Big Data from Space

Legal Issues Related to Access and Dissemination of Large Volumes of Space-Generated Data

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Abstract

The term "big data" is used to describe large amounts of data, generated in great velocity and variety and processed to match the needs of different types of users. In the space field, big data is translated to large pools of information acquired using Earth and space observation technologies.

Data collected from remote sensing activities are used for several purposes, varying from military and civil services, to commercial uses. The EU Copernicus Earth monitoring system, as well as other similar private projects, is aiming at providing their users accurate, near real-time data. Scientists, policy-makers, government authorities and public entities, industry and the general public are increasingly gaining access to the multiple applications of space data. New technologies have accordingly created commercial potentials for users who view big data as a competitive advantage and a value-generating asset.

This growing demand for space data was not foreseen thirty years ago, when the UN Remote Sensing Principles of 1986 were drafted. The legal regime related to Earth observation should be reviewed, in light of the needs of this emerging domain.

The purpose of this paper is to discuss the legal challenges related to access and dissemination of big data from space, taking into account international space law, as well as data protection and privacy regulations.

I. Introduction

Space big data is an emerging field of space applications. The growing number of satellites launched is accordingly leading to large amounts of data generated and transmitted.[1] At the same time, there is increasing demand for space data that can be further used for various purposes. Nowadays, space data and its applications are equally targeting scientists, governments, businesses, as well as individuals. Information about the outer space environment, infrastructure maintenance with the help of satellite imaging,

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1 How Big Data from Space Helps Life on Earth, World Economic Forum, 2015.

acquisition and process of raw data for added value end solutions, and navigation services are only a few instances where space data is used by the various stakeholders.

The main difference with the introduction of space "big" data is that it is collected in significantly bigger quantity compared to the past. Due to the great volume of data produced and distributed the information concerned can be addressing multiple different issues. Space technology is not only deployed for telecommunication purposes, Earth observation or remote sensing, but it is nowadays used for the transfer of various other types of data.

This paper will elaborate on the topical subject of space big data from the perspective of international space law and data privacy and protection regulations.

The UN Remote Sensing Principles[2] were concluded three decades ago, when space applications were still in their infancy and the amount of data from space and were primarily serving civil and military causes. It will be supported in the following paragraphs that, even though the Principles are addressing some of the pressing space big data issues, they are not sufficient in meeting the legal challenges with respect to the generation, dissemination and use of space big data.

Additionally, the growing commercialisation of the space sector and the increasing opportunities provided from the utilisation of space data are raising, among other concerns, issues of privacy and data protection.[3] Therefore, it is important at this stage of space big data revolution to discuss the appropriate regulatory response. Towards this end, the paper will suggest a definition of space big data and propose solutions to the rising legal challenges.

II. Space Big Data

In order to be able to identify and respond to the mounting challenges, it is imperative to provide a definition for the subject in question. Even though the notion of "space big data" is increasingly used lately both in legal and technical language,[4] there is not yet a commonly accepted understanding as to what the term entails.

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2 Principles Relating to Remote Sensing of the Earth from Outer Space, GA Res. 65, UN GAOR (Supp. No. 53) at 115, U.N. Doc. A/41/53 (1986).

3 J. Soria-Comas, J. Domingo-Ferrer, Big Data Privacy: Challenges to Privacy Principles and Models, 1 Data Science and Engineering, 21, 2016, pg. 22.

4 "Big Data from Space refers to the massive spatio-temporal Earth and Space observation data collected by space-borne and ground based sensors", ESA BiDS 2016, http://esaconferencebureau.com/2016-events/16m05/objectives; "large amounts of different types of data produced with high velocity from a high number of various types of sources", Communication from the Commission to the European Parliament, the Council, the European and Economic and Social Committee and the

Definition

"Big data", as the notion suggests, refers to significantly large amounts of data. It is distinct in terms of quantity in that it presents challenges during its process and analysis.[5] The term is usually described through its subsequent characteristics, namely the data *volume, variety, velocity, and veracity*.[6] In this sense, big data is the information that is generated in great speed and wide diversity, spread in fast pace and produce meaningful information. Often *value* is added to the aforementioned elements, based on the argument that data is useful or relevant as long as it results to a meaningful or desired outcome.[7] The data-driven economy of the recent years is putting more weight in creating valuable information out of data processing. While in the past data was viewed as source for general information, it is now regarded as a fountain of scientific and business intelligence.

