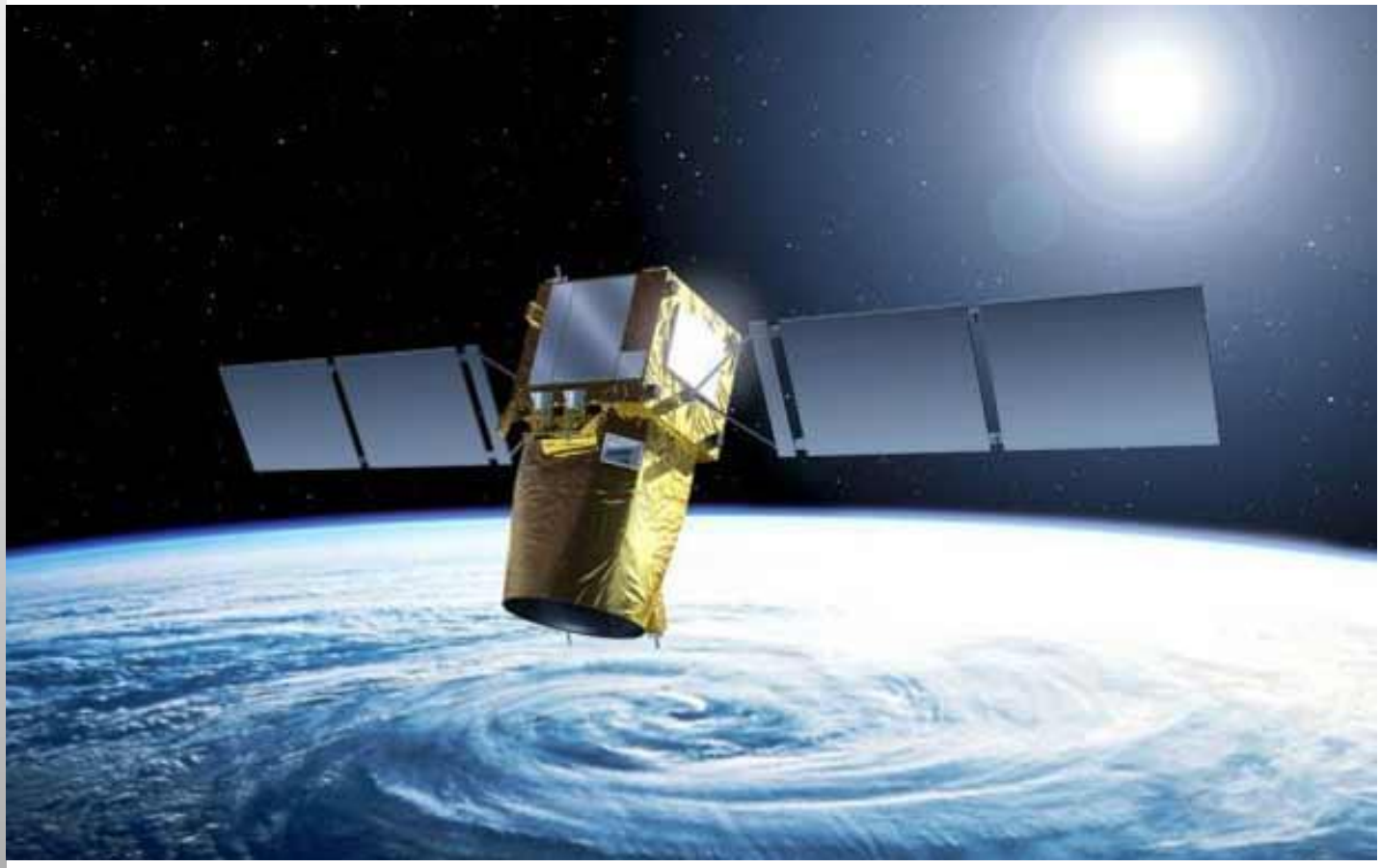
TOULOUSE BUSINESS SCHOOL

IS THE SPACE INDUSTRY EXPERIENCING A SPECULATIVE BUBBLE?

VENTURE CAPITAL IN THE SPACE SECTOR



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In the last years we have observed an increase in venture capital in space sector startups. Investors mainly financed smaller startup companies with new applications based in Silicon Valley. The space sector by itself has also grewn in revenues, the global satellite industry grew 4% in 2014 and the last 10 years has shown a constant revenues increase. (Satellite Industry Association, 2015)

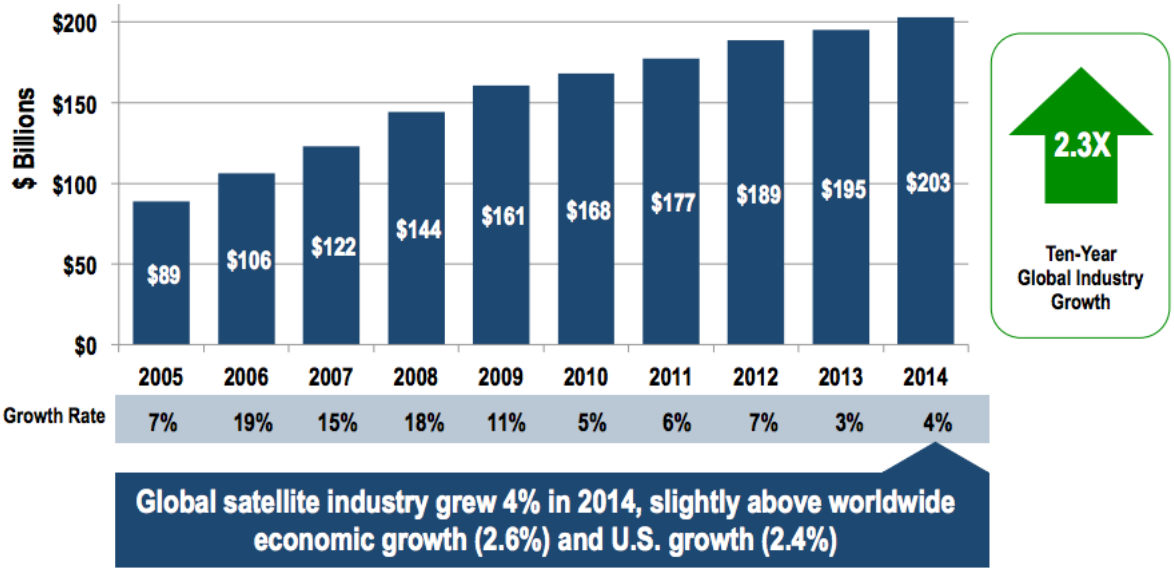

Figure 1. Global Satellite Industry Revenues ($ Billions).

I.1. Space investments

The definition of venture capital is the money provided by investors to startup firms and small businesses that have a prospect of growth potential in the long term. Even though it has a high level of uncertainty, it also has the potential of positive returns. (Investopedia, 2015). In the space sector the venture capital has increased; in 2014 the space companies raised more than US $1.8 Billion. The venture capitalist tries to invest one of the main applications in the space sector such as communication, observation and debris; but also in new applications as mining, tourism and space access. The main investors and startups between 2012 and first half of 2015 are shown in Table 1:

Rank	Investor	Selected investments
1	Lux Capital	Planet Labs, Orbital Insight
1	RRE Venture	Spaceflight Industries, Spire
1	Bessemer Venture Partners	Spire, Skybox Imaging
2	Khosla Ventures	Rocket Lab, Skybox Imaging
2	Promus Ventures	Spire, Mapbox
2	Founders Fund	Planet Labs, Accion Systems

Table 1. Main investors and startups, 2012-2015.

In Figure 3. we can observe the evolution of the investment activity in the space sector. It shows a high increase in 2014, also it seems to repeat the fallback in the present year. (CB Insights, 2015) The amount of investments in startups only in the first half of 2015 was US$ 1.76 Billion.

