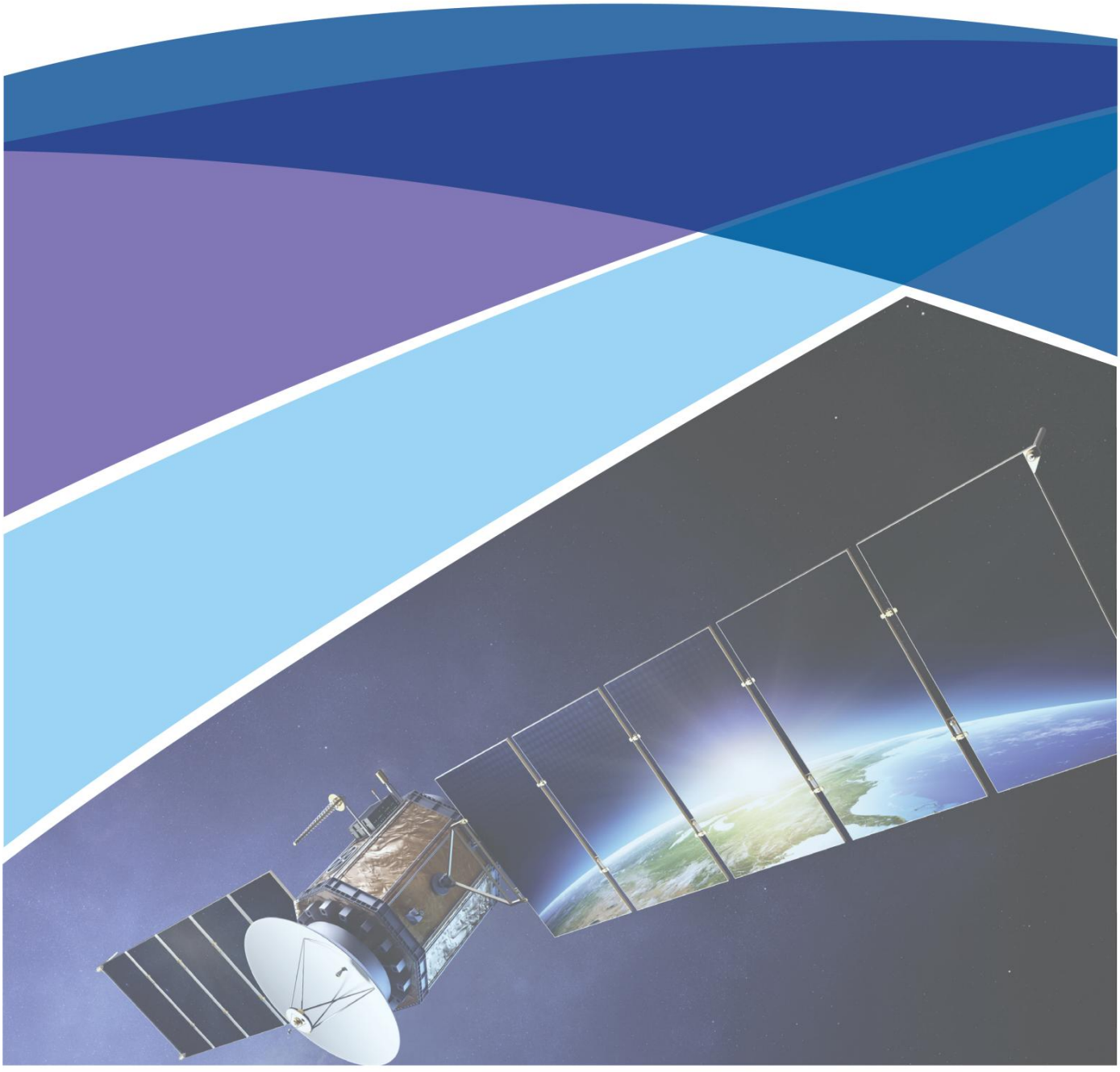
Intellectual Property Office

Eight Great Technologies

Satellites

A patent overview



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#8Great

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Contents

1 Introduction

The UK Government has identified ‘eight great technologies’ 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.

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 is producing 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 and in which direction the technology is developing.

This report is the first in the series of reports relating to the eight great technologies and analyses the worldwide patent landscape for satellite technologies. The dataset used for analysis 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 satellite technologies. In addition to patents for actual satellite hardware in space, the dataset for analysis also included patents relating to GPS-based technologies, both space-based and earth-based (receiver-side) technologies.

This report is based on analysis of published patent application data and not granted patent data. Data for published patent applications gives more information about technological activity than the figures for granted patents 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.

2 Worldwide patent analysis

2.1 Overview

Table 1 gives a summary of the extracted and cleaned dataset used for this analysis of satellite technologies. All of the analysis undertaken in this report was performed on this dataset or a subset of this dataset. The worldwide dataset for satellite patents published between 2003 and 2013 contains almost 85,000 published patents equating to over 22,000 patent families. Published patents may be at the application or grant stage, so are not necessarily granted patents. A patent family is one or more published patents originating from a single original (priority application). Analysis by patent family more accurately reflects the number of inventions present because generally there is one invention per patent family, whereas analysis by raw number of patent publications inevitably involves double counting because one patent family may contain dozens of patent publications if the applicant files for the same invention in more than one country. Hence analysis by patent family gives more accurate results regarding the level of innovation taking place.

Table 1: Summary of worldwide patent dataset for satellite technologies

Number of patent families	22,090		
Number of patent publications	84,842		
Publication year range	2004-2013		
Peak publication year	2013		
Top applicant	Qualcomm (USA)		
Field choices	**Field name**	**Number of entries**	**Coverage**
People	Inventors	29,286	99%
Applicants	Patent assignees	6393	100%
Countries	Priority countries	53	100%
Technology	IPC sub-group	5398	100%

Figure 1 shows the total number of published patents by publication year (above) and the total number of patent families by priority year (below – considered to be the best indication of when the original invention took place). Figure 1 suggests a general increase in satellite-related patenting over the past decade but it is too soon to conclude if the annual level of patenting has stabilised, as suggested by a similar level of patent publications in both 2012 and 2013. The patent family chart in red does not show any patents filed after 2011 because a patent application is normally published 18 months after the priority date or the filing (application) date, whichever is earlier. Hence, the 2012 and 2013 data is incomplete and has been ignored.

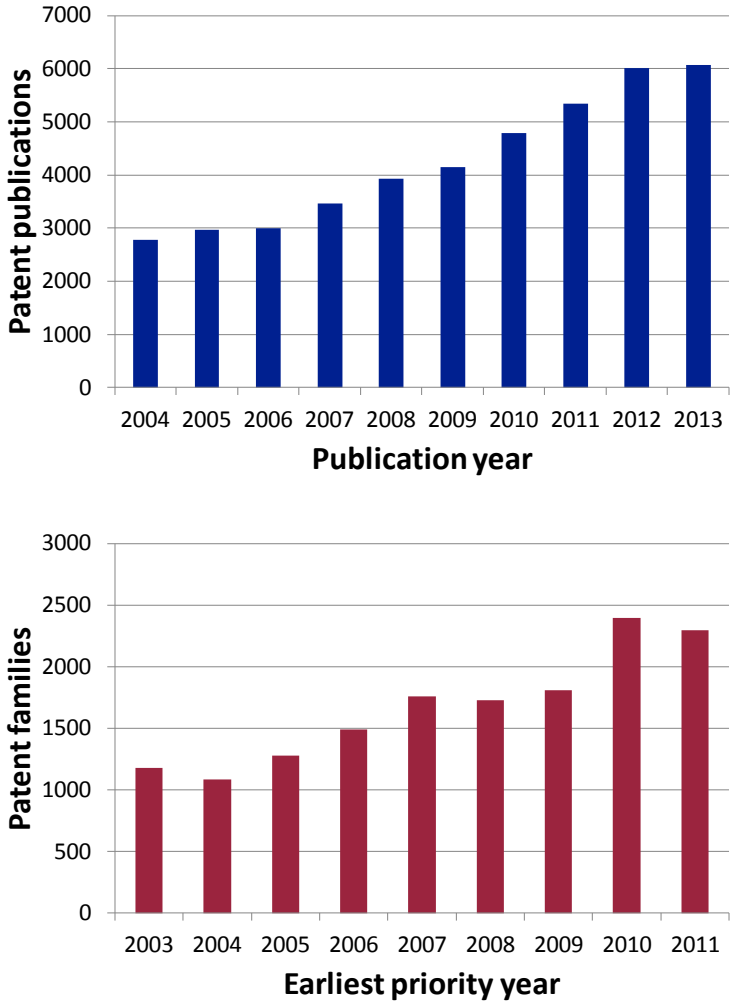

Figure 1: Patent publications by publication year (above) and patent families by priority year (below)

In real-world terms only limited information can be gleaned from the upward trends shown in Figure 1 because general patenting levels globally continue to grow at an ever-increasing rate. Figure 2 addresses this issue by normalising the data shown in Figure 1 and presenting the annual increase in the size of worldwide patent databases across all technologies against the year-on-year increase in the size of the satellites dataset. For example, between 2010 and 2011 worldwide patenting across all areas of technology increased by 5.8% and this can be compared to an 11.6% increase in satellite patenting over the same time period.

Although Figure 1 shows that there has been a year-on-year increase in patenting in the field of satellites over the past decade, Figure 2 shows that this increase has typically been well above the general increase in the size of the worldwide patent databases across all technologies. Across the nine data points shown in Figure 2, patenting activity in satellites has been, on average, almost 3.5% above the year-on-year increase in global patenting activity.

