

PATENTARY MAPPING USING THE ORBIT DATABASE ON COSMONAUTICS

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Abstract

Access to space is a theme that, in recent decades, has been totally guided by governments; the aerospace industry increasingly promotes a new market, driven by large companies, startups and investors. This study aims to analyze the innovation capacity in this new market, observing the patent documents on this topic, according to specific search criteria, using the Orbit Intelligence base, we retrieved 16,593 patent documents, where we can observe an increasing behavior until 1993, 1998-2001 and after 2012. Facts like the construction of the International Space Station and the great interest of billionaires like Sir Richard Branson, Jeff Bezos and Elon Musk in the creation of their personal space flight industry that already have their Startup operations as SpaceX and Blue Origin on the market. It was found that most of the patent documents on cosmonautics deposited in the last 10 years are related to satellites and were deposited in China.

Keywords: cosmonautics; mapping of patents; patent document; orbit.

Resumo

O acesso ao espaço é um tema que, nas últimas décadas, foi totalmente orientado pelos governos, a indústria aeroespacial promove cada vez mais um novo mercado, impulsionado por grandes empresas, startups e investidores. Este estudo tem como objetivo analisar a capacidade de inovação nesse novo mercado, observando os documentos de patentes deste tema, conforme critérios de busca específicos, utilizando a base Orbit Intelligence, foram recuperados 16.593 documentos de patente, onde se pode observar um comportamento crescente até 1993, 1998-2001 e após 2012. Fatos que como a construção da Estação Espacial Internacional e o grande interesse de bilionários como Sir Richard Branson, Jeff Bezos e Elon Musk na criação de sua indústria pessoal de voos espaciais que já contam com suas operações da Startup como SpaceX e Blue Origin no mercado. Foi levantado, que a maior parte dos documentos patentários sobre cosmonáutica depositados nos últimos 10 anos é relacionada a satélites e foi depositada na China.

Palavras-chave: cosmonáutica; mapeamento de patentes; documento de patente; órbita.

1 Introduction

The aerospace industry is selected for those who wish to access space, a space race has always been surrounded by strategies and the military. From this patented study, we will understand the influence of new participants in this market.

Over the years, we have noticed the entry of players such as SpaceX and Blue Origin, as well as attention to shared and sponsored missions by billionaires, such as increased attention to investments in technologies where we focus our attention on patent documents in cosmonautics, which this covers: main technologies of the central part of the axis, of the satellites (launch by satellite, solar panel by satellite and separation by satellite), all of these of great market interest.

2 Theoretical Reference

Aerospace technology has been developing since the second world war, mainly with government investment both individually and in cooperation, the oldest programs are the North American and the Russian, and among the most recent, the Indian and Chinese program stands out, we started to observe how strategically important access to space is. With the emergence of the need for other satellites, with emphasis on the development of low-cost launchers, investments have migrated to the private sector, for example, companies: SpaceX, Blue Origin, Rocket Lab, Firefly space system and Vector space system (BRAUN, 2019).

In addition, space exploration technologies suffered a paradigm break, the gigantic and heavy equipment was replaced by small and light equipment, called microsatellites, which can be organized in networks or constellations, providing better time resolution with an affordable price all thanks to miniaturization of circuits technologies and greater processing capacity (CAMPOS and QUEIROZ, 2017; CGEE, 2018). Recalling that Portz, in 2004, already described for the next decades this scenario: with international cooperation with the use of microsatellites and launchers. In this favorable environment for the development of pioneering technologies, one of the development indicators of a country or region is the presence of these technologies.

The development and use of space applications can be divided into three main elements: (a) access to space, which includes: launcher, rockets, airplanes and balloons; (b) the spacecraft, that is, the satellite or scientific probes themselves, which, once in orbit or in space, collect information from the earth or other study object that are sent back; and, (c) the information received, which includes: the communication infrastructure, sensors for obtaining and using this information or so-called space applications, in addition to the spacecraft guidance and control system. In addition to these applications, there are others such as: meteorology, navigation and positioning (BÔAS, PESSOA FILHO, DAMILANO, 2007). It is worth mentioning that among the three main elements, most of the investment is made in the first and second, while the third is where most of the final revenue is obtained (ARBULU, 2019). Launcher technology is a mature and well-known technology; the technology related to satellites and spacecraft, has developed again due to the evolution of electronics, especially with the emergence of micro satellites (BRAUN, 2019). With the growth in the number of satellites, a fourth branch has emerged, dealing with space debris (Space debris), which still has little impact on the volume of technology (CAMPOS e QUEIROZ, 2017; CGEE, 2018).