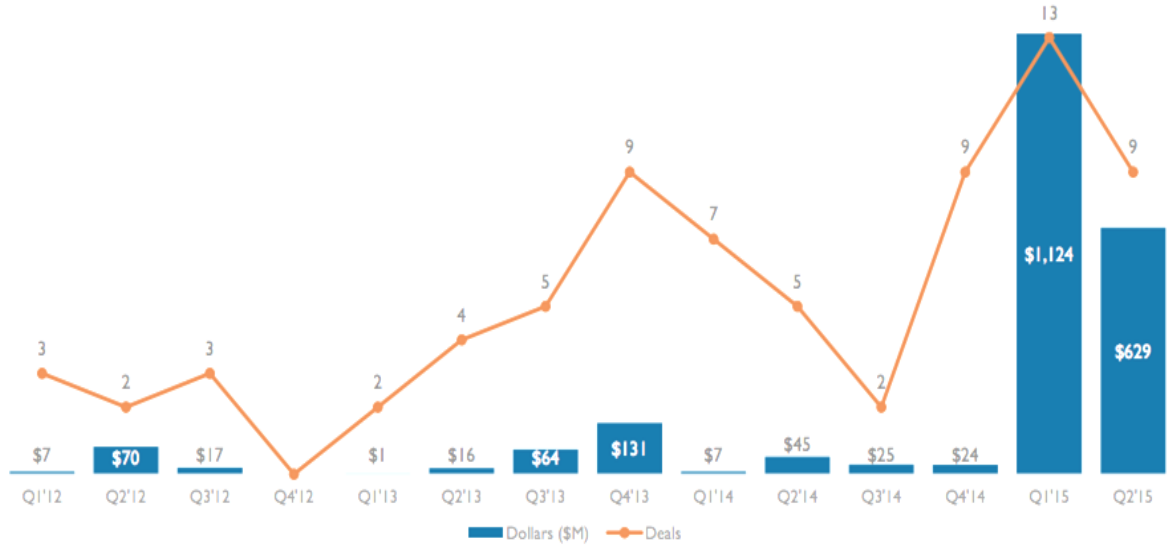

Figure 2. Space investment activity, 2012- 2015.

The advantage perceived by the investors for investing in space sector startups is that companies are disrupting the aerospace industry developing faster, cheaper and better products. In the past the production and development of space sector was linked to the government research, being the reason why since the Apollo Lunar Mission until 1963 the sector was stagnating, even after reduction of launching costs. Instead, this new kind of enterprise can move quickly, attract the best talent with equity ownership, and take calculated design risks that government contractors cannot afford to. (Bessemer Venture Capitals, 2015) NASA itself has invested in startups such as Orbital and SpaceX to expedite the development of different technologies and services as is shown Table 2.: (NASA, 2015)

Agreement or Contract	Investment to Data	Partners	Scope
Commercial Orbital Transportation Services	$891M	Orbital and SpaceX	Cargo transportation system technologies and concepts
Commercial Resupply Services	$3.4B	Orbital and SpaceX	Cargo resupply to ISS
Commercial Crew Development Round 1	$50M	Blue Origin, Boeing, Paragon, Sierra Nevada and ULA	Crew transportation system technologies and concepts
Commercial Crew Development Round 2	$315M	Blue Origin, Boeing, Sierra Nevada and SpaceX	Elements of a crew transportation system
Commercial Crew Integrated Capability	$1.1B	Boeing, Sierra Nevada and SpaceX	Integrated crew transportation systems
Certification Products Contract	$29.6M	Boeing, Sierra Nevada and SpaceX	Early certification products

Table 2. NASA has distributed more that US$ 5.7 Billions in contracts and Space Act Agreements for commercial crew and cargo.

The funding capital invested in the space startups have a breakdown between space services, with companies like SpaceX that is developing reusable rocket technology, and Astroscale which is working with space debris cleanup. In second place, the 35% of the funding companies are focus in earth-observation satellites to capture images of earth on a daily basis, an example of this startup classification is Planet Labs and Spire. And finally, the Imagery startups, like Orbital Insight and Windward, utilize satellite imagery to derive unique insights about earth, made the 19% in the market.

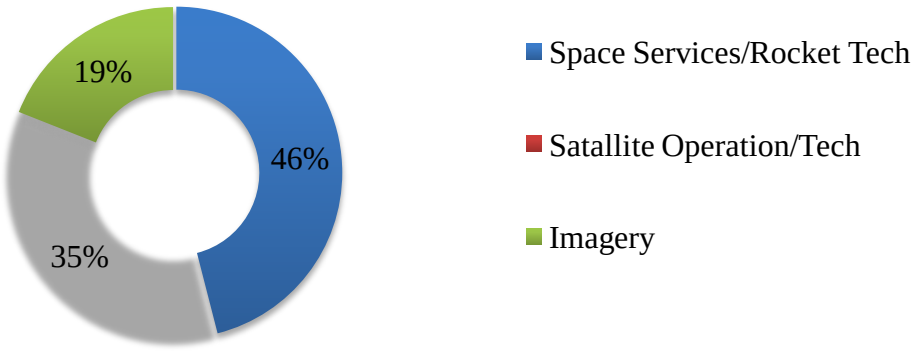

Figure 3. Funded space companies by focus

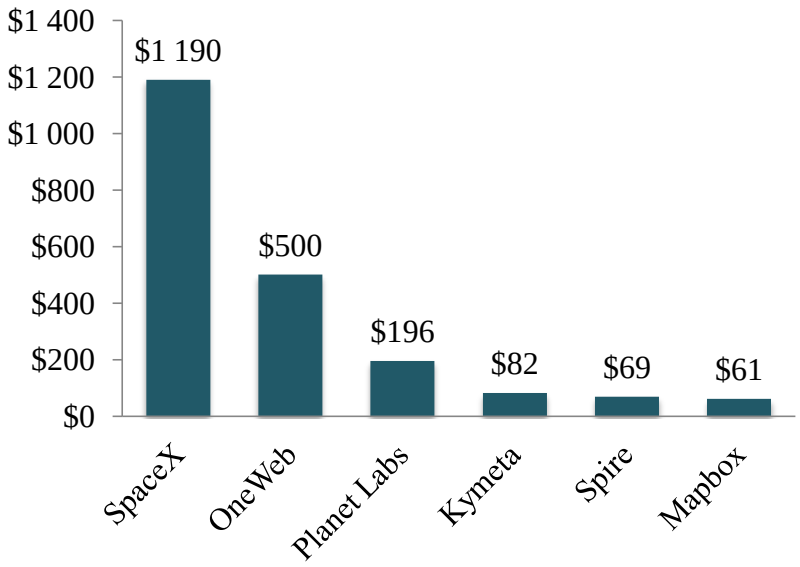

Figure 4. Total funding (US$ Millions)

The main investments in the space sector are SpaceX that designs, manufactures and launches advanced rockets and space crafts; the second place on for One Web that is developing a Project to launch more tan 600 satellites in space to give global access; Planet Labs is the third place who collects and analyses data about the earth via satellite; in fourth place Kymeta which develops a new form of satellite antenna to provide mobile networks; the next is Spire that collects and analyses data related to global trade, weather and more information via satellite constellations and finally Mapbox that makes map data, designs and publishes platforms. (CB Insights, 2015)

I.2. The harsh path of the predecessors

If we look back 25 years, we can find examples of previous projects which seemed to have a big potential, but at the end they have failed. Globalstar, Iridium and Teledesic experienced failure, bankruptcy, changing ownership.

Globalstar is a low earth orbit (LEO) satellite constellation aiming to give satellite communication services for areas which were not reachable by terrestrial phone. It was launched in 1991, and within seven years it already had 12 failed satellites lunch. By 2000, it began full commercial service with its 48 satellites, but only two years after it faced bankruptcy. It was bought out by Thermo Capital Partners LLC in 2003, which gave a second chance for the company. (Wood, 2010)

Iridium is a low earth orbit (LEO) satellite constellation aimed to give satellite communication services (mainly satellite phonecalls) around the world. The company was launched in 1987, and has completed 66 satellites launch in 1998.

It has only achieved 55,000 subcribers while 1 million was needed for its break even point. In 1999 it had declared bankruptcy caused by many reasons (including the equipment's heavyness). In 2000 it was bought out. (Hayk, 2008)

Teledesic was launched in 1990 with a goal to provide internet services around the world. In 1994 the company worthed US$ 900 Millions. In 1997 Boeing has joined the company to achieve 300 satellite launches. Only one year after Boeing was replaces by Motorola, then Alenia Spazio and the number of planned satellites has decreased only to 30. At the end not even one satellite was launched. (Chan, 2002) All three companies have experienced economic failure (bubble). All the money at the beginning of the project risen by venture capitalists were lost without even reaching the company's break even point.

II. EARTH-OBSERVATION AND TELECOMMUNICATION SATELLITES

Satellites can be classified by their orbit types (**L**ow **E**arth **O**rbit – LEO, **M**edium **E**arth **O**rbit – MEO, **H**igh **E**arth **O**rbit – HEO, **Ge**ostationary **O**rbit – GEO) by their customer (government or commercial use) or by their functions. Satellites are launched into space for a specific reason. They can be used for communication, observation, R&D, navigation, military, scientific or meteorology purposes. According to SIA (**S**atellite **I**ndustry **A**ssociation), in 2014 more than half of the operating satellites were used for communications (38% for commercial plus 14% for governmental) reasons, which was followed by Earth-observation services (with 14%). (Satellite Industry Association, 2015) Based on the high ratio of the satellites and the recent news about the successful launches of Earth-imaging and telecommunication satellites, we took a closer look at these two segments.