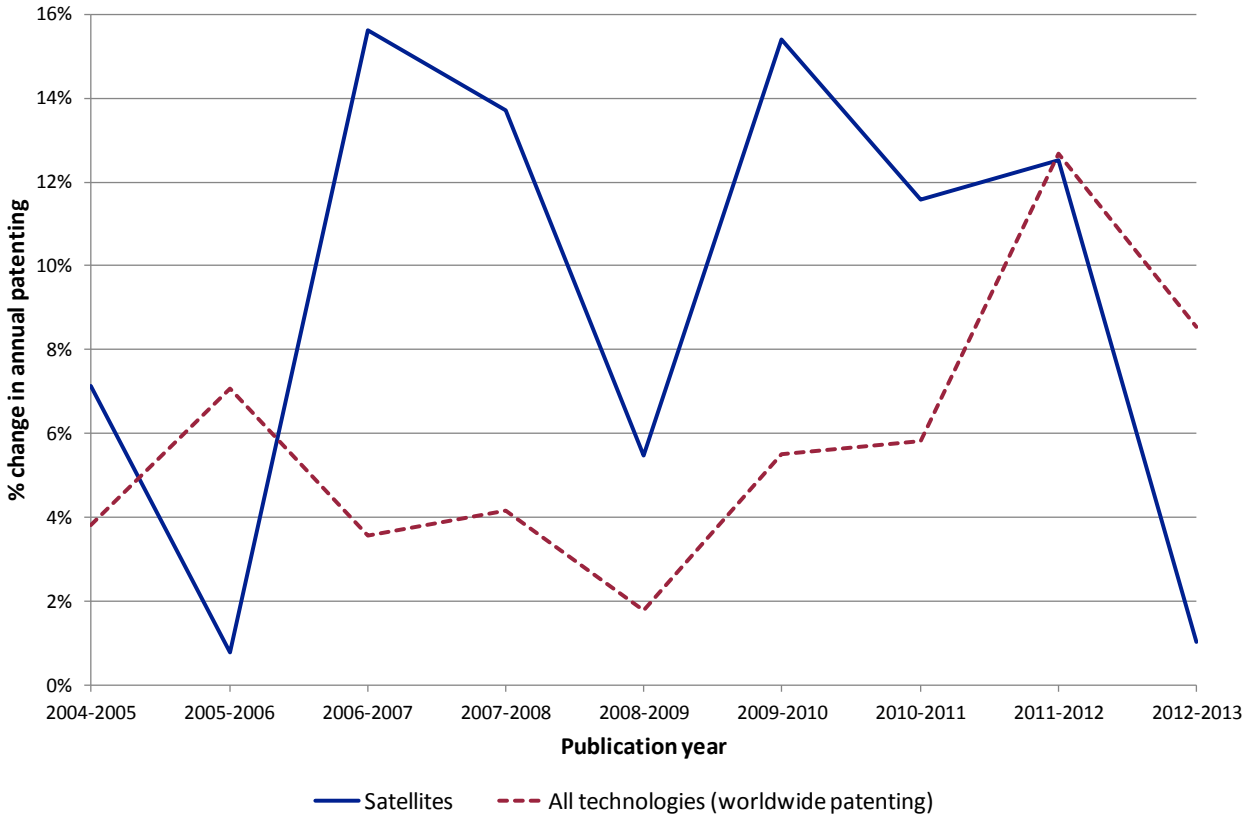

Figure 2: Year-on-year change in satellite patenting compared to worldwide patenting across all technologies

Figure 3 shows the priority country distribution across the dataset with over one-third of satellite patent families having their first filing in the USA. Less than 2% of satellite-related patent families are first filed in the UK. Traditionally priority country analysis has been a good indicator of where the invention is actually taking place because many applicants will file patent applications first in the country in which they reside[1], but in recent years drawing firm conclusions from this data is harder because there may be other strategic reasons for an applicant choosing the country of first filing (*e.g.* tax treatment).

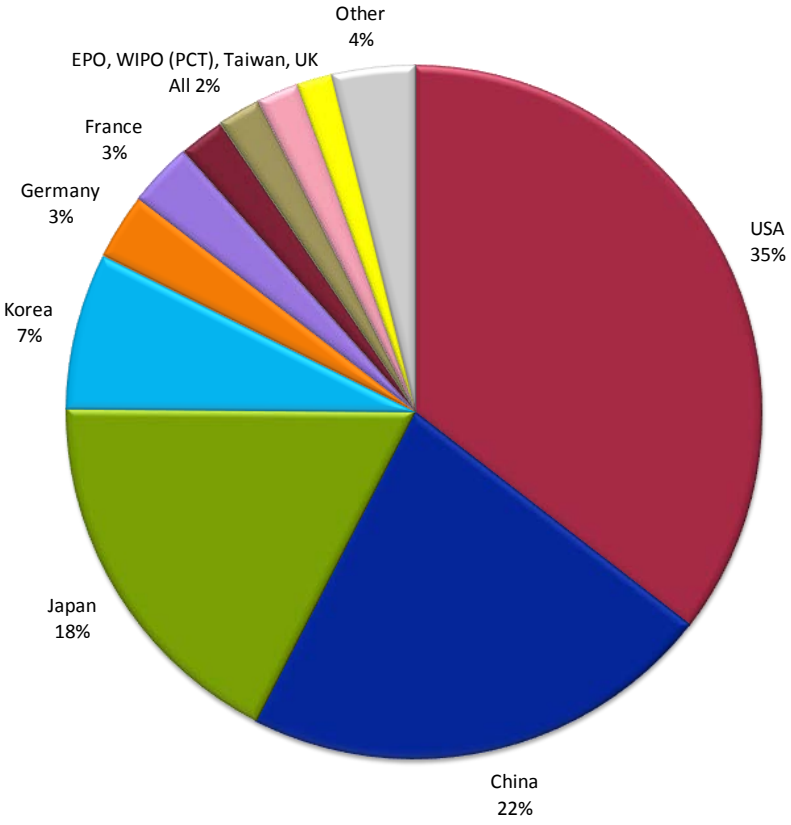

Figure 3: Priority country distribution

It is interesting to compare the similarities between the priority country distribution shown in Figure 3 and the applicant country distribution shown in Figure 4. WIPO (PCT) and EPO data[2] will appear in Figure 3 and not Figure 4, but the ranking and percentage distribution of the 'actual' countries follows a broadly similar trend in both figures as expected, with the exception of the USA. Figure 3 shows that over 35% of all satellites patent families are first filed in the USA, but Figure 4 shows that only 25% of satellite patent families come from US applicants – the most likely reason for this disparity is that the USA is considered to be an important jurisdiction for many companies even if they do not reside in the USA.

[1] In some countries this is/was a requirement (*e.g.* in the UK this was a requirement until 2005).
[2] Alternative filing routes to single national patents, as outlined in Appendix A.3.

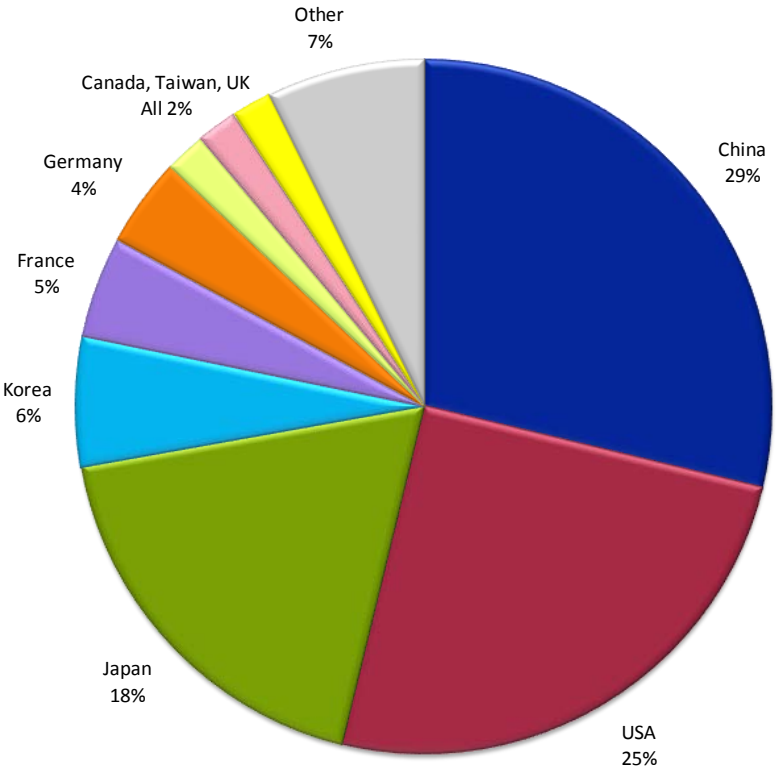

Figure 4: Applicant country distribution

It is well known that there is a greater propensity to patent in certain countries than others, and the trends shown in Figure 4 may change if the figures are corrected for this difference in behaviour. Therefore the Relative Specialisation Index (RSI)[3] for each applicant country (Figure 5) has been calculated to give an indication of the level of invention in satellite technologies for each country compared to the overall level of invention in that country.

The RSI shown in Figure 5 appears to suggest a different picture to that shown in Figure 4. China and the USA are ranked 1st and 2nd in the top applicant countries and appear relatively specialised in the field of satellite technologies since they account for over half of all satellites patent families, but this is now reversed when the RSI is applied as these two countries rank 11th and 7th respectively, below countries such as Finland, Israel, Luxembourg and Australia which do not even appear in the top applicant countries shown in Figure 4. These high-ranking countries show much greater levels of patenting in this technology space than expected, despite their modest absolute levels of patenting (*e.g.* Finland is ranked 10th and Israel 13th in the top applicant countries). The UK is ranked 13th with an RSI value of -0.07, suggesting that there are slightly fewer satellite patents filed by UK applicants compared to the overall level of patenting from UK applicants across all technology areas.

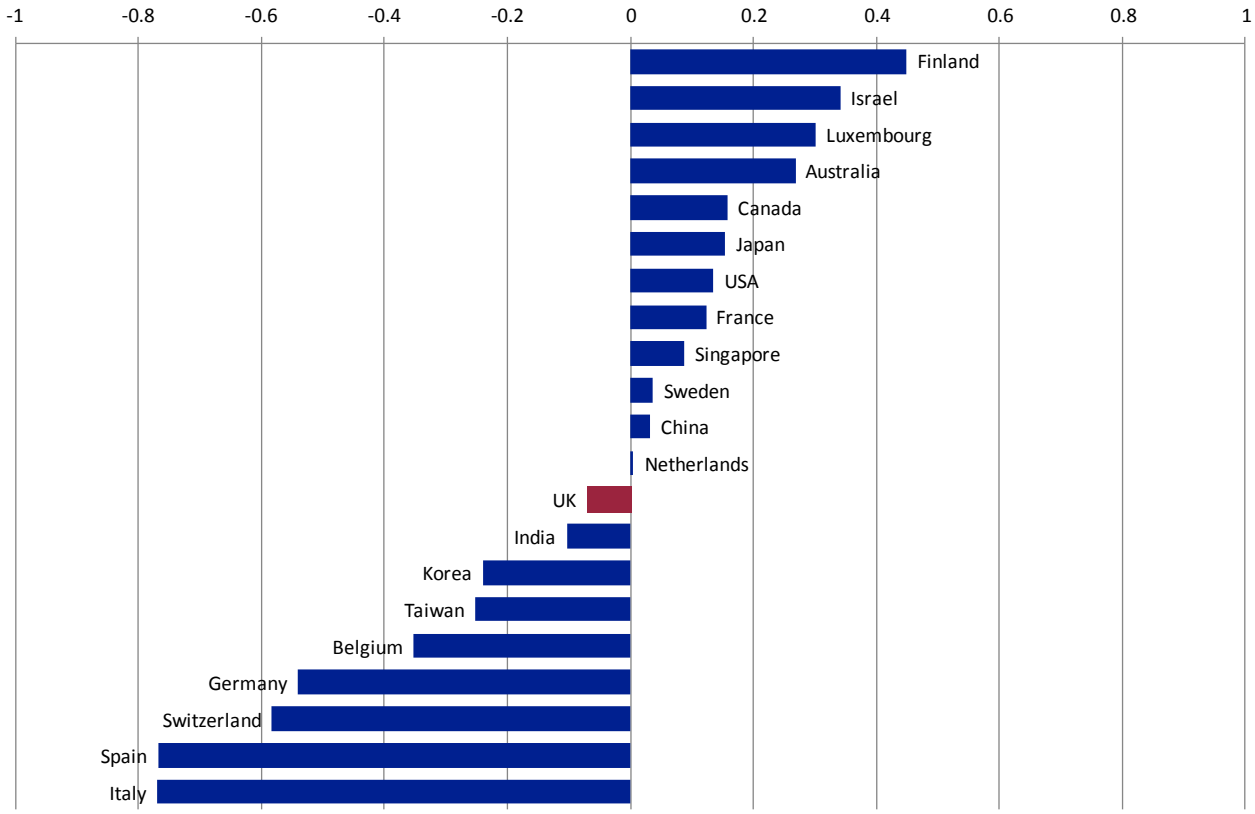

Figure 5: Relative Specialisation Index (RSI) by applicant country

[3] See Appendix B for full details of how the Relative Specialisation Index is calculated.