The patent is a title granted by the State that grants a monopoly to its inventors or holders for a period of time. In addition, this is one of the ways of measuring technological advances. This monopoly allows privileged exploitation generating value for companies. The patent is the way to capitalize on economic results from the application of science and technology research that are protected in it (FERREIRA *et. al*, 2009). Patents can be considered an indicator of science, technology and innovation, in other words, it is a useful tool in the preparation of panoramas, technological mappings, technological prospects, among others; these in turn can be the basis for

strategic decision making, public policy development, business strategy development, etc.; in addition to being an excellent tool for measuring intangible assets (FARIA *et. al*, 2014). The purpose of patents is to encourage economic and technological development, it is the first step of innovation, the protection of invention, the second step is to put it into practice, that is, to produce or license. For this reason, it is considered an indirect way of measuring innovation (MENDONÇA *et. al*, 2018).

This work aims to carry out a patent mapping on cosmonautical technologies without location restriction and without date restriction using the Orbit Intelligence database in order to obtain the historical evolution of cosmonautical technology, the main technologies, where there is greater protection and the main players.

3 Methodology

This article used as a methodology the patent mapping for activity defined by Porter (1991) containing the steps of: definition of search criteria, search and data processing.

The following search criteria were defined: (a) database = Orbit Intelligence; (b) no territorial search restriction was used, using the broadest patent collection: world patents (full text & biblio) grouped by invention-based families (FamPat); (c) the following Keyword Search Wizard concepts were used: "spacecraft", "satellite", "aircraft", "aeronautics", "aerospace", "aviation", "orbit", "space" "vehicle", "launch "" vehicle ", " spacecraft ", " attitude ", " celestial "" body ", " satellite "" body ", " satellite "" attitude ", " space "" technology "" field "; combined with the IPC subgroup equal B64G; and, (d) application date after 1990 (included).

The search was carried out in the database: Orbit Intelligence using the criteria defined above. Then the data were treated in the analysis module of the Orbit Intelligence database.

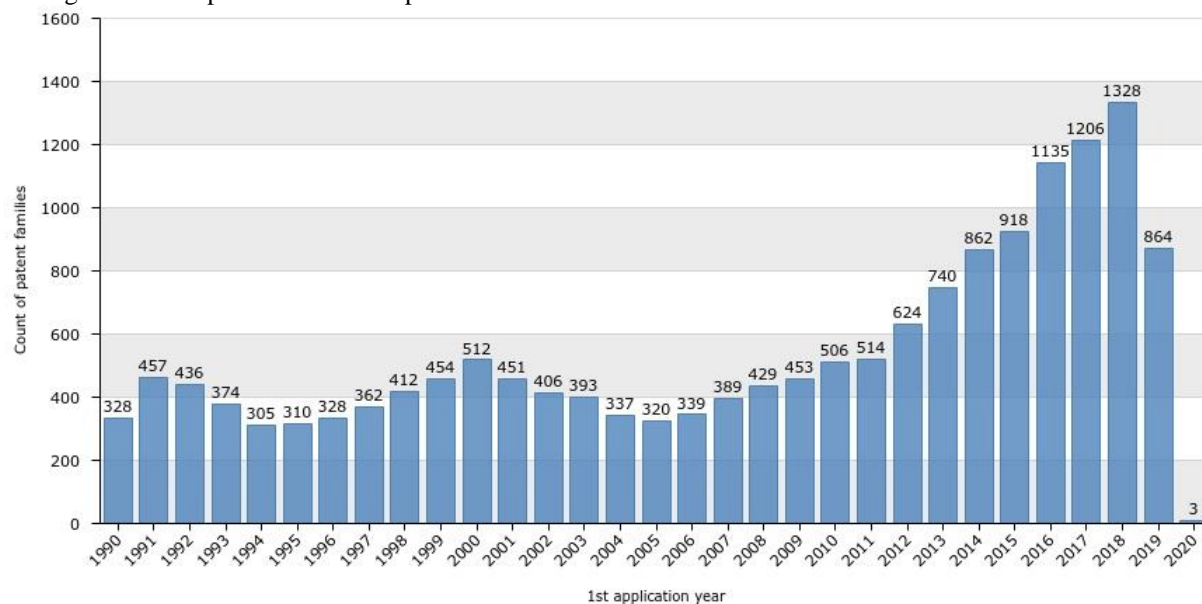
4 Results and Discussion

Using the methodology described above, 16593 patent documents were recovered. Figure 1 shows the time evolution of the deposit of these documents, it can be seen an increasing behavior with 3 peaks, 2 small peaks (until 1993 and 1998-2001) and a larger peak (after 2012).

