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# EUROPEAN SPACE PROGRAMS AND THE DIGITAL CHALLENGE

**Laurence NARDON (ed.)**

November 2017

New Space Program

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# Foreword

**By Jean-Jacques Dordain**

The exploration of space and the use of digital tools and systems have in common to be quite recent in human history but to have changed the world, society and economy in just one generation by connecting people and things, reducing distances, breaking down borders, and redistributing knowledge, power and control.

However, the timing, drivers and paces of these two revolutions have been quite different, preventing until very recently the two from organising synergies and drawing mutual benefits from one another. I have experienced myself a world without space and digital tools, followed by a fantastic decade of space exploration fuelled by competition among the two superpowers of a stable bilateral world, followed by successive waves of digital transformations driven by billions of hungry customers fed by active and successful entrepreneurs which have thus reached an economic dimension comparable to that of countries.

In spite of the continuous development and successes of space activities in the world, pushing the frontiers of knowledge and serving economy and society through new services, space has not been able to catch up with the pace of the exponential digital acceleration. Even if the respective paces will continue to be different, the mutual interests between these two continuing revolutions are such that each has started to support and feed the other – and this is just the beginning!

Indeed, the digital transformation is a fantastic opportunity for space for at least three main reasons on which cooperation between the two is building up: Big Data, design and manufacturing, culture and dynamics.

- Big Data, because digital tools and systems are based upon more and more data collection, storage, exchange and utilisation, and satellites are unique tools for collecting data from anywhere and for distributing it anywhere, including to mobiles. This is one of the reasons for digital companies (notably the GAFA) to invest in space, bringing new resources, new design methods and a new culture.

- Design and manufacturing, because step by step, space is integrating concurrent design methods, deep learning, autonomy for spacecrafts, in-orbit reconfiguration and 3-D manufacturing on the ground and in-space, thus opening perspectives to use space in-situ resources.
- Culture and dynamics, because space is also step-by-step integrating customer-driven decision-making, time-to-market, successive improvements, private investments, risk-taking and failure tolerance.

As a result of these moves, a number of start-ups have grown and flourished in each segment of the value chain of the space-based economy, obviously starting in the Silicon Valley but now in all parts of the world including in Europe, which has been for a long time a leading place for space developments. And this dynamic is not limited to new actors but has extended to well- and long-established space actors which realise the benefits they can draw, including by taking new initiatives and investing in new projects.

As a matter of fact, none of the space sectors (launchers, satellites for observation and telecommunications, space-based services) or regions addressed further in the different chapters can afford not to integrate the above changes.

As far as space sectors are concerned, I wish to address one specific dimension of space activities of great importance for the future: human spaceflight. I have underlined on many occasions the role of astronauts as ambassadors of space for the public and in particular for younger generations. Such role was until recently limited to a large extent to the period when the astronaut was on the ground, but thanks to digital tools and networks, this role is even more essential now when the astronaut is in-orbit, as demonstrated recently by Thomas Pesquet during his flight. Digital entrepreneurs have captured the inspirational power of human spaceflight and are all seeking to open perspectives for a multitude to experience space exploration, resetting the dreams beyond the business.

In a similar manner, no region can stay aside the momentum of "New Space", which started in the Silicon Valley and which is extending more and more for the benefit of providers in many places as well as of space users all over the world. Europe was late at start, for reasons related to the deficit of private investments, the shortage of public markets in space and the absence of large digital actors, but the momentum is there now and I am confident that based on its wealth of talents and diversity, Europe will catch up. This confidence is based on experience since Europe has already demonstrated in space its ability to catch up a delay at start when governments, notably through ESA, and entrepreneurs join forces to share objectives and resources. Actually, despite starting late when the U.S. and the USSR were already competing in flying astronauts and using satellites for observing and communicating, Europe was able to become a leader in many domains of space sciences and space-based services despite public investments which are still much lower than those of the U.S.

The momentum of New Space is irreversible because it has been opening doors and breaking walls between:

- Public and private actors and investors,
- Well-established space companies and New Space entrepreneurs,
- Space industry and non-space industry,
- Space and planet Earth.

Thus joining forces, transforming spectators into actors and extending the economic sphere of Earth into space, and removing the finite character of planet Earth and contributing to its sustainable future.

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## PART II – THE IMPACT ON THE DIFFERENT INDUSTRIAL SECTORS

# Introduction: New Space – When Digital Technology and Space Get Together

**By Laurence Nardon**

In the taxi, hotel or healthcare businesses, the advent of online platforms deeply reorganizes the way customers interact with service providers and product sellers. More broadly, IT actors redefine the business model of these traditional sectors, demanding quicker processes and more private funding (and taking a major part of the profits in the process). We see this happening in the space programs area when American IT actors (Facebook for instance) plan to deploy their own LEO satellite constellations to beam their applications and contents directly to the customer, and extend their reach. We also see the impact of New Space in the modification of the business models at play, as in the case of the new Ariane launcher program, Ariane 6.

In the case of space, however, the digital revolution meets a number of additional, specific features. First, a large number of satellites are gathering data for the IT industry to crunch and exploit. This happens with telecommunication, navigation and observation systems.

Additionally, telecommunication satellites (satcoms) are the very means by which a big chunk of internet content and mobile phone communications travel. The number and nature of future space programs is impacted, their business model is impacted, but indeed, they also are one of the enablers of the digital revolution.

Space is also considered a sector of high strategic value for a number of countries, due to the role it plays in terms of defense, and due to its technological worth. This is why many European governments devote a share of their public budgets for space programs. This is also why there is an element of transatlantic competition in this New Space phenomenon. Europeans must resist the GAFA domination if they want to remain a strong and independent actor of international relations. In order to do so, we must strive to better understand what is going on.

In keeping with its long-standing research effort on space policies, it was very natural that Ifri should try to make sense of the New Space phenomenon, and present the results of its analysis to a large audience. The way we chose to do this was by asking actors and experts to explain what they think are the most important transformations brought by New Space to their specific areas.

It is an honor to start this note with a foreword by Jean-Jacques Dordain, who headed the European Space Agency for 12 years and who is in a unique position to describe and compare the digital and space conquest. The note then starts with a description of the wide-ranging issues raised by the digital revolution for humankind (Julien Nocetti) and with an analysis and history of its impact on space (Steve Bochinger).

The study then addresses the different industrial sectors of space, showing how they are impacted by the New Space phenomenon: launchers and in particular the Ariane 6 program (Guilhem Penent); observation satellites, where a mass market may be appearing at last (Stéphane Janichewski); satcom, where the lion share of space revenues remains to this day (Sebastien Moranta and Matteo Cappella); downstream applications, with the very interesting case of Sigfox, a French startup using satellites for its innovative IoT application (David Fernandez). This first part ends on a sobering note, with a chapter addressing the vulnerability of space architectures to cyber attacks, and what is being done to mitigate the risk (Géraldine Naja and Luca del Monte).

Next, the note turns to geographical perspectives. Jean-Michel Huet and Alejandro Rojas analyze the role satellites play in the vital development of internet and mobile phone access in Africa; Narayan Prasad discusses the impact of New Space on the Indian, Chinese and Japanese space programs, all very different; Joanne Wheeler gives an in-depth description of the renewed British space program, an endeavor that has put the emphasis on trying to adapt the model of the digital world to space; finally, Olivier Sichel advocates for a reinforced French-German effort to develop their digital strength.

It is by choice that we decided that the conclusion of the note would be devoted to a description of the role and responsibilities of the EU in the development of a sustained European space and digital governance. Olivier Lemaitre points the evolution, successes and challenges met by the EU in an area that is key to its future.

# PART I: THE DIGITAL REVOLUTION AND SPACE

# "Talkin' 'Bout a Revolution": Thinking the Digital Era in Global Terms

**By Julien Nocetti**

The digital revolution is one of today's most hotly debated topics in politics, economics and business. Faced with large-scale disruptions in many areas, politicians are considering the type of framework they should put in place, economists ponder productivity increases and trade unions worry about the future of work. Taking all the dimensions of this disruption into account is a necessity.

Today, 3.8 billion people -more than 50% of the Earth's inhabitants- are considered Internet users. Half of those people live in Asia, but the most promising prospects for growth today is in Africa.[1] For the past decade, the center of gravity of the Internet has thus moved towards the East and the South; in other words, it has been removed from the Transatlantic "bubble" from which it emerged and thrived.[2]

## Far-reaching consequences

The plummeting cost of digital technologies means that the world around us is becoming ever more connected. In 2005, there were 500 million devices connected to the Internet; today there are 8 billion. By 2030, it is estimated that there will be one trillion. Unsurprisingly, digitalization brings about large-scale and sweeping transformations across multiple aspects of business, providing unparalleled opportunities for value creation and capture, while also representing a major source of risk for traditional actors. The democratization of technology, increased access to funds and a rising entrepreneurial culture means that there are now hundreds of startups attacking traditional markets. Uber threatens the old taxi business, Airbnb threatens the hotel business, Netflix threatens the movie

1. Figures extracted from InternetWorldStat. Data as of June 2017.
2. J. Nocetti, "Puissances émergentes et internet : vers une troisième voie ?", *Politique étrangère*, No. 4, 2014, pp. 43-55. On Africa specifically, see J. Manyika, A. Cabral, L. Moodley, *et al.*, *Lions Go Digital: The Internet's Transformative Potential in Africa*, McKinsey, November 2013.

business, Tesla challenges car manufacturers, and social network apps such as WhatsApp and Snapchat change the way we interact with other people. All these companies, and many others in virtually all economic sectors, are achieving scale far quicker than analog companies ever did.

The digital era is based on an exponential growth of information and analysis: more data, coming from increasingly diverse sources, processed more and more rapidly by increasingly efficient algorithms. The convergence between the economy of data, robotics, the Internet of things (IoT) and artificial intelligence gives rise to a "fourth industrial revolution", that will disrupt not only the global economy, but also most social interactions.

Consequences of the digital revolution are tangible and multiple. In the United States, capital and talents are turning away from Wall Street to converge to the Silicon Valley and Boston. General Electrics, for instance, is disengaging from finance to reinvest the digital industry. The market capitalization of the "GAFA"[3] passes $800 billion, approximately equal to the GDP of Pakistan.[4]

The digital revolution affects every economic sector and blurs the lines between industry and services. It is universal, unfolding fast and in real-time. New frontiers are no longer in the technology but in all areas of human life. The consequences are economic, with the disruption of traditional development models which are moving to the consumers and vendors to the detriment of producers. Consequences are social, with the likely disappearance of half of existing jobs by 2030 and the erosion of traditional employment modes. Consequences are legal, with the questions raised by the ownership, protection and modalities of personal data exploitation. Consequences are political, with governments unable to regulate and collect taxes on digital platforms. Consequences are geostrategic, with the domination of the digital economy by the U.S. and China, and the loss by other nations of their sovereignty, as the worldwide electronic surveillance set up by the National Security Agency (NSA) demonstrated. Finally, consequences are ethical, with the multiplication of initiatives to modify or "augment" human bodies by acting on their gene pool and performing connected transplants.

3. The acronym refers to Google, Apple, Facebook and Amazon. The "M" of Microsoft is sometimes added.
4. Calculation made by the author based on data extracted from the International Monetary Fund's website.

## The three ages of the digital revolution

The digital revolution impacts the whole economy as well as all institutions, companies and individuals. Most people are struggling to get a firm grip on the subject, however. "Digital revolution" already seems an outdated term since we have been hearing of it for the past two decades. Indeed, the 2000's are the decade when we witnessed the tremendous rise in Internet access throughout the world, the emergence of new platforms that are now part of our daily lives (Google, YouTube, Amazon, Facebook, etc.), and the invention of smartphones – which disrupted connectivity and habits. Still, the digital revolution may remain in its infancy yet. Maybe we have an incomplete idea of its magnitude so far.

The "first age" of the digital revolution witnesses the acceleration of innovations, as described by Moore's law. Capital surges to allow startups to get global as fast as possible and secure an advantageous global market share. This is a "do or die" age, in which traditional economic actors struggle to adapt, less they disappear. Governments and institutions are increasingly overwhelmed by social and economic dynamics that question their efficiency, power and legitimacy.

The United-States and China seem to be the winners of this first phase, taking away a significant part of economic value from the rest of the world. In such a massively capital-fed economy, digital platforms manage to concentrate high levels of wealth while Western middle-classes are getting significantly poorer. Schumpeter is no king in the digital world: the distribution of wealth that comes after a process of destruction does not seem any to apply anymore.

Furthermore, the destruction of traditional jobs by digital applications is of immense magnitude – the most pessimistic estimations consider that by 2050 about 42% of U.S. jobs will have been destroyed. Unemployed people will not all become robotic engineers or service technicians as these jobs will be automated. Critics of classical economics, such as Jeremy Rifkin, talk about the need to devolve capital by facilitating the emergence of a citizens' revolution; a necessity also pushed by ecological constraints.[5]

As a consequence, the "second age" of the digital revolution may be less capitalist than the first one. Indeed, it may be a "commons" era of digital services, stemming from a new technological generation. "Open source", a technology that promotes universal access *via* an open-source or free license to a product's design or blueprint, and "fab labs", small-scale

5. J. Rifkin, *The Zero Marginal Cost Society: The Internet of Things, the Collaborative Commons, and the Eclipse of Capitalism*, New York: Palgrave Macmillan, 2014.

workshops offering (personal) digital fabrication, represent the avant-garde. Other technologies – also open – are likely to appear. Recent innovations such as blockchain are revolutionary: beyond being open source, they are also distributed, that is, the property of a service platform can be handed over to the community with no possibility of predation. These technologies might allow the emergence of a new era for civil society; they allow the introduction of very high levels of trust in all types of transactions – be they market-oriented or social. They might be at the heart of a new human ecology – at the heart therefore of Rifkin's circular economy.

But the ultimate age of the digital revolution may well be that of a "great choice" for humankind. Machines are playing an increasingly significant role in our lives. A major anthropological disruption is at play,[6] as we become more and more dependent on machines. By 2035 – maybe before – the tremendous development of AI may transform humans into subordinates of machines.

Careful consideration of the role we want to give machines is necessary. Machines can liberate individuals from Taylorism and help them to ward off Malthusian nightmares (we will need to feed 11 billion humans in 2050); on a different level, they can also bring us to explore new consciousness horizons with the victory of the (chilling) vision of transhumanists and/or the submission of humankind to robots. That choice could well be imposed if we let innovation happen without any debate about the direction it is taking.

This choice between two futures will bring us to either embrace the 20th century nihilist thinking, revolving around mechanization, objectivism and the consequence of reductionism; or exacerbate the poetic singularity of humankind.

## A challenge for democracy

In the beginning, public opinion was motivated by Twitter, Facebook or the petition platform Change.org. It wanted to be heard, to take a larger part in the political life of their country and even jostle institutions.[7] Barack Obama, Bernie Sanders and Donald Trump, as well as Beppe Grillo in Italy have felt the importance of online communication for politics, and have used digital technologies to impose themselves. The result of the U.S.

6. P. Beckouche, "La révolution numérique est-elle un tournant anthropologique ?", *Le Débat*, Vol. 193, No. 1, 2017, pp. 153-166.
7. J. Nocetti, "Le pouvoir de l'algorithme : Internet et démocratie font-ils bon ménage ?", *in* T. de Montbrial and D. David, *RAMSES 2016. Climat, une nouvelle chance ?*, Paris: Ifri/Dunod, 2015.

presidential election and the right-wing caucus in France in 2016 were due to online meddlings. The digital revolution also has political consequences – but how exactly is it altering democracy?

First and foremost, digital technologies contribute to make post-World War II-inherited political parties obsolete. Beyond that, digital politics question the very concept of democracy and of a social compact. Born alongside the industrial revolution, the welfare state no longer matches the "cybernetic imaginary" which dominates today's minds around the ideal of a "governance by numbers" – in other words, we are passing from the idea of the "subordination" of individuals to that of their "programming".[8]

Generally speaking, the fear of a large-scale "uberisation" of politics, leading to a loss of control over democratic processes is popular amongst political and media elites. Added to this is the feeling that democracies are undermined by populism and the destabilization of the middle classes as well as the pace and scope of the digital revolution, and that this is deeply irreconcilable with the traditional pace of social debates, and of the elaboration of decisions and laws by state institutions.[9]

# Challenges for security

Unsurprisingly, the digital revolution has a far broader impact than strict socioeconomic consequences.

## *Countering cyber threats*

A major issue relates to cyber threats – as our dependence on the Internet continues to increase, the scope and severity of security challenges and vulnerabilities will only intensify. Responses to date have been thoroughly insufficient and the costs are escalating. Cyberattacks and cybercrime will shape the Internet and our relationship to it. Misinformed or disproportionate government responses will threaten freedoms, and contribute to a climate of fear and uncertainty. The scale of cyberattacks is steadily growing, and many anticipate the likelihood of catastrophic cyberattacks in the future.[10]

8. A. Supiot, *Governance by Numbers: The Making of a Legal Model of Allegiance*, Oxford: Hart Publishing, 2017.
9. J. Lanier, *Who Owns the Future?*, New York: Simon & Schuster, 2013.
10. J. Wirtz, "The Cyber Pearl Harbor", *Intelligence and National Security*, Vol. 32, No. 6, 2017, pp. 758-767.

As the Internet becomes intertwined with national security, cyber offense and defense strategies will shape the future Internet for industry and individual users alike. Cyberspace is now considered the fifth domain of warfare by most developed countries, but there are few agreed rules of engagement. Conflicts will be initiated not only by nation states, but also by their surrogates, and by independent political movements and private actors. Acts of cyber conflict will be coupled with disinformation and propaganda to destabilize states and economies. Recent cyberattacks that appear to be designed to destabilize political systems are especially alarming and point to a future in which undermining governance structures, and therefore the values that they stand for, will become more commonplace.

As the digital network becomes intertwined with everything from lights bulbs to health care to cars, users are increasingly vulnerable to cyberattacks. Today's narrow approach to critical infrastructure protection will be ineffective in a hyper-connected society and economy where all digital infrastructures will be critical. Business models will depend more and more on data sources and on interconnected data and its analysis, creating more attack vectors. If "data is the new oil"[11], then the growing market for hacking and data theft puts the foundation of our economy at risk.

Efforts to develop new norms of behavior, legal frameworks or even treaties will accelerate over the coming years, as governments try to address the dizzying array of challenges in cyberspace. The pressure to put "rules of the road" in place will continue, but it is unclear whether governments will prioritize cross-border cooperation over national sovereignty and security.

The long-discussed need for a global culture of cybersecurity will take on new relevance and urgency as cybersecurity becomes the responsibility of everyone. From financial markets to elections to health care provision, no system will be immune to cyberattacks and cybercrime in the future. The idea that "the network is only as strong as its weakest link" takes on new meaning in a hyperconnected world, where an individual's connected devices can undermine most critical infrastructure. The Dyn attack in 2016 demonstrated how a simple connected device can be used as part of a botnet to attack critical infrastructure.[12]

11. "The World's Most Valuable Resource Is No Longer Oil, But Data", *The Economist*, 6 May 2017.
12. The Dyn cyberattack took place on October 21, 2016 and involved multiple denial-of-service attacks targeting systems operated by Domain Name System provider Dyn, which caused major Internet platforms and services to be unavailable to large swathes of users in Europe and North America.

## *Protecting users' rights online*

A second crucial issue deals with personal freedom and rights. As the scope and severity of cyber threats intensifies, and as global Internet platforms are used to deliberately spread disinformation, users will lose trust in the Internet. Advanced deployments of AI and IoT will result in the generation and collection of enormous amounts of information about individuals that can be analyzed in ways that are deeply personal and that will raise the potential for a "surveillance society" to emerge.[13]

All governments are under increasing political, economic and social pressure to respond to cyber threats, terrorism and violent behavior online. Measures that may be intended to secure cyberspace will increasingly undermine personal freedoms and rights – as showed the long standoff between Apple and the Federal Bureau of Investigation (FBI) in late 2015-early 2016.[14]

By and large, data encryption holds a prominent place among the key problems of the modern world. The tension between the supreme interests of the state and the popular demand for privacy has come to a head. Such a debate used to help make a distinction between democratic and authoritarian states. But this seems increasingly moot, as Western countries faced by terrorism threats have passed laws that threaten web data privacy. In the United Kingdom, data encryption is central to a provision of an extremely controversial intelligence reform bill. In 2015 the French government supported the introduction of a web traffic tracking system. Similar debates are taking place in Germany.[15]

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The Internet has profoundly shaped our world and has changed our lives in both big and small ways. The technology change around us has happened both quickly and imperceptibly. The very first connections

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The groups Anonymous and New World Hackers claimed responsibility for the attack, but scant evidence was provided.

13. See – with different perspectives – B. Schneier, *Data and Goliath: The Hidden Battles to Collect Your Data and Control Your World*, New York: W.W. Norton & Co, 2015; and S. Zuboff, *Master or slave? The Fight for the Soul of our Information Civilization*, New York: Public Affairs, to be published in 2018.

14. In February of 2016, a U.S. federal judge ordered Apple to help the FBI hack into the iPhone owned by one of the shooters in the December 2015 attacks in San Bernardino. Apple refused. The tug-of-war between the firm and the U.S. government quickly became a symbol of political struggles in many countries - between governments fighting for access to certain data they need in order to track down terrorist activities, and major tech companies that had started implementing data encryption technology. See H. Farrell, "Called Out: The Global Consequences of Apple's Fight with the FBI", *ForeignAffairs.com*, 7 March 2016.

15. For an overview of the surveillance legislations passed in Europe, see A. Lubin, "A New Era of Mass Surveillance Is Emerging across Europe", JustSecurity.org, 9 January 2017.

between computers nearly fifty years ago have given way to a wave of connectivity that covers the planet. New devices and innovations have given us more ways to harness the power of connectivity wherever we go and have given us functionalities we could never have imagined.

The tremendous development of the digital economy seems to be the best antidote to Malthusian forecasts which postulate an ineluctable slowing down of economic growth and increases in productivity. A new digital era is now opened by the convergence between computing, nanoscience and biology. IT, after the age of calculation and the age of networks, enters the age of data thanks to the possibility of storage on the cloud, of their access with open data, and of their mass processing with big data.

But similar to other technological revolutions, the digital era is about means and not ends. The risks it holds are proportional to its promises. Expanded powers of communication and information-sharing, increased capabilities for existing technologies, and the advent of new technology bring with them opportunities as well as challenges. The digital revolution ushers in a new age of mass surveillance, generating a range of new civil and human rights issues. Reliability of data becomes an issue as information can easily be replicated, but not easily verified. Last but not least, advances in artificial intelligence and machine-learning will transform the world with such speed that society will struggle to address crucial ethical considerations and economic consequences.

# New Space and the Transitional Phase of the Space Sector

**By Steve Bochinger**

## A new paradigm

New Space is a new paradigm in the space industry. Long considered a conservative sector dominated by governments and large aerospace and defense industries, the space sector is currently experiencing a remarkable transformation, as a result of several factors disrupting its traditional environment and players.

There is no single, official definition of New Space which can be understood in limited terms. Broadly, it usually refers to the phenomenon in which entrepreneurs take initiatives aiming at revolutionizing the traditional space sector through the introduction of innovative technologies, business models, and solutions. Their efforts are universally underpinned by the same stated goal: make space activities more accessible, affordable and profitable. In doing so, traditional business models are often challenged and disrupted.

New Space is a specific term used in the space industry, sometimes also referred to as "Space 4.0" or "Open Space". But it is more correctly seen in a wider context of *disruptive innovations* across industries, whereby digitization impacts products, processes and business models, with notable examples including Apple with the music industry, Tesla with the car industry, Uber with the taxi/vehicle transport industry, and others. Today, the advances in artificial intelligence and robotization are further accelerating this phenomenon and supporting its rapid spread across many sectors around the world.

Viewed through this lens, space is not an exception or an outlier; rather, New Space is merely this same disruptive phenomenon taking place in the specific context of the space sector.

## The genesis of New Space

The U.S. private sector's interest in the space industry is not recent. Proposals from the private sector to develop alternatives to large government space programs were numerous after the lunar odyssey. They shared common features, such as being led by visionary space enthusiasts and possessing enough capital to enable the financing of a demonstration phase, most often on a limited scale. The rationale for these initiatives was the simplicity, effectiveness – and often, thriftiness – of a private start-up approach, compared to the complexity and cost of administrations such as the Department of Defense (DoD), NASA, and their large prime contractors from the military/defense industry that had very little interest in proposing more cost-effective solutions. Despite their objective of offering efficient alternative solutions, most of these initiatives relied on limited technological and industrial bases which could not match the complex requirements of the space sector. Therefore, the vast majority were unable to pass the demonstration phase, with projects often remaining stuck on the drawing board.

