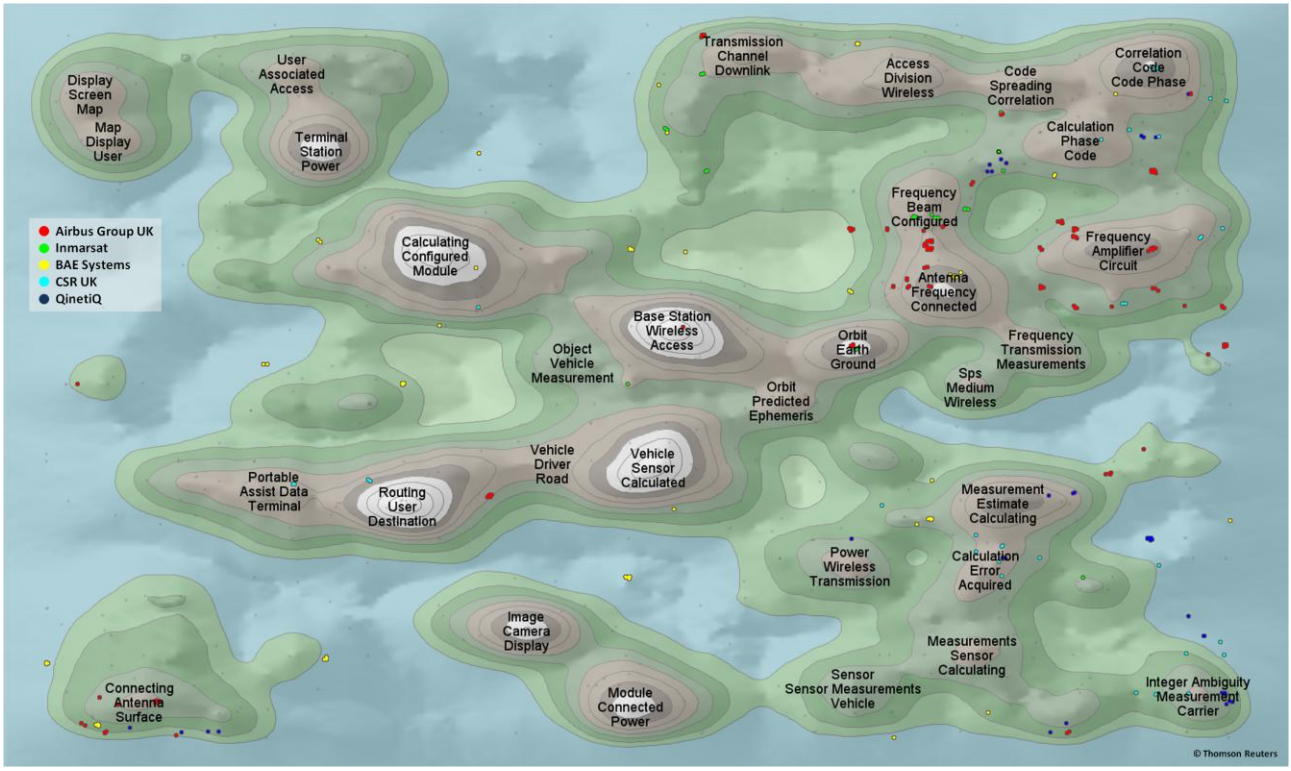

Figure 5: Patent landscape map for satellites and commercial applications of space with patents belonging to the top five UK applicants highlighted

4 Robotics and autonomous systems

This report analyses the worldwide patent landscape for robotics and autonomous systems. For robotics, the focus is on control technology and novel aspects of robotics, such as emotion simulation and home robots, rather than conventional robotic manipulators per se. Autonomous systems includes automated vehicles of all types (passenger vehicles, aircraft, drones, and submarines, for example), and includes various degrees of automation, from driver aids in human-controlled passenger cars to fully self-driving cars.

There were almost 120,000 published patent applications between 2004 and 2013 relating to robotics and autonomous systems, resulting in over 35,000 patent families (inventions). Patenting in this area has grown consistently over the ten year period studied, with a tripling of patent publications over this period altogether.

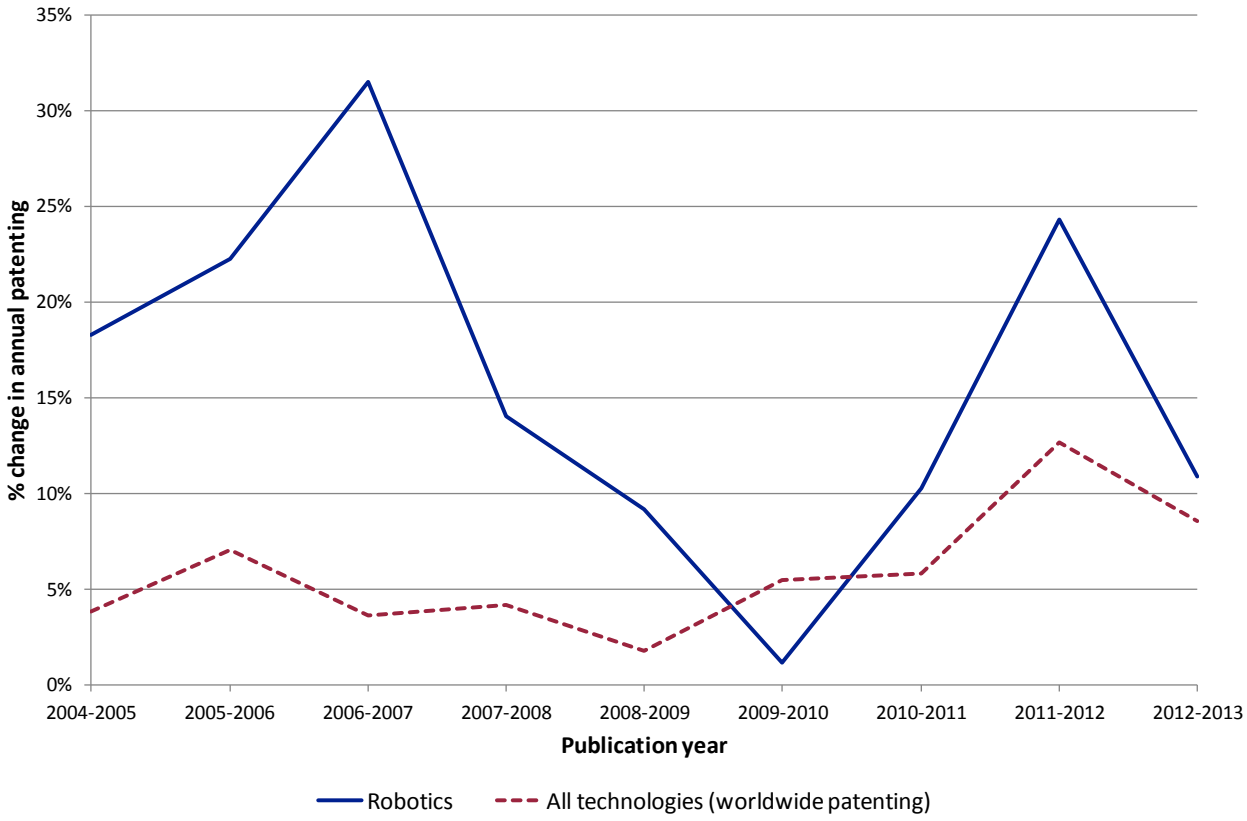

Figure 6: Year-on-year change in robotics and autonomous systems patenting compared to worldwide patenting across all technologies

Japan is the clear leader worldwide in robotics and autonomous systems, both by the country in which patent applicants are based and the country in which patent applications are first made. The USA, Germany, China, and Korea are other significant innovators.

It is clear that automotive manufacturers have a large part to play in robotics and autonomous systems, and in fact autonomous vehicles form a large part of the dataset used in this study. Many, if not all, of the major automotive manufacturers appear in the dataset, and manufacturers of other types of vehicles are also present. Developments are therefore not limited to road vehicles and also include aircraft, commercial vehicles, and agricultural vehicles.

Collaboration exists within the robotics and autonomous systems field but not between the leading applicants who appear to be in competition with each other. The leading automotive applicants do, however, collaborate with original equipment manufacturers, smaller automotive manufacturers, or other companies. Honda, on the other hand, appears to be almost self-contained, with little collaboration at all. Google is not a leading patent applicant but is currently well known for its prototype autonomous vehicles, and is also found to work independently. Its patent portfolio is also growing at a significant rate.