"Space data", although lacking a mutually recognised definition, has been regularly used to describe the data that is generated by space-based sources or that is related to knowledge about outer space. Thus, the term encompasses data from satellite transmissions, space-based or ground-based sensing and imaging devices, along with any other method that produces information derived from or associated to outer space. "Space data" has been normally linked with research carried out by national space agencies and academic institutions, but is now also finding commercial application.

Attempting a combination of the aforementioned description of big data and space data, an arbitrary definition could be concluded. For the purpose of this paper, "space big data" will refer to all sorts of space-generated or space-related data. Space big data sources will not be limited only to satellites or space telescopes, but will include any other instrument that collects space data. Occasionally, the end result of data processing does not exclusively derive from a space source, but is calibrated with other data, for example collected through land, atmosphere or ocean sensors. To the extent that the latter forms an indispensable part of the final result or has significantly contributed in its processing, it should not be disregarded from the definition.

Nevertheless, a single direct definition of space big data is not at this point essential. The amount of data, as well as the speed in which it is produced is growing exponentially and it is difficult to predict future developments. This

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Committee of the Regions, Towards a thriving data-driven economy", European Commission COM (2014) 442 final, 2.7.2014.

5 J. Manyika, M. Chui, B. Brown, J. Bughin, R. Dobbs, C. Roxburgh, A. Byers, Big Data: The Next Frontier for Innovation, Competition and Productivity, McKinsey Global Institute 2011.

6 IBM big Data & Analytics Hub, the Four V's of Big Data, http://www.ibmbigdatahub.com/infographic/four-vs-big-data.

7 B. Marr, Why only one of the 5 Vs of Big Data really Matters, 2015, http://www.ibmbigdatahub.com/blog/why-only-one-5-vs-big-data-really-matters.

could render the said definition out dated or redundant in short time. Instead, it is preferable to focus on a definition that would acknowledge and encompass the aforementioned principal elements of space big data. This way, the regulatory framework remains relevant, regardless of subsequent technological advancements.

Considering the above, the elements that are most characteristic for space big data are volume, velocity, variety, and veracity.[8] These features should be present in any space big data definition. Volume is the key element of space big data. It is not solely associated with the amount of data generated, but rather refers to the challenges this amount poses in data processing, dissemination and use. Velocity refers to the speed in which data is generated and down-linked to the Earth, while variety stems from the different types of data, the various available sources, and the diversity of information that can derive from it. Lastly, veracity describes the quality of the data obtained and extracted. The accuracy and authenticity of the information produced depends on the processing as well as the integration of the various data at hand.

Copernicus and Other Examples of Space Big Data

As already discussed, space big data does not only refer to remote sensing, Earth observation or satellite positioning. It also includes the transmission of any information through outer space and any other intermediate procedure, such as storage. Space big data finds nowadays various civil and commercial applications, which can be better understood through the example of the Copernicus EU flagship programme and other undergoing commercial projects.

Copernicus is the world's largest single Earth observation programme and is based on a space component, in situ sensors and ground stations, which collect and distribute near real-time, highly accurate satellite imagery. The main objectives of Copernicus are to improve decision-making in the public sector and to create commercial opportunities for the private sector, by acquiring fast accurate Earth observation data. It consists of a constellation of Sentinel satellites and Contributing Missions that produce massive amounts of data on daily basis. The Copernicus Regulation[9] lists among the aims of the programme the protection of people and assets through the increase of general knowledge on the planet, as well as the monitoring of the environment so as to improve the efficiency of the environmental policies and better adapt to climate change. At the same time it also intends to manage

8 P.G. Marchetti, Big Data from Space, ESPI Big Data and Space event, 2015, http://www.espi.or.at/misc/big-data-and-space-event.

9 Regulation (EU) No 377/2014 of the European Parliament and of the Council of 3 April 2014 establishing the Copernicus Programme and repealing Regulation (EU) No 911/2010, OJ L 122, 24.4.2014, p. 44-66.

emergencies and generating jobs and economic growth by fostering the European Earth observation downstream sector. Those are few of the benefits that the use of space data applications are able to offer.