Figure 6 shows the countries in which applicants in the field of satellite technologies are interested in seeking patent protection, with the strength of colour reflecting the quantity of published patents in each jurisdiction. It is not surprising to see strong coverage in the same countries as shown in Figure 3 and Figure 4 (*i.e.* USA, China, Japan and Korea) since a patent applicant will often always file an application (within the patent family associated with that invention) in their home country. Published patents filed via the EPO [ ] and WIPO (PCT) [WIPO] routes are also presented, with Figure 6 showing a relatively strong level of patenting via the EP patent and PCT routes.

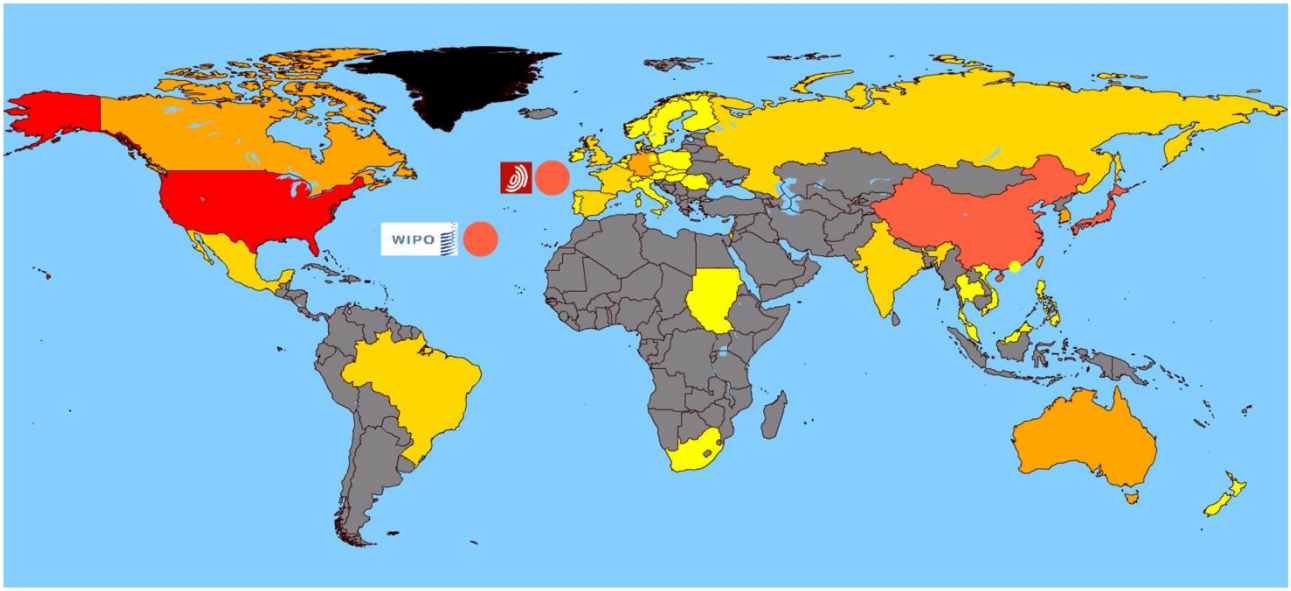

Figure 6: Patent coverage (publication country coverage)

2.2 Top applicants

Patent applicant names within the dataset were cleaned to remove duplicate entries arising from spelling errors, initialisation, international variation and equivalence[4]. Figure 7 shows the top 20 applicants in the satellites dataset.

Published patents in the name of Airbus, EADS, Astrium or Cassidian were grouped together as the Airbus Group following the reorganisation and renaming of this European multinational aerospace and defence corporation in January 2014. Sony patent publications include Sony Mobile Communications which is the new name for Sony Ericsson. ETRI is the Electronics and Telecommunications Research Institute in Korea. CSR is a UK company formerly known as Cambridge Silicon Radio and their portfolio includes published patents in the name of SiRF following CSR's acquisition of the US company SiRF in 2009.

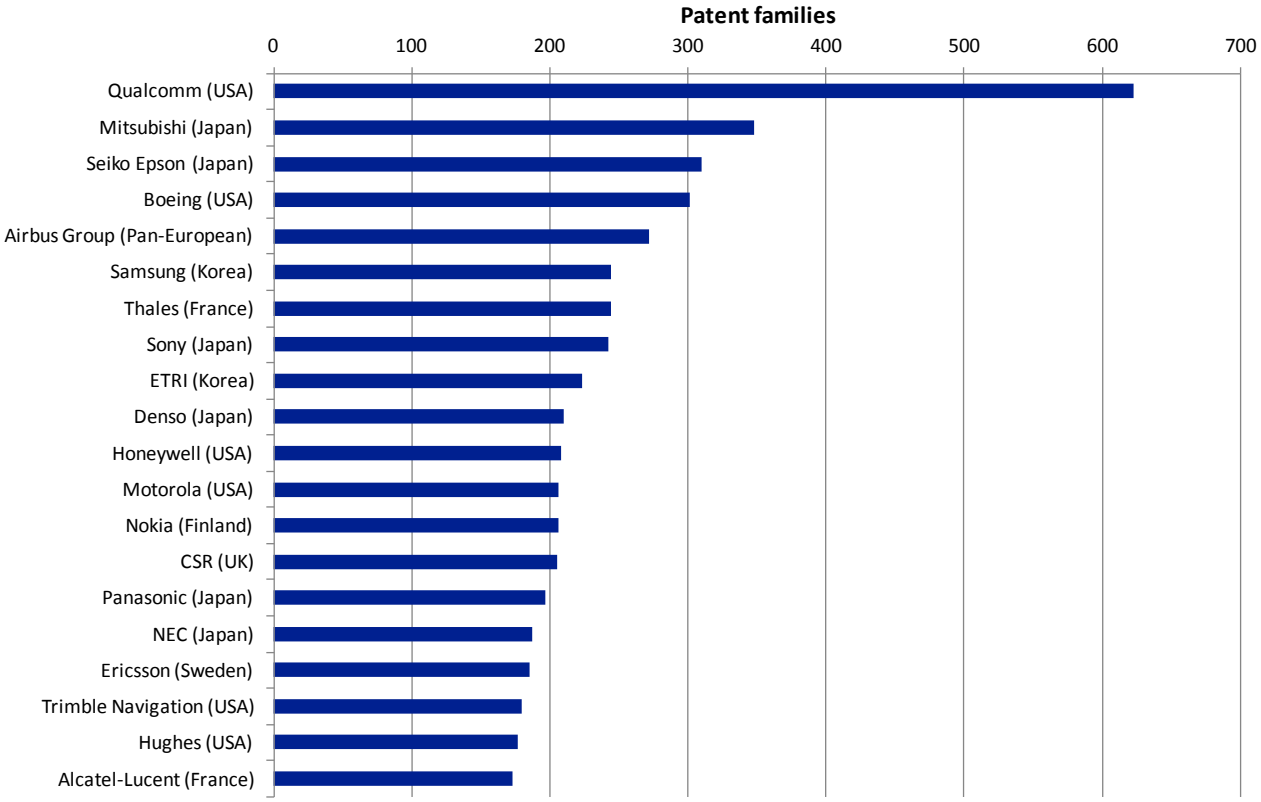

Figure 7: Top applicants

[4] See Appendix A.4 for further details

Figure 8 is a bubble map showing a timeline for the top 20 applicants and shows the filing activity of these applicants in the last 10 years. It shows that most of the top applicants have been involved in satellite patenting throughout the last decade albeit in varying degrees. For example, the leading applicant, Qualcomm, have patented strongly since 2004 whereas others, such as the Airbus Group, ETRI (Electronics and Telecommunications Research Institute, Korea) and Thales have increased their patenting activity in this area in recent years.

