Legal and policy aspects of space big data: legal implications of the use of large amounts of space data – regulatory solutions and policy recommendations

Stefoudi, D.

5 Regulatory strategies for enhancing the benefits of space big data

This chapter addresses to research question 4, namely "which regulatory solutions can address the legal challenges and facilitate the use of space big data?". In particular, it provides suggestions for addressing the challenges identified in chapter 4. As was concluded in chapter 2, the benefits of space big data depend on their collection, access, use, and dissemination, which can be affected by the legal aspects surrounding them. Chapter 3 analysed the laws that are relevant to the collection, access, use, and dissemination of space big data, and chapter 4 pointed to the legal challenges of their application. This chapter builds upon the findings of chapter 4 and aims to propose solutions for each of the legal challenges described therein.

Section 5.1 assesses the various ways in which space big data can be approached from a regulatory perspective. On that basis, section 5.2 proposes solutions for the identified challenges, taking into account the impact of the challenges on the space big data lifecycle. Section 5.3 focuses on the actors that can bring forward the proposed solutions and section 5.4 summarises the chapter's finding by answering research question 4.

5.1 A REGULATORY APPROACH TO SPACE BIG DATA

The analysis regarding the legal challenges of applying the relevant laws and data policies to space big data, conducted in chapter 4, reveals that different types of action are required, depending on the nature of these challenges. This factor dictates the regulatory approaches that should be followed for resolving these challenges, which include a new regulation, the enforcement of the existing legal framework, the interpretation of applicable laws, licensing and contractual arrangements, the implementation of technical and organisational measures, and maintaining the existing status quo. Some challenges may call for a new regulation to address a novel or specific type of activity that has not been previously regulated or to fill in gaps in existing regulations. Other challenges can be tackled through the interpretation or enforcement of the current framework or regulatory arrangement on a bilateral level, such as through licenses and contracts. Yet other challenges can be resolved without legal measures, by implementing technical or organisational changes. Finally, some challenges do not require any action, either because they cannot be resolved or because they do not represent a significant hardship. Against this

backdrop, before delving into specific solutions in section 5.2, this section elaborates on the various regulatory approaches towards resolving the legal challenges created by space big data.

The various regulatory approaches are discussed because they form the basis for the solutions proposed in section 5.2. While the recommendations are not exhaustive, the different regulatory approaches can offer solutions additionally or alternatively to the suggested ones. Furthermore, the purpose of this thesis is to address the legal implications of space big data, which was done in chapters 3 and 4, as well as to investigate avenues for their regulation. To do that, section 5.1 explains some ways in which the regulation of space big data within the existing framework and beyond can take shape.

Six approaches are discussed here (*see* table 5.1), in order of their level of binding force, starting from the ones with the most far-reaching consequences (new regulations, enforcement of the existing framework, and interpretation of applicable laws), continuing with the ones bearing upon the involved parties (licensing and contractual arrangements, and the implementation of technical and organisational measures), and finishing with the one maintaining the current status (maintaining the status quo). The section concludes with some considerations regarding the implementation of the various regulatory approaches, i.e. aspects relating to time, effort, and lasting effects.

First, new regulations can be introduced on different levels, depending on the desired sphere of influence. National laws are binding within the territory of the State that adopts them or over the persons under its jurisdiction. Regional laws find equal application among several countries within a region, as is the case with EU law. International laws are binding for the States that adhere to them and accept the rights and obligations they create. A new law can overrule a previous one, add or review parts of an existing law, or regulate a novel matter. Among the advantages of new regulations is that they are binding to their subjects and are tailored to the specific issue that triggered their adoption. New laws are created according to contemporary needs for regulating a particular matter and are therefore the most comprehensive legislative option. However, introducing a new law requires significant effort towards its negotiation and adoption, as well as awareness of the need for a new regulation and political incentive to instigate the procedure. Furthermore, the decision-making process of the international forum that is tasked with the drafting, negotiation, and adoption of a new law can influence the efficiency of this regulatory approach. These factors may result in a lengthy process and the risk that, by the time a law is introduced, the circumstances that surround it have changed or that a necessary future review will be equally

consuming.[1] UNCOPUOS, which initiated the adoption of the UN space treaties,[2] operates on the requirement of consensus of all its Member States. Such a process can render the prospect of a new regulation lengthy and practically unrealistic. That is especially the case when a new law regulates a nascent activity or a technological field that is rapidly evolving, such as space big data.

The *second* most comprehensive way of addressing a matter through legal means is to ensure the enforcement of the existing relevant framework, on a national and regional level. The enforcement of laws is carried out by the competent public authorities in each jurisdiction, which ensures that national laws, as well as regional and international laws that are transposed into the domestic system, are followed. This approach relies on the available legal capabilities and does not require further legislative action. Although an obvious solution, relevant laws may lack consistent application or may be overlooked because they are not considered applicable in a given context. Chapter 4 observed that several laws that are relevant to space big data are not enforced, because space big data is an emerging activity, and the applicability of these laws has not yet been ascertained. When it comes to applicable international space law, Article VI OST requires States to authorise the activities of their nationals and ensure that they are carried out in a way that complies with international space law. This way, international space law provisions can be enforced by States. When it comes to other fields of law, a national regulation can be enforced by the relevant national authorities. International laws may require further acts of implementation into a national framework before they can be enforced on that level. In the present analysis, regional laws mainly refer to EU laws, namely Regulations or Directives, which can be enforced

1 The drawbacks, as well as the advantages, of adopting new laws for space activities are discussed in E Galloway, 'Space law in the 21st century'(1988) 26 JSL 187, 190. Potential alternatives for the regulation of space activities in the future are discussed in M Sundahl, 'The expansion of private activity in space and its impact on the development of the international law of outer space' in C M Jorgenson (ed), *Proceedings of the International Institute of Space Law* (AIAA 2010) 260.

2 For the international space law analysis, the following international space treaties were examined: Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (opened for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205 (hereinafter Outer Space Treaty, OST); Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (opened for signature 22 April 1968, entered into force 3 December 1968) 672 UNTS 119 (hereinafter Rescue and Return Agreement, ARRA); Convention on International Liability for Damage Caused by Space Objects (opened for signature 29 March 1972, entered into force 1 September 1972) 1023 UNTS 15 (hereinafter Liability Convention, LIAB); Convention on Registration of Objects Launched into Outer Space (opened for signature 14 January 1975, entered into force 15 September 1976) 672 UNTS 119 (hereinafter Registration Convention, REG).

by national or EU authorities, with or without the need to implement acts.[3] The enforcement of existing rules can provide guidance as to how they should be applied, and, through their application, create precedent or potentially reveal other challenges that had not been previously encountered. However, there may be disparities in the way that the same or similar laws are enforced by different States or different authorities in the same State. This holds for novel activities or matters that require associated technical or other expertise, such as the various applications of space data.

The *third* approach, the interpretation of applicable laws, is another way of utilising existing legal means without the need to introduce new ones. Laws can be interpreted by courts and other competent public authorities, as well as by scholarly literature.[4] The interpretation of international law can be conducted using various methods, such as good faith, the ordinary meaning of terms, the object and purpose of a law, its preparatory work, and the circumstances under which it was adopted.[5] Among the benefits of interpretation is the relatively easy process it involves, compared to a new regulation, as well as its flexibility, in that it is adjusted to a given context. The interpretation method is prominent in international space law doctrine, where several terms used in the international space treaties are not defined in their text. The drawbacks of interpretation include its lack of authoritative effect unless it has been crystalised as custom,[6] as well as the lack of a uniform approach, since a law may be interpreted differently depending on the interpreting authority.

The *fourth* approach to regulating space big data entails the resolution of challenges through licensing and contractual arrangements. Such arrangements can be concluded on a bilateral or multilateral level, between the licensing authority and the licensee or between the parties to the contract. They create binding provisions and can find application regardless of the jurisdiction at hand or determine a jurisdiction that applies to the issues they entail. Furthermore, they are directly enforceable and do not require further interpretation. Given that their subjects agree to enter into these arrangements, it is expected

3 'Types of legislation' (*European Union*) <https://european-union.europa.eu/institutions-law-budget/law/types-legislation_en>.

4 U Linderfalk, *On the interpretation of treaties – The modern international law as expressed in the 1969 Vienna Convention on the Law of Treaties* (Law and Philosophy Library vol 83, Springer 2017) 12. The author refers to operative interpretation and doctrinal interpretation, citing the work of other authors.

5 Vienna Convention on the Law of the Treaties (opened for signature 23 May 1969, entered into force 27 January 1980) 1155 UNTS 331 art 31 and 32. A thorough analysis of these provisions can be found in R Gardiner, *Treaty interpretation* (2nd edn, OUP 2015) 16 and M E Villiger, 'The rules on interpretation: Misgivings, misunderstandings, miscarriage? The 'crucible' intended by the International Law Commission' in E Cannizzaro (ed), *The law of treaties beyond the Vienna Convention* (OUP 2011) 105.

6 V S Vereshchetin, G M Danilenko, 'Custom as a source of international law of outer space' (1985) 13 JSL 22, 24.

that they are executed in good faith. Both methods can extend to matters that do not form part of existing regulations or be used to adjust or clarify them. As was previously explained, the licensing of space activities by States is a way of implementing the provisions of Article VI OST, according to which States should authorise their national space activities. The licensing procedure and requirements vary greatly among States, reflecting the different priorities that States have, in terms of overseeing the space activities of their national public and private actors. As far as contracts are concerned, they are commonly used in several facets of the space sector. Even though they are directly binding, they only create rights and obligations for the parties involved, so their overall regulatory impact is not considerable. Moreover, since they are customisable according to the situation they address, they may not have uniform results. At the same time, they may not offer equitable terms to the stakeholders they concern. For instance, a State may have the discretion, albeit justified, to add to or increase the threshold of the licensing requirements for certain parties. Likewise, the contract conditions presented to one party may be significantly different from the conditions presented to another.

The *fifth* approach, the implementation of technical and organisational measures, involves the employment of new or the adaptation of existing working methods and technologies. Some examples include increasing transparency in the course of the space big data lifecycle or appointing people to oversee certain tasks. These measures can function alternatively to or concurrently with regulatory measures. They are immediately applicable and flexible to adjustments since they are devised on a case-by-case basis to handle specific technological or other circumstances. In addition, they can be implemented by the actors that are directly concerned, without the need to mobilise third parties and further procedures. However convenient and efficient technical and organisational measures are, they are not binding and do not create a regulatory precedent. Similar to licensing and contractual arrangements, they may result in heterogeneous approaches to the same matter by different actors. This is not necessarily unfavourable, since the matters they resolve have limited general effect. For the same reason, such measures are occasionally the only feasible solution.

The *sixth* approach involves maintaining the existing status quo. Some of the identified challenges may not require action, their resolution may be complex, time-consuming, or not feasible, while there may be a limited appetite to address the challenges by the actors involved in space big data. On the one hand, preserving the current state of affairs allows time for technology and policy to mature, until one of the other approaches examined above emerges as a convenient or necessary solution. This may be essential in a field that is rapidly developing, such as space big data, to avoid the risk of regulating an activity that has evolved in the meantime. On the other hand, not acknowledging or not acting upon the challenges created by the relevant laws can result in other risks. First of all, the legitimate rights that these laws protect

may be at stake, whereas regulatory breaches may, knowingly or unknowingly, occur. Besides, the application of law to new fields of technology and activity does not advance, leading to further challenges and incoherence in the regulatory landscape. On top of that, the identified legal challenges are more likely to be augmented than disappear, if no action is taken to resolve them. That being said, in the meantime, the identified legal challenges may shift to other areas and actors, as technology and business progress.

Some of the examined approaches, namely the implementation of technical and organisational measures and maintaining the existing situation, are not themselves legal issues. Nevertheless, they are included as regulatory approaches because they facilitate compliance with relevant regulations and can be used instead of regulations or until regulations are put in place. Moreover, some approaches may not produce a legally binding effect. The interpretation of applicable laws is authoritative only if it has been crystalised in custom or has been determined in jurisprudence. The implementation of technical and organisational measures is arbitrary and, unless it forms into standards or good practices, does not have mandatory effects. Similar may be the case with maintaining the existing status quo, when the current situation does not bind the parties involved. They are still considered regulatory approaches because they put forward specific arrangements or have the potential to become binding. In sum, the six regulatory approaches analysed above are characterised as such, because they offer an approach to a regulatory matter. Regardless of their legal nature and binding effect, their rationale, their means, or their source is tied to a regulatory issue.

Whatever approach is taken, there are some further considerations for each regulatory approach, especially the time they require to be introduced, the level of effort in introducing them, and their lasting effect once they are introduced.

In terms of the *time required* to put each approach into practice, maintaining the existing status quo is the least time-consuming, as it does not require any change to the current circumstances. Following, the implementation of technical and organisational measures and the enforcement of the existing legal framework can be realised within a short time period. Licensing and contractual arrangements are not very time-consuming, in comparison to some other approaches, like drafting new legislation, but are only put in place when a need arises and therefore not very proactive. This also applies to the interpretation of applicable laws, which may take considerable time to emerge, depending on how their interpretation is carried out. The adoption of new regulations can be demanding in terms of time since it involves several stages before entering into negotiations and agreeing on a new piece of legislation. In some cases, such as amending an annex or list attached to legislation, regulatory reform can take place in a relatively brief timeframe. Some of these approaches can be administered in anticipation of or in parallel with others. The implementation of technical and organisational measures and licensing and con-

tractual arrangements can be undertaken in conjunction with efforts to enforce, interpret or introduce regulations. Likewise, the enforcement of the existing legal framework and the interpretation of applicable laws can function as placeholders until the adoption of a suitable regulation.

The *level of effort* in promulgating the various approaches depends on the means available to the actor or actors that will follow that approach. Maintaining the existing status quo is the easiest among them, as it does not require further action. The implementation of technical and organisational measures requires some effort, but the actors that plan and execute them are in the best position to determine the most suitable strategy in this regard. Licensing and contractual arrangements are put forth by actors who are familiar with these processes and dedicate part of their work to that, hence are not difficult to conclude. Conversely, the enforcement of the existing legal framework and the interpretation of applicable laws require the mobilisation of specific authorities, which may be cumbersome to carry out. Finally, the adoption of a new regulation is the most complex approach, given the several components involved.

In terms of their *lasting effect*, new regulations, the enforcement of the existing legal framework, as well as licensing and contractual arrangements are binding and create long-standing rights and obligations. The interpretation of applicable laws can produce a binding effect, but this effect can be overturned by an updated or conflicting interpretation or by a subsequent regulation. The implementation of technical and organisational measures is not binding, even though it can generate a pattern of work or behaviour in the form of standards and good practices. The effect of maintaining the existing status quo depends on whether and when changes will occur to the existing circumstances.

As explained, each approach has advantages and disadvantages. On that basis and the basis of the main elements of each regulatory approach, section 5.2 proposes solutions for each legal challenge identified in chapter 4.

Table 5.1 – The six regulatory approaches for space big data

Overall, there are six types of regulatory approches suggested for space big data:
(a) New regulation
(b) Enforcement of the existing legal famework
(c) Interpretation of applicable laws
(d) Licensing and contractual arrangements
(e) Implementation of technical and organisational measures
(f) Maintaining the existing status quo

5.2 Overcoming the challenges in the relevant laws and data policies

This section specifies how the regulatory approaches presented in section 5.1 can be used to resolve the legal challenges from the application of the relevant laws and data policies to space big data. Each solution is based on the features of the various regulatory approaches, the time and effort they require, and their lasting effect. To propose these solutions, the impact and number of the challenges they address are also taken into account. The analysis takes as a benchmark the benefits of space big data explained in chapter 2, which rely on the collection, access, use, and dissemination of data, and explores solutions for the issues that affect them.