II.1. Earth-observation startups

These spacecrafts are raised by venture capital funded startups and not by traditional aerospace companies. Even though, their per-pixel resolution has the worst quality, the satellites cost less than traditional spacecraft, and they are capable of visiting sites more frequently at a cheaper price. They are able to provide faster, fresher data, as they can revisit sites more times a day. (Kumagai, 2014) The startups are keeping their cost down by using other sector's components (such as radio components from cellphones, cameras from photography, processors from automobiles, software from the internet) and by using smaller spacecraft.

Besides offering a cheaper data, companies need to provide services, convert datas into useful information and create a user friendly interface for their customers. For that they need to analyse the images and piece the information with others to get the knowledge. (Kumagai, 2014) Services can include counting cars on the streets, monitoring the farmer's animals state of health or countries in bombing areas. In a decade, we can assume that more and more startups will be represented in this industry, and world will be everywhere under surveillance. The list below contains the recent startups who are making this world become a reality.

Planet Labs:

Founded in 2010 by a team of ex-NASA scientists, Planet Labs is driven to image the entire Earth every day, and provide universal access to that data. (Planet Labs, 2015) In order to achieve their mission, Planet Labs has lauched over 100 Dove satellites to image the Earth in 24 hours. The largest constellation in history consist very small satellites weighing 6

kilograms. Their applications include maps, change detection, continuous monitoring and logistics. It can suit to many industries including mapping, infrastructre, forestry, energy, agriculture. (Boucher, 2014)

UrtheCast:

The Vancouver-based company operates commercial cameras providing 24/7 high-definition videos of Earth for monitoring the environment, humanitarian relief, social events, agricultural land, media. The company has released its first high-definition video from space station camera (called Iris) last June. Iris can take images and videos at a resolution of one meter per pixel. It is more capable, because it has a larger field of view and providing color video, than its competitors (SkyBox, HDEV). The company is also developing an L- and X-band synthetic aperture radar and a camera with a resolution of 0.5 meter. (Foust, 2015)

Skybox Imaging:

Founded in 2009, Skybox Imaging is a California-based company backed by leading venture firms and comprised of internet and aerospace professionals. The firm offers high spatial- and temporal-resolution Earth imaging, videos at a competitive price. The 24 satellites constellation revisit the Earth four times daily. The satellites's life span are 6-years, they are able to operate with 0.9 meter per pixel resolution, and each of them cost less than US$ 20 Millions. (Kumagai, 2014)

GeoOptics:

GeoOptics is developing a constellation of small satellites (called CICERO) to collect data about Earth's climate and environment. The first CICERO (**C**ommunity **I**nitiative for **C**ontinuous **E**arth **R**emote **O**bservation) is scheduled to be launched in March 2016. CICERO-1 will consist six LEOs in 2016, and it will be expanded to 12 in 2017, and 24 in 2018. Applications will include weather forecasting, space weather monitoring, climate research. Datas will include atmospheric density, temperature, winds, ocean circulation, 3D maps of the electronic distributions.

Traditional space based Earth sensors are sizeable, carried on large spacecrafts, which leads to more costs, limited coverage and more time (many days) to cover the planet. (The cost of NOAA's weather satellites exceeds US$ 5 Billions each.) But CICERO can provide global coverage in less than one hour and deliver measurements at a lower cost. It will comprise

many small spacecrafts equipped with more small, low-cost, high-performance sensors (the same found in modern cell phones). The spacecraft design is also modular for expandability. (Geo Optics, 2015)

	Planet Labs	UrtheCast	Skybox Imaging	GeoOptics
Founded in	2010	2010	2009	2006
Number of satellites	100	16	24	24
Mass	6 kg	Few hundreds	83 kg	<100 kg
Resolution	4 m	0,5 m	0,9 m	-
Revisit	90 min	-	6 hours	<1 hour
Funding	$ 183 M	$ 15 M	$ 91 M	-

Table 2. Earth observation startups comparison

How Earth Observation startups are changing the industry

As Table 2 shows all of the startups were founded in the 21th century, most of them in the Silicon Valley. The number of startups is growing thanks to the bigger demand than available supply. The entrance of startups has accelerated innovations, introduced cost effective technologies by using small satellites compared to gigantic and heavy satellites launched by national space organizations. But it is not enough. They not only need to have technological superior or cost effective satellites, but they need to adopt to the changing environment (customers' behaviour, laws and regulation) and their customer needs. The companies say there is no shortage of potential clients: mining companies, scientists, insurance companies. There can be a market among everyday consumers, such as property owners (to check the vacation home's status), nonprofit organizations (to monitor social unrest). (Dwoskin, 2014)

Earth-observation industry is undergoing a paradigm shift in the production cycle (the time from the concept to the launch). It is more the temporal resolution (how frequently the place can be revisited), then the spatial resolution which excites people more. CubeSats has led to interesting innovations and made the companies think outside the box. Companies are utilizes pieces of components from commercial off-the-shelf equipments and other industry's components, which would never have been the case in traditional satellites. The cost of their failure can be therefore much less, which makes them able to experiment more. Small satellites are opening the gates for innovation and applications using satellite imagery. (Kumar, 2014)

II. 2. Telecommunication satellites

Telecommunication is the main commercial use for satellites. The domain includes activities such as:

- **Television:** nowadays the main application. The main asset of satellite television in comparison with other television communicating systems is its ability to reach almost the whole planet (with some exception). The coverage area is approaching 100% of the digital terrestrial television (DTT) coverage area is lower. Another competitive advantage is the price, lower than DTT or cable television.
- **Telephone:** a declining application though it was the first commercial application for satellites. This application is declining due to the expansion of optic fiber and cables going through the ocean. Yet, this application is still used for places hard to reach for optic fiber or submarine cables, especially when these places are not very populated. This is the case of remote islands or non-populated places (such as desert, polar sphere, Amazonia).
- **Internet:** opposed today to the broadband Internet connection. Once again, the main advantage is the coverage area that reaches remote island, desert or countryside as long as the connecting device is located in the area covered by the satellite. The main drawback in comparison with broadband connection is that the large distance between the connected device and the satellite implies more or less short lags, which makes that system perfectible.
- **Radio:** opposed to ground-based radio, this system offers a strong alternative especially thanks to a much bigger coverage area. This sector remains quite new.

There are three main private actors that are changing this industry: SpaceX, OneWeb and O3B.

OneWeb

For now, OneWeb is at the state of a project, but the company, founded by Greg Wyler, exists (Space News, 2015). The OneWeb is financially backed by Google. It aims to operate a 700-satellite constellation in 2019. These satellites would provide internet telecommunication. The receivers of these internet services would be individual users. This project is a response to the fact that nowadays, half of the population does not have internet access (OneWeb website, 2015). These satellites would be circulating low-Earth orbit and would be operated in 2020.

Some of OneWeb's clearly defined missions are (OneWeb website, 2015):

- Guaranteeing global communication: the advantage of satellite telecommunication in comparison of other type of telecommunication is that it does not require ground infrastructure. That is very beneficial for population that has to face a disaster (arsons, floods, earthquakes, tornados) that damaged the ground telecommunication infrastructures.
- Internet connection for air travelers: whether it is for military purpose, business passengers or other passengers, OneWeb claims to be able to provide a latency internet at the heights of 9,000 meters.
- A focus on social infrastructures such as schools, hospitals or libraries. OneWeb foresees that internet will be a strong and inevitable educational tool in the future and that satellite telecommunication will be primordial. Some buildings such as schools or hospitals (but also houses) need to be connected to the rest of the world.
- Reaching rural areas. These areas are usually forsaken by telecommunication because it requires stronger investment in order to reach them and with a lower return as it concerns less people than in an urban area. But regardless of the profitability of telecommunication in urban areas, a non-negligible part of the population lives in rural areas and providing them with communication technologies is both necessary and profitable.

SpaceX

The company was founded in 2002 by Elon Musk. Elon Musk is the revolutionary entrepreneur behind the creation of PayPal and a former CEO of Tesla Motors. SpaceX innovation strategy goes beyond launching satellites. Elon Musk wanted to create radical changes in the space transportation, with the ultimate goal of making people live in another planet. For example, he believes SpaceX would be able to send passengers to Mars within the ten incoming years (Daum, 2015).

SpaceX develops its own rockets and spacecraft and tests them itself. Since the beginning, SpaceX used Dragon spacecraft and Falcon launch vehicle (SpaceX Press Kit, 2013). SpaceX started gaining visibility in the early 2010s with the launching and return of a spacecraft in the low-Earth orbit. Later, a Dragon spacecraft succeeded in exchanging cargo payload with the ISS (International Space Station) and return to Earth. That record was only established by

governmental space agencies. Since then, the company started making frequent Commercial Re-Supply (CRS) missions with the ISS (SpaceX Press Kit, 2013).