In the last two decades, however, the continuous effort of the U.S. government to favor the emergence of a strong commercial space sector has stimulated the development of New Space. Two sectors, Earth Observation and Manned Spaceflight, provide prominent examples:

- In the Earth Observation sector, the U.S. government, under both Democrat and Republican Administrations, adopted several regulations aiming at ensuring priority usage of commercial remote sensing data from government users. Following the 1992 Land Remote Sensing Policy Act, Lockheed Martin, Ball Aerospace and Orbital Sciences Corp. funded the first commercial high-resolution optical Earth observation systems based on DoD contracts. In 2003, the Commercial Remote Sensing Policy resulted in the Clearview, followed by the Nextview, contracts, a “take-or-pay” model in which the U.S. Government guaranteed a minimum level of funding to the two commercial data providers Digital Globe and GeoEye—who have since merged due to government budget reductions, highlighting the fragility of the commercial remote sensing industry and its dependence on the government market. More recent examples include the National Geospatial-Intelligence Agency’s (NGA) CIBORG new procurement program targeting data acquisition from emerging commercial providers and aiming at leveraging the flow of satellite data being available from new commercial satellite constellations.

- In 2003, the Shuttle accident pushed NASA to reconsider its strategy regarding Manned Spaceflight. It led to the discontinuation of the Shuttle program and the decision to externalize cargo – and ultimately crew – services to the International Space Station to the private sector. As part of the Commercial Orbital Transportation (COTS) program, two Commercial Resupply Services (CRS) contracts were won by SpaceX and Orbital ATK in 2008, which to date have launched a total of 17 resupply missions to the ISS. The program was extended in 2016, with the qualification of a third company, Sierra Nevada Corp. NASA initiated the Commercial Crew (CCDev) program in 2010, which will enable Boeing and SpaceX to also provide crew transportation services to the ISS. With RS and CCDev, NASA and its commercial partners have successfully demonstrated so far how to innovate faster by spending less.

## A new ecosystem taking shape

New Space's entrepreneurship is linked to the Silicon Valley spirit, start-up ecosystem, incremental innovation and unique financing capability. It is often associated with Space-X and its iconic CEO Elon Musk who pioneered the New Space movement in the early 2000s by shaking up market rules in one of the most conservative business, the launch business.

Venture capital is concentrated in Silicon Valley, where private investors' appetite for space has become strong. This interest is less driven by a sudden attraction for space by itself than by the promises of the huge data flow that would be generated by new ventures creating additional opportunities in the big data market. In addition, the proximity and interest of digital giants Google, Facebook, Apple and Amazon for space ventures (even investing in some of them), as well as the growing interconnections between the digital and the space worlds, created a new exposition for space-based solutions that have become more "bankable" than before. However, the risk of a speculative bubble exists, as a significant proportion of the funds available for New Space companies are from inexperienced investors betting on fragile business plans.

Today, New Space goes far beyond the Silicon-Valley; the last five years have seen a proliferation of start-ups and projects in all kinds of domains and applications.

Two categories of ventures shall be considered:

- Companies aiming at launching constellations of small satellites for Earth observation or telecommunication solutions. As of today, over 40 projects can be counted, planning to launch several hundred to thousands of small satellites with the objective of providing global connectivity from a single system (satellite communications), high-frequency change detection (Earth Observation), and/or establish connectivity between devices and vehicles (Internet-of-Things/ Machine-to-Machine). These satellite constellation projects have in turn spurred the development of several small satellite launcher projects dedicated to serve this potential new market.[16]
- Projects aiming at opening new markets currently unserved by commercial solutions, such as space tourism, suborbital flights, in-orbit servicing, space debris removal, space resource exploitation and mining, etc. These projects are based on new and high-tech solutions and remain in the demonstration or concept phase.

### Table 1 – Dynamism and diversity of this New Space environment

| A SAMPLE OF NEWSPACE COMPANIES (List not exhaustive) |
|---|
| **TELECOM** |
| **Oneweb (U.S./UK) – Leosat (U.S./UK) – Casic (China) – Laser Light (U.S./UK) – Karousel (U.S.) – Kymeta (U.S.) – Xinwei (China) – Magpie Bridge (China) – Outernet (U.S.) – SkyFi (Israel) – Phasor (U.S.) ...** |
| **EARTH OBSERVATION & INFORMATION** |
| **Planet (U.S.) – Planet IQ (U.S.) – UrtheCast (Canada) – Satellogic (U.S.) – Blacksky (U.S.) – Astro Digital (U.S.) – Iceye (Finland) – GeoOptics (U.S.) – Axelspace (Japan) - Hera (U.S.) – Aistech Space (Spain) – Capella (U.S.) – EightyLEO (Germany) – Fleet (Australia) – Northstar (Canada) ....** |

16. In the 1990s, as commercial satellite markets emerged (especially for communications and broadcasting), similar initiatives aimed at launching satellite constellations (Ellipso, Teledesic, Skybridge...), which generated the interest from several investors to develop dedicated new launch solutions (Rotary Rocket, Kistler RocketPlane, etc.). Only three constellations were successfully funded and launched (Iridium, Globalstar, Orbcomm) while launchers projects did not materialize.

| ACCESS TO SPACE |
| --- |
| **SpaceX (U.S.) – Blue Origin (U.S.) – Rocketlab (New Zealand) – Virgin Galactic (U.S./UK) – Zero2Infinity (Spain) – Generation2 Orbit (U.S.) – Vector Space Systems (U.S.) – Orbital Express (UK) – Land Space (China) – PLD Space (Spain) ...** |
| **MANNED SPACEFLIGHT AND SPACE EXPLORATION** |
| **Bigelow Aerospace (U.S.) – Ispace (Luxembourg) – Deep Space Industries (U.S./Luxembourg) – Planetary Resources (U.S.) – Moon Express (U.S.) – Made In Space (U.S.)** |

## Disruptive market effects

Even though most of the projects carried out by these new companies are still in early development and many of them are unlikely to reach their full operational phase, they are already having a considerable impact on the space sector's value chain, both upstream and downstream.

Looking upstream, more than 6,200 small satellites are expected to be launched in the next 10 years, driven by the roll-out of satellite constellations, accounting for 70% of these satellites. In comparison, during the last decade "only" 890 smallsats were launched. According to our most recent forecasts, future smallsat launches should include over 1,100 satellites for Earth observation projects (including 970 for four companies: Planet, DigitalGlobe, Spire and BlackSky) and close to 3,100 satellites for broadband communications projects (including the OneWeb, SpaceX, and Telesat Ka/V band constellations). While these numbers largely depend on successful financing of current projects, they drastically change the traditional satellite development process from design to operation.

Manufacturers are now planning mass production of small satellites for constellations with more automation in assembly and testing with faster production cycles. For example, Airbus is committed to manufacture one satellite every 8 hours for the OneWeb constellation. More generally, satellite manufacturers are investing in their production facilities in order to maximize profitability and adapt to customers' requirements in terms of price and time delivery. The current revolution taking place in manufacturing processes across industries worldwide brought about by advanced technologies such as automated manufacturing, digitally-enabled production, artificial intelligence, virtual/augmented reality and 3D/4D printing offer significant potential for manufacturers to adapt themselves to this rapidly-evolving market environment.

On the other hand, several new private entities are entering the industry to capitalize on the demand for small satellites with Commercial Off-The-Shelf (COTS) equipment, bringing down cost and development times, based on their heritage in the academic and research domain with cubesats, nanosats and microsats. A dozen new small satellite manufacturers have appeared in the market offering alternative production models for constellations (Clyde Space, Dauria, Berlin Space Technologies, etc.). They are themselves part of this New Space environment.

Looking downstream, the promising massive volumes of capacity supply brought by these projects and their global (or near-global) coverage are pushing historical satellite operators to rethink their business strategy. In the satellite communication domain, planned broadband constellations would add upwards of 40 Terabits per second (Tbps) of supply in the market – for comparison, current capacity stands at slightly over 1 Tbps! With current market shifts from traditional broadcast to data-driven and mobile applications, and the resulting significant price decline in the satcom capacity lease market, several historical satellite operators have integrated satellite constellations in their development plans (e.g. Telesat), engaged in partnerships with future projects (e.g. Intelsat with Oneweb) or have acquired new ventures (e.g. SES with O3B). The same story can be seen in the Earth Observation sector, where new constellations are generating massive amounts of data, significantly affecting prices and driving commercial players to focus on information services through investment on data analytics, artificial intelligence and more generally Big Data, rather than raw data sales.

## Opening space to unlock business opportunities

New Space entrepreneurs share a common goal: make space solutions more affordable, accessible and profitable. To do so, they must unlock new market opportunities. Broadband constellations aim at enlarging the satellite-addressable market for global connectivity, especially in unserved areas. Earth observation projects look to finally open a true commercial market for geo-information services which has been long to emerge. New launch ventures have the objective to drastically reduce the cost of access to space. In the field of space exploration, new companies consider the creation of brand-new markets, such as the extraction of planetary resources through cooperation with space agencies' programs.

To do so, they rely to the maximum extent possible on COTS and non-space-specific technologies and processes, with a strong influence from the software industry in a traditional hardware-driven industry. They also accept higher risk levels to bring costs down, while traditionally, the space industry has been driven by a high quality, high cost, low risk approach. Unlocking these business opportunities will not be an easy task as many factors will come into play for their successful deployment and introduction. No one can predict how many and which of them will be successful. However, if even only a few of the many proposed projects materialize, this movement will have a lasting impact by opening up new markets for space-based solutions and transforming the way stakeholders conceive their business.

# PART II: THE IMPACT ON THE DIFFERENT INDUSTRIAL SECTORS

# Ariane 6: Europe's Adaptations to the New Rocket Equation

**By Guilhem Penent**

The story of the Ariane 6 launcher has taken on a mythic quality in the mind of Europeans. Indeed, it is somewhat reminiscent of the Symphonie's episode of the 1970's, when the U.S. reluctance to launch a French/German telecommunication satellite set in motion the emergence of Ariane, the European rocket family. Today, the birth of Ariane 6 is triggered to that of the California-based company SpaceX.

Notwithstanding the important efforts already made by Europeans, concerns of falling behind or going against the tide have grown in the face of fierce competition and continued innovation. Are Europeans willing or able to keep pace with the rapidly evolving launcher sector?[17] At that stage, there are basically two approaches: either to keep committed to finishing what has been started, even if the outcome seems modest in view of coming issues; or put everything back into question so as to go further and faster but without a complete certainty on the soundness of the adopted model.

Facing the dilemma of an accelerating "SpaceX-ization", Europeans have chosen caution and discipline over inconsistency.

Still, one cannot help but notice the contrast with the U.S., where representations of Europe's efforts to stay in the game are called obsolete before Ariane 6 has even started. Europe's failure to take into account the advent of the so-called twenty-first century commercial space imperative – which supposedly traces a dividing line between "old rockets", as symbols of power and prestige, and "new launchers", more openly money-oriented – will only lead to an impasse.

Americans naturally tend to believe their own advertising, but different contexts provide different answers. This chapter tries to provide a more balanced and contextual portrayal of Ariane 6's challenges and responses. To do so, it focuses on the known factors explaining the success met by SpaceX (deliberately setting apart the limits of the model). It then

17. See G. Penent, *L'Europe spatiale : le déclin ou le sursaut*, Paris: Argos, 2014.

puts into perspective the choice Europe had to make between what it should emulate and what it should keep aside.

## SpaceX's business case

During a congress of space experts held in 2006 in Washington, an unknown person took the floor, much to the amusement of the audience: "Hello everyone, my name is Elon Musk. I am the founder of SpaceX. In five years, you will be dead."[18] Four years later, in 2010, Falcon 9 lifted off for the first time and Elon Musk doubled down: "In space, June 4th is famous for two reasons, as a failure for Ariane 5 in 1996 and as a success for us today." This time, Musk's statement, though still annoyingly provocative for Europeans, was listened to more carefully. For it became rapidly obvious that SpaceX's aggressive pricing policy and relentless pursuit of upgrades, including promises of strengthened derivative and even reusability, was in the process of accomplishing what many informed observers believed to be impossible: becoming the first privately-funded company – albeit with the technical help and financial support of the U.S. government – to successfully fly a space launcher conceived with a totally different approach than the one traditionally used by the industry.

In the face of the trauma that this (re)discovery of competition causes for Europe, many there find explanations in the personality and involvement of Elon Musk,[19] or in the way that SpaceX uses public subsidies[20]. Yet, though these ingredients are part of the story, it seems not unreasonable to speak of SpaceX as a representative of a larger movement of transformation underway in the space sector and which started in the United States before winning over other parts of the world.

This "New Space", as it is now called, is only the latest incarnation of a trend which was already in the making in the immediate post-cold war period, culminating in the middle 1990s when decisions were taken at the highest levels to combine all forms of public and private investments so as to gain in efficiency. For this reason, the reality that is referred to when using the term is not actually as commercial as claimed. It should also rather be described in the plural since it encompasses at least three levels of transformation:

18. See for instance, D. Gallois, "Elon Musk, cet entrepreneur qui s'invite dans l'aventure spatiale", *Le Monde*, 26 November 2013; D. Gallois, "Le dernier combat d'Ariane", *Le Monde*, 14 September 2014.
19. A. Vance, *Tesla, SpaceX, and the Quest for a Fantastic Future*, New York: HarperCollins, 2015.
20. As put by the then French Prime minister, Manuel Valls in the mission statement he sent to his former minister of Research, Geneviève Fioraso: "French and European leadership [...] is subject to fierce international competition, in particular coming from the United States which supports massively both NASA's scientific programs and private societies' launchers and satellites activities, notably SpaceX, that receive very high public and private investments." See G. Fioraso, *Open Space : l'ouverture comme réponse aux défis de la filière spatiale*, Report to the Prime Minister, July 2016, p. 138.

- New Space as a technological transformation: the space sector that has been for its most part insulated from the digital revolution (Moore's law) is finally catching-up, giving free run to the possibility of doing things "smarter, better, faster and cheaper", as went the NASA mantra of the early 1990s;[21]
- New Space as a business model transformation: in the aftermath of the Columbia accident (2003), both NASA and the Pentagon recognized the need to foster more competition, private investments and innovation into the space industry, in order to lower costs for space access and replace the space shuttle;[22]
- New Space as a societal transformation: as illustrated by the interest for space cultivated by private actors, particularly high-tech billionaires coming (notably) from the GAFA world and bringing with them internet-inspired work practices and renewed world-scale ambitions and means. As put by Xavier Pasco, "in the space world, the figure of the innovative and visionary entrepreneur is gradually replacing those of the scientist and engineer that had marked the first space age".[23]

Indeed, the SpaceX model differs from the traditional model in three important ways:

- SpaceX has found ways to simplify the design of its rocket and to tighten its industrial organization in order to significantly reduce launch costs, thus bringing the U.S. back to the international market – from which it was largely absent due in part to the lack of competitiveness;
- SpaceX relies on a positive, "altruistic" vision for the future of space, presenting the colonization of Mars for the benefit of humanity as its *raison d'être*,[24] hence distinguishing itself from its rivals whose strategy is more business and short-term;
- Last but not least, SpaceX is perfectly adapted to governmental payloads. It can therefore target the lucrative public markets (military missions, cargo launch services, science…), in addition to the commercial one that the Falcon 9's design is aiming at more specifically – incidentally inviting accusations of dumping from frustrated competitors…

21. H. E. McCurdy, *Faster, Better, Cheaper: Low-Cost Innovation in the U.S. Space Program*, Baltimore: Johns Hopkins University Press, 1999.
22. W. Henry Lambright, "Launching Commercial Space: NASA, Cargo, and Policy Innovation," *Space Policy*, Vol. 34, 1 November 2015, pp. 23-31.
23. X. Pasco, *Le nouvel âge spatial. De la Guerre froide au New Space*, Paris: CNRS, 2017, p. 64.
24. "Creating the technology needed to establish life on Mars is and always has been the fundamental goal of SpaceX. If being a public company diminishes that likelihood, then we should not do so until Mars is secure." See A. Vance, *Tesla, SpaceX, and the Quest for a Fantastic Future*, *op. cit.*, p. 377.

## Keeping up with the challenge of low-cost

How does Ariane 6 respond to this new rocket equation? The first parameter or variable of paramount importance is cost reduction. Culturally, this requires a change of mentality of historic proportions, synonymous of a transformation of the production process at the heart of Europe's guaranteed access to space. Indeed, forget the "technology-driven" spirit that has inspired Europe's efforts since the beginning of the Ariane adventure: time has come to develop what is now called a "design-to-cost" launcher, more competitive and therefore better armed to deal with the competition. One way to do so is to take into account the existing technical and industrial heritage rather than to commit to achieve major technological breakthroughs.

The Ariane 6 way to achieve its goal of reducing per-kilogram launch prices by 40-50 percent compared to today's Ariane 5 by the year 2020 is three-fold: through simplified design, streamlined organization, and a new reduced governance.

First, just as SpaceX designed its launchers with commonality and proven technology in mind, Ariane 6 will be based on the existing Vulcain and already in development Vinci engines. It will also be modular and flexible, combining a two-booster medium configuration (62 version) with a more powerful four-booster heavy one (64 version with dual-launch capability), both suited to respond to all types and orbital characteristics of government and commercial missions. What is more, the use of the P120 engine common to both Ariane 6's variants and the upgrade of the Vega small launcher, known as Vega C, will bring economies of scale and a sharing of industrial costs between the programs. Finally, the new launcher will employ 3D-printed parts and will be integrated horizontally, easing the time and cost of production.

Second, Ariane 6's production and launch operations will benefit from a new simplified industrial organization, based on vertical integration, in the spirit of SpaceX's very own strategy of building most of its launchers and engines in-house. This centralized model reduces the number of actors involved and does not fully respect geo-return requirements. Indeed, this was identified as one of the tool needed to achieve maximum efficiency as well as greater flexibility and adaptability to market changes. As President of CNES Jean-Yves Le Gall said of SpaceX in 2014: "At the ground level you have a linoleum-covered floor where they do rocket production and integration; on the next level, with the carpeting, you have the design offices; and on an upper floor you have the sales and marketing team, with the parquet floor. In Europe, we have far too much linoleum."[25] With the merging of Airbus and Safran rocket production's activities and the de facto subsidiarization of Arianespace, Europe created the ArianeGroup (ex-Airbus Safran Launchers), a European champion boasting 8,000 employees and over a dozen plants and research centers.

Third, a new division of responsibility between the industry and governments has been decided. The Ariane 6 program will be launched by the European Space Agency (ESA); in exchange, ArianeGroup will assume most of the risks behind the launcher's design, cost of development and exploitation, and future commercial profitability. To be more specific, the new private-public partnership works on the assumption that public investments in Ariane 6 will be balanced by €400 millions of the industry's own money (almost 10% of the total representing €4 billion), on the one hand, and that European governments will commit to use European launchers only, and in return will no longer help Arianespace balance its books once Ariane 6 definitely succeedes Ariane 5 after 2023 on the other hand. Of course, Ariane 6 being developed right now, the continuation and implementation of the commitment depends largely on the condition that both deadlines and price targets are actually met by the program.

## Normalizing Europe as a space power

This is why the second parameter that needs to be addressed is of a more political nature. It has to do with Europe's own conception of "space power" and more precisely its ability to act collectively. For reasons linked to its political construction, Europe's plea for independence has always been relative rather than absolute. For lack of a true institutional market, based in particular on security and defense needs as in other countries, and without a clear and shared preference regarding its own launchers among its different member states, Europe has always needed to mix long-term aspects of sovereignty (strategic autonomy) with more short-term logics of commerce (Arianespace) as well as cooperation (Soyuz in Guiana) to provide, at very low cost and risk, an access to space "on the cheap". The balance thus established, though successful until now with a 50% share of the open market, can only be precarious. The fact that it implies a high dependence on the outside world and a vulnerability to unforeseen external threats and shocks such as increased competition – as will be the case in the years to come with renewed ambitions coming from the United States, China, Japan, or even India – is problematic.

25. P. B. de Selding, "Le Gall: To Beat SpaceX, Europe Needs to Shed Launch Sector's Excess of Linoleumn," *Space News*, 24 July 2014.

The issue brings two related questions: 1/ How far are Europeans willing to go to support an autonomous space capability when the alternative consists of depending upon the competition on the commercial market?; 2/ How much Europe do Europeans actually need?

The first question deals specifically with SpaceX's somewhat suspicious practice of having heavily paid contracts with U.S. institutions (NASA, DOD, NOAA)[26] and highly competitive prices on the open market, gaining a few customers in European member states. Already at a disadvantage with respect to its competitors because of its low level of government satellites demand, Europe lacks an equivalent of the "Buy American Act", that would state that member states must give priority to European launchers. Only this can restore the famous "fair competition" and "level playing field". Only core customers can give Arianespace the critical mass it so desperately requires to consolidate its launch rates, conquer new export markets and reduce costs, igniting a virtuous circle that would benefit the taxpayers in the end. This is the reason why the industry is telling governments that the business model of Ariane 6 (€70 million or about half of the Ariane 5 current price) needs five guaranteed government launches a year to be viable, as well as 2-3 per year for Vega C, and this based on a real contractual commitment.

In order not to fall back into the old contradictions that have put their model in difficulties in the first place, Europeans need to assume the responsibilities that come with independent access to space. Since the Council asked the European Commission (its executive arm) to "establish a mechanism that would aggregate demand by Union institutional customers for European launch services to ensure a cost-effective and affordable, independent, reliable and autonomous access to space",[27] European preference is no longer a taboo. Indeed, the European Commission is already Arianespace's first institutional client, planning to launch more than 30 satellites for its Galileo and Copernicus programs in the next decade. Yet, meeting this commitment will actually demand arrangements between the EU and the space organizations that are not under its control, such as ESA and Eumetsat. They may find a multi-year guarantee difficult to implement. Member states are also usually reluctant to limit their launcher choices without certainty on the competitiveness of the solutions they are buying, even though they are heavily involved in their development.

26. Peter B. de Selding, "SpaceX Says Requirements, Not Markup, Make Government Missions More Costly," *Space News*, 27 March 2014. Broadly speaking, the advantages of the launch services contracted by the U.S. government are at least two-fold: their prices, quite significant given the volumes; and the fact that they are paid nearly in full at the time of the order.
27. Council of the European Union, 8486/17, Brussels, 11 May 2017, p. 8.

# Transforming Europe's approach

Whether these two important issues have been dealt with successfully will be known at an early stage. Another broader and more long-term element is also at stake, however. The third parameter of relevance in the new rocket equation is societal and deals with the ongoing redefinition of the identity and meaning of the space effort. It is also the most difficult to evaluate. As put by the former French Minister of Research, Geneviève Fioraso, following her mission statement to write a report imagining new "strategies of partnerships and economic models" to develop and diversify the benefits of space[28] : "In order not to be tricked by the idea of a *New Space* implying the abandonment of a form of out-of-date *old space* originated from the post-war boom, [one] needs to defend a less artificial and much deeper transformative approach, one that focuses on an *open space* and takes advantage of the acquired expertise to open up to a new culture."[29] In other words, public authorities must make sure that the European space sector comes up to its real potential without endangering the principle of autonomy or risking its complete takeover by the growing and possibly less controllable information industry.

Bearing in mind the fact that comparisons may be misleading, there are at least three mutually-supportive elements on which Europe can work on to its benefit: resilience, risk acceptance, and ambitions.

The first element is the capacity to recover quickly from difficulties through the willingness to continually rethink and question matters as well as keeping the goal clearly in focus. During its brief history, SpaceX was confronted with three spectacular failures, the last two happening in just over the span of a year with the rocket exploding just after its launch in June 2015 and even still on the launchpad in September 2016. In each case, the company was able to launch again within a few months, even improving the rocket's reliability rating. The current situation that Europe is into with competition looming from every direction beckons such a resilient posture. If the transformations that have been agreed upon are perhaps less extreme than the ones first envisaged, they are nonetheless vulnerable to hesitation or ambiguity. To make their choice viable, both industry and European institutions have to commit to transparency, be it by showing realistic figures or expressing a minimum of goodwill and European solidarity.