Another example, concerning the scientific use of space data, is the Hubble telescope, which supplies space observation images and transmits around forty gigabits of data per week.[10] Since its launching in 1990, the Hubble has been a valuable source of information about the space environment. In the next couple of years, the Square Kilometre Array (SKA) ground telescope is expected to be built and operate for purposes similar to Hubble, but with much higher quality of data.[11] It is anticipated to produce data of volume ten times bigger than the global internet traffic,[12] which would give another dimension to the notion of "big" data.

Another space data application is Internet.org, an ambitious collaboration between Facebook and various telecommunication providers aiming at offering internet connectivity to less developed areas around the world via satellite.[13] Similarly, O3b has launched a satellite constellation to provide network communication to emerging markets.[14] These missions are designed to transmit through satellite large amounts of data, which divert from the usual remote sensing and Earth observation information.

Furthermore, there are commercial companies, such as Orbital Insight that are developing computing and artificial intelligence capacity, in order to process space data of large volume.[15]

Big data from space is another aspect of the general big data trend and is recently growing as more commercial actors find uses for data collected with the use of space technology. Space big data presents significant business, as well as scientific advantages. The large variety of available data and the predictive capabilities from its combination create the potential for well-informed decisions and accustomed services, significant commercial and scientific assets.

Challenges

The continuously improving data resolution, combined with the high veracity and variability pose new challenges in the regulatory environment. Identifying them is important, bearing in mind the wide impact of space big data ranging from the international space sector to the everyday life of individuals.[16] On

10 http://hubblesite.org/the_telescope/hubble_essentials/quick_facts.php.
11 https://www.skatelescope.org/project/.
12 https://www.skatelescope.org/newsandmedia/outreachandeducation/skawow/big-data/.
13 https://info.internet.org/en/.
14 http://www.o3bnetworks.com/about/.
15 https://orbitalinsight.com/.
16 Except from data uses and data privacy and protection, other challenges related to space big data include: intellectual property and copyrights, liability for raw or

the one hand, companies involved in commercial space data activities wish to enjoy a certain degree of legal certainty in their business, particularly as far as data collection and distribution are concerned. On the other hand, this growing information flow leaves data subjects vulnerable to violation of their privacy and personal information. The following paragraphs will discuss these challenges in conjunction with the relevant space law and data privacy regulations.

III. The UN Remote Sensing Principles of 1986

The UN Resolution on Principles relating to Remote Sensing of the Earth from Space provides basic guidelines with regard to remote sensing activities.[17] Even though it does not have binding effect, it was warmly welcomed by the international society and has greatly influenced the activities of States in the field of sensing activities. It also constitutes the first, and up to date the single space law document dedicated to remote sensing. The following paragraphs will elaborate on the content of the Resolution, particularly in connection to the current space data environment.

The Remote Sensing Principles contain fundamental provisions concerning the collection and dissemination of remote sensing data. They are implanted with the ideals of the benefit and interest of all countries (Principle II) and with compliance to international law (Principles III and IV) in the conduct of remote sensing activities. They also call for the States to cooperate not only in carrying out remote sensing (Principle VII) and exchanging technical assistance in this regard (Principle VIII), but also in the collection, storage and processing of sensing data (Principle VI). These provisions are particularly relevant in today's space data market, where data is manufactured, processed and transferred worldwide. The Principles are also associated to contemporary data applications for civil purposes, since they promote the use of remote sensing for the preservation of the natural environment (Principle X) and the protection from natural disasters (Principle XI).

At the same time, the Principles support a degree of data openness, given that they call for the dissemination of data on a non discriminatory basis (Principle XII). However, in this context, they require the sensing State to make the processed data available to the sensed State. This could be proven as counterincentive for companies involved in the commercial exploitation of remote sensing data. Similarly, the Principles require the sensing State to allow participation of other States in remote sensing activities (Principle V). Even though it is implied that participation is expected for civil purposes,

processed data, as well as restrictions to the transfer of data that could be considered sensitive under respective export control regulations.