The legal challenges are categorised according to their corresponding legal fields, mirroring the structure of chapter 3 and chapter 4. To aid the structure of this section, reference is made to table 4.1, which labels and summarises each of the challenges. The solutions to the legal challenges are addressed in sections 5.2.1 to 5.2.6, where each heading describes the legal challenge, and the subsequent text describes potential solutions. At the end of sections 5.2.1 to 5.2.6, a table summarises the solutions proposed for each challenge of the respective relevant laws or data policies. The solutions are presented in the order of the level of binding force of the regulatory approach on which they are based. In most cases, one or more solutions are suggested for each legal challenge. However, in a few cases, the same set of solutions is recommended for more than one challenge that is similar. Section 5.2.7 recommends methods for determining the most suitable regulatory approach and solution, based on the findings of its preceding sections.

Before delving into the individual legal challenges, it is worth addressing the recurring challenges raised by some of the features of space big data. The volume in which space big data are generated and the velocity in which they are transferred, cross-border or from space to the ground, hinder the identification of applicable laws that may vary across jurisdictions and their proper application. Apart from the solutions discussed here to address these intrinsic challenges, it is suggested to maintain a compartmentalised approach during the design and operation of a space big data lifecycle and a high level of transparency regarding the processes that take part in each stage of the lifecycle.

5.2.1 International space law

As far as international space law (ISL) is concerned, chapter 3 concluded that it finds general application in space big data and does not substantially affect their collection, access, use, and dissemination. The freedoms of outer space, the prohibition of appropriation, the responsibility and liability for space

activities, the jurisdiction and control over space objects, and the consultation requirement before potential interference regulate the space objects that generate, store, and disseminate space big data, but not the data as such. Subsequently, chapter 4 identified several challenges in applying international space law to space big data. Their common characteristic is their questionable application to space big data. On the one hand, given that space big data are enabled by space activities, it seems logical to connect them to international space law provisions. On the other hand, in the process of applying international space law to space big data, it becomes apparent that the principles of space law are not designed to apply in this context. The following paragraphs suggest ways in which these challenges can be overcome, in a way that maintains the legitimate interests put forth by the international space treaties. Estimating the low likelihood of reviewing or amending the international space treaties, the focus is on suggesting ways to interpret and implement them for the purposes of space big data.

ISL 1 – The sharing of benefits from space activities (Article I OST) may be considered a legal obligation and may extend to space big data.

The freedom to use, explore, and access outer space of Article I OST does not pose significant challenges to space big data. However, the sharing of benefits from space activities among all countries, also enshrined in Article I OST, can be interpreted either as a sort of moral obligation or as a legal requirement that should be complied with. Based on the *interpretation of applicable laws* approach, in both cases, the threshold of benefit-sharing is met, as long as wider access to space big data and applications is maintained. In case of a strict interpretation of the benefit-sharing provision as a legal obligation though, any limitation to access and dissemination of space big data, due to technical or commercial reasons, may be seen as counterintuitive for the actors involved in space big data. Then, the solution can come through *licensing and contractual arrangements* and specifically by including conditions for wide access and dissemination standards among the licensing requirements for space data systems, as a way of sharing the benefits from these activities. Since States are responsible for authorising the satellites that collect space data, they can require that such conditions are included in the licensing process. This solution could work for countries with existing legislation on the licensing of remote sensing satellites, as described in section 3.6.3, countries with legislation concerning the licensing of satellites in general, as well as countries that may adopt such legislation in the future.

Nevertheless, part of the solution is *maintaining the existing status quo*, by considering the commercialisation of the space sector, including space big data and applications, outside the scope of the benefit-sharing principle of Article I OST. The users that request data openness should also contemplate the technological and commercial incentives that mandate eventual limitations and should

emphasise the many benefits of space data, as described in section 2.1.3, which are already available, despite any restrictions that may be in place.

ISL 2 – The lack of national sovereignty in outer space (Article II OST) challenges the application of laws to activities that take place there.

The non-appropriation principle of Article II OST prohibits national sovereignty in outer space and hampers the application of national laws on activities that take place there. That is a recurring challenge that affects several laws that are relevant to space big data. Part of it can be alleviated through the *enforcement of the existing legal framework* particularly Article VI OST and Article VIII OST. The requirement for authorisation and supervision of national space activities (Article VI OST) and the jurisdiction and control over a space object granted to the State of registry (Article VIII OST) create a regulatory link between a State and its objects, in a way that enables the application of laws to activities that take place in outer space, an area outside the sovereignty of States. The process of authorisation, supervision, and registration of space objects falls under the mandate of States and international intergovernmental organisations that launch objects into outer space and have declared their acceptance of the space treaties.[7] This solution can render immediate results, as it is relatively simple to enforce the provisions of Article VI and Article VIII OST. This solution is also served by the approach of licensing and contractual arrangements since the licensing and occasionally the registration process is part of that approach.

Even after authorising and registering space objects, distinguishing the parts of the space big data lifecycle that take place in outer space and are covered by the non-appropriation principle remains a challenge. The lifecycle parts are constantly and seamlessly connected, due in part to the velocity of space big data and the architecture of space data systems. For the same reasons, it may be difficult to determine whether an activity took place on Earth or in outer space, even when the lifecycle parts are separated. An alternative can be offered through the *implementation of technical and organisational measures*, namely by designing space big data systems in a compartmentalised manner that separates the activities that take place on the Earth from the activities that take place in outer space. This would require technical measures that can be implemented by the stakeholders that manufacture and operate space objects. Once the design is in place, this solution can be directly imple-

7 As of 1 January 2023, four international intergovernmental organisations have declared their acceptance to some of the space treaties. EUMETSAT, ESA, and INTERSPUTNIK have declared their acceptance of ARRA, LIAB, and REG. EUTELSAT has declared its acceptance of LIAB and REG. Status of International Agreement relating to activities in outer space as at 1 January 2023 (20 March 2023) UN Doc A/AC.105/C.2/2023/CRP.3.

mented. However, reaching that stage of planning and determining the appropriate methods may involve a lengthy process.

ISL 3 – It is unclear whether space big data fall under the national activities that States should authorise and supervise (Article VI OST), especially when more than one State may be involved in the same space big data activity.

The international responsibility of States for their national space activities, as enshrined in Article VI OST, faces a twofold challenge, namely whether space big data qualify as space activities and, if so, which State is appropriate to authorise and supervise them. As far as space activities are concerned, their definition is not included in the Outer Space Treaty and varies among the various domestic legislations. Therefore, the approach of the *interpretation of applicable laws* can be the first step towards the solution of this legal challenge. When it comes to space big data, whether they form part of space activity is a matter of which parts of the space big data lifecycle are considered as such, regardless of being located on the ground or in outer space. The purpose of Article VI OST is to minimise uncertainties surrounding activities that take place in the risky environment that is outer space. However, space big data do not entail similar risks, as they mainly consist of the transformation of data to information solutions that do not require the same level of authorisation and supervision. Consequently, the scope of Article VI OST should be interpreted as extending to objects that are found in outer space and to equipment on the ground that is essential for the operation of these objects. This interpretation is also substantiated by the fact that licenses that are granted through national laws as a means of implementing Article VI OST cover processes that are connected to the manufacturing, launch, and operation of space objects. It is doubtful whether space big data are connected to these stages of space activities. Whereas the objects that collect, store, and disseminate space big data are covered by Article VI OST, the generated data is another kind of activity, which cannot be categorised as space activity. The purpose of data is to be used as information, regardless of where they come from. Hence, the legal regime that governs the source of the data does not necessarily cover the data as such. With this in mind, it can be supported that the extension of the authorisation and supervision obligation to space big data exceeds the scope of Article VI OST beyond the activities that it is meant to regulate. To resolve this challenge using the interpretation approach, Article VI OST should be interpreted narrowly and space big data should be governed by it only as far as the space objects that generate and transmit them are subject to licensing conditions. Operators of objects that generate space big data are active in the field of developing space big data applications. However, only the activities related to the space objects are licensed under the provisions of Article VI OST. The suggestions regarding licensing that are analysed below refer to these activities. Whether national space laws extend the scope of

authorisation and supervision to activities further than the operation of a space object remains under their competence and may be proposed for reasons that do not have to do with Article VI OST. Eventually, space big data are detached from the space object that collects and transmits them. If anything, authorising and supervising space big data activities under Article VI OST would place unjustified conditions on their collection and dissemination.

The challenge regarding which State, among the several that may be involved in the space big data lifecycle, is appropriate to authorise and supervise space big data activities can also be resolved through the approach of the *interpretation of applicable laws*, namely in this case Article VI OST. Based on the conclusion above that Article VI OST should not be seen as directly applicable to space big data, the fast cross-border dissemination of space big data does not influence the procedures under which space objects are licensed, under the various national laws. A different approach would lead to the unnecessary burdens of having to identify the appropriate State and seek several authorisations. At the same time, it would make it cumbersome for States to properly supervise their space activities if those included space big data. Overall, the application of Article VI OST to space big data is a matter of interpretation according to international law[8] or a matter of interpretation by the States that transpose Article VI OST to their domestic legislation.

ISL 4 – Damages caused by space big data may not be covered by Article VII OST and the Liability Convention.

The space law liability provisions, described mainly in Article VII OST and the provisions of the Liability Convention, foresee damage caused by space objects, and their legal challenge is connected to the definition of the term 'caused by', i.e. how direct the connection between the space object and the damage should be. In terms of space big data, the contentious issue is whether the damage caused within their lifecycle can qualify as the damage envisioned by the space law liability regime. This legal challenge can be addressed through the *interpretation of applicable laws* approach. The scope of space law liability should be narrowly interpreted, given the purpose for which the liability provisions were adopted. Accordingly, damage directly connected to a space object, such as damage occurring during a collision, should be viewed as damage caused by it. Subsequent damages may be covered by liability provisions, depending on how directly they are related to a space object. By and large, damage that would not have been caused without the specific involve-

8 The Vienna Convention on the Law of the Treaties (n 5) art 31 and art 32 describe the general and supplementary rules of interpretation of international treaties, such as the space treaties. Among the general rules is the interpretation of a treaty in accordance to the ordinary meaning of the terms in the context of the treaty and in the light of its object and purpose. This is the suggested method of interpretation of the OST.

ment of the space object may be considered among the damages covered by space law liability, regardless of whether they are called direct or indirect. In any event, damages connected to space big data cannot fit in the scope of international space law. On a practical level, the scope of space law liability was not intended to be that wide. Such a wide approach would be disproportionate since space objects that were not involved in causing damage would still be considered as having caused the damage. Moreover, the high risks that justify the absolute liability (Article II LIAB) and the fault liability (Article III LIAB) provisions would end up covering damages of smaller risk and scale. Therefore, the legal challenge regarding space law liability in the framework of space big data can be resolved by acknowledging that damages caused by space big data are not covered by the provisions of the Outer Space Treaty and the Liability Convention unless they are caused by the space object that collects and disseminates them.

Nevertheless, recourse for damages can be sought through other legal avenues, by virtue of the *licensing and contractual arrangements* approach.[9] As was observed in the data policies examined in section 3.6, liability clauses can be part of the provisions that are agreed between the parties that enter into a transaction for acquiring or distributing the data. Several of the examined data policies include liability waivers that prevent data users from liability claims related to these data. Even then though, the identification of the cause of the damage for the attribution of liability may be cumbersome. That is due to the features of space big data, which may lower the likelihood of identifying the liable party, but, as explained, present considerable benefits to counterbalance this shortcoming.

ISL 5 – More than one State can qualify as launching State for the purpose of registration under Article VIII OST and the Registration Convention, while the purpose of a space object involved in space big data may not be clear.

The registration of space objects involved in space big data faces legal challenges similar to the ones identified above for international responsibility. In particular, implementing the registration requirements of Article VIII OST and the provisions of the Registration Convention may be difficult. This is because the same object can serve several purposes, so the specific description of its mission for their registration may be complicated, or because the space objects of several States are involved in the same space big data lifecycle and the identification of the State of registry of the space object in question may be

9 Some ways to provide for the damages that are not covered by international space law liability through national law are suggested in R E Alexander, 'Measuring damages under the convention on international liability for damage caused by space objects' (1978) 6 JSL 151, 154.

trying. These challenges are accentuated when space objects are not registered by the appropriate State.

The legal challenge regarding complying with registration requirements can be remediated through the *implementation of technical and organisational measures*. In particular, it can be alleviated by increased transparency regarding the uses of the space objects that collect and transmit space big data. This solution can be put forth by the actors who are aware of how space data are used, such as those who supply, use, and disseminate the data. Likewise, the challenge regarding the identification of a space object among many and its State of registry can be overcome with increased transparency in the design and operation of space big data systems on behalf of the respective actors.

As far as the requirement to register a space object is concerned, the *enforcement of the existing framework* can provide a solution. States could focus their efforts on transposing this framework, namely the registration requirements of the Outer Space Treaty and the Registration Convention, into binding obligations, such as including them in their licensing requirements or their domestic space regulation. To that end, the UN General Assembly has adopted a Resolution with recommendations for States and organisations to enhance their registration practice.[10]

Overall, adherence to the registration requirements of the Outer Space Treaty and the Registration Convention establishes jurisdiction and control over space objects, which in turn facilitates the application of the law of a State to activities that are carried out in outer space. This is particularly relevant because, unlike the challenges regarding international responsibility and liability that are not directly impacting space big data, the registration that results in jurisdiction and control enables the application of other relevant laws that protect the legitimate interests of several stakeholders, including privacy, intellectual property, and cybersecurity, as described in chapter 3.

ISL 6 – The duty to consult under Article IX OST does not offer adequate protection against potential harmful interference.

The legal challenge regarding the application of Article IX OST that requires consultation before engaging in an activity that can cause potentially harmful interference is not particular to space big data. The lack of clarity as to what constitutes a potentially harmful interference and the fact that interference is not specifically prohibited render the provisions of Article IX OST challenging in many facets of space activities. Part of this challenge can be addressed through the *interpretation of applicable laws* of the provisions of Article IX in

10 UNGA Res 62/101 (10 January 2008) Recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects UN Doc A/RES/62/101.

the context of the rest of the Outer Space Treaty.[11] On the premise that a potentially harmfully interfering activity may lead to the international responsibility and liability of States, Article IX should be seen as limiting any activities that have foreseeable risks for damage. Besides that, without a definition of potentially harmful interference and without a clear prohibition of interfering, the content of Article IX OST remains an object of contest. As far as interference in the context of ITU is concerned, no legal challenge was detected, hence no solution is necessary and *maintaining the existing status quo* is suggested.

Table 5.2 provides an overview of the proposed regulatory approaches to the legal challenges concerning international space law.

11 *See* (n 5). Among the general rules of treaty interpretation is the interpretation of a treaty in accordance to the ordinary meaning of the terms in the context of the treaty and in the light of its object and purpose.

Table 5.2 – Overview of the recommended solutions and regulatory approaches for each international space law legal challenge.