SpaceX, which launched in December 2013 the SES-8, is the first satellite launcher privately financed. This is quite a revolution as previously all satellites were launched by governmental agencies. SES-8 is a geostationary orbit (SpaceX website, 2013) and the 55th satellite in orbit. The SES-8 was launched in Cape Canaveral (Florida) (SpaceX Press Kit, 2013). Due to its location – 95° east orbital slot – the satellite should be able to:

- Cover South Asia and Asia-Pacific regions
- Support growing markets in these regions
- Provide expansion capacity for the direct-to-home television and government applications
- Provide satellite communication services to broadcasters, Internet providers, governments and mobile and fixed networks providers (SpaceX Press Kit, 2013)

SpaceX would keep up its momentum by launching two years later the Deep Space Climate Observatory (or DSCOVR), an Earth-observation satellite, once again privately funded (SpaceX website, 2015).

O3B

The company's name stands for Other 3 Billion, is a communication and internet satellite launching company which has a goal of connecting the area deprived of internet and telephone communication due to:

- Geographical difficulties: hardly reachable places such as remote islands, deserts or high mountains,
- Poverty issues which makes it difficult to pay an access to a satellite connection,
- Lack of population which makes the operating of a satellite less interesting for a launcher,
- Or political instability.

In order to reach that goal the satellite constellation is planned to cover the whole area between 40° North and 40° South of the Equator, where the biggest part of the population deprived of Internet access due to the reasons above population lives. (De Selding, 2014) Many private funding are behind this project: Google (Fitchard, 2013), SES (De Selding, 2015), HSBC (O3B Network, 2011), Allen & Company (O3B Network, 2011), Liberty Global (Palmer, 2008), North Bridge Venture Partners (O3B Network website, 2011). The launch of the first four satellites happened in 2013 (Fitchard, 2013).

III. SPACE INDUSTRY COMPARISON WITH DIFFERENT VENTURE CAPITAL SECTORS

The following chapter presents the comparison between space sector and other industries that receive the majority of venture capital investments. Geographically speaking it appears, that the leading majority of venture capital is placed in USA. However, from year 2013 China has had a rapid growth and obtained the second position instead of Europe. Both Israel and India has a steady growth of investments pouring in during the last four years. (JSON.TV, 2014) The occurring global changes in venture investments are presented in the Figure 5.

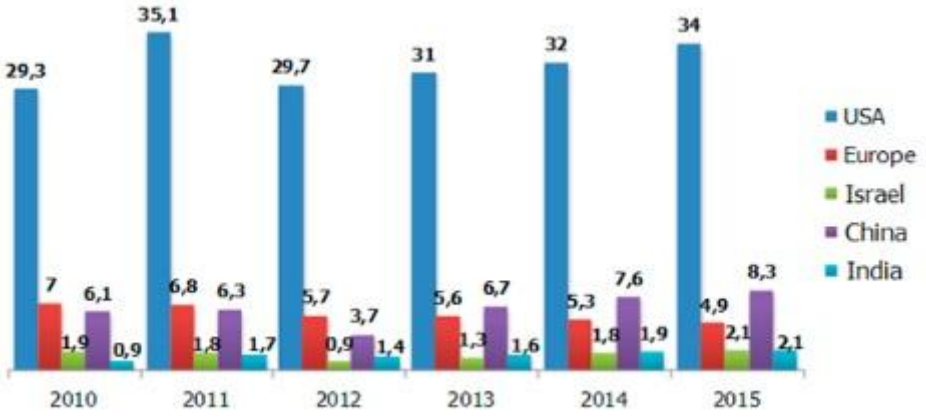

Figure 5. The volume of venture capital investments in the leading countries, 2010-2015 (US$ Billions).

The following subchapters will aim to distinguish the different major venture capital industries by introducing the general overview of the latest trends in, software, biotecnology and finally space activity.

III.1. Venture funding in software industry

As previously referred, software industry has the leading position in venture capital investments with US$ 7,3 Billions in the second quarter of 2015. Although the analysts have forecasted the topside of tech-bubble industry being not in a far distance and being compared with the dotcom bubble burst in the year 2001, there are motives to believe that higher figures are about to arrive in this industry. (Warmoth, 2015) The growth of venture capital funding in software industry is indicated in Figure 6. There is a high increase in the demand of customized requirements, as the user interface is developing in the unsettled directions. Thus, the companies that evolve the ways to differentiate the customer experience (by establishing infrastructure or tracking customer experience) will be the ones that exterminate the current system and will take the lead. (Warmoth, 2015)

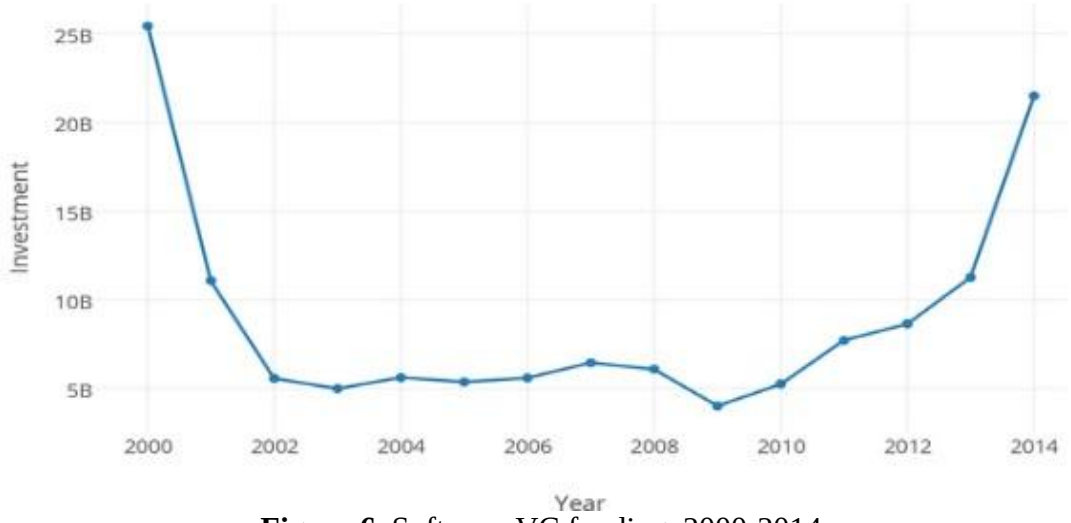

Figure 6. Software VC funding, 2000-2014.

As the Figure 6 above presents, a steady and rapid growth after the global crisis in software industry is continuing, assuring the top position in venture capital investments among every other industry.

III.2. Venture funding in biotechnology industry

According to the First Trust Portfolio (2015) software industry got more money from venture capitalists than biotechnology. Although the number of arrangements in biotechnology industry has remained quite consistent between the years 2011-2014, the amount of funding exceeded US$ 4 Billions per annum, cumulating with total of US$ 5,97 Billions in the 2014 (see Figure 7), whereas solely US$ 2,3 Billions was invested in the second quarter in 2015. In comparison to that, software funding reached from US$ 7,5 Billions to US$ 19,8 Billions within the indicated time range of 2011-2014.

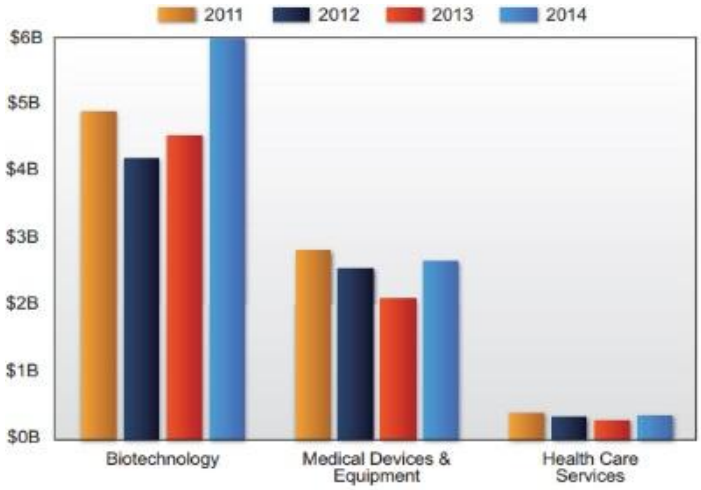

Figure 7. Venture capital funding in biotechnology and medical industry, 2011-2014.