17 M. Williams, The UN Principles on Remote Sensing Today, Proceedings of the forty-eighth Colloquium on the Law of Outer Space, 2005.

there is no specification as to the categories of data that should be shared. In this sense, a requirement to distribute space data of commercial value would be detrimental to the space data stakeholders.
Finally, the Remote Sensing Resolution requires notification of the UN Secretary-General for the conduct of remote sensing activities, similar to the Outer Space Treaty and the Registration Convention. However, this provision was tailored to the times when satellite launching was primarily promulgated by governments and public entities. Given the amount of remote sensing satellites currently being deployed, such notification would be cumbersome and impose additional formality requirements to the companies involved.
Apart from regulatory guidelines, the Resolution includes useful definitions with regard to space data. At first, it includes in the definition of remote sensing activities the sensing operation, as well as the collection, storage, interpretation and dissemination of the data (Principle 1e). This definition is very helpful as it encompasses all actions following the sensing, thus avoiding the exclusion of processes that are otherwise closely associated to remote sensing. The Resolution also provides definitions for other important terms, namely "primary", "processed", and "analysed" data (Principle 1 b, c, d, respectively). Thanks to the comprehensive definitions provided, the Resolution could serve as basis for future legal reference.
Despite their inclusive character, the UN Remote Sensing Principles are not representative of today's space data sector. When they were drafted three decades ago, Earth observation technologies were significantly different. The scope of the Principles is limited to civil uses of space data (Principle Ia), since the current growing commercial uses were not anticipated at the time. Further, they only address remote sensing activities, without covering other methods for generating space data. Moreover, they suggest data openness, without implying any limitation thereon. This does not reflect the concerns that are currently raised with regard to the protection of private data from being openly distributed.
Nevertheless, even if the Remote Sensing Principles do not correspond to the contemporary challenges raised by space big data, they constitute a clear and coherent regime and can serve as ground for revision and re-opening of the discussion on space data.

IV. Data Protection & Data Privacy in the Space Era

The increasingly improved resolution of Earth observation imagery is providing more detailed information on the sensed areas and people.[18] In addition, the great volume and variety of data, individually or when combined and processed, could result to high-accuracy information. Another

18 R. Fuller, Structuring Big Data to Facilitate Democratic Participation in International Law, 2013, available at SSRN 2346188, pg. 1.

factor of concern is the openness of specific datasets along with the demand for more freely available data.

The main challenge with regard to data privacy and protection is that space big data is deriving from different sources, which are associated with different legal requirements and are not uniformly regulated. In this respect, the elements of veracity and variability are also significant. According to their degree of process, and in particular, when subject to analytics, small and unconnected data can reveal significant information about the sensed objects and persons.

At the same time, the actors involved in the process, the data owner, the data analyst, and the data user are usually different people, making it even more challenging to control the end product, and to regulate or limit the rights of the parties involved in the space big data value chain. The lack of transparency of the people involved in the space data value chain, along with the increasing quality of the available information, is raising legal concerns. Among the most prominent ones, are the protection of the information of the data subjects, as well as the safeguarding of their personal privacy, particularly as far as data dissemination is concerned.

Despite the fact that there is no international regulation that imposes any limitation to data openness or resolution precision, data privacy and the protection of personal information are highly regarded in law.

Privacy is recognised as a basic human rights principle. The UN Universal Declaration of Human Rights,[19] manifests the right of every individual to maintain their privacy and establishes the obligation for the State not to interfere or attack this value. Similar provisions are included in other international instruments, which proclaim the respect of the private life of individuals.[20]

In addition to privacy, data protection is regulated in international law as well. Under the relevant regulations unauthorised use and distribution of personal data is prohibited.[21] For any issue related to the sharing of someone's

19 Article 12, Universal Declaration of Human Rights, GA res. 217A (III), UN Doc A/810 at 71 (1948).

20 Article 17, UN General Assembly, International Covenant on Civil and Political Rights, 16 December 1966, United Nations, Treaty Series, vol. 999, p. 171; Article 8, Council of Europe, European Convention for the Protection of Human Rights and Fundamental Freedoms, as amended by Protocols Nos. 11 and 14, 4 November 1950, ETS 5.

21 Regulation (Eu) 2016/679 Of The European Parliament And Of The Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation), OJ L 119, 4.5.2016, pg. 1-88; Council of Europe, European Convention for the Protection of Human Rights and Fundamental Freedoms, as amended by Protocols Nos. 11 and 14, 4 November 1950, ETS 5.

personal information, specific permission should be granted by the subject of the right.