28. G. Fioraso, *Open Space*, *op. cit.*, p. 139.
29. *Ibid.*, p. 5.

The second element refers to the so-called "culture of failure" that is allegedly so unique to the "New Space" and in particular SpaceX's way of conducting space activities. In order to achieve routine reuse of first stages in both ground and sea landings, Elon Musk faced 10 failures out of 16 attempts between 2013 and 2016. Since the return to flight of January 2017, 13 successful landings have been performed out of 13 at the time of writing. By contrast, 81 successful Ariane 5 launches in a row might be revealing of an approach that is too risk-averse! Yet, innovation is key, and without risk-acceptance, the probability to move into more technology-disruptive industries is lower. To reduce risk associated with development, validate the technology emerging from the research program and encourage the development of new not-yet-proven applications, Europe – which traditionally places publicly-funded demonstrators at the heart of its strategy of preparation for the future (i.e. the Prometheus engine or Callisto experimental rocket stage) – might try to associate the private sector even more depending on the commercial potential (microlaunchers, suborbital spacecrafts, on-orbit servicing system). Even more so as the other avenue of investments that is worth considering – private funding – remains Europe's Achilles heel, despite some recent success (Softbank-led investments in OneWeb).

The third and final point is the promotion of renewed all-encompassing ambitions, that redefine the place of space in society in the image of what "New Space" is doing right now in the U.S. (SpaceX's projet of a satellite megaconstellation for broadband being an example). The corollary of having European preference for launchers is indeed to have ambitious missions to implement such as Copernicus and Galileo, the very same that have made the European Union the largest institutional customer in Europe, surpassing even member states. Space applications are numerous: from monitoring climate change to better planning policies or implementing a true digital economy. Only by boosting opportunities will innovation follow, such as, for instance, the viability of reusability already achieved by SpaceX and envisaged by ArianeGroup for the next evolution of Ariane 6 (the current announced launch capacity of Ariane 6 from Kourou is 12 launches per year), as well as for other types of launchers. Only by demonstrating the added-value and the necessity to invest in space in support of society and the economy will this vision materialize and a true public-private virtuous "ecosystem" emerge.

# In short

The fact that the overall balance of political and industrial interests in Europe has not been upset despite the changes implemented in the name of increased efficiency is proof that, if it could, Europe would try to continue to work the "old-fashioned" way, with public investments remaining the heart of the matter and autonomy the name of the game. In a way, the arrival of Elon Musk's company in the satellite-launching landscape provided the excuse Europe needed to finally enhance the competitiveness of its launching sector. For sure, time had come for action as Musk himself told the Europeans.[30] No need to engage in more though, and notably add to the now-acknowledged issue of shared "capabilities" between the public and the private sectors, the still open question of parallel "visions", still a monopoly of governments on this side of the Atlantic. This explains why there is no actual European SpaceX coming up in the near future and no desire for one. Ariane 6, should it become reality, would nonetheless be part of the new rocket equation.

*Guilhem Penent is an associate researcher at IFRI. The views presented in this text are those of the author alone and do not represent the positions of the Ministry of Europe and Foreign Affairs.*

30. J. Amos, "SpaceX CEO Elon Musk: Europe's Rocket 'Has No Chance'," *BBC News*, 19 November 2012.

# New Space Developments in the Earth Observation Market

**By Stéphane Janichewski**

Earth Observation (EO) is changing its traditional model to one that may boost its development into the mass market, and would reach everybody in his or her daily life through numerous applications. This evolution is driven by new players, mainly coming from the IT (Information Technology) world, both as investors and suppliers. It is important to understand the drivers behind this change of paradigm, which are fostering this new evolution and are key for the real take-off of this space domain.

## The traditional Earth Observation business case

The development of Earth Observation satellite systems was a real technical challenge. Simply because of the technical difficulties to observe from space (sensor performance, platform stability, flow of data management to be handled, to mention just a few) which require a great amount of capability and developments.

Military and scientific demands have been major drivers in the first age of EO development. Indeed, the pioneer age has seen the following characteristics: race to performance, low consideration for costs, and dedicated exploitation capabilities for each satellite family.

This challenge has been successfully achieved. We have built a sound EO data-user community, including defense, scientific communities, weather forecasting, oceanography as well as public users (i.e. agriculture statistics). This community knows how to handle and process the data and the satellites are specified according to their needs, which is also the case with multipurpose satellites, such as the Copernicus series (i.e. the EU Earth Observation program).

The traditional business case of Earth Observation is therefore fully driven by sovereignty needs (defense, weather forecasting, monitoring natural disasters, land survey, tax collection), with overwhelmingly public funding, very slow cycles (it takes, in general, more than 10 years to develop a new generation of satellites) and one service policy for all, with a great majority of identified users.

## The limits of the traditional Earth Observation business case

Though technically successful and capable of delivering high-level services to its end-users, the traditional EO has its drawbacks. The first one is clear: in terms of the statistics of space application development, the EO domain is clearly lagging behind, compared with satellite communications or navigation.

In fact, Earth Observation remains a discipline targeted at an expert user community, and the real development of mass market applications has so far been somewhat limited. When new applications are developed, they are not used on a regular or recurrent basis, at least not at a level sufficient to sustain the development of the required satellites and corresponding ground segment.

As a consequence, almost all private initiatives developed to exploit existing services would not be able to be developed without large public grants or revenues.

## Why this limited outreach?

This situation may have different explanations.

First of all, access to mass-market end-users requires an intermediation by space applications developers, who do not belong to the so-called "space community". For them, space data is not easy to access and to process, and few actions have ever been taken to make their life easier in this perspective. On the other hand, many key players in the space sector have made huge efforts to develop their offerings downstream in the value chain, where the real value of space developments lies.

However, the process and development of space applications, based on the handling and the fusion of data (what we now call "big data") requires specific skills that can only be found in the IT World. What we're talking about is data cycle management, with specific knowledge about data storage, data process (data analytics), cognitive and Artificial Intelligence capabilities, and data presentation. It is also about combining this data with many other sources, and being fully involved in the data economy and market. These are topics in which a worldwide IT player such as Atos has invested for many years and in which the space industry can clearly benefit. In fact, it is only the combination of space companies' expertise (deep knowledge of the specificity of space data) and IT players' skills (deep knowledge of the data cycle management) that can together overcome this data processing gap between space data producers and potential end users.

The traditional EO business case is mainly driven by "known user requirements". This is, of course, fully legitimate. But on the other hand, space application developers have had no occasion to express their data-centric needs: Which data? How frequently? What possible interaction with the satellite to focus it on interesting points? In other words, the question of how can life be made easier for those consuming the data was never fully discussed until now.

## Data-centric initiatives

New initiatives coming from the United States show a new paradigm. These initiatives are led by IT World players and investors. Their approach is a real breakthrough: they consider satellites as a commodity that produces data. The value of their investment is fully aligned with their expectation to transform data into real outcomes.

Let us look at the characteristics of these new initiatives, which really challenge the traditional EO business case.

First of all, these initiatives, such as Skybox Imaging, Planet Labs or Spire, are led by very young managers (their average age is 27 years and the average age of the project manager is only 33!). These people admit they have no specific skills in the space observation field, but they do not hesitate to get the skills they need from the Earth Observation community, especially the European EO community.

These actors do not come from the Space world, but from the IT World and the Silicon Valley cluster. They have some experience in media and events management and more generally in the "New Economy". For them, EO is not a goal in itself, but merely a mean to provide enriched information to end-users. To illustrate this new paradigm, the acquisition of Skybox Imaging by Google was, above all, motivated by Skybox Imaging's powerful tool to detect changes in images, likely to be combined with databases, networks and behavior analysis.

In other words, these initiatives mainly look for contextual "real-time" elements, coupled with geolocation, in order to bring evidence. The heart of these endeavors is not Space but Big Data. The behavior analysis is essential; it drives what is observed. It is very different from the traditional way in which observation is limited to predictable zones-obvious for Defense purpose, as well as oil research or monitoring natural disasters for instance.

These new investors are not aligned with codes or traditions. They have no patience with complexity and if confronted with too much of it, may look for solutions elsewhere. For instance, monitoring a satellite with a tablet, just as they would monitor a drone, is fully conceivable. In addition, they are not frightened by failure: Planet Labs satellites have only a cost of $20,000, but a lot of them have failed. Still, the objective is to lower their price to $6,000 per unit, thanks to piggy-bag offers. Planet Labs aims to launch 300 satellites with the hope that at least 80 of them will actually work.

In fact, these new investors do not target the same clients as the traditional Earth Observation programs. Their goal is to serve business decision-makers, such as financial analysts, insurers or bankers. These clients are not interested by images but by derived information, which has business value for them.

These new investors know how to communicate. Their mottos are attractive: "Love at first sight", "Open the future" or "Moore's Law in Space" and they know how to attract both good skills and funds. They have even created a trend in the United States to invest in Space (such as Space X). They also know how to leverage innovative funds: the first Spire satellite was funded by a crowdsourcing initiative.

Another characteristic of these new initiatives: they are not purely national. These investors know how to build alliances with European and even Russian partners. For instance, three out of the fleet of Skybox satellites are sold to the Japanese government.

It is also interesting to note that these new initiatives position themselves across the entire value chain. As an illustration, Google provides satellite imagery (Google Earth, Google Maps) and also uses it internally for its analysis services (Google Analytics), acting as an imagery reseller and providing cloud data hosting.

## The creation of space application ecosystem clusters in Europe

There is a real risk for the traditional EO business case, in particular the European one, to be challenged by these new initiatives and consequently to be reduced to niches in the market, such as hyper-resolution for intelligence purpose or climate change monitoring.

Europe realizes it has to rethink its model, in order to mitigate this risk. Indeed, a real commoditization of EO data would mean a marginal role for European initiatives with the risk to discourage public funding, which is increasingly motivated by mass market Return on Investments.

There is now a good level of awareness of this challenge. Evidence of this can be seen in the fact that the European Commission has launched initiatives to deploy easy-to-use Copernicus data platforms on a worldwide scale, based mainly on European IT technology. This initiative is meant to foster the development of space application ecosystem clusters throughout Europe. This is the best way to link the Space World, the IT World, the space applications developers and the potential end-users.

## The future of Earth Observation

At this stage, it is difficult to say if these new initiatives will be successful. At least, we are testing and trying new approaches that pave the way for a real boost in this field.

What is certain is that a pure vertical approach of the EO value chain is not the way to succeed. It does not rely on IT best-of-breed solutions and cuts access to mass-market applications. The key success factor is to develop collaboration between the Space World and the IT World.

New funding sources, beyond the traditional public ones, are also of key importance for the development of this sector. In order to find new funding sources, we must be able to answer the following important question:

Where is the real market, beyond the traditional well-known public users?

In general, more pragmatic approaches that are geared towards end-users' expectations need to be developed. It is also important to create adaptable, agile and reactive systems. No one can predict in advance the real killer applications and the systems have to be scalable and adaptable to the surge of market-use cases.

Just after the tornado in the city of Moore (suburbs of Oklahoma City) on 20 March 2013, crowdsourcing enabled a start-up, called Tomnod, to assess the disaster damage in just one hour. Traditional methods would have taken at least 24 hours. How can we leverage all new sources of available information?

Images have to move to services. Earth Observation systems have to be designed at a minimum cost, and additional customizable performance/services can justify additional specific fees. The service policy has to be frequently revisited to meet market evolution expectations. This way, service developers will remain flexible in their appreciation of the final use of information. All potential needs must be analysed and promising applications must be assessed.

# Conclusion

The future of EO depends on its ability to merge the huge amount of information it collects with other sources, in order to provide business value-added information services.

The coexistence of traditional Earth Observation initiatives, which are adapted to sovereignty uses, and new data-centric initiatives, show that we are entering a new and promising era, likely to extend the reach of EO to many new end-users.

The intermediation of this complex data with potential end-users is key. It needs new initiatives, far from traditional ones, focused on the IT World and big data for business. This new approach will rely on new players, mainly companies from the IT World and the New Economy.

The coming years will be decisive for Earth Observation and its impact on the economy. It is likely that this evolution will pave the way for the creation of a real breakthrough in EO, i.e. the development of a real mass-market.

# The Digital Transformation of the Satcom Sector: between Opportunities and Challenges

**By Sebastien Moranta**
**and Matteo Cappella**

## An exponential growth in the telecommunication sector

Over the last decades Information and Communication Technologies (ICT) have become increasingly pervasive in both the economy and society. Triggered by the introduction of the Internet[31] and the development of ever more powerful and miniaturized computing systems, these technologies have grown to become essential tools for modern social and economic activities, profoundly influencing our daily life and the conduct of business.

This evolution towards the so-called "Digital economy and society" has, first and foremost, been characterized by the introduction, and then adoption, of new technologies by an exponential share of businesses and households. From this standpoint the democratization of Personal Computers and then of the Internet have been instrumental to initiate and boost the on-going transition commonly referred to as the "Digital Revolution".

In developed countries, the digital revolution is now driven by an exponential number of new technologies introduced in the market every year. After the quick adoption of smartphones and wearable devices that created a massive demand for mobility, "Smart" technologies are expected to be the next step toward an increasingly connected ecosystem. Smart cars, Smart homes, Smart factories, Smart cities, Smart grids or Smart health, these technologies are based on advanced computing capabilities such as Artificial Intelligence (AI) and extensively rely on connectivity.

31. The Internet is understood here as the global system of interconnected computer networks that use the Internet protocol suite (TCP/IP) to link devices worldwide.

As the backbone of the digital economy and society, telecommunication infrastructures have been continuously evolving at an incredibly fast pace. In parallel with the rapid development and democratization of ICT, these complex infrastructures have to meet an ever-increasing demand in terms of the number of users, connected devices and bandwidth. While only 16 million people had access to the Internet in 1995 (0.4% of the World population), it is now 3.7 billion people (more than 50% of the World population) that are connected to the network[32]. Accordingly, and further pushed by ever more data-hungry applications, the global internet traffic grew exponentially, from about 100 gygabites (GB) per day in 1992 to 47,500 GB per second in 2017[33]. By 2021 this traffic is expected to double and reach 105,800 GB per second.

### Table 1 – Growth of Global Internet Traffic 1992-2021

| | 1992 | 1997 | 2002 | 2007 | 2016 | 2021 |
|---|---|---|---|---|---|---|
| **Global Internet Traffic** | 100 GB per day | 100 GB per hour | 100 GB per second | 2,000 GB per second | 26,600 GB per second | 105,800 GB per second |

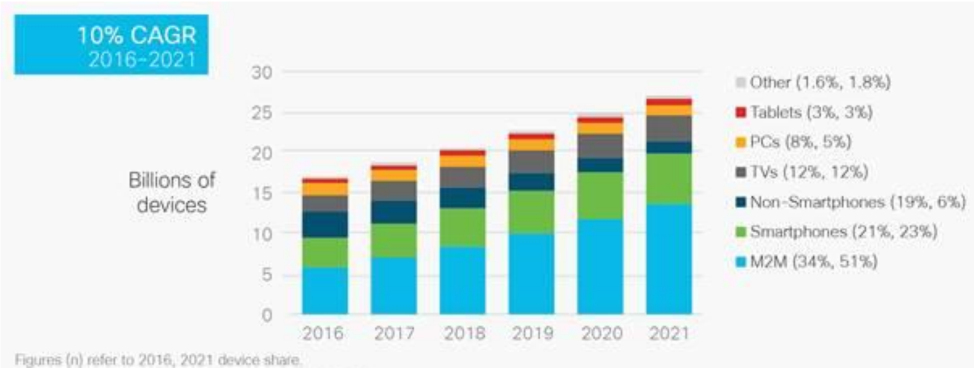
*Source: Cisco statistics.*

In addition to an increasing traffic, telecommunication infrastructures are also challenged by the growing demand for coverage, not only to link more users to the network but also to ensure that users have access to Internet on-the-go, giving way to the paradigm of C*onnectivity, everywhere, all the time*. As a matter of fact, mobile communications are expected be the fastest growing segment of the global IP traffic over the period 2016-2021, reaching a Compound Annual Growth Rate (CAGR) of 46% while fixed internet growth should be in the order of 23%[34].

The Internet traffic also involves a skyrocketing number of connected objects and devices. As pointed out by Cisco “each year, various new devices […] with increased capabilities are introduced and adopted on the market.” Including connected cars, cities, homes but also energy networks to name a few, M2M connections are expected to reach 51% of the total devices and connections by 2021.

32. Internet World Stats: www.internetworldstats.com.
33. “The Zettabyte Era: Trends and Analysis”, Cisco, June 2017, www.cisco.com.
34. *Ibid.*

**Figure 1 – Growth of Global Internet Traffic 1992-2021**




*Source: Cisco Statistics.*

Despite these outstanding developments, connecting the remaining 50% of the World population and providing ever-fast, -reliable, -secure and -mobile access to telecommunication networks and in particular to the Internet is a key objective for both governments and businesses.

For governments, the digitization of the economy and society is a critical component of their strategy to support economic growth and societal inclusion. The importance of access to internet for economic development has been demonstrated in a recent report of the World Bank[35] evaluating that an increase of 10% in broadband penetration would contribute to a 1.21 point increase in Gross Domestic Product (GDP) in developed countries and to 1.38 point increase for developing countries. In addition, access to internet is also essential for societal inclusion in particular at a time where an increasing number of government services are going online and many new commercial services are web-based. Priorities differ from one nation to another according to the maturity of the digital revolution in the country but all governments have put the deployment and upgrade of domestic telecommunication infrastructures at the top of their political agenda. As a matter of fact, bridging the "Digital Divide"[36] is one of the flagship objectives of the European Union Digital Agenda, itself one of the seven pillars of the Europe 2020 Strategy[37]. Based on this framework, the European Union aims to provide access to fast broadband speeds of above 30 Mbps to all European citizens by 2020.

35. M. Minges, "Exploring the Relationship between Broadband and Economic Growth", World Bank, 2016.
36. The OECD defines the "Digital Divide" as "the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access information and communication technologies (ICT) and to their use of the internet for a wide variety of activities".
37. European Commission, Europe 2020 Strategy, February 2015.

Regarding businesses and in particular large ICT corporations such as Google, Facebook or Amazon, unconnected populations are becoming a key target for commercial development as they represent an important growth potential. From this standpoint, supporting and accelerating the digital revolution, including in less developed areas, directly contributes to expanding their accessible markets.

# A strong demand for new satcom products

As an integral component of the information and communication industry, the satellite telecommunication (satcom) sector is naturally impacted by the evolution of consumption patterns arising from the digitization of the economy and society. As ViaSat CEO Mark Dankberg recently underlined, "the way people use the internet and get video entertainment [...] creates the opportunity for a new era".[38] The satcom industry certainly looks at promising new commercial opportunities stemming from developments in ICT technologies but also at considerable challenges to secure their business in the long-run.

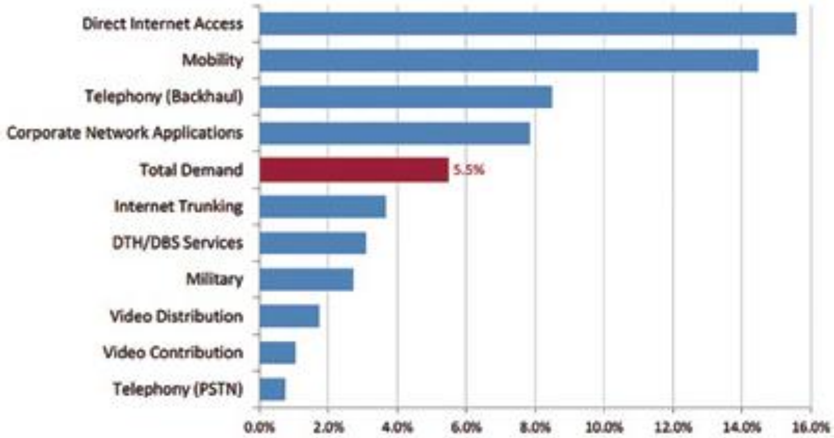
Historically structured around specific markets for which satellites demonstrated operational and cost advantages over terrestrial technologies, the satcom business is confronted with new threats on its core markets: Direct Broadcasting Services (DBS) and Direct-To-Home (DTH)[39]. New technologies and services such as IPTV[40] and Over-The-Top content (OTT) now allow consumers to get media via the Internet, on-demand, and are progressively changing how entertainment is consumed, fueling the so-called interactive media revolution. For the first time, in 2015, more people watched streamed on-demand video at least twice a week than broadcast TV[41]. Business indicators for satellite pay-TV remain green today, and will likely remain so for a few more years, supported by an important subscription growth in developing countries and by the rising demand for HD and 3D channels on mature markets[42]. Various factors, including in particular media rights management, also contribute to slowing down the uptake of alternative solutions but the threats to this vital business segment of the satcom sector in the long run should not be underestimated.

38. M. Holmes, "LEO Constellation Announcements: The Industry Reacts", http://interactive.satellitetoday.com.
39. A. Tobin, "The End of DTH?", *CSI Magazine*, 2014.
40. Internet Protocol Television (IPTV) is the delivery of television content over Internet Protocol (IP) rather than through traditional over-the-air, satellite or cable formats. IPTV services include live television, time-shifted media and video on demand.
41. *Ericsson Mobility Report*, 2015 WRC Edition.
42. Euroconsult/NSR forecasts.

To secure business sustainability in this challenging market landscape, satcom operators are pushed to adjust their offer and seek new business growth engines. From this perspective, the digital revolution also offers business opportunities to satcom operators and a promising environment for the development of two-way broadband satellite solutions.

Until recently, satellites served government and corporate data markets essentially through narrowband communication services but the fast- and ever-growing bandwidth demand from these customers, combined to new consumer markets for Direct Internet Access in the still wide areas poorly covered by terrestrial infrastructure, is paving the way for a growing role for satellites in data networking. The upward satellite bandwidth demand impacts both Fixed and Mobile Satellite Services markets (FSS/MSS). As a matter of fact, recent developments in satellite and user terminal technologies blurred the lines between these traditionally distinct segments[43] and FSS and MSS operators are nowadays moving toward comparable high-speed solutions delivered to smaller and cheaper user terminals. Market forecasts consensually position Broadband and Mobility applications as the fastest growing satcom markets with a CAGR expected to reach 16% and 14% respectively by 2021, well above other core satcom markets such as Direct-To-Home and Direct Broadcasting Services.

**Figure 2 – Demand growth rates by satcom application – Projected CAGR 2012-2021**




*Source: Futron.*

43. O. D. Kurtin, "FSS and MSS: Blurring the Lines", Via Satellite, May 2012.

Satellite broadband market growth is also expected to be boosted by commercial opportunities on new market segments such as In-Flight Connectivity (IFC), which is projected to grow from $700 million in 2015 to nearly $5.4 billion by 2025[44]. Following new consumer habits and expectations for *Connectivity everywhere, all the time*, airlines see the provision of IFC services for passenger experience enhancement as an increasingly important business differentiator. This market, which has been so far rather small, is expected to grow rapidly with the deployment of new technical solutions substantially improving the quality and price of the service. Another much anticipated opportunity for satcom operators lies in the growth of Machine-2-Machine (M2M) connections and bandwidth consumption, itself fostered by the progress of smart technologies across a broad range of sectors from transport to energy. On these emerging markets, satellites have strong value propositions that are expected to support the competitive position of satellite solutions.

Although the satcom industry can expect promising commercial opportunities, stakes are high for operators not only to capture niche and remote markets but also to address financially stable mass markets. From this perspective, the challenge is to fully integrate satellite to the upcoming 5G-infrastructure, as opposed to the current situation where it is just an isolated complement to the 4G terrestrial networks.

Ubiquity, availability and resilience are obvious satellite operational assets which make it a good candidate to become a central element of an integrated hybrid infrastructure meeting the *Connectivity everywhere, all the time* paradigm and supporting the digital transformation. As a matter of fact, satellite features provide specific added value in multiple areas:

- **Coverage inclusiveness:** As already reported by the European Parliament, satellites are instrumental to bridge the digital divide in the European Union[45]. Satellites can provide a cost-effective mean to expand coverage to remote and isolated areas and ensure inclusiveness of access to 5G.
- **Mobility applications:** Satellites also offer valuable advantages for mobility applications requiring a permanent and resilient connection. Space-based solutions are particularly relevant for emerging autonomous and connected transport systems including cars, trucks, ships, trains, airplanes and unmanned aerial vehicles.

44. Euroconsult, “In-Flight Entertainment & Connectivity Prospects”.
45. European Parliament, “Bridging the Digital Divide in the EU”, December 2015.