ISL 1 – The sharing of benefits from space activities (Article I OST) may be considered a legal obligation and may extend to space big data.	
Legal challenge summary	Proposed regulatory approach
The 'sharing of benefits' from space activities principles should be interpreted in a way that does not create a legal obligation to share the benefits.	Interpretation of applicable laws
Broader access to data collected by space systems can be included in their licensing requirements.	Licensing and contractual arrangements
The sharing of benefits from space activities can be seen as discouraging commercialisation efforts.	Maintaining the existing status quo
ISL 2 – The lack of national sovereignty in outer space (Article II OST) challenges the application of laws to activities that take place there.	
Legal challenge summary	Proposed regulatory approach
Space activities should be authorised and supervised by States (VI OST) and space objects should be registered by the appropriate State (VIII OST).	Enforcement of the existing legal framework
The space big data lifecycle can be compartmentalised, in order to determine the infrastructure that is found in space and when it becomes part of the lifecycle.	Implementation of technical and organisational measures
The licensing procedures should ensure the proper authorisation of space activities and the registration of space objects in a timely manner.	Licensing and contractual arrangements
ISL 3 – It is unclear whether space big data fall under the national activities that States should authorise and supervise (Article VI OST), especially when more than one State may be involved in the same space big data activity.	
Legal challenge summary	Proposed regulatory approach
The term 'national activities' in space should be interpreted in a way that does not entail space big data activities, but only the space objects that collect, store, and disseminate big data.	Interpretation of applicable laws
ISL 4 – Damages caused by space big data may not be covered by Article VII OST and the Liability Convention.	
Legal challenge summary	Proposed regulatory approach
The term 'damage caused by a space object' should be interpreted in a way that does not include damage caused by space big data.	Interpretation of applicable laws
Issues of liability regarding the collection, access, use, and dissemination of data can be included in contract clauses.	Licensing and contractual arrangements

ISL 5 – More than one State can qualify as launching State for the purpose of registration under Article VIII OST and the Registration Convention, while the purpose of a space object involved in space big data may not be clear.	
Legal challenge summary	Proposed regulatory approach
The registration practice of space objects should be enhanced, in order to increase transparency regarding their uses and to identify the appropriate State that exercises jurisdiction and control over the registered space object.	Enforcement of the existing legal framework
The space object involved in space big data should be overseen, in order to ensure that its described purposes are maintained and to identify whether space objects of other States are involved in the same big data activity.	Implementation of technical and organisational measures
ISL 6 – The duty to consult under Article IX OST does not offer adequate protection against potential harmful interference.	
Legal challenge summary	Proposed regulatory approach
The term 'potentially harmful interference' should be interpreted in a way that does not disrupt space big data activities.	Interpretation of applicable laws

5.2.2 Privacy and data protection law

The relevance of privacy and data protection (PR) to space big data stems from the potential of space big data to include information of a personal nature. Requirements for the collection, processing, and distribution of personal data may be in place for the actors that control and process them. Concerns regarding privacy and data protection, especially in terms of the increased exposure of personal information in the digital world and the processing of personal data beyond lawful purposes, are not only raised in the context of space activities. Space big data make these concerns more visible by combining two elements that are contentious for privacy. Space data include location data and high-resolution images, which are direct streams of personal information. Similar may be the case with internet traffic through satellite-based connectivity. Big data raise several privacy concerns as they facilitate the creation of personal data through the variety and veracity of the information they contain. Ultimately, the challenge lies in the balance between enhancing the benefits of space big data, risking triggering privacy concerns, and preserving the legitimate interests of privacy and data protection.

PR 1 – The conditions that determine whether privacy concerns are raised and personal data are involved vary among countries and are not easy to identify.

The velocity, variety, and veracity of space big data create a two-fold legal challenge. First, it is not always clear whether personal data are included in space big data, thus invoking the application of the relevant laws. Second,

the relevant laws that lay down the necessary definitions and the requirements of data protection vary among countries and may be difficult to identify, while they also depend on whether personal data are involved. To eliminate the definitional question, this thesis takes into account the terms of the GDPR,[12] without prejudice to definitions and provisions described in other privacy frameworks.

As for the qualification of space big data as personal data, to apply relevant laws, it is suggested that no change is necessary and *maintaining the existing status quo* is the recommended solution. The definition of personal data in the GDPR is sufficiently clear to apply to space big data and does not require change. Location data are explicitly mentioned as a category of personal data. High-resolution Earth observation data can be personal data if they identify or can identify individuals. The same is valid for the information contained in satellite-based connectivity data if individuals are identified or identifiable. The definition is also straightforward when it comes to space data that are not personal data per se, but become personal data when combined with other space or non-space data. If that combination renders data that identify or can identify individuals, then the combined product will be considered personal data.

When space data result in personal data through their fusion with other data, the challenge is to determine which part of the fusion process results in personal data and when, to properly comply with data protection laws. This hurdle can be overcome through the *implementation of technical and organisational measures*. The space big data products that are created with the characteristics of personal data should be marked as such at the beginning of the space big data lifecycle. For other products that involve the creation of personal data along the process, it may be difficult to identify the stage and the moment when data protection laws become applicable, especially given the data volume, variety, velocity, and veracity. There, it is essential to observe how data are handled during the stage of their collection and use, by the stakeholders that are involved in these stages. When collecting or acquiring data, keeping track of the data sources can aid in the determination of whether they form personal data. When processing data, monitoring their manipulation can determine whether personal data are created as a result. To effectively track the flow of space big data, it is also important to monitor in general the actions of the stakeholders involved in their lifecycle. This can be a task for the national authorities that oversee compliance with data protection regulations.

12 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 their personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) [2016] OJ L119/1 (hereinafter GDPR).

As for the diverging regulation of privacy depending on the jurisdiction, data protection laws vary significantly among countries, including their scope, their requirements, and their subjects, whereas some countries may lack an overall data protection framework. A *new regulation* could be a solution since it would provide harmonisation as far as data protection standards are concerned, although an international agreement governing privacy seems to be an unlikely scenario. The harmonisation effort can also focus on defining whether and when personal data are involved in space data and space big data, in order to further determine the application of privacy and data protection laws. In the EU, harmonisation comes in the form of the GDPR, which aligns the regulation of data protection among the twenty-seven EU Member States. Given its extraterritoriality provision, it can find application outside the EU, thus setting a benchmark for privacy worldwide that should not be overlooked.

Lacking an international regime and in countries without domestic regulation, recourse can be sought in the *licensing and contractual arrangements* approach. In particular, privacy can be part of the agreements on data supply, use, and distribution that are concluded among the stakeholders involved in the space big data lifecycle. Such agreements could set out terms that apply regardless of the jurisdiction and, hence apply regardless of the location of these stakeholders. This solution could also be employed in cases where a data protection regime is in place, in order to facilitate its application and arrange the matter in further detail. Such agreements can involve terms regarding the applicable law, as well as conditions for the treating of personal and other data in a given data context.

Overall, maintaining a higher level of data protection, even if not legally required, can safeguard the legitimate interest of privacy and enhance interoperability with data that fall under the scope of privacy regulations.

PR 2 – The identification of the actors responsible for complying with the data protection requirements is challenging.

Some of the stakeholders that take part in the space big data lifecycle are vested by the law with the obligation to adhere to data protection laws, as data controllers or processors, if personal data are involved. In chapter 4, the identification of controllers and processors was characterised as cumbersome, due to the obstacles posed by the space big data characteristics and due to the hesitation of the appropriate stakeholders to assume their role as data controllers and processors. Adding to this challenge is the fact that these roles may change along the space big data stream. A solution can be found in the *implementation of technical and organisational measures*. To be precise, appointing specific actors as data controllers and processors when the space big data lifecycle is designed can clarify the roles and the associated obligations, as far as privacy and data protection are concerned. This action can be undertaken

by these actors themselves, given that they are the ones who should adhere to the applicable privacy regulations. The suppliers of space data would be ideal candidates for that role, given that they are responsible for collecting and further supplying the data, thus having the necessary knowledge to perform in this role. The stakeholders that process data could also function as data controllers and processors,[13] since they are aware of whether personal data are handled or produced, despite their volume, variety, velocity, and veracity. In addition, the stakeholders that supply and process or otherwise handle space data can monitor privacy compliance at least in the first instance. Since some of them have a significant market presence and can establish industry standards, this approach of implementing technical and organisational measures can function concurrently with or until further regulatory developments occur.

Furthermore, the approach of *licensing and contractual arrangements* has the potential to offer a solution to this legal challenge. Provisions related to the allocation of privacy-related obligations can be inserted by States among the requirements to obtain a license to operate space systems. This would provide a definitive and binding solution for the parties involved and, similar to the solution addressed in the previous paragraph, can create practice around the matter of privacy compliance in space data activities.

As far as the definition of data controllers and data processors included in the GDPR is concerned, no review is necessary and *maintaining the existing status quo* is proposed. The description of these terms is sufficiently clear for the concerned stakeholders to identify in which category they belong. However, they can benefit from additional clarifications, as to how the terms can be properly applied in the context of space activities and space data. The processing of data is an essential component of the definition of the controllers and processors. However, 'processing' as it appears in the legal text and as is carried out in the practice of space data may be different. This is a contentious point that merits clarification. Another issue that could be specified is whether the entities that collect space data only for the purpose of distributing them to users qualify as data controllers, even if they do not determine the purpose and means of processing, which are decided by the data users. It could also be specified whether the actors that collect data qualify as data controllers, if they only conduct the preliminary processing necessary to make raw data legible. These clarifications can be promoted through the approach of a *new regulation* or the approach of the *interpretation of applicable laws*.

13 In this paragraph the use of term 'data processors' in the phrase 'data controllers and data processors' refers to the definition of the GDPR (n 12) art 4.8. Data processors in the practical sense, as in the stakeholders that are involved in the space big data lifecycle by processing data, do not necessarily belong under this definition and are mentioned in this paragraph as 'stakeholders that process data'.

PR 3 – Compliance with the requirements of lawful collection and processing of personal data is difficult.

A legal challenge that appears difficult to resolve is the requirement for the consent of the data subject before the collection of their personal data. Notably, a change in the consent requirement, as described in the GDPR, would not resolve the challenges presented by space big data. However, the approach of the *interpretation of applicable laws*, through a creative application of the requirement by the actors that must implement it, can alleviate a significant part of these challenges. For GNSS and satellite-based connectivity data, the consent requirement is not as challenging to interpret and subsequently enforce, since the users of these data consent to the terms of the applications that involve them and transform these space data into personal data. For EO data, the situation is vastly different. Obtaining the consent of the data subject before collecting high-resolution EO data that may be personal would render remote sensing practically impossible. The personal nature of the data to be collected is known before their collection, so the only solution would be to not proceed with the data collection or to use less sophisticated technology. This would result in a decrease in the quality of the collected data and consequently in the limitation of some of their benefits, which is in stark contrast with the purpose of this thesis, which is to enhance the benefits of space big data. To maintain the existing level of sophistication in the collected data, an intermediary solution should be explored, in order to interpret the term appropriately. On the one hand, the consent requirement is in place to protect legitimate interests. On the other hand, obtaining consent before data collection is not feasible. A middle ground can be found in raising awareness among data subjects over the fact that data are collected from space and over the uses of these data. This way, even if they are not able to provide clear and direct consent, data subjects would be informed about the possibilities of the collection of their personal data. Such action would require large-scale mobilisation, involving the stakeholders that collect and process data, but also the national, regional, and international authorities and organisations in charge of promoting space applications and the use of space technology.

At the same time, the approach of the *implementation of technical and organisational measures* can be applied. In particular, measures can be taken by the stakeholders that collect, process, and disseminate space data, to ensure that the data they handle do not contain personal information and, when they do, it is minimised to the extent feasible and adequately concealed. This is a concern that is mostly relevant to high-resolution EO data that are able to identify individuals, when used on their own or in combination with other available data. There are several technical means that can be taken in this

regard.[14] Data anonymisation can help remove or alter information in a dataset, in order to limit or exclude the possibility of identification of personal information. Mechanisms that prevent reverse-engineering can ensure that personal information are not dissected from processed data or data applications. Likewise, metadata that may include information that can deduce personal data should be shared with caution regarding privacy and data protection.

For the same reasons that obtaining consent is challenging, determining the data uses in the context of the lawfulness of their collection and use is difficult. A solution could be to follow the approach of a *new regulation*. Its purpose would be to declare a number of broadly described purposes for

14 ISO/IEC 29100:2011(en), Information technology-Security techniques-Privacy framework, 2.2 Anonymization. For an example of anonymising satellite-based internet data, *see* A Andelsbach, U Greveler, 'ANOCAST: Rethinking broadcast anonymity in the case of wireless communication' (Sicherheit 2008: Sicherheit, Schutz und Zuverlässigkeit. Konferenzband der 4. Jahrestagung des Fachbereichs Sicherheit der Gesellschaft für Informatik e.V. (GI), Saarbrücker Schloss, 2-4 April 2008) <https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=e81d2d3faa0600673d8eaffb8bd578908cf78323>. For an example of anonymising satellite-enabled location data, *see* M G Moncayo-Unda, M van Droogenbroeck, I Saadi, M Cools, 'An anonymized longitudinal GPS location dataset to understand changes in activity-travel behaviour between pre- and post- COVID periods' (2022) 45 Data in Brief 108776, 10; K Sila-Nowickaa, P Thakuriah, 'The trade-off between privacy and geographic data resolution. A case of GPS trajectories combined with the social survey results' (The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLI-B2, 2016, XXIII ISPRS Congress, 12–19 July 2016, Prague, Czech Republic) <https://isprs-archives.copernicus.org/articles/XLI-B2/535/2016/>; K Hasanzadeh, A Kajosaari, D Häggman, M Kyttä, 'A context sensitive approach to anonymizing public participation GIS data: From development to the assessment of anonymization effects on data quality' (2020) 83 Computers, Environment and Urban Systems 101513. For an example of anonymising remote sensing data, *see* J D Michler, A Josephson, T Kilic, S Murray, 'Privacy protection, measurement error, and the integration of remote sensing and socioeconomic survey data' (2022) 158 Journal of Development Economics 102927. For an example of anonymising geospatial information, *see* 'The MICS GIS Initiative – How do we anonymize spatial data?' (*UNICEF*, 28 October 2022) <https://mics.unicef.org/news_entries/226/THE-MICS-GIS-INITIATIVE:-HOW-DO-WE-ANONYMISE-SPATIAL-DATA>. Some technical methods for managing or limiting access to high-resolution EO data are discussed in S A Chun, V Alturi, 'Protecting privacy from continuous high-resolution satellite surveillance' in B Thuraisingham, R Riet, K R Dittrich, Z Tari (eds), *Data and application security – Developments and directions* (Kluwer Academic Publishers, 2001) 233. The challenges in anonymising space data are discussed in H Zang, J Bolot, 'Anonymization of location data does not work: a large-scale measurement study' in *Proceedings of the 17th annual international conference on Mobile computing and networking (MobiCom'11)* (Association for Computing Machinery 2011) 145; N B Koenigswater, 'Big data is hard to anonymize; here is what it means for development' (*Medium*, 13 November 2019) <https://medium.com/swlh/big-data-is-hard-to-anonymize-here-is-what-it-means-for-development-39e309f3b136>. For the risks of reverse engineering space data, *see* M Harris, 'Starlink signals can be reverse-engineered to work like GPS-whether SpaceX likes it or not' (*MIT Technology Review*, 21 October 2022) <https://www.technologyreview.com/2022/10/21/1062001/spacex-starlink-signals-reverse-engineered-gps/>.

which space data can be used, keeping in mind the contemporary state of the market and technology. Since such a solution may limit the creation of novel data uses a counterproposal would be for such regulation to identify the purposes of data collection and use that are not lawful and therefore not permitted under data protection laws. This process would require a dialogue between States, being the authorities that oversee privacy compliance, the actors that collect and process space data, and the various users of space data, to ensure that the described unlawful purposes do not inhibit the development of data uses.

PR 4 – Space technology is privacy-pervasive.

A legal challenge that is connected with the inability to obtain consent and determine the purpose of data collection and use is the evidently pervasive nature of space technology. On the one hand, it enables the collection and transmission of information on an unprecedented level. On the other hand, the vast capabilities of space technology are a natural development after decades of technological advancement, which cannot and should not be reversed. The unique features of space technology that enable the potential of space data, such as the constant and panoramic global coverage, are at the same time the source of privacy-related concerns. These features would not have been enabled, had there not been practical and political drivers behind them. In practical terms, there is no easy way to prevent a satellite from collecting space data. The alternative is to withhold such data after they have been acquired. Therefore, it is suggested to follow the approach of *maintaining the existing status quo*, namely to acknowledge the eventual privacy risks inherent to the operation of satellites. This acknowledgment should serve as the focal point in the discussion around privacy in space activities. Without restricting the benefits offered by space technology, the only way forward is to shift the narrative from the potential of space data to the circumstances that created the need for such potential to emerge.