Regarding the investments in biotechnology, the majority (~80%) has been placed in the research and development of new drugs, rather than in the development of the existing ones (Booth, 2015b). The main factor that attract venture capitalists to invest in biotechnology and, in particularly to the research and development of novel drugs, which has a higher level of risk and uncertainty, is in the presence of exit strategy. Weintraub (2015) indicates the attractive exit strategy in biotechnology industry as one of the important drivers for venture capitalist's interest to place money in this sector. However, possible risks exist regarding the present boom, in particular the number of competitors who can eventually cause a pricing pressure. If several businesses attempt to sell the same outcome, insurance companies will not be willing to pay as high price as with only one result offering. This can be illustrated by the example of Sovaldi speciality drug, developed by Gilead's with the aim to cure hepatitis C, with the price of $84 000 for a 12-week course of treatment, that was confronted by equally effective, but less pricey alternatives emerging to the market. (Barrett, Langreth, 2015; Weintraub, 2015)

III.3. Venture funding in space industry

Investing money in the space projects can be considered as a risky move. Illustration can be derived from the SpaceX project in January 2015, where the unmanned Falcon 9 rocket managed to fulfil its first mission, but failed the second appointed task. The launch of the rocket is seen partly as a success, but not completely. Although it did propelled critical Dragon supplies to the International Space Station, it did not manage to propel the rocket safely back on Earth and landed with an explosion. (Blakemore, 2015)

Regarding the numbers, space industry has hit the high-peak in 2015 with US$ 1,17 Billion raised by 21 companies. (Perry, 2015) Most of the investments (US$ 1,12 Billion) were placed to USA companies, with solely US$1 Billion to the SpaceX. There are estimations that from the 125 companies that started in 2011, the number has increased considerably and currently already 900 companies are involved in the commercialization of space. The bulk private funding is raised by SpaceX, however Planet Label Inc. (raised $183 million) and Spire Global Inc. (raised $26,5 million) are on the record accordingly as the second and third best-funded New Space companies. There is an increasing number of more seedling companies, mainly near NASA Ames Research Center. (Silicon Valley Startups, 2015)

Many venture capitalists investing to the industry are great space enthusiasts, however, this is not considered as the main reason of placing money there. Peter Platzer, CEO of Spire notes that venture capital is allocated in the industry with the notion of investing in highly proprietary data and data analytics, whereas space is the location to generate this sort of intelligence. Therefore, this is the idea investors are holding when backuping financially the undertakings in space sector. (Silicon Valley Startups, 2015)

To the following, four novel space startups to invigilate in Silicon Valley are presented (Silicon Valley Startups, 2015):

- Bagaveev Corporation - This company is developing 3D printed rocket engines.
- Moon Express - This business has the objective to become the first private company to land a robot on the moon's surface, travel leastwise 500 meters and convey images back to Earth.
- Deep Space Industries - The company intends to mine asteroids that are rich in minerals near Earth, which can be employed in space propellants and as primary material for 3D printing.
- Made In Space - The company concentrates on 3D printing, in order to provide the businesses and scientists for a certain remuneration making things on the printer, which then provides a capability to be sent back to Earth through a shuttle or used in space.

Huston (2015) describes the existing situation in Silicon Valley as a "risk bubble", where employees and investors are ready to contribute their time and money into unprofitable startups. Example that follows is based on Snapchat that has the price of US$ 15 Billions on its funding rounds, but yet is configuring the methods to monetize its platforms in real. An important element in the "risk bubble" is the behaviour of venture capital companies - they pour money into private startups' late rounds and deal with them as they had gone already public. Those venture capitalists are not able to control well the money, either assess how the company might operate as a public entity. (Huston, 2015)

Startup	Valuation	Sector
Xiaomi	US$ 46.0 Billions	Electronics
Uber	US$ 41.2 Billions	Ride-hailing
Palantir	US$ 15.0 Billions	Software
Snapchat	US$ 15.0 Billions	Messaging
SpaceX	US$ 12.0 Billions	Space exploration
Pinterest	US$ 11.0 Billions	Online curation
Flipkart	US$ 11.0 Billions	E-commerce
Airbnb	US$ 10.0 Billions	Home rental
Dropbox	US$ 10.0 Billions	File storage
Theranos	US$ 9.0 Billions	Health technology

Table 3. Ten biggest venture capital startups nominated as unicorns.

The Table 3. above presents, among other sectors, one unicorn from space industry is reported - SpaceX, the U.S. based company in space exploration sector (see also Chapter III.2.). SpaceX has succeed to be one of the few companies in space industry to exceed its valuation to US$ 12 Billions and receiving the unicorn title. Nevertheless, the big sums of money involve big issues. Booth (2015a) points out the critical questions regarding the direction that large money allocations are leading to: whether the investments are placed efficiently; and the current performance of discipline in the way companies use this money. There is a threat of establishing rapidly excessive amounts of infrastructure without comprehensive analytical assessment and hiring promptly big teams, also funding unformed projects before proving themselves. (Booth, 2015a) In addition to that, the number of competitors entering to the market can have influence and create price pressure. (Weintraub, 2015) Another matter to pay attention to is the examination of how the redundant capital is influencing valuations and expectations. Several companies might consider the money windfalls as a license to waste money at an excessive level, rather than using it at a standard justified by their own realistic revenue prospective. (Associated Press, 2015)

Concerning all the previously compared industries and the large amounts of money invested in their mostly onset phase activities, it can be stated, that this behaviour resembles to a great extent to the previously experienced effect. There has been a parallel drawn between the dotcom boom and the current money pourings into start-ups in software, biotechnology, and

even space industry. Venture funding reached it height of dotcom investments in 2000 with US$ 105 Billions. With the wave of downfall of new Internet companies, many fell short on making any money. Venture funding made a big jump not until year 2013, before that the investments were ranging exclusively between US$ 20 Billions and US$ 30 Billions, resulting from the burst of dotcom boom. (Associated Press, 2015) This pattern can be now recognized by the money flow to projects in their commence phase and without any success guarantee. The discussion on the possible bubble effect in space industry, however, will be discussed furthermore in the Chapter V.

As the current chapter concludes, biotechnology industry helds the third position in total of venture capital investments in the second quarter, but as previously mentioned, is just at the back of software industry concerning the number of deals (US$ 2,3 Billions placed in 126 deals). **(**Venture Capital Investing, 2015) The second position for dollars invested stands for media and entertainment industry with US$ 2,7 Billions going into 118 deals and the software industry captured the largest amount of fundings in comparison to all the other industries (including 491 deals with US$ 7,3 Billions). **(**Venture Capital Investing, 2015)

IV. ANALYSIS AND DISCUSSION: IS THE SPACE INDUSTRY EXPERIENCING A SPECULATIVE BUBBLE?

To the following, an attempt to analyse the continuity of the venture capital euphoria in space sector and its effect in a 5-year term is implemented. The focus is on the motivations, limitations and on the impact of the venture capitalist investments, as well as on exploration, whether this activity creates a possible bubble.

IV. 1. The drivers

There are several drivers that motivate investors to put their money in companies in general and also in space industry, despite of the high risks and high level of uncertainties. The incentives include tax-system, comprehensive communication, the availability of financial resources, psychological motivations and trends followed by the person's ambitions.

Investments can be considered as means to pay less taxes and therefore can be reckoned as a driver, citing "*if you have less profit, you have less taxes. More investment (considered as expense) means less profit and so less taxes. The choices are: either you put your money as an investment, or you take it as profit and you pay the tax."* (D. Hernandez, personal communication, October 21, 2015)

Another important incentive for placing money in the space sector is communication, incorporating the public communication and the information not published. Citing: *"The reality is [Google] have more failures than success, but the publications make it look like Google has only success. Then, people are motivated to invest in the same companies. The news suggest people to take more risks, to invest more."* (D. Hernandez, personal communication, October 21, 2015) Hence, there are more success stories reported than actual failures, which can create an unbalanced and false apparition of the actual situation. As these sort of news give hope and great expectations, it creates a condition where people want to invest.

Regarding the most evident source for investments - the availability of monetary resources, it might appear that people with an immense amount of financial means are possibly more prone to allocate their money, as these kind of people are looking a place to put their money. As long as there is a slight chance to get higher return, they will invest in the project. *"If*

[venture capitalist] would do nothing with the money, the money would just be gone because of inflation. So, if there is any demand, the investment will be made right away." (D. Hernandez, personal communication, October 21, 2015) Combined with the "sweet talk and sweet news", this kind of people can be attracted to invest. Therefore, investors with greater financial means connected with the attractive advertisement, are willing to place their money in risky projects.

Hazard, risks and the thrilling experiences that high level of uncertainty provides can be seen as a psychological driver, as D. Hernandez (personal communication, October 21, 2015) indicates following: "*people, especially US citizens like to take risks and they like the idea of conquest. People like to test. It is easy to test when you have nothing to lose (people with no or a huge amount of money)."*

Globalization and maintaining the connection to the discovered, hardly reachable areas has its effect on venture capital investments. It can be reckoned as an incentive for people to contribute to the development by giving money to space projects. As J.-P. Noté (personal communication, November 18, 2015) states: "*the trend is to a worldwide connection without white regions (or "white oceans")... One cannot connect when travelling over oceans and deserts or semi desert regions; however, more and more people are travelling through those regions or working there…"* Taking into consideration the previous statement, it is clear that there are changes happening as nowadays, the regions in the world that before were considered as "white" regions are becoming more and more colorful. The term "white" marks an area where there are no people, villages, activities, transport routes or any kind of infrastructure over the area. Therefore, people want to connect those unconnected areas, thus support from space area and through various space projects enables to facilitate the connection process.