- **Network backhaul:** Satellites offer efficient solutions for terrestrial networks backhaul (i.e. transport of data from distributed network sites to the network core), in particular for fast-growing cellular networks. Recent technology developments position satellites as an increasingly cost-effective and reliable mean to accommodate growing bandwidth needs and to relieve congestion caused by high data throughput technologies and for disaster recovery overlay networks[46].
- **Infrastructure security:** In the modern digital economy and society, telecommunication infrastructures are more than ever critical and securing access to core networks is a rising strategic concern. In case of an event (natural or man-made) resulting in partial or total interruption of services provided by terrestrial infrastructures, satellites remain unaffected and can provide continuous connectivity both to local institutions, businesses and population and to response teams deployed on site.

In order to develop and successfully deploy satellite services as part of the future 5G-infrastructure, the satcom industry, with the support of public authorities, needs to dedicate specific efforts in the following areas:

- Technology and industrial capacity developments both for space and user segments (i.e. chipset and user terminals) up to demonstration of capabilities: This effort will require a suitable investment plan but fund-raising may prove challenging for satcom operators who are confronted with a downturn on their core markets.
- Optimisation of spectrum use and shared allocation: Given the scarcity of this resource, frequency use must relentlessly be optimized, and it might become a necessity to enter an era of frequency sharing as reported by the FCC.
- Compliance with appropriate standards to ensure interoperability and seamlessly integrate space assets into a hybrid communication mix;
- Establishment of a coherent and consistent licensing framework across Europe to support access to the single market.

To conclude, in the context of the digitization of the economy and society, the satcom sector is confronted with progressive but radical changes in customers' behavior and demand-pushing operators to adjust their positioning and look into new markets, not only for business development but also to secure new revenue sources and mitigate current business downturn.

46. T. Peyla, "Why & How Mobile Operators Embrace Satellite for Backhaul", July 2014.

# ICT actors enter the space business

In this challenging market environment, well-established operators are also confronted with new entrants from the entrepreneurial and ICT sectors whose ambitious mega-constellation projects hold the capacity to profoundly disrupt the satcom competitive landscape from a technical, industrial and business standpoint and to change the dynamic of a business that has, until now, been shared by a handful of large regional operators mostly relying on geostationary satellites.

This emerging competition is rooted in the current structural change faced by the space sector commonly referred to as “New Space”. This rather complex sectorial dynamic is characterized by a series of interrelated disruptive trends driving the sector towards a more business- and service-oriented step. New Space is the outcome of two complementary forces: a sustained governmental effort, in particular in the U.S., to foster the emergence and growth of commercial space activities, combined to a rising interest from private actors, in particular entrepreneurs and large ICT firms, to leverage private and/or public funding to initiate innovative business models and address new markets or existing markets with disruptive solutions. The economic rationale behind the New Space transition is fostered by the digital revolution and by the increasing importance of data for economy and society. In this new paradigm, satellites are increasingly perceived as a unique mean to collect and/or distribute data that can be leveraged within innovative end-to-end commercial service concepts. Last but not least, New Space is also characterized by radically different technical and industrial approaches aiming principally at cutting down costs with the underlying objective to create the conditions either to disrupt existing markets with aggressive pricing, or to address new mass markets.

In the satcom sector more specifically, New Space is often associated to the recent announcement of ambitious plans from a number of insurgent entrepreneurs and ICT companies aiming to offer a global communication service through mega-constellations of smaller satellites in the Low or Medium Earth Orbit (LEO/MEO). The following table provides a list of currently proposed LEO/MEO constellations. By March 2017, FCC applications amounted to more than 18,000 satellites[47], about four times the current number of artificial satellites orbiting Earth.

47. D. Messier, “SpaceX Wants to Launch 12,000 Satellites”, March 2017.

## Table 2 – Planned and current NGSO communications constellations[48]

| Company | Orbit | Freq. band | Main target market | # of Sats | Schedule* | Support | Status |
|---|---|---|---|---|---|---|---|
| OneWeb | LEO/ MEO | Ku, V | Broadband | 720 - 2,720 | 2018 | Intelsat, coop with Airbus | Under development |
| SpaceX | LEO | Ku, V | Broadband | 1,600- 11,943 | by 2022 | Google | Announcement |
| Boeing | LEO | V | Broadband | 147 - 3,103 | by 2022 | Apple (?) | Announcement |
| LeoSat | LEO | Ka | Broadband | 84 - 108 | 2018 | SKY Perfect JSAT | Under development |
| Telesat | LEO | Ka, V | Broadband | 117 - 234 | 2017 | | |
| Xinwei | LEO | - | Telephony | 32 | 2014 (test) | | No news after announcement |
| Yaliny | LEO | - | Telephony | 140 | 2017 | | Likely cancelled |
| Samsung | LEO | mm wave | Broadband | 4,600 | - | | Likely cancelled |
| Astrome Technologies | LEO | mm wave | Broadband | 150 | 2019 | | Under development |
| KasKilo | LEO | Ka | M2M | 288 | by 2019 | | |
| CAST/CASIC | LEO | - | Broadband | | by 2020 | | |
| Helios Wire | LEO | S | M2M | 30 | 2018 | | Under development |
| Sky & Space Global | LEO | S, L | Telephony | 200 | 2017 | | Under development |
| Astrocast/ELSE | LEO | - | M2M | 64 | 2018 | Thuraya | Under development |
| Kepler | LEO | Ku | M2M | 140 | 2017 | | Under development |
| Lucky Star | LEO | - | - | 156 | - | | Likely cancelled |
| ViaSat | MEO | Ka | Broadband | 24 | by 2022 | | Announced |
| Laser Light | MEO | Optical | Broadband | 8-12 | 2019 | | Likely cancelled |
| O3b Networks | MEO | Ka, V | Broadband | 48 | 2018 | Owned by SES | Ongoing deployment |
| Spire Global | LEO | | AIS | ~100 | 2015 | | Ongoing deployment |
| Iridium | LEO | L, Ka | Telephony | 66 | 2017 | | Ongoing deployment |
| Globalstar | LEO | L, S, C | Telephony | 24 | 2010 | | Fully deployed |
| *per company announcements | | | | | | | |

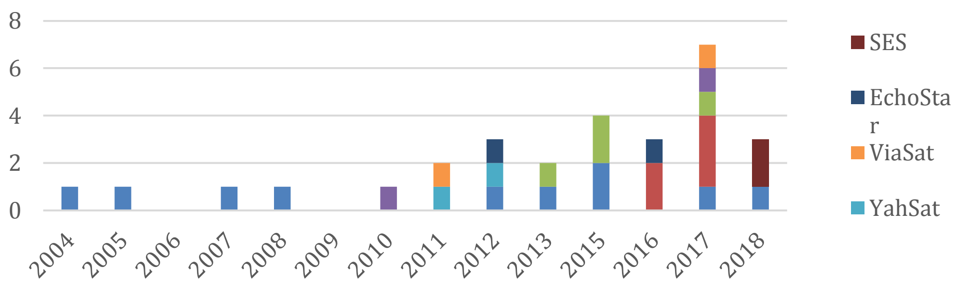
*Sources: APSCC, NSR, Company websites.*

48. LEO Satellite Constellations, Asia-Pacific Satellite Communications Council, September 2017.

The exact nature of the services that such mega-constellations will offer is quite heterogeneous, ranging from narrowband communications (AIS, M2M, texting) to high-speed internet access. As a matter of fact, few business models and service offering details have been disclosed and they are likely to continuously evolve as the projects unfold. Yet, mega-constellation concepts are motivated by specific technical features related to the lower altitude of operations and by an objective to achieve a global coverage. Lower altitude enables in particular to reduce signal latency and to optimize link budgets which translates, from a customer perspective, into a better connectivity service and smaller terminals, two aspects that had, so far, been an obstacle to satellite solutions uptake on broadband and mobility markets.

Technical innovation in the satcom sector is not limited to these ambitious mega-constellations and a vast majority of traditional operators is already deploying new generations of GEO satellites specifically designed to meet new customers' demand in terms of bandwidth and mobility. In this respect, the concept of High-Throughput Satellites (HTS) which allow, through frequency reuse and spot beam technologies, to increase dramatically (by a factor 20 or more) the available bandwidth on a single satellite for the same amount of allocated orbital spectrum, is a major technical step forward. This technology is also used, or planned to be used on a number of mega-constellations dedicated to the broadband market such as OneWeb and O3B but was first introduced by GEO satcom operators.

### Figure 3 – Number of GEO HTS launched per year 2004-2018




*Source: ESPI database.*

Since the launch of the first HTS in 2004 (Telesat Anik 2), the number of GEO HTS has skyrocketed and the deployment of HTS is expected to continue to grow in the future with a number of these satellites under construction and planned for launch in coming years.

**Table 3 – Main HTS GSO Projects**

| Company/Series | Satellite | Status* |
|---|---|---|
| SES | SES 12 | Waiting for launch |
| | SES 14 | Waiting for launch |
| | SES 17 | Under development |
| Intelsat's EPIC NG | Intelsat 29e | Deployed |
| | Intelsat 32e | Deployed |
| | Intelsat 33e | Deployed |
| | Intelsat 35e | Deployed |
| | Intelsat 37e | Waiting for launch |
| Eutelsat | KA-Sat | Deployed |
| | Eutelsat 172B | Deployed |
| | Africa Broadband Satellite | Under development |
| Inmarsat's Global Xpress | Inmarsat-5 F1 | Deployed |
| | Inmarsat-5 F2 | Deployed |
| | Inmarsat-5 F3 | Deployed |
| | Inmarsat-5 F4 | Deployed |
| | Inmarsat-5 F5 | Under development |
| EchoStar's JUPITER | EchoStar XVII | Deployed |
| | EchoStar XIX | Deployed |
| | Echostar XXIV | Under development |
| ViaSat | ViaSat-1 | Deployed |
| | ViaSat-2 | Deployed |
| | ViaSat-3 | Under development |
| *as for 2017 | | |

The potentially upcoming competitive situation in the satcom sector has been excessively simplified as a rivalry between emerging "New Space" operators proposing ambitious new concepts and well-established "Traditional" operators already positioned on the market but relying on aging concepts. In reality, the involvement of traditional players such as SES, Viasat, SKY Perfect JSAT, Telesat or Thuraya in mega-constellation projects[49] (i.e. Table 2) and the intensifying deployment of new generation GEO HTS (i.e. Table 3) suggests a much more complex competitive landscape.

At this stage it is important to recall that OneWeb, SpaceX and other mega-constellation promoters have to overcome substantial financial, technical, industrial and regulatory barriers before deploying their systems and start delivering operational services. As underlined by various satcom industry executives, capital requirements, scarcity of frequencies and industrial challenges to produce and launch hundreds of satellites at very low cost are obstacles that should not be underestimated.[50] Competition is not there yet.

Uncertainties also arise regarding the economic viability of low-orbit broadband networks once operational. With a massive initial capital investment to pay off not only for the space segment but also for the ground stations and ensuing high fixed costs to maintain the system operational, mega-constellation businesses will have to generate considerable revenue streams to be profitable. To do so in a market environment where the price of bandwidth is plummeting, capturing a solvent mass market will be a strict condition to ensure a viable business. From this standpoint, securing a quick and large uptake on mass markets will be a matter of services but also of user terminals that, together, will have to provide an excellent value proposition at market prices. Tracking and seamless handoff between several satellites is an additional technical challenge that makes ground antennas more costly.

Well-established operators ultimately doubt that mega-constellations will pose an actual competitive threat. Tom Choi, CEO of Asia Broadcast Satellite, who was involved in evaluations of the viability of LEO broadband network at Hughes Electronics, explains that "they concluded that the LEO network was just not financially practical to implement for commercial broadband services. While it could be done, it was reasoned that it simply would not make money."[51] Comparable projects have been contemplated with a similar enthusiasm from investors in the 1990s and, although a few reached operations, none of them succeeded in establishing a profitable and sustainable business. Yet, generating profits out of the provision of broadband services may not be the ultimate objective of all mega-constellation backers. For ICT firms such as Google and Apple, the

49. SES invested and then acquired O3b; Intelsat invested in OneWeb targeting a merger; Thuraya is backing the start-up ELSE; Boeing and Airbus (in partnership with OneWeb) are both working on a constellation.
50. M. Holmes, "LEO Constellation Announcements: The Industry Reacts", April 2015, http://interactive.satellitetoday.com.
51. *Ibid.*

logic behind their investment is rather related to expanding their commercial outreach to unconnected and under-connected populations than to making a direct profit. Satellites (or high-altitude platforms in which ICT firms also invest) therefore provide a particularly appropriate solution and the benefits they would get from global delivery of broadband services could lead them to accept a financial loss. As William Wade, CEO of AsiaSat admits, “markets are changing and SpaceX has already accomplished some very impressive things. You would be a fool to discount them right off hand”.

Should one or more of the mega-constellation projects reach service delivery and prove successful from a business standpoint, a competition would certainly materialize between LEO/MEO- and GEO-based solutions as these two radically different business and technical concepts would undoubtedly offer competing solutions on a number of market segments. Thierry Guillemin, former CTO of Intelsat, explained that “LEO constellations can be a complementary, rather than competing, offering to GEO satellites”.[52] Still, satcom operators carefully watch each milestone achieved by OneWeb and other mega-constellation insurgents.

Competitive tension is further amplified by an expected surge in demand for satellite broadband that has yet to occur, creating fears of an orbital capacity oversupply that would have dramatic consequences on operators’ revenue streams. As a result, the number of commercial GEO satellites ordered in 2017 has been very low (7 orders, compared with 19 orders in 2016). Samer Halawi, COO of OneWeb, emphasized instead an “undersupply”, pointing out that, in Beirut, netsurfers must cope with a mere 1.5 Mbps[53]. The bigger issue may actually not be the availability of access but rather the affordability as Mark Zuckerberg, CEO of Facebook, said, recalling that some 85% of those without Internet actually have local Internet services available to them[54]. Zuckerberg went further in a Bloomberg Business interview suggesting that the biggest challenge may be social since “the majority of people who aren’t connected are actually within range of a network and can afford it, but they don’t know what they would want to use Internet for”.

52. T. Guillemin, “LEO Constellations: What You Need to Know”, March 2015.
53. T. Dubois, “Satellite Demand: Surge Or Oversupply?”, AviationWeek, September 2017.
54. Peter B. de Selding, “Wall Street Grills Fleet Operators over Mega-Constellation Threat”, SpaceNews, February 2015.

# Conclusion and key takeaways

In the digital revolution context, the satcom sector is undergoing a major transformation, pushed in every corner to operate a radical business reorganization. With a clouded future on the broadcast horizon, traditional and emerging operators seem to have found in the broadband and mobility markets a promising growth engine. Yet, the road toward a large, profitable and sustainable satellite business on these markets is paved with major challenges arising, first and foremost, from a fierce competition with fast-expanding terrestrial networks.

There is certainly a lot of room for satellite solutions that can rely on unique features, highly relevant in the *Connectivity everywhere, all the time* paradigm, to capture a share of these fast- and ever-growing markets. The core challenge actually lies in the satcom operators' capacity not only to address niche applications but also become an integral component of a future hybrid network infrastructure addressing mass markets. Stakes are high and the industry, with the support of public authorities, must act quickly to avoid missing a boat that, once departed, will be hard to board. Failing this, the transition may very well have dramatic consequences for the future of satellite telecommunications and hence, for the overall space sector.

# Applications and Software Based on Satellite Data: the Example of Sigfox

**By David Fernandez**

## What does Sigfox do?

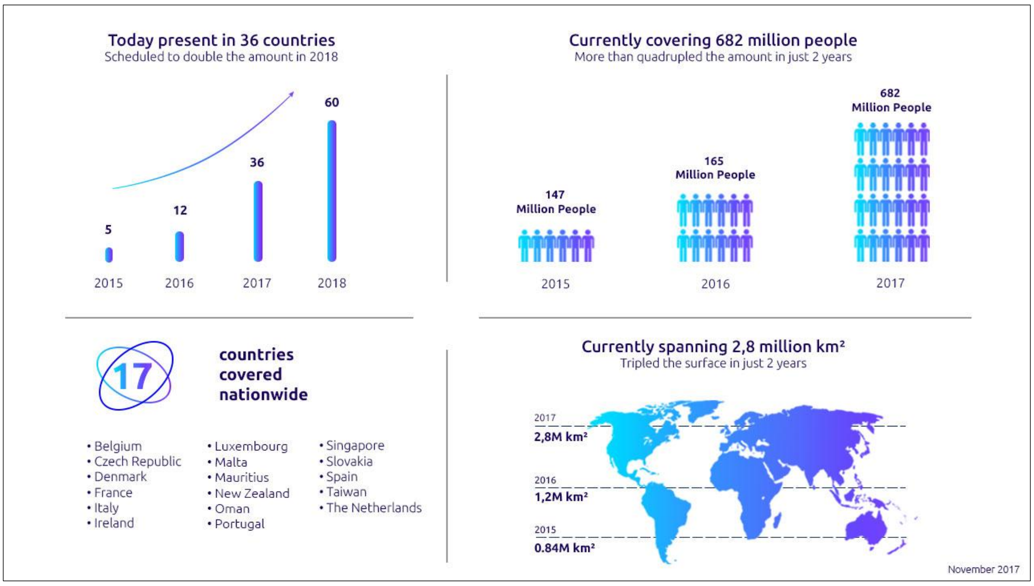
Sigfox is a Toulouse-based company that has developed a network dedicated to the “Internet of Things” (IoT). It is a fine example of how a start-up can develop a digital application that relies (partly) on space technology.

Sigfox connects all type of objects that need to communicate a small amount of data, such as car and motorbike trackers, so they can be found in case of theft. It also provides the connectivity for container trackers and other pieces for the industry, so that for instance, they can get automatic inventories. “Personal trackers” are also developed for small objects such as key-rings, for use by kids and other individuals.

The company currently covers 682 million people and is present in 36 countries. If Sigfox was initially launched in France in 2010, the service quickly spread to eleven other European countries and continues its implementation across the Atlantic Ocean, Asia, Africa and Middle East. In North America, the Sigfox network is available in 19 regions, including major metros such as San Francisco, Chicago, Atlanta, New York City, Los Angeles, and Las Vegas. Its desire for rapid international expansion requires significant capital. Since its creation, Sigfox raised more than €277 million, a success made possible thanks to the participation of major companies such as Air Liquide, Telefonica, GDF Suez and SK Telecom. Sigfox’s success in connecting a science station in Antarctica proves its willingness to settle anywhere in the world. Indeed, the company now covers 2.8 million square kilometers and wishes to set up in 60 different countries by the end of 2018. The network is available nationally in 17 countries such as France, Spain, New-Zealand and Singapore. Sigfox stopped communicating on its turnover since 2015, yet at that time, the revenue of the company was around €5 million.

In early 2017, Sigfox presented a geolocation system called *Sigfox Atlas*, which works without GPS that consumes a lot of energy. This new system locates connected objects through machine-learning that allows the position of a given point to be determined by measuring the received signal power. To achieve this, Sigfox uses its ground-based relay antennas. This new service is particularly helpful for logistics companies that want to know if a package reached its destination, for instance.

**Figure 1 – Sigfox's Customers**




# The Sigfox business model

The Sigfox business model takes a top-down approach. The company owns all of its technology, from the data server and cloud to the software library used in Sigfox objects. The specificity of the Sigfox model is that it sets up an IoT network that relies on very low data-rate communications, consumes very little energy and is very low price. For instance, a mobile phone subscription will cost €10 per month and €120 per year, whereas having an object tracked by Sigfox costs a few euros per year. This is because a phone or internet communication needs 1 or 10 gigabytes per month, whereas tracking an item uses 1 or 10 kilobytes per month – one thousand times less! Sigfox objects use basic radio techniques that are therefore relatively inexpensive. A cost below a dollar and a module less than $2 in large volumes.

Sigfox targets the market of things that emits small data; and this market represents the major part of the IoT market. There are 7 billions of connected telephones in the World in 2017, probably close to 10 billions in

2020. But the main growth that is anticipated right now is the growth of internet needs for connecting these things that emit little data.

# How is Sigfox different?

## *A strategic choice: low energy consumption*

The Sigfox technology on the object consumes very little energy because the additional data required by the network (overhead) to transmit useful object data is minimized as much as possible. Sigfox reduced the battery consumption as much as it could, there is no mandatory signaling on a network for the object to communicate. The latest delivers almost only the data that is must transmit. The network is bidirectional, that is to say that items send and receive data from a cloud platform.

## *The reasons for a low price*

Sigfox uses what we call an ultra-narrowband (UNB) technology. It requires a standard radio transmission method and with low data rate it takes very narrow chunks of spectrum. It allows the network receivers to see objects out of noise. It requires an inexpensive object radio. This is energy efficient and uses frequency bands that are free but regulated: the ISM (Industrial, Scientific and Medical) bands; in Europe, it is the 868 MHz. Sigfox technology maximizes the number of connected objects for a given network infrastructure: for instance, it is possible to connect more than 10 millions of objects per Sigfox base station, which reduces network infrastructure costs.

Also, Sigfox presents a unique offer worldwide. The network is fully operated by Sigfox and its “Sigfox operators”; it follows the principle of interconnectivity: subscribing in a country gives access to all countries if needed.

# The use of satellites by Sigfox?

Primarily used for audiovisual broadcasting through the exploitation of a linear television system associated with connected TV services (social networks, multi-screen, live participation in entertainment programs), the French SmartLNB technology of Eutelsat also allows low-rate interaction between communicating objects. It is precisely for this purpose that Sigfox decided to integrate it on its cellular network dedicated to the IoT and M2M in 2015. Sigfox base stations are connected through Ethernet, fiber, 3G/4G, cellular, or satellite. Satellites bring several interesting particularities to the Sigfox architecture.

They are used first and foremost for backhauling between base stations. Indeed they allow the routing of information flows to entry points. Backhauling complements the telecom structure way beyond the "telecom backbone". In this case, Sigfox relies on Eutelsat's geostationary orbit telecommunication satellites, which provide them with global coverage. There are fewer constraints on the installation site: the service can be accessed from anywhere, wirelessly and without 3G/4G coverage. For now, connectivity prices are similar between satellites and cellular. The difficulty with cell operators is that they cover only small geographic areas and contracts must be negotiated with each of them.

The use of Global Navigation Satellite Systems (GNSS) by Sigfox is also relevant. Sigfox uses the GPS satellite navigation network (pending the launch of the European Galileo system). Indeed, the main function of GNSS is to do asset tracking. It can determine where an object is located. For this purpose, the Sigfox technology is used by the object in combination with a GNSS application. Yet, Sigfox only sells subscriptions but not tracking items, which are produced by "object makers". Among other companies that develop innovative technologies to the optimized use of GNSS battery, we can cite Ubiscale for instance. A few Asian companies develop combined modules for Sigfox/GNSS tracking devices.

Finally, Sigfox's Research and Development (R&D) teams and Sigfox partners are exploring the idea of completing the company's network with object connections only by satellite, in areas where there is no terrestrial infrastructure. By spreading its services on areas poorly covered by telecommunications infrastructures, the company could for example connect lifejackets on boats to help rescue services through an extension of satellite coverage. Yet, this cannot be done today as the hardware is too expensive and the technical constraints too strong.

Sigfox endeavors to provide network coverage everywhere, so that connected items can travel seamlessly from one region to another without customers having to worry about roaming.

# Hack-My-Sat: Cyber-Threats and the Digital Revolution in Space

**By Luca del Monte**
**and Géraldine Naja**

## Opportunities and challenges introduced by the ICT

The convergence of the Space Industry with the Digital Economy has generated the rise of the so-called New Space revolution in the U.S. The importance of Information and Communication Technologies (ICT) in space is growing at a steady pace. The dynamism of the ICT sector is far higher than that of the traditional space industry, driven by a short generation cycle of 2-3 years, high competitive and innovative pressure in mass markets, and the increasingly broader digitalisation of the global economy and the private world. There have already been two IT generations – in the sense of Moore's law, according to which the chip performance doubles regularly – over the last six years. In this same period, $2 to $3 billion have been invested in companies and projects such as SpaceX, SkyBox, Spire, PlanetLabs or OneWeb in the U.S. Mega-constellations on the basis of mini-, micro- and nano-satellites ("CubeSats") are the icons of the New Space scene. They have the potential for diverse commercial applications, particularly in earth observation, for broadband connections and for the Internet of Things (IOT). Inspired by internet entrepreneurs, new Big Data and geoinformation business models are developing.