PR 5 – The freedom to use and explore outer space may conflict with the right of States to safeguard information about areas under their jurisdiction.

Whereas the legal challenges related to the privacy of individuals can find some solutions, as showcased above, what is described as sovereign privacy in section 4.2 contests the legitimacy of space technology as information-gathering technology and is therefore difficult to address. It is proposed that the approach of *maintaining the existing status quo* is followed for this legal challenge as well. This translates to preserving the distinct treatment of satellites, as information-gathering technology that does not require prior permission to collect data. As was explained earlier, the ultimate question is whether the legal basis for operating data-gathering satellites, that is the

freedom to use and explore outer space, sufficiently justifies the capabilities of space technology to collect information about States. In other words, satellites are permitted to sense the territory of States, without their consent, in a manner that is more sophisticated compared to other technologies, for which authorisation to monitor a State's territory is required. The difference between satellites and other information-gathering technologies is that satellites operate from outer space, an area that States cannot control because it is outside national sovereignty. This area is covered by the freedom to use and explore outer space of Article I OST which enables the launch and operation of satellites. Whether the different legal treatment is justified seems like a theoretical exercise, but it is worth maintaining it as part of the general discussion because it is the source of privacy concerns over space data. It can have practical consequences, if a State raises the defence that information about areas under its sovereign power cannot be collected without its permission, simply on account of the different regulation of outer space. To the extent that the benefits from the use of space data continue to outweigh the legitimate concerns, remote sensing falls under the freedom of exploration and use of outer space. In the opposite scenario, the concept of sovereign privacy should be taken into account.

Table 5.3 summarises the regulatory approaches that are suggested for addressing the challenges in the field of privacy and data protection law.

Table 5.3 – Overview of the recommended solutions and regulatory approaches for each privacy and data protection law legal challenge

PR 1 – The conditions that determine whether privacy concerns are raised and personal data are involved vary among countries and are not easy to identify.	
Legal challenge summary	Proposed regulatory approach
Privacy rules can be harmonised on international level.	New regulation
Personal data should be defined in the scope of space data, space big data or space activities.	New regulation
The creation of personal data in the course of data fusion should be identified and a high level of protection should be maintained.	Implementation of technical and organisational measures
Contractual or licensing conditions for data supply, use, and distribution can include provisions related to privacy and to the selection of applicable laws.	Licensing and contractual arrangements
The applicable definitions of 'personal data' are sufficiently clear.	Maintaining the existing status quo
PR 2 – The identification of the actors responsible for complying with the data protection requirements is challenging.	
Legal challenge summary	Proposed regulatory approach
The terms 'controller' and 'processor' should be defined in the scope of space data, space big data or space activities	New regulation
The data controllers and data processors should be identified among the stakeholders involved in space big data.	Enforcement of the existing legal framework
The terms 'controller' and 'processor' of personal should be interpreted in a way that reflects the practice in the framework of space data, space big data or space activities.	Interpretation of applicable laws
Data controllers and processors should be appointed for each stage of the space big data lifecycle.	Implementation of technical and organisational measures
The licensing requirements or contractual agreements can appoint controllers and processors within a specific data system or within the space big data lifecycle.	Licensing and contractual arrangements
The applicable definitions of 'controller' and 'processor' are sufficiently clear.	Maintaining the existing status quo
PR 3 – Compliance with the requirements of lawful collection and processing of personal data is difficult.	
Legal challenge summary	Proposed regulatory approach
Unlawful or prohibited data uses can be declared in a regulation.	New regulation
The term 'consent' should be interpreted in a way that does not conflict with the potential of space technology to collect and disseminate personal data.	Interpretation of applicable laws
Methods that ensure anonymisation of personal data, prevent reverse engineering, and limit the distribution of metadata should be implemented.	Implementation of technical and organisational measures

PR 4 – Space technology is privacy-pervasive.	
Legal challenge summary	Proposed regulatory approach
Space technology is privacy-pervasive.	Maintaining the existing status quo
The uses and not the potential of space technology should be the focus of discussion around privacy in space big data.	Maintaining the existing status quo
PR 5 – The freedom to use and explore outer space may conflict with the right of States to safeguard information about areas under their jurisdiction.	
Legal challenge summary	Proposed regulatory approach
Sovereign privacy is affected by space technology and space big data.	Maintaining the existing status quo

5.2.3 Intellectual property law

Intellectual property law (IP) has narrow application to space big data, but wide impact because it grants considerable advantages to the owners or creators of an IP right. Although IP rights pose significant limitations to the access, use, and dissemination of space big data, they protect legitimate interests. Therefore, the objective of resolving the challenges from the application of IP laws to space big data is not to lower the barrier of regulatory protection but to create consistent practice in their application.

IP 1 – IP laws are jurisdiction-based and the identification of applicable laws is cumbersome.

Some of the legal challenges described in chapter 4 relate to the fact that IP rights are recognised and treated differently among various jurisdictions.[15] A solution can be found in the approach of the *implementation of technical and organisational measures*. Overseeing the different phases of the space big data lifecycle, especially the ones linked to procedures concerning IP rights, potential IP inferences could be detected and treated according to the applicable legal framework. For instance, during the data acquisition phase, data protected by IP rights are identifiable, so their permitted uses are understood and can

15 In the legal analysis, some international and European laws were examined, including WIPO Convention (adopted 14 July 1967, entered into force 26 April 1970) 828 UNTS 3; WIPO Copyright Treaty (adopted 20 December 1996, entered into force 6 March 2002) 2186 UNTS 121; Berne Convention for the Protection of Literary and Artistic Works (as amended) 1161 UNTS 3; Agreement on Trade-Related Aspects of Intellectual Property Rights (15 April 1994) 1869 UNTS 299; Directive 96/9/EC of the European Parliament and of the Council on the legal protection of databases [1996] OJ L 77/20; WIPO Patent Cooperation Treaty; Directive 2016/943 of the European Parliament and of the Council of 8 June 2016 on the protection of undisclosed know-how and business information (trade secrets) against their unlawful acquisition [2016] OJ L 157/1.

be tracked throughout the lifecycle. Likewise, during the data processing, the extent of creative processing becomes apparent, simplifying the assessment of IP implications. The suggested oversight can be conducted by the owner or creator of the IP right, since it is the party with the highest interest in maintaining it, as well as by the users of data and technology protected by IP since they have an obligation to treat them according to their prescribed terms and conditions.

IP 2 – The level of protection of IP rights varies among different States.

One of the main drawbacks of IP rights is that they are only recognised and protected in the jurisdiction in which they were created. This is not an issue that is particular to the space sector, but it can lead to diverging levels of regulatory protection of the same IP subject. One solution could be to follow the approach of a *new regulation*, where countries take steps to streamline their IP laws. Another solution could be to recognise that the jurisdiction-based approach to IP may offer inadequate legal protection and follow the approach of the *implementation of technical and organisational measures*. Based on that, the various parts of the space big data lifecycle that involve IP rights could be concentrated, when possible, under the same jurisdiction.

Given the international character of space big data, the lack of uniformity in the way IP laws are applied across various jurisdictions will remain a problem, resulting in parts of the space big data lifecycle being limited or not protected by IP. The *licensing and contractual arrangements* approach can function as an intermediary solution. Accordingly, copyright provisions can be included in the licensing terms of some datasets, as described in section 3.6.2.1, since they are tied to the data they govern, regardless of their location. Such provisions are usually found in the licensing terms for commercial datasets that are themselves copyrighted. Including them in terms of use for open data would provide some clarity as to when these data become worthy of protection, but limit significantly the open nature of these data. Such a measure can be undertaken by the owner of the IP right.

IP 3 – The application of IP rights to space big data is not uniform.

The legal challenges regarding the application of intellectual property laws to space big data have to do with whether data are protected by copyrights and how copyrighted data can be handled. For that, the approach of *maintaining the existing status quo* can be followed, given that the legal requirements as to how copyrights are created and protected are clear and do not need changes, in order to be applicable to space big data. Copyright protects the intellectual process of the creator, who is granted the right to determine whether and how the outcome of this process can be used by others. Granting

this right depends on the level of creativity involved. In the case of space big data, that depends on the level of processing that data undergo.

However, this legal challenge could be further assisted by the approach of the *interpretation of applicable laws* and the approach of *licensing and contractual arrangements*. So far, copyrights mostly appear in the licensing agreements for data supply, which include specific provisions regarding the permitted use, level of processing, and dissemination. This practice can continue, as it provides clarity and helps determine the copyrights involved. It is based on a case-by-case determination of the process of transforming non-copyrighted data into an intellectual product, which provides a solution tailored to the given background. At the same time though, wider practice in applying copyright laws through licensing agreements can facilitate the interpretation of these laws in the context of space big data.

Additionally, with the growing demand for data supply and the available processing methods for non-copyrighted data, copyright matters may arise more often. Therefore, it is worth considering the approach of the *implementation of technical and organisational measures*, through the development of standards and good practices for space data, based on the similarities between the characteristics and processing methods of different data categories. Such tasks can be performed by the actors who are involved in the processing and dissemination of data and by the users of data. It could also be raised to the approach of *new regulation*, with regional and international organisations that deal with matters of IP adopting regulations dedicated to IP in the scope of space data.

The recommended regulatory approaches for overcoming the IP law challenges are summarised in Table 5.4.

Table 5.4 – Overview of the recommended solutions and regulatory approaches for each intellectual property law legal challenge

IP 1 – IP laws are jurisdiction-based and the identification of applicable laws is cumbersome.	
Legal challenge summary	Proposed regulatory approach
The stages of the space big data lifecycle that are linked to the creation of IP rights and the level of creativity involved in data uses should be overseen.	Implementation of technical and organisational measures
IP 2 – The level of protection of IP rights varies among different States.	
Legal challenge summary	Proposed regulatory approach
The requirements for the establishment and protection of IP can be harmonised.	New regulation
All the stages of the space big data lifecycle can be concentrated under the same jurisdiction, in order to enjoy uniform IP protection.	Implementation of technical and organisational measures
Provisions related to IP rights can be included in the contractual arrangements for data supply, use, and distribution.	Licensing and contractual arrangements
IP 3 – The application of IP rights to space big data is not uniform.	
Legal challenge summary	Proposed regulatory approach
Measures for the protection of copyrights in the course of space data, space big data or space activities can be introduced.	New regulation
The terms connected to IP rights, and especially copyrights, should be interpreted in a way that reflects the practice in the framework of space data, space big data or space activities.	Interpretation of applicable laws
The transformation process of data and technology that is not protected by IP to IP-protected material should be monitored.	Implementation of technical and organisational measures
Conditions regarding the treatment of copyrighted material can be included among the contractual arrangements for data supply, use, and distribution.	Licensing and contractual arrangements
The process of creating IP rights is sufficiently clear.	Maintaining the existing status quo

5.2.4 Cybersecurity law

Cybersecurity (CYB) is one of the most crucial legal aspects of space big data because it can compromise the supply of data and impact the entire space big data lifecycle. The regulatory changes brought forward by the NIS 2 Directive also point in this direction.[16] Besides, maintaining a sufficient level of cybersecurity is in the interest of all the stakeholders involved, regardless of regulatory requirements in this direction.

16 Directive (EU) 2022/2555 of the European Parliament and of the Council of 14 December 2022 on measures for a high common level of cybersecurity across the Union, amending Regulation (EU) No 910/2014 and Directive (EU) 2018/1972, and repealing Directive (EU) 2016/1148 (NIS 2 Directive) [2022] OJ L 333/80.

CYB 1 – Part of the space big data lifecycle may not fall under the protection scope of cybersecurity regulations.

CYB 3 – The presence of cyber infrastructure in outer space hinders the application of cybersecurity regulations.

The steady flow of reliable information that space big data requires can be jeopardised by signal disruption and unauthorised data access. Therefore, it is essential to address the legal challenge created by the gaps in cybersecurity legislation that may leave critical parts of the space big data lifecycle unprotected. This reasoning was followed during the adoption of the revised NIS 2 Directive, which includes ground-based infrastructure among the network and information systems that should be protected, contrary to its predecessor which did not make such reference. Nevertheless, the NIS 2 Directive creates obligations only for larger companies and not for small and medium companies that can play an active role in the space big data lifecycle. It is also unclear whether it protects the assets of the EU Space Programme, both on the ground and in space. Additionally, it only covers ground-based infrastructure that supports the provision of space-based services, leaving other vulnerable ground infrastructure outside its scope, while it does not directly cover space assets, which still form part of the space big data lifecycle. Three options can tackle this challenge.

First, the approach of a *new regulation* can be followed on the EU level. As was noted in section 4.2, one of the legal challenges is connected to the content of the NIS 2 Directive, a law adopted by the EU. A similar law is required to alter, amend, or overwrite its provisions, in order to overcome this challenge.[17] Such a law can add provisions to Annex I of the existing Directive, without altering its main provisions. In particular, the reference to the space sector in the Annex can include sub-sectors referring to operators others than the operators of ground-based infrastructure that supports the provision of space-based services and other modifications. As far as the actors are concerned, the description of the space sector can involve operators of space-based infrastructure that supports the provisions of space-based services, as well as operators of NIS systems connected to space assets. A description of the term 'space-based services' should also be provided, in order to specify which activity that is offered through space technology is protected and whether data transmission by a space object that is not offered as a service is also covered. However, in order to extend the scope of the Directive to services and activities carried out not only by Member States, but also by the EU, such as the EU Space Programme, would require amending the text of the Directive, particularly Articles 1 and 2, as well as other provisions that

17 Treaty on the Functioning of the European Union (consolidated version) [2012] OJ C 326/47 art 294 (hereinafter TFEU).

refer specifically to Member States and are designed to apply to States rather than organisations. Such an amendment could be considered, should the NIS 2 Directive be reviewed in the future.

Second, the approach of a *new regulation* can be followed at the level of EU Member States. Until changes on the EU level are introduced, EU Member States can implement higher cybersecurity standards and address sectors that are not foreseen in the Directive. They can do that and provide for cybersecurity compliance among the operators of space-based infrastructure, through the adoption of national measures or through adding relevant requirements for obtaining a license.

Third, the approach of the *enforcement of the existing framework* and the *interpretation of applicable laws* can be considered. Space objects should be registered in accordance with the provisions of the Outer Space Treaty and the Registration Convention, as a means for States to extend the application of their national laws to space objects and create a consistent practice in this regard. Even if ground-based and space-based infrastructure is included in its scope, the NIS 2 Directive does not clarify how far the interconnection among the protected devices goes. For instance, the extent of the connection among interconnected devices that form part of a NIS is not specified in the regulations, in that it is not clear until when, within the space big data lifecycle, a device or a network associated with a satellite network remains connected to the protected network. A narrow interpretation would only cover networks and devices that are directly connected to the protected network, whereas a broad interpretation would involve other stages of the space big data lifecycle. A solution would include a broad interpretation, in favour of maintaining a higher level of cybersecurity. Such an interpretation can be promoted by States in their national legislation or the national implementation of EU legislation, as well as on the level of the stakeholders involved in the space big data lifecycle, who are in a position to determine the proximity of the connection among the various parts of cyber infrastructure.

Another hindering factor in the application of cybersecurity regulations to the space big data lifecycle is the company size. This is a decisive factor in characterising companies in the space sector as essential and important entities, in order to enjoy the protection of the NIS 2 Directive. This can be alleviated through the *implementation of technical and organisational measures*. Although cybersecurity compliance may require additional capacity for smaller and medium enterprises, some of them are particularly active in space big data. As an alternative to a regulatory change, practical approaches can be followed by the stakeholders involved in the various stages of the space big data lifecycle, to safeguard their assets. For example, following a minimum

viable protection approach,[18] stakeholders can identify the stages that are most critical to cybersecurity and interpret the legal definitions accordingly.

CYB 2 – The level of regulatory protection toward cyber threats and incidents against space big data may be insufficient.