Some facts that may have contributed to the appearance of the peaks: during the first peak, the construction of the International Space Station (ISS) occurred (BÔAS *et. al*, 2007); during the second peak, has a strict coincidence with the Ansari X Prize (XPRIZE, 2020). The Ansari XPRIZE requirements was fulfilled on September 29, 2004 (SpaceShipOne flew first time) and the 100-kilometer (62.5 mi) mark was broke, internationally recognized as the boundary of outer space (BOYLE, 2004). That time, more than \$100 million was invested in new technologies in pursuit of the prize. Result from the interest of billionaires as Sir Richard Branson, Jeff Bezos and Elon Musk in creating their personal spaceflight industry. What coming to the third peak occurred during the beginning of Startup's activities as SpaceX (SPACEX, 2020) and Blue Origin (CARTER, 2019 e BLUE ORIGIN, 2020), in the market and the development of micro satellites (CAMPOS and QUEIROZ, 2017; CGEE, 2018). These facts corroborate with Braun (2019) because they show cooperative government investments (first peak), in the second peak the migration to private sector investments and in the third peak private investments, mainly in Startup's.

The drop in the numbers of patent documents for 2019 and 2020 is due to the confidentiality period that the application remains between application and publication, as the application is only available to the public and databases after publication, despite the application date being always before the publication date.

Figure 1 – Temporal evolution of patent documents on cosmonautics

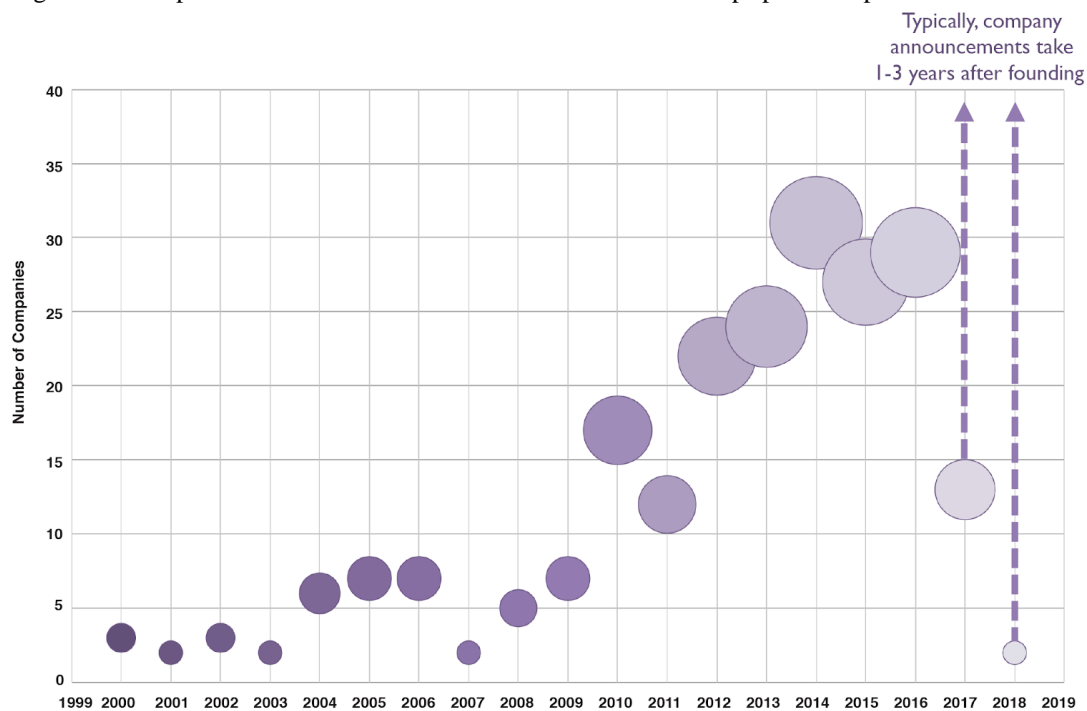


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Source: Orbit Intelligence (2020)

Figure 2 shows the time evolution of the active announced and funded start-up space companies, it can be seen an increasing behavior with 2 peaks, one small peaks (2004-2006) and a larger peak (after 2012). Comparing Figure 1 and Figure 2, it can be seen that the third peak in Figure 1 coincides with the second peak in Figure 2, and if it occurs during the beginning of Startup's activities as SpaceX (SPACEEX, 2020) and Blue Origin (CARTER, 2019; BLUE ORIGIN, 2020), in the market and the development of micro satellites (CAMPOS and QUEIROZ, 2017; CGEE, 2018).