Nonetheless, the great volume of space data available and its high degree of accuracy and openness, render the identification and regulation of potential threats to privacy problematic. The increasing complexity of the sources of data manufacturing, along with the advanced technological means of measuring and processing big data from space, makes it difficult to identify the owner, processor and end-user, in order to further safeguard the lawful use and distribution of personal information.

Apart from that, the aforementioned privacy and protection regulations do not adequately cover the content of space big data. More often than not in legislation sensitive personal information is translated to personal details of the individuals (name, age, nationality, gender), but not necessarily to imaging, positioning or other information related to this person. This is due to the fact that up to now, this information was provided by the individuals themselves in various occasions when they were requested. Therefore, the data privacy and protection regulations focus on limiting the dissemination of personal data without prior authorisation. In this regard, space big data pose a two-fold problem. First, satellite imaging or geographical position information is becoming more available. This data is closely connected to the data subject, which can be easily identified therefrom. Second, the data volume, variety, velocity, and veracity, create a new system of information distribution, where data could be more accurately processed and combined to produce personal information, which could be technologically challenging to restrict.

Given the above, the existing regime with respect to data privacy and protection does not sufficiently cover potential privacy violations from the use of big data from space.

Copernicus Data Policy

The functioning of Copernicus is based on the Copernicus constellation, the Contributing Copernicus Missions, and the in-situ measurement data.[22] The constellation consists of the five different types of Sentinel satellites,[23] funded and owned by the European Union and operated by the European Space Agency, which is responsible for the collection and dissemination of the generated data. In order for Copernicus to provide the highest quality of data

22 G. Sawyer and M. de Vries, About GMES And Data: Geese And Golden Eggs, A Study on the Economic Benefits of a Free and Open Data Policy for GMES Sentinels Data, Final Report, European Association Of Remote Sensing Companies Brussels, 6th December 2012, available at: earsc.org/file_download/134/Open+Data+study+Final+report.pdf.

23 Sentinel-1: radar imaging, Sentinel-2: optical imaging, Sentinel-3 and 6: ocean and global land monitoring, Sentinel-4 and 5: atmospheric composition monitoring, http://www.copernicus.eu/main/sentinels.

possible, the Sentinel imagery is complemented by data collected by space missions that contribute to Copernicus services. These missions belong to third parties, which have concluded agreements with the European Space Agency to provide part of their data under specific pre-defined conditions for the purposes of Copernicus, in exchange with monetary or other compensation.[24] In-situ measurements come from instruments based on the atmosphere, the ocean or the ground, usually belonging to national authorities of the respective States. Their purpose is to simply confirm and validate the data obtained by the space missions and, in terms of regulation, they form part of the Sentinel data.

The data collected from the different aforementioned functions fall under different categories. The Copernicus Space Component data, collected primarily by Sentinel satellites are of medium and low resolution, thus of low commercial value and are owned by the EU. The Copernicus Contributing Missions are relied upon in order to provide high resolution satellite imagery, to serve emergency and surveillance purposes, and is owned by the respective satellite owners and operators. Given the different nature and appropriation of these two data categories, their dissemination is based on different policies. This is also depicted in the Regulation 1159/2013 on the registration and licensing conditions,[25] which provides for different categories of users and user access for different data categories, as well as in the Copernicus Regulation, which describes different policies associated to different datasets.

On the commercial aspect of the programme, the Copernicus objectives could only be achieved if the Copernicus data and information are widely used in practice.[26] Towards this end, the main incentive offered to potential users is a liberal access to all data available. This presents great business opportunities for the development of the European and global industry offering the chance to innovate and develop business cases.[27]

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24 Currently Contributing Missions come from ESA missions, EUMETSAT missions, their Member States, and other European and international third party missions, http://www.copernicus.eu/main/contributing-missions; in particular, all CCM: https://spacedata.copernicus.eu/web/cscda/missions.

25 Commission Delegated Regulation (EU) No 1159/2013 of 12 July 2013 supplementing Regulation (EU) No 911/2010 of the European Parliament and of the Council on the European Earth monitoring programme (GMES) by establishing registration and licensing conditions for GMES users and defining criteria for restricting access to GMES dedicated data and GMES service information Text with EEA relevance.

26 The Copernicus Value Chain Workshop, Summary Report, 26-27 April 2016, http://event.stpmedia.be/sites/event.stpmedia.be/files/content/files/commission_conclusions_v3.pdf.