Even when cybersecurity regulations are applied, the measures they prescribe may not be sufficient to provide adequate protection. Therefore, following the approach of a *new regulation* with actionable and efficient cybersecurity measures can provide a far-reaching solution. The NIS 2 Directive introduced a development in this regard. Instead of focusing on the vague criteria of confidentiality, availability, and integrity of data and on the notification of cyber incidents, it requires EU Member States to adopt national cybersecurity strategies with specific aims and priorities. States can also implement higher cybersecurity standards if they deem it necessary. In order to eliminate risks in the transmission of data, as was explained above, cybersecurity measures can be required as part of the licensing procedure. For the protection of stored data, States can identify the relevant stakeholders and introduce measures in their national cybersecurity strategies that address them. Supplementing the existing Directive with additional targeted measures or introducing another regulation on cybersecurity in general or on cybersecurity in space can offer a higher level of protection of space big data systems and a longer-term solution to the legal challenge connected to the regulatory protection of cybersecurity laws.

CYB 4 – The causes and results of cybersecurity incidents cannot always be spotted.
CYB 5 – Space big data infrastructure is prone to vulnerabilities.

The treatment of cybersecurity incidents can benefit from the approach of the *implementation technical and organisational measures*. Without meaningful consequences for their perpetrators, the level of compliance with the cybersecurity regulations is weakened. Enforcement starts with identifying the causes of such incidents, their instigators, and the location where they took place. To determine these factors, the design of the space big data lifecycle should allow the identification of the actors involved and the points of potential vulnerability. Moreover, the approach of a *new regulation* can lead States to adopt higher

18 Minimum viable security can be described as the minimum of measures that can be implemented to ensure security. An example of minimum cybersecurity measures can be found in ISO/IEC TS 27110:2021(en) Information technology, cybersecurity and privacy protection – Cybersecurity framework development guidelines. A concise analysis of corporate strategies to assess their risk appetite limit can be found in 'Risk appetite frameworks – How to spot the genuine article' (*Deloitte EMEA Centre for Regulatory Strategy*, 2013) <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Financial-Services/gx-fsi-ecrs-riskappetite-16072013.pdf> 7.

cybersecurity standards that aid the process of identifying the root of cybersecurity incidents and provide for retribution methods.

A mechanism for identifying the causes and results of cyber incidents can also serve as a response to the legal challenge related to the inadequate or outdated level of protection that is embedded into some space assets and makes them vulnerable to cyber threats, regardless of the regulatory level of protection. This can be done through *licensing and contractual arrangements*. In this regard, technology should be forward-looking and anticipate future risks. One method to specify, anticipate, and retribute risks related to cybersecurity and especially to subsequent data breaches is seeking insurance, either because it is among the licensing requirements for a satellite system that collects and transmits space big data or it is chosen as a protection mechanism by the operatory of that system.[19] At the same time, cybersecurity should be treated by regulators, policy-makers, and stakeholders not only as a response to potential threats or in the framework of security but as a mechanism for ensuring the resilience of space systems and their connected applications. This solution is based on a combination of the approach of the *implementation of technical and organisational measures* and *interpreting the applicable framework*.

Table 5.5 gives an overview of the regulatory approaches that can resolve the legal challenges associated with cybersecurity.

19 A J Harrington, *Space insurance and the law* (Edward Elgar Publishing 2021) 194-196. In their conference paper, Kerolle and Capurso describe methods for calculating insurance coverage for satellite cybersecurity, M Kerolle, A Capurso, 'How to estimate insurance coverage for cybersecurity protection for satellites: A case study' (IAF, October 2020) <https://spacegeneration.org/wp-content/uploads/2022/04/INSURANCE-IAC-20E92.D5.46x58403.pdf>.

Table 5.5 – Overview of the recommended solutions and regulatory approaches for each cybersecurity law legal challenge

CYB 1 – Part of the space big data lifecycle may not fall under the protection scope of cybersecurity regulations. *CYB 3 – The presence of cyber infrastructure in outer space hinders the application of cybersecurity regulations.*	
Legal challenge summary	Proposed regulatory approach
The entirety of the space sector, including the EU Space Programme, should be incorporated into the protected sectors and the company size thresholds should be removed.	New regulation
Higher cybersecurity standards can be introduced.	New regulation
The registration practice of space objects should be enhanced, in order to apply cybersecurity regulations to cyber infrastructure in space.	Enforcement of the existing legal framework
The extent of the interconnection among devices, which form part of the network and information system protected by cybersecurity regulations, should be interpreted in a way that allows the protection of parts that are essential to space big data.	Interpretation of applicable laws
The space big data lifecycle should be assessed to determine the extent of the interconnection among network and information systems that are protected by cybersecurity regulations.	Implementation of technical and organisational measures
CYB 2 – The level of regulatory protection toward cyber threats and incidents against space big data may be insufficient.	
Legal challenge summary	Proposed regulatory approach
Measures for stored space data should be introduced.	New regulation
CYB 4 – The causes and results of cybersecurity incidents cannot always be spotted. *CYB 5 – Space big data infrastructure is prone to vulnerabilities.*	
Legal challenge summary	Proposed regulatory approach
Higher cybersecurity standards can be introduced.	New regulation
The concept of cybersecurity should be interpreted in the context of resilience.	Interpretation of applicable laws
The cyber technology that is used in the space sector and especially on board space objects should be improved.	Implementation of technical and organisational measures
The cyber infrastructure deployed in the space big data lifecycle should be compartmentalised, in order to facilitate the enforcement of cyber regulations.	Implementation of technical and organisational measures
Licensing requirements of space systems can include the implementation of appropriate cybersecurity measures.	Licensing and contractual arrangements

5.2.5 Export control

Export control (EXP) finds limited application to space big data, but being a prominent concern for space activities in general, it may have a significant impact when controlled technology is involved. The lists of controlled items

undergo frequent changes, with additions, changes, and removals of items that require prior authorisation or are prohibited from exporting.

EXP 1 – Export control affects the cross-border movement of space big data.

The application of export rules depends on the uses and the users of the controlled items. The plethora of uses and users, along with the volume and velocity of space big data make their identification challenging. As was concluded in section 3.5.3, the export concerns surrounding space big data relate to their character as dual-use technology, rather than the possibility to be used as munitions. Therefore, it is proposed to adopt the approach of *maintaining the existing status quo* and carry on with the application of export rules to data and technologies related to the collection, storage, and processing of data that fall under lists of controlled items. Their export should be authorised on the basis of their expected uses and users. Given their sophisticated nature, data and technology covered by export control are not widely accessible, so it is likely that both their potential uses and users can be identified in advance, allowing for the application of the relevant export rules.

Data may become dual-use after undergoing processing, in which case the initial identification of uses and users may no longer be valid. Similar to what was suggested in the case of privacy and intellectual property, the *implementation of technical and organisational measures* is recommended. Specifically, monitoring the development of space big data by the stakeholders involved throughout their lifecycle may ensure compliance with applicable regulations.

EXP 2 – The uses and users of controlled technology cannot be easily identified.

Lists of controlled items may impose limitations on the proliferation of very sensitive data, but mostly cover the technologies used for data collection, storage, and processing. In any event, they are clear as far as their application to space big data is concerned. Therefore, the suggested approach is the *enforcement of the existing framework*. Should changes occur in the future, due to the approach of a new regulation, in terms of the intricacies of available data and technology, the list of controlled items can be updated. The EU Regulation on the export of dual-use items has been amended several times to include additional items, as necessary.[20] Other export regimes, such as the US ITAR and EAR, are also updated as needed to incorporate changes and additions.[21] Whereas the addition of data to controlled lists will safeguard

20 Regulation (EU) 2021/821 of the European Parliament and of the Council of 20 May 2021 setting up a Union regime for the control of exports, brokering, technical assistance, transit and transit of dual-use items (recast) [2021] OJ L 206 art 294.

21 15 CFR §730-774 (hereinafter EAR); 22 CFR §120-130 (hereinafter ITAR).

the legitimate interests that export control aims to protect, they will also create obstacles to the further development of space big data. Considering the above, compliance with export rules is a task for the actors that supply and disseminate data and related technology since they are in a better position to know their prospective uses and users.

Lastly, part of the solution involves *maintaining the existing status quo*, which eventually limits certain uses and users of space data. Export rules impact the inherently international trait of the space sector and permeate all its facets, not only space big data. On the one hand, more and stricter export rules hinder cross-country cooperation and limit access to and use of space technology, including space data. On the other hand, export rules protect the legitimate interests of States, as dictated by their national security priorities and their international obligations. Space data have demonstrated their capacity in cases of conflicts between States. Satellite imagery has captured the aftermath of attacks, while satellite-based internet provided a connectivity lifeline when no other avenue was available.[21] Such applications confirm the dual-use of space data and may justify a further extension of export controls on data and associated technology. This challenge is ultimately connected to the current geopolitical landscape which affects the regulations accordingly and may lead to additions or removals from the lists of controlled items.

Table 5.6 outlines the regulatory approaches proposed for the legal challenges related to export control.

Table 5.6 – Overview of the recommended solutions and regulatory approaches for each export control legal challenge

EXP 1 – Export control affects the cross-border movement of space big data.	
Legal challenge summary	Proposed regulatory approach
Potential export control implications during the various stages of the space big data lifecycle should be monitored.	Implementation of technical and organisational measures
Most of the times data and technology covered by export control can be identified prior to their use.	Maintaining the status quo
EXP 2 – The uses and users of controlled technology cannot be easily identified.	
Legal challenge summary	Proposed regulatory approach
Changes and additions can be made to the lists of controlled items and technology.	New regulation
Compliance with export regulations within the space big data lifecycle should be monitored.	Enforcement of the existing legal framework
The global geopolitical circumstances affect export control in the space sector.	Maintaining the existing status quo

21 '100 days in Ukraine' (*Planet Snapshots*, Issue 28, 2 June 2022) <https://learn.planet.com/Snapshots-06-02-22.html>; Z Sheftalovich, 'Elon Musk activates Starlink satellites to give Ukraine data backup' (*Politico*, 22 February 2022) <https://www.politico.eu/article/elon-musk-activates-starlink-satellites-to-give-ukraine-data-backup/>; A Jones, 'Pentagon confirms it's buying SpaceX Starlink services for Ukraine' (*Space.com*, 8 June 2023) <https://www.space.com/pentagon-buying-spacex-starlink-services-ukraine>.

5.2.6 Data policies

Data policies (DP) apply to the particular sets of data that fall under their scope. The data policy of the EU Space Programme and space agencies, such as ESA and NASA, only apply to data generated in the course of their missions.[22] National data policies in countries like Germany, France, the US, Canada, and India, apply to the data collected by satellites licensed under their regime.[23] The Dutch Satellite Data Portal provides for open access to EO data concerning the territory of The Netherlands that come from various sources, each of which is ruled by its own terms and conditions.[24] Therefore, their scope of application is specific and rather limited, given the multitude of data sources that power space big data. However, their impact on space big data may be significant, depending on the limitations they impose on data collection, access, use, and dissemination. Moreover, the various data policies highlight the distinction between open data and data from public and commercial sources that are subject to specific terms and conditions. Alongside the various national and regional policies, the UN Remote Sensing Principles were also analysed,[25] as an example of a data policy.

DP 1 – Data policies only apply to specific parts of space big data.

DP 2 – Data policies may affect only a small part of space big data or data that are not under their scope.

Data policies govern data that come from specific sources, such as dedicated space missions like the EU Copernicus and Galileo constellations, space systems

22 Regulation (EU) 2021/696 of the European Parliament and of the Council of 28 April 2021 establishing the Union Space Programme and the European Agency for the Space Programme and repealing Regulations No 912/2010, No 1285/2013, No 377/2014, and Decision No 541/2014/EU [2021] OJ L 170/69 (hereinafter EUSPA Regulation); ESA Data Policy for ERS, Envisat and Earth Explorer missions (October 2012). Terms and Conditions for the Utilisation of ESA's Earth Observation Data between the European Space Agency and the Principal Investigator, ESA-EOPG-PDGS-PR-1 (21 April 2020); Science Mission Directorate Policy SMD Policy Document SPD-41 (4 August 2021); Data and Information Policy (updated 25 May 2021) <https://www.earthdata.nasa.gov/data-and-information-policy>.

23 Gesetz zum Schutz vor Gefährdung der Sicherheit der Bundesrepublik Deutschland durch das Verbreiten vor hochwertigen Erdfernerkundungsdaten (Satellitendatensicherheitsgesetz – SatDSiG), Zuletzt geändert durch Art. 5 G v. 19.4.2021 I 771; French Space Operations Act, LOI no.2008-518 du 3 Juin 2008 relative aux opérations spatiales, Journal Officiel de la République Francaise, 4 juin 2008 ; 51 USC §601 – Land Remote Sensing Policy; 15 CFR §960 – Licensing of private remote sensing space systems; Remote Sensing Space Systems Act, S.C. 2005, c. 45 (last amended on April 5, 2007); Remote Sensing Space Systems Regulations, SOR/2007-66 (last amended on April 5, 2007); Remote Sensing Data Policy (2011).

24 Satellite Data Portal <https://www.satellietdataportaal.nl/>.

25 UNGA Res 41/65 (3 December 1986) Principles Relating to Remote Sensing of the Earth from Outer Space UN Doc A/RES/41/65 (hereinafter UN Remote Sensing Principles).

licensed in certain countries, or datasets that are owned or made available by public or private actors. Space big data come from a combination of sources, which can make it challenging to identify at all times whether a data policy governing part of the data contained therein is followed. However, when it comes to data policies put forth by countries or by publicly-funding programmes, the conditions are usually basic and do not have a significant impact on how the data they cover are handled, once they become a part of space big data. Although they should be adhered to, challenges that come from the lack of timely identification of data governed by a data policy will not likely result in a major breach. At the same time, data policies of commercial actors occasionally pose significant restrictions, by prohibiting the generation of derivative or value-added products. Therefore, it is important to recognise the terms of these policies when the data they cover become part of the space big data lifecycle and monitor that they are followed throughout the process. This solution is based on the approach of the *implementation of technical and organisational measures.*

DP 3 – Data from multiple sources that are combined into space big data may be covered by various data policies.

The simultaneous application of different data policies in the same space big data lifecycle raises a legal challenge regarding compliance with the various applicable data policies vis-á-vis the desired data availability. Even when data policies are identified and adhered to, the differences between their provisions may lead to a complex set of permitted and restricted actions for data that are part of the same space big data product. This difficulty is especially visible in the case where data policies apply only to a small data sample but can be lifted through the approach of the *implementation of technical and organisational measures*. A practical solution in this regard would be to prefer, when possible, data covered by the same or similar policies.

Another solution, following the approach of *new regulation*, would be the adoption of data policies by more countries. The existing national data policies vary significantly among them. The establishment of data policies by more countries could create further harmonisation that would facilitate uniformity among data policies and the selection of data governed by similar terms and conditions. Concurrently though, this may lead to the creation of more policies that remain diverging and to forum-shopping, both of which hinder the consistency among data policies and the availability of data.

Proposing a solution to streamline data policies may be hard, since there are valid reasons behind the existence of diverging data policies, especially in terms of open and restrictive policies. Therefore, it is worth considering *maintaining the existing status quo*, where data policies may vary significantly among them. On the one hand, open policies with only fundamental restrictions promote the uptake of data from publicly-funded projects. On the

other hand, restrictive data policies from commercial operators justify their expected return of investment and market presence. A general request for more openness in the supply of data is not reasonable, as it does not give consideration to the factors that drive commercial activities. Notwithstanding the associated costs and potential market disruptions, a claim can be made for data from open sources to reach the quality of data from commercial sources, thus forcing an approach towards wider data accessibility.

DP 4 – Conditions regarding the collection, access, use and dissemination of data do not only come from data policies.