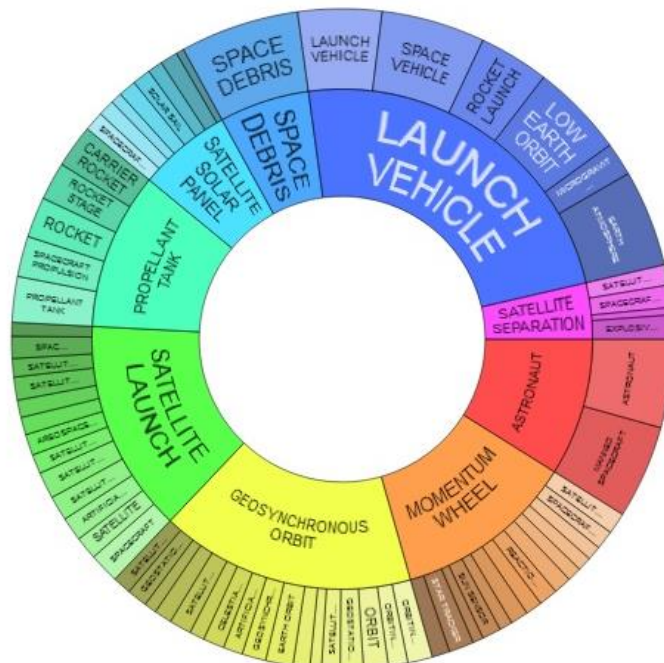
Figure 2 – Temporal evolution active announced and funded start-up space companies



Source: Adapt from Bryce Space and Technology (2019)

Figure 3 shows the main technologies of patent documents on cosmonautics, the 9 major technologies are presented (central part of the axis), with emphasis on satellite with 9761 patent families, divided in: satellite launch (9288), satellite solar panel (2012) and satellite separation (595) (remember that on patent could refer to more than one technology).

Figure 3 – Technologies of patent documents on cosmonautics



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Source: Orbit Intelligence (2020)

Figure 4 presents the main technologies of patent documents on cosmonautics versus time. It can be seen that the red dark peak refers to satellite and aircraft technologies, corroborating what was previously presented: mission to Mars (G1, 2014) and micro satellites (CAMPOS and QUEIROZ, 2017; CGEE, 2018).

As can be seen in Figures 3 and 4, the satellite launcher technology has the highest number of patent registrations but the lowest number of recent patents, indicating that it is a mature and well-known technology corroborating with Braun (2019); with respect to satellite and spacecraft technologies, it is possible to see a large number of patents and also an increase in deposits since 1990 (with a peak starting in 2014) indicating that there was an evolution of technology, especially with the emergence of the micro satellites corroborating with Campos and Queiroz (2017) and CGEE (2018).