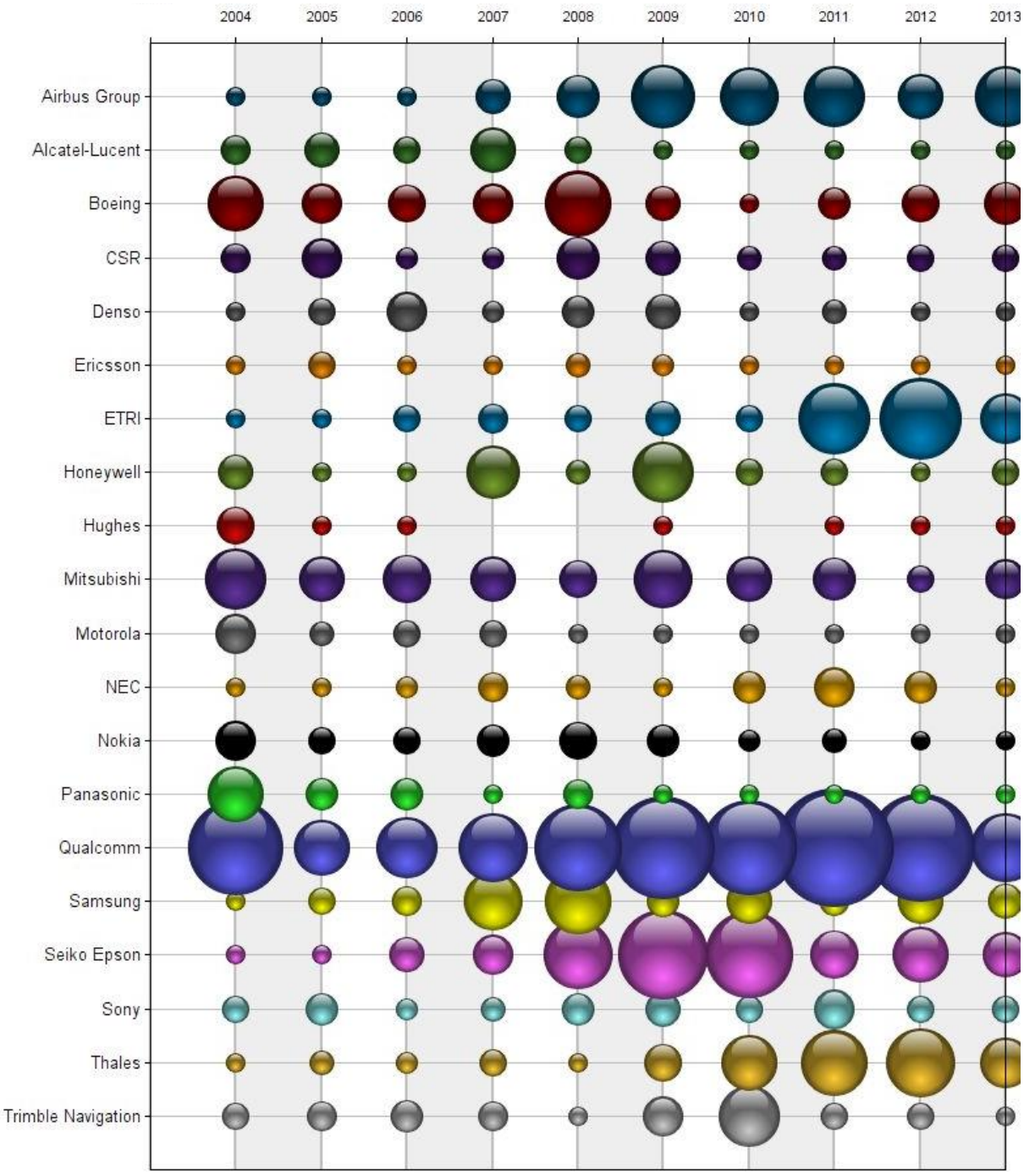

Figure 8: Applicant timeline of patent families by priority year

2.3 Collaboration

Figure 9 is a collaboration map showing all collaborations between the top five applicants in the dataset (the top five shown in Figure 7) and their collaborators. Each dot on the collaboration map represents a patent family and two applicants are linked together if they are named as joint applicants on a patent application. A collaboration map is a good indicator of technology transfer.

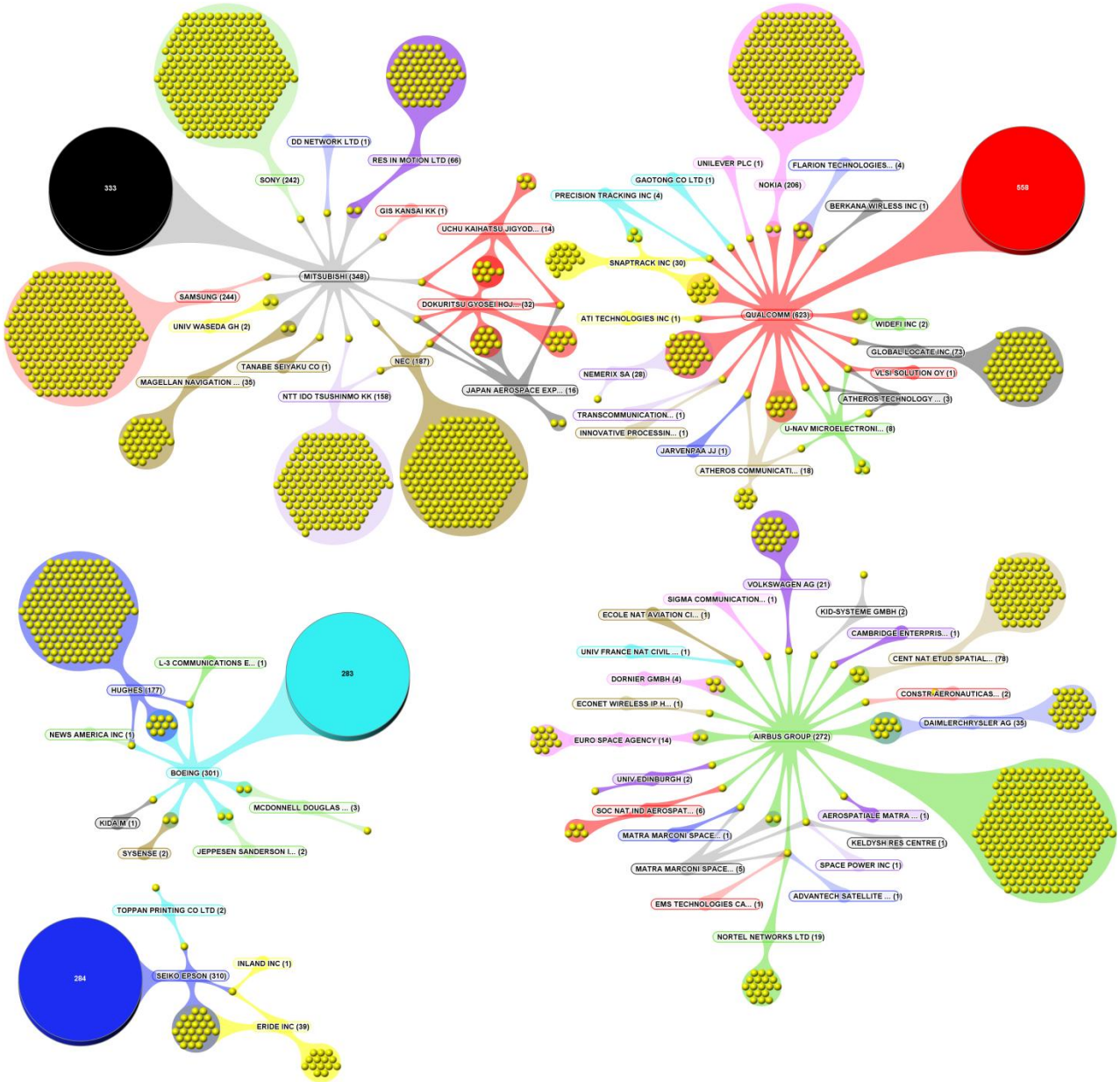

Figure 9: Collaboration map showing all collaborations between the top 5 applicants and their collaborators

Figure 9 shows that none of the top five applicants (Qualcomm, Mitsubishi, Seiko Epson, Boeing and the Airbus Group) have worked together on any joint patent applications, but it does highlight a reasonable amount of collaboration, both corporate and academic, and domestic and international between these companies and other collaborators. UK presence in the collaboration map revolves around the European-wide Airbus Group collaborating with UK academia in the form of joint patent applications with the University of Edinburgh and separately with Cambridge Enterprises (University of Cambridge).

2.4 Technology breakdown

Figure 10 shows the top International Patent Classification (IPC) sub-groups and Table 2 lists the description of each of these sub-groups. The IPC provides for a hierarchical system of language-independent symbols for the classification of patent applications according to the different areas of technology to which they pertain.

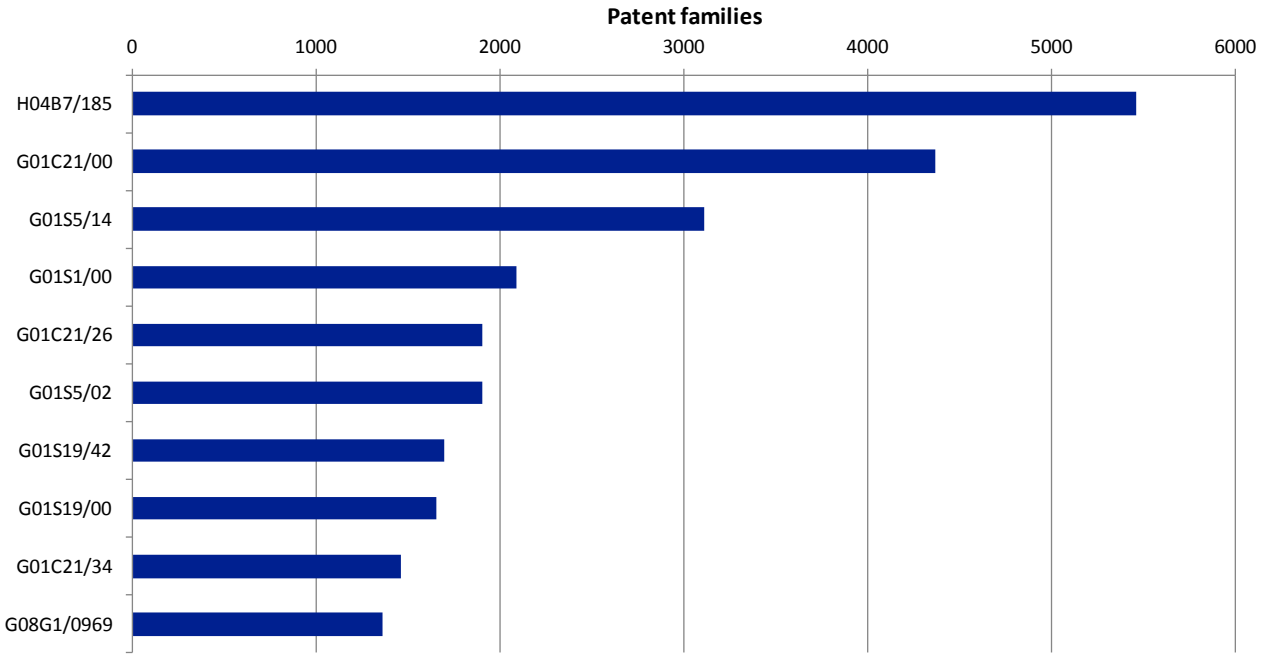

Figure 10: Top IPC sub-groups

Table 2: Key to IPC sub-groups referred to in Figure 10

H04B7/185	Radio transmission systems, *i.e.* using radiation field -> Relay systems -> Active relay systems -> Space-based or airborne stations
G01C21/00	Navigation; Navigational instruments
G01S5/14	Position-fixing by co-ordinating two or more direction or position-line determinations; Position-fixing by co-ordinating two or more distance determinations -> using radio waves -> Determining absolute distances from a plurality of spaced points of known location
G01S1/00	Beacons or beacon systems transmitting signals having a characteristic or characteristics capable of being detected by non-directional receivers and defining directions, positions, or position lines fixed relatively to the beacon transmitters; Receivers co-operating therewith
G01C21/26	Navigation; Navigational instruments -> specially adapted for navigation in a road network
G01S5/02	Position-fixing by co-ordinating two or more direction or position-line determinations; Position-fixing by co-ordinating two or more distance determinations -> using radio waves
G01S19/42	Satellite radio beacon positioning systems; Determining position, velocity or attitude using signals transmitted by such systems -> Determining a navigation solution using signals transmitted by a satellite radio beacon positioning system -> the satellite radio beacon positioning system transmitting time-stamped messages, *e.g.* GPS, GLONASS or GALILEO -> Determining position
G01S19/00	Satellite radio beacon positioning systems; Determining position, velocity or attitude using signals transmitted by such systems
G01C21/34	Navigation; Navigational instruments -> specially adapted for navigation in a road network -> Route searching; Route guidance
G08G1/0969	Traffic control systems for road vehicles -> Arrangements for giving variable traffic instructions -> having an indicator mounted inside the vehicle, *e.g.* giving voice messages -> Systems involving transmission of navigation instructions to the vehicle -> having a display in the form of a map