This revolution is enabled by a number of paradigm shifts both at the technological and policy level. The list of the most visible technological game-changers supported by such policies is long and includes e.g. advances in processor and storage capability; breakthroughs in image recognition and analysis software; growing availability of cloud computing and big data analytics; Commercial off-the-shelves (COTS) components radiation-hardened through software; and software defined satellites.

The new entrants usually bring new approaches prioritising cost over performance and reliability. This is attained through agile manufacturing, streamlined/simpler processes, use of COTS software and of the Cloud, open-source hardware plug-and-play satellites[55]. In general terms, these new enterprises are pitched as IT or media companies where the investments are regarded as being in data products and services rather than in space (which is just another place where data is collected).

Alongside the immense opportunities offered, this growing space-based activity is also introducing new challenges for the global space community, both on the ground and in space. Among these, one of the most remarkable and rapidly growing is the cyber-security of space systems, as well as the specific cyber threats associated with New Space systems.

## Space missions in a contested cyberspace

The concept of cyber-security of space systems should be conceived not only in terms of fighting cyber-threats which are transported through space systems, but also in terms of security, protection and reliability of space technologies and systems themselves, as potential targets of the cyber-threats. The possibility to operate space mission payloads across networks through public internet connectivity (or through Virtual Private Networks which, although secluded, are mutually interconnected through the net) opens up many threats against space-based assets and services, threats that did not previously exist. As a result, military and civil space missions must now take into account a wide variety of security menaces.

These preoccupations have been substantiated by some serious security incidents which are, only now, progressively becoming publicly known. On October 20, 2007, Landsat 7, Earth Observation satellite experienced 12 or more minutes of interference. Again, on July 23, 2008, the same satellite experienced another 12 minutes of interference. The hackers did not achieve all steps required to command the satellite, but the service was disturbed[56]. Similarly, on June 20, 2008, TERRA, another Earth Observation satellite, experienced two or more minutes of interference. This time, the responsible party achieved all steps required to command the satellite but did not issue commands. Some weeks later, on October 22, 2008, the same system experienced again nine or more minutes of interference. The responsible party achieved all steps required

55. Such as the Space-Wire networks proposed by the Sputnix company. See www.sputnix.ru.
56. *Theguardian.com*, 27 October 2011.

to command the satellite but did not issue commands. The above-mentioned attacks affected satellites used for earth climate and terrain observation. The hackers used the Internet connection to get into the ground station's information systems[57].

Access to a satellite's controls could allow an attacker to damage or destroy the satellite. An attacker could also degrade as well as forge or otherwise manipulate the satellite's transmission. Military theorists have developed a holistic view of counterspace operations. They advocate for the use of both "soft" kill (i.e., informational, temporary, or reversible) attacks and "hard" kill (i.e., destructive or permanently disabling) attacks against every aspect of space power: ground-based systems, space-based systems, and communications links. Partial infiltration could allow the attacker to share data from the compromised satellite, though this would likely be detected given the limited bandwidth of the orbiter. Indeed this is how the current attacks were identified. Knowledge of the volume of data transferred by the satellite can reveal the nature of the satellite's capabilities, such as imagery, for instance. Opportunities may also exist to compromise other terrestrial or space- based networks used by the satellite. Command-and-control infiltration could lead to even worse impacts, most notably the ability to trigger some sort of mechanical/electrical overdrive, which could damage critical devices like imaging lenses or the communications antenna. They could also be used to provide equally damaging misinformation to the victim. If executed successfully, such interference has the potential to pose numerous threats, particularly if achieved against satellites with more sensitive functions.

## Cyber threats creeping through a globalised supply chain

The cybersecurity of space missions is also a matter of competitiveness for our European space industry, and, at the same time, is a key issue for the EU as owner of the Copernicus and Galileo infrastructures. The emerging mega-constellation systems will only make this problem worse. The need to guarantee high production rates (e.g. 4 satellites per day in the case of the OneWeb constellation) may require, in fact, the system integrators to stretch the existing supply chain globally, and to include new components providers. The globalisation of manufacturing capabilities and the increased reliance upon commodity software and hardware for space and ground segments has expanded the opportunities for malicious modification in a manner that could compromise critical functionality.

57. "Chinese Military Suspected in Hacker Attacks on U.S. Satellites", Bloomberg News, 27 October 2011.

In such context, some spacecraft on-board components and items available off-the-shelf may contain spyware or logic bombs, which, when triggered, would render the system useless or worse, vulnerable to espionage or sabotage, even from a faraway distance. These and other vulnerabilities may not become apparent until the systems are under attack. When that happens, fixing the problem would require close coordination between supplier and user.

## New Space cybersecurity: new actors, new cooperation, new technologies

Within this contested and aggressive cyber-environment, the European institutional response to cyber-threats is progressively becoming more visible and efficient in stimulating awareness within the space community and in the protection and development of critical infrastructures. With the objective of ensuring a safe and secure environment for their own respective institutional missions and of those of their stakeholders, the European Space Agency and the European Defence Agency have joined forces and are leading joint classified studies to develop ex ante a risk assessment and risk treatment plan for each category of space mission. Another complementary objective of this activity is to "raise awareness in the space community about the cyber-security issues" throughout the entire mission lifecycle. Threats considered in the studies include all possible menaces: either intentional or accidental, from external or internal attackers, of any type (physical, technological, organizational, etc.), generic for any service or infrastructure and also those exclusive for space missions and independent from the attacker motivation.

Building on the recommendations stemming from some recent studies carried out by ESA about emerging cyber threats to space missions, the Agency also developed and inaugurated in April 2017, the first European "space-assets specialized cybersecurity training range" based in ESEC,[58] focused on the need for specific training to increase the preparedness level of the space system operators to detect and react to a cyber-attack. The exercises performed in this facility to train space mission managers and operators,[59] include role-playing by different teams (e.g. attackers, defenders, spies, hackers, hacktivists, crackers, etc.) trying to manage or to damage (depending on the role) the outcome of a specific simulated space mission, focusing on space-specific threat scenarios. The expected areas of

58. ESEC: ESA European Space security and Education Centre, Redu (Belgium).
59. ESEC only trains ESA staff right now, but will also train people from public and private entities of the member-states in the future.

further evolution of the ESEC cyber range are technology research, development, experimentation and test, and, in the longer term, security monitoring and operations, responding to the needs of a growing market demand for cyber security services.

At the same time, ESA is also teaming up with several non-space industrial domains to develop space cybersecurity solutions for autonomous vehicles such as connected cars, drones and ships. As an example, a cooperation between the ESEC space cybersecurity range and the Unmanned Aerial Vehicle (UAV) test range in Grottaglie (Italy) is currently on-going to address situations as “dronejacking” and/or UAV data corruption and data alteration when the drone is controlled via satellite.

Another aspect of cybersecurity is Quantum Key Distribution (QKD). This technology allows the secure exchange of encryption keys for security applications. The use of QKD Systems to enable the secure exchange of data via communication lines is already well established in terrestrial fiber optical communication systems. However, long distance QKD is only possible via satellites. A first system was recently launched by China (the Quantum Experiments at Space Scale (QUESS) spacecraft, launched in August 2016). Quantum Cryptography Space Technologies might enable new markets and several European Countries are already competing to develop their own QKD space system to deliver cybersecure solutions to protect e.g. financial transactions and other confidential data exchange.

One of the most exotic and recent development of the deep web – blockchain technology – is also currently under assessment to be applied in space cybersecurity applications to guarantee the authenticity of space-based information and data, and its integrity at each data processing step of the value chain, from acquisition to delivery to the customer or to the Service Provider. For instance, Earth Observation satellite data stored in an archive victim of a cyber attack could be stolen, and, even worst, could be substituted by fake copies that can invalidate all the information to be extracted from these data. Blockchain, originally developed for crypto-currency such as the Bitcoin, seems to be a promising technology capable of certifying the identity, integrity and freshness of space data in peer-to-peer networks, employing public-key cryptography, and through distributed consensus. By exploiting those characteristics, the space-based services and applications market could get out of its protected shell and be integrated in more complex and complete value chains without the need for intermediation or centralized trusted authorities.

An example of the very diversified forms that cybersecurity is taking in the New Space environment is represented by the issues faced by IT giants like IBM, Google or Microsoft, trying to get data around the world through Internet Of Thing (IOT) and their edge sensors. The biggest downfall of terrestrial-based networks is that the information must pass through multiple peering and exchange points along its journey, giving hijackers ample opportunity to intercept and reroute the data. However, New Space solutions are emerging, based on large LEO constellation of minisatellites bypassing terrestrial networks entirely by leveraging capacity from Geosynchronous Earth Orbit (GEO) satellites. Cybersecurity through satellites is an alternative that is more difficult to penetrate, preventing the hacking and hijacking of data.

## Space and cyberspace elements of the Global Commons

From the above-mentioned considerations, it should be now clear that Space and Cyberspace[60] have many similarities and are closely interwoven. Yet each has its own distinct properties, and thus they need to be addressed both individually and as a whole. European countries have highly globalized economies that depend on assured and secure access to these domains, and the free flow of goods, services, people, and information. The commonalities and interlinks between the space and the cyber-space domains have been well described by the doctrine of the "Global Commons",[61] providing a useful lens through which to view the world as a complex, globalized whole that depends for its security and prosperity on access to four domains: maritime, air, space and cyber. Space and cyberspace are therefore defined as regions which do not fall under the jurisdiction of any nation. It is in, through, and from the Global Commons that trade, communications, transportation, and security operations take place.

Already existing inter-institutional cooperation between ESA, the European Commission (EC) and the European Defence Agency (EDA) could be extended to include reflections and/or activities to enhance the cyber-security of the European institutional and commercial space missions, taking stock of the EU Critical Infrastructure Protection programme, the Code of Conduct for Outer Space Activities, the recent EU

60. According to the NATO Cyber Defence Concept, cyberspace is "a digital world generated by computer networks in which people and computers co-exist, and which includes all aspects of online activity".
61. S. J. Buck, *The Global Commons: An Introduction*, Washington, D.C.: Island Press, 2nd edition, 1998, p. 6.

Cyber-security strategy, and the EC/ESA/EDA Joint Task Force on Critical Space Technologies for European Strategic Non-Dependence.

The key is collaboration and coordination: ESA, European and International Institutions, national space agencies worldwide as well as commercial space entities share the same concerns and will require similar if not identical solutions.

Think-tanks and international for a world-wide should be instrumental in facilitating the dialogue among these stakeholders and international partners, raising the level of awareness about the blurring legal distinctions defining outer space and cyberspace, and paving the way to the development of a governance needed to guarantee a sustainable use of outer space in an ever more contested, congested and competitive space and cyber-security environment.

# PART III: GEOGRAPHICAL PERSPECTIVES

# New Space for Africa: the Role of Space-Based Platforms in Providing Connectivity for the African Continent

**By Jean-Michel Huet**
**and Alejandro Rojas**

We have witnessed in recent years the takeoff of internet access in Africa. The region's telecommunications industry has currently the world's fastest growth rate, with 4% per year according to Idate[62]. A low penetration rate, combined with strong expected demographic and economic growth should allow this trend to continue in coming years.

The internet service provider industry gained momentum with the rollout of submarine cables in coastal African countries starting in 2009[63]. Submarine cables fostered internet access by lowering bandwidth cost in coastal countries. However, despite current growth, internet access penetration rate remains relatively low, and presents important disparities between and within countries. The majority of internet connections are-based on mobile broadband, while the fixed broadband penetration is expected to remain low. The average mobile telephone penetration rate in sub-Saharan Africa was of 49% in 2016, while mobile broadband penetration reached 20% in 2016[64]. While mobile broadband expansion is set to continue, the future of fixed-line networks seems less bright.

The traditional role of satellites in Africa has been to provide backhauling and TV access. However, several initiatives are being developed to provide internet access to the segments of the population still lacking it. These initiatives include the use of High Throughput Satellites (HTS), low-orbit satellite networks and the use of drone or balloon

62. *Digiworld Yearbook 2016. Les enjeux du monde numérique*, Idate, 2016.
63. E. Forden, "The Undersea Cable Boom in Sub-Saharan Africa", USTIC Executive Briefing on Trade, June 2015, www.usitc.gov.
64. *Digiworld Yearbook 2016. Afrique et Moyen Orient*, Idate, 2016.

networks that would act as “transmitting stations”. The goal of this article is to analyze the potential role of these New Space technologies in providing connectivity services in Africa.

To assess the potential of these technologies, we will begin by analyzing the current state of connectivity markets in Africa. This analysis will provide an idea of the current demand and connectivity needs. We will then examine existing technologies and service providers, and how these technologies match (or not) current demand conditions. In view of current demand conditions and existing technologies we will then present the potential use cases for satellite in Africa, and the industry expected trends.

# Internet connectivity in Africa

## *The current state of internet connectivity*

- ***Internet access penetration rate per region***

Telecommunication services penetration rates show important disparities between regions. North African countries and South Africa have a high mobile penetration rates (>100% population). Coastal countries have mobile penetration rates ranging between 75% and 100% of the population. Finally, “landlocked” countries have lower penetration rates (bellow 50%) of the population. After considering the effect of multi-SIM (the fact that one person may have several mobile phones), the average mobile penetration rate in sub-Saharan Africa is close to 50%. Disparities between countries and regions are not only linked to differences in terms of per capita income or economic development, but also to the availability of backbones (and submarine cables), and to the impact of local institutional and regulatory frameworks. According to Idate, smartphones represented 40% of mobile phones sold in the continent in 2015. The think-thank expects mobile broadband penetration rates to reach 44% by 2019, while fixed broadband penetration rates should reach 14% of the population.

- ***The impact of regulation and institutions on internet access in Africa***

Some regulatory aspects are frequently mentioned as constraints to the development of telecommunications in Africa. One of the main obstacles are high corporate and value-added taxes that discourage investment and increase final consumer prices. Other tax-related issues are high import duties, which can discourage the importation of equipment.

Government rent-seeking behavior can also lead to bias on the industry's regulatory framework. Regulatory issues can be present both in the fixed and mobile segments. On the mobile segment, regulators often provide licenses to too many operators, which prevents economies of scale. For example, in Somalia the government granted licenses to eight mobile operators, while in most countries, there are only three to four mobile operators.

On the fixed-line segment, former state-owned operators often remain in a monopoly position. These companies tend to underinvest and provide low quality services. Monopolies present in the fixed-line segment also tend to underinvest on their backbone, which in turns slows down the development of both fixed and mobile networks.

- ***The link between internet access and economic development***

Conducting reforms allowing to lower entry barriers and make the telecommunication industry more efficient would improve the economic potential of African countries. Several studies show the positive link between broadband availability and economic growth. Telecom Advisory Services LLC (2016) analyzed the link between the mobile broadband penetration rate and economic growth in Tunisia, Morocco and Jordan. Their results indicate that an increase of 10% in the mobile penetration rate leads to a 1.1% GDP growth in Tunisia, 1.4% in Morocco and 1.2% in Jordan. In the case of fixed broadband, a 10% increase in the penetration rate leads to 0.7% GDP growth in Jordan, 0.8% in Morocco and 1% in Tunisia. These numbers are in line with the analysis made by Nina Czernich *et al.* (2009), that finds that a 10-percentage point increase in broadband penetration rate raises annual per-capita growth by 0.9 to 1.5 percentage points.

Some steps are being taken to harmonize the telecommunications regulatory framework of African countries, led by the ITU. One example is the ITU-led project to "Harmonize ICT Policies in Sub-Saharan Africa" (HIPSSA), which aims to "establish harmonized policy, legal and regulatory frameworks at the regional and continental levels to create an enabling environment that will attract investment and foster the sustainable development of competitive African Telecommunication/ICT regional markets, infrastructures, and to increase access [of its people to the related services]". A more stable legal and regulatory framework fosters investment and leads to industry growth, with all the benefits mentioned before.

## *Competing connectivity platforms and available technologies*

Mobile Broadband is used to provide mass market access to the internet. The most widely spread technology is 3G, but LTE is being rolled out in most of the countries of the continent. According to Idate, the average mobile broadband penetration rate should therefore reach 44% by 2019.

Fixed-line connectivity has shown a slower development due to fixed-to-mobile substitution. Since copper line coverage is declining in most countries, we don't expect ADSL to play a major role in the future. However, this technology could have a commercial potential in urban areas. Fiber networks are being rolled out essentially in business districts, and smart cities projects. The relatively low uptake of fixed-line services offers an opportunity for satellite service providers.

Satellite technologies play an important role in the African telecommunications landscape. The majority of African TV access (47% according to Idate) use satellite-based technologies. Satellites have also been used to provide backhauling services to mobile networks in areas lacking fixed-line backbones. Finally, satellite technologies can be used to provide connectivity in areas not yet covered by 3G. For this type of services, individual connection prices ranges from $20 to $30 per month.

The rollout of submarine internet cables and the presence of many competitors combined with new technologies such as HTS satellites have generated a decline in the price of satellite communications (High Throughput Satellite, or HTS, architectures allow to multiply by 20 times the throughput of a regular geostationary satellite. This performance is achieved by providing multiple spot beams to increase throughput and reduce cost per bit delivered). The price of one MBs/month dropped from $4,000 per MBs/month in 2010 to $300 per MBs/month nowadays.

In the next section, we will provide a deeper dive in the available satellite technologies and the operators and potential users of these technologies.

# Providing internet access to remote areas

In this section, we will present three types of "aerial" connectivity platforms: geostationary satellites, low Earth orbit satellites and alternative technologies (drones and balloons).

## *Satellites*

Telecommunication services can be provided either by geostationary or low orbit satellites.

- ***Geostationary (GEO) satellites***

Traditional geostationary satellites are designed to cover wide areas, representing thousands of kilometers, or even continents. This technology is relatively costly, however, and due to the inherent characteristics of geostationary orbits (36,000 km from the Earth), and in spite of recent HTS technologies, they presents high latency times.

Numerous satellite connectivity providers are present on the continent. They can be classified by size and core business. International actors present in Africa include Eutelsat, SES, Intelsat and Inmarsat. Regional players include Yahsat, Arabsat and Turksat. In terms of core services, Eutelsat and SES are rather specialized in TV services, whereas Inmarsat, Yahsat and Arabsat rather focus on providing internet connectivity. Among these companies, Eutelsat, Yahsat and Intelsat have launched HTS satellites.

- ***Low earth orbit (LEO) satellites***

Low Earth orbit satellites were imagined to solve the latency problems inherent to geostationary satellites. Since their orbit is much closer to Earth, as close as 625 km from the planet's surface, these satellites can also provide high-speed connections. LEO satellites are smaller and simpler than GEO satellites. Their unit production cost is much lower than that of a geostationary satellite. However, their lifespan is also much shorter, close to five years compared to 15 years for a geostationary satellite. Due to the large number of satellites required, and their relatively short lifetime, deploying a low Earth orbit network would require large amounts of capital.

There are currently three major low Earth orbit connectivity initiatives, aimed at providing either backhauling or individual internet connections.

SpaceX is a satellite constellation project that will be made of approximately 4,000 satellites, circulating in orbits at 645 km from the Earth. The initiative is led by Elon Musk and finds Fidelity and Google among its investors. SpaceX aims not only at providing backhauling services, but also individual connections. The cost of end-user premises would be close to $200.

OneWeb is a satellite constellation project that will be made of approximately 650 satellites orbiting at an altitude of 1,200 km. OneWeb's mission is to "enable affordable internet access for everyone, connect every school on Earth and bridge the digital divide by 2027". The company has already raised $1.7 billion, and has Softbank, Qualcomm, Airbus and the Virgin Group among its investors. Airbus Defense and Space will produce the satellites at a rate of one satellite every 21 days. The company announced in 2017 that it had already sold most of its capacity.

Finally, O3B – which stands for "Other 3 Billion" –, is a medium Earth orbit satellite constellation owned by SES, and providing voice and data communications to telecom operators. The company currently has 12 satellites orbiting at an altitude of 8,000 km.

## *Alternative technologies aiming at providing internet access in remote areas*

While satellites can provide connectivity everywhere, alternative projects aim at providing connectivity in remote, less densely covered and populated areas by using balloons or drones.

Project Loon is a project developed by the X company[65] to provide Internet access to rural and remote areas using high-altitude balloons flying at an altitude of 18 km. The balloons will use directional antennas to transmit signals to ground stations or LTE users, and should be able to cover an area close to 80 km. This technology is currently at an experimental stage, with tests being conducted in Sri Lanka. One of the limits of this technology is that it requires LTE coverage which is not always available.

Drone connectivity involves drones flying at an altitude ranging from 18 to 30 km. Each drone remains at a relatively stable position and can cover an area of 50 km. Drones would communicate with base stations using a laser beam, which would provide a large bandwidth.

65. X, formerly called GoogleX is a subsidiary of Alphabet Inc.

These technologies still face technical challenges, as they remain not yet proven. They are developed by actors such as Google or Facebook, who are not connectivity providers *per se*, but companies requiring connectivity to provide their core services. If target areas were to be covered by alternative technologies (fixed or mobile), we consider unlikely that these technologies will become mainstream.

# Types of customers: the technologies

Satellites provide connectivity to Corporate and Government actors. They are also active in the consumer segment.

## *Large corporate clients*

Satellites can be useful for large companies. Large corporate clients require reliable networks, and high service quality. Local carriers fixed-line connectivity doesn't fulfill these characteristics, which pushes African companies to use satellite connectivity instead of ADSL services. Thus, companies requiring a high quality of service for multiple sites, such as banks or large agroindustry players use satellites as a connectivity solution. For example, Cacao producer Barry Caillebaut uses Eutelsat's services to connect its various Côte d'Ivoire plantations with the local headquarters in Abidjan.

## *SMEs, hotels and liberal professions*

Satellite connectivity can also be used to provide connectivity for SMEs, hotels or liberal professions. Satellite connectivity gross resellers have developed hotspot services suitable for this type of actors. After making an initial investment starting at $2,000 to purchase the equipment, the purchaser can resell connectivity services using prepaid cards or coupons. In the case of TamTam, developed by service provider Afrique Telecom, the hotspot owner receives a commission of 20% on every prepaid card sold after the initial purchase. The price of prepaid cards varies depending on connection speed. This type of actors can use devices operating in Ku or Ka bands. These technologies are more affordable than VSAT and require simpler and smaller devices.

## Agriculture

Agricultural productivity in Africa remains low. Providing even narrow-band connectivity to farmers could boost their productivity in various ways. Satellite-based telephony or narrow-band internet access can be used to locate agricultural markets. It is important to recall that some agricultural markets in Africa are mobile. These technologies can also be used to provide information concerning crop prices and weather forecasts, enabling farmers to increase their revenues and reduce losses related to adverse weather conditions.

Satellites can also be used to communicate data of crops located in remote areas to agricultural engineers. Data can be transmitted either by farmers, or by using surveillance drones. This data can be used to optimize irrigation or prevent plagues.

## Public sector

After large corporate groups, governments remain the main customers of satellite-based internet access. Governments can use satellites technologies in two different ways. Satellites can be used to improve public sector digitalization, and to improve internet penetration rate with universal service initiatives.

In terms of public sector digitalization, satellites can among others be used to provide connectivity in the education and healthcare sectors.

Concerning education, satellites can broadcast the same information simultaneously to several sites. This feature can be used to provide e-education services in countries or regions where teachers are scarce. The operating costs for a school with one thousand connected students can be as low as 30 cents per month. Satellite operators such as Inmarsat have connectivity offers tailored to meet the connectivity needs of schools located in rural areas.

In the healthcare sector, satellites can provide connectivity to remote hospitals and clinics. Telemedicine requires carrier-grade connectivity, which can be only be provided via satellite in some regions. For example, Afrique Telecom provides connectivity to a network of 600 healthcare facilities in the Democratic Republic of Congo. The service is paid by the government and benefits from the support of foreign lenders.

Governments can also finance satellite-based initiatives to provide connectivity using the “Wifi Hotspot” format. An example comes from Côte d’Ivoire’s *“Agence Nationale du Service Universel des Telecommunications”*

(ANSUT), which funds the purchase of TamTam hotspots to accelerate the uptake of internet penetration rate via its Universal Access fund.

### *Consumer markets*

Finally, satellites can also be used to provide connectivity to households. Connectivity solutions using Ka-band technology can provide connectivity at the same price and speed as an ADSL connection. Ka-band antennas are much smaller that their VSAT counterparts, making it more suitable for household usage. However, connection quality for this type of technology is vulnerable to adverse weather conditions. The emerging African middle class offers a large potential market that could be served by satellite offers. There are currently 75 million satellite pay-TV subscribers in the Middle-East and Africa (MEA), with premium segment customers generating an Average Revenue per User (ARPU) of $60 to $80. These households represent a potential target for Double or Triple Play satellite-based offers.