IV. 2. The probability of the bubble in a 5-year perspective

There are three industries that receive the highest amount of venture capital investments with investors hoping to get high return while not controlling the company: software industry, biotechnology and space. Space industry has a longer life cycle of projects compared to digital industry. A project in space area may take 5 – 10 years to be finalized. There are also some constraints that will make the development and breakthrough process in space area longer to succeed.

One major constraint that needs to be considered is related to the technical aspects and the cost. According to the conducted expert interview with D. Hernandez (personal communication, October 21, 2015), it appeared that issues related to the usage of appropriate technology in the long run, as the designated deadline can be distant, are important. In addition to that, the relevant number and expertise for launching satellites needs to be taken into account. The timeline and the financial resources need to be suitable, therefore considering if there is enough money until the end of the project is crucial.

Another limitation embodies legal aspects. The great obstacle lies in *"the need to get authorization from hundreds of nations, the permission from ITU to use frequency, and many more."* (D. Hernandez, personal communication, October 21, 2015) ITU permission is mandatory for launching these frequency projects. Currently, there is no space left for new frequencies and the applicants who wants to use the frequencies, need to wait for 2 – 3 years, as this is the interval when the ITU make the decision with such uncertainty.

A further limitations lies in the market demand. As claimed by D. Hernandez (personal communication, October 21, 2015), when launching a system, the reflection needs to be done on *"how long does it take to get the minimum amount of customers to be considered as a business."* It will take time to get enough customers and necessarily not everyone in the world want to get connected or pay the services, as the final price for the customers is still relatively high in space industry. Therefore, having enough customers to succeed the project can be difficult and become as an obstacle in realizing the undertaking.

Taking into consideration both the drivers that push the venture capitalists to invest in the space sector as well as the limitation that can possibly pull down the success of the implementation of the space projects, it can be discussed that in 5-year perspective the current activity of euphoria will create highly likely merely a space bubble. The venture capitalists want fast return, they are not patient enough to willingly wait for 10 to 20 years. Any changing information in the market might make the euphoria collapsing, for example if ITU will not give permission to use frequencies or there are some government declaring they want to take care of their own people connectivity, etc. If one of the big projects like SpaceX or OneWeb collapses (resulting with the venture capitalists taking back their money), it will

also affect the suppliers who will be crashed, therefore creating a domino effect. In this case the occurrence will be a bubble in the industry.

Nevertheless, in this event, there will be bubble only in economic term, in technological aspect, there will not be any collapse. The demand by the big player is pressuring many research entities like labs, universities, suppliers, etc. in order to accelerate their pace in research and trial and errors to find the cheaper and more advanced technology. The development will always be there and someday will reach the maturity and a breakthrough will surely be achieved. The learning curve will not collapse either despite of the happening of economical bubble. What the researcher have learnt until now will keep increasing and expanding, so in the future there will be less costs, more effective and more efficient ways developed to produce and implement space projects.

IV. 3. The effect of the possible bubble to space companies

In case of the possible occurrence of bubbles and the resulting economy collapse, certainly the companies in space industry will be affected. However, the effect might be different for each company. The companies in space industry might be categorized into two distinctive groups and they will receive different effect. The categorization is as follows:

The "All in One"

The players of this groups are for example: SpaceX, OneWeb, O3B and Planet Labs. They need huge money and big resources to do their projects. For instance, OneWeb wants to launch 1000 satellites at once or in a short period of time. In order to do so, they need facilities to build all of the satellites and find the launchers. In addition to this, they also need to deal with permission and authorities from many institutions at once. If the bubble happens, this kind of company will lose a lot of money and has an instant bankruptcy as a result.

The "Specialists"

The players are small companies which usually target niche market. They usually serve small segments of market and only need small amount of money or resources to operate. The example is a company who arise to serve the farmer in certain country in order to watch the crop condition from time to time. They can start with just only one satellite (can buy or just rent), and depending on the situation, they can grow bit by bit, by serving another country, and then expand more widely by comprehending more countries and satellites. These kind of

companies might still survive after the explosion of the bubble, even if they experience a loss, it will be minor compared to the bigger ones. Due to their more realistic factor and their survivability, banks and other venture capitalists may want to invest in them, even after the crash of the bubble.

V. CONCLUSION

In the past few years a huge amount of venture capital has been invested in the space industry, and in many startups. The venture capitalist do not want to control the company itself, they invest into a concept. They believe, they have high hope that the blueprint will succeed. They are very sure that they will receive huge profit in the very near future. Even though 40 years ago the history told the world that the it will become bubble, they have still invested in it.

In the next 5 years, there will be a high chance that the bubble will happen. The history will repeat once again. The huge amount of the venture capital will not become solid as everyone expects. Doubts from many experts and professionals has been raised about this succeess rate of the blueprint (SpaceX, OneWeb, O3B).

This bubble is an economic bubble. If it happens, the thing that will collapse is the money, the venture capital. The project may loose money in two terms. Firstly, the money that has been used, will fail, file bankruptcy, and will not give the money back to the venture capitalists. Secondly, there is bad news that will surely lead to the failing of the projects, affecting the venture capitalists take back their money before it vanished. Both are bubbles.

In term of technology, there will be no collapse. In 40 years history the level of technology maturity and learning curves has been continuously improving, and this development will not stop. Someday, the projects will achieve success, but not in the next 5 years. It may take more than 10 years.

The research and development will always be there.
The trial and error will never stop.
People’s dreams in space area will always live.

REFERENCES

Associated Press (2015). *Some worry of bubble as venture capital firms rain cash on tech startups.* Available at: Boulderopolis Website. <http://boulderopolis.com/some-worry-of-bubble-as-venture-capital-firms-rain-cash-on-tech-startups/> (accessed 10th October 2015).

Barrett, P. - Langreth, R. (2015). Pharma Execs Don't Know Why Anyone Is Upset By $94,500 Miracle Cure. *Bloomberg Business.* Available at: Bloomberg Business Website. <http://www.bloomberg.com/news/articles/2015-06-03/specialty-drug-costs-gilead-s-hepatitis-c-cures-spur-backlash> (accessed 10th October 2015).

Bessemer Venture Capitals (2015). *Space tech.* <http://www.bvp.com/space#sthash.mrZE6i3K.dpuf> (accessed 2nd November 2015).

Blakemore, E. (2015). What the SpaceX Rocket Crash Really Looked Like. *Smart News*. Available at: Smithsonianmag Website. <http://www.smithsonianmag.com/smart-news/what-spacex-rocket-crash-really-looked-180953919/> (accessed 10th October 2015).

Booth, B. (2015a). The Venture Funding Boom In Biotech: A Few Things It's Not. *Forbes.* Available at: Forbes Website. <http://www.forbes.com/sites/brucebooth/2015/07/23/the-venture-funding-boom-in-biotech-a-few-things-its-not> (accessed 10th October 2015).

Booth, B. (2015b). Where Does All That Biotech Venture Capital Go? [Web log comment]. Available at: Life Sci VC Website. <http://lifescivc.com/2015/02/where-does-all-that-biotech-venture-capital-go> (accessed 10th October 2015).

Boucher, M. (2014*). Planets Labs Plans to Launch Over 100 Smallsats Within a Year. Available at: SpaceRef Business Website.* <http://spaceref.biz/company/planets-labs-plans-to-launch-over-100-smallsats-within-a-year.html> (accessed 24th November 2015).

CB Insights (2015). *The future of frontier tech. Analysing trends in drones, space, and AR/VR technology* [PowerPoint slides]. Available at: CB Insights Website. <https://www.cbinsights.com/reports/Frontier-Tech-Report-8-28.pdf> (accessed 2nd November 2015).

Chan, S. P. (2002). *The birth and demise of an idea: Teledesic's 'Internet in the sky'.* Available at Seattle Times Website. *<http://community.seattletimes.nwsource.com/archive/?date=20021007&slug=teledesic070>* (accessed 24th November 2015).

Daum M. (2015). Elon Musk Wants to Change How (and Where) Humans Live. *Vogue.* Available at: Vogue Website < http://www.vogue.com/13349221/elon-musk-profile-entrepreneur-spacex-tesla-motors/> (accessed 25th November 2015).

Deep Space Industries (2015). *Silicon Valley Startups Enter the Space Race.* Available at: Deep Space Industries Website. <https://deepspaceindustries.com/silicon-valley-startups-enter-the-space-race> (accessed 10th October 2015).