3 The UK landscape

3.1 Top UK applicants

Figure 11 shows the top UK-based applicants within the satellites dataset. The number of patent families shown in the name of Airbus and CSR are lower than the values shown in Figure 7 because the data presented in Figure 11 relates to the UK-based parts of these companies (*i.e.* Airbus is a pan-European corporation and Figure 11 shows the patent families (inventions) originating from the UK part of the business; CSR is a UK company but acquired most of its satellites patent portfolio following its acquisition of the US company SiRF in 2009, with Figure 11 only showing published patents in the name of CSR UK). Examples of some of the most recent UK satellite patenting from these top UK applicants includes; a method for processing a reflected signal to provide a delay Doppler map using a global navigation satellite reflectometry system for oceanographic applications (Airbus UK), satellite beam monitoring (Inmarsat) and a calculating apparatus with a location algorithm that generates a receiver location based on signalling events received by the receiver from a set of satellites (CSR UK).

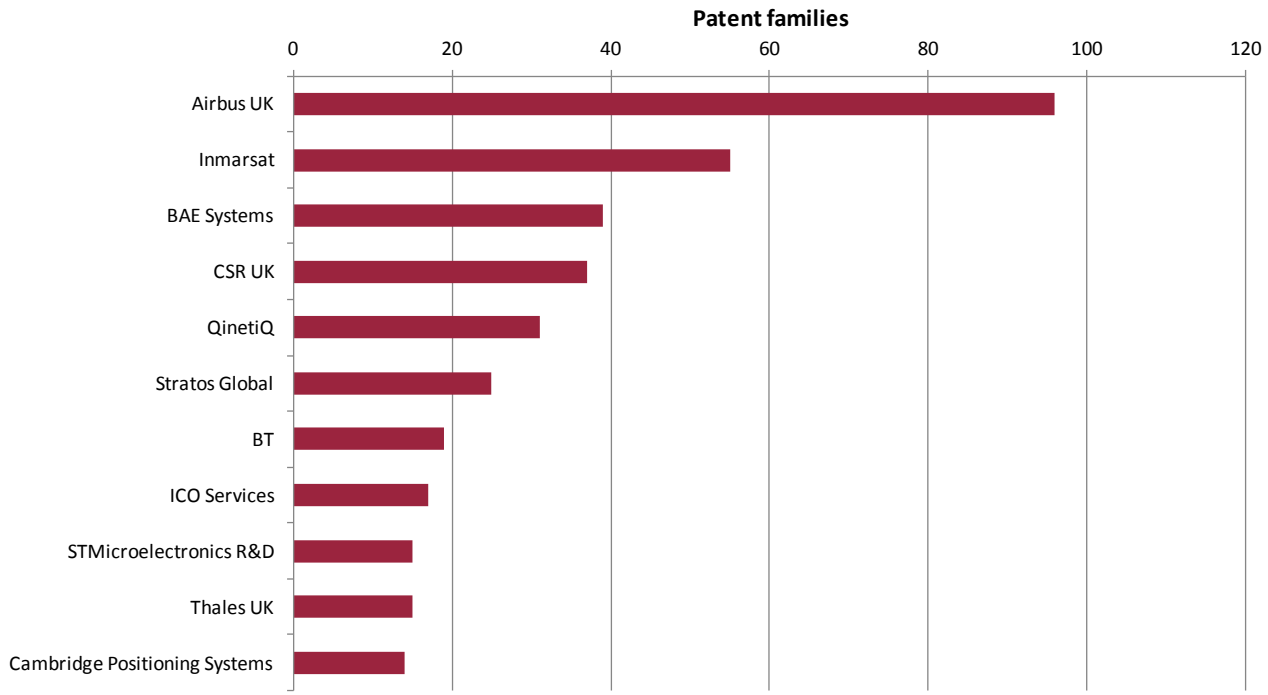

Figure 11: Top UK applicants

It should be noted that UK-based Surrey Satellite Technology Ltd (SSTL), the world's leading small satellites company[5], does not appear in Figure 11. SSTL is a spin-off from the University of Surrey and is now majority-owned by EADS Astrium, which is part of the Airbus Defence and Space group and therefore falls within the Airbus UK grouping. SSTL patent applications appear to be filed under the name Astrium and are therefore grouped alongside other Airbus Group patent publications.

[5] http://www.sstl.co.uk/About-SSTL

3.2 UK inventor mobility

Figure 12 shows the top worldwide applicants with named UK inventors on their published patents. Even if the pan-European Airbus Group is grouped as a “UK company”, only four of the top 12 applicants shown in Figure 12 are based in the UK, with three Dutch companies and two Swiss companies appearing in the list of top applicants. This highlights the mobility of the UK knowledge base since UK inventors are innovating for other companies outside of the UK.

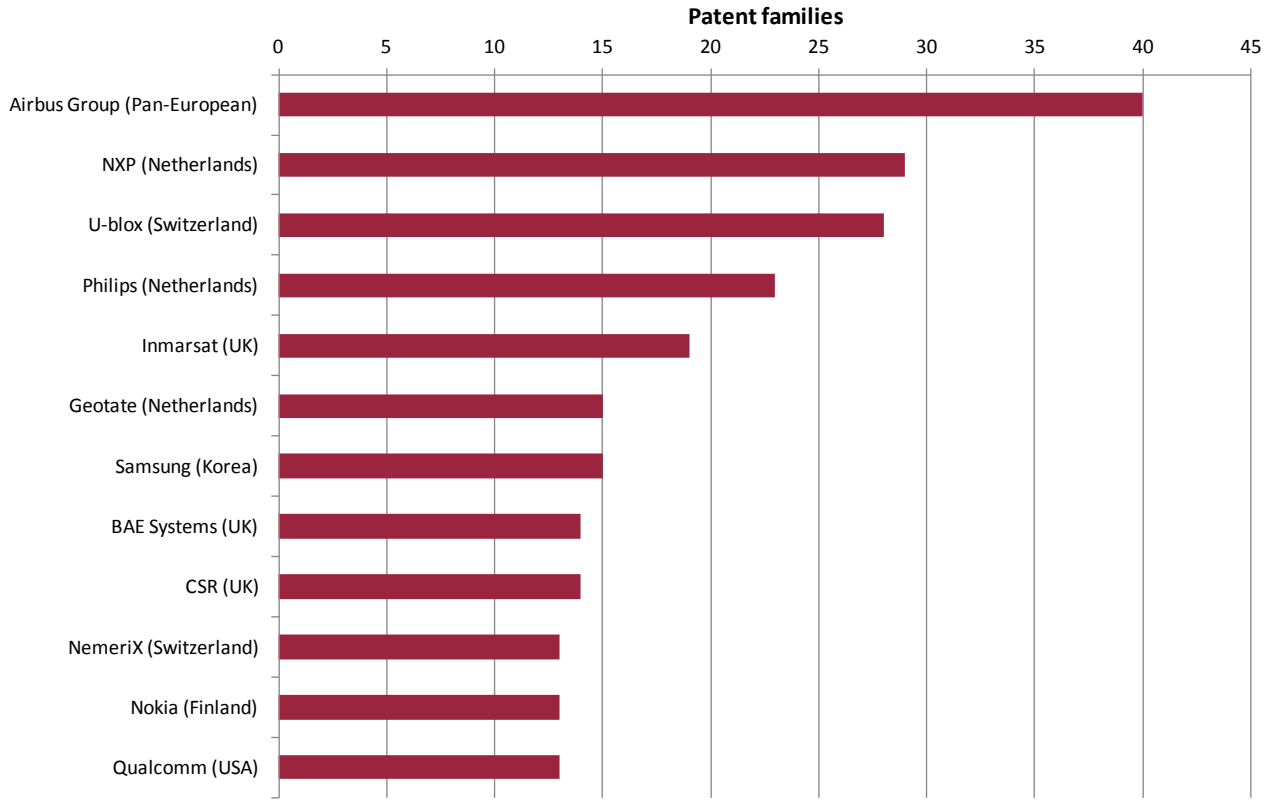

Figure 12: Top worldwide applicants with named UK-based inventors

3.3 How active is the UK?

A subset of the main worldwide patent dataset designed to reflect UK patenting activity was selected. Figure 13 shows the annual change in satellite patenting arising from UK patenting activity against the worldwide year-on-year change in satellite patenting shown in Figure 2; this shows that UK patenting activity in satellites grew considerably between 2006 and 2008 and at a far faster rate than the steadier year-on-year increase in worldwide satellite patenting. However, since 2008 UK patenting activity in satellites has remained fairly steady with minimal annual growth or decline.