However, satellite-based internet access offers for the consumer market should consider the risk of piracy, which is important in the satellite pay-TV segment. As an example, in Côte d'Ivoire, TV satellite provider Canal Sat has 386,000 paying subscribers, and 1.8 million "illegal customers".

## Potential evolution scenarios for satellite connectivity

We expect the current fixed-line infrastructure expansion to continue in Africa. Similar to the evolution in other regions of the world, fiber-based networks will become the main network technology. This trend began in the early 2000's with the rollout of submarine cables, and was followed by the development of networks backbones. However, last mile fixed-line network coverage remains extremely scarce. Although 3G mobile networks are widely available, the average speed is close to 10 Mbps. Current satellite providers such as Eutelsat are currently capable of providing connectivity services at prices ranging from €20 to €30 per month for a speed of 20 Mbps, which constitutes a competitive alternative to current and future fixed-line network developments.

We expect satellite technologies to maintain their current role as a technology that can bring connectivity to rural areas, and can bring high quality services to corporate clients. The current challenge for satellite service providers is to expand the reach for their services to the continent's growing middle class. This could become possible if operators develop plans to reach a wider population, which in turn could lead to lower terminal prices (antennas and modems). As the cost of currently available geostationary satellite connectivity is expected to continue to decrease with the launch of new technologies such as Super HTS, we expect alternative satellite technologies (low orbit webs) to become an alternative rather than the main type of satellite technology (at least in the short term).

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# New Space Developments in Asia

**By Narayan Prasad**

While there is no internationally accepted technical definition of "New Space", principally, the ethos of the movement has been to challenge the traditional ways of space exploration that are widely considered as too expensive, time-consuming, and lacking in room for inventive risk-taking.[66]

Space exploration in major space-faring countries in Asia, including India, China and Japan, have mostly been led by governmental institutions. Space agencies in these countries have undertaken systematic capacity-building in order to have indigenous capacities to build, launch and operate satellites. This is the very foundation of New Space developments that are emerging in these geographies. Entrepreneurs in India, China and Japan have access to a critical mass of traditional space heritage that is crucial from an ecosystem perspective in sourcing suppliers, manpower, infrastructure to be able to create New Space ventures.

The rise of New Space in Asia possibly has roots in their inherent motivations to replicate some of the success of U.S. companies (such as SpaceX, Blue Origin, OneWeb). Entrepreneurs and investors who kicked off such ventures over the past couple of decades have no doubt inspired several entrepreneurs in this part of the world to also want to embrace risk-taking in their pursuit of developing new, innovative, cost-effective products/services that can rally around competencies of their national capabilities and requirements. Furthermore, entrepreneurs in India and Japan have also taken up challenges posed via international competitions such as the Google Lunar X-Prize to showcase their grit in independently developing complex missions within the private sector and use the competition as their brand-building exercise to spin-off products/services to customers internationally.

66. N. Prasad Nagendra, "Traditional Space and New Space Industry in India," *ORF*, accessed 21 June 2017.

It is important to note that Western companies have some barriers to entry for doing business in the space industry in Asia, especially India and China, due to the difference in the culture of the mode of engagement of the local commercial space industry. While several Western space companies act as competitive contractors of either supply of launch/satellites to their own government needs (e.g. SpaceX competitively bidding against United Launch Alliance – ULA – for a launch), the positioning within countries like India and China is of space agencies and public companies delivering a majority of the end-to-end products/services with SMEs mostly acting as Tier-2/Tier-3 vendors in the ecosystem. This is possibly a double-edged sword as the entrepreneurs in this region might be well protected against Western companies exploring possibilities within the region due to the difference in the culture of commercial space industry engagement, while they may have a conflict of interest when intending to build products/services that are already in the roadmap of a public-sector institution.

The global rise of New Space has mainly been backed at the start-up phase by private capital for companies to create space products/services to find B2B, B2C market opportunities where space acts as an infrastructure to deliver value to end users. However, one needs to note that most of the exploitation of space for any applications in Asia has been traditionally led by governmental agencies due to the sheer amount of capital, infrastructure and manpower needed to accomplish the task of putting together infrastructure up in space. With most of the applications in the existing value chain being occupied within the realm of G2G, G2B, there is a lack of a vibrant history in these cultures of capital from private institutions infused into commercial space industry for independent products/services that can go down directly to either businesses or customers themselves. This can affect the ability of New Space entrepreneurs in raising capital as private institutions may have jitters when investing large amounts of capital into completely unchartered territories for themselves, while government-led institutions are already playing major roles and control overall policy architecture of the sector.

The size of the markets in India and China can be especially interesting for New Space ventures. New products/services may not need to look for their initial scaling via export markets, but rather have access to a large local market. For example, a New Space venture in India creating a broadband LEO constellation to provide internet access to people living in semi-urban or rural areas has a market-size of over 800 million to address with hardly 10% having been installed with potentially competitive fiber connections. Therefore, several of the New Space endeavors in India and

China might witness a growth in early start-up capital as ventures mature in their value propositions.

To understand the intricacies of each of the major ecosystem in Asia (India, China and Japan), insights from each of the ecosystems have been provided in the sections below.

# New Space in India

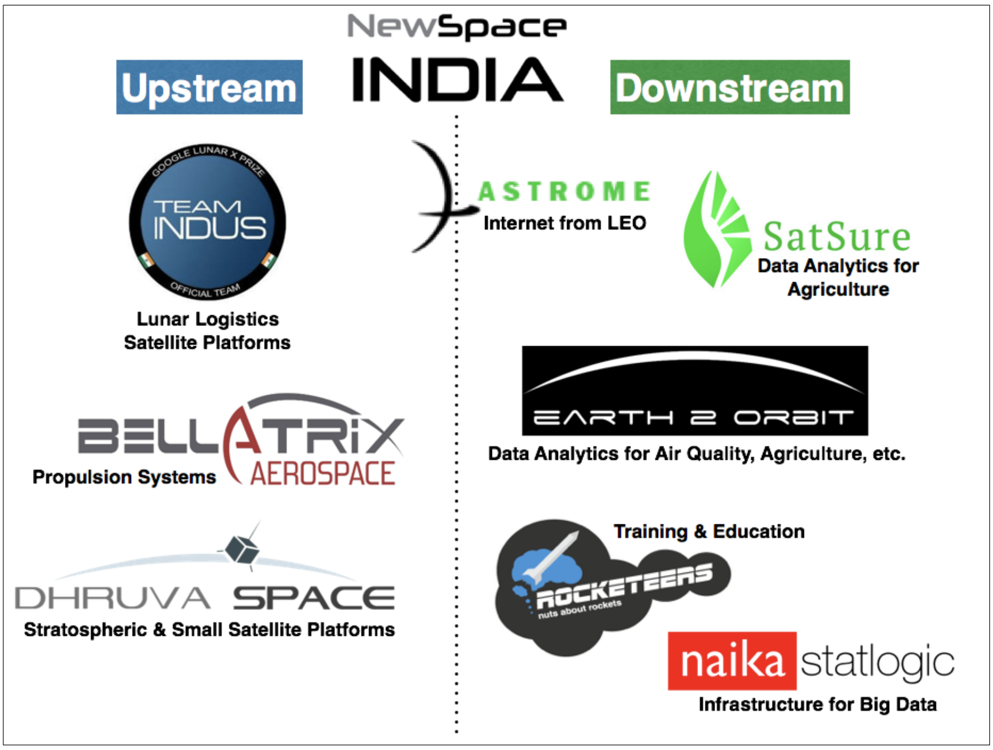
India has witnessed the emergence of New Space over the last decade with companies vouching to take up challenges in both upstream and downstream parts of the ecosystem. Figure 1 provides an overview of the current landscape of the New Space phenomenon in India. It is important to note that the keystone player in the Indian space programme encompassing both the upstream and downstream ecosystem is the Indian Space Research Organisation (ISRO). The traditional space exploitation is based on providing key services to the society based on space capabilities and is organised on thematic basis of remote sensing, telecommunications, navigation and science missions. While ISRO provides both G2G and G2B services, New Space activity in India is based on a two-pronged approach of possibly complimenting ISRO in technology/services and exploiting the cost-talent-infrastructure benefits within the country to export abroad.

From a business incubation and growth perspective, New Space in India has been mostly backed by private risk capital of either the entrepreneurs themselves or high-net worth individuals who act as angel investors to support the growth of start-ups. Unfortunately, there are no dedicated or formal start-up incubation/acceleration programmes in the country similar to ESA's Business Incubator Programme or NASA's Small Business grants for entrepreneurs to gain initial support in the incubation phase of business. However, start-ups do have possible support in terms of consultancy and access to facilities based on the heritage established within the government-led space programme (both in terms of manpower and infrastructure).

While India has a reasonably able SME foundation that supports ISRO in its routine activities of development of launch vehicles and satellites, none of them are involved as independent service providers who provide an end-to-end offering. Therefore, from an ecosystem perspective, the New Space crop in India aims at filling this void in the ecosystem. With the emergence of small satellites and Commercial-Off-The-Shelf (COTS) technologies, actors in the upstream are trying to benefit from creating platforms on which new services such as Automatic Identification Systems (AIS), Automatic Dependent Surveillance-Broadcast (ADS-B), Machine to

Machine (M2M), etc, can be explored in the country. Similarly with the extensive availability of space data, actors in the downstream are trying to fuse space, ground and socio-economic data to create insights for businesses in sectors such has agriculture, healthcare, retail, telecommunications, etc.

**Figure 1 - The emerging Indian New Space ecosystem**




## Case Study: SatSure providing data analytics to farmers

Over 12,000 suicides have been reported in the agricultural sector of India every year since 2013.[67] One of the fundamental reasons for such an unfortunate reality is a large number of farmers living below the poverty line. How do you address this problem in the short term while also trying to double or quadruple the income of farmers?

67. D. Mahapatra, "Over 12,000 Farmer Suicides per Year, Centre Tells Supreme Court – Times of India," *The Times of India*, 3 May 2017.

The crop-insurance claimants in India are likely to touch 130 billion Rupees (~$2b) in the 2016-2017 crop-year ending in the Summer of 2017, in spite of good monsoon, indicating other risks weighing heavy on the farm sector.[68] Meanwhile, according to the agriculture ministry data, a approx. 159 billion Rupees (~$2.4b) premium is estimated to have been collected by the 11 empanelled insurance companies who sold crop-insurance policies to the farmers in both the kharif (summer) and the rabi (winter) season during the 2016-2017 crop-year. Despite a good monsoon year, crop-insurance claims are seen to be huge, showing how risky the farming is in the country, due to the risks varying from place to place and region to region.

Some of the other immediate challenges faced by the farmers in India are: depleting groundwater resources; climate change – increase in the frequency of extreme events like droughts, floods etc.; lack of fair and timely compensation for losses incurred; lack of transparency in fixing the fair price for the produce; difficulty in accessing markets. Other than weather-related issues, lack of proper insurance market and unlocalized insurance index developed by insurance companies are the major issues why fair insurance premiums are not triggered when needed. These are compounded by existing problems such as debt burden, lack of access to scientific agricultural practices, dwindling farm-holding sizes and institutional apathy in access to markets.

## Can satellite data be of help?

Can we use technology to solve this problem? Can we create a possible e-governance framework to solving problems scalable from a farm level perspective to the entire nation? I believe satellite data analytics can lay the foundation to solving this huge societal problem and empowering farm communities in India.

SatSure as a New Space India data analytics enterprise is integrating satellite, weather, and IoT analytics to provide accurate estimates of remotely-sensed agriculture-related data to insurers, so that farmers receive a fair and immediate compensation on loss of crop due to adverse climatic conditions, and insurers can settle claims speedily due to the availability of data in near-real time without any manual intervention.

68. "Crop Insurance Claims Seen Soaring to Rs 13,000 Cr in 2016-17," *The Financial Express*, 18 May 2017.

This is one of the examples of how New Space companies can go beyond using single-sources data and instead combine multiple sources of data in creating a precision-analytics product that can be an enabler of change, and can be used for doing good in the society. Take for instance, the way crop-cutting experiments (CCEs) are conducted throughout the country for getting an estimate of the total agricultural production. CCEs are a very manual and time-intensive process. Smart sampling, using satellite-based crop clustering techniques can be used to reduce the time for identification of these plots and to optimise their locations. Depending upon the diverse crop health and types, the number of the samples for CCEs experiment can be optimised to reduce cost and time. Similarly, digitisation of cadastral records could help in identifying the land-ownership records and updating existing records, overlaid with corresponding information on the crops grown in individual parcels of land. The benefits/claim compensation can then be directly transferred to the respective farmers.

While satellite data has been used to monitor the agricultural sector for the last three decades, the complex relationships between parameters governing crop growth and soil health limited its scope to the research community. This is also a case for going beyond the traditional GIS techniques and to use machine-learning and parallel-computing techniques, to resolve these complex relationships and get insights into the crop phenology. There is an extremely strong case for creating a disruptive technology solution for financial and government institutions, who are among the key stakeholders for ensuring that the country's agricultural growth ensures our food security, along with financial security for farmers.

## The need for updated policy frameworks

New Space developments in India possibly call for new policy updates in order for start-ups to scale. These new requirements are both in the upstream and downstream of the value chain and fundamentally stem from the vision of several New Space enterprises to provide end-to-end products/services, which are unlike the traditional vendors within the space value-chain today who only cater to manufacturing or servicing the requirements of ISRO.

For example, in the case of data analytics companies, the Remote Sensing Data Policy (RSDP) needs to be updated to ensure that they have access to high-resolution imagery on a timely basis, in order to process them and generate analytics. The current RSDP needs approval for high-resolution imagery to be procured and a committee shall decide on the approval. Such roadblocks make the situation harder for start-ups. In such cases, companies might be forced to set up parent companies abroad and do their backend work in India. This is the cost the country will pay for its lack of proactive policy making.

In order to take advantage of New Space developments, a transparent data policy for the use of different sources of data (national and foreign high-resolution satellites and ground-based data) is to be rolled out to create a vibrant geospatial service ecosystem. A transparent regulatory framework has a strong effect on attracting large-scale investments especially from private risk capital. Given the nature of the space industry, private institutions' capital investment remains one of the fundamental requirements for the expansion of New Space India companies in establishing upstream and downstream end-to-end platform capabilities.

Therefore, it becomes necessary that an ecosystem perspective is taken to encourage New Space in India by creating an independent, single-window led, transparent and time-capped framework taking into account both upstream and downstream requirements across the value chain.

## New Space in Japan

The post-WWII self-imposed ban on the use of space technology for military use has restricted the growth of the Japanese industry ecosystem over the past seven decades.[69] However, Japan is now opening up to the importance of a vibrant industry ecosystem and is pushing ahead for the creation of a sustainable and scalable New Space ecosystem.

Japan realised the importance of a top-down policy in creating a holistic ecosystem and charted a Basic Plan for Space Policy which originated in 2009 and was modified in 2013. This plan includes building a roadmap for the systematic development of space technology capabilities and industrial delivery of these for next two decades. While these top-down decisions might largely benefit larger Japanese industrial giants such as Mitsubishi Electric, Mitsubishi Heavy Industries, IHI Corporation, etc., they are definitely a sign of the openness of the administration to support new industrial development for commercialisation of space.

69. A. Lele, *Asian Space Race: Rhetoric or Reality?*, Springer, 2013.

**Figure 2 - New Space ecosystem in Japan**


It provides a map of the New Space ecosystem in Japan. The difference between the New Space ecosystem in Japan and that of India or China is possibly the strong role that academia is playing in creating the foundation to the commercial spin-offs. One of the success stories is that of Axel Space, which has largely benefited from academic investments made by the University of Tokyo and the Tokyo Institute of Technology.

The ecosystem in Japan seems to be more rounded in terms of the upstream and downstream sectors and targets not only the local market but is trying to aggressively capture international markets. This is linked to the evolution of the Japanese industry which has sustained and scaled on the basis of exporting products and services. Entrepreneurs aiming to create extremely niche business that might still be in infancy in areas such as space debris and space entertainment show a larger risk-taking appetite among Japanese ecosystem than its peers in Asia.

One of the most recent consolidation in the start-up scene is the new developments in the Google Lunar X-Prize. In an interesting move, the Japanese team Hakuto signed an agreement with its Indian competitor Team Indus to hitchhike their rover on Team Indus's spacecraft.[70] It will indeed be an interesting few months ahead as some of the X-Prize teams look to launch their spacecraft to the Moon to claim the $20 million prize.

Another interesting phenomenon is the example of Canon, a traditional commercial electronics company, now entering the space business with investments in the development of a launch vehicle as well as its own microsatellite platforms to provide analytics solutions based on its imaging platform. This is an example of how an innovation from a commercial electronics company is being tried and tested as an innovation pivot in the space industry.

From a policy standpoint, there seems to be no special or dedicated policy as far as New Space is concerned. However, the access to institutional private capital is evidently easier in Japan than in India or China. Japan obviously has a richer historical culture of seeding technology companies by institutional private capital than developing countries such as India and China.

## New Space in China

The Chinese space programme, being as heavily State-driven as India, is possibly the biggest investor in space technology in Asia. Several New Space companies with private investments are now surfacing in China in both upstream and downstream. The posturing of New Space in China is not clear, with several State-owned companies planning to go after some of the New Space technology initiatives such as re-usable rockets and modern satellites.

Generally, New Space is looking at developing new technologies with a low-cost philosophy allowing private investors to see opportunities for entry and exit, and these mostly complement State-led initiatives. However, it seems that New Space is China is two-pronged, with both private investors backing private companies to create new offerings, while State-owned entities are also creating "quasi-New Space companies" that can create low-cost access to space. This possibly makes it harsher for New Space companies to find their niches, since competing directly with a State-owned company will be far more difficult for them.

70. "Team Indus To Partner With A Japanese Company To Land The Rover On The Moon," *Huffington Post India*, 22 December 2016.

The Twenty-First Century Aerospace Technology (21AT), which is the only commercial EO satellite operator providing EO data and value added service in Beijing with a focus on meeting the demands from the commercial and international sectors, is an interesting success-story. 21AT has been around since 2005 and seems to have created a niche for itself within China and is looking to internationally increase its footprint.

**Figure 3 - New Space ecosystem in China**


There are signs of Chinese State entities closely following the technology developments of New Space leaders such as SpaceX with Chinese State-owned companies possibly backing the development of similar technologies in China. At the same time, there seems to be tremendous interest by New Space companies mainly in the small satellite sector to develop low-cost rockets. The New Space launch vehicle interests in China is more mature than in India or Japan, since there are several Chinese companies which are backed by investors to build launch vehicles privately. However, reports suggest that there are bureaucratic hassles in getting access to launch-pads since they are mainly controlled by the military.

The New Space launch companies in China are postured in such a way that not only do they have to compete with other international peers in securing orders, but they will also compete against State-owned launch providers. New Space launch vehicle companies are confident that they will be substantially more low cost than State-operated rockets.[71] However, with State-owned quasi-New Space companies such as Expace already signing commercial contracts[72], it is definitely an uphill task for completely private New Space entities to find customers. There is progress in this regards, however, with the Danish small-satellite manufacturer GomSpace choosing the Chinese LandSpace Technology to launch a series of GomSpace satellites to a near equatorial orbit.[73]

One of the interesting phenomenon with respect to the private investments into New Space is the interest of Chinese investors to back New Space companies in the West. Investors from private institutions such as Tencent Holdings have backed companies such as Moon Express and Planetary Resources. Its latest investment is in Satellogic, a satellite company.[74]

From a policy perspective, there seems to be no coherent strategy with respect to specially making way for privately-backed New Space in China. However, the investments being made by State-owned companies suggest that China does not want to get behind the technology curve and will embrace both State-owned companies and privately-backed New Space companies in order to be internationally competitive.

71. S. Chen, "A New SpaceX? China Developing System for Recycling Space Rockets," *South China Morning Post*, 17 March 2017.
72. P. B. Selding, "New Chinese Commercial-Launch Company Advertises High Launch Rate, Low Price", *SpaceNews.com*, 29 November 2016.
73. "First International Contract for Commercial Rocket Launch Signed by Denmark and China," *Room, The Space Journal*, accessed 3 July 2017.
74. "Tencent's Startup Investment Frenzy Now Reaches Outer Space," *Bloomberg.com*, 20 June 2017.

# How the British Space Effort Has Been Redesigned

**By Joanne Wheeler**

Historically, the UK developed its first spatial capacities in the telecommunication field with the purely military satellites programme called Skynet, which was first launched from 1969-1970. It was necessary at the time that the ships of the British Navy could communicate with London. The lack of resources and ambition from the British government in the post-war period and the strong demand for profitable public investments obstructed the development of spatial resources, the objective of which would not have been profit but prestige and scientific research.

In 2009 the setting up of a recovery plan for the British space programme appeared like a small revolution, as the project was very ambitious. Indeed, space is now one of eight priority areas of technology for growth, prosperity and employment in the UK, along with big data, robotics and energy. The UK's goal is to raise its share of the expected £400 billion global space-enabled market to 10% by 2030. The UK also defined an interim goal, namely growing the UK space industry to £19 billion turnover by 2020.

The Space Innovation and Growth Strategy (IGS) of 2010 led to concrete developments in an effort to reach this goal. Given the poor immediate results, the government re-launched the programme with an upgrade – coined the "Restack" –, in 2014, through five recommendations in the Space Growth Action Plan. Ultimately, this major reform of the space sector should provide opportunities in a wide range of areas, though the results of these efforts remain to be seen, also leaving the question open as to how they can be deployed in the context of Brexit.

# The Space Innovation and Growth Strategy of 2010

The publication of the Space IGS has led to the creation of the Space Leadership Council, which is the forum through which the space sector engages with government and has been a significant contributor to the success of UK space policy since its establishment in 2010. The purpose of this Council is to assist ministers with responsibility for space in developing their strategic policy and supporting actions by providing expert inputs to be set alongside advice from officials.

In 2010, the UK also decided upon a 33% increase in optional funding to the European Space Agency (ESA), increasing the UK's work and influence in crucial areas such as satellite communications and Earth observation. Among other decisions within the IGS of 2010, the UK also decided to create the UK Space Agency (UKSA) tasked with providing a unified voice in championing the sector, advising on policy, setting strategy, and coordinating funding with a budget of around £250 million per annum. The UKSA is also the licensing authority for launch and operations licensing in the UK. The Satellite Application Catapult was also devised from the Space IGS. It is situated in Harwell, Oxfordshire and supports the growth of the UK space sector by developing novel mission operational concepts and supporting low-cost access to space. The National Space Technology Strategy was also formed (£35 million funding), and this led to the creation of the National Space Technology Programme. The expansion of ESA matches the increased importance of the space sector in the UK. Indeed, ESA built a new facility known as The European Centre for Space Application & Telecommunications (ECSAT) that was developed following agreements reached between the UK and ESA. It is currently supporting activities related to telecommunications, integrated applications, climate change, technology, and science. The quantitative objectives call for a general overhaul of the sector. The focus is on markets and research that may support space activity. It is also necessary to make the space industry out-looking, crossing the boundaries between sectors to stimulate demand in a wide range of areas.

The Space IGS published in 2010 created a real momentum in the sector. It brought industry, academia, and government together around the common cause of driving economic growth and providing the foundation for a transition of the UK space sector. Yet, the results were not as satisfying as expected, thus calling for the 2014 Space Growth Action Plan. It proposed five high level recommendations to seize the opportunities open to the space sector.