Figure 4 – Technologies of patent documents on cosmonautics versus time

Concepts	SATELLITE	68	87	112	99	92	93	106	131	166	181	182	148	155	109	115	81	85	106	120	114	129	150	164	195	266	299	319	372	310	235	1									
	SPACECRAFT	62	97	119	80	69	92	93	117	134	131	140	97	125	116	101	89	96	102	96	110	112	138	174	171	220	239	308	281	290	170	2									
	ORBIT	38	32	52	38	38	45	42	61	65	63	80	58	74	55	52	45	41	38	42	47	61	54	84	102	107	135	138	158	102	89										
	ARTIFICIAL SATELLITE	34	70	91	95	65	57	80	83	92	81	95	84	66	52	46	28	25	28	57	56	56	46	68	47	63	73	75	67	60	11										
	ORBITING SATELLITE	21	28	42	28	34	35	43	43	46	62	67	57	47	30	37	20	26	41	37	30	32	43	45	49	71	92	89	91	63	20										
	LAUNCH VEHICLE	14	13	16	18	17	20	27	23	42	48	29	26	35	31	13	23	22	18	18	28	36	41	46	47	57	68	91	96	88	42	1									
	SATELLITE ATTITUDE	11	22	29	15	17	17	26	32	24	35	39	24	29	21	17	11	22	21	20	17	23	21	24	34	33	52	53	58	43	36										
	GEOSTATIONARY ORBIT	13	17	17	19	15	20	28	32	31	20	23	23	18	21	11	8	16	18	15	13	28	15	32	33	33	33	34	41	24	14										
	SPACECRAFT ATTITUDE	15	13	21	13	11	25	23	25	34	26	32	13	16	16	14	13	13	21	15	21	14	23	22	20	26	30	39	26	24	15										
	SATELLITE BODY	9	21	9	12	11	13	20	15	22	33	14	13	22	7	8	4	10	9	14	20	13	19	19	28	28	46	38	43	31	11										
	ORBITING SPACECRAFT	10	14	15	9	13	22	10	16	21	18	20	10	16	15	10	11	6	17	7	15	9	7	25	24	31	24	35	26	27	10										
	PROPELLANT TANK	4	7	13	17	6	10	8	10	13	16	11	12	12	17	11	13	13	10	15	9	16	22	24	33	31	21	27	18	20	13	1									
	SPACECRAFT BODY	7	11	16	14	16	25	18	19	21	17	19	12	13	8	9	7	10	17	6	7	3	10	15	20	23	23	30	19	18	2										