Whereas data policies impose considerable requirements regarding the collection, access, use, and dissemination of the data they govern, they are not the only source of such requirements. As was analysed in chapter 3, such conditions may stem from several fields of law that are applicable depending on the context. Consolidating the laws applicable to space big data in one place is an entirely new challenge, which may be resolved through the approach of *new regulation* and particularly with the adoption of a national, regional, or international regime dedicated to space big data and containing all the laws and data policies that are applicable.

Until the alternative of a law on space big data is realised or in case this is not realised, the *implementation of technical and organisational measures* is proposed. A thorough awareness on behalf of the stakeholders involved in space big data is required, concerning the existence of legal implications, rights, and obligations that should be taken into account during the various stages of the space big data lifecycle. Such awareness can be promoted by national, regional, and international authorities in charge of space activities and the promotion of space data applications. As will be explained in section 5.4, space data and applications are part of the policies and several undergoing initiatives by UNCOPUOS, the EU, and the EU Agency for the Space Programme. Through them, they can draw attention to the frameworks applicable to data collection, access, use, and dissemination, by making clear connections and references in the documents that concern their space data-related activities. Similarly, on national level, the government entities responsible for space activities and the uptake of space data, the governmental entities using space data, as well as the national space agencies can inform the data users of the applicable frameworks.

DP 5 – The application of the UN Remote Sensing Principle is limited, as they only describe a narrow definition of EO.

The main criticism of the UN Remote Sensing Principles is their narrow scope. This mostly has to do with the narrow definition of EO, or remote sensing, which does not correspond to the contemporary uses of that technology. By

restricting remote sensing to the purposes of improving resource management and the environment, they are excluded from applying to the plethora of other uses of EO data. The scope of the principles is also limited to one type of space data, EO data, although this is the most commonly used type of space data and the subject of several of the examined data policies. The approach of the *interpretation of applicable laws* can help describe the term EO data more broadly, thus extending the scope of the Principles. However, it does not resolve other issues related to their outdated content and does not provide sufficient clarity, as far as the definition of EO data is concerned. Without removing the reference to specific purposes, regardless of its interpretation, the definition can still be seen as limiting. Therefore, the approach of a *new regulation* can be followed, to adopt a revised document, binding or non-binding, which will set new grounds for the treatment of remote sensing technology.

At the same time though, as was previously pointed out, the UN Remote Sensing Principles are not binding and do not establish definitive rights and obligations for the sensing and the sensed State. Therefore, they remain remotely relevant to the current developments in the field of space data and, without a serious will to address remote sensing on the level of the UN, may not be worth revising, thus *maintaining the existing status quo*.

DP 6 – The access of the sensed State to data concerning its territory is not established.

Tied to the legal challenge mentioned above, the UN Remote Sensing Principles do not establish a specific framework for the access of the sensed State to data concerning its territory, so they do not create considerable effect in terms of data access. Their provisions call for non-discriminatory access to data collected by the sensing State and for access to data on a reasonable basis. However, they do not translate to unconditional and free entry for the sensed State. As was explained before, under ISL 1 in section 5.2.1, an absolute standard of openness would work counter-intuitively to commercial initiatives in the field of space and space data. Therefore, removing these barriers is not a realistic, or reasonable, expectation; hence *maintaining the existing status quo* is suggested, along with maintaining the right of the sensed State to access data concerning its territory is subject to no discrimination and to subsequent cost, as far as the UN Remote Sensing Principles are concerned. Some data policies offer open access, so States, as well as private actors, can rely on them for data acquisition. If sensed States change their position and the matter becomes pressing, another regulatory approach can be sought.

The recommended regulatory approaches for overcoming the legal challenges concerning data policies are summarised in Table 5.7.

Table 5.7 – Overview of the recommended solutions and regulatory approaches for each challenge connected to data policies

DP 1 – Data policies only apply to specific parts of space big data. *DP 2 – Data policies may affect only a small part of space big data or data that are not under their scope.*	
Legal challenge summary	Proposed regulatory approach
The data used throughout the space big data lifecycle should be inventoried, in order to determine whether data covered by a data policy are utilised.	Implementation of technical and organisational measures
DP 3 – Data from multiple sources that are combined into space big data may be covered by various data policies.	
Legal challenge summary	Proposed regulatory approach
Data policies can be adopted by more countries and organisations.	New regulation
Data covered by the same or similar data policies should be preferred.	Implementation of technical and organisational measures
The request for wider availability of high-quality data should be followed or replaced by a request for higher-quality open data.	Maintaining the existing status quo
DP 4 – Conditions regarding the collection, access, use and dissemination of data do not only come from data policies.	
Legal challenge summary	Proposed regulatory approach
A law consolidating all legal aspects of space big data can be adopted.	New regulation
Legal issues connected to space big data other than the ones included in data policies should be identified.	Implementation of technical and organisational measures
DP 5 – The application of the UN Remote Sensing Principles is limited, as they only describe a narrow definition of EO.	
Legal challenge summary	Proposed regulatory approach
A revision of the UN Remote Sensing Principles can entail a broader scope of remote sensing and remote sensing data uses.	New regulation
The definition of remote sensing can be interpreted to include remote sensing uses other than the management of natural resources and the protection of the environment.	Interpretation of applicable laws
The relevance of the UN Remote Sensing Principles is limited, so it is not worth reviewing them.	Maintaining the existing status quo
DP 6 – The access of the sensed State to data concerning its territory is not established.	
Legal challenge summary	Proposed regulatory approach
The UN Remote Sensing Principles do not have significant impact on data access on behalf of the sensed State and a higher standard of openness is neither feasible nor justified.	Maintaining the existing status quo

5.2.7 Determining the optimal regulatory solution

The solutions suggested in sections 5.2.1 to 5.2.6 are based on the various regulatory approaches analysed in section 5.1. Some findings emerge from the connection between the regulatory approaches and the proposed solutions for each legal field. These findings can assist the decision about which of the

several solutions is optimal when the implementation of all of them is not feasible or desirable. First, in some cases, one solution can address several legal challenges, while in other cases, one legal challenge necessitates several solutions. This indicates a different level of *efficiency* for the regulatory approach, based on the number of solutions it enables. Second, the solutions and regulatory approaches concerning the legal fields with greater effect on the space big data lifecycle or with more challenges can also have a greater *impact* on the regulation of space big data.

As far as *efficiency* is concerned, and depending on the legal field, certain solutions appear more fit than others. This is evidenced from the tables 5.2, 5.3, 5.4, 5.5, 5.6, and 5.7, which provide an overview of the solutions and regulatory approaches for each legal field.

International space law can mostly benefit from a suitable interpretation of its provisions (ISL 1, ISL 3, ISL 4, ISL 6). Some space law issues can be sorted through wider enforcement (ISL 2, ISL 5) and licensing and contractual arrangements (ISL 1, ISL 2, ISL 4), while technical and organisational measures can be of limited use (ISL 2, ISL 5).

Privacy and data protection do not warrant significant action (PR 1, PR 2, PR 4, PR 5) and several challenges can be resolved through technical and organisational measures (PR 1, PR 2, PR 3). At the same time, new regulations (PR 1, PR 2, PR 3) along with licensing and contractual arrangements (PR 1, PR 2), and to a lesser extent interpretation (PR 2) and enforcement (PR 2) of existing provisions, can help adapt some challenges to the context of space big data.

Intellectual property challenges can find solutions primarily through technical and organisational matters (IP 1, IP 2, IP 3). Some of them can be arranged through licenses and contracts (IP 2, IP 3) and new regulations (IP 2, IP 3). A few of them can be met through interpretation (IP 3) or maintaining the status quo (IP 3).

Technical and organisational measures can respond to several cybersecurity challenges (CYB 1 & CYB 3, CYB 4 & CYB 5), as do new regulations (CYB 1 & CYB 3, CYB 2, CYB 4 & CYB 5). Others can be addressed with interpretation (CYB 1 & CYB 3, CYB 4 & CYB 5), enforcement (CYB 1 & CYB 3), as well as licensing and contractual arrangements (CYB 4 & CYB 5).

Export control does not necessitate changes (EXP 1, EXP 2), and can be settled through enforcement (EXP 2), technical and organisational measures (EXP 1) or changes in the lists of controlled items through a new regulation (EXP 2). Finally, data policies are served mainly by maintaining the status quo (DP 3, DP 5, DP 6), introducing new policies (DP 3, DP 4, DP 5), and implementing technical and organisational measures (DP 1 & DP 2, DP 3, DP 4). The interpretation of existing policies is a less common solution (DP 5).

Considering the regulatory approaches that can offer a greater number of solutions as more efficient, table 5.8 summarises how regulatory approach offers solutions to the challenges raised in each legal field.

Table 5.8 – Overview of the recommended solutions and regulatory approaches for each challenge connected to data policies

Legal challenge	New regulation	Enforcement of existing measures	Interpretation of applicable laws	Implementation of technical and organisational measures	Licensing and contractual arrangements	Maintaining the status quo
ISL 1			X		X	X
ISL 2		X		X	X	
ISL 3			X			
ISL 4			X		X	
ISL 5		X		X		
ISL 6			X			
PR 1	X			X	X	X
PR 2	X	X	X	X	X	X
PR 3	X		X	X		
PR 4						X
PR 5						X
IP 1				X		
IP 2	X			X	X	
IP 3	X		X	X	X	X
CYB 1&3	X	X	X	X		
CYB 2	X					
CYB 4&5	X		X	X	X	
EXP 1				X		X
EXP 2	X	X				X
DP 1&2				X		
DP 3	X			X		X
DP 4	X			X		
DP 5	X		X			X
DP 6						X

As observed from the overview in table 5.8, new regulations and the implementation of technical and organisational measures can solve the largest number of challenges. They are followed by the interpretation of applicable laws, licensing and contractual arrangements, and maintaining the existing status quo. The enforcement of the existing legal framework seems to resolve the smallest number of legal challenges. Combining the numbers with previous findings regarding the time, effort, and lasting effect of each regulatory approach, as discussed in section 5.1 can result in additional observations. New regulations remain the preferred approach since they can offer the most far-reaching solutions, by addressing broad issues and bringing significant changes. They do not only involve the adoption of entirely new rules, but also amending, supplementing, and harmonising the existing ones. The enforcement of the existing legal framework settles some practical matters, but its overall impact is not significant. Likewise, the interpretation of applicable laws offers clarity around some terms and concepts that are useful, but not central in the regulation of space big data. On the contrary, the implementation of technical and organisational measures directly tackle critical matters. As far as licensing and contractual arrangements are concerned, they provide actionable solutions,

but their efficiency is determined on a case-by-case basis. Lastly, maintaining the existing status quo ensures that the issues that are properly addressed by existing regulations and the issues that do not merit change remain intact.

As far as the *impact* of the regulatory approaches and solutions is concerned, the conclusion of chapter 4, and especially table 4.2, indicated that international space law, export control, and data policies can impact all stages of the space big data lifecycle. Changes in these fields influence all stages of space big data activity and may therefore be given preference. Even though international space law, as discussed, does not have a direct impact on space data, other than on the satellites involved, export control and data policies have far-reaching implications, which can influence the collection, access, use, and dissemination of data. Consequently, approaches and solutions addressing these fields could have meaningful results. Privacy and data protection, IP law, and cybersecurity law only affect specific parts of the space big data lifecycle. Whereas the legal challenges that concern them should also be resolved, these solutions may tackle issues with a narrower scope and impact.

Another avenue for determining the impact of each approach is to consider the number of legal challenges that each field presents. As shown in table 4.2, the fields with the most challenges are, in declining order, international space law, privacy and cybersecurity, data policies, intellectual property, and export control. Looking beyond the number of legal challenges, some solutions can lead to the necessary clarity and higher degree of legal certainty. First and foremost, the authorisation of the satellites that collect and disseminate space big data by the appropriate State and their registration by their launching State would facilitate the overall application of international, regional, and national laws to these objects and the activities in which they are involved. Some matters of privacy will also shape how space big data activities are carried out. The acknowledgment that space technology is privacy-pervasive is a step towards addressing some privacy matters efficiently. To do that, a balance should be found between the freedom to use and explore outer space that enables unrestricted monitoring by satellite and the right of States -or other actors- to decide how information that concerns them is collected. Because space technology enables the collection of data in a way that is not comparable to other similar technologies, its potential should be factored in, not only as far as the vast benefits it offers, but also in terms of the implications it eventually creates against the legitimate interest of privacy. This train of thought will in turn guide the resolution of the legal challenge that is brought by the fact that the conditions surrounding privacy are regulated differently in each jurisdiction and are difficult to identify. Based on how the issue of privacy is treated on a higher level, a strict or flexible approach to interpreting and enforcing privacy and data protection laws can be followed. In terms of IP and cybersecurity, practical matters require urgent solutions. Since the way in which IP rights operate within the space sector, including in space data, is not uniform, further promoting their application can facilitate this process.

A central issue in cybersecurity is that some parts, often essential, of the space big data lifecycle do not fall under the protective scope of regulations. Resolving this matter will lead to better application of the relevant laws and a higher degree of protection. An important factor related to export control is the identification of the uses and users of the controlled technology. Settling this issue will elucidate the proper application of export rules and help resolve the rest of the relevant challenges. Lastly, as far as data policies are concerned, an important factor is to ensure that their provisions are adhered to at all stages of data access, use, and dissemination. Whereas the rest of the legal challenges are essential to address, these overarching challenges can have far-reaching effects and help resolve other adjacent issues.

The solutions presented in this section are not exhaustive. They are subject to change, following changes in the aforementioned criteria, as well as changes in the legal challenges they concern and technological advancement. Except for impact and efficiency, the priorities and capabilities of the actors that can implement them are determining factors. Some fields may seem more relevant than others in a given context, which means that the solution that works for one actor may not work for another. Based on the stages that each actor considers more important to address, according for instance to the status of a local space ecosystem or the needs that space big data are called to tackle, the optimal strategy can vary among them. The concerned actors and their role are discussed in section 5.4. Some of the proposed solutions hint at the adoption of a dedicated regulation for space big data, which is further discussed in section 5.3.

5.3 A LAW DEDICATED TO SPACE BIG DATA

As observed in section 5.2, a new law specifically dedicated to space big data could consolidate all the relevant legal matters and function as a single point of reference for the actors involved in the space big data lifecycle, thus enhancing regulatory compliance. Such a law could be adopted on a national, multilateral, or international level, but an international law dedicated to space big data is the most efficient solution, as explained in the following paragraphs. A dedicated law is based on the regulatory approach of new regulation.

The main advantage of a dedicated law is that, being tailored to space big data, it can alleviate the legal challenges that are connected to their distinct features and particularly the traits of big data. Taking into account the volume in which data is collected, the velocity in which they are transmitted, and the veracity and variety of the information they contain, such a law on space big data can offer a solution to several of the identified legal challenges. However, drafting, adopting, and implementing a new law can involve a lengthy process, and, tackling an issue that is under technological and business development, may be rendered outdated or obsolete even before its adoption.

As far as the *scope* of a potential law of space big data is concerned, its provisions can address the various aspects of space big data, such as legal, technical, and scientific matters, depending on the priorities of the actors initiating its adoption. The provisions of a law on space big data can entail new principles for the collection, access, use, and dissemination of space big data, based on the relevant legal and policy aspects analysed in chapter 3. Some issues that are missing from the existing legal framework can be regulated, while the issues that are governed by the existing framework can be described in the context of space big data. Alternatively, a dedicated law can describe how these fields find application to space big data. This would not require drafting new provisions and would utilise the existing legal framework, without the potential conflicts that a new regulation may create. Another option would be for the dedicated law to be limited to providing the basic definitions of space big data, in a way that facilitates the application of relevant laws, ideally by indicating these laws, but without including descriptive or new provisions. The scope of such a law can incorporate all or some of the types of space data (e.g. EO data, GNSS data, satellite-based internet data) and data uses (e.g. when space big data are used for automation) and can extend, beyond data, to data applications (e.g. when space big data are used in quantum technologies or digital twins) and data actors (e.g. large-scale data processors).