## The Space Growth Action Plan of 2014

- The first recommendation encourages developing the high value priority markets identified to deliver £30 billion per annum of New Space applications by promoting the benefits of space to business and government and engaging service providers. The plan sets up various concrete actions to fit this recommendation. The Satellite Applications Catapult, working closely with UKspace (the trade association of the UK space sector) will lead the majority of the actions in this area with support from the UKSA and InnovateUK (previously, known as the Technology Strategy Board). The first actions proposed to satisfy this recommendation involve the Satellite Applications Catapult supported by UKspace. They should undertake an integrated marketing campaign to champion the use of space services, applications and data in other sectors of the global economy, to develop a delivery roadmap plan for each of the priority markets initially identified and to ensure that this activity is coordinated with stakeholders and is visible to the Space Leadership Council and eventually to update and re-validate priority market delivery roadmaps at least annually. Another action would be using InnovateUK to launch R&D calls that require cross-sector collaboration as part of the call scope and require a business case that promotes value in the space and recipient industries. Eventually, some acts imply the input and collaboration of the UKSA. It should lead to the positioning of the UK's exploitation of Earth Observation data by supporting the community to implement a Climate Services Centre for Europe in the UK, and will also be a way to work with the Earth observation community to identify and invest in new commercial opportunities for premium services beyond those supplied by institutional satellites and finally lead to the moving of the National Space Applications Programme from a set up to an operational phase.
- The second recommendation encourages making the UK the best place to grow existing and New Space businesses and attracts inward investment by providing a regulatory environment that promotes enterprise and investment in the UK. The UK has already done much to promote high-technology businesses such as those involved in the space sector. Competitive corporation tax, the patent box regime and the Enterprise Investment Scheme all provide a helpful background. The Government set out in the Growth Review 2011 that it would cap the unlimited third-party liability for UK satellite operators under the Outer Space Act 1986 (OSA); work with the international regulatory authorities to define regulations for novel space vehicles that offer low cost access to space; and continue to work with the Office of

Communications (Ofcom) to ensure that British industry has full and fair access to the limited supply of satellite orbits slots.

It is crucial that the UK's regulatory, financial, legal and insurance framework is regularly monitored to assess its competitiveness and provide early warning of potential problems and case studies of benefits. There are three principles that underpin the necessary actions: the first one is to achieve UK's growth objective through promoting it as the place to run a space business and ensure that the regulatory environment is competitive. The second one relates to the efficient allocation of scarce national resources, such as spectrum allocations and orbit slots for instance. The third one is that the regulatory burden on SMEs and starts-up should be lightened as much as possible. The UKSA, Ofcom and industry will need to work closely together and in good faith to balance these principles and succeed at realizing the necessary actions defined in the programme. The UK should prioritize its access to scarce spectrum to companies that already significantly contribute to the UK's economic growth or that intend to grow in the UK. Ofcom and the UKSA should therefore ask applicants for UK satellite network filings to the International Telecommunication Union (ITU) and UK space licences respectively, to provide evidence of their existing and future plans to grow employment and facilities in the UK.

- The third recommendation encourages increasing the UK's return from Europe by continuing to grow the UK's contributions to ESA programmes and securing greater influence in large European-funded programmes. The European market and the UK's position as a key contributor to ESA are central to achieving the goals of the plan. The 2010 Space IGS recommended that the UK should invest earlier, more consistently, and at higher scale in ESA space programmes in order to maximize the UK's economic and social benefits from European investment and programmes. The UKSA needs to increase its deployed resources to influence EU space policies and opportunities, raising its effort in line with the EU's increased spending on space. It is also important that the industry more effectively coordinates its interests across Europe. The UK could play a more influential role in Europe and contribute its expertise to EU institutions by ensuring that skilled UK representatives are appointed to EU bodies. The ESA Public-Private-Partnership (PPP) model in telecommunications satellites must be sustained as it should continue its long-term build-up of capability at Harwell, Oxfordshire.

- The fourth recommendation encourages supporting the growth of UK space exports from £2 billion to £25 billion per annum by 2030 by launching a National Space Growth Programme and defining an international policy that will improve collaboration with nations across the world, enhance the UK's competitive edge in export markets and enable targeted and market-led investments in leading edge technology. Strong export growth in space technologies and space enabled applications and services are a cornerstone of this plan. A key enabler of this is the development of a National Space Growth Programme alongside the contribution to ESA. To satisfy the recommendation, the UKSA must establish and seek funding for a National Space Growth Programme that enables the UK to seize growth opportunities that exploit bi-lateral collaboration with other nations, national technology research and demonstration, national science projects and national missions in a way that secures continuity of funding for planning and maximizes value-for-money. A National Space Growth Programme should include provision for repayable investments. This should clearly focus on the identified priority markets. The aim would be to support exceptionally high-value projects that are close to market and hence drive the export of services from the UK. As recognized in the Civil Space Strategy, Space Science can make a direct contribution to growth in the UK sector by providing the basis for collaboration between the UK and other nations in a spirit of common endeavour that will build confidence in each other's capabilities in space; pioneering and developing cutting edge game changing technologies or materials that cannot be done commercially because of the risks involved; catalyzing spill-over benefits from developing technology in uses that cannot be predicted today and increasing the number of skilled workers in the space industry.
- The fifth and last recommendation encourages stimulating a vibrant regional space SME sector by improving the supply of finance, business support, information, skills and industry support. If the UK is to achieve its growth targets, it needs to grow its current SMEs in order to attract and anchor many more in the UK, either as inward investors or as startup businesses. Therefore, the Satellite Application Catapult UKSA, UK Department of International Trade, InnovateUK, the Knowledge Transfer Network and UK Export Finance will come together to develop value-added services including a commercially-focused facility to aid SMEs with regulatory licensing processes; a potential business opportunities service for overseas opportunities based on the UK Department of Trade's information from posts and the EU's Journal; information and a roadmap to navigate the

Government's generic and space finance grand schemes for SMEs. To answer this recommendation, there is also a need for growing space in UK regions; indeed, some 95% of all new jobs and activities are likely to be located away from Harwell.

## How could Brexit impact the British space sector?

As space plays an increasingly essential role in our daily lives and our well-being and as it provides an excellent opportunity to grow the UK economy, as new services and applications contribute to a more connected and secure world, government, industry and academia should be satisfied of the progress made since the 2010 Space IGS. Various institutions that integrate all the interests and fields related to the space sector have been created: The Space Leadership Council, the Regulatory Advisory Group, the Spectrum Advisory Group, the Export Advisory Group and the Defence Advisory Group. The Space Leadership Council, as the most senior space sector advisory group in the UK, will take overall responsibility for governance and delivery of the IGS 2014-2030 Space Growth Action Plan. There will then be a need for measuring the success. It will depend on successfully delivering the actions; the highest-level metric will be growth in UK revenues.

On the 23rd of June 2016, the UK voted to leave the European Union. Throughout the science and academic sectors, this change has spawned questions as to the future of the British space sector, especially given how important the cooperation with Europe is. There are some issues that must be discussed such as ESA membership, freedom of movement, EU funding, the EU/UK space policy, security and defence issues and the UK's planned spaceport. The UK space industry has grown at an average rate of 8.5% since 2010.The industry directly employs around 35,000 highly skilled employees. The UK captures 6.3% to 7.7% of the global space economy and is stronger in the fields of space applications and operations. The UK is particularly competitive in satellite manufacturing, claiming 40% of the small satellite market with only one company: Surrey Satellite Technology. As ESA is an intergovernmental and independent organization and UK's membership is not dependent on membership of the EU, its membership will not be directly affected by the decision to leave the EU. Even if the consequences of Brexit on Britain's space sector are not totally measurable, it is obvious that membership of ESA can still be a significant asset for many opportunities.

## Market Opportunities

Easier and less costly access to space could transform public policies by optimizing management, risk prevention and the regulation of rail, road and air transport. It can also promote space tourism and small payload launch, space planes or even low-cost LEO launch vehicles. Space could also be a significant asset for national security. Indeed, it can provide maritime geospatial services such as maritime surveillance or maritime environment monitoring; secure satellite communications; polar infrastructure for shipping and exploration; prevent and respond to disasters and emergencies; or even provide space robustness services such as removing space debris, space weather or space situational awareness. Space may also be relevant in the environmental protection sector with better weather forecasts, agricultural and food security policy and environmental services such as climate applications, carbon monitoring and modeling and environmental policy. Finally, the access to space should create a decisive opportunity for the distribution of broadband internet: "Broadband for everyone, everywhere". Indeed, it can provide direct home TV; fixed satellite broadband (backhaul, telemedicine and assisted living); broadband to ships and aircrafts; location based services; seamless personal communication; and management of unmanned vehicles; and hosted payloads. Eventually, we could cite some game changing technologies and infrastructures, which will put weight on the space sector. Among them, indoor satellite navigation; ultra low-cost platforms; high resolution remote sensing from GEO; large integrated constellations in LEO; miniaturised antennas for consumer; fractionated satellites; high altitude atmospheric platforms (HAP/HALE) or the in-orbit power.

# For a German-French Common Digital Agenda

**By Olivier Sichel**

The digital revolution is the main challenge European economies will continue to face in coming years. But Europe is far behind the U.S. and, even more worrying, it is now also far behind China. Europe is clearly dominated by large U.S. platforms, Google for search, Facebook for social media, or Ios and Android for operating systems. Europe also lost the handset manufacturing industry with the sharp decline of Nokia, and, apart from the German SAP and the French Dassault Systèmes, Europe is definitely not the area for great software companies such as Microsoft, Oracle or Saleforces.com.

Moreover, Europe is more and more a passive onlooker for digital American start-ups, who disrupt one after the other its traditional strong industries: Uber disrupts public transportation, Amazon disrupts retail, Booking.com and Airbnb disrupt hotel industries, and Space X disrupts Arianespace

Tomorrow, new fintech will disrupt banks and insurance companies, while initiatives in the driverless car area will upset the automotive industry.

Meanwhile, Europe has generated very few new tech giants, even if start-ups and the VC industry are gaining traction. After the failure of the Lisbon agenda,[75] it is now time for Europe to address this challenge very seriously. To achieve this, France and Germany should launch together a common digital initiative, in order to "make Europe great again in technology".

This initiative could address 5 issues: investment, regulation, data protection, tax, and training.

75. C. Wyplosz, "The Failure of the Lisbon Strategy", *Vox*, CEPR, 12 January 2010.

## Invest massively in four key sectors

In December of 2015, France and Germany announced that they would set up a €1 billion fund for the digital economy. This effort should probably be multiplied by a factor of 10 to sustain the momentum versus the U.S. and China. But it should also be oriented into areas where the EU has a chance to win the battle, such as space, automotive, biotech and quantum computing. Over the Atlantic, billions have already been invested in Big Data and Artificial Intelligence. It is probably too late for us to get back into that game. We should avoid a repeat of Quaero initiative, a program focused on search launched in 2009, when Google was already a powerful monopoly.

On the contrary, automotive is a sector that is largely dominated in Europe by German and French players. The capacities of Daimler, Volkswagen, BMW, PSA and Renault, combined with the ecosystems of providers such as Valéo, Faurecia, or Bosch or Benteler provides Europe with a real advance. Over the past few months, driverless programs at Google, as well as similar initiatives by Uber or Apple have lost momentum. These groups are probably facing difficulties to monitor a sector where decades of expertise are making a difference. It is time to invest and support a huge effort of R&D in the automotive industry. A common goal could be to launch an operating system for the European industry.

Space is also an area where France and Germany share a high level of expertise. As we see more and more innovations and a seemingly boundless ambition for space projects in the Silicon Valley, Europe should accelerate and maintain its real advance in this area.

Biotech will face a digital revolution with the arrival of new image technology dedicated to medical applications and the generalization of big data in the biotech industry. France, relying on Sanofi – a brilliant research actor in medicine and a buoyant venture industry in life sciences –, and Germany who also has great companies such as Bayer or Boehringer, could invest massively in that area in order to be the next giants of this emerging sector.

Finally, we should also invest in the next generation of computers. We totally missed the smartphone wave, with the loss of Sagem and Alcatel and the dominance of Apple and Samsung (now challenged by Chinese manufacturers); we also missed the big data and the cloud opportunities; and now probably the AI. But we could get smart and invest very early in the next generation!

The example of Africa is inspiring: the continent is “leapfrogging” the phase of fixed telecom and entering the phase of mobile networks directly. In a similar way, Europe should support the Atos initiative in quantum computing (indeed, Europe tends to follow the model of developing countries in the digital industry, importing high-value goods and exporting its best engineers). Atos bought Siemens in 2010 and is now a French-German company. France and Germany have worked closely to fund the European Organization for Nuclear Research (CERN) in 1954, where physicists and engineers are probing the fundamental structure of the universe. They use the world's largest and most complex scientific instruments to study the basic constituents of matter – the fundamental particles. Let’s build a new CERN focused on quantum computing in Strasbourg.

## A better regulatory framework

In an extremely naive way, the EU has widely opened its market to U.S. digital giants. While China carefully protected its market, filtering Google, closing its frontier to Facebook, enabling its players to copy/paste main American companies with low respect for their intellectual property rights, we have offered our market. Even worse, we favored American companies outrageously by letting them develop their companies in Europe without paying any tax, and abuse their dominant position. For instance it is only after seven years, that Google was condemned for its abuse of dominant position in the search industry. And this was only done for a very limited sector, i.e. the consumer search engine. Enquiries are still on-going concerning the android, the scraping of sites, maps etc. which are still waiting for a decision.

In March, 2017, the “Bundesministerium fur Wirtschaft und Energy” published a brilliant White Paper on the challenges Germany is facing in the area of digitalization[76]. It stated that regulation must evolve: “The applicable elements of the general and rather reactive competition law – as defined by the Act against Barriers to Competition (GWB) – will be combined with a distinctly more active and systematic market supervision and robust intervention powers. The aim is to institutionalize an “early warning system”. A well-staffed authority will be empowered to take a proactive approach in the case of abusive behavior. Proof of a dominant market position – so far required by the GWB – is no longer a prerequisite for intervention. Above all, the authority should also be able to directly

76. Weißbuch Digitale Plattformen Digitale Ordnungspolitik für Wachstum, Innovation, Wettbewerb und Teilhabe, Marz 2017.

sanction infringements of the general law on fairness (protection of competition from distortion by unfair business practices).

This could be achieved jointly in France. As long as this is not the case, start-ups are smothered by giants, investments are no longer done, venture capitalists are not funding this sector, and entrepreneurs are scared to innovate in those fields.

Today, it should be clear that regulation is for Europe the only way to innovate. When there is no regulation, only the strongest wins, i.e. U.S. dominant platforms will prevail over any European attempt. France and Germany should join forces to promote a regulatory framework to ensure fairness, legal certainty and participation possibilities for all.

## Providing a high level of data protection

Due to its history, Germany has a real and deep concern with data protection and a strong will to protect privacy. France with its data protection authority (CNIL) led a European initiative to condemn Google because it was infringing upon the basic rules of data protection.

During the last digital summit, France and Germany agreed to label the security and integrity of the data stored by a cloud provider. This initiative is going in the right direction. While Estonia and some Nordic countries, heavily influenced by internet giants lobbies, widely support freedom of data, it should be possible to gather a German and French agreement on three main principles regarding data protection:

- **Transparency:** every company operating in Europe and using personal data should be transparent about the use of that data. For instance, who knows that some apps geolocalize every user on its mobile every minute?[77]
- **Agreement:** while we all automatically tick the box for the agreement of conditions of use, there is not enough clarity about what we agree to. Here again, Germany and France could launch an initiative forcing large operators to communicate more openly on what you really agree to. In the future, a one page summary of the relevant service and contractual content should be requested of all digital platforms. It should also mention the commercial use of personal data, so that users are made more aware that seemingly free services are actually funded by the sale of their personal data.

77. See "La Lettre Innovation et Prospective de la CNIL", November 2014, www.cnil.fr.

- **Portability:** the only way to enable European companies to compete is to enable them to easily retrieve and transfer their data from one operator to another one. If I have spent time creating a playlist for my music, I need to be able to get it back easily, in order to switch to another music-streaming service, for instance. Same for an address book, or a photo service. By enabling all mobile consumers to keep their phone number when they switch telecom operators, the EU largely fostered competition and innovation.

## Enforcing a fair tax system

Untaxed foreign earnings by American companies top $2,400 billion at the end of 2014[78]. Estimations show that over $3,000 billion are offshore, most of them coming from digital companies: $230 billion for Apple, $113 billion for Microsoft, $62 billion for Cisco, $52 billion for Oracle, $49 billion for Google…

This massive tax evasion is well known and identified in Europe: the "double Irish with a Dutch sandwich" is a tax avoidance technique massively used by U.S. digital firms, involving the use of a combination of Irish and Dutch subsidiary companies to shift profits to low – or no – tax jurisdictions. It involves sending profits first through one Irish company, then to a Dutch company and finally to a second Irish company headquartered in a tax haven. This technique has allowed most web giants to reduce their overall corporate tax rates considerably.

The EU recently condemned Apple to pay back over €13 billion to the Irish State, considering this tax arrangement as public subsidies from the Irish State to the U.S. company and as such, forbidden by our competition laws. While this was a smart move, it should not become the normal way to make companies operating in Europe pay their taxes. We need to re-think our tax system to adapt it to the new digital environment.

Germany and France could simultaneously implement a diverted profit tax, such as the one already implemented in the UK. This tax should be a deterrent for aggressive tax-avoidance schemes, which are easy to use in the digital economy, since you can bill in one country a service that is digitally delivered in another country.

Germany and France could also propose to review the definition of a "permanent establishment" by adding a significant digital presence in the country as a defining criteria. Presently, Google has technically no permanent establishment in any European country except for Ireland. But

78. Audit Analytics, April 2015, www.auditanalytics.com.

every country has, of course, a google.fr, google.de or google.it website. Google uses a considerable bandwidth, has millions of users and thousands of advertisers in every country. All these elements are signs of a significative digital presence, which constitutes at the end of a day a permanent establishment. This enlargement of the notion of a permanent establishment would allow to account the real revenues made in each country and tax the correct profit.

This issue is an emergency. Right now, the Trump administration is considering a very special low tax rate to transfer the $3,000 billions of offshore profits back to the U.S. since China has been far less naive than Europe as regards this tax avoidance system, most of these $3,000 billion represents the total amount of profit made in Europe over the last decade. It would be the hold-up of the century if this huge amount in profit made in Europe were to finally benefit the U.S. treasury.

## A significant training effort

France and Germany share a long tradition of a high level of education into “science, technology, engineering, and mathematics” (STEM). But this effort must be improved. First, because most brilliant researchers are recruited by U.S. companies. The recruitment of French scientist Yann Le Cun as head of the Facebook Artificial Intelligence research lab epitomizes this type of brain drain. But on the other hand, our engineering schools cannot train the number of coders the digital economy needs. This shortage was so disastrous that French millionaire Xavier Niel set up a school dedicated to coding. “Ecole 42” was founded in 2014 to provide the native French digital industry with the hundreds of coders it needs. It is quite a paradox in a country with such a high level of unemployment, especially amongst younger people, that a private initiative was necessary.

So the effort could be done in two directions. Excellence, in order to keep the best scientific talents in Europe – to be at the top of the innovation; but also develop a more quantitative approach, in order to dramatically increase the number of coders, who are the real soldiers in this digital war.

Europe is now at a stage where it realizes it has missed the digital revolution. While digital is a large part of our future in the economy, as well as in other large sectors such as health, education, and culture, getting back in the race is now an absolute priority. France and Germany have assets, but they need a political will and clear common goals to lead the European comeback into the next world.

# Conclusion: European Space Governance – Are We Getting Ready to Enter the Digital Age?

**By Olivier Lemaitre**

Although several definitions exist for the word "governance", it is usually understood, in the specific context of the European space policy, in a relatively restricted way, as the sharing of power between the different stakeholders, and in particular between the European Union and the European Space Agency. More specifically, most debates in the last 15 years have essentially focussed, on the one hand, on which institution should have the pre-eminence in defining and proposing the strategy of Europe in space and, on the other hand, if, how, and to what extent, the space programmes of the European Union should be implemented by the European Space Agency.

The Communication on the "*Space Strategy for Europe*" by the Commission[79] in October 2016, followed by the adoption of very positive conclusions from the Council (in May 2017), and report from the Parliament (in September 2017), seem to have eventually sorted out the issue of the political leadership in favour, as one would have expected, of the European Union. In the aftermath of the launch of this "Space Strategy", ESA (represented by its Director general) and the EU (represented by Commissioner for Internal Market, Industry, Entrepreneurship and SMEs Elzbieta Bieńkowska) signed a "*Joint Statement on Shared Vision and Goals of Europe in Space*", expressing their intention to reinforce their cooperation in the future.

Still, today, major questions remain:

- The role of ESA in the implementation of the programmes of the EU in space: when is it necessary, where should it begin and end, at what cost and conditions…

79. Communication from the Commission "Space Strategy for Europe", COM(2016) 705 final.

- The issue of the coordination and possible synergies amongst Member States and between them and the EU, and
- The ways to further integrate space as an "enabler" of public policies and growth, in particular in the context of the development of a "digital society".

# Space governance

## *Obsolescence is also an issue in space policy*

Since the beginning of the 2000s, EU's ambition in space has continuously grown, first with its flagship programmes, Galileo, EGNOS and Copernicus (formerly known as GMES) and now with the consensus on its strategy in space. But to summarize the challenge faced by Europe at the beginning of the century, it should be reminded that the EU had no space agency (and still has not), and that ESA is not a political body – hence the utilitarian relationship that has developed between the two institutions, codified in an international agreement ratified in December 2003.

The objective of this framework agreement was to reinforce the complementary strengths of both institutions in the fields of research, economy, environment and security. Nevertheless, the agreement is unclear about the decision-making process; it simply created a Joint Secretariat, composed of civil servants of the European Commission and the ESA executive, and this Secretariat is now in charge of preparing the joint and concomitant meetings of the Council of the EU and the ESA Council at the ministerial level (the "Space Council"). The way to prepare common decisions within these "Space Councils" used to follow a complicated *ad hoc* process, completely disregardful of the competences of every institution involved[80]. After the entry into force of the "Treaty of Lisbon" and the competence in space granted to the EU (see hereafter), the political willingness to convene "Space Councils" has understandably eroded.

Nevertheless, the *de facto* extinction of the "Space Councils" did not prevent, for instance, Luxembourg, the Netherlands or, soon, Estonia[81], when in charge of the rotating presidency of the Council of the EU, to organise informal meetings – now called EU-ESA Informal Space Ministerial Meeting (EU-ESA ISMM) –, gathering ministers in charge of space matters from EU and ESA Member States. But then again, these

80. "European Space Policy: 2 Years after Lisbon", Desingly A. & O. Lemaitre, Space News, 7 December 2011.
81. Respectively in November 2015, May 2016 and November 2017.

"informal summits" are nothing more, in their composition, than informal meetings of the Council of the EU plus ministers from Switzerland and Norway; yet, there is a subtle difference: these informal meetings actually allow for a greater influence of the executive of ESA, as well as a lesser influence of the Coreper[82], in the declaration that will be endorsed, although informally, than when it comes to the formal conclusions of the Council of the EU.

## The "parallel" competence of the EU in space[83]

The increasing reluctance by some stakeholders to continue to prepare and organise "Space Councils" as defined in the EU-ESA framework agreement, finds its (logical) explanation in the difficulty to reconcile the objectives of these meetings (notably the coordination of activities) with the legal competences granted to the institutions though the Treaty of Lisbon. More specifically, the Council of the EU has a legislative competence in the EU, not an executive one, as the executive competence is in the hands of the Commission, which holds in addition the "right of initiative".

Indeed, the role of the EU in space policy was formally established with the Treaty on the Functioning of the European union (TFEU), also called "Treaty of Lisbon" in 2009. Article 189 of the Treaty gave the EU a shared competence in space[84]; however, art. 4 of the same TFEU states that the EU "*shall have competence to carry out activities, in particular to define and implement programmes; however the exercise of this competence shall not result in member States being prevented from exercising theirs*".

82. The Permanent Representatives Committee, or Coreper, is responsible for preparing the work of the Council of the European Union. It consists of representatives from the EU countries with the rank of ambassador to the European Union.

83. For a more in-depth analysis, see for instance F. Mazurelle, J. Wouter and W. Thiebaut, "The Evolution of European Space Governance: Policy, Legal and Institutional Implications", *Working Paper*, No. 25, Leuven Centre for Global Governance Studies, April 2009 ; or J. Béclard, "The Lisbon Treaty and the Evolution of European Space Governance", *The Europe & Space Series*, No. 12, Ifri, July 2013.

84. Art. 189 of the TFEU :

1. To promote scientific and technical progress, industrial competitiveness and the implementation of its policies, the Union shall draw up a European space policy. To this end, it may promote joint initiatives, support research and technological development and coordinate the efforts needed for the exploration and exploitation of space.

2. To contribute to attaining the objectives referred to in paragraph 1, the European Parliament and the Council, acting in accordance with the ordinary legislative procedure, shall establish the necessary measures, which may take the form of a European space programme, excluding any harmonisation of the laws and regulations of the Member States.