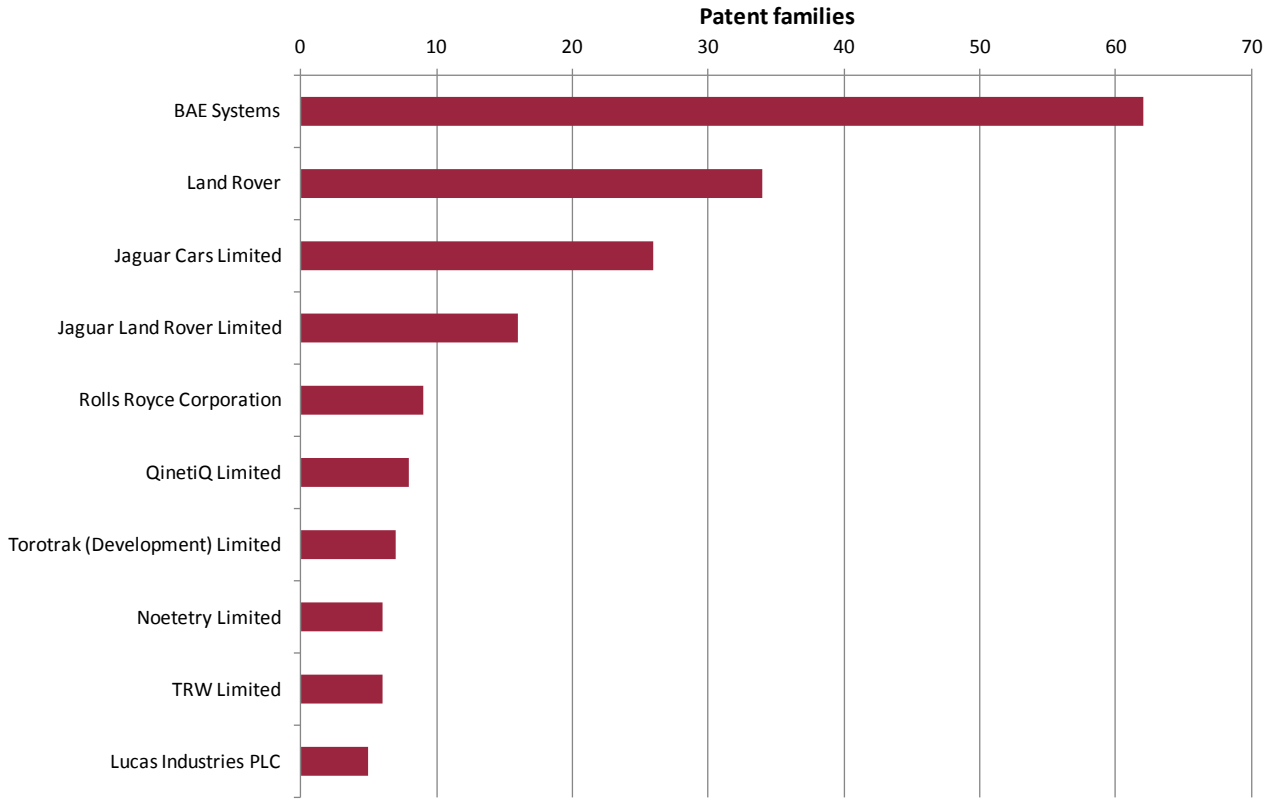

Figure 7: Top UK applicants in the patenting of robotics and autonomous systems

Robotics and autonomous systems does not appear to carry the hallmarks of an emerging technology, because of the presence of many large organisations, lack of university and academic applicants, and lack of applicant turnover. Smaller companies who may be engaged in innovative work may be present but hidden by the larger companies. Robotics and autonomous systems appears to be developing mainly out of larger organisations in an incremental fashion. For example, fully autonomous vehicles become gradually enabled by the improvements to conventional vehicles to provide semi-automation of specific functions in the form of driver aids.

5 Life sciences, genomics and synthetic biology

This report analyses the worldwide patent landscape for life sciences, genomics, and synthetic biology. The scope of the search strategy included preparation of mutants and associated screening processes, hybrid cells, and all aspects of recombinant DNA technology. There were over 500,000 published patent applications between 2004 and 2013 relating to life sciences, genomics, and synthetic biology, resulting in over 80,000 patent families (inventions). Patenting in this area has grown only slightly over the ten year period studied and has not kept up with general patenting trends for all technologies worldwide.

It is difficult to draw accurate conclusions from simply presenting data based on the country of residence of patent applicants because there is a greater propensity to patent in certain countries than others. The Relative Specialisation Index (RSI) for each applicant country was calculated to give an indication of the level of invention in life sciences, genomics, and synthetic biology patenting for each country compared to the overall level of invention in that country. Belgium, Israel, Australia, and Singapore show a positive specialisation in life sciences, genomics, and synthetic biology (indicating a greater than expected degree of patenting for that country). The UK shows a small positive degree of specialisation. Despite their substantial growth in recent years, China and Korea have a negative specialisation, which is a reflection of the very low baseline from which the growth has developed at the beginning of the period, and also of the substantial level of patenting in other fields in those countries.

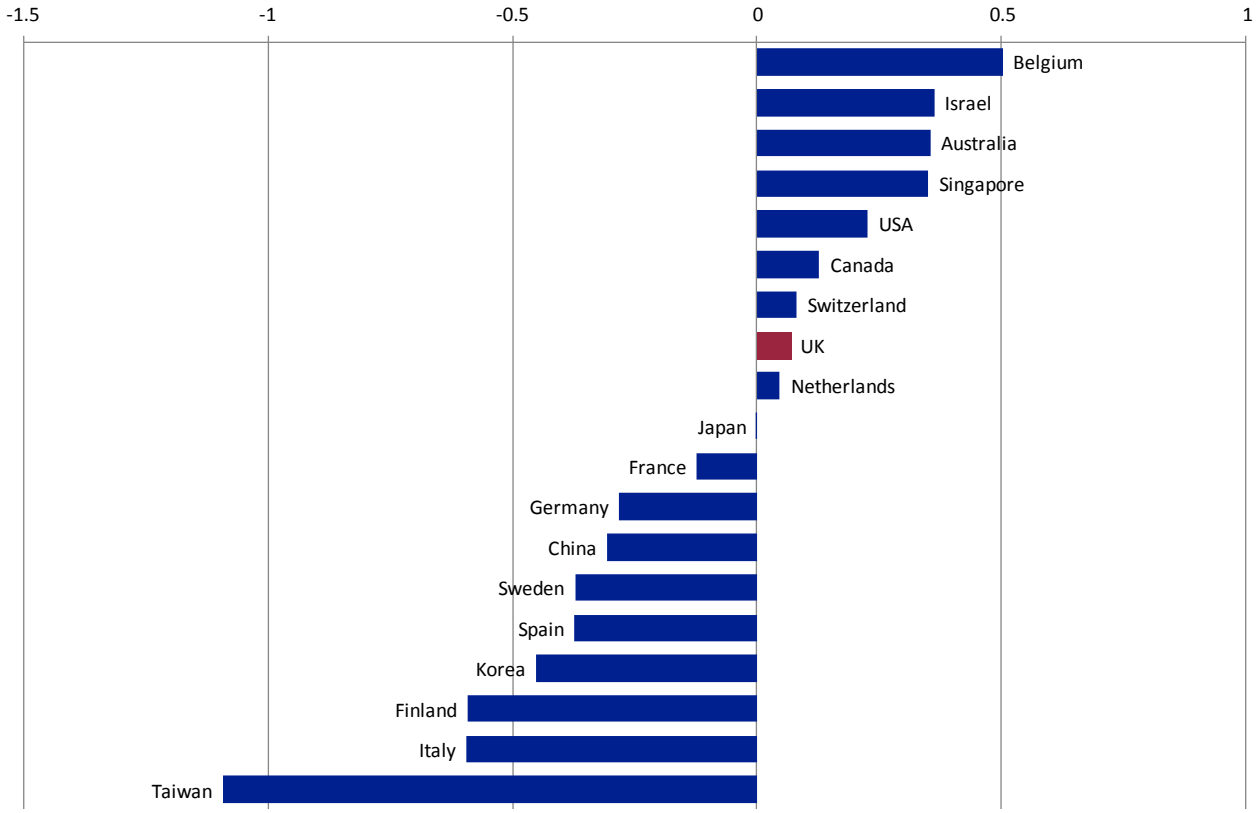

Figure 8: Relative Specialisation Index (RSI) by applicant country for life sciences, genomics, and synthetic biology patenting

Many of the leading applicants are US-based, with four of the top five positions being occupied by Pioneer Hi-Bred International, Monsanto Technology, University of California, and Genentech. The Japan Science & Technology Agency also appears in the top five. Other chemical and pharmaceutical companies from Germany (BASF, Bayer), USA (Du Pont, ISIS Pharmaceuticals), Switzerland (La Roche, Novartis, Syngenta), and Japan (Ajinomoto) are also among the leaders. However, several of the leaders are non-commercial entities such as universities (Zhejiang University, Chinese Agricultural University) or research institutes (Centre National de la Recherche Scientifique, Korea Institute of Bioscience and Biotechnology). Government agencies are also present.

A significant amount of collaboration appears to be going on between leading applicants in the life sciences, genomics, and synthetic biology field. Much of this collaboration is limited to within the US and within Japan, but all leading UK applicants also show significant collaboration. Leading UK inventors are generally associated with the leading UK applicants, suggesting that life sciences, genomics, and synthetic biology is a field where inventors stay within the UK.