De Selding P. B. (2014). Google-backed Global Broadband Venture Secures Spectrum for Satellite Network. *Space News.* Available at: Space News Website <http://spacenews.com/40736google-backed-global-broadband-venture-secures-spectrum-for-satellite/> (accessed 25th November 2015).

De Selding P. B. (2015). SES Eyes Larger O3b Stake amid Rising Satellite Broadband Demand. *Space News.* Available at: Space News Website <http://spacenews.com/ses-eyes-larger-o3b-stake-amid-rising-satellite-broadband-demand> (accessed 25th November 2015).

Dwoskin, E. (2014). *SF Startup Launches Eyes in the Sky. Available at: Wall Street Journal blog <http://blogs.wsj.com/digits/2014/01/09/sf-startup-launches-eyes-in-the-sky/>* (accessed 24th November 2015).

First Trust Portfolios (2015). Biotechnology Continues To Attract Big Bucks From Venture Capitalists. Available at: First Trust Portfolios Website

<http://www.ftportfolios.com/Commentary/MarketCommentary/2015/3/26/biotechnology-continues-to-attract-big-bucks-from-venture-capitalists> (accessed 10th October 2015).

Fitchard K. (2013). Google-backed O3b successfully launches its first four satellites into the heavens. *Gigaom.* Available at: Gigaom Website <https://gigaom.com/2013/06/25/google-backed-o3b-successfully-launches-its-first-four-satellites-into-the-heavens/> (accessed 25th November 2015).

Foust, J. (2015). *UrtheCast Releases High-Definition Video From Space Station Camera*. Available at: Spacenews Website. <http://spacenews.com/urthecast-releases-high-definition-video-from-space-station-camera/#sthash.Cfp1wQR0.dpuf> (accessed 22th November 2015).

Geo Optics (2015) The Constellation. [Online] Available at: <http://geooptics.com> (accessed 22th November 2015).

Hayk (2008). *Failures – exposed, reflected, considered: Story of Iridium.* Available at: Wordpress Website. <https://fail92fail.wordpress.com/2008/10/01/story-of-iridium/> (accessed 24th November 2015).

Huston, C. (2015). Silicon Valley's 'risk bubble'. *MarketWatch.* Available at: Market Watch Website. <http://www.marketwatch.com/story/silicon-valleys-risk-bubble-2015-03-17> (accessed 10th October 2015).
Investopedia. (2015). *Dictionary: Venture capital.* <http://www.investopedia.com/terms/v/venturecapital.asp> (accessed 2nd November 2015).

JSON.TV (2014). *Rating of Venture Capital Funds.* Available at: JSON Website. <http://json.tv/en/ict_telecom_analytics_view/rating-of-venture-capital-funds-20140906406245394> (accessed 10th October 2015).

Kumagai J. (2014). *9 Earth-Imaging Start-ups to Watch. - A tech boom will shake up commercial satellite imaging.* Available at: IEE Spectrum Website.<http://spectrum.ieee.org/aerospace/satellites/9-earthimaging-startups-to-watch> (accessed 24th November 2015).

Kumar M. (2014). *How Earth Observation Startups & CubeSats are changing the industry.* Available at. LinkedIn Website <https://www.linkedin.com/pulse/20140929201950-62494240-how-earth-observation-startups-cubesats-are-changing-the-industry> (accessed 22th November 2015).

NASA (2015). *Emerging space. The Evolving Landscape of 21st Century American Spaceflight.* Washington: NASA Available at: NASA Website <http://www.nasa.gov/sites/default/files/files/Emerging_Space_Report.pdf> (accessed November 2015).

O3B Networks (2011). *O3b Networks set to double fleet capacity as financing secured for four more satellites.* Available at: O3B Networks Website <https://www.o3bnetworks.com/o3b-networks-set-double-fleet-capacity-financing-secured-four-satellites/> (accessed 25th November 2015).

OECD Observer (2007). *Space: More than meets the eye*. Available at: OECD Observer Website.<http://www.oecdobserver.org/news/archivestory.php/aid/2316/Space:_More_than_meets_the_eye.html> (accessed 30th October 2015).

OneWeb (2015). *Home page.* Available at: O3B Networks Website < http://oneweb.world/> (accessed 25th November 2015).

Palmer C. (2008). O3b Networks, With Support from Google, Liberty Global and. *Gigaom.* Available at: Bloomberg Website <http://www.bloomberg.com/apps/news?pid=newsarchive&sid=awY_EQy654Xk> (accessed 25th November 2015).

Perry, T. (2015). Venture Money Flows To Space Startups. IEEE Spectrum. Available at: IEEE Spectrum Website. <http://spectrum.ieee.org/view-from-the-valley/aerospace/satellites/venture-money-flows-to-space-startups> (accessed 10th October 2015).

Planet Labs (2015). *About us.* [Online] Available at: <https://www.planet.com/about/> (accessed 22th November 2015).

PwC (2015). *Venture Capital Investing Exceeds $17 Billion For The First Time Since Q4 2000, According To The Moneytree Report*. Available at: PwC Website. <http://www.pwc.com/us/en/press-releases/2015/venture-capital-investing-exceeds.html> (accessed 10th October 2015).

Satellite Industry Association. (2015). *State of the satellite industry report.* [PowerPoint slides]. Washington: Satellite Industry Association. Available at: Satellite Industry Association Website. <http://www.sia.org/wp-content/uploads/2015/06/Mktg15-SSIR-2015-FINAL-Compressed.pdf> (accessed 2nd November 2015).

Spacenews (2015). *In Conversation with OneWeb Founder Greg Wyler*. Available at: Space News Website <http://www.bloomberg.com/apps/news?pid=newsarchive&sid=awY_EQy654Xk> (accessed 25th November 2015).

SpaceX (2013). *SpaceX Successfully Completes First Mission to Geostationary Transfer Orbit.* Available at: SpaceX Website <http://www.spacex.com/press/2013/12/03/spacex-successfully-completes-first-mission-geostationary-transfer-orbit> (accessed 25th November 2015).

SpaceX Press Kit (2013). *Press Kit SES-8 Mission.* Available at: SpaceX Website <http://www.spacex.com/sites/spacex/files/spacex_ses-8launch_presskit.pdf> (accessed 25th November 2015).

SpaceX (2015). *SpaceX Launches DSCOVR Satellite to Deep Space Orbit.* Available at: SpaceX Website < http://www.spacex.com/news/2015/02/11/spacex-launches-dscovr-satellite-deep-space-orbit> (accessed 25th November 2015).

Warmoth, B. (2015). Why Venture Funding for Software Ballooned in Q2 – and It May Keep Growing. *DC Inno.* <http://dcinno.streetwise.co/2015/07/17/venture-funding-totals-q2-2015> (accessed 10th October 2015).

Weintraub, A. (2015). Biotech Investing Hits An All-Time High - But Is It A Bubble?. *Forbes.* <http://www.forbes.com/sites/arleneweintraub/2015/07/21/biotech-investing-hits-an-all-time-high-but-is-it-a-bubble> (accessed 10th October 2015).

Wood, L. (2010). *Lloyd's satellite constellation overview***.** Globalstar. <http://personal.ee.surrey.ac.uk/Personal/L.Wood/constellations/globalstar.html> (accessed 25th November 2015)

APPENDIX

Interview with Daniel Hernandez

Daniel Hernandez is the founder of Devil-Hop, a consultancy agency in business strategy and project development mostly for space companies. He is also a teacher at Toulouse Business School and in engineering schools (ISAE in Toulouse, ENSIM ...).

1. *What make venture capitalists do to put their money in start-up companies or projects that bear huge risks?*

a. Taxes

If you have less profit, you have less taxes. More investment (considered as expense) means less profit and so less taxes. The choices are: either you put your money as an investment, or you take it as profit and you pay the tax. But paying the tax considered as loss. If you put the money in a venture capital you have some chance of winning. The higher the rate of the taxes, the more people are willing to invest.

b. Psychological reasons

People, especially US citizens like to take risks and they like the idea of conquest. People like to test. It is easy to test when you have nothing to loose (people with no or a huge amount of money). For people with mediocre money, they think that "If I lose 1 or 2 euro, it will not change my life, but if I win, it will change my life."

c. Communication

Google is linked to success stories, everything they do makes money. But this is not enitrely true, it is only communication. There is a Google cemetery, they do a lot of projects and all of them are failures, and they do not care as they have a lot of money. The reality is they have more failure than success, but the publications make it look like Google has only success. Then, people are motivated to invest in the same companies. The news suggest people to take more risks, to invest more.

d. People with a lot of money

People with a lot of money can become easily confused. There is a story of Mr. Moreno, the one who found the chip in a credit card and the machine to read it. He patented it and for 40

years he gets a lot of money. If he would do nothing with the money, the money would just be gone because of inflation. This kind of people are putting money here in this industry as well. They invest in Italy, Spain and France. There are more offers of investment than demand. So, if there is any demand, the investment will be made right away.