	SATELLITE LAUNCH	6	8	16	14	7	10	18	15	23	17	14	22	19	8	13	6	7	12	16	8	9	6	12	19	23	29	18	17	18	7										
	MOMENTUM WHEEL	15	12	18	9	9	15	16	14	19	14	16	11	18	6	7	7	10	9	14	8	7	6	12	10	22	29	16	22	22	17										
	SATELLITE ATTITUDE CONTROL	8	10	5	9	4	8	16	7	18	18	9	4	12	7	6	5	8	11	13	7	10	8	10	12	11	12	15	21	23	21										
	SPACE DEBRIS	1		7	1		1	2	4	7	2	5	5	4	4	6		2	2	4	8	13	12	14	13	13	20	37	40	33	33										
	SPACECRAFT ATTITUDE CONTROL	9	6	11	8	6	16	7	15	16	10	11	5	12	4	6	6	6	8	8	7	8	6	9	12	11	8	19	6	15	6										
	MAGNETIC TORQUER	5	5	7	3	1	8	6	8	7	9	10	6	5	8	2	3	2	5	3	4	8	3	3	9	13	15	20	19	13	17										
	SPACECRAFT ORIENTATION	9	5	13	3	7	14	7	14	9	7	9	2	7	4	4	8	8	4	7	3	7	7	9	7	7	13	8	7	6	1										
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020									
		1st application year																																							

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Source: Orbit Intelligence (2020)

Figures 5 and 6 refer to the country in which the patent documents were applied. There is a concentration of documents in China and the United States, and Brazil appears among the 30 first.

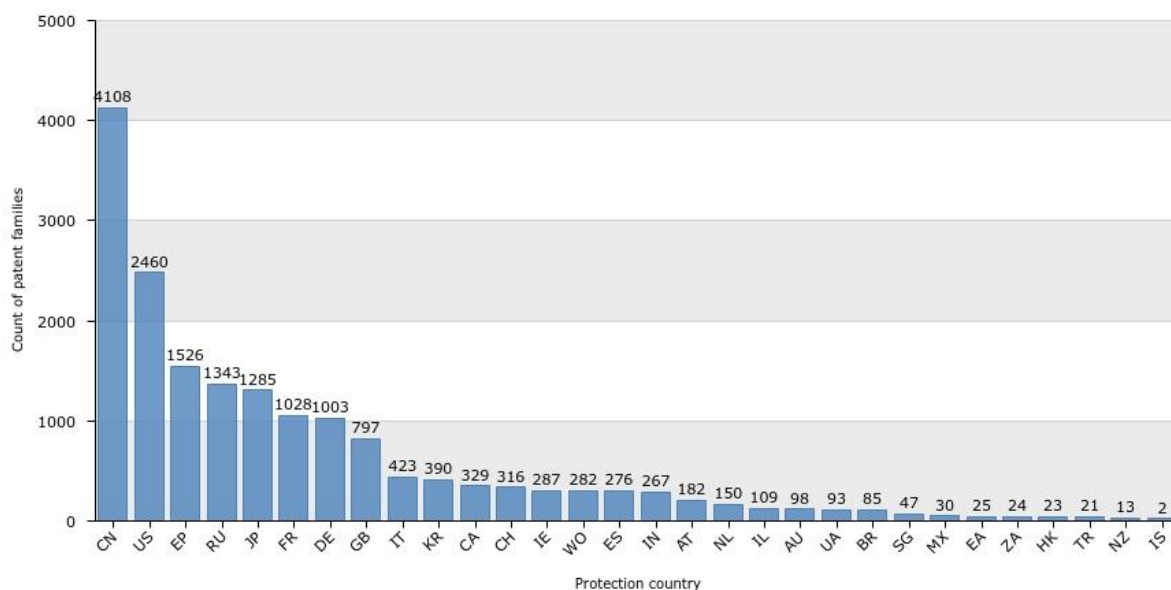
This highlight is due to the fact that the United States has one of the largest space programs, with emphasis on the American programs: Mercury, Gemini, Apollo, Ranger, Surveyor and Lunar Orbiter; the construction of the ISS in partnership with other countries; and China started its manned space program in 1966 in a program similar to Gemini, in the 1970s the Chinese launched several satellites, and in 1985 China was already making commercial satellite launches (BÔAS, PESSOA FILHO, DAMILANO, 2007).