3. The Union shall establish any appropriate relations with the European Space Agency.

4. This Article shall be without prejudice to the other provisions of this Title.

The TFEU allows therefore the Member States to exercise their competence in space in "parallel" to the EU, which can certainly be interpreted as the result of the reluctance of some Member States to "abandon" to a supranational level a sector that they consider strategic for their national sovereignty.

Besides, it has been argued that the mission granted to the EU of "drawing up a European space policy" overlaps ESA missions as defined in Art. 2 of its Convention[85]. However, the task granted to ESA of "*elaborating and defining a long-term European space policy*" has a clearly defined objective, which is simply to "*provide for and to promote [...] cooperation among European States in space research and technology and their space applications*". The scope of the space policy to which the TFEU refers has a significantly broader objective, and aims at "*promoting scientific and technological progress, industrial competitiveness and the implementation of its policies*".

In any case, the need for coordination in this intricate context is obvious, although the text of the TFEU provides little support, as it allows the EU to "*establish appropriate relations with the European Space Agency*" and even to "*coordinate the efforts*", but leaves ample room for creative interpretations. This obviously stirs up the suspicion of some Member States that have no intentions whatsoever to see their activities being "coordinated" within an EU framework.

## *The ambiguous role of Members States*

Yet, paradoxically, Member States are all, in a touching ensemble, pleading for more "coherence", "coordination" and/or "complementarity"; in November 2015, during an "Informal Meeting of the EU and ESA Ministers in charge of Space"[86], Member States stressed the need for a "joint forum" in which the EU, ESA and their respective Member States would coordinate and exchange views on the European space policy.

This repeated demand for "coordination and exchange of views" is actually difficult to grasp because the Member States have levers at every level:

85. Convention for the Establishment of a European Space Agency.
86. Brussels, 30 November 2015, under the co-chairmanship of deputy Prime Minister E. Schneider from Luxembourg and M. Dell'Ambrogio, Swiss State Secretary for Education, Research and Innovation.

- At multilateral level, to define the way they want to contribute to joint efforts, they can intervene in the ESA Council and ESA decision-making bodies;
- At EU level, to contribute to the elaboration of the EU space policy and programmes, they can use the different channels at their disposal to dialogue with the EC (Space Policy Expert Group, Programme committees…) and then their prerogatives in the Council, as co-legislators.

Therefore, a "coordination forum" with ESA would actually only be useful for the EU to explore the possible collaborations with Norway and Switzerland (and, soon, the UK), which although important, is of a relatively limited scope.

That being said, it seems more and more urgent that the Member States (which indeed keep their competence in space policy) start coordinating among themselves in order to define if and how they want to make use of their competence to contribute to the objectives of a common (EU and Member States) European space policy. But the danger with "parallel" competences is that, as parallel lines, they risk to never meet up.

Unfortunately, it seems much easier for most Member States to define the boundaries of an EU space policy, and especially the red lines of the future action of the Commission, than to define their contribution to a collective endeavour.

And indeed, the promising experience to set up a support framework[87] allowing Member States[88] to network their national capacities to track space objects in order to develop a risk-assessment service at EU level, is still in a very disappointing situation. An integrated architecture built on complementarity is still missing, and progress is still hampered by poor cooperation between the Member States of the Consortium on security-related aspects.

The difficulty for Member States to join forces when it comes to pool their actions or to share their results is worrying in the context of the increasing political willingness, at EU level, to leverage collaborative efforts by Member States in developing defence capabilities to respond to security challenges[89]. More specifically, new initiatives at EU level such as

87. Decision No 541/2014/EU of the European Parliament and of the Council of 16 April establishing a Framework for Space Surveillance and Tracking Support (SST).
88. Willing to participate, and owning adequate capacities (sensors and operational analysis): see art. 7 of the Decision mentioned above.
89. The Council of the EU itself, in May 2017 recognised that "space technology and derived services contribute to providing solutions to security challenges" and acknowledged "the need for stronger synergies to be pursued between the civilian and military use of space assets" ("A Space Strategy for Europe", Council Conclusions, 9817/17.

Govsatcom[90], which will be a dual-source and dual-use programme, could probably benefit in its build-up phase from funds coming from the future European Defence Industry Development programme[91]. But only if Member States develop enough trust among themselves and a renewed confidence in the European project.

## ESA-EC "symmetry": a major delusion

An important factor explaining the difficulty to reach serenity in Europe when addressing the governance of space lies probably in a relative lack of "political literacy" and knowledge of the EU in a sector that, during decades, focussed all its attention on technological challenges, national sovereignty issues and multilateral scientific and technical cooperation.

There is for instance, on the ESA side – both within the Executive and amongst delegations – this tendency to see a "symmetry" between the "EU Member States" and "ESA Member States", between the Council of the EU and the Council of ESA and, subsequently, a symmetry between "the European Commission" and "the ESA Director General and staff".

This is of course wrong. The EU acts through supranational institutions (their role and functioning are defined in the "Treaty of Lisbon" and their decisions apply to the Member States) and its Member States are, within the Council of the EU, "only" a co-legislator. ESA, on the contrary is an intergovernmental organisation, established by its Convention, and its decisions apply only to ESA (and not to its Member States).

More specifically: ESA is composed of only two official organs, the Council and "the Director general assisted by a staff"; according to the Convention, the Council defines the policy and approve the activities, while the Director general submits proposals (concerning activities and programmes) to the Council and manages the Agency and the programmes.

As an illustration of the consequences of the confusion of positions, recent official texts issued by several institutions[92], including EU ones, continue to speak about the necessary "cooperation between the EU, the ESA and the Member States" as if ESA – an intergovernmental agency –

90. The Govsatcom initiative intends to offer guaranteed access to secure satellite communication for all military and civilian security actors in the EU and Member States.
91. "Proposal for a Regulation of the European Parliament and of the Council establishing the European Defence Industrial Development Programme aiming at supporting the competitiveness and innovative capacity of the EU defence industry", COM(2017) 294 final.
92. The most recent example being probably the "report on a Space Strategy for Europe", European Parliament, Committee on Industry, Research and Energy, rapporteur Constanze Krehl, A8-0250/2017.

was an institution that could be independent and have a different position than the one agreed by its Member States in its Council. The responsibilities of ESA are only the ones collectively entrusted to it by its Member States.

Institutions would therefore be better inspired to speak about the "cooperation between the EU and the Member States, acting either independently or collectively within ESA".

Could the fact that ESA now draws a significant part of its income independently from the contributions of its Member States[93] be helping to fuel some desire of "emancipation" from its Council amongst the staff, and the perpetuation of confusing formulations?

## *Space programmes*

As we have seen, the implementation of EU programmes through cooperation amongst Member States is challenging, but it should not be assumed that their implementation through ESA is in any way easier, even after nearly 15 years of experience, from the co-funding of the development of the In-Orbit Validation phase of Galileo or the EU contribution to the GMES programme, to the delegation agreements on Copernicus and Galileo deployment, or the working arrangements with the GSA[94] on EGNOS and on Galileo exploitation. Quite astonishingly, none of these agreement have the same administrative and financial schemes, and so generate a lot of bureaucracy and frustrations.

ESA, for instance, is complaining – especially regarding the implementation of Galileo – that the focus of the EC on mitigating its accountability risks (imposing high reporting and evaluation constraints to the ESA staff) is actually diminishing ESA capacity to efficiently manage technological and programmatic risks. The delegation agreement concerning the Copernicus programme is considered within ESA as an improvement as it gives ESA a larger degree of autonomy and the possibility to make an increased use of its procurement rules, and gives industrial contractor a single interlocutor. On the EC side, despite the heaviness of ex-ante and ex-post evaluation processes, the lack of resources is preventing it from truly challenging the technical proposals made by ESA regarding the architecture of the systems or the results of the procurement

93. Around €1 billion are now transferred annually by the Commission to ESA since the last few years, for the implementation of the GNSS and Copernicus programmes; see the Annual Activity Reports 2015 and 2016 of DG GROW.
94. The European Global Navigation Satellite System (GNSS) Agency (GSA).

boards, abandoning therefore its prerogatives of programme manager, and inhibiting its possibility to implement industrial policy measures.

The problems even worsen for the EC when the first elements of a programme are developed under the responsibility of ESA – applying its procurement rules, notably the geo-return – and then handed over to the EU for the recurrent units, as it challenges the capacity of the EC to use competition at later stages.

Despite the current difficulties, ESA executives insist in positioning ESA as "THE" European Space Agency, and set the obtention of the exclusive authority over the end-to-end management and implementation of EU-funded space programmes as a goal. This ambition probably contributes to explain why ESA was eager, last year, to launch activities on a "Govsatcom precursor", in order to ensure its role as implementing agency in a future EU Govsatcom programme: ESA apparently feared that the EU could otherwise proceed with direct contracting to the Industry (and Member States, for public capacities), thus setting a precedent that could put into question ESA role in other domains.

## The case of R&D

Regarding the support to R&D, with the Horizon 2020 programme of the EU, the funding for space has increased significantly,[95] generating fears at ESA that this would deter Member States from investing in its own R&D programmes and provoking recurrent calls amongst Member States for "avoiding unnecessary duplications" and ensuring "complementarity". But of course "complementarity" has different meanings: some Member States aim at avoiding that the EU finance developments in an area that they are financing through ESA (and that they therefore "keep" for their domestic industry) while others aim at avoiding that ESA finance technologies that they do consider interesting but that they cannot afford to finance through ESA optional programmes (and whose funds would therefore escape their domestic industry – because of the geo-return rules).

In any case, the work programmes under H2020 (with the exception of the part dedicated to Navigation, preparing the evolution of EGNSS programmes) are definitely not yet conceived as part of a long-term strategy for space, to the disappointment both of ESA, strongly dependant on R&D activities for the preparation of its own programmes, and of the

95. Even though the budgets for space research in the previous programme (FP7) and H2020 are more or less equivalent, FP7 was mostly used as a vector to finance the contribution of the EU to the space component of the GMES programme (now Copernicus).

Industry, vitally reliant on R&D to support its competitiveness and to face the massive technological disruptions happening in the sector.

As expected, the Director general of ESA is proposing the EC to support the Commission in the definition, management and implementation of H2020/Space and considers that an entrustment of the EU space technology and research budget to ESA is key to the future improvements in the cooperation framework with the EU.

Space industries also have their views on the specific issue of the governance of R&D activities and are proposing to the EU to enter into a PPP scheme ("Joint Technology Initiative") dedicated to the support to the development of enabling and critical technologies for competitiveness. With this initiative, the industry intends to overcome some of the limitations of the current H2020/Space programme (projects too small, too much focus on activities relevant to science and public research institutes, unbalance in favour of low "technology readiness levels"…) and to put the industry more in the "driving seat" when it comes to the support to competitiveness on commercial markets.

## Operational programmes need… operators

With the significant increase of the ambitions of the EU in space, through its two flagship programmes, the institutional demand is today more and more driven by the political willingness to address societal challenges (transport, environment, security…) and the ambition to generate economic growth. The European institutional market therefore requires operational infrastructures.

The consequence is, as was the case for telecom or meteorology, an ever-increasing importance of the quality and guarantee of service, stability, sustainability, increased cyber security and, of course, security of supply (hence the need for an efficient industrial policy). None of this will happen in the absence of "educated" and empowered customers[96] of space systems and of efficient operational schemes:

- To ensure the proper interface between the stakeholders (industries and agencies) in charge of the development phase, the service providers and the end-users;
- To take responsibility for long-term operations and adaptation of the infrastructure;

96. A good example of such a "customer" is Eumetsat, an intergovernmental organisation in charge of supplying weather and climate-related satellite data, images and products to the National Meteorological Services of its member States.

- To ensure the delivery of continuous and reliable data and services to users.

The current responsibility in the exploitation of the EU space programmes has fallen on a hotchpotch of agencies (GSA, Eumetsat and ESA), although the exploitation of the navigation programmes is not even part of the official mission of the GSA[97], and ESA is an R&D Agency with no particular skills in the exploitation of operational infrastructures.

Interestingly, the Commission, the Council of the EU and the Parliament are all calling for a strengthening of the role of the GSA regarding the exploitation of Galileo and EGNOS, and are considering to extend the GSA's responsibilities to other space programmes. All the same, the Parliament wisely asks the Commission to ensure that the GSA has the capacity to take on new tasks before any are conferred upon it – which would call for the ambitious overhaul of its missions and evolution of its human resources management.

But the road will not stop there.

## Space, a strategic infrastructure of the digital society

The natural next step after the deployment and exploitation of operational space infrastructures is a shift of power from the data supply side to the processing and distribution of information. This trend benefits the large IT companies which are particularly strong in the US but largely absent in Europe. As they become a key channel to the markets, those owning data management platforms will take control of the distribution of critical information (geospatial information in particular). Europe will have difficulties in competing with the business models of Google, Amazon, Apple or Facebook, but it must set up a competitive "ecosystem"[98].

The reason why it is urgent for Europe to capture the breadth of this evolution is simple: satellites are *in fine* means – most of the time unique and essential – to collect and to distribute data all over the world. The efforts of the European Union to accelerate the transition towards a data-driven economy can only be conceived if Europe exerts sufficient control over its capacity to access and disseminate information. Space is not only

97. The exploitation of Galileo and EGNOS has been entrusted to the GSA through a delegation agreement with the Commission.
98. A first move in this direction is the launch by the EC of an initiative to develop Copernicus Data and Information Access Services (DIAS); by providing data and information access alongside processing resources, tools and other relevant data, this initiative is expected to boost user uptake, stimulate innovation and the creation of new business models based on Earth Observation data and information.

part of the digital agenda, it is a critical infrastructure that is strategic to exist in a digitalised and globalised world.

In the expected "hyper-connected" world, satellites will deliver strategic advantages in the following aspects:

- Connecting remote assets and populations living in areas not (or no longer, in case of catastrophes) accessible to terrestrial networks
- Driving the use of widely distributed sensor networks
- Transforming transportation infrastructure - satellite communications is key to enabling the next generation of mobility services and guaranteeing the availability of safety features in remote areas around the world (including in the sky).
- Acting act as a reliable backup network for services with critical safety and security aspects (connected cars, telemedicine…).
- The growth of the space applications sector and the full exploitation of European space capacities – that all European public authorities are calling for – can only be considered in the context of a strengthened "hybridisation" between the different application domains, the ICT sector and the space industry.

## The irruption of the ICT sector in space

This hybridisation is already happening and the revolution that took place in the field of launchers (with SpaceX, for instance) is now affecting the satellite industry. In the field of telecommunications as well as in Earth Observation, with mega-constellations and new actors coming from a very strong private US ICT sector, "New Space" demands that the space sector adapt to new techniques and production processes. Production volumes and rates, associated to changes in satellite lifetime and requirements, are leading to significant disruption in design, development, production, qualification and validation processes.

## The private sector knocks on the door

As the Secretary General of the European Policy Institute in Vienna, Jean-Jacques Tortora, underlined recently, a lot is going on around the world with the bubbling of bold initiatives from private actors, some of them being new-comers in the sector. It is too early at the moment to assess how many will ultimately prove to be successful, both technically and financially. However, all claim – and to some extent demonstrate – that relaxation of constraints inherent to public procurement allows them to dramatically increase effectiveness in the development phase, and to radically optimise recurring and operational costs.

Taking advantage of such supposed benefits implies that public buyers shift from a position of almighty customer to a position of consumer, procuring off-the-shelf products or services developed under pure private management. NASA and DoD have started to evolve along these lines in carefully selected areas. This is one step ahead of the traditional PPP arrangements currently considered in Europe for innovative procurement and it implies long-term commitments for the procurement of products and services that are not compatible with the current practices of both ESA and EC.

The trend towards "entrepreneurial space" means that the implementation of operational programmes, even institutional ones, is left to the Industry with a greater degree of freedom, while the customer commits to long-term use of services.

This trend encourages the emergence of a new actor in "space governance": the private sector[99]. And it seems clear that the European Commission has an interest in exploring a similar approach, at least with Copernicus: it is investigating ways to strengthen the industry's role in the programme, giving it greater visibility on the evolutions, to elaborate new forms of public-private partnerships.

## New Space, new threats

Over the last four decades, the exponential multiplication of inexpensive computing devices and the creation of the Internet created the basis of today's digital economy. A similar phenomenon might well take place right now in space. The first driver will be the result of the ongoing reductions in the cost of launching satellites into orbit; a second one is the quick development of satellites that are dramatically smaller, lighter, and thus easier and less expensive to launch. The manifold implications of this movement will be felt on governance too.

Geneviève Fioraso[100] underlined that New Space comes along with new threats and with the multiplication of initiatives and actors. This will inevitably put additional pressure on the space environment. Unlike previous generations, we now know that space has some limitations. And accounting for the limitation of resources radically changes the nature of

99. As already witnessed in Europe with ArianeGroup (formerly Airbus Safran Launchers) in the domain of access to space.
100. G. Fioraso, former French minister for Research and Space, Closing address at the 9th Conference on European Space Policy, Brussels, January 2017.

international negotiations to come. Moreover, the whole existing international space-related legislative framework is meant for dealing with the slow-pace evolution of a sector nearly entirely dominated by states and governmental bodies. This has little to do with the situation unfolding now.

Indeed, we can reasonably anticipate in the near future some lively discussions in the international instances dealing with space, which will definitely require that Europe will by that time have found the ways to speak with a stronger voice on the international scene, as it plays its role in future unavoidable negotiations related to space traffic management, security of operations in orbit, and evolution of space laws and regulations. This would be the right opportunity to assess a unified European approach against multiple national legislative steps.

## The irruption of space in the ICT sector

### Space and telecommunications: a new hope

The hybridisation between space and the ICT sector also implies increased participation of the stakeholders involved in the governance of the ICT sector, which is itself confronted to major disruptions – in particular the globalisation and acceleration of the development cycles of new products and services. Moreover, the institutions in charge of regulating and supporting the ICT sector, at least in Europe, have always had difficulties in structuring their relation with the space sector, because of their completely different and much smaller markets, particular standards, quality management methods and the perception that it represent very expensive investments. At least in the "business to consumer" (B2C) context.

Now, with the emergence of new standards and the expected emergence of the "Internet of Things" and of "Machine to Machine" communications, the situation might rapidly change and, as stated by Magali Vaissière, the ESA Director of Telecommunications and Integrated Applications, "*5G provides a major opportunity for our space industry, for space and satellites to become integral parts of the future generation of communications networks and services*". Furthermore, the traditional competition between terrestrial networks and space could decrease as the density of the objects to be connected will not necessarily superimpose itself onto the density of the population.

In the EU, this evolution will unquestionably call for increased teamwork between the Directorate general in charge of space and the one in charge of communications[101].

## *A digital world calls for a global governance*

The amount of – free! – data generated only by the currently operational Sentinel satellites represents almost 6 Terabytes daily and, with the expected deployment of new Earth Observation and data-collection constellations, this figure will be multiplied. This shows how much space will be a generator of "big data", and a major provider of the "raw material" of future high performance computing capacities.

The foreseeable consequence of this phenomenon is that it will dramatically ease the monitoring of everything that happens on the surface of the planet, for good and for bad: from crop monitoring to maritime surveillance or even to tracking the number of cars at shopping centres as indicators of consumer confidence.

This brings up very fundamental questions[102]: Who should own the data and the resulting analyses, and how can we balance private ownership of data one group has paid for, against its value to the public? How can this infrastructure be regulated so as to prevent its misuse by governments, businesses, criminals and/or terrorists without stifling innovation? How should these data, services and transactions be taxed and by whom? These questions will soon appear on the table of international forums, and the EU, capitalising on its experience with Copernicus, could take a considerable edge.

A very concrete application that will also require new developments in governance is the monitory of international treaties[103]. The current use of satellite data has not yet been laid down in international agreements (although it is being used by the International Court of justice as evidence). Nevertheless, the obvious benefits provided by satellite data call for specific provisions detailing the use of space-based data to monitor international agreements. However, such provisions will be politically polemical, as States might be reluctant to accept third parties monitoring their compliance and would question the integrity of satellite data of other States. There is thus a question of confidence in the data, reliability of the processing of the data, and neutrality of the interpretation of the data.

101. Respectively DG GROW — Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs and DG CNECT — Directorate-General for Communications Networks, Content and Technology.
102. "Space-based "Digital Twin" of Earth Brings Affordable Insights", Medium, 25 March 2017.
103. "Satellite Data to Monitor International Agreements", *ESPI Briefs*, No. 14, European Space Policy Institute, June 2017.

How to verify the integrity of the data, and who has the authority to verify the integrity of the data, can only be resolved at an international level.

Today, we are all living in a globalised world, and it is not only the trade, or the information, that are globalised, but also transport, natural resources, environmental issues… If Europe wants to play the role of a global actor and develop business in a globalised world, it needs a global view and a way to communicate globally – and this is exactly what space is about!

However, Europe needs to consolidate its voice in preparation of the globalised governance that will affect space directly and, even more important, of the worldwide governance (or conflicts) that will emerge from the evolution of global capacities in space.

*The opinions expressed here are those of the author and are not to be considered as the official position of his institution.*

# GLOSSARY

- **ADS.B**: *Automatic Dependent Surveillance-Broadcast*; surveillance technology in which an aircraft determines its position via satellite navigation and periodically broadcasts it, enabling it to be tracked.
- **AIS:** *Automatic Identification System;* automatic tracking system used on ships and by vessel traffic services.
- **ARPU**: *Average Revenue Per User;* measure used primarily by consumer communications, digital media, and networking companies, defined as the total revenue divided by the number of subscribers.
- **B2B**: *Business to Business;* situation where one business makes a commercial transaction with another.
- **B2C**: *Business to Consumers*; all the technical structures and software programs used to connect businesses directly with consumers.
- **CCE**: *Crop Cutting Experiment;* process used to estimate crop yields of a location.
- **CERN**: European Organization for Nuclear Research.
- **COREPER:** Committee of Permanent Representative.
- **COTS**: *Commercial Off-the-Shelf*; commercial items, including services, available in the commercial marketplace that can be bought and used under government contract.
- **EC:** European Commission.
- **ESA**: European Space Agency.
- **EU**: European Union.
- **GAFA**: Google, Apple, Facebook and Amazon.
- **GAFAM:** Google, Apple, Facebook, Amazon and Google.
- **GNSS:** *Global Navigation Satellite System;* system that uses satellites to provide autonomous geo-spatial positioning.
- **GSA**: European Global Navigation Satellite Systems Agency.
- **G2B**: *Government to Business*; online business transactions between

organizations of public administration and a company.

- **G2G**: *Government to Government;* electronic sharing of data and/or information systems between government agencies, departments or organizations.

- **HTS**: *High-Throughput Satellite*; classification for communications satellites that provide at least twice the total throughput of a classic FSS satellite for the same amount of allocated orbital spectrum, thus significantly reducing cost-per-bit.

- **H2020**: *The Framework Programmes for Research and Technological Development ("Horizon 2020");* funding programs created by the European Union to support and foster research in Europe.

- **ICT:** *Information and Communication Technologies*; Extended term for Information Technology (IT) which stresses the role of unified communications and the integration of telecommunications, computers as well as necessary enterprise software, middle ware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information.

- **IoT**: *Internet of Things*; network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to connect and exchange data.

- **ISMM**: Informal Space Ministerial Meeting.

- **IT:** *Information Technology*; application of computers to store, study, retrieve, transmit and manipulate date, or information, often in the context of a business. It is considered a subset of ICT.

- **ITU:** *International Telecommunication Union*; specialized agency of the United Nations that is responsible for issues that concern information and communication technologies.

- **LTE**: *Long Term Evolution*; a standard for high-speed wireless communication for mobile devices and data terminals, based on the GSM/EDGE and UMTS/HSPA technologies.

- **MEA**: Middle-East and Africa.

- **MB**: *Megabyte*; multiple of the unit byte for digital information.
- **Mbps**: Megabit per Second.
- **M2M:** *Machine to Machine*; direct communication between devices using any communication channel, including wired and wireless.
- **PPP**: *Public-Private Partnership;* cooperative arrangement between two or more public and private sectors, typically of a long term nature.
- **QKD**: *Quantum Key Distribution*; secure communication method which implements a cryptographic protocol involving components of quantum mechanics.
- **STEM**: Science, Technology, Engineering, and Mathematics.
- **Tbps:** Terabit per Second.
- **TFEU:** Treaty on the Functioning of the European Union (Treaty of Lisbon).
- **UAV:** *Unmanned Aerial Vehicle;* aircraft without human pilot aboard, commonly known as a drone.
- **VSAT:** *Very Small Aperture Terminal;* two-way satellite ground station with a dish antenna that is smaller than 3.8 meters.

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