27 G. Sawyer, Growth by Copernicus, European Association of Remote Sensing Companies, May 2015, http://earsc.org/library/.

The Copernicus Regulation establishes a "full, open and free-of-charge" policy for the Copernicus dedicated missions. It is important to highlight this distinction; the said policy only applies to Sentinel data, the genuine Copernicus mission data. This data constitutes the largest part of the data available through the Copernicus system and refers to "all data and products which will be generated at the basis of observations by Sentinel missions delivered to ground segments".[28] For the remaining data categories that do not fall under the full-open-free policy, licensing requirements are in place. This applies to the data obtained by third parties in the framework of the Copernicus Contributing Missions (CCM). In contrast with the rights associated with the Sentinel data, which is owned by the European Union, third-party missions' data rights belong to the owners and operators of the CCM satellites. In order for the Copernicus System to provide this data for free, it must be cleared from intellectual property rights.[29] For this purpose, the data is licensed for use and distributions by their owners to the Copernicus Operators.[30] This follows a negotiation with the European Union that provides some rights in return for the contributions received. Given that ESA organises the procurement of the Earth observation data from a series of Contributing Missions, the license required to access the said data is concluded between ESA and the interested user. The license can be found online on the Copernicus website and can be signed and returned electronically.[31] It only requires some basic information from the individual or the company representative who asks for access to the CCM Database. The licensing process is free of charge, under the conditions described in the previous paragraph, and are provided on a full basis.

Despite the open data policy being an essential element for the success of Copernicus, there are legitimate reasons that justify limitations to the access and use of the data. The Regulation lists among these reasons the rights of third parties, security concerns and restrictions of technical nature.

Copernicus most significant characteristic is the open-data policy for the access and distribution of its information. The concept though is not new. The US Landsat programme established in 2008 similar free and open data policy, which led to the widespread use of the Landsat data.[32] It did not

28 Annex 1 of the Sentinel Data Policy, European Space Agency, Earth Observation Programme Board, Joint Principles for a GMES Sentinel Data Policy, ESA/PB-EO(2009)98, rev. 1 Paris, 23 October 2009.

29 R. Harris, R. Browning, Global Monitoring for Environment and Security: data policy Considerations, 19 Space Policy 265, 2003, 267.

30 G. Sawyer and M. de Vries, ibid.

31 ESA User License, https://spacedata.copernicus.eu/documents/12833/14545/CSCDA_ESA_User_Licence.

32 Landsat Data Policy, http://landsat.usgs.gov/documents/Landsat_Data_Policy.pdf.

achieve however the scale of services currently provided by Copernicus, but paved the way to develop the trend of data openness.

V. The Regulatory Future of Space Big Data

Summing up, the Remote Sensing Principles and the laws on data privacy and protection are only partially addressing the space big data challenges. In order to provide for adequate legal regulation, the current regime should be reconsidered.

Towards this end, efforts will have to be devoted on setting up a flexible environment, capable of: collecting existing assets and coordinating synergic initiatives, and opening up possibilities for the future, this meaning establishing an architecture that will allow for integration of innovative tools as long as these are developed in the area of dissemination, archiving and computing technologies. These possibilities will have to provide for conservation of past data, information and processes, as well as exploit forward looking technologies as much as possible.

In this regards, it has been suggested that an international treaty on remote sensing or data from space could provide a solution. However, the technological advancement in the field of space data and its further impact on data applications and their use is uncertain; hence a binding international text could be rendered redundant or proven restrictive for this purpose.

Soft law on the other hand could be accommodating to meet the needs of the space big data field.

The Remote Sensing Principles contain functional provisions, but would need substantial amendments, in order to accommodate the changes in space data in the past three decades since their adoption. Even though they do not constitute binding commitments, they remain important since they contain accepted guidelines.

Alternatively, a new international soft law instrument could be introduced. It could either be based on the UN Principles or contain other best practices efforts, which would take into account the previously discussed challenges. Ideally, this regime would be regularly reviewed, in order to follow technological advancements.

Space big data is a topical issue, interesting from the point of view of business opportunities in the space sector, as well as improvement of daily lives with the use of space technology. This paper is aiming at providing a first insight on the legal challenges raising in this field and suggest some ways to deal with them.