Figure 5 – Country in which the patent documents were applied on patent documents on cosmonautics.



Source: Orbit Intelligence (2020)

Figure 6 – Top 30 countries in which the patent documents on cosmonautics were applied

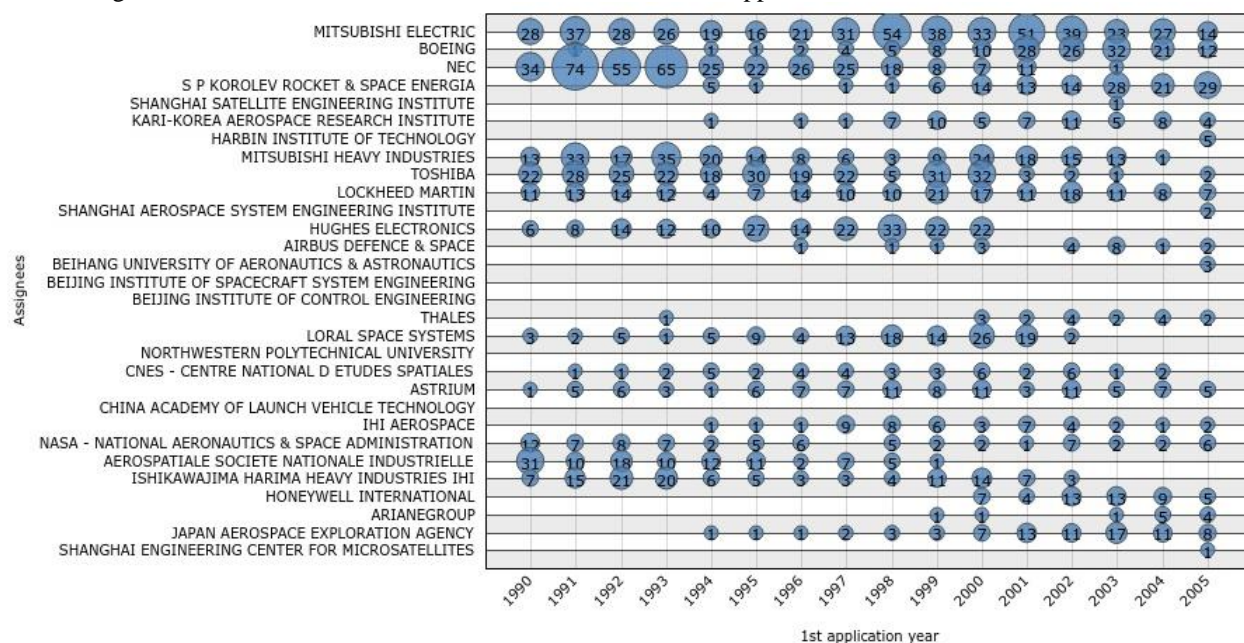


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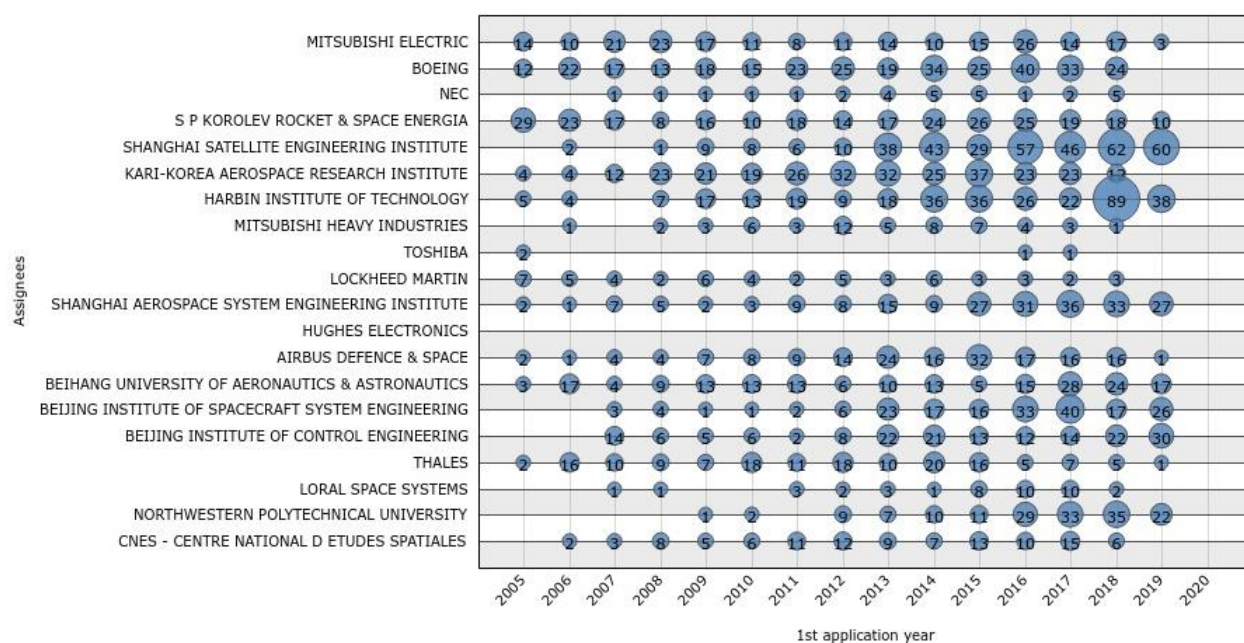
Source: Orbit Intelligence (2020)

Figure 7 refers to the patent documents of the first 20 applicants in the past 10 years, part (a) refers to the period from 1990 to 2005 and part (b) refers to the period from 2005 to 2020. It is observed that although the main depositors are: Mistubishi Electric (Japanese), Boeing (North American) and NEC (multinational with headquarters in Japan) but in the last 10 years the following applicants stand out: Harbin Institute of Technology (Chinese) and Shanghai Satellite Engineering Institute (Chinese). Corroborating with the highlight of China as country of apply shown in Figures 5 and 6.

Figure 7 –Patent documents on cosmonautics of the first 20 applicants



(a)