2. *The story of Learning Curve and OneWeb.*

Figure that consists the number of companies means little or nothing, but if we compare the amount of money invested in the industry, it means something. OneWeb proposed to make a constellation of 1,000 smaller and cheaper satellites, while the competitor offered 4,000 satellites. Now, this is still only a promise, but we can observe the space industry's learning curve. NASA use a factor of 0.85 learning curve, means that in the production of 1001^{th} unit, the cost will be only 40% of the 1^{st} unit produced. While this OneWeb and other startups said they can produce the 1001^{th} unit with only 10% of the cost of the 1^{st} unit. It was not known yet in history. You need to produce millions or billions to arrive at that number. Space industry has never done 1000 identical satellites, only 100 in the case of Irridium and GlobalStar or 10 identical really often. This kind of proposal has some benefits. The rapid growth phenomena in inventing new ways and technologies reduce the cost of production due to the pressure from the company to the suppliers. If OneWeb will be a failure, the rapid research done by many companies will certainly contribute to something new in the space industry. 20-30 years ago there was a bubble similar to today. The projects were Irridium and Global Star, they ended up as an economic failur. Today they still exist, and space industry has learned a lot from their phenomena.

3. *If the big one like SpaceX, OneWeb and Planet Labs will not succed in the next 5 years, how about the smaller ones? Will they face economic failures?*

There are specialists, companies which only have few satellites and the serve niche market like farmers or police with certain degree of resolutions depending on the customer needs. This kind of companies will grow step by step and not in large leap like the big ones. They can start their operation right away with only one satellite, while OneWeb needs to have 1000 satellites to operate. This companies can stay alive in the bubble. You do not need to invest billions of dollars in these businesses. This small companies could only loose much less money and will be able to convince more bankers.

4. *In Silicon Valley, there are many digital start-up companies with huge amount of money valuation. When there is a bubble this kind of software companies will be pretty sure loose a lot of money. But how about Space-X which has valuable physical things, like launchers and satellites. Will it loose a lot of money like other digital companies?*

Yes, of course, because all the suppliers behind Space-X will fail also. When there is a bubble in the space industry, the investors simply take their money everywhere from the value-chain of the space industry and move it to other industries like biotechnology. What can Space-X do without suppliers? Nothing.

5. *But space projects need years to have their result, while digital projects only need days or months. How can we assume that a space project is a failure while it only runs for a few months from some years timeline?*

There are projects assessing if this is a bubble or not, because there are a lot of people that hesitate to invest. Any announcement could trigger the bubble. Let's use OneWeb as the example. Every satellites need authorization (from local and international government) and frequencies to operate. ITU is the one who gives frequencies, and now all the frequencies are occupied. They will conduct a meeting in every 2 – 3 years to see who will release and who will use the frequency. On top of that there are a long queue of satellite user companies who apply to have a frequency. Let's say that ITU gives the frequency for OneWeb in 2021, what does it mean? The investors will take their money from OneWeb and put it in another companies, because OneWeb will not be in operation until 2021. It will not make money until 2021. One Web still needs to negotiate and pay money to each country to get authorization to operate in the territory, and many other constraints. It is a long process. Unless you invent a non-interference based system, you need to wait for ITU's decision to get the frequency. Even if US government gives pressure to ITU, it means little or even nothing because there are countries which are not affected by US pressure like China, Russia and Iran.

6. *How strong is the demand for Space industry induced the investment in the area?*

Not so strong, some are dream projects and to make a major breakthrough, you need to consider the demand market. In telecom industry, there are 5% of the industries who wants to use satellite services. Netherland use cables for the internet, so they do not need satellites.

Every countries have different views and demand in the space industry. Telecom industry is growing and then so do the demand for satellites, but it is not exploding. One Web said that it will give internet for everybody. But, does everybody want to use internet? Does everybody have money to pay the service? How many potential customers are there? In space area you need to consider the cost and the price offered to final customers. Since it is still high, it is hard to make the notion "internet for everybody" come true.

7. *What kind of concern or factor makes you believe that in the next five years this euphoria will only be a bubble and companies like SpaceX, Planet Labs or One Web will come to at least economic failure?*

a. Technical and Cost

Will the technology matured at the designated deadline time? Will the money be enough to afford all of that? Do we have enough launchers to launch 1000 satellites? How long? Is it visible to launch 1000 satellites in the next two or five years? Do we have launchers specialized to launch small satellites?

b. Legal Aspect

The need to get authorization from hundreds of nations, the permission from ITU to use frequency, and many more.

c. The Market

If you launch the system, how long does it take to get the minimum amount of customers to be considered as a business? It will be a bubble, but the time, when it will be appear is hard to predict. It might appear in the next 2 years or 10 years, nobody knows. It is better to be specialist in the space industry and growing step by step, serving niche market using small satellites, special antennas, creating small satellites launchers, etc.

Interview with Jean-Pierre Noté

Jean-Pierre Noté is the co-founder and the manager of Energence, a consulting company for the space and telecom industry with a special focus on contract negotiation. He is also a giving lectures at Toulouse Business School and in other schools such as the CNAM (Centre National des Arts et Métiers).

1. *There is a growing interest in the satellite industry. The space company investment activity went from $82M in 2012 to $1,167 in 2015* [These figures according to J.-P. Noté are highly underestimated]. *What reasons (drivers) do you believe there are behind this infatuation? How can an activity with such long-term profitability attract some much capital?*

There are still numerous regions in the world that are not connected: for instance, large portions of the African landmass are still "white" regions representing a significant number of inhabitants (with an impressive growth rate). Also, one cannot connect when travelling over oceans and deserts or semi desert regions; however, more and more people are travelling through those regions or working there (oil rigs, mining activities, maritime trade, etc …). Thus, the trend is to a worldwide connection without white regions (or "white oceans").

2. *Can we talk in your opinion about "space bubble"? Will in the next 5 years, big project like SpaceX and OneWeb successful? Or will it only be a bubble like their predecessor projects, The Irridium and GlobalStar?*

Globastar and Irridium were conceived more than 25 years ago. They were targeting the same market that the cell phone; and they were overwhelmed by the rapid deployment of the terrestrial cell phone, cheaper and focusing first on very populated areas. Today, the question is totally different: it is no longer a matter of telephony. People, companies, organizations want connection to Internet everywhere on a seamless manner, even in the remote areas. Projects like SpaceX or OneWeb are proposing cheaper solutions, that are global (worldwide) and without any alternate ground solutions.

3. *According to the different sources, the venture investments are mainly put into the projects that are in the very early stage of development (both in biotechnology as well as in space industry), which makes the level of risk of failure higher. According to the CEO of Spire Global Inc., the venture capitalists hold a notion of investing in highly*

proprietary data and data analytics, believing space is the location for generating this information. In your opinion, do you believe there are other certain drivers or specific motivations the venture capitalists put their money in the early stage of the space project?

It is certain that the main motivation is based on the fact that the first company (ies) that will provide a global and cheap access will be the winner. The one that will own the pipes will also control the contents (or at list the flow of the contents) to be provided to billions of humans.

4. *There has been a rapid growth of seedling businesses in space industry, from 125 companies in 2001; the number has increased to 900 by now. Do you consider the number of growing competitors as a risk factor in competition can cause a pricing pressure)?*

The competition is still at the stage of research. It is not a completion in the offer. So, it is a race to see who will establish the first global system and thus who will kill the commercial competition.

5. *In the software industry, which has the leading position in the venture investments, there is a high increase in the demand of customized requirements, therefore companies do try to evolve the methods for differentiating the customer experience (by tracking or establishing specific infrastructure). Now, drawing the parallel with the space industry, do you think there is enough demand for space projects (f.e. satellites) to give reasons to/justify the growing investments in this domain?*

Satellite demand is supported by different vectors: (i) the lifetime of a satellite is around 15 years; thus there is a "natural" demand in order to replace the fleet. (ii) Contents are increasing and satellite operators target to cover the last under equipped regions (Africa). (iii) New global projects are based on very different technologies (instead of geosynchronous satellites, worldwide coverage are requiring LEO satellites) requiring the development of new technologies.

6. *Do you believe that this space activity expansion is temporary or is to remain?*

The universal need for good quality, seamless connection is not a bubble. One of the best ways to answer this need is space. So, the investment in space is a long term necessity to make Internet as easy, evident and cheap than other basic needs (power, water).

7. *Depending on your opinion and believe, whether this space expansion euphoria only be a bubble or not in the next 5 years, What are the factors that make it will be a bubble or not? (example of factors: Technical, Legal, Market, etc)*

See question 6. In addition, I would say that everybody will not win. Just a few technologies will remain viable and we don't know yet which ones: what is the future of the geosynchronous satellites universally used by the historical operators? Who will win the new technologies battle?