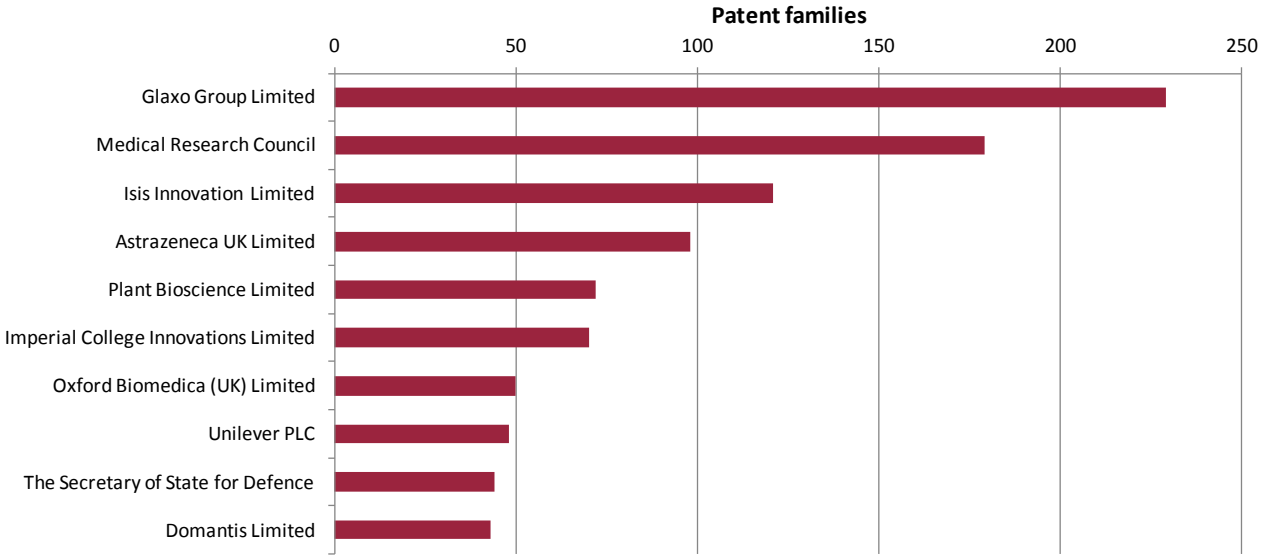

Figure 9: Top UK applicants in the patenting of life sciences, genomics, and synthetic biology

Patent landscape map analysis shows that major applications of the technology being patented are plants and crops (such as new varieties of staple cereal crops and soybeans, cotton, animal feed, and the enhancement of nutritional content), treatment of diseases (including many types of cancer, degenerative diseases, autoimmune disorders, and complications of diabetes), and microorganisms used in industrial processes (such as production of biofuels and chemicals used in further industrial processes). Universities and research organisations are found to have patents distributed more widely around the landscape when compared to companies, which tend to be focussed on particular areas in the landscape. This is possibly a reflection of research activity being more fundamental and of general application, whereas companies are concerned with the protection of specific products in the marketplace.

6 Regenerative medicine

This report analyses the worldwide patent landscape for regenerative medicine. Regenerative medicine involves replacing or restoring cells, tissues, or organs in the body. This includes transplanting new cells, tissues, or organs into the body, stimulating the body's own self-repair mechanisms and developing new materials for structural repairs.

There were over 70,000 published patent applications between 2004 and 2013 relating to regenerative medicine, resulting in almost 10,000 patent families (inventions). Regenerative medicine patenting has seen a slowdown and perhaps even a decline over the ten year period studied, both worldwide and even more so in the UK. This slowdown contrasts with the general increase in patenting globally over the same period. Despite this, however, regenerative medicine also shows the patenting characteristics of an emerging technology with the potential for further growth.

Almost two-thirds (64%) of regenerative medicine patent families have a first filing in the USA, with the next largest country being Japan at 9%. The UK is at 3%. Patent applicants based in the USA, however, account for just 50% of patent families, with other applicants spread across a diversity of countries, indicating the importance of patent protection for regenerative medicine patents in the USA for applicants worldwide.

An index of relative specialisation of applicant countries indicates that China, Korea, Japan, and Germany in particular show a low specialisation in regenerative medicine. However, China, Korea, and Japan show consistent and positive percentage growth since 2004 and so the emergence of regenerative medicine may turn out to be focussed in those countries. Israel, Australia, Canada and the USA, meanwhile, have the greatest levels of specialisation. The UK has a small degree of specialisation in this report although this has increased since an earlier study on regenerative medicine patenting which was carried out in 2011.

Sixteen of the top twenty applicants in regenerative medicine are based in the USA, eight of them are academic institutions, and a further four are government departments or national research agencies. The University of California (USA) takes the leading position with 171 patent families, with General Hospital Corporation (USA) being some way behind at 102 patent families, and the University of John Hopkins (USA) in third place with 97 patent families. 28% of patent families overall include an academic applicant. The role of business in regenerative medicine patenting is therefore small and could be expected to increase as the scientific research base is subsequently developed and commercialised. The mix of top applicants includes newer entries and some who have become less active in recent years, suggesting that there is still a significant turnover of organisations involved with regenerative medicine and much more scope for organisations to establish and maintain leading positions. In the UK, Edinburgh University (16 patent families), Cambridge Enterprises (14), and Imperial Innovations (14) take the lead. UK inventors tend to be associated with UK applicant companies and universities.

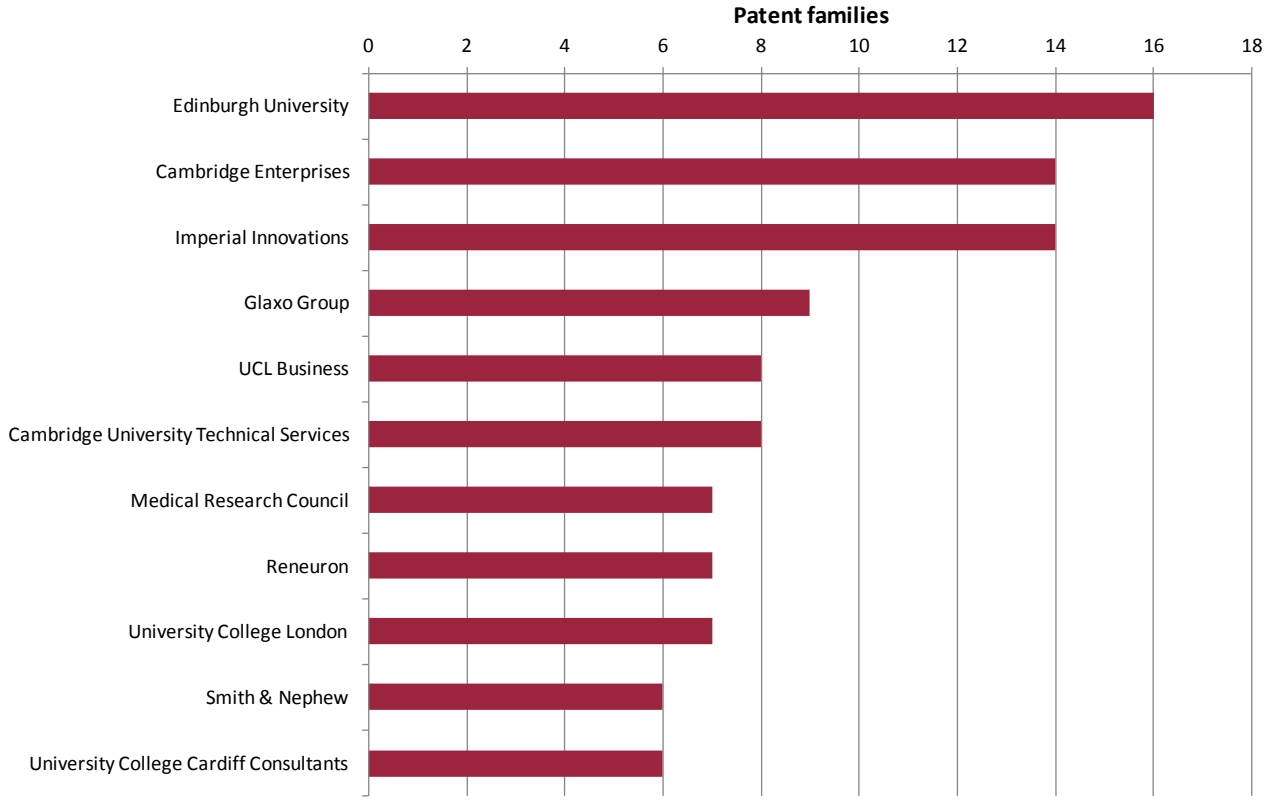

Figure 10: Top UK applicants in regenerative medicine patenting

The significant academic input into regenerative medicine and the lack of corporate incumbents has allowed a collaborative environment to flourish both in the US and across the globe, with significant levels of co-assigned patents between organisations. Collaborations from university-to-university and university-to-business have created a tightly integrated web of collaborations amongst the leading applicants. In the UK, separate clusters have developed but the levels of collaboration are still significant. Cambridge University, University College London, the University of Edinburgh, and associated technology transfer companies, have links to UK businesses and to the USA.

Patent landscape map analysis further demonstrates the collaborative nature of regenerative medicine patenting, with applicants tending to show interest in the entire field and to lack niches. Inventions addressing various types of cancer and neurodegenerative conditions are found to be common topics within the patent landscape.

7 Agri-science

This report analyses the worldwide patent landscape for technology directed towards agri-science. Agri-science is the study of the science and management of biological systems for the sustainable production of food. It encompasses a broad range of different technologies including pest control, crop production techniques, irrigation management, maximising agricultural productivity and addressing the global food demand. There are millions of published patents worldwide relating to agriculture and food production but the dataset used for this report was limited to core agri-science patents that relate to the application of scientific principles to agriculture. However, this does not mean that the dataset was limited to patents originating from the research laboratory (pesticides, fertilisers etc); core agri-science patents also include the mechanical hardware required to improve agricultural production and implement modern agricultural management systems, such as smart combine harvesters and automated agricultural robots.

There were more than 400,000 published patent applications between 2004 and 2013 relating to agri-science, resulting in almost 120,000 patent families (inventions). Patenting activity in this field grew steadily over the first half of the last decade at a level well above the general worldwide increase in patenting but agri-science patenting has levelled out in recent years and since 2010 it is around 10% lower than the general worldwide increase in patenting.

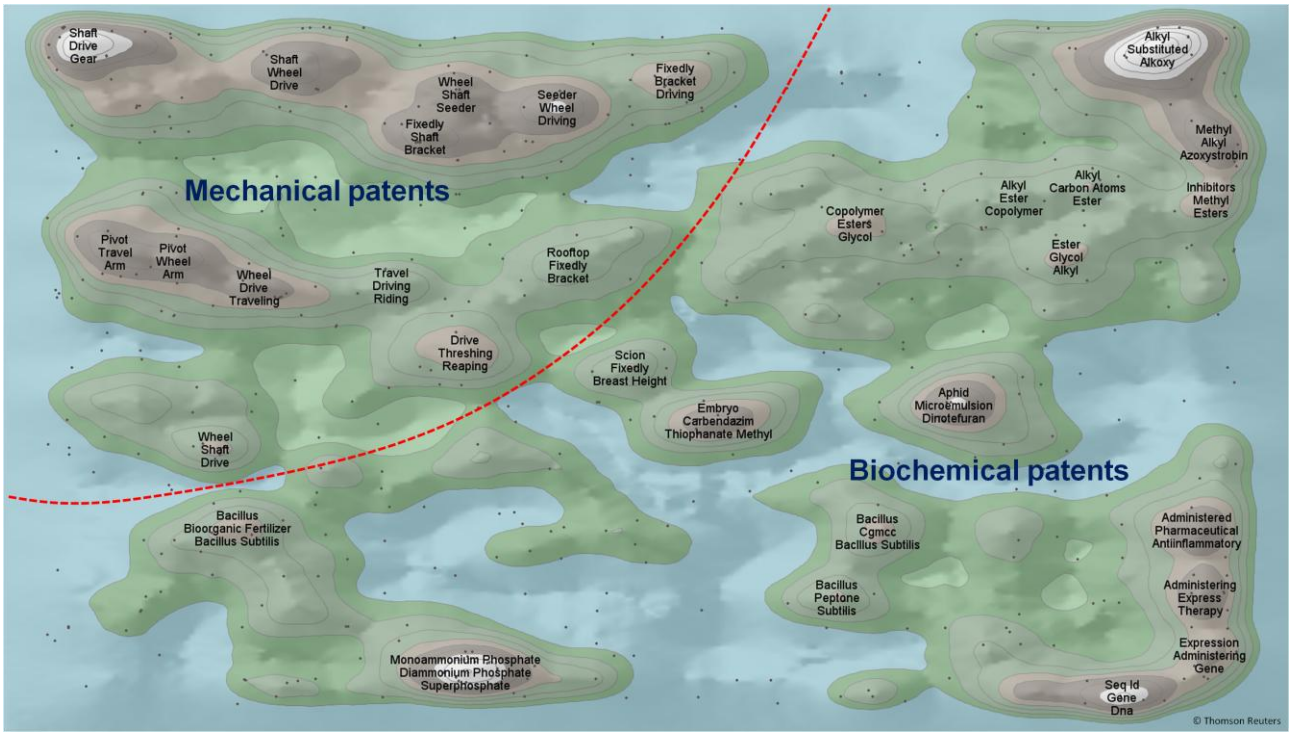

Figure 11: Agri-science patent landscape map (2011-2013)

The Japanese agricultural machinery company Iseki has the most patent families with several other manufacturing companies appearing in the list of top applicants, including Kubota, Yanmar, Mitsubishi and John Deere. Unsurprisingly there is also a large proportion of agri-science patents belonging to major chemical companies, including Bayer, BASF and Syngenta, who are developing new chemicals to improve, for example, pest control and crop productivity rates. Approximately three-quarters of all agri-science inventions are filed by Chinese, US and Japanese applicants, with UK applicants accounting for just 2.3% of the dataset. However, the UK has filed slightly more agri-science patents than expected given the overall level of patenting activity from UK applicants across all areas of technology; the Relative Specialisation Index suggests that UK applicants are more specialised in agri-science than their counterparts in Japan, USA, Germany, Netherlands, France, Sweden, Italy and Spain.

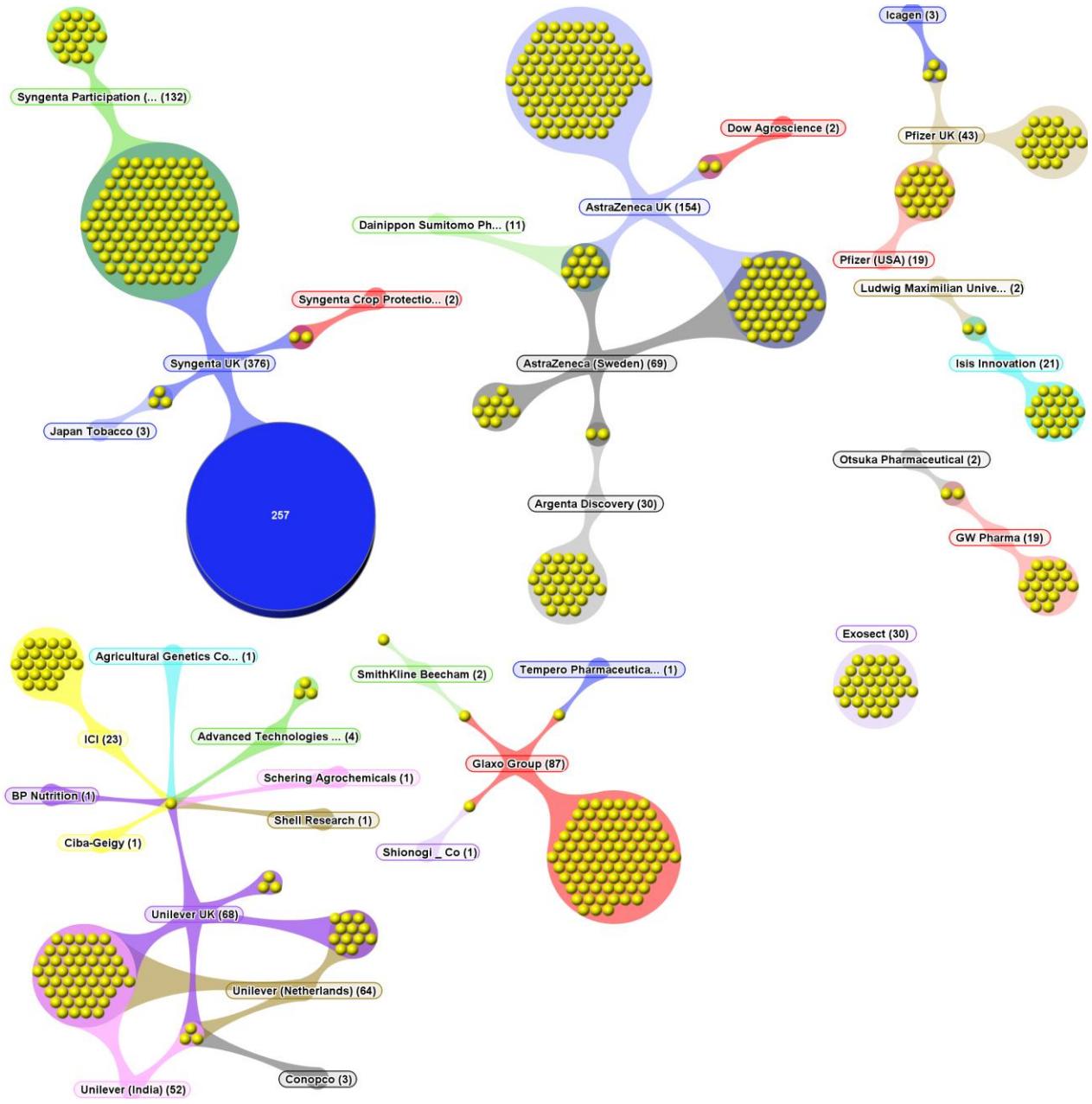

Figure 12: Patent collaboration map showing all collaborations between the top 10 UK agri-science patent applicants and their collaborators

8 Advanced materials and nanotechnology

This report analyses the worldwide patent landscape for technology directed towards advanced materials. Advanced materials and nanotechnology provides a very wide ambit for the construction of a meaningful search of relevant patent documentation. Therefore the report is divided into four separate parts, each of which is analysed in turn, in an attempt to give a broad overview. The four areas taken from the area of advanced materials and nanotechnology are: forms of carbon (*i.e.* graphene and nanostructures), metamaterials, renewable energy enabling materials technology, and wearable technology.

The worldwide dataset for forms of carbon patents published between 2004 and 2013 contains more than 35,000 patent families (inventions) equating to over 110,000 published patents. The forms of carbon dataset showed that the UK has a good research base and a high degree of interest in this technology. Following on from the initial research into graphene it can be seen that the UK has continued with work in the area of nanotechnology. There is considerable academic interest in this area from the University of Cambridge, the University of Oxford and the University of Manchester in the general area of nanotechnology. In aerospace, Airbus and BAE Systems are working in use of nano-sized carbon elements for use in composites.

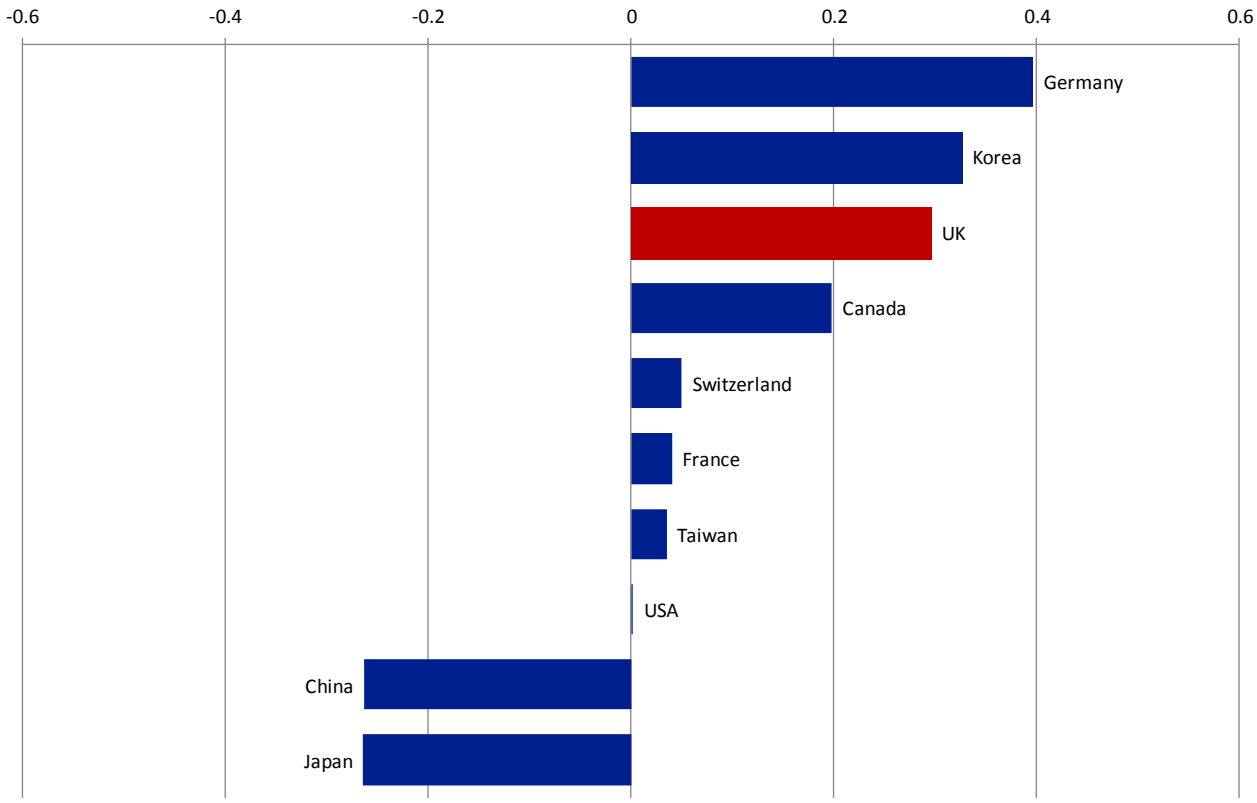

Figure 13: Relative Specialisation Index (RSI) by applicant country for carbon patenting

The worldwide dataset for metamaterials patents published between 2004 and 2013 is small and contains 120 patent families (inventions) equating to 328 published patents. The area of metamaterials is developing but appears to be in its early stages; there is significant Chinese patent activity relative to other countries' patents occurring in this area. There are many potential commercial applications for this technology. In the UK, Isis Innovation (University of Oxford) is using metamaterials in transformers, and EADS is working in the field of optical devices, as is the University of Southampton.

The worldwide dataset for the renewable energy enabling materials patents published between 2004 and 2013 contains more than 23,000 patent families (inventions) equating to over 80,000 published patents. Renewable energy enabling technologies is a growing area. In the UK, Merck is the biggest patent filer. There is also academic interest in this area from the University of Cambridge, University of Oxford and Imperial College. There is a mixture of UK applicant types in this dataset with some multinationals, academic (or technology transfer companies with an academic base) and SMEs present.

The worldwide dataset for wearable technology patents published between 2004 and 2013 contains more than 18,000 patent families (inventions) equating to over 40,000 published patents. This technology area appears to be dominated by a number of multinational companies, some of which employ UK inventors who are not based in the UK. However, this is a fast moving technology area and should be regularly reviewed in order to ensure that relevant information about the development of this field is used to promote UK interests. There are few UK-based patenting organisations; patenting in this area is dominated by Japanese multinationals.

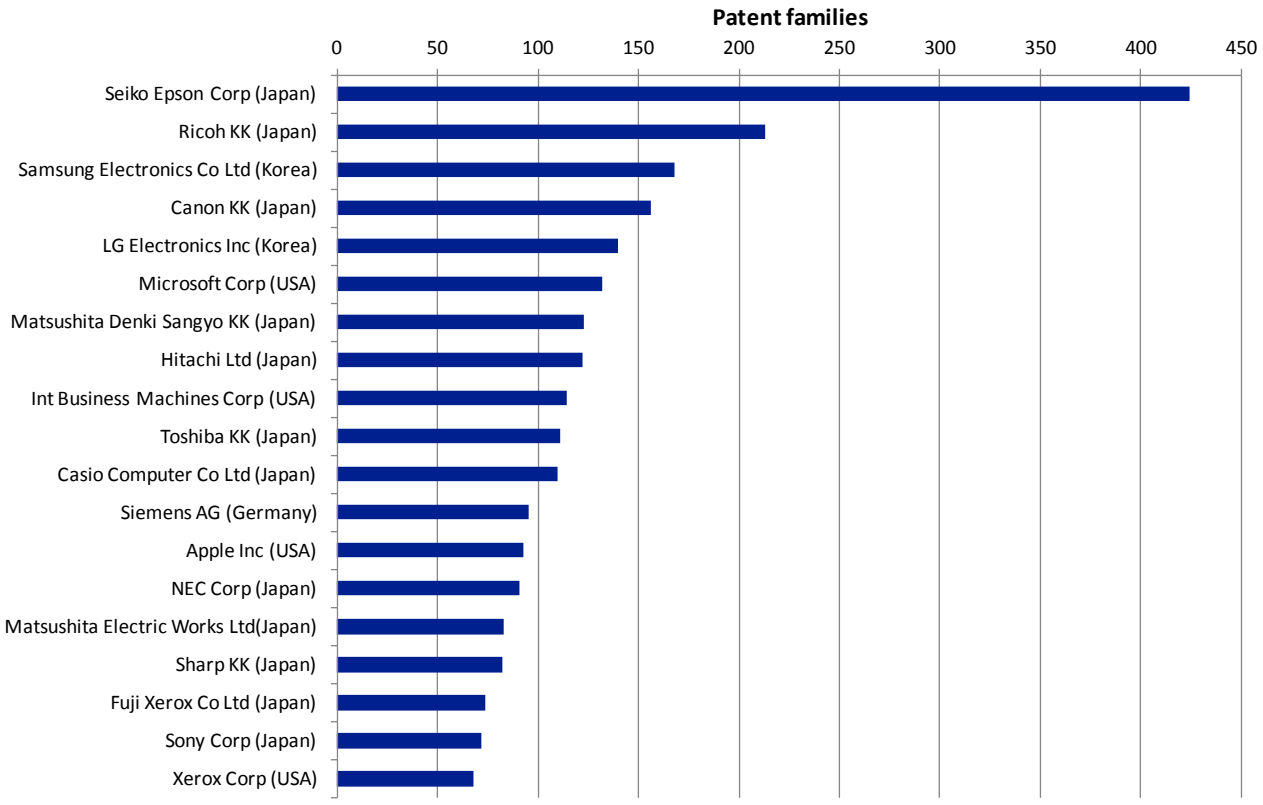

Figure 14: Top applicants worldwide in the patenting of wearable technology

9 Energy and its storage

This report analyses the worldwide patent landscape for energy and its storage. This encompasses many different technologies, but the report concentrated on small modular nuclear reactors, energy storage for vehicles, fuel cells, nanotech for batteries, supercapacitors, flow batteries and smart grids. There were more than 440,000 published patent applications between 2004 and 2013 relating to energy and its storage, resulting in almost 160,000 patent families (inventions). Patenting in this technology area has seen an increase over the last ten years, both worldwide and in the UK. It also shows the patenting characteristics of an emerging technology with the potential for much further growth.

Almost half (45%) of energy and its storage patent families have a first filing in China, with the next largest country being Japan at 20%. The UK is at 0.5%. China, Korea, Japan and the UK all show consistent and positive percentage growth since 2004 and so further technological developments may occur in those countries. An index of relative specialisation of applicant countries indicates that China, Japan, Korea, and Hong Kong in particular show a high degree of specialisation in energy and its storage. The Netherlands and Switzerland have the lowest levels of specialisation. The UK has a reasonable degree of specialisation in this study.

Fifteen of the top twenty applicants in energy and its storage are based in Japan. The role of multinational businesses in energy and its storage patenting is therefore important and could be expected to increase as further developments in technology are subsequently developed and commercialised. In the UK, Intelligent Energy (83 patent families), Johnson Matthey (56), and Nexeon (51) take the lead. UK inventors tend to be associated with UK applicant companies and multinational companies.

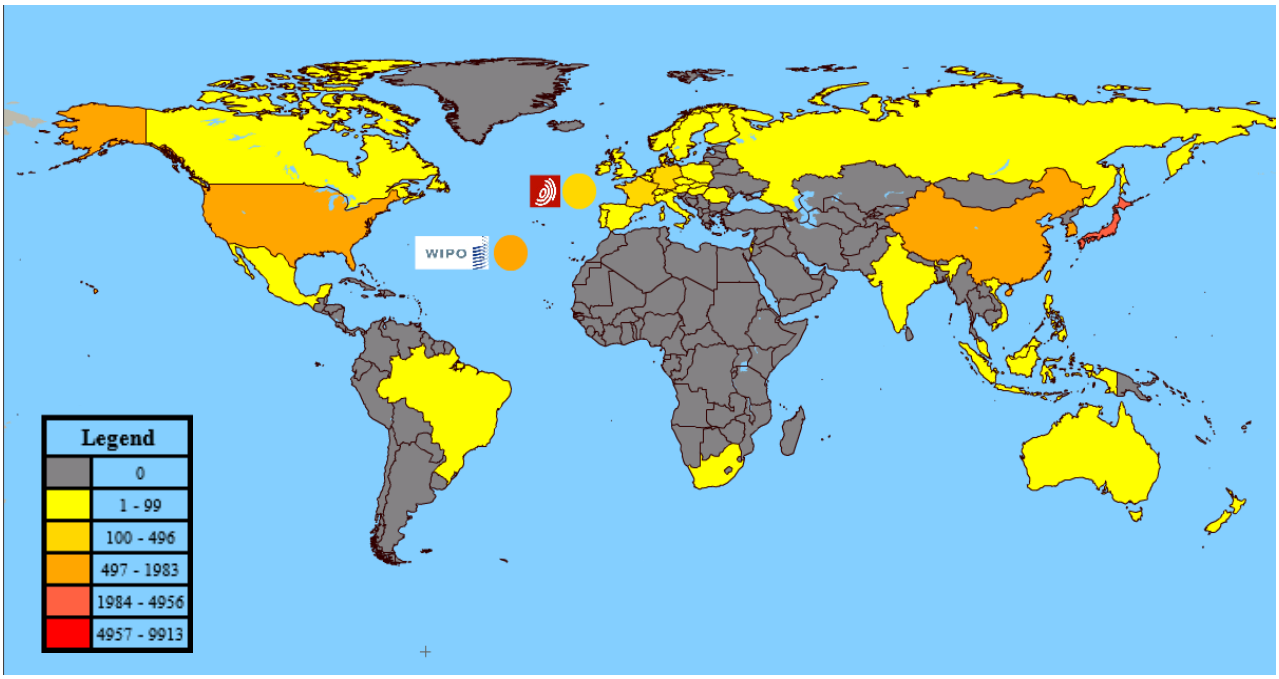

Figure 15: Patent coverage (publication country coverage) for energy and its storage

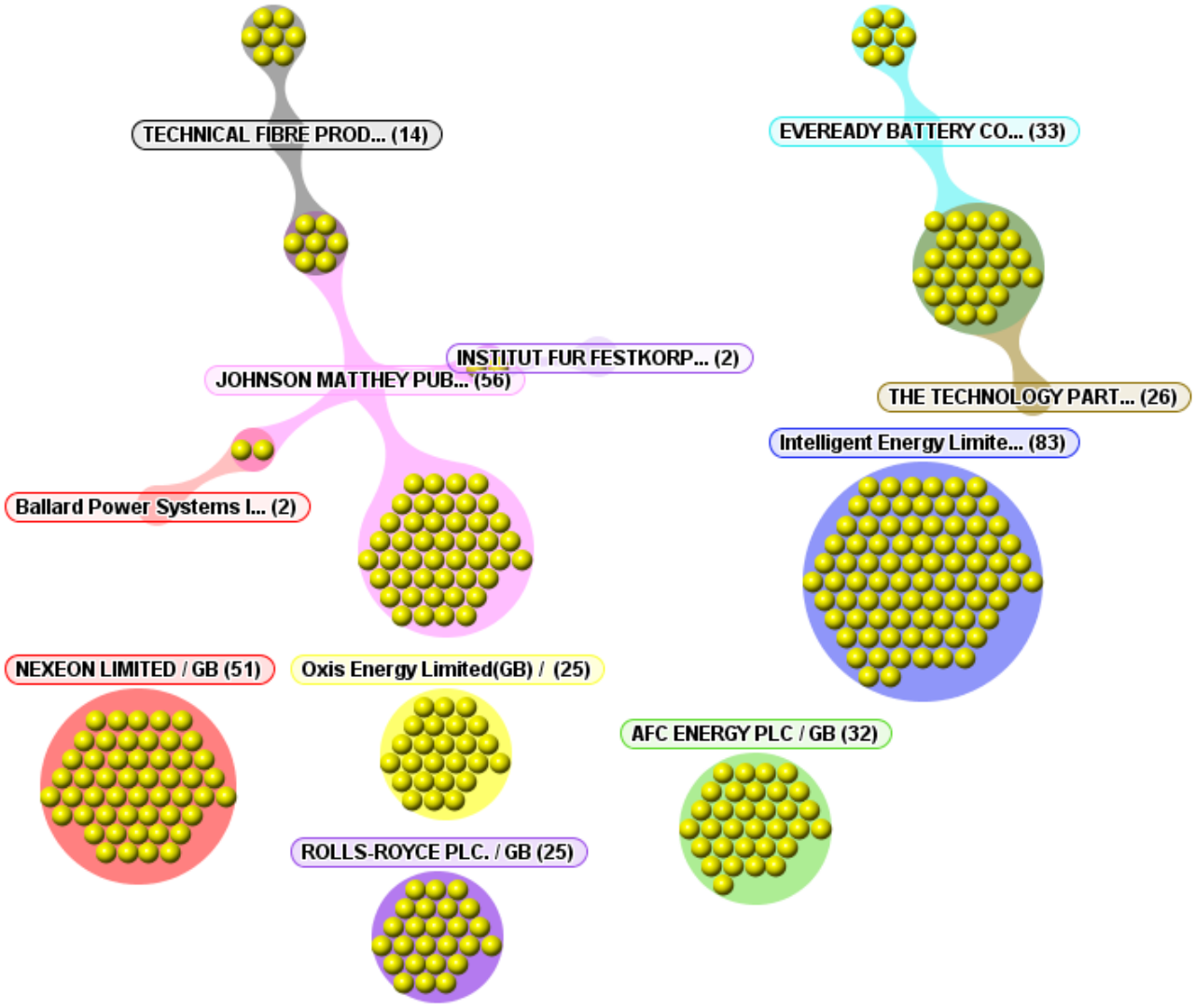

Figure 16: Patent collaboration map showing collaborations between the top UK patent applicants and their collaborators relating to energy and its storage

Collaborations appear to occur most frequently in large multinational organisations in the UK. As would be expected, technology-specific UK-based companies do not tend to collaborate with others.

Patent landscape analysis further demonstrates the general nature of energy and its storage patenting, with worldwide applicants tending to show interest in the entire field and to lack niches. However the main feature of the dataset is its domination by large multinational companies.

10 Quantum technologies

This report gives an analysis of the worldwide patent landscape for quantum technologies. These technologies fall into the distinct technology areas and between 2004 and 2013 there has been worldwide patenting activity in quantum telecommunications technologies (950 patent families/inventions), quantum computation technologies (777 patent families/inventions), quantum sensor technologies (547 patent families/inventions) and quantum timing and atomic clock technologies (160 patent families/inventions). In comparison to patent filings in other areas of technology, these are small but significant levels of patenting.

There is some overlap between these areas, particularly since many components which utilise quantum effects can be applied to both telecommunications and computation, whilst timing and clock technologies find application in sensing and telecommunications. On the whole however, these are largely distinct areas of technology which are subject to different trends and therefore warrant separate patent landscaping analysis.

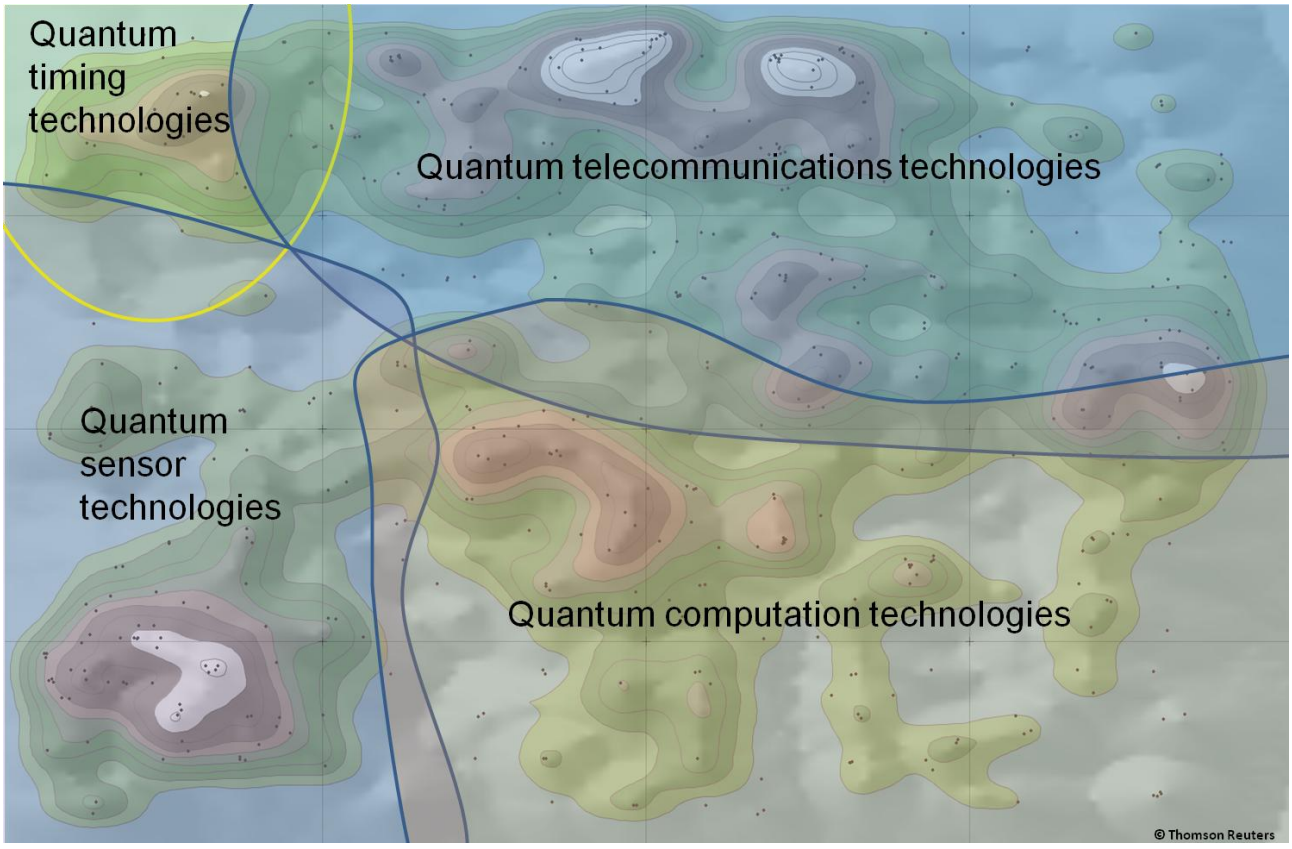

Figure 17: Patent landscape map of all patents relating to quantum technologies combined with the distinct technology areas overlaid

In quantum telecommunications technologies there was a peak in patenting activity in 2005 with 100 patent families filed. Following this there has been a lower, but sustained, level of patenting activity of around 65 patent families per year. Patenting from UK applicants is relatively specialised in quantum telecommunications technologies with the UK amongst the most specialised applicant countries in the world in this field, alongside Japan and Australia. The UK is significantly ahead of any other European country in terms of its patenting specialisation in this area. Large companies and multinationals from Japan and the USA are the most prolific patent applicants in this area; Toshiba, the third largest applicant in this area, with 40 patent families, carries out quantum technologies research in the UK at its Cambridge research laboratories. Hewlett-Packard, the fourth largest applicant, has research labs in Bristol and, of their 37 patent families, 20 originate from here.

In quantum computation technologies there has been a slight decline in patenting activity over the time period of the analysis from more than 70 patent families filed in 2003 and 2004 to just over 50 in 2010 and 2011. UK applicants are the third most specialised of any country's patent applicants in the patenting of quantum computation technologies; more specialised than applicants from the USA and Japan and second only to Australia (2nd) and Canada (1st). D-Wave Systems of Canada are head and shoulders ahead of any other applicants in terms of the number of patent families (80) that they filed over the time period analysed. The most prolific applicants consist predominantly of Japanese and North American companies. Toshiba, with its UK research base, is the third most prolific patent applicant with just under 40 patent families. Hewlett-Packard (6th) and Hitachi (13th) also use the UK as a base for their research into quantum computation technologies.

In quantum sensor technologies there were around 50 patent families filed per year between 2003 and 2006 followed by around 30 families a year from 2007 to 2011. UK patent applicants are relatively less specialised in patenting in this technology area when compared to an average level of patenting for UK patent applicants across all technologies. Despite this lack of relative specialisation, UK applicants are still more specialised in patenting in this field than any other European country. Japanese applicants, including a larger number of agencies and institutions than were seen in the quantum computation or quantum telecommunications datasets, dominate the top patent applicants chart in quantum sensing technologies. However, the most prolific patent applicants are Japanese multinationals Hitachi and Sumitomo (NEC). Toshiba are by far the most prolific of UK-based applicants in this technology area with 9 patent families relating to improvements and uses of superconducting quantum interference devices (SQUIDs).

Quantum timing and atomic clock technologies is a very small dataset which contains only 160 patent families. It exhibits a recent increase in patenting activity from around 10 patent families filed per year from 2003 to 2005 to around 20 patent families per year being filed from 2009 to 2011. Honeywell and Seiko Epson are most active in patenting, both of whom are developing portable chip-scale atomic clocks based on quantum mechanical effects.

11 The internet of things

This report analyses the worldwide patent landscape for the Internet of Things (IoT). The IoT is a concept where a network of everyday physical objects are accessed through the internet and are able to automatically identify themselves to other devices because of their inherent 'ambient intelligence', creating a smarter world. In 2012 it was estimated that there were 8.7 billion connected devices and this is predicted to rise to between 50 billion and 75 billion devices by 2020. Examples in the home include smart metering and remote control appliances, and in the wider world include traffic congestion/optimisation, intelligent shopping, smart monitoring, e-health, industrial auto-diagnosis and smart farming.

There were almost 22,000 published patent applications between 2004 and 2013 relating to the internet of things (IoT), resulting in almost 10,000 patent families (inventions). Not surprisingly patenting activity in this field has grown sharply and rapidly in recent years and in the last three years the annual increase in IoT patenting activity has been over eight times larger than the general worldwide increase in patenting.

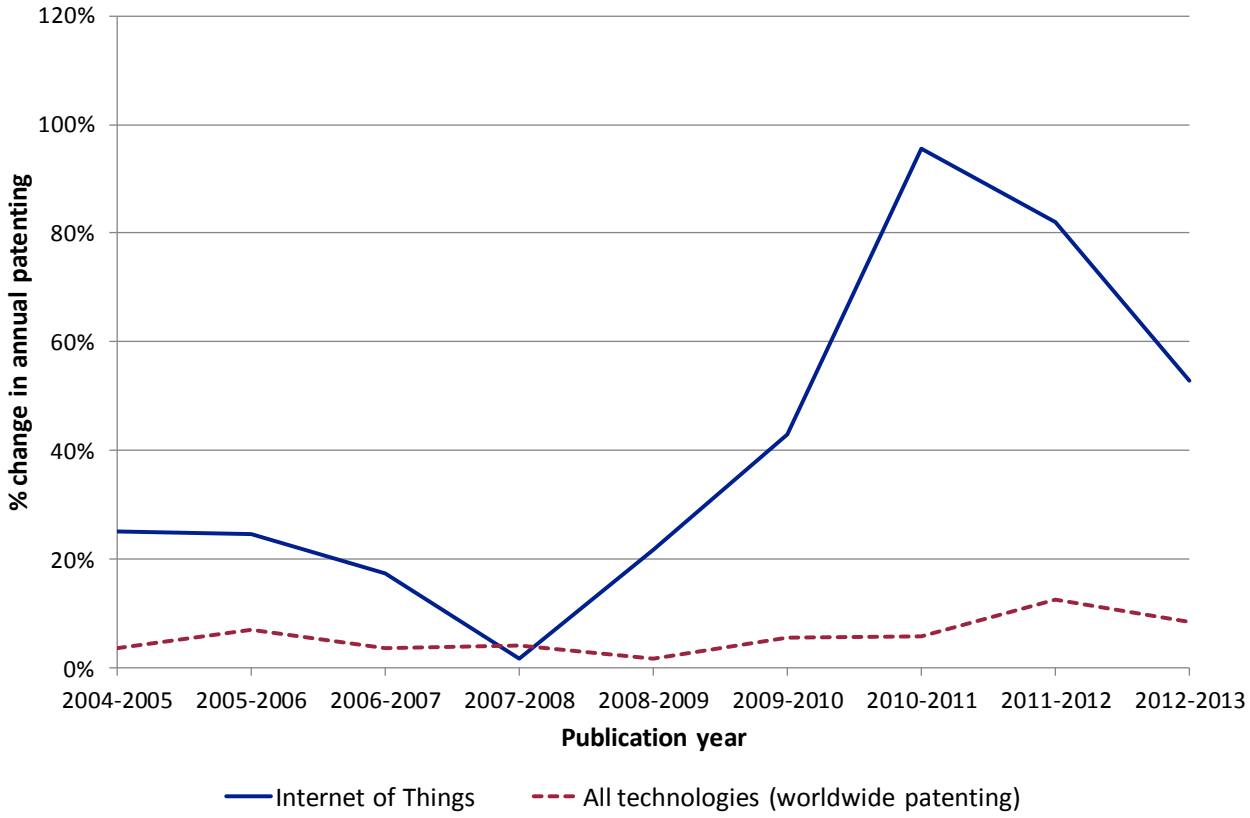

Figure 18: Year-on-year change in the internet of things patenting compared to worldwide patenting across all technologies

The Chinese telecommunications company ZTE has the most patent families with several other well-known multinational companies appearing in the list of top applicants, including LG, Samsung, IBM and Sony. The leading UK applicant is Neul, a dedicated IoT company incorporated in 2010 to exploit the full potential of the IoT. Neul has been a major contributor to a new wide-area wireless networking technology designed specifically for the

IoT with better coverage, battery life, module cost and efficiency than current mainstream wireless solutions. In 2013 Neul produced the first single chip baseband implementation of this standard in the world and this technology is capable of delivering high coverage, low-power and low-cost wireless networks for the IoT. Neul has recently worked alongside BT and Google to fast-track the development and push the boundaries of these technologies.

UK patenting activity in the IoT has significantly increased in recent years with a rise of over 150% in the number of published IoT patent applications between 2011 and 2012. In 2013 there were almost 250 IoT patents published from UK patenting activity compared to less than 50 in 2009. Although UK patenting activity in the IoT is relatively small, on a direct comparison it is on a par with the growth in patenting activity from several other countries including Germany, France, Korea, Japan and the USA.

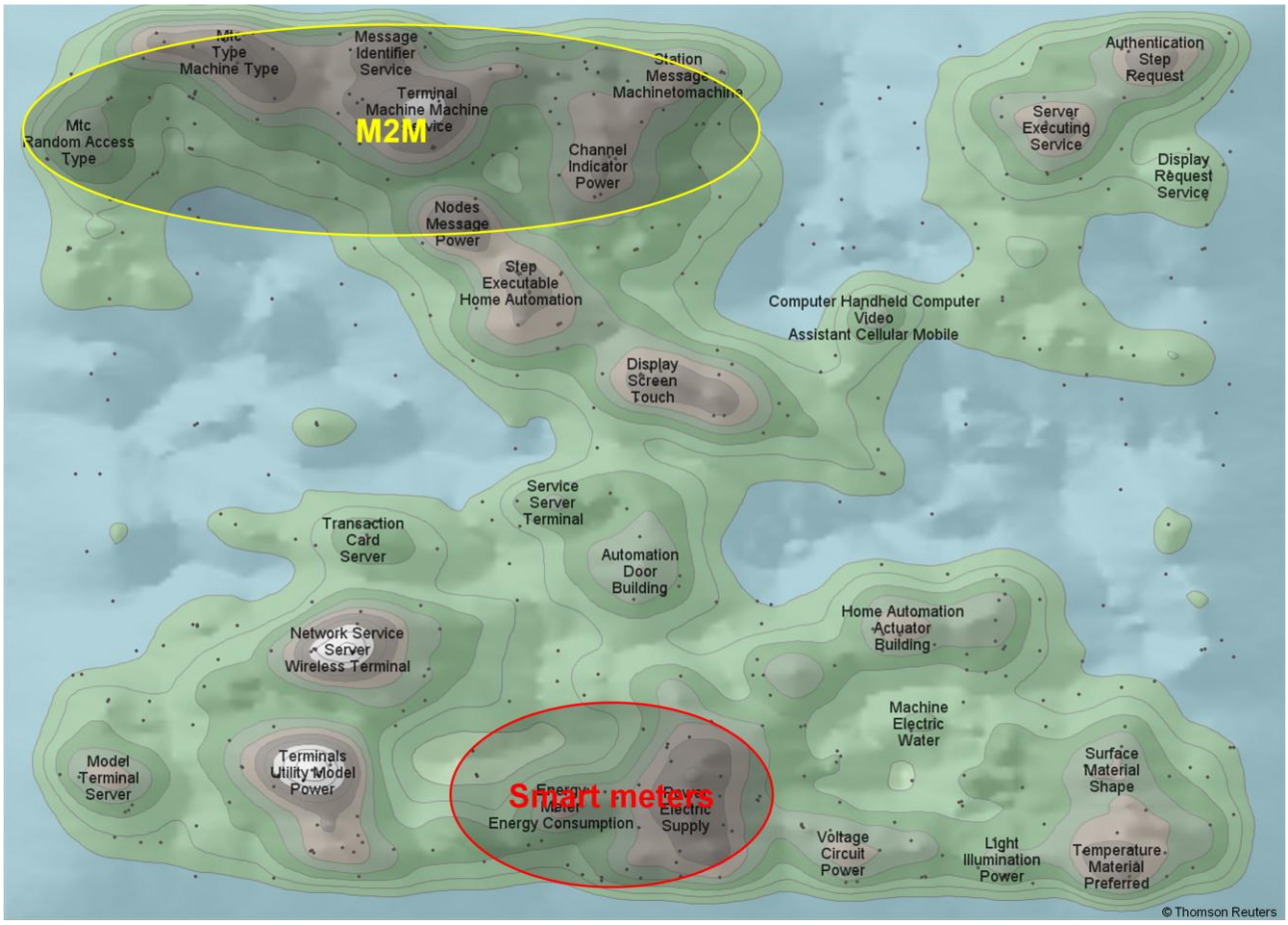

Figure 19: Patent landscape map of all patents relating to the internet of things

There are an increasing number of internet-connected devices in modern life and a smart home environment that creates a framework for communication and control is on the cusp of being a mainstream consumer technology. For example, Apple's latest mobile operating system (iOS 8) released in September 2014 has an added functionality to allow manufacturers of smart home appliances to develop software that will allow their devices to interact with each other and be controlled using Apple's mobile devices. With an estimated 75 billion connected devices by 2020, it appears that the IoT is likely to radically change the way we live our lives in a smarter digital world.

12 Conclusions

Patent data can be a useful starting point to analyse the innovative activity within different technologies and these ten IPO reports were designed to look at the worldwide patent landscape for each of the eight great technologies and to assess the UK's current position on the global stage. Full versions of each patent landscape report can be downloaded from the gov.uk website by following the hyperlinks below:

- the big data revolution and energy-efficient computing;
- satellites and commercial applications of space;
- robotics and autonomous systems;
- life sciences, genomics and synthetic biology;
- regenerative medicine;
- agri-science;
- advanced materials and nanotechnology;
- energy and its storage;
- quantum technologies;
- the internet of things.

This information should not be taken as a direct measure of the level of innovation and should be considered in conjunction with other sources of information to form a fuller picture.

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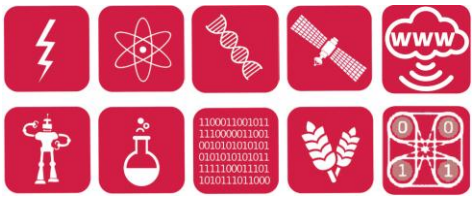

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