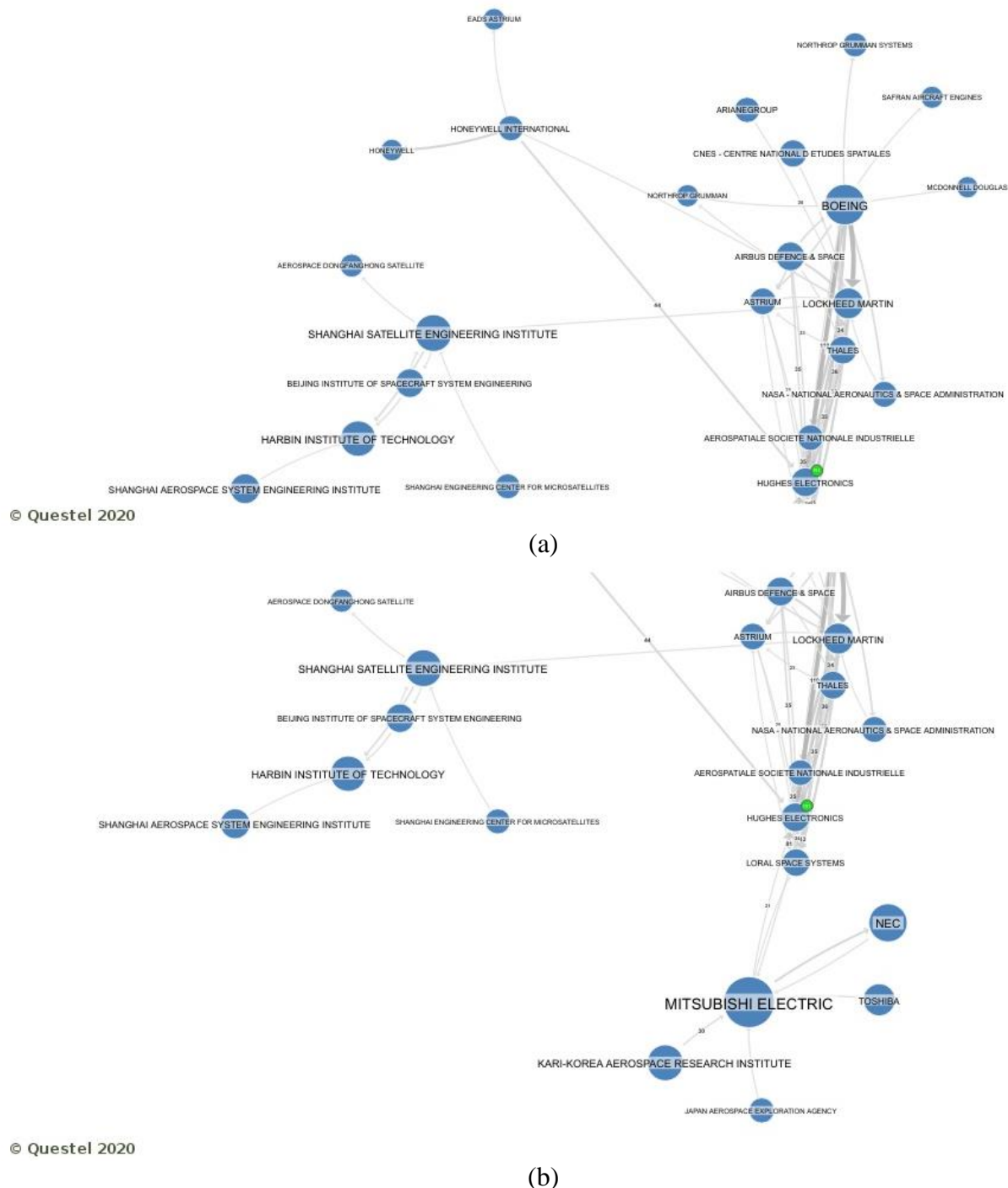


(b)

Source: Orbit Intelligence (2020)

Figure 8 refers to the applicants' dependency with minimum node size of 20 patents per assignee and minimum link of 20 citing patents, it is divided into part (a) and (b) that must be observed sequentially, as a single dependency niche. Part (a) in the right is the big niche with Boeing with extended to the south to part (b), in the left bottom there is the Chinese niche (Harbin Institute of Technology and Shanghai Satellite Engineering Institute) connecting by Lockheed Martin to the niche in the Boeing niche; in part (b) there is the Mitsubishi Electric and NEC niche in the bottom of the Boeing niche.

Figure 8 – Dependence of applicants on patent documents on cosmonautics.



Source: Orbit Intelligence (2020)

The main results of this patent mapping on cosmonautical technologies are: that the technology with the largest number of patent documents is that of launchers, however these documents are mostly prior to 1990, in patent documents after 1990 the highlight is the patent documents of technologies satellites and aircraft. In addition, the country with the largest number of patent documents deposited is China, the Chinese cluster has great interaction among themselves, but little interaction outside China (a single link), highlighting the fact that the main depositors of the last 10 years are Chinese.

5 Conclusion

The patent mapping carried out in this article proved to be a viable tool for monitoring and managing technology, as it uses data from patent documents that are known to be a rich source of technical information.

From the patent mapping carried out, it can be concluded that most patent documents on cosmonautics refer to technologies related to satellites, with a greater number of deposits in China, with emphasis in the last 10 years for: Shanghai Satellite Engineering Institute (Chinese) and Harbin Institute of Technology (Chinese), what could be related to the CBERs program (CBERS, 2018); however, in the Chinese niche there is little interaction outside of China.

And it can also be concluded that the rising growth is in line with the growth of star-ups in the micro satellite development sector.

As suggestions for future work there are three lines: (1) do it in other databases and compare the results, (2) limit in the country of deposit, for example: Brazil and, (3) limit the technology, for example: satellite.

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