A law dedicated to space big data can address in parallel space data, in order to find wider application and resolve some legal challenges that are connected to space data as well. Such a wider scope facilitates the creation of a coherent framework, given that the legal and data policy aspects related to space big data are similar or the same as the aspects related to space data.

As far as the *content* of a dedicated law is concerned, two options can be recommended. One option is to create entirely new provisions with terms and concepts that are not associated with existing legislation. For instance, instead of controllers and processors of personal data, the definition of controllers and processors of space big data or of personal data in space big data can be provided. Similar can be the approach for other terms, such as network and information systems, databases, and copyright. Introducing a novel framework should first lay down the purpose of the regulation, which promotes a data governance environment that should enable the collection, access, use, and dissemination of data, without significant barriers, but also with respect to the legitimate interests of data subjects, data actors, and data users. On that basis, it can provide the necessary definitions and demarcate its scope. The definition of space big data should be sufficiently flexible, to adapt to the changing landscape, as well as clear enough to distinguish space big data from other types of data and justify the adoption of a new regulation. Another option is to rely on existing regulations and describe the way in which they apply to space big data. Building upon one or several existing frameworks can involve definitions and terms of reference, but instead of introducing new

provisions, it can describe how the existing ones can be applied to space big data, as defined within its scope.

In terms of the *level* of legislation, initiatives can be introduced on national, multilateral, and international level. Even though a law is easier to adopt on the national level, domestic laws only apply within the given jurisdiction, stumbling upon some of the legal challenges relating to the cross-border movement of data, as described in chapter 4. Furthermore, a national law may create diverging frameworks, if several countries introduce frameworks of different scope and content. It could also entice forum shopping, which is counter-intuitive to the effort of creating a harmonised framework that enables data collection, access, use, and dissemination. Similar are the drawbacks of a multilateral framework, which can be concluded among interested countries or at a regional level, such as at the level of the European Union. Its extent of application would be wider, potentially leading to an international agreement. While such a framework is easier to adopt compared to an international one, it may lack legitimacy specifically because it is not internationally accepted. It may also exclude some countries, if they are not involved in the process, or lead them to adopt another, potentially different framework. An international framework would offer the highest degree of harmonisation and be open for all interested countries to subscribe. However, the process may be time-consuming, subsequent necessary reviews may be difficult to implement, and the risk of over-regulating a developing field may hinder its further advancement.

Having followed the analysis in the previous chapters, it is reasonable to question the *feasibility* of a legal framework dedicated to space big data. Its establishment can be justified by its expected results, namely to streamline the regulation of space big data, remove barriers to data collection, access, use, and dissemination, and ultimately enhance the benefits of space big data. Nevertheless, such a framework requires a concerted effort on the various matters described in this subsection, as well as a strong policy incentive to initiate negotiations. Without overriding existing laws, its creation may cause further regulatory fragmentation and lead to the legal challenges discussed in chapter 4, concerning the identification of the applicable laws. The laws related to space big data as a result of space activity and as a type of space data, such as international space law, export control, and the various data policies, may eventually be superseded by a specific law on space big data. However, laws related to space big data as part of information technology, such as privacy, IP, and cybersecurity are not likely to be replaced by a regulation on space big data. These laws will continue to exist in parallel with a space big data regulation that dictates how they are applied in this field. That would create two equivalent regimes that would be difficult to synchronise and implement. Unless these laws explicitly extend their scope to space data, the legal challenges regarding their application in this field will remain.

Against this backdrop, a combination of the aforesaid alternatives is suggested. This thesis advocates in favour of a law dedicated to space big data, especially because according to the personal experience of the author, several of the actors involved in space big data wonder about the associated legal aspects that currently remain unanswered. At the same time, the legal challenges that rely on interpretation, technical and organisational measures, and licensing and contractual arrangements can be addressed by law, which would provide a sufficient amount of clarity and have binding effect. Without a central point of reference in terms of regulation, these issues will be subject to diverging alternatives. In turn, this will hinder the legal certainty that is necessary for further developing the field of space big data sustainably, in a way that allows for legitimate legal interests without hindering technical, scientific, and commercial developments. With this in mind, a law dedicated to space big data should be adopted on an international level, in order to ensure wide and uniform application. The law should provide the definitions that are necessary as terms of reference for space big data. In other words, it should delineate its scope by describing what are the space big data to which it applies. The law should also refer to the relevant legal fields and describe them in the context of space big data. Its provisions regarding these legal fields can be drafted on a two-tier approach.

– The first tier concerns the legal fields that are relevant to space big data as a type of space activity, namely international space law (ISL), export control (EXP), and data policies (DP). For them, new rules should be drafted, explaining how they should be treated, as far as space big data are concerned. This means that the existing relevant provisions, as described in sections 3.1, 3.5, and 3.6, will be superseded by the new rules, which will be more specific and will not leave room for diverging interpretation or implementation of the space-related provisions.
– The second tier concerns the legal fields that are relevant to space big data as a part of information technology, namely privacy and data protection law (PR), IP law (IP), and cybersecurity law (CYB). For them, instead of introducing new rules, the space big data law should provide guidance as to how to determine the existing relevant laws, on national, regional, and international levels, and how to apply them to space big data. This means that the existing relevant provisions, as described in sections 3.2, 3.3, and 3.4 will continue to apply. The only change brought by the space big data law is the indication of which privacy, IP, or cybersecurity law should apply, according to the jurisdiction and lifecycle at hand.

The two-tier approach is suggested because the space-related laws are meant to govern space-related matters. Therefore, whenever they lack clarity or context, as is often the case with space big data, they should be reviewed accordingly. On the other hand, information technology laws are not meant to govern space data. As a result, space big data should be viewed through

the lens of their existing provisions, which in turn should apply to space big data as they are.

Until an international law on space big data is adopted or if this scenario becomes unlikely, other avenues can be pursued. A regulation on the level of the EU, especially given its role and policy priorities, can be an alternative. That would also promote the use of data from the EU Space Programme further. Another alternative could be the adoption of a non-binding document, such as a UN Resolution or an EU Communication. In any event, it is recommended that the efforts toward a law dedicated to space big data take into account the concept of adaptive governance, according to which, in the face of uncertainty or complexity, different theories should be considered.[26]

5.4 A POLICY APPROACH TO SPACE BIG DATA

This section includes some observations regarding the proposed regulatory approaches and solutions, and the actors that can put them forward. It draws conclusions from section 5.3, which found that the choice of the optimal regulatory approach and solution depends on their efficiency and impact, but is ultimately decided by the actors that can materialise them. This section explains the role of the various actors mentioned in sections 5.1, 5.2, and 5.3 in the regulation of space big data. In particular, it discusses the mission and function of the UN Committee on the Peaceful Uses of Outer Space (section 5.4.1), the European Union and the EU Agency for the Space Programme (section 5.4.2), States (section 5.4.3), private actors (section 5.4.4), as well as other examples of space data governance (section 5.4.5).

5.4.1 The role of the UN Committee on the Peaceful Uses of Outer Space

The UN plays an important role in international law and policy. In the field of space, UNCOPUOS is a focal point for collaboration, exchange of information and expertise, promotion of research, as well as law and policy-making.

26 Adaptive governance or adaptive management can be explained as the process of using previous experience to adjust to changing circumstances in a flexible and appropriate manner. C Folke, T Hahn, P Olsson, J Norberg, 'Adaptive governance of social-ecological systems' (2005) 30 Annual Review of Environment and Resources 441, 447; L Hasslman, 'Adaptive management; adaptive co-management; adaptive governance: what's the difference?' (2017) 24.1 Australasian Journal of Environmental Management 31, 32-40. Whereas it often appears in connection with environmental studies, it has also been explored in the context of data-related matters as seen in M Janssen, H van der Voort, 'Adaptive governance: Towards a stable, accountable and responsive government' (2016) 33 Government Information Quarterly 1, 3; L Goasduff, 'Choose adaptive data governance over one-size-fits-all for greater flexibility' (*Gartner*, 11 April 2022) <https://www.gartner.com/en/articles/choose-adaptive-data-governance-over-one-size-fits-all-for-greater-flexibility>.

It was established in 1959 with the purpose of fostering international cooperation and discussing legal issues connected to outer space.[27] UNCOPUOS, along with its Scientific and Technical Subcommittee and its Legal Subcommittee are mandated with strengthening the legal framework on space activities, maximising the benefits from space technology, and promoting international cooperation in space activities. UNCOPUOS was instrumental in the creation of the international space treaties which include several provisions related to space big data, as discussed in section 3.1. Although the space treaties do not warrant review or amendment, UNCOPUOS, and especially its Legal Subcommittee, can take several actions to further the discussion on the legal and policy aspects of space big data. Among others, it can stir the topic of the legal extensions of space applications, raise awareness over the potential of space technology vis-à-vis the consent of the data subjects, create an inventory of existing laws and policies among its Member States, and catalogue relevant existing and prospective developments among States and international organisations. If it becomes a matter of interest for its Member States, it can be added to the agenda of the plenary or the Legal Subcommittee, which is tasked with discussing the legal questions related to space exploration, with the prospect of assessing the need for an international framework, either in the form of an international treaty or as a non-binding Resolution. Likewise, UNCOPUOS should be the most suitable forum to work on reviewing or replacing the UN Remote Sensing Principles.

Separately, UNCOPUOS has undertaken several efforts to promote the use of space technology, particularly space data. The UN Programme on Space Applications has been running since 1971 with the purpose of supporting and developing the use of space technology in various regions around the world.[28] In 2006, UNCOPUOS introduced the UN Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), which promotes the use of space data for disaster management and response.[29] It has also launched the Space4SDGs initiative that describes the various ways in which space technology can contribute to the UN Sustainable Development Goals and primarily involves space data solutions.[30] UNCOPUOS has also

27 UNGA Res 1472/1959 (XIV) International co-operation in the peaceful uses of outer space (12 December 1959).

28 UN Programme on Space Applications <https://www.unoosa.org/oosa/en/ourwork/psa/index.html>.

29 UN Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) <https://www.unoosa.org/oosa/en/ourwork/un-spider/index.html>; Office for Outer Space Affairs UN-SPIDER Knowledge Portal <https://www.un-spider.org/>. More on the work of UN-SPIDER can be found in K Zollner, 'UN platform for Space-Based Information for Disaster Management and Emergency Response (UN-SPIDER)' in C Brünner, G Königsberger, H Mayer, A Rinner (eds), *Satellite-based Earth observation-Trends and challenges for economy and society* (Springer, 2018) 235.

30 Space supporting the Sustainable Development Goals <https://www.unoosa.org/oosa/en/ourwork/space4sdgs/index.html>.

cooperated with ESA to launch in June 2023 the Space Solutions Compendium which aims to integrate data, resources, and information from space agencies and governmental entities.[32] In addition, the UN Long-Term Sustainability Guidelines for Outer Space Activities, adopted by UNCOPUOS in 2019, include reference related to space data. In particular, they call for sharing space-based data and information for disaster management and capacity-building and for utilising data for SSA and collision avoidance. Space data are also discussed as part of the agenda item on the legal aspects of space traffic management of the UNCOPUOS Legal Subcommittee.

The mandate, work, and expertise of UNCOPUOS make it an appropriate forum to address on an international level the matter of regulating space big data. This is also because it gathers a large number of Member States, including less developed countries that can benefit from space big data and countries active in the field of space applications. It also involves organisations that deal with space data and space applications as observers[33] and can be given the opportunity to share their practical insights. Its main drawback is its decision-making process that requires the consensus of all Member States and can result in lengthy procedures and outcomes that no longer reflect the existing state of affairs.

5.4.2 The role of EU and EUSPA

The European Union has heavily invested in the creation of EU space capabilities with the launch of the EU flagship space programmes, Copernicus, Galileo, and EGNOS which are components of the EU Space Programme, along with GOVSATCOM, SSA, and IRIS^2.[34] The Directorate-General for Defence Industry and Space (DG DEFIS) is in charge of the activities of the European Commission in the space sector,[35] including the implementation of the EU space programme. Space is also among the policy areas of the EU External Action Service (EEAS),[36] whose purposes can be served by space data, although uses that are not civil or commercial are not examined in this thesis. Moreover, the Knowledge Centre on Earth Observation of the European Commission

32 Space Solutions Compendium Pilot <https://www.unoosa.org/oosa/en/ourwork/space4sdgs/SSC_pilot.html>.

33 To name but a few, the European Union, the European Space Agency, the Committee on Earth Observation Satellites, Eurisy, and EUTELSAT. UN Committee on the Peaceful Uses of Outer Space: Observer Organisations <https://www.unoosa.org/oosa/en/ourwork/copuos/members/copuos-observers.html>.

34 The EU Space Programme <https://www.euspa.europa.eu/european-space/eu-space-programme>.

35 Defence Industry and Space <https://commission.europa.eu/about-european-commission/departments-and-executive-agencies/defence-industry-and-space_en>.

36 EU External Action Service, Space <https://www.eeas.europa.eu/eeas/space_en>.

Joint Research Centre works on identifying uses for space data, especially space big data, and the areas of EU policy that can benefit from them.[36]

As far as the regulation of space activities is concerned, the mandate of the EU is limited. While it can regulate the development and operation of the components of its missions, it does not have the power to directly introduce space regulations. Article 189 TFEU calls for the establishment of a European space policy and legislation related to the European space programme, but excludes any 'harmonisation of the laws and regulations of the Member States' from the mandate of the EU.[37] This is an obstacle to introducing on the EU level any space regulations besides the ones that concern EU space activities. Even though the EU has unveiled plans for the development of a European space law to address matters of safety, resilience, and sustainability of space activities,[38] at the time of this research, this remains a contentious point. Despite the benefits of harmonisation, such an initiative in the field of space can bring significant disruption, given the number of EU Member States with existing national space laws that have been implemented for years and may vary among them. Even if an EU space law does not directly address matters regulated on the national level by EU Member States, it can affect their implementation and the regulatory priorities of Member States. However, EU-wide legislation on space big data could alleviate some of the described challenges and existing discrepancies, elucidating the legal and policy landscape. Without prejudice to the EU mandate in space, such a regulation could be seen as separate from the space sector and space activities, given the various applications of space big data beyond it,[39] or as part of another area of EU competence.[40]

Notwithstanding the limitations tied to the competence of the EU and the scope of the relevant EU laws, as analysed in chapter 3, these laws that are relevant to space big data are not only connected to the area of space. Privacy, IP, cybersecurity, and export control are areas under EU competence and

36 Knowledge Centre on Earth Observation <https://visitors-centre.jrc.ec.europa.eu/en/media/infographics/knowledge-centre-earth-observation>.

37 Treaty on the Functioning of the European Union (n 17). The Space Policy of the European Union <https://defence-industry-space.ec.europa.eu/eu-space-policy_en>.

38 Targeted consultations on EU Space Law <https://defence-industry-space.ec.europa.eu/targeted-consultation-eu-space-law_en>.

39 DG DEFIS suggests the use of space technology, including space data for various causes, such as the EU Green Deal, digitalisation, 'promoting the European way of life', and COVID <https://defence-industry-space.ec.europa.eu/priorities_en>. The Space Strategy for Europe equally reiterates the role of space data for achieving the policy objectives of the EU. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – Space Strategy for Europe [2016] COM(2016) 0705 final.