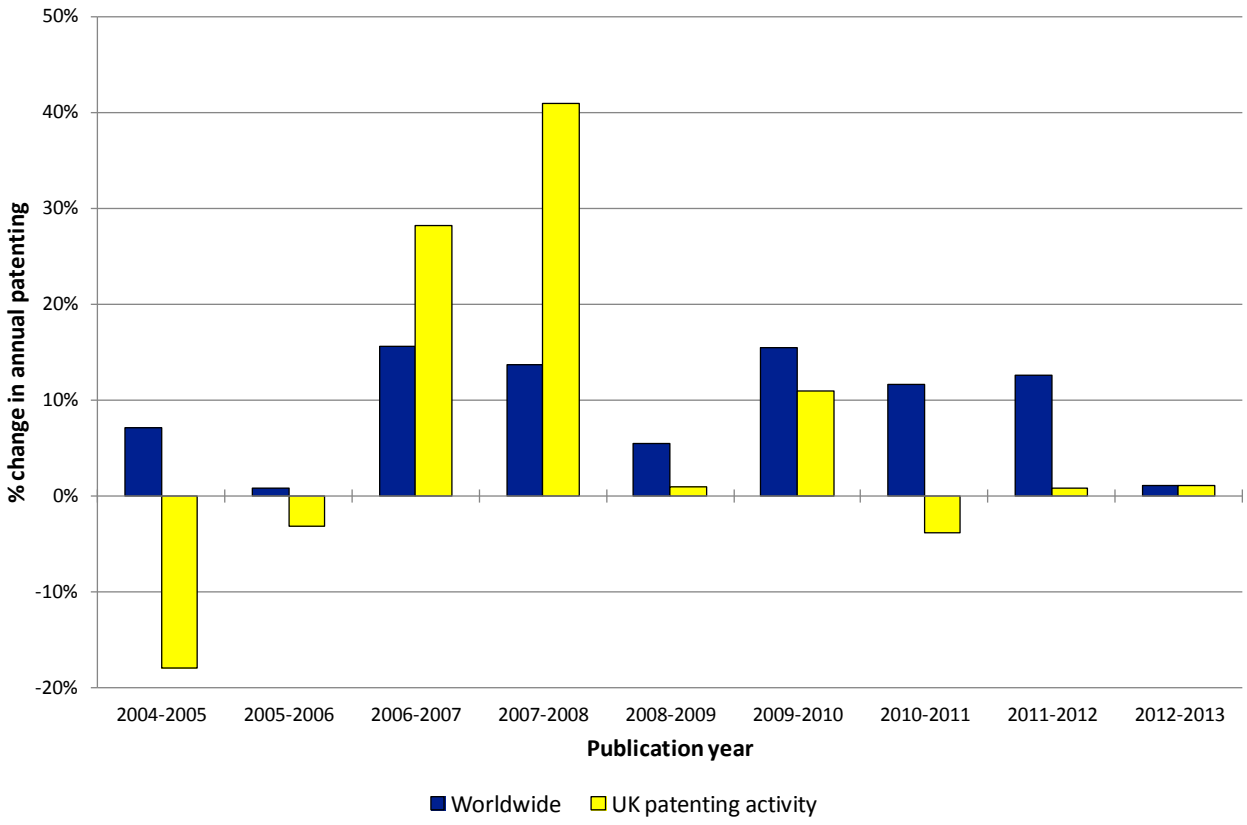

Figure 13: Year-on-year change in UK and worldwide satellite patenting

Similar patent subsets were created to reflect patenting activity taking place in several comparator countries (France, Germany, USA, Japan, China and Korea) to produce the comparison chart shown in Figure 14.

Chinese patenting activity overshadows all the other data points across most of the time period analysed, with a 330% increase in patenting activity between 2006 and 2007; in 2004 Chinese patenting activity resulted in under 60 patent families compared to almost 5500 in 2013 and the average annual growth of Chinese patenting activity in satellite technologies over the time period measured is over 80%. This significant and rapid market penetration resulting from Chinese patenting activity is not specific to satellite technologies and is often seen in a wide range of different technology spaces.

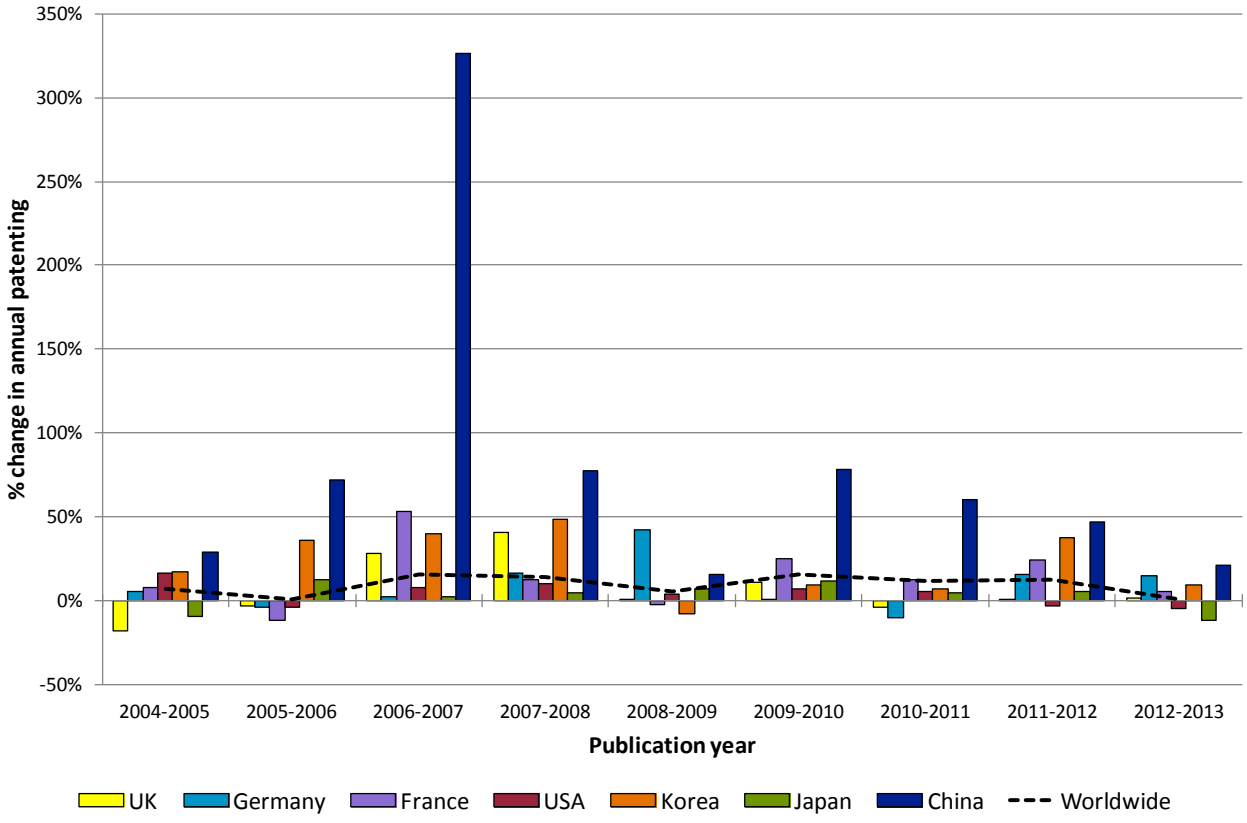

Figure 14: Year-on-year change in UK satellite patenting against comparison countries

The influence of the significant increase in Chinese patenting activity makes it difficult to draw comparisons between the other countries presented in Figure 14, so the same content has been reproduced in Figure 15 but with Chinese patenting activity removed. Figure 15 makes it a lot easier to compare UK patenting activity against the other comparator countries and the worldwide trend.

Although the quantity of US patenting in satellites is very high (as shown in Figure 3 and Figure 4), Figure 15 highlights that US satellite patenting activity has shown minimal change with an average year-on-year growth over the time period analysed of only 4%. This is in direct comparison to the growth arising from Korean patenting activity which has averaged almost 22% year-on-year growth over the ten-year time period studied.

Although UK patenting activity is relatively small (as shown in Figure 3 and Figure 4), Figure 15 shows that when the data is normalised UK patenting activity is not as low as it may originally appear. Figure 13 and Figure 15 show that UK year-on-year growth in satellite patenting between 2004 and 2013 is not dissimilar to the worldwide trend and that seen from other major countries such as Germany and France, and the average year-on-year growth from UK patenting activity (approximately 6.5%) is higher than that seen from patenting activity stemming from Japan (3%) and the USA (4%).

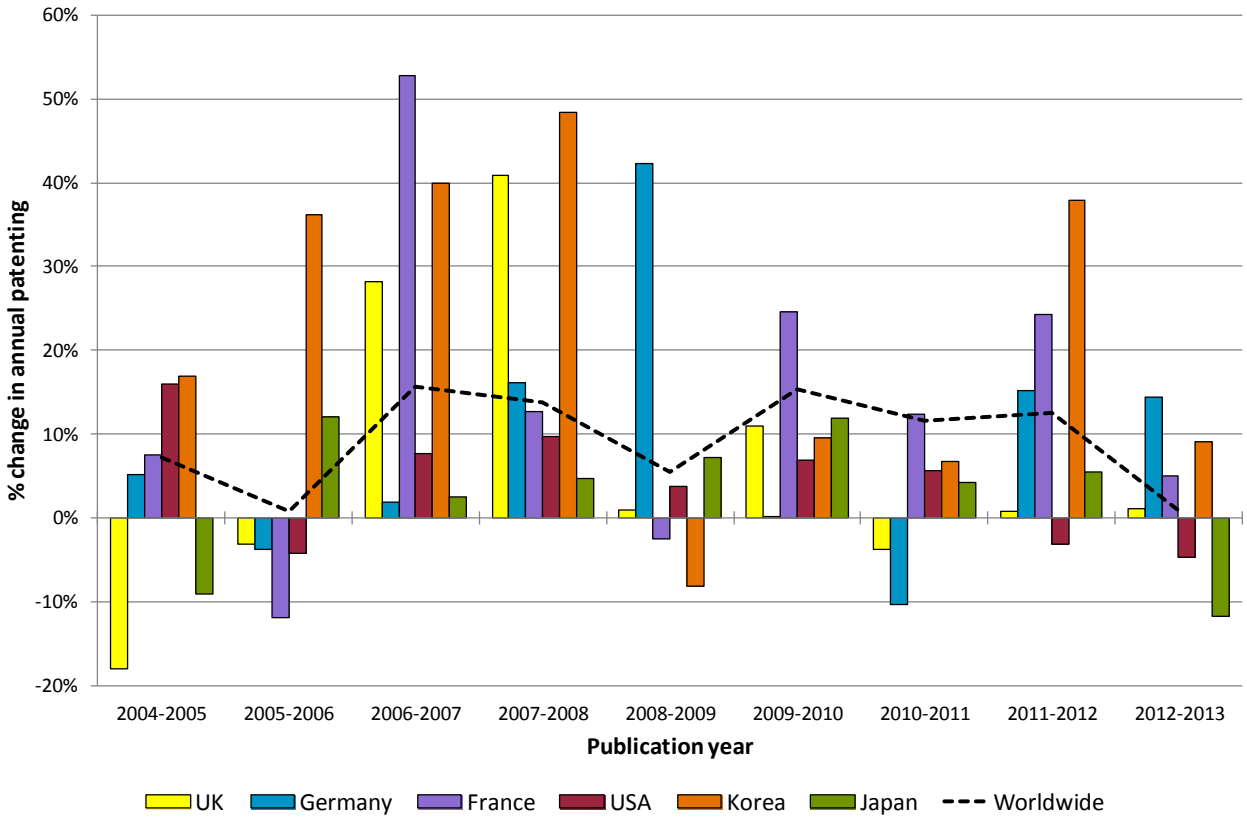

Figure 15: Year-on-year change in UK satellite patenting against comparison countries (excluding China)

4 Patent landscape map analysis

In order to give a snapshot as to what the patent landscape looks like for this technology space, a patent map provides a visual representation of the dataset. Published patents (not patent families) are represented on a patent map by dots and the more intense the concentration of patents (*i.e.* the more closely related they are) the higher the topography as shown by contour lines. The patents are grouped according to the occurrence of keywords in the title and abstract and examples of the reoccurring keywords appear on the patent map[6].

Figure 16 shows a patent landscape map of the most recent five year period for satellite technologies (2009-2013). The largest 'snow-capped peaks' around the centre of the map show that the highest concentration of patents in this dataset relate to patents comprising keywords such as "calculating"/"configured", "base station"/"wireless", "vehicle"/"sensor" and "routing"/"user", which suggests the content and potential end-use of these most prolific areas of patenting within the satellites patent landscape, namely GPS-based technologies.

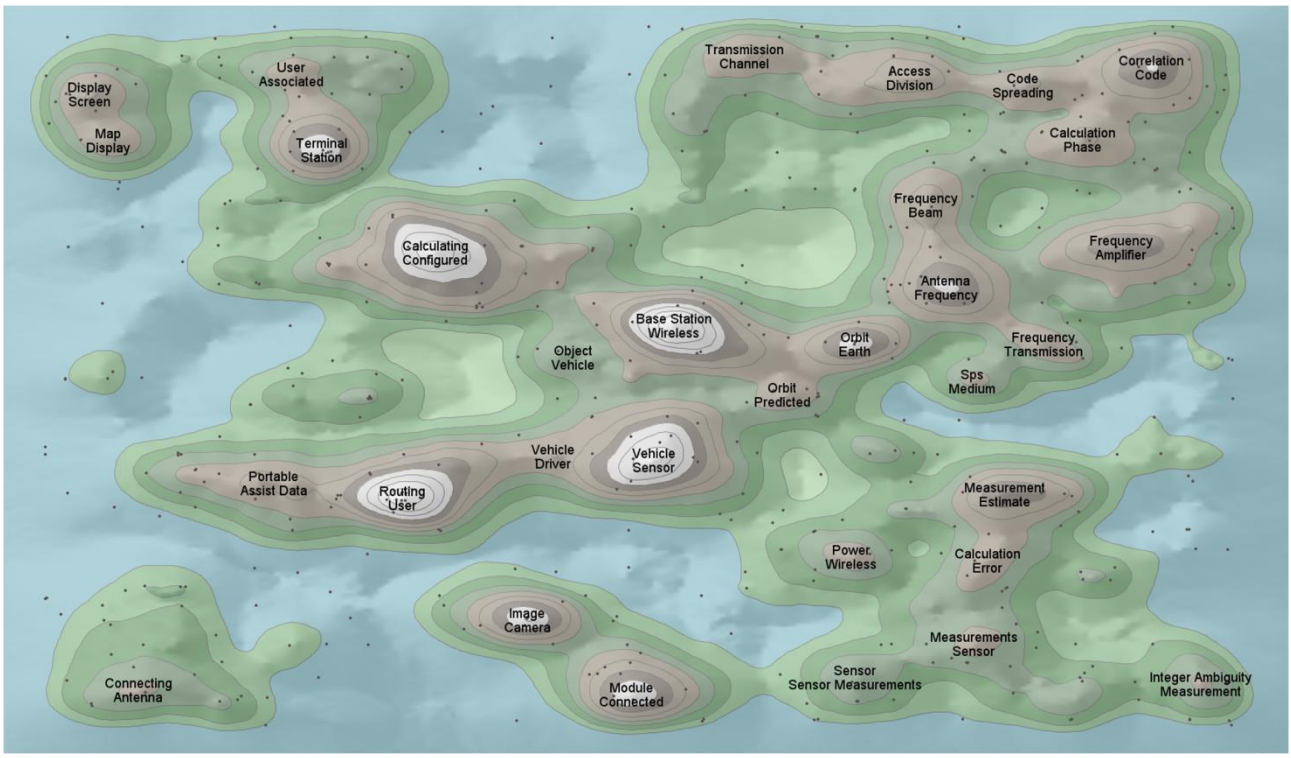

Figure 16: Patent landscape map of all patents relating to satellites (2009-2013)

[6] Further details regarding how patent landscape maps are produced is given in Appendix C.

The patent landscape map shown in Figure 17 is the same patent map shown in Figure 16, but with specific patents (dots) highlighted. The map in Figure 17 highlights the patents filed by the top five worldwide applicants (as shown in Figure 7) between 2009 and 2013. Since these patent landscape maps are produced using all patent publications rather than patent families, very tight clusters of several patents are likely to be from the same applicant and relate to one patent family (invention) rather than several similar, but separate inventions.

Figure 17 shows that most of the top worldwide applicants have a fairly broad spread of interests across the technology space with a range of satellite patents across the majority of the patent landscape map. Seiko Epson is the only company with distinct clusters of patents (the yellow dots in Figure 17) in certain areas rather than the wider patenting activity of the other four applicants highlighted.

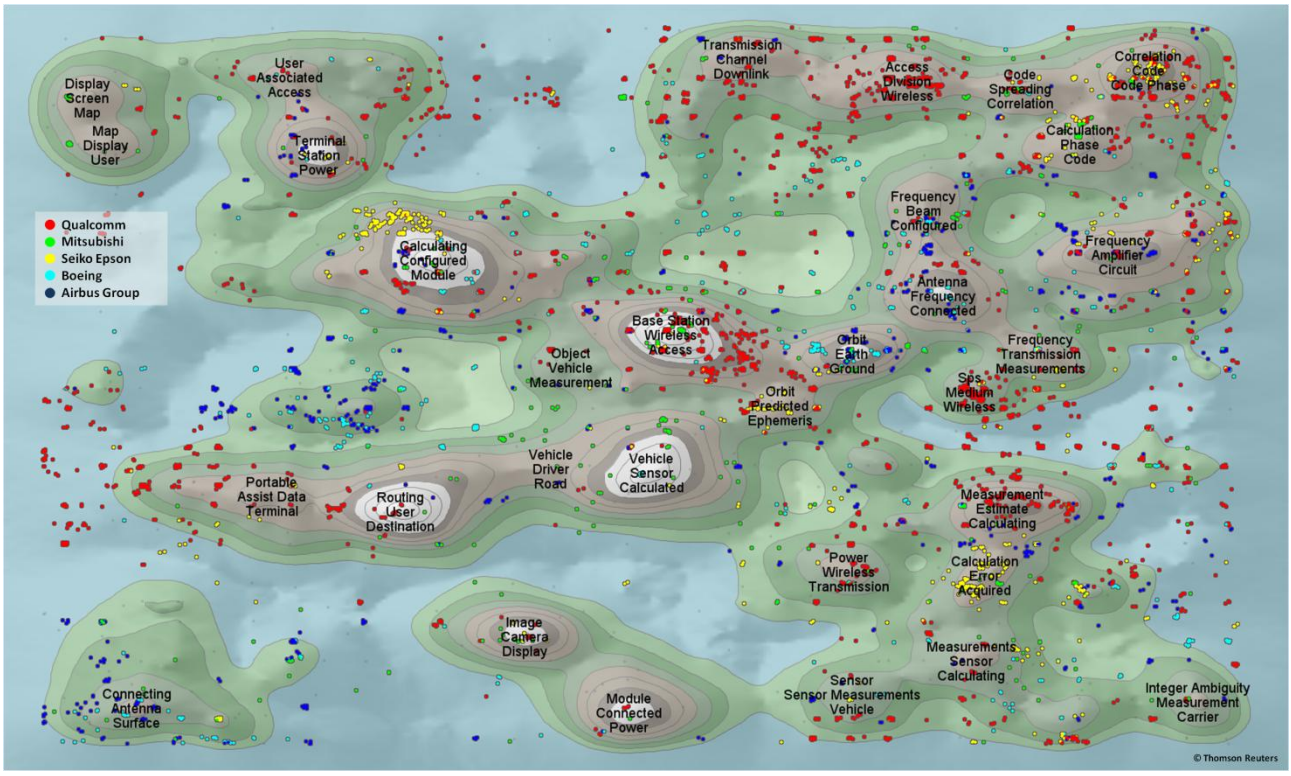

Figure 17: Patent landscape map with top 5 worldwide applicants highlighted

Figure 18 highlights the satellite patents published between 2009 and 2013 from the top five UK applicants. Within the time period analysed, the top UK applicants have been most active in the areas shown on the right-hand side of the patent landscape map, including patents relating to satellite antennae and the configuration and wireless transmission of data.

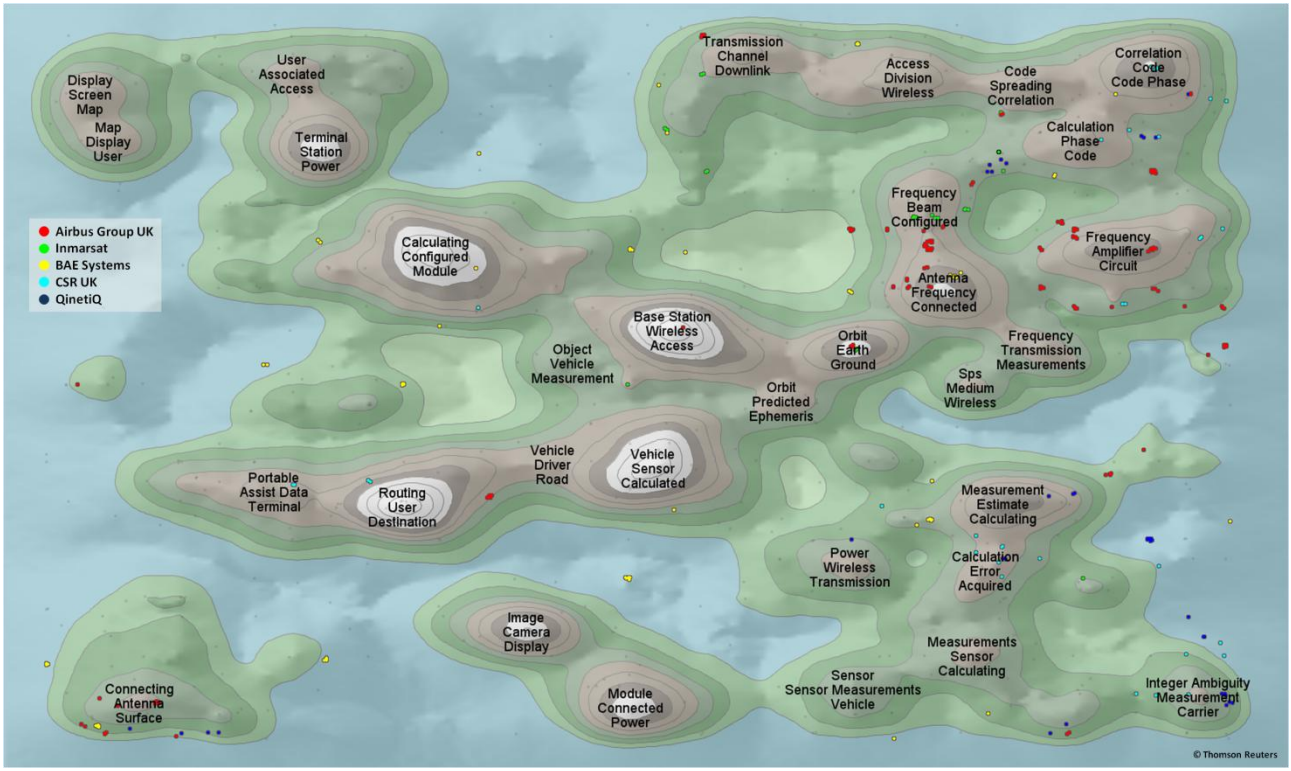

Figure 18: Patent landscape map with top 5 UK applicants highlighted

Figure 19 has been split by publication year with patents published in 2009 shown in green and patents published in 2013 shown in red. This shows the areas of patenting activity in the first and last years of the analysable date range (2009-2013) and highlights the patenting shift into new areas. The two most noticeable areas of increased patenting activity in 2013 compared to 2009 are circled in yellow and, when compared alongside Figure 17, it is clear that Airbus UK is innovating in the highlighted area around the peak labelled with the keywords “frequency”, “amplifier” and “circuit”, which include patents such as re-configurable beamforming network processing within a satellite antenna, filtering satellite communication channels, and hybrid network multiport satellite amplifiers.

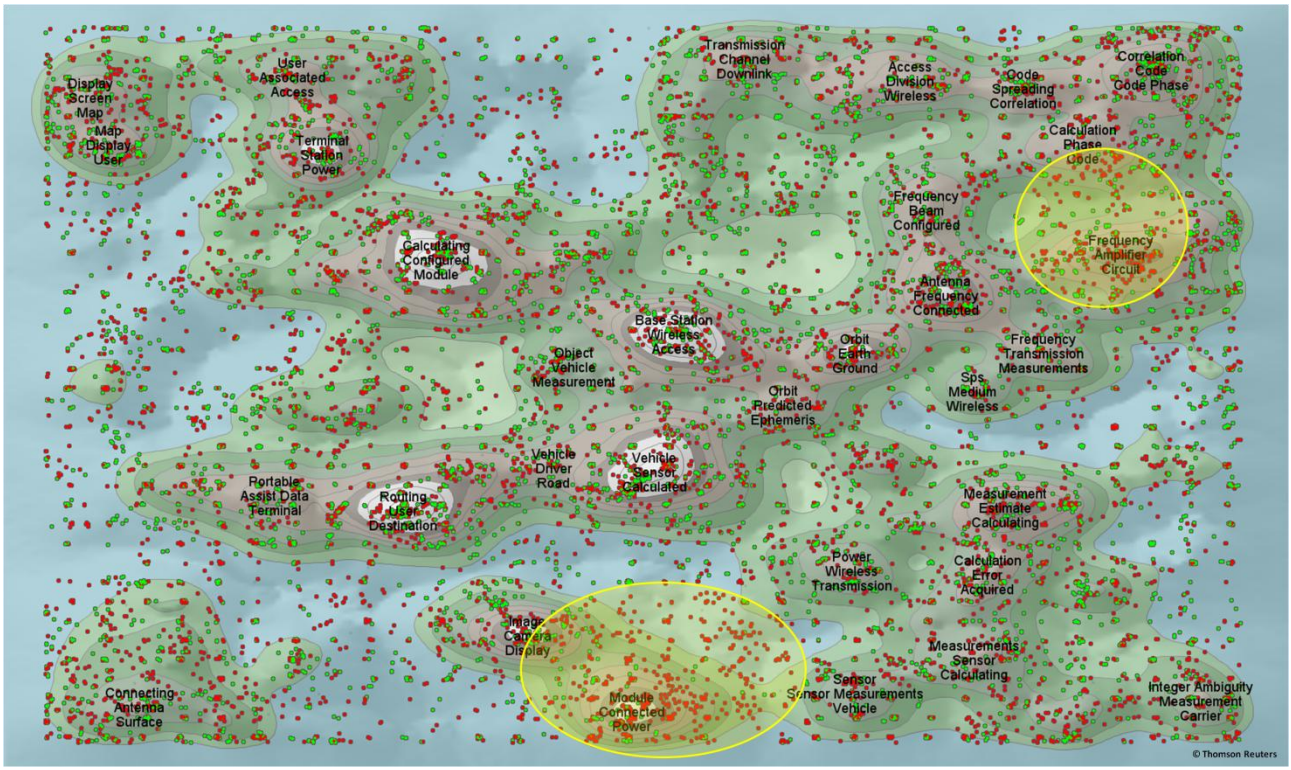

Figure 19: Patent landscape map split by publication year (2009 in green; 2013 in red)

5 Conclusions

There are almost 85,000 published patent applications between 2003 and 2013 relating to all satellite technologies, resulting in over 22,000 patent families. 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 5 applicants worldwide according to patent family size. Other UK companies active in satellite technologies include Inmarsat, BAE Systems, CSR, and QinetiQ.

Over 70% of all satellite patent families (inventions) 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%).

Appendix A Interpretation notes

A.1 Patent databases used

The *Thomson Reuters* World Patent Index (WPI) was interrogated using *Thomson Innovation*[7], a web-based patent analytics tool produced by *Thomson Reuters*. This database holds bibliographic and abstract data of published patents and patent applications derived from the majority of leading industrialised countries and patent organisations, *e.g.* the World Intellectual Property Organisation (WIPO), European Patent Office (EPO) and the African Regional Industry Property Organisation (ARIPO). It should be noted that patents are generally classified and published 18 months after the priority date. This should be borne in mind when considering recent patent trends (within the last 18 months).

The WPI database contains one record for each patent family. A patent family is defined as all documents directly or indirectly linked via a priority document. This provides an indication of the number of inventions an applicant may hold, as opposed to how many individual patent applications they might have filed in different countries for the same invention.

A.2 Priority date and publication date

Priority date: The earliest date of an associated patent application containing information about the invention.

Publication date: The date when the patent application is published (normally 18 months after the priority date or the application date, whichever is earlier).

Analysis by priority year gives the earliest indication of invention.

A.3 WO and EP patent applications

International patent applications (WO) and European patent applications (EP) may be made through the World Intellectual Property Organization (WIPO) and the European Patent Office (EPO) respectively.

International patent applications may designate any signatory states or regions to the Patent Cooperation Treaty (PCT) and will have the same effect as national or regional patent applications in each designated state or region, leading to a granted patent in each state or region.

European patent applications are regional patent applications which may designate any signatory state to the European Patent Convention (EPC), and lead to granted patents having the same effect as a bundle of national patents for the designated states.

Figures for patent families with WO and EP as priority country have been included for completeness although no single attributable country is immediately apparent.

[7] http://info.thomsoninnovation.com

A.4 Patent documents analysed

The satellite patent dataset for analysis was identified in conjunction with patent examiner technology-specific expertise. A search strategy was developed and the resulting dataset was extracted in April 2014 using International Patent Classification (IPC) codes, Co-operative Patent Classification (CPC) codes and keyword searching of titles and abstracts in the *Thomson Reuters* World Patent Index (WPI) and limited to patent families with publications between 2003 and 2013.

The applicant and inventor data was cleaned to remove duplicate entries arising from spelling errors, initialisation, international variation (Ltd, Pty, GmbH *etc*.), or equivalence (Ltd., Limited, *etc*.).

A.5 Analytics software used

The main computer software used for this report is a text mining and analytics package called *VantagePoint*[8] produced by *Search Technology* in the USA. The patent records exported from *Thomson Innovation* were imported into *VantagePoint* where the data is cleaned and analysed. The patent landscape maps used in this report were produced using *Thomson Innovation*.

[8] http://www.thevantagepoint.com

Appendix B Relative Specialisation Index

Relative Specialisation Index (RSI) was calculated as a correction to absolute numbers of patent families in order to account for the fact that some countries file more patent applications than others in all fields of technology. In particular, US and Japanese inventors are prolific patentees. RSI compares the fraction of satellite patents found in each country to the fraction of patents found in that country overall. A logarithm is applied to scale the fractions more suitably. The formula is given below:

$$\log_{10}\left(\frac{n_i/n_{total}}{N_i/N_{total}}\right)$$

where
n_i = number of satellite patent publications in country i
n_{total} = total number of satellite patent publications in dataset
N_i = total number of patent publications in country i
N_{total} = total number of patent publications in dataset

The effect of this is to highlight countries (in this study, Finland, Israel, Luxembourg and Australia in particular, as shown in Figure 5) which have a greater level of patenting in satellites than expected from their overall level of patenting, and which would otherwise languish much further down in the lists, unnoticed.

Appendix C Patent landscape maps

A patent landscape map is a visual representation of a dataset and is generated by applying a complex algorithm with four stages:

i) **Harvesting documents** – When the software harvests the documents it reads the text from each document (ranging from titles through to the full text). Non-relevant words, known as stopwords, (*e.g.* “a”, “an”, “able”, “about” *etc*) are then discounted and words with common stems are then associated together (*e.g.* “measure”, “measures”, “measuring”, “measurement” *etc*).

ii) **Analysing documents** – Words are then analysed to see how many times they appear in each document in comparison with the words’ frequency in the overall dataset. During analysis, very frequently and very infrequently used words (*i.e.* words above and below a threshold) are eliminated from consideration. A topic list of statistically significant words is then created.

iii) **Clustering documents** – A Naive Bayes classifier is used to assign document vectors and Vector Space Modelling is applied to plot documents in n-dimensional space (*i.e.* documents with similar topics are clustered around a central coordinate). The application of different vectors (*i.e.* topics) enables the relative positions of documents in n-dimensional space to be varied.

iv) **Creating the patent map** – The final n-dimensional model is then rendered into a two-dimensional map using a self-organising mapping algorithm. Contours are created to simulate a depth dimension. The final map can sometimes be misleading because it is important to interpret the map as if it were formed on a three-dimensional sphere.

Thus, in summary, published patents are represented on the patent map by dots and the more intense the concentration of patents (*i.e.* the more closely related they are) the higher the topography as shown by contour lines. The patents are grouped according to the occurrence of keywords in the title and abstract and examples of the reoccurring keywords appear on the patent map. Please remember there is no relationship between the patent landscape maps and any geographical map.

Please note that the patent maps shown in this report are snapshots of the patent landscape, and that patent maps are best used an interactive tool where analysis of specific areas, patents, applicants, inventors *etc* can be undertaken ‘on-the-fly’.

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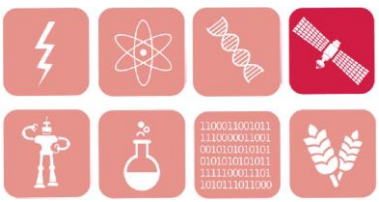

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