40 A broad overview of the competences of the EU and its Member States can be found here: Areas of EU action <https://commission.europa.eu/about-european-commission/what-european-commission-does/law/areas-eu-action_en>.

include provisions that affect the regulation of space big data. Section 5.2 mentions the instances where EU law could be reviewed or amended, an action that should be undertaken by the EU. Except for mitigating the said challenges, the EU can work towards incorporating space data in its existing and future legislative documents, thus extending its regulatory initiative in this field. Although several pieces of EU legislation can be served by space data, their use is not always foreseen in their text. By adding an explicit mention of space data, a legal pattern around their use can emerge and they can form part of the broader EU legislative framework. Moreover, space data and the capabilities of space technology should be considered and form part of future legislation. The example of the NIS 2 Directive, which extends the scope of its predecessor to some parts of the space sector that connect to space big data, showcased that in many regards space technology and space data should be explicitly mentioned as part of digital infrastructure. With this in mind, space data and space big data can be seen as part of the EU Digital Strategy,[41] the EU Data Strategy,[42] and the EU Data Spaces.[43]

EUSPA is tasked with the operation of the EU Space Programme and the promotion of its capabilities.[44] With its knowledge of user needs and its efforts in developing downstream applications, it can promote the discussion around the legal and policy aspects of space big data. It can also facilitate the use of the data from the EU Space Programme by creating accessible policies for its services.

5.4.3 The role of States

States can play a significant role in the regulation of space big data. Vested with the power to authorise and supervise the activities of their nationals in outer space, they can take steps to regulate several facets of the space big data

41 A Europe fit for the digital age <https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age_en>. Space, particularly satellite-based connectivity and space traffic management, is mentioned as part of the current actions in the framework of the EU Digital Strategy <https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/space-eu-initiatives-satellite-based-connectivity-system-and-eu-approach-management-space-traffic_en>.

42 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – A European Strategy for data [2020] COM(2020) 66 final, which foresees the integration of Copernicus data into the EU data spaces.

43 Data Spaces are envisioned as collaborative data infrastructure and governance frameworks that facilitate data use and are guided by common principles such as security, privacy, and transparency. Commission Staff Working Document on Common European Data Spaces [2022] SWD(2022) 45 final.

44 EUSPA Mission Statement, About EUSPA <https://www.euspa.europa.eu/about/about-euspa#missionstatement>.

lifecycle. Some examples mentioned in section 5.2 include the clarification of the privacy implications of space big data through national laws, the adoption of higher or more specific cybersecurity standards for space big data on the national level, and the potential of enacting national laws dedicated to space big data. States can adopt new regulations until the efforts to establish regional and international regulations come to fruition or in the place of coordinated efforts.

National measures can find direct application under the State's jurisdiction, while they can be introduced and reviewed more easily, compared to regional and international measures. The number of countries with a national framework on space activities in place showcases their willingness and capabilities in this regard.[45] States with existing national frameworks can include space data in their scope through a subsequent amendment or review. One option would be to incorporate requirements for the licensing of satellites involved in space big data, which will also have an impact on data. Another option is to adopt dedicated national data policies that can function concurrently with or separately from the national legal framework. In doing so, they can prioritise the legal issues and fields that fit their existing frameworks and policies, while minding the limits drawn by international space law, as discussed in section 3.1, as far as the regulation of space activities are concerned. Likewise, countries that have national data policies in place may wish to expand their scope or adjust them to current technological developments, while also addressing specific legal fields. For instance, an existing policy can be complemented with elements from some of the relevant fields of law, privacy, IP, cybersecurity, and export control that may be missing or require further elaboration.

Except for regulating, the proposed solutions involve the implementation of existing regulations on behalf of States. This refers especially to the enforcement and interpretation of existing laws and the licensing arrangements that States make, in order to comply with their international and other obligations. Several issues that can be addressed this way include the registration of space objects, according to the provisions of the Outer Space Treaty and the Registration Convention, the oversight of privacy compliance, as well as the interpretation of the terms included in cybersecurity and IP laws.

Alongside their legislative authority, States can promote certain priorities on the national level, as well as on regional and international levels. For example, some States may wish to enable commercial activity in the field of space data and hence opt for a framework that regulates such an activity in a manner that safeguards commercial interests. Other States may strive for the maximum level of openness in the access and sharing of data and create a framework that removes limiting parameters, such as export control or intellectual property. There may also be States that want to direct the use of

45 UNOOSA National Space Law Database <https://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/index.html>.

space data to specific areas that can benefit from that, such as the ones described in section 2.1.3. Alongside the establishment of a framework for space data, these States can also involve space data in frameworks related to other fields, such as environmental monitoring or urban planning, so that they increase the uptake of space data.

States can be assisted in these tasks by their national space agencies, or other governmental authorities, which plan, develop, manage, and execute space projects and can be instrumental in the adoption and application of relevant legislation. Additionally, States and their national authorities can help raise awareness of the potential of space big data in the scope of privacy and on the legal issues of space big data. They are also the ones who can determine whether the matter of sovereign privacy is worth addressing.

5.4.4 The role of private actors

Private actors are the entities that are involved in space big data without political connections to a State or a public organisation. Although they fall under the jurisdiction of a State and require State authorisation for conducting their activities in outer space, their interests and competence differ compared to those of States and public organisations. In this thesis, they are referred to as 'stakeholders', since they have direct interests in space big data and are active in various stages of the space big data lifecycle, from data collection to processing, use, and dissemination.

Private actors can play a prominent role in delivering the solutions proposed in section 5.2. Despite not being able to regulate, enforce or interpret the laws and data policies related to space big data, they can put forward licensing and contractual arrangements or technical and organisational measures that respond to several of the identified legal challenges. Their significant position is justified by the fact that they are the subjects of the relevant laws and data policies, which mostly create rights and obligations for them, they are the ones that operate within the existing regulatory framework, so their actions influence it significantly, and they are able to resolve some of the legal challenges on an *ad hoc* basis and without having to go through the regulatory procedures that States and organisations do.

In terms of technical and organisational measures, private actors can work on creating a compartmentalised space big data lifecycle, which will aid in the identification of the processes that take place and their outcome, for the purpose of applying the relevant laws and data policies. Albeit simple, this solution appears under several legal challenges. Data protection, IP, cybersecurity, and export control laws can benefit from a clear distinction among the various lifecycle stages, that can better determine whether and how they can be applied. Private actors can also monitor the space big data lifecycle, ensure that applicable laws are adhered to, and notice any changes that can trigger

a different regulatory treatment. In this regard, the role of private actors has been stressed on numerous occasions in section 5.2.

In terms of licensing and contractual arrangements, private actors have considerable leverage. When it comes to the licensing of their activities by the appropriate State, they have to comply with the given requirements. However, when it comes to the licensing for using their data, data products, and related technology, they are solely responsible for the terms and conditions they will include. Although they should consider the supply and demand for their services, as well as the interests of their users, they are in the position to determine the grounds on which several of the legal aspects are arranged. This is particularly the case for data suppliers. Except for user licenses, they can also handle these matters through contracts with the parties they interface with. As was discussed in section 5.2, several solutions rely on licensing and contractual arrangements, hence the role of private actors is pivotal.

Private actors are affected both by the existing regime and all the proposed solutions since they are directly engaged in the activities that relevant regulations govern. Therefore, any future regulatory effort should factor in their needs, in order to ensure that the measures at hand are suitable and applicable. For the same reasons, their input should be part of the equation and reflected in future regulatory initiatives.

5.4.5 Other examples of space data governance

Besides the actors mentioned above, there are examples from others, which can serve either as an inspiration for regulatory approaches brought forth by the actors above or as alternative regulatory approaches. These other actors comprise organisations of States, private entities, or both that are active in the area of space data. Most of them have developed guidelines, standards, or practices, based on the collective expertise of their members, which can serve as guidance for similar initiatives in the field of space big data.

The *Committee on Earth Observation Satellites (CEOS)* consists mainly of governmental organisations and focuses on matters of interoperability of EO systems.[46] Among its objectives is the optimisation of the benefits of EO data, through streamlining, based on information and knowledge exchange, factors that can be considered in terms of space big data as well. The *Consultative Committee for Space Data Systems (CCSDS)* is a multi-national forum, comprising space agencies and industry representatives, working on the development of standards for data systems and information systems.[47] Even though this type

46 CEOS Overview <https://ceos.org/about-ceos/overview/>; CEOS Terms of Reference, November 2013 <https://ceos.org/document_management/Publications/Governing_Docs/CEOS_Terms-of-Reference_Nov2013.pdf>.

47 About CCSDS <https://public.ccsds.org/about/default.aspx>.

of data, technical data related to space projects, is not particularly examined in this thesis, the processes that are in place and have led to the creation of technical standards and good practices[48] can also be applied in the context of space big data. The *Group on Earth Observations (GEO)* is a partnership among governments and organisations that aim to promote informed decision-making based on space data.[49] For that, they have created a system of systems, the *Global Earth Observation System of Systems (GEOSS)* to function as a single point of access to various EO data sources. They have also introduced Implementation Guidelines for the GEOSS Data Sharing Principles[50] that involve a full and open exchange of data, metadata, and products, facilitated data integration and re-use, consistent pricing policies, time and quality considerations, and are coordinated with existing policies, legislation, and instruments.

The *Space Data Association* is an organisation that enables collaboration among satellite operators in the sharing of data for the purpose of avoiding collisions.[51] Through its *Space Data Centre*, relevant data are collected from the participating operators and are offered to the participants that use them for conjunction assessment and similar uses.[52] The permitted uses of the submitted data, their sharing with third parties, and related liability matters are arranged via contracts between the Space Data Association and its member organisations.[53] The *International Charter Space and Major Disasters* is another collaborative initiative, which aims to make EO data available to participating governmental authorities for the purpose of disaster management and response.[54] The data come from space agencies and commercial operators that subscribe to the Charter and commit to providing data on a voluntary basis to help address imminent disasters and their aftermath.[55]

The *International Data Spaces Association* is an initiative for the creation of standards for the sharing of data, which could also be applied to space data.[56] It allows certified users to access a data ecosystem and make their data avail-

48 CCDS Standards Development Process <https://public.ccsds.org/Publications/StandardsDevProcess.aspx>.

49 GEO at a Glance <https://www.earthobservations.org/geo_wwd.php>.

50 Implementation Guidelines for the GEOSS Data Sharing Principles, 17-18 November 2009 <https://docplayer.net/17681568-Geo-vi-implementation-guidelines-for-the-geoss-data-sharing-principles-document-7-rev2-17-18-november-2009-as-accepted-at-geo-vi.html>.

51 Space Data Association <https://www.space-data.org/sda/>.

52 Space Data Centre <https://www.space-data.org/sda/space-data-center-3/>.

53 C Leurquin, 'Introduction to the Space Data Association' (*Secure World Foundation*, 3 November 2011) <https://swfound.org/media/52875/christine_leurquin.pdf>.

54 The International Charter Space and Major Disasters <https://disasterscharter.org/web/guest/home>.

55 Charter On Cooperation To Achieve The Coordinated Use Of Space Facilities In The Event Of Natural Or Technological Disasters, 25 April 2000 <https://disasterscharter.org/web/guest/text-of-the-charter>.

56 International Data Spaces Association <https://internationaldataspaces.org/we/the-association/>.

able on their own terms to other users. Its regulatory framework refers to EU initiatives on data and digital technologies and points to legal aspects to consider when sharing data, such as competition, data protection and security, and IP.[58] It also suggests a 'legal anatomy' of data governance that encompasses rights over data, contractual arrangements, organisational aspects, and technical implementation. Likewise, the *Common European Dataspaces* aims to create pools of data to support various priority areas of the European Union.[59] They are structured on the basis of interconnection and interoperability and function according to various principles, such as security, privacy, fairness, and transparency.[60]

5.5 Chapter conclusion

This chapter addressed research question 4 "which regulatory strategies can address the legal challenges and facilitate the use of space big data?". There are six regulatory approaches that can be applied in various ways, in order to overcome the legal challenges and enable the collection, access, use, and dissemination of space big data. These approaches are (1) new regulation, (2) the enforcement of the existing legal framework, (3) the interpretation of applicable laws, (4) the implementation of technical and organisational measures, (5) licensing and contractual arrangements, and (6) maintaining the existing status quo (*see* table 5.1). Among them, the approach of a new regulation and the implementation of technical and organisational measures resolve the most legal challenges. Moreover, the adoption of an international law dedicated to space big data can also resolve significant legal challenges.

New regulations that review, amend or supplement the existing framework, and the implementation of technical and organisational measures have the potential to resolve the majority of the legal challenges. Among the twenty-seven legal challenges that were identified in chapter 4, a new regulation can potentially resolve twelve challenges and the implementation of technical and organisational measures can resolve fourteen challenges. Maintaining the status quo offers a potential solution to eleven legal challenges, the interpretation of applicable law ten, licensing and contractual arrangements eight, and the enforcement of the existing framework five. Each of the examined regulatory approaches has its own attributes and requires a certain level of time and effort. It also resolves legal challenges with different impact on the space big data lifecycle. The choice of the most suitable regulatory approach and their

58 International Data Spaces Legal Dimension <https://docs.internationaldataspaces.org/ids-knowledgebase/v/idsa-rulebook/idsa-rulebook/6_legal_dimension>.

59 A European Strategy for Data (n 42).

60 Data Spaces <https://joinup.ec.europa.eu/collection/semic-support-centre/data-spaces>.

associated solution depends on these factors and on the competences and priorities of the actors that can implement them.

As far as the attributes of each regulatory approach are concerned, maintaining the existing status quo without implementing any changes is the easiest and least time-consuming approach, but entails the risk of regulatory breaches and inadequate protection of legitimate rights and interests. The implementation of technical and organisational measures mainly by the actors that are directly involved in space big data activities offers an intermediary solution, as it can quickly address some of the most pressing challenges, but without creating any binding result. Enforcing and interpreting existing relevant laws and data policies make efficient use of the existing means, but do not suffice to fill in several gaps and omissions. Licenses and contracts do not guarantee a uniform application of the law. The adoption of new regulations on national, regional, and international levels can resolve several challenges, but is time-consuming, and complex and can lead to regulations that are surpassed by rapid technological advancement. The introduction of a regulation dedicated to space big data can have a considerable impact, if the effort involved in its adoption is justified by the rising development of space big data as a field of technological and business activity.

The six regulatory approaches formed the basis for the solutions that were recommended for each of the legal challenges identified in chapter 4. Some solutions address more than one challenge, whereas some challenges call for more than one solution. To prioritise or choose solutions, in cases where the implementation of all of them is not feasible or desirable, the analysis considered the number of challenges that each regulatory approach tackles and the impact of each legal challenge on the space big data lifecycle. Consequently, as mentioned above, new regulations and the implementation of technical and organisational measures emerged as the regulatory approaches that can resolve the greatest number of legal challenges. International space law, export control, and data policies surfaced as the fields with the most impactful legal challenges since they affect all the stages of the space big data lifecycle. Privacy and data protection law, intellectual property (IP) law, and cybersecurity law also influence several stages of the lifecycle, and hence should not be overlooked. The proposed regulatory approaches and solutions are not exhaustive, but rather provide a comprehensive overview of the legal aspects of space big data.

As far as the possibility of a law dedicated to space big data is concerned, this thesis posits that an international regulation on space big data can tackle significant part of the legal challenges and provide legal certainty as to the application of the existing legal framework to space big data. A dedicated law is necessary to address pressing legal matters and can serve as a vehicle to address other aspects of space big data, such as their technical, scientific, and commercial extensions. In particular, it is supported that an international law on space big data is worth pursuing. Its content should be a combination of provisions including new rules and provisions providing guidance for the

application of existing rules on space big data. New rules should be created for matters of international space law, export control, and data policies related to space big data. Guidance should be provided as to how privacy and data protection law, IP law, and cybersecurity law can be best applied to space big data, in order to ensure the protection of the legitimate interests these laws govern.

The proposed solutions cannot be implemented without an initiative from the actors that can put them forward, which prompts the policy discussion. The main actors include the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS), the European Union (EU), and the EU Agency for the Space Programme (EUSPA), States, and private actors. The actor or actors that will implement the proposed solutions vary depending on whether these actors want to instigate such a procedure and whether they are able and have the mandate to do so. The States and the private actors involved in space big data have the potential to enact most solutions and should therefore be given a prominent role in the process of addressing the legal challenges. UNCOPUOS, the EU, and EUSPA have the highest authoritative power, thanks to their wide tasks and their expertise in matters of governance of space activities